Ways of Looking at a Virus

Reflections on the COVID-19 Pandemic

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Since the beginning of 2020, we have been swept up in a chain of events that has called into question much of what we have come to take for granted. It has been a time when, to paraphrase Goethe, Nature wakens us. How can we best place ourselves in relation to the events that have unfolded over the course of the pandemic? Or: Can we find a way to think about them that allows us to experience ourselves as participants capable of making considered decisions? This seems to us to be important. What decisions an individual makes should be rooted in understanding and the intention to act responsibly, yet out of freedom. Action born of "manufactured consent,"[1] enforced by societal pressure and government regulations, deprives us of the fundamental sense of agency that lies at the core of being human. And this seems to be a pivotal question. The presence of the virus is linked inextricably with the way we choose to enact being human.

The initial conversations that led to this article took place in the spring of 2020. We thought that the best way to find a productive relationship to the growing pandemic was to engage with it in all its various aspects. We began with the question: What is a virus? This led to the publication of three papers: on viruses in the dynamics of life,[2] on extendedness and permeability in understanding organisms,[3] and a critique of the book *The Contagion Myth*.[4] As the pandemic developed, the questions shifted. We realized that although SARS-CoV-2 was a necessary condition for the spread of COVID-19, the response to this new viral presence had little to do with the virus itself. The pandemic was and is an ecological, social, and worldview phenomenon. What follows is an attempt on our part — as of October 2021 — to orient ourselves in what is without question a complex, confusing, and still evolving situation.

Questions on the boundaries

Is there anyone on the planet who has not been aware of the events of the past 18 months? Anyone who has not heard of SARS and COVID, who has not had to wrestle with questions of isolating, masking, and social distancing? Anyone who has lived through this time in the way he or she is accustomed to? What would the presence of this new virus have been like for many of us if we hadn't been told so much about it?

Despite the almost constant barrage of information concerning SARS-CoV-2 and the dangers it poses, it still remains, in many ways, a mystery. We actually know little about it. The global response has been based on theories concerning its nature and origin that are to a great extent still open questions. We don't know where this virus came from. Although we have been working under the assumption that it spilled over into humans from a still unknown animal host, recently even this has been called into question. Scientists around the globe have called for closer examination of the possibility that it came into circulation in the human population on account of a lab accident.[5–7]

The questions SARS-CoV-2 raises are in many ways true for viruses in general. The more closely we look at viruses the more interesting they become. Although we could say that this is true of most everything, viruses are proving to be especially intriguing. They present a multitude of riddles that challenge the narrative concerning the nature of organic life and humanity's place in it that we have developed over the course of the last hundred or so years.

Viruses are a boundary phenomenon. They are neither alive nor not alive. We believe that they look like something, yet they are too small to see. We believe that they cause disease, yet not every organism of a species that is infected by a given virus falls ill. Their origin is a matter of conjecture, the role they play in the evolution of organic life an open question. According to some estimates, viruses make up the majority of Earth's biomass. Yet the largest virus is still far too small to be seen with the naked eye. The smallest are well below the threshold of possible magnification in a light microscope. The only images we have of them are the traces left in the image field of an electron microscope.

Yet since early in 2020, a tiny, living-yet-not-living, unseen yet vividly imagined biological entity has become a singular focus of human attention world-wide. SARS-CoV-2 has been viewed as an enemy to be defeated, and most measures concentrate on that task. At the same time, the pandemic has laid bare long-existing social ills — think inequality, discrimination, or inadequate health care. And the response to it has itself brought about widespread suffering — think anxiety, joblessness, or depression. Will an end to the pandemic mean forgetting this larger context? It would be nice to think that all the problems and issues would force humanity to stop and reconsider, to ask what is important and less important, to seek ways to care for the planet and for one another. But this is something we will need to choose to do; no external stimulus can force us to do so.

Boundary phenomena push us to think anew. They arise when we meet something that is not easily categorized, something that doesn't quite fit. In such situations, we often overlook the possibility that is being offered and attempt to tweak established ideas and conceptual frameworks to make space for the new appearance. This has certainly been the case in the development of our understanding of viruses. We have tried to find the way to make them fit into the modern scientific conception of what life is, rather than allowing the questions they raise to lead us into broadening and deepening our understanding of life as it presents itself to us.

It is a good time to step back and ask ourselves what we do know and what we don't know. What can we be certain of? What are the phenomena? What are the assumptions underlying our response to the phenomena?

COVID-19 — Unfolding Pandemic and Riddles

We are going to proceed from the assumption that early in 2020, based on the recognition of certain atypical pneumonias, researchers identified a previously undescribed virus now present in human life.[8,9] We are further going to assume that the doctors and researchers involved were serious, that they acted to the best of their knowledge, and that they truly believed that they were acting for the good.

The initial research was carried out in China.[8] At the beginning the story was quite compelling. A small cluster of patients, atypical respiratory symptoms, a wet wild-life market in Wuhan. Within days a first hypothesis was in circulation and laboratories in various parts of the world were gearing up to develop diagnostic tests. At that point no one had isolated the virus, there were no viral cultures to be tested. The entire first response was based on RNA sequences that pointed to a beta-corona virus known to be present in certain species of bats.[10] (It would later become clear that no bats were to be found at the wet market. The assumed, now once again questioned, spillover of a zoonotic virus — one that lives in

animals — into human beings was not direct. There was an intermediary involved. The intermediary or intermediaries have yet to be identified.[11])

The global health community has long anticipated the emergence of a highly contagious viral disease. Because of this there are paths of communication in place in most countries as well as national centers for disease control. Most countries today have research facilities working with highly infectious agents. Within a very short period, the entire global health network had been informed that a new or novel infectious agent had been identified among patients in China.[12] Soon reports began to come in from other countries.[13]

Although the Chinese doctors had initially questioned whether the virus was transmitted from human to human, the growing number of cases in places far away from one another soon brought about a change of mind. Countries began to track contacts and construct a picture of how the virus had begun to spread. There was soon little doubt in the public health community that we were dealing with a highly contagious virus, an ever-widening emergency. What has happened in the ensuing time appears to bear this out.

If we look more closely, however, the simplistic statement "SARS-CoV-2 causes the disease now known as COVID-19" doesn't completely capture what we have seen happen. In some people, the specific symptoms of the disease and the presence of viral genetic material as shown through polymerase chain reaction (PCR) tests coincide. They appear together. The standard understanding of pathogens infers that the virus causes the disease. It is, however, not always the case that the presence of the virus coincides with someone becoming ill. In a yet undetermined number of people, the PCR tests for the virus come back positive and yet there are no discernible symptoms. These people are termed asymptomatic. Since there has been no large-scale accurate testing of the healthy population, we do not know exactly what percent of the population is asymptomatic.[14] Asymptomatic individuals do not experience illness, yet the presence of the virus in tissues can be detected over time, indicating that the virus is being propagated in the cells. You can be a host to SARS-CoV-2 but develop no symptoms of the illness called COVID-19. Many studies have found that over one-third of all cases are asymptomatic.[15] Some indicate much higher percentages; an October 2020 study published by University College London concluded that "COVID-19 symptoms are poor markers of SARS-CoV-2 infection. Thus, 76.5% of those who tested positive reported no symptoms and 86.1% reported none of the specific COVID-19 symptoms on the day of the test."[16]

