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Viral Becomings: From Mechanical Viruses to Viral (Dis)Entanglements in Preventing Global Disease

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This paper explores the contribution of an ethos of (dis)entanglement arising from quantum thought to interpreting and (re)acting on the current global pandemic of Covid-19. The Covid-19 pandemic is giving rise to a world of pandemic separation, in which infection barriers such as masks, disinfection, social distancing, and isolation may be necessary in the immediate moment of avoiding sickness and death. However, these exclusionary and short-term response mechanisms do not address the larger question relating to global interspecies living, which in its current dynamic is increasingly giving rise to newly emerging infectious diseases such as Covid-19. The Covid-19 pandemic is showing that the *health* of human beings is deeply entangled with that of other species and places. However, it is also showing the limits to the mechanistic ontology driving modern public health thinking. I build on the work by political ecologists of health and biosocial scholars, especially Frost's concept of biocultural emergence and her engagement with ontological plurality in the human subject, to make the case for a different global politics of disease in preventing the emergence of infectious disease.

La pandémie de Covid-19 a entraîné l'émergence d'une série d'initiatives de séparation. Les mesures anti-infection telles que les masques, les procédures de désinfection, la distanciation sociale et l'isolement peuvent être nécessaires dans l'immédiat pour éviter la maladie et la mort. Toutefois, ces mécanismes d'exclusion et de réponse à court terme ne permettent pas de penser, de manière plus large, notre manière d'habiter la Terre, aux côtés d'autres créatures (y compris les virus), de façon à éviter que de nouvelles maladies infectieuses ne se transforment en pandémies. Celle du Covid-19 nous montre que la vie des êtres humains est profondément et pleinement imbriquée avec celle d'autres espèces, des non-humains incluant les animaux, les virus et autres micro-organismes. Les récents travaux scientifiques dits post-génomiques, ainsi que l'épigénétique et la microbiomie, ont déjà commencé à démontrer l'étroitesse des liens entre les espèces, jusqu'à ce qui est considéré comme le plus petit élément composant nos organismes et ceux des autres créatures. Récemment, des microbiologistes et des chercheur·euses en sciences sociales orienté·es physique quantique ont d'ailleurs suggéré que ces étroites relations interespèces pourraient être théorisées, et même démontrées, jusqu'au plus petit élément, dans le dynamisme indéterminé des particules élémentaires. En m'appuyant sur la notion d'émergence bioculturelle, j'analyse comment la contribution de la pensée quantique, notamment avec la notion d'intrication, permet de comprendre l'origine des pandémies. Cette posture en appelle à une manière différente de réagir aux pandémies, au-delà des stratégies de séparation ayant caractérisé les dernières politiques en la matière. Elle requiert une ontologie non dualiste et alter-moderniste, telle que celle qui découle des réflexions bioculturelles quantiques sur notre manière d'interagir avec le reste du monde.

La pandemia de Covid-19 está dando lugar a un mundo de separación pandémica. Las barreras contra la infección, como las mascarillas, la desinfección, el distanciamiento social y el aislamiento, pueden ser necesarias en la inmediatez para evitar la enfermedad y la muerte. Pero estos mecanismos de respuesta excluyentes y a corto plazo no abordan la cuestión más amplia de cómo convivimos en la tierra con los demás (incluidos los virus) para evitar que otra enfermedad infecciosa de reciente aparición se convierta en pandemia. La pandemia de Covid-19 está demostrando que la vida de los seres humanos está profunda y globalmente entrelazada con otras especies y seres no humanos, incluidos los virus y otros microorganismos, así como los animales. Las recientes ciencias postgenómicas, la epigenética y la microbiómica, ya han empezado a demostrar lo profundamente entrelazadas que están las especies hasta lo que se cree que es el núcleo mismo de lo que nos constituye genéticamente a nosotros y a los demás. Los microbiólogos cuánticos, así como los científicos sociales cuánticos, han llegado a sugerir recientemente que esta profunda relacionalidad entre especies puede teorizarse e incluso demostrarse hasta en lo más pequeño, en el dinamismo indeterminado de los cuantos subatómicos. Basándonos en la noción de emergencia biocultural, analizamos la contribución del pensamiento cuántico y el entrelazamiento para la importancia de la enfermedad en términos pandémicos. Esta postura exige una forma diferente de responder a las pandemias, más allá de la política de separación que ha caracterizado las recientes reacciones a la pandemia. Requiere una ontología no dualista y altermodernista, como la que surge de las reflexiones bioculturales cuánticas sobre cómo nos relacionamos con el mundo.