Another striking characteristic of COVID-19 is the variation in susceptibility and the wide range of symptoms now associated with the disease. It shows itself differently in different people.[17,18] In some populations it is more virulent than in others. COVID took a greater toll in the Bronx than it did in Manhattan;[19] many more people fell ill in Europe and the industrialized countries earlier in the course of the pandemic than in Africa or India. When the pandemic began it was a surprise to epidemiologists that so few children fell ill, since children are susceptible to other respiratory infections such as the seasonal flu. The elderly, by contrast, have been highly susceptible to serious progressions of the disease,[20,21] and in the U.S. it has been especially devastating for people of color[22] and those at the lower end of the economic spectrum.[23,24] Often the individuals who suffer most from the disease and those who die have an array of other conditions — so-called co-morbidities — that play a role in disease progression. These include, to name a few: cardiovascular disease and hypertension, obesity, diabetes, other lung diseases, and cancer.[25]

The great variation in the the way the disease presents and develops indicates that the larger reality of each person's life — from age to diet, from living environment to pre-existing medical conditions — and not only viral infection is involved in the disease. In fact, an over-active and disordered immune response

in the form of hyper-inflammation is often implicated in severe cases that lead to multiple organ failure and death.[26]

The context within which the pandemic has unfolded has been shaped by human action and inaction. There is little doubt that if we wish to understand why this is happening now, we must pay more attention to that larger context. The different ways that the virus has impacted communities worldwide highlights systemic racial and economic disparities in our social systems. We also need to consider human impact on the earth's ecosystem: encroaching on wildlife habitat; changing climate and warming of the earth; disregard of the impact of electromagnetic-radiation, noise, or air pollution; the impact of plastics on fragile ecosystems; dependency on agricultural practices that are poisoning the soil and the entire web of life that keeps the planet alive. In a variety of ways, we have created conditions that have made the pandemic possible, and they are without question complex. Saying that the virus is the sole problem is a dangerous over-simplification of the situation.

The Importance of Perspectives

> In analyzing a problem, the biologist is constrained to focus on a fragment of reality, on a piece of the universe which he arbitrarily isolates to define certain of its parameters. In biology, any study thus begins with the choice of a 'system.' On this choice depend the experimenter's freedom to maneuver, the nature of the questions he is free to ask, and even, often, the type of answer he can obtain.[27]

This passage from Nobel prize winning biologist Francois Jacob's autobiography captures one of the great dilemmas and dangers of modern science. The way we choose to look at something determines how we are able to engage with it and, thus, what it is able to show us. The narrower the focus, the more limited our understanding. Perhaps better: If we narrow the focus too much, we may become masters of the details but lose the context within which the details make sense. It is only in the context of the whole that we can test our understanding of the details. It is only when we place them in the context of the whole that we can correct our thinking and find the questions through which we can deepen our understanding.

This is also something we have to take into consideration in the current situation. Our capacity to understand what the presence of this new virus means has been limited by the narrow lens through which we have viewed it. The focus, and with it our capacity to grasp the implications of our response to this new presence, has been two-pronged: 1) understanding in detail the make-up of the virus in order to grasp how it functions in the human body and, 2) understanding how it is transmitted in order to minimize the spread of the disease. The first area of inquiry has had the goal of developing vaccines and anti-viral drugs specific to SARS-CoV-2, the second led to measures such as lockdowns, masking, and physical distancing.

Very early on in the process certain assumptions became axiomatic. In Jacobs' words, an agreed upon 'system' set the parameters for experimentation, the nature of the questions to be asked, and the answers that could be expected. The narrowing of the parameters and the subsequent actions of governments around the world based on that narrowing have been decisive. Yet there is still much unclarity about how the measures have actually impacted the spread of the virus or the reduction in the number of deaths. And those same measures have had devastating effects on the livelihoods, health, and well-being of millions of people.[28]

We want to widen the discussion. There are different ways of looking. The way we look can both color and illuminate what we see. If we take different perspectives, we can hope to discover more nuances

and layers in the reality we are dealing with. In what follows, we are going to explore different ways of looking at viruses, with a focus on SARS-CoV-2 and the COVID-19 pandemic. We begin by considering the virus in isolation, as a discrete thing. Then we look at the virus in relation to the fluidity of life, discuss the ways we think about things and the stories we tell, and finally turn our attention to how the presence of the virus challenges us to see ourselves and the virus in the context of a greater whole.

I. The Virion

A number of researchers over the years have highlighted our tendency to confuse virus and virion.[29] The virion is the viral particle. It is inert, seed or spore-like without being truly similar to or homologous with either. The virion is one phase of the life cycle of a virus. The only time that we can speak of the virus as a physical, material some-thing is during this phase. The depictions of SARS-CoV-2 on the covers of so many journals and magazines, on the front pages of newspapers, and on countless websites are of the stylized virion, the non-active phase of the viral cycle. Only when it is non-active does the virus have a morphological structure.

In a very stimulating paper published in 1983 in the *Journal of Theoretical Biology*, Claudiu Bandea, a researcher in the Department of Microbiology at the University of Georgia (USA), addressed the question whether viruses are alive or not.[30] He took a novel approach and focused his attention on the way viruses bring themselves to expression. He distinguished between the organism as a morphological structure and the life that is occurring in its physiological functions. In his view, life refers to all the physiological activities that are occurring through time in the organism's life cycle. It is a salient characteristic of organisms that they maintain morphological coherence throughout their lives.
Viruses are different. They have a specific morphological structure only when they are inert, a viral particle. The virion has a morphological structure. Once the virus is integrated into the life process of a cell, it loses its morphological structure. Bandea differentiates between a vegetative phase and a particle phase in the ontogenetic cycle of a virus. The vegetative phase is intracellular, the particle phase extracellular. In the former, the virus is active but has no cohesive morphological structure; in the latter the virion has a clear morphological structure but is not active. Unlike organisms in which morphological integrity is an essential feature of their life, viruses express themselves in the two very different phases: Either there is physiological function — life — or there is morphological structure. The two are not present together. When the virus is active it has no body.

We are used to thinking of biological entities as things. Our understanding of viruses is also based on first positing and then creating the methods to "prove" its thingness. According to our current understanding of virion morphology (remember: virions are extremely small), SARS-CoV-2 is comprised of an envelope, a capsid, and RNA. The capsid surrounds the RNA; the envelope surrounds the capsid. The envelope and the capsid create a protected interior space containing the RNA. Both the envelope and the capsid are comprised of proteins, the envelope partially of host cell proteins and lipids.[31,32]

The first images of virions were published in 1940 by Helmut Ruska and his colleagues at the Siemens & Halske laboratory in Berlin using the newly developed transmission electron microscope (TEM). The images were obtained by focusing what is conceived of as a stream of electrons on a prepared specimen mounted above a fluorescent plate. Depending on the composition of the specimen, a gray-scale image on the fluorescent plate is obtained. The earliest images were from unstained, raw specimens that were obtained either from a solution or a tissue thin slice and then fixed with aluminum oxide. Since the imaging took place in a vacuum, specimens had to be completely dried. The consensus was that these

"early electron micrographs proved once and for all the particulate nature of bacteriophages."[33] (Bacteriophages are viruses that infect bacteria.)

During and following World War II, the magnification of the microscopes improved and new techniques for preparing the specimens were developed. In 1946, Ralph Wyckoff, at the University of Michigan, developed a technique called metal shadowing in which a heavy metal vapor was obliquely deposited on a prepared specimen. In the following years, further fixation techniques were developed including freeze-drying and cryofixation.[34] Once prepared, samples are embedded in epoxy, sliced extremely thinly and imaged. To date, the only way to gain an image of a virion is by removing all traces of fluidity and then re-imagining the "wild" virion based on what is left.

Physically, the SARS-CoV-2 virion is practically non-existent. Estimates based on electron microscope images place its diameter at about 100 nanometers, its volume at 10^{-3} femtoliter, and its mass at 1 femtogram.[35] Keeping in mind that a nanometer is 1/1,000,000,000 (1/billionth) of a meter, a femtoliter is 10^{-15} liter, and a femtogram is 10^{-15} grams, it is clear that what we are dealing with is something very, very small. It is impossible to see in the normal sense of the word. As a physical quantity, the virion exists on the boundary to nothingness.

Popular depictions of the virion have skewed our sense of what we are dealing with. They lead us to think that the virion is much more substantial (in a physical sense) than it is in fact. Imagine a ping-pong ball beside a full-grown man or woman. If we were to grow the virion to the size of the ping-pong ball and keep the person in scale, he or she would be roughly the height of Mount Everest. The artists' renderings of SARS-CoV-2 increase public awareness of the presence of the virion but they do little to help us find a healthy relationship to this presence. They don't help us understand; they simply reinforce the public health narrative that we are under attack from some thing.

Most of what we are being told about the way the virus is transmitted from human to human is based on the virion's physicality. To the best of our knowledge, the virions are disseminated into the air within the water droplets that we exhale.[36,37] The number of droplets exhaled depends on our activity. Are we breathing regularly, speaking gently, holding passionate monologues, arguing, singing joyfully, coughing, sneezing? Although it is clear that each of these activities differs from the others psychologically, they also do so from a purely physical point of view. We expel many more droplets when sneezing than we do when breathing regularly. If there are virions present in the airways they are expelled in these droplets.[38]

The distance that they travel depends on the nature of the exhalation on the one hand and the size of the droplets on the other. A sneeze produces more droplets than breathing, the droplets tend, however, to be larger. Larger droplets will tend to fall more closely to the breathing person than smaller ones do if the air is still. The smaller droplets — the aerosols — can be suspended in the air for longer periods of time and disperse more widely. These are less than 5 microns in size. The largest of the aerosols are thus about 50 times larger than the SARS-CoV-2 virion. Here too the physical size — the smallness of the virion — plays a decisive role. They are small enough to journey with the aerosols. The extent to which they do is still debated. The fact that it is physically possible has led most scientists and public health officials to infer that the SARS-CoV-2 virions are transmitted through the air. This is in keeping with what has become the dominant paradigm governing our understanding of infectious diseases: Pathogens responsible for disease are passed from person to person through direct bodily contact or bodily fluids. The use of masks and physical distancing to reduce the likelihood of infection is based on this inference as are policies of self-isolation and quarantine of infected individuals. Local and national lockdowns are logical consequences of this way of thinking about transmission and infection.

If the SARS-CoV-2 virions are transmitted through aerosols and if infection occurs through breathing in air containing viral particles, these measures all make sense from the point of view of physics. Virions are subject to the same laws as all other particulate matter.

What sets them apart as biological entities is the need for an environment that maintains their viability. Without a fluid environment, virions have an ephemeral existence; they disintegrate and turn to dust.

II. Virus and Fluidity

> A virus is not an individual organism in the ordinary sense of the term but something which could almost be called a *stream of biological patterns*.
>
> — Immunologist Sir Macfarlane Burnet (cited in [39]; emphasis added)

Long before scientists identified viruses as virions — as the tiny particulate entities described in the last section — they observed with the naked eye transformations in plants and animals that seemed to be contagious. The tobacco mosaic disease, which was named after the discolored blotches appearing on the plant's leaves, appeared to spread from plant to plant. But how was the disease spreading? In the 1880s scientists extracted juice from the plants and when they injected it into healthy plants, the latter developed the symptoms of the disease. Fluid could be extracted again from those plants and used to infect still other plants. Dutch scientist Martinus Beijerinck spoke of a "*contagium vivum fluidum*" — a contagious living fluid that infects tobacco plants.[40] So "virus" (you couldn't really use the plural, because they were not discrete entities yet) had to do at first with observable pathological transformations that spread via "living fluidity."

In the late 19th century, there was great excitement in scientific and medical communities about the ability to ascribe illnesses to tangible (albeit microscopic) organisms — bacteria. Many bacterial infectious diseases were being discovered, and it fit into the developing thought style of the times to think that bacteria might be involved in tobacco mosaic disease. But there was a problem. Before Beijerinck had done his experiments, other scientists already had discovered that the contagious fluid could be passed through a filter that holds back bacteria. So maybe the "it" of the contagion was in fact a living fluid? But how could a fluid reproduce? Isn't it only formed organisms that reproduce? Mustn't the agent be some kind of tiny biological entity?

From the latter part of the 19th century into present times, a main thrust in biology has been to find the material causes of biological phenomena. The "thing" perspective has dominated. The "gene," which we all imagine to be material, was at first a theoretical construct that allowed scientists to interpret certain inheritance patterns discovered in experiments with organisms such as peas and fruit flies. That the gene concept could be connected with specific substances (nucleic acids) was only discovered in the 1940s. It appeared to become an entity, one that today we picture as the DNA double helix. Research in infectious diseases followed a similar trajectory. It began with observable symptoms and also focused increasingly on discovering and elucidating the structures and "mechanisms" of infection.

The thought framework of mechanisms drove the research, and the discoveries were made possible by the invention of ever more sophisticated, technology-mediated lab techniques and instruments. There was an increasing fusion of science and technology. As discussed in the last section, it became possible to remove all fluidity from *contagium vivum fluidum*, and yet there was still something left over to observe in an electron microscope: Scientists obtained images of a structured something, what we now call a

virion — the virus as a body. Over time, there has been a growing understanding of virion structure and biochemical constitution, down into the genes.

Structures only begin to tell us something meaningful in a biological context when we bring them into relation to processes, to doings. Processes have to do with change and transformation — one state morphing into another. In process you enter the realm of fluidity. But how do you approach the doings of viruses given the fact that you can only obtain images of them when you've stopped all processes and stripped them of their fluidity? This is a real and humbling problem, one that we need to keep in mind.

In order to build up a picture of what viruses do — which is when they give up their virion nature — scientists must literally and figuratively freeze moments of activity, and then analyze the static images and substances as captured in successive moments. They then build up, in thought, a tentative picture of processes. It is up to thinking and imagination to make what is frozen fluid again to gain any sense of viral doings. And it is no easy task to see relations within the vast amount of minutiae. Moreover, we shouldn't forget that we are imagining processes thought to be occurring in and around spaces that are unfathomably small.