Introduction

> We must answer here and now for our life on Earth *with others* (including viruses) and our shared fate. (Mbembe 2020, S59)

The Covid-19 pandemic is giving rise to a world of pandemic separation, in which infection barriers such as masks, disinfection, and social distancing (Voelkner 2019) may be necessary in the immediate moment of avoiding sickness and death. However, these exclusionary and short-term response mechanisms do not address the larger question, as the philosopher Achille Mbembe asks, concerning global interspecies living, which in its current dynamic is increasingly giving rise to newly emerging infectious diseases (EIDs). The Covid-19 pandemic is showing that the *health* of human beings is entangled with that of other species and environments.

SARS CoV-2 viral strains move biologically *and* socially within and across species over global routes connecting

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distant places. Biologically, the SARS CoV-2 viral strain (the germ) infects and moves within its human host, interacting with the microorganisms and healthy cells comprising the physiology of the human body. However, medical microbiologists working with a configurational or ecological model depart from the germ theory of disease dominating biomedical and public health thinking. Here, disease is not simply the outcome of a specific virus or other microbes. Rather, viruses and other microbes are not inherently pathogenic but their virulence arises from specific contexts (Méthot and Alizon 2014). The recent postgenomic sciences, epigenetics and microbiomics, have begun demonstrating just how deeply species are interrelated down to what these scientists assert is what makes us up genetically (Meloni 2018). The emerging works on quantum microbiology (e.g., see Marais et al. 2018) suggest that this deep interspecies relationality may be theorized and even demonstrated "all the way down" to the way the very smallest of particles making up all matter, the subatomic quanta, are entangled. Following ecological scholars on the subject across the natural and social sciences, Covid-19 is then the outcome emerging from "complex, spatial–temporal interactions between the host immune system and the internal and external microbial environment" (Hinchliffe et al. 2017).

Socially, in the process of transmitting through bodies in the world, differentiated vulnerabilities running along familiar overlapping sociopolitical lines are crystalizing. As Covid-19 disproportionately affects racialized and working-class peoples around the world, the pandemic is revealing the deep inequalities of the modern global. This is demonstrated further by the failure of (biopolitical) policies to address issues leading up to both the vulnerabilities to Covid-19 and the current ongoing crisis situation. The Covid-19 pandemic is, thus, not just a biological but a *biosocial* event. The viral strains and the Covid-19 pandemic need to be understood as deeply related to the contemporary sociohistorical condition. Similar to ecological microbiologists, geographers Hinchliffe et al. usefully speak of disease as "multispecies conditions configured by specific socio-ecological 'situations'" (Hinchliffe et al. 2017; Lorimer 2017, 545). As medical anthropologist David Napier and others suggest, "SARS CoV-2 is us, too" (Napier 2020; de Chadarevian and Raffaetà 2021, 2).

Understanding and responding to the Covid-19 pandemic as a global crisis of multispecies relations necessitate a holistic kind of global politics of disease than current pandemic responses. These widely take the SARS CoV-2 viral strains as the main agents responsible for the current pandemic. This, in turn, has prompted a global securitized and martial language and actions against the viral strains in the worldwide Covid-19 response, largely detracting from the natural and social conditions enabling and accelerating the pandemic. Various scholars have noted how this "virus as disease" view neglects to appreciate the intricacies of the socioeconomic relations, which can exacerbate human–animal–microbial interactions, sometimes contributing to the emergence of a global disease. Quantum physicist Karen Barad (2007, 2014) and quantum social scientists (Wendt 2015; Frost 2016; Murphy 2021; O'Brien 2021; Fierke 2022) suggest that this deep multispecies relationality may be theorized "all the way down" (Wendt 1999) to the dynamism in the quantum realm. What, then, is at stake in the reductionist politics of the current Covid-19 pandemic if we take seriously the intricate entanglement of the biological and the social "all the way down" to the potential vibrant dynamism of quanta? With the recent advancements in the natural sciences, particularly around quantum physics and microbiology, notions such as quantum nonseparability and entanglement further strengthen and deepen a biosocial reading of the pandemic. Specifically, in answer to Mbembe's challenge, I consider the contribution of quantum thought and quantum entanglement for thinking further the multispecies entanglements involved in, and the capacity of the human to act in relation to, global infectious disease emergence. Such a stance begs for a different way of understanding and responding to pandemics beyond the politics of separation, namely an ontological holism in how we engage with the world.

Quantum physicists and biochemists understand the quanta, for example, electrons, protons, neutrons, and photons, to move and interact as processes that are wholly different to things such as bodies in a room or substances for which size, location, and speed are attributable. Rather, they are taken to be non-things, *flows* of energy. Quanta move and interact in ways that physicists understand only in terms of mathematical equations that express probabilities. Samantha Frost's (2016) notion of biocultural creatures builds on the energetics of matter in living processes to theorize the deep entanglement of biosocial beings and environments. She starts from the energetic interplay of quanta to make the case that the substantive binary distinction between body (bio) and environment (social) only partially holds (Frost 2016, 25). Yet, this binary directs much of the study of microorganisms (microbiology) upon which biomedicine and public health are built. Energy moves across bodies, generative of quanta enabling interacting biochemical processes, regardless of human boundaries. For Frost, humans and other beings are formed of a dynamism of (de/re)composition in resonance to their habitat, raising important questions about the category of "the human," its relation to others, and its capacity to act in the world.

In making sense of the biosocial conditions and processes enabling global infectious disease, I build on Frost's theorization to reflect on the holistic and context-dependent mode of being that such a perspective compels. From a holistic perspective as endorsed by key quantum physicists Niels Bohr (1934), David Bohm (2002), and others (Healey 1991, 2009), the human, the virus, and other biocultural beings, and their ability to act, do not preexist their encounters but emerge bioculturally with the environments composing them. I explore this in the multispecies and ontological entanglement in becoming with SARS CoV-2 viral strains in the current pandemic. This allows me to consider the way a quantum-inspired interpretation of the pandemic also calls for a holistic form of attentiveness and way of being, and in resonance, with other beings in the world. It requires caring for what materializes in the world, starting with sensitivity in seeing our relation with other species, or as Donna Haraway has argued, our "messmates" (Haraway 2007).

Viruses as Pathogenic Machines

In their early response to the emerging Covid-19 pandemic, many governments and heads of states invoked the language of war. Indeed, the pandemic has seen the normalization of martial language in both liberal and illiberal states. As with the SARS outbreak in 2003, hospitals were presented as battlefields, healthcare workers construed as frontline soldiers, and economies (re)organized in terms of war. With terms such as shelter-in-place, panic-buying, and lockdown permeating through societies in the everyday, war was everywhere. The language of war determines how governments and societies respond to Covid-19. It is a powerful metaphor in that it simplifies threats in terms of a friend–enemy binary

(i.e., us against them), creates urgency, and allows for the concentration of political power in times of war. Invoking war creates an urgent reality, which necessitates a state of exception that demands an interruption to normalcy and exceptional measures. Of course, it aids raising awareness and preparing for and meeting the current needs and challenges of health systems around the world. It helps to compel people to comply with governmental orders such as "stay at home." It enables changes to the polity and economy to face current Covid-19 challenges including economic stimulus policies, nationalizing key services and industries to support the production and distribution of medical materials such as ventilators and face masks (Caso 2020).

Historically, modern war is a policy instrument protecting the political community against a threatening foreign enemy. Protecting the state against a threat is the subject of national security. It legitimizes authoritarian-like rule, where fear is a tool of control that increases acceptance of exception measures and limitations of individual freedom such as was already the case during the first major SARS outbreak in 2003 (Keil and Ali 2009). In fact, as studies into the latter outbreak have shown, "the new normal" with the exceptional measures remained in place long after the outbreak. That the threat is a microbial agent is not new in global politics. By invoking war and security in an outbreak, the responsibility for the vulnerabilities to a disease are externalized to the microbial pathogen rather than to ill-equipped health systems, failing social policies, and social and health inequalities, which render people more vulnerable to infection and more serious courses of illness. Indeed, conceptualizing biosecurity in response to perceived threats from zoonotic and EIDs, as Hinchliffe et al. (2013) have argued, has often resulted in a spatial segregation of forms of life. As could be seen in the raising of infection barriers during and after the SARS epidemic in Hong Kong, Toronto, and elsewhere (Keil and Ali 2009; Voelkner 2019), societies struggled to separate healthy life from diseased bodies. Practically, this involved the generation of an enduring state of exception in which "a new normal" of exceptional rules curtailing civil freedoms became normalized, while the movement of SARS viruses continued in spaces falling outside of governmental priority, for example, homeless people or other disadvantaged peoples (Tsai and Wilson 2020).