Since most of the images we see in the popular press and in the scientific literature suggest discrete (and immensely complicated) structures, we must keep in mind that every such structure is a snapshot, or a constructed composite image. In the past decades, molecular biologists have discovered how earlier conceptions of proteins or nucleic acids (RNA and DNA) as stable structures are inadequate. Stephen L. Talbott expresses the dynamic nature of the substances and happenings in cells based on extensive reviews of the scientific literature:

> Among proteins (those "workhorses of the cell") every individual molecule lives in transformational movement — as a dynamic ensemble of rapidly 'morphing', or interconverting, conformations — and therefore does not have a 'precisely invariant three-dimensional shape'…. Proteins can be true shape-shifters, responding and adapting to an ever-varying context — so much so that (as the noted experimental biologist, Stephen Rothman has written) the "same" proteins with the same amino acid sequences can, in different environments, "be viewed as totally different molecules" with distinct physical and chemical properties.[41]

This is important to have in mind when we speak below about a virus, a cell that has been infected, or all the "parts" involved in the processes — virus envelope, spike protein, other viral structural proteins, viral RNA, cellular proteins, cellular organelles, and so on. Inasmuch as there are actual processes of transformation going on — as happens when a virion infects a cell — all static images have to be left behind. Our ability to suggest the real fluidity and dynamics of processes in a description is constricted by language, by the unavoidable use of nouns, which suggest discrete entities when in fact interpenetration reigns and boundaries dissolve. So with all these caveats in mind, here is an attempt to provide a sense of some of the processes connected with viral entry into a cell and virion propagation within the cell.

One thing is clear: a virion does not break into or bore into a cell. A virion on its own cannot move. It needs to be brought, usually via body fluids, into contact with an organism's tissues. If it is to enter a cell, the cell also has to do something. The host organism is not a passive sufferer of an invasion. Virologists speak of virus tropism to indicate which organisms, tissues, or cell types a particular virus has an affinity with and can infect. In the current understanding of SARS-CoV-2 infection (and much remains unclear and unknown), it seems that the virus' spike proteins, that are part of its envelope, need to come in contact with and interact with receptors (specific proteins) on the cell surface. Most research to date points to the ACE2 receptor. With the help of enzymes that a cell produces (not the virus!), the spike proteins are

broken down into two subunits, and this interaction allows the virus envelope and cell membrane to fuse, which in turn makes it possible for the viral nucleocapsid to be received into the cell.

If the process continues, the virion, within the cell, gives up its structure and weaves as process with the dynamic fluidity of the inner-cellular environment. Viral RNA interacts with cell organelles and cell enzymes, and in the process new virions form and are then released from the cell. This last sentence sounds straightforward. It is also vague enough to probably not be wrong and not specific enough to suggest that scientists actually know precisely how the new virions arise in the complex interplay of host and virus. We come to a boundary that asks of us to dissolve any simple and solid notions we might have about viral propagation in the cell when we learn that an initial study of SARS-CoV-2 indicated that over 300 interactions occur between viral and host proteins.[42] Earlier studies of other coronaviruses indicated that more than 500 different host proteins could be detected in the microenvironment of the cell where the formation of new virions occurs.[43] This is truly astounding.

It is clear that RNA (or DNA in the case of other viruses) from a virion is needed for more virions to be propagated within the cell. The RNA alone, however, does nothing. Every aspect of the synthesis of viral enzymes, viral structural proteins, and new viral RNA also involves the activity of host organism enzymes and cell organelles. And the material for the new viral proteins and RNA derives from the host organism. We should not say that "viruses reproduce in cells." It is more accurate to say: "the cell can, with viruses, produce more viruses." The importance of distinguishing between the active virus-in-cell and the virion-as-particle outside the cell led microbiologist Patrick Forterre to coin the term "virocell" to signify the biological cell-virus entity that produces viruses.[29] From the perspective of process, we want to emphasize how all the activity and transformation occurs in a micro-world of living fluidity.

A last process in the configuration of virions (in coronaviruses and other enveloped viruses) is the formation of the viral envelope membrane. This lipid membrane stems from the host. A few viral proteins, such as the spike protein, are integrated into it. So we must imagine that SARS-CoV-2 virions are "clothed" in a host mantle when they are released from a cell. The new virions do not destroy the cells; they bud out of it through the cell's membrane.

The virion results from joint virus-organism activity. It has unique characteristics as a biological entity when it has emerged out of life processes. Once the virion-as-body is constituted, it does not grow or develop further. It does not move on its own and can only be passively moved from place to place. It cannot feed, digest, metabolize, or excrete. These are some of the characteristics that lead us to say that virions are not alive like bacteria. And yet a virion has a conformation and substance that has arisen out of living cells. When it comes again into contact with the life of a cell, it can give up its structure and static existence and, under certain conditions, the co-mingling with the cell will lead to creation of new virions. When Burnet spoke of the virus as a "stream of biological patterns," this stream includes the life of the host organism.

The virus can also change in the process of virion formation. Everyone following the COVID-19 pandemic has heard of the SARS-CoV-2 variants. The new virions that arise are not "exact copies" of the virion or virions that infected the cell. The genetic make-up of most viruses — as expressed in the fine structure of their RNA or DNA — can undergo changes while the virions are being produced. Viruses mutate much more frequently than bacteria and multicellular organisms. There are, for example, at least 160 strains of the most frequent common cold virus (rhinovirus), which is the main reason why scientists have not yet been able to create one effective vaccine. As you may know, the vaccine that is intended to stifle the outbreak of the seasonal flu is only partially effective; since 2009 the effectiveness in the U.S. has ranged between 19 and 60 percent.[44] The effectiveness changes from year to year as new variants arise. According to the Centers for Disease Control (CDC), 131 subtypes of Influenza A virus, which is a

primary seasonal flu virus, have been found.[45] So the genetic make-up of the virus is changing on an ongoing basis, which in turn can alter virus-host interactions. Here too there is fluidity.

The lives of all creatures on earth intersect with viruses and in mostly unknown ways. Thanks to all the technologies related to genome sequencing — the ability to isolate and determine the fine structure of DNA and RNA — scientists have discovered the ubiquity of viruses in nature. Not only humans, but bacteria, plants, and animals are all hosts to viruses. In environments writ large, such as ocean water, scientists have detected countless different viral genome types. Similarly, in environments writ small — the microbiome of organisms — viruses are also prevalent. They usually don't isolate whole virions, but only pieces of DNA or RNA that reveal a sequence with a specifically viral signature. So while scientists can say that the sequences they discover from samples out of a given environment are in this sense viral, around 70 percent of them bear no precise resemblance to known viral genomes. This is called "viral dark matter," to give a name to, as some researchers have put it, "an ever-growing pool of unknowns."[46]

The most abundant viruses are those that infect the most abundant type of organism on earth — bacteria. They are known as bacteriophages. Bacteriophages in our digestive tract form the bulk of viruses that humans harbor, and they differ from individual to individual. Some types of bacteriophages adhere to the mucus layer in the gut and then infect and destroy pathogenic bacteria. Human feces contain up to an estimated billion virions of different types per gram.[47] Most are bacteriophages.[48] The remarkably abundant and diverse viruses in the ocean are, as far as is known today, mainly bacteriophages. While much is still to be understood, it is clear that they alter the bacterial and microbial community near the surface of the water, and when the bacteria they have infected die, nutrients are released and influence nutrient cycling in the ocean.[49]

Traditionally, the main focus of viral research has been on virus-host organism relations in which the virus can be considered a pathogen. Yet even when the cells of the organism are infected by a virus considered to be pathogenic, the host organism can respond in a variety of ways. Here we want to consider different types of host-virus interactions that expand our understanding beyond the "virus as enemy" paradigm.[50]

Today there are at least ten types of viruses that are continually present in cells of most people on earth and many more types that fewer people carry.[51] The virus that is connected with the outbreak of chicken pox (varicella zoster virus) is mainly gone at the end of the disease, but in some cases inhabit the ganglia of nerve cells and can remain there in a dormant state for the rest of a person's life. Occasionally, an active body-virus relation revives and the disease called shingles arises. So, the same virus can be connected with very different whole-organism responses. It has been estimated that up to 90 percent of the world's population harbors the herpes simplex-1 virus, which is related to cold sores. In most cases this virus remains dormant during the person's life.[52]

With other types of virus there are no symptoms at all (e.g. adeno-associated virus, anellovirus) or only occasionally in immunocompromised individuals (e.g. polyomaviruses). In the case of the asymptomatic annellovirus, it has been estimated that a billion virions are replaced daily. In this case — unlike with dormancy in other viruses — the virus is being actively produced and shed, but there are no apparent negative symptoms. In a review of virus-host interactions, microbiologist Ken Cadwell concludes that the adverse or beneficial effects of viruses "are dependent on the anatomical location, host genotype, and the presence of other infectious agents and commensal microbes. It is often the context that determines whether a virus is deleterious, neutral, or beneficial to the host."[53]

There are fascinating cases of symbiosis involving a variety of different organisms and viruses. Here are two examples.[54] A particular grass species (*Dichanthelium lanuginosum*) can grow in soil temperatures greater than 50 degrees C (122 degrees F). The grass houses a fungus within it. Neither the

grass nor the fungus can grow in these extreme conditions alone; the symbiotic relation is needed. Moreover, it was discovered that the fungus harbors a virus, without which the fungus-plant symbiosis loses its heat tolerance. So it is a three-member symbiosis that allows a plant — and its partners — to thrive in such extreme conditions.

In a similar way, aphids harbor a number of different symbiotic bacteria. In the pea aphid a particular bacterial species protects the aphid against a parasitic wasp. The wasp lays eggs in the aphid and the bacteria create a toxin that kills the developing wasp larvae. Further investigation showed that DNA from a virus is required for the bacteria to produce the toxin.[55]

This intermingling of different types of organisms can go even further than what we typically consider symbiosis. When we think about the diversity of life on earth, we often think of the diversity within different types of organisms — within animals, fungi, plants, or bacteria. We have in mind the stream of heredity that connects organisms of a particular species. We consider how, through inherited changes, ongoing diversification arises within a group of organisms. This standard view of vertical inheritance is not the whole story. Biologists have discovered that genetic material can move between different kinds of organisms. This is called horizontal gene transfer and is a further way in which organisms, and organisms and viruses, interpenetrate. For example, bacteriophages in the gut can also bring genes from one bacterium to another, which is one way that antibiotic resistance spreads in bacteria.[56]

In the genomes of all organisms, molecular biologists have discovered segments of DNA that carry a viral signature (as gleaned from the specifics of the DNA sequence). These "endogenous" viral elements (often called retroviruses) have been incorporated into the genome of the viral host. It is estimated that eight to nine percent of our genome consists of such viral elements.[57] They are also present in plants and animals and can have a variety of functions. In mammals, for example, one such retrovirus plays an important role in the normal development of the placenta.[58] What's also fascinating is that many of these endogenous viral elements in the genome can be replicated and the duplicate DNA sequence can then be integrated into a different place in the genome.[59,60] As virions spread through the larger organismic environment, so also do these "transposable elements" spread through the genome. The integration of transposable elements into the genome may, as with viral infection, have no apparent effects, be deleterious or beneficial — all depending on the specific context.

All these phenomena indicate how wrong it is to think of viruses as "foreign agents." It is interesting that scientists use the friendly term "host" to describe our relation to viruses, even though we usually think of them as enemies that invade us to replicate, making us sick. Whether we like the thought or not, viruses are deeply connected with the organisms they infect. And since this relation has to do with intermingling and co-creation, we need to shed the notion of any distinct boundary between host organism and virus. When "viruses" spread, something of "us" is also spreading. Virions are spread through the environment and then taken up by organisms. When the virions become process in their interwoven activity with the host organism and new virions arise, new diversity is often created and thereby new relations to the host organism may arise when they spread. And just as the viral changes may be significant, changes in the host may be key to how the relation develops. Interpenetrating and weaving together of changing life forms is the fluid process-reality of life on earth. And viruses, in their unique way, are part of this weaving.

III. Looking at us looking at the pandemic

In the following we shift our attention away from "virus" as a biological phenomenon and look more closely at the nature of our response to the arrival of SARS-CoV-2 in our collective consciousness. This too is an aspect of the phenomenal context of the last year and a half. The pandemic is as much a social phenomenon as it is an ecological one. Or, perhaps better, we could say that the ecology of the pandemic has taken shape within specific societal contexts and ways of thinking. The nature of our response has been shaped, and will continue to be shaped, by the stories we tell and adhere to.

Polarization

The Nature Institute is located in a rural environment in the northeastern United States. It is an area of small towns, family farms, and homes spread throughout the forested land. The streets of the towns blossom on the weekends with escapees from New York City. Increasingly, conservative local inhabitants find themselves brushing shoulders with city folks who have wandered north permanently.
The pandemic has brought deep differences in the community to light. People take sides. Children speak of those who are scared of COVID and those who are not. To mask or not to mask is an ongoing debate. There are hardliners on both sides of the aisle. In the beginning of the pandemic, it was not uncommon to see people who, if forced to wear a mask to do their shopping or get a haircut, did so with a decided lack of grace. White masks with an angry red x drawn across them were not uncommon. This has shifted over the course of the last year. Masks became to some extent fashion accessories. They are often colorful, occasionally designed to make a statement.

As is probably true in communities around the world, we have our share of outspoken proponents of two opposing points of view. One acquaintance carries a pocket-sized edition of the US constitution around with him and is always ready to show anyone who displays the least interest just how a gubernatorial edict or legislative decision infringes on our constitutional rights. Another collected a fleet of trucks and mounted large signboards on them. The messaging ranges from "The future says no to a breathless, touchless new normal" to a large sign (similar to what one might expect from a personal injury lawyer) that reads: "Vaccine Injured? You Are Not Alone! Please Tell Your Story." These trucks are moved around from place to place, provide the backdrop for rallies, and are often to be seen parked on the side of the road somewhere.

The active anti-COVID, anti-government, anti-vaccination movement, although "underground" — no electronic messaging, no smart phones at meetings, gatherings by personal invitation only for fear of government surveillance — is not invisible. The members of the group organize festivals, work parties, and rallies. They invite "experts" to speak and nurture an active social and cultural life. They are, however, adamant that:

- The COVID threat has been hyped out of all proportion.
- Government, Big Pharma, Bill Gates and others are using the, what they call, "plandemic" or "scamdemic" to infringe on civil liberties, to make money, and to rob us of the ability to act independently.
- People need to fight against the forces that have coalesced against them.

In some discussions with members of this group, we have been astonished by how much information they can offer in support of their positions. They appear remarkably well-informed. They have studies,

statistics, and anecdotes to support their arguments. They have done homework. They point to what they see as untruths and to weaknesses in the mainstream arguments. They question the integrity of anyone who subscribes to those arguments. They tend, however, to be less critical of the assumptions and the supposed facts underpinning their own narrative, which they believe are rock solid.[4]

You don't have to go far to find the opposing perspective. Isn't it clear that the virus has spread disease around the globe? COVID-19 has impacted the lives of people living in Rome and Helsinki, New York City, Cape Town, Buenos Aires, Guadalajara, Mumbai, and Wuhan. It has altered the lives of people in cities, in suburbs, in slums, in mansions, in towns and villages, on board ship, and at the edge of the desert. Millions have lost loved ones. Health care workers have been stretched to the breaking point. How can people be so callous and so ignorant as to deny these facts? Can't they see that scientists and governments have done their very best to deal with a crisis?

Government policy, the public health community, and mainstream media have been in lock-step regarding the response to the pandemic. A compelling and omnipresent narrative has been created — one that vehemently opposes that of the "non-conformists." The information and the language is the same worldwide: masking, social distancing, self-isolation, quarantining, vaccination, and social responsibility. Those who deviate from this view and its guidelines or who question its validity are patronized, silenced, and ultimately forced to the sidelines. Anyone who questions the narrative is "anti-science," and anyone who is cautious about vaccines becomes an "anti-vaxxer," a term synonymous with heretic. A picture of science as a unified authority that knows what's right has been created — a perceived orthodoxy that is as unassailable in modern society as Catholicism was in the European Middle Ages.

In an opinion piece published in May 2020, Vinay Prasad, a hematologist-oncologist and associate professor of medicine at the Oregon Health and Science University, and Jeffrey Flier, endocrinologist, professor of medicine, and former dean of Harvard Medical School (we refer to their positions to indicate that they are not from the "fringe") wrote:

> When major decisions must be made amid high scientific uncertainty, as is the case with COVID-19, we can't afford to silence or demonize professional colleagues with heterodox views. Even worse, we can't allow questions of science, medicine, and public health to become captives of tribalized politics. Today, more than ever, we need vigorous academic debate.[61]

As the pandemic progressed, openness for public debate that could have led to a more comprehensive and nuanced understanding, and also acknowledge uncertainty, largely disappeared.

During the pandemic there has been virtually no social breathing space, that is, a space for exchange of perspectives. The two perspectives we have characterized (and there are others) do not come into conversation. As individuals, we have had to keep physical distance from one another. Socially, we strive to keep opposing attitudes at bay. We are careful about what we say to whom. Disagreements abound, also within families.

When you have a strong conviction of felt rightness and marshal a constellation of "facts" to underpin that conviction, you end up with ideology. We are witnessing clashing ideologies. Because of that it is hardly possible in the current social atmosphere to establish forums for open, respectful dialogue. And yet, such would be needed in order to move beyond firm standpoints that battle each other. The two of us don't pretend to have a strategy to achieve this. We too are puzzled about how it is possible to become so entrenched in a perspective.

We do know that a striving for critical self-awareness can help soften hardened views and provide more openness for dialogue: awareness that I have a point of view; awareness that this point of view is

focusing my attention in a particular direction; awareness that only certain things can show themselves depending on the lens; awareness that with a perspective I may be seeing more of myself than of the world. All this can create an opening to see things from different vantage points, and thereby gain more flexibility of mind for the sake of the many-layered nature of the world.

Fear

In the late 1800s, when the germ theory of disease was being formulated, there were vigorous discussions about the new focus on germs as the primary cause of infectious diseases. Reputable scientists such as Max von Pettenkofer or Rudolf Virchow argued that environmental and social contexts were just as or even more essential in understanding disease. But the germ theory became the dominant paradigm. Wendell Stanley was the first scientist to isolate in pure form the components of a virus, for which he was awarded the Nobel prize in chemistry in 1946. In his acceptance lecture, he pointed out that the entire field of virus research was carried out in the context of the generally accepted germ theory of disease. This theory, following the work of Pasteur, Koch, and others, "was accepted so completely that it became heresy to hold that such diseases might be caused in any other way."[62]

From its inception, the virus has been viewed as a disease-causing agent. That is the conceptual and emotional atmosphere in which "virus" is embedded. The conception of the fluid or ecological virus has only recently entered "mainstream" science, but it is definitely not the paradigm that is promoted by public health institutions. For most people, the idea of a virus is interwoven with the fear of falling ill. Disease is something we try to avoid. In the Western world, the desire to avoid disease has become an obsession. Disease is not only something to be avoided, but also something that must be avoided at all cost. The fear of disease, intertwined as it is with the fear of death, is thus for the most part present when the question of viruses comes to our attention.

During the pandemic, humanity's attention has been systematically focused on SARS-CoV-2 as an agent of disease and death, i.e. as something attacking us, something against which we have to defend ourselves. This could never have happened without the ubiquitous presence of digital media and the ability of those controlling it to highlight and disseminate globally the perspective most likely to capture public attention. Those who control the means of capturing attention have considerable power to determine where our attention is focused. By constantly feeding this underground current of fear, the media has helped ensure the implementation of governmental restrictions across the board. It has rarely been possible to discuss or question their appropriateness relative to particular locations and institutions.

Awakening and nurturing a sense of fear has been an essential aspect of the pandemic as a social phenomenon. We have been reminded constantly that we are facing an unseen killer that has no respect for boundaries. It hides in the breath of strangers, of friends and of family members. Infections and deaths are posted on a daily basis. At some point during the pandemic a box appeared on the first page of the *New York Times* online entitled "exposure risk in your area." On April 9, 2021, for example, we were told, in bright red print, that there is a "very high risk" in neighboring Greene County, NY. Taken at face value, this implies that you should be concerned about the possibility of exposure if you were to venture into Greene County. If you click on the link for more detailed information, you could read that "very high risk" is defined as "an average of 20 daily cases per 100,000 people reported in the past two weeks".[63] This means that on average 0.02 percent of Greene County's population tested positive per day, or 2 daily cases among 10,000 people. The "very high risk" only drops to "high" when there are fewer than 11.4 cases per 100,000 people. What makes that a "very high risk" is not made clear; you would have to study primary journal articles by statisticians and scientists to perhaps come to some understanding of what led

to the creation of that range and the clearly arbitrary cutoff percentages. In any case, "very high risk" is a conceptual abstraction.

Greene County is a rural county and has a population of around 47,000 people. According to its health department's reports of daily new cases there was an average of 6.6 new positive cases each day from March 26 to April 8, 2021.[64] This number only indicates the number of people who tested positive; it says nothing about whether they had no symptoms, light symptoms, or were seriously ill. The county reports that the total number of county citizens who were hospitalized during those two weeks ranged from 3 to 5 people. In contrast, the *Times* graph for "Greene County area" hospitalizations shows an average of 79 patients hospitalized during the period March 26 to April 1. This is highly misleading, since the graph includes hospitalized COVID patients from a number of hospitals in a much larger area, including the state capital of Albany. If you read that graph uncritically, you think: that's a lot of hospitalizations for this county. And that is a lot scarier than 3 to 5 hospitalizations. The large number has, however, no actually bearing on the situation in Greene County. Having followed the *Times* during the course of the pandemic, we have been struck by how the front-page reporting in images and text — and this is just one example — has done an excellent job of enflaming fear. Do the editors and reporters of the *Times* feel they are doing their civic duty by enkindling fear so readers will "do the right thing"? Are they perhaps also being driven by fear? Have they forgotten their slogan "all the news that's fit to print"?[1]

Early in the pandemic we were told to disinfect all surfaces and wash our hands thoroughly or use disinfectant after each time we touch something. Everywhere lurked contaminated surfaces. How could I know whether some little bit of virus was not still lingering on the faucet that I just turned off with my newly disinfected hands? Scientists knew, on the one hand, that as an encapsulated virus SARS-CoV-2 is covered with the host cell's membrane and that such viruses degrade quickly — a few hours to maybe a day — when outside of the body on a surface. Laboratory scientists, however, wanted to see if SARS-CoV-2 behaved like other encapsulated viruses and carried out many different experiments. Ones that made the news — that were made into news — were largely those "showing" that the viruses remained viable for some days.

Such studies, as other scientists pointed out already in the summer of 2020, hardly mimicked real-life conditions, since, for example, they used unrealistically high concentrations of virus.[65] In their view, the risk of surface transmission was very small. Yet the CDC continued to warn about the possibility of viral infection through contact with surfaces, reinforcing a sense of fear for the world around us, until April 2021 when it finally softened its recommendations.

The CDC also exaggerated the likelihood of becoming infected outdoors, which is extremely small. Some of the studies used to support higher likelihood of outdoor transmission actually included indoor settings. When a CDC official was asked by journalist David Leonhardt why the exaggeration, the answer was that the CDC "errs on the side of protection when it comes to recommending steps to protect health."[66] But it is hard not to see that it is misleading, and fear-creating, when you say that the risk of outdoor transmission is less than 1 in 10 (10 percent), when the likelihood is in fact more like 1 in 100 or 1 in 1000. As Leonard points out, "Saying that less than 10 percent of Covid transmission occurs outdoors is akin to saying that sharks attack fewer than 20,000 swimmers a year. (The actual worldwide number is around 150.) It's both true and deceiving."[66] When people wear masks outdoors in uncrowded situations, their action is likely informed by a false perception of infection risk (thinking they know the "facts") and a desire to conform to social pressures or governmental stipulations.

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[1] There are, of course, exceptions; we think, for example, of some of David Leonhardt's articles (see references 28 and 66).

A critical understanding of experimental procedures and their relation to real life situations is part and parcel of experimental science. Experiments are not real life and in a strict sense do not "prove" anything. They suggest connections. So, what about all the placards on lawns that say: "science is real"? Of course, science is real, but it is real as a human process, subject to errors and limited in its actual scope. When we hear: "science proves," we wisely ask a number of questions: What were the assumptions that informed the experiments? What was the experimental context and how does it relate to a real-world situation? What pressures might there have been to present the findings in this or that way (e.g. publish or perish)? Science is also a social phenomenon.

Fear brings psychological contraction — pulling in against what threatens. On a hike in the spring of 2020, we encountered another hiker standing masked well off the other side of the trail, evidently waiting for us to pass by. There would have been an ample six feet between us had she stayed where she was, but as we approached, she shrank further to the side with a startled look. Fear? Uncertainty? Desire to be respectful? Whatever the case, it has been disturbing to witness again and again people wearing masks where it makes no sense at all — where even the CDC wouldn't recommend them. In such situations it is not hard to have sympathy with those who see the response to the pandemic as leading down a slippery slope on which people no longer think and act with independent judgment in concrete situations, but follow a kind of phantom authority, formed from a strange mix of inner uncertainty and bombardment from outer influences. Out of fear people do things and allow things to happen to them that they would otherwise resist rigorously.

When a new disease appears on the planet, it is clear that there will be uncertainty about what the best responses are. We cannot blame people in government for not knowing exactly what the most humane measures would be. We understand the need for caution in the light of uncertainty. And yet we wonder: Would it have been possible for measures to have been addressed in a way that did not instill and enflame fear? Can you admit uncertainty and still motivate people to take actions? Doesn't "talking down" to people out of a position of authority — and out of supposed knowledge of a situation that actually has many unknowns — justifiably kindle doubt and resistance?

IV. Parts of a Single Whole

In the previous section we considered how the way we think about viruses, i.e., the stories we tell of them, is not only a determining factor in how we understand and respond to them but also in how they affect us. The pandemic, our response to the sudden presence of SARS-CoV-2, and the effect it has had on each of us have all been shaped by the way we have chosen to understand viruses and the relationship between humans and the natural world.

Paradigms, and the narratives they give birth to, bring certain aspects of what we experience as reality to the forefront. They focus our attention. This is their strength. On the other hand, by narrowing the focus, they can lead us to overlook or disregard aspects of our experience. The current scientific and medical paradigm, on which much of our response to the pandemic has been based, reflects a one-sided focus on the object-nature of the experienced world. This focus lets the world appear as an array of discrete entities engaged in a multiplicity of interactions. It leads us to believe that by striving to understand the physical properties of the entities, we will be able to accurately posit the nature of the interactions.

The experience of being separate from the world we are trying to understand is integral to modern thought. Scientific consciousness rests on those inner experiences that allow us to conceive of ourselves

as being distinct from the things around us. This approach has shown its validity in helping us understand the way inanimate objects relate to and affect one another. Yet these experiences reflect only one aspect of our relationship to the world.

The 20th century French philosopher, Henri Bergson, discusses intellectual thought as a mode of consciousness in which "we separate in space, we fix in time." The intellect does not apprehend "the continuity of change that is pure mobility"; it is therefore "characterized by a natural inability to comprehend life."[67] Bertrand Russell speaks of the intellect as "the power of seeing things as separate one from another, and matter is that which is separated into distinct things. In reality there are no separate solid things, only an endless stream of becoming."[68] Albert Einstein went even further when he wrote in a letter (quoted in a 1972 *New York Times* article):

> A human being is a part of the whole called by us universe, a part limited in time and space. He experiences himself, his thoughts and feeling as something separated from the rest, a kind of optical delusion of his consciousness. This delusion is a kind of prison for us, restricting us to our personal desires and to affection for a few persons nearest to us. Our task must be to free ourselves from this prison by widening our circle of compassion to embrace all living creatures and the whole of nature in its beauty. Nobody is able to achieve this completely, but the striving itself is a part of the liberation and a foundation of inner security.[69]

Are we capable of coming to an understanding of the world that reflects the processual interweaving of life? What would we discover about the virus if we were to approach it from a premise of connectedness rather than separateness? Would we make sense of it differently? Would it make more sense to us?

The shift from an assumption of separateness to one of connectedness requires us to see the world as an ecological whole rather than as a mechanical construct. The term *ecology* was coined by the German scientist Ernst Haeckel in 1869. He used it to describe a discipline in science focused on the relationship of living things to their environment. The term derives from the Greek *oikos* meaning house. A house is a dwelling place, the place we feel at home. Although the way we understand ecological relationships has evolved over the course of the last 150 years, what has remained is the basic recognition that we can only understand organisms within the context of the dynamic multiplicity of relationships that come to expression between the organism and the place it calls home. Essential is the recognition that we, as human beings, are also entwined; we, too, are part of the living whole.

The relationship, for instance, between viruses and their host cells, as described earlier, has a processual dynamic quality that cannot be understood mechanically. The cell is not a "factory" whose "machinery" is hijacked by an "invading" virus. The interactions between a virus and a host cell can only be understood within the living context within which they occur.

Understanding aspects of how an organism is woven into its larger environment and at the same time is permeable to environmental happenings is becoming increasingly critical, as is the need to move from a mechanistic to an ecological understanding of nature. Life knows no boundaries. Humans and viruses, bats and grasses, trees and fungi are all specific expressions of the totality of the life organism of our planet.

By the summer of 2020 it began to be apparent that there were certain unexpected ecological consequences related to the pandemic.[70] The lockdowns that had been implemented to limit the spread of SARS-CoV-2 were contributing to a reduction in certain forms of pollution.[71] The air was clearer.[72] Some waterways were cleaner.[73] In contrast to COVID-19's effect on humans — both somatically and

psychologically — Earth was able to "breathe" more freely. Some observers went so far as to question whether the virus was an immune response on the part of the planetary organism. Biswaranjan Paital, an Indian zoologist, suggested that the pandemic is "Mother Nature's way of trying to bouncing [sic] back."[74] Science journalist Sonia Shah has also suggested that humanity must reconsider its relationship with the natural world. The pandemic "is both a biological reality and a social phenomenon shaped by human agency."[75] The exploitative relationship of humans towards the earth created the conditions that both made the pandemic possible and exacerbated its socio-economic effects.

As we observe the dramatic shifts taking place in the natural world on a global level today — from rising sea levels to mass migrations, from viral spillover to climatic warming, from the collapse of delicately balanced ecosystems to the disappearance of species in habitats around the world — the depth of the human connection to Earth should be eminently clear to any thoughtful human being. She is wounded by our abuse.

In the late winter and early spring of 2020, as the pandemic began, and people around the globe were first trying to understand what was happening, there was an openness to explore some of the deeper questions related to the emergence of this new viral presence. People sought to find ways to make sense of what was happening. It quickly became apparent that the spread of the pandemic was highlighting not only critical environmental problems but also, importantly, long-term systemic social inequities. None of these were new. Yet in the context of the pandemic, they seemed to take on a new significance. On March 15, 2020, Max Fisher and Emma Bubola published an article in the *New York Times* titled "As Coronavirus Deepens Inequality, Inequality Worsens Its Spread" in which they speak of the "pandemic-inequality feedback loop" — a positive feedback loop with devastating effects.[23] On April 7, 2020, an article appeared in the same paper with the title "Black Americans Face Alarming Rates of Coronavirus Infection in Some States."[76] As research into the spread and impact of the pandemic accumulated, it became apparent that the hardest hit communities in the U.S. were Black and Latino, especially those located in areas of adverse environmental impact. Air pollution has been named repeatedly as an exacerbating factor in COVID-19.[77]

A central question is: Will we begin to address some of these questions of inequity in the post-COVID world? Underlying that question is another: Can we come to understand that social inequity also belongs to the ecology within which the pandemic unfolded, that human relations are as much a factor in the health of the ecosphere as is the relationship between warming and acidity in the world's oceans? Life does not necessarily stop where human consciousness begins.

The Wachowskis, in their film *The Matrix*, let Agent Smith voice the unpleasant truth about human behavior towards Earth:

> I'd like to share a revelation that I've had during my time here. It came to me when I tried to classify your species and I realized that you're not actually mammals. Every mammal on this planet instinctively develops a natural equilibrium with the surrounding environment but you humans do not. You move to an area and you multiply and multiply until every natural resource is consumed and the only way you can survive is to spread to another area. There is another organism on this planet that follows the same pattern. Do you know what it is? A virus.[78]

Agent Smith describes what we might call the dark side of humanity's evolving presence on Earth. Over the course of the last two hundred years, during which the scientific and medical paradigm underlying our understanding of viruses became the dominant global paradigm, we have systematically

exploited the resources of our planet with little concern for the long-term consequences. The popular conception of "virus" is in many ways a projection of our own way of relating to what is around us.

What could humans have shown Agent Smith that might have led him to a different conclusion? He certainly wasn't that enamored with human intelligence. What he didn't see is something that is uniquely human and might have led him to say: "You are mammals but there is also something there that I don't recognize as mammalian: You can certainly choose not to care; but you can also choose to care, and you could choose to care about all of life."

The more we have come to "look at" the natural world, to manipulate and dissect it, to freeze it in order to allow us to "know" something about it, to bend it to our own will, the less we are able to feel a part of it. A fundamental experience of connectedness is lost. Thus, we also lose sight of an essential aspect of being human. Both we and the virus belong to the same organism — Earth. We share a life context. The challenge we face is not trying to figure out how to eradicate SARS-CoV-2, but rather to understand it within this organism and, in doing so, perhaps come to a new understanding of our own place in this dynamic tangible/intangible riddle of being a part of life on Earth.

We can recognize ourselves as participants in the ongoing living processes that come to expression in the natural world. Only as participants can we begin to experience the nature of agency and learn to recognize that there is a realness in what lives between: that there are non-human or other-than-human agencies also at work in the world around us. It is no accident that viruses completely lose their "thingness" when they are integrated into cellular activity.

Would a recognition of agency have altered our response to COVID-19? The confusion between thing and activity has been a problem from the beginning of the pandemic. This confusion has misconstrued the nature of the relatedness evident between what we think of as the virus and the host organism. Reducing this relationship to one of pathogenic causality, with the virus cast in the role of disease-bearing agent and human beings in that of unwitting victims, skews our view of what is happening.

Throughout the pandemic there has been constant pressure for people to conform, to accept not being able to act independently, out of a sense of understanding. The individual human being — the thinking and questioning individual presence — has been largely taken out of the equation. And yet, it is individual human beings who respond, each in their own way, to news about the pandemic, to governmental measures, and to viral infection itself.

In an essay on embodied learning, Wilfried Sommer, a contemporary German educator and physicist, turned his attention to the *Fridays for Future* movement. He writes:

> Since 2019, young people have joined together in the well-organized social movement *Fridays for Future*. … Their voices are being heard; their demands have become part of the political debate. They are being listened to primarily because it is evident that they are affected by the changing climate in fundamental and existential ways. … They do not experience themselves as isolated parts of humanity. They do not see themselves as single subjects, the sum of which, when added together, makes up humanity. For them It is not as though each individual is not simply a piece of humanity: Each one models humanity as a whole. Each action has a decisive or an essential effect on how the relationship between humanity and the earth develops. Their relationship with Earth is one of *living with* rather than *living on*. They do not experience this relationship solely from a bodied or distanced perspective. Earth is not merely a planet whose resources are there to support the human population and the current economic system currently being practiced. Their relationship to Earth is much more immediate, embodied. Earth is the

resonant space in which they live. One of their placards reads: “Give the trees good air to breathe.”[79]

The lockdowns imposed during the pandemic brought the *Fridays for Future* movement, which was especially strong in Europe, to a standstill. The students were banished from the streets; school moved online. Instead of joining together to engage with the world as a tangible presence, they found themselves isolated. Direct participation in the world was replaced by the virtual reality of online-learning. And in the process, Earth lost some of her most vibrant voices.

In living through and reflecting on the pandemic, we have gained an increasingly strong sense, on the one hand, of our connectedness to the whole of life on earth — seeing ourselves as parts of a whole. On the other hand, we recognize the critical need for individual human agency within that whole. This agency has been dammed up through uniform measures that ignore concrete contexts. When “social responsibility” becomes conformity, then essential aspects of humanness cannot be developed.

It may not be so apparent that the current pandemic involves a problem of worldview. This is only because we don’t tend to think that ways of viewing have much to do with the real world or with the problems of daily existence. This is a mistake. The way we think about things — the things we meet, the things we do — defines the way we place ourselves in relation to them. We expand our humanness when we are willing to risk a narrow sense of self by recognizing ourselves as members of a dynamic whole and at the same time engage fully, each in our own way, with an ever-growing awareness of that whole. What the pandemic has shown us is that the question of relatedness is an existential question for the future.

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