SARS CoV-2, or the severe acute respiratory syndrome coronavirus 2, is usually taken to be the central agent that is the microorganism *causing* the disabling or lethal Covid-19 disease and the current pandemic. Viruses, we learn from scientific narratives, usually find their way into a host cell such as a human or another animal (e.g., bat or mink) where they produce more viruses, which may lead to pathogenesis or the diseased state. Viruses and other microorganisms come from outside our bodies, befalling us, causing great harm, sickness and death as experiences of recent viral outbreaks have shown including influenza, Ebola, and HIV/AIDS across the world. The usual model of causality explains that A causes B causes C, where the steps to pathogenesis are discrete, distinct, and predictable (Neely 2020). This mechanistic logic has informed the life and biomedical sciences, and consequently also public health thinking, for much of the last century. Biological life, it is assumed, is made up of discrete organisms (*things* or substances), which exhibit clear boundaries and intrinsic properties. From a *mechanistic* ontology perspective organisms are conceived as "the sums of organised collections of entities bearing certain spatial and causal relations to one another," that is, organisms of whatever complexity are "specialised sorts of machines" (Austin 2020).

This reductionist ontological thinking whereby "the human" is ontologically separate and detached from matter such as microorganisms can be traced back at least to the scientific revolutions in the seventeenth century. As quantum social scientist Laura Zanotti notes, this thinking relies on the Cartesian dualism of mind and matter and the ontological assumptions of classical physics (Wendt 2015; Zanotti 2019, 1). In the Cartesian perspective, she writes, matter is homogeneous and inert or "to be moulded to serve the purpose of rational thought" (Zanotti 2019, 1). In classical physics, the world consists of ontologically stable entities that stand "in a relation of externality to one another" (Zanotti 2019, 2). For prominent molecular geneticist Johnjoe McFadden and theoretical physicist Jim Al-Khalili, the Cartesian perspective understands that all living organisms are essentially machines. There may be differences in kind and complexity; however, all are "in principle from those machines that had driven the industrial revolution" (McFadden and Al-Khalili 2018). As biological life, in this conception, is reducible to no more than the sum of its parts, it is explainable in terms of classical physics since it is made up of "the fundamental building blocks of matter and forces that connect them" (McFadden and Al-Khalili 2018). Like all organisms, then, the virus is but a machine obeying deterministic physical and chemical laws when entering a host body.

Ontological assumptions about what makes up the world deeply shape how we humans understand our agency to affect the world, how we conduct ourselves in the world, but also what we consider "valid knowledge, and how we design and assess policy" (Zanotti 2019, 2). The quantum physicist David Bohm, for example, has critiqued the mechanistic worldview as sustaining fragmentation that obfuscates from understanding the complex context of which a fragment such as the virus is but a constitutive part (Bohm 2002). Understanding the virus as a pathogenic machine, on the other hand, creates a public health logic in which infectious disease outbreaks such as the Covid-19 pandemic are best responded to by *separating* or removing the human from the pathogenic viral strains through social distance, disinfection, and masks. The "virus-as-disease" view creates fear of viruses and other microorganisms, having recently also given rise not only to a global public health surveillance system, which serves a world permanently under attack from EIDs (e.g., see Weir and Mykhalovskiy 2010). It has also generated a host of security-specific reactions in relation to not only their epidemic spread such as seen in the militarized response to the West Africa Ebola outbreak and elsewhere but also in their potential misuse in biological terrorist activities (e.g., see Rushton and Youde 2014).

While some of these fragmenting public health mechanisms may be important in the moment of an outbreak, they address only issues visible from the "virus-as-disease" view while failing to understand other issues relating to "the nature of viruses" that perpetuate an outbreak (de Chadarevian and Raffaetà 2021). In reducing viral transmission to "a mechanical model of contact and contamination," according to the medical historian Warwick Anderson,

> The environmental, social, and cultural complexity of disease transmission, the varied and contingent configurations of spread, are erased, replaced by fear of proximity to others. Disease prevention dwindles into a purification ritual. (Anderson 2020)

A biosocial or ecological reading of the pandemic, on the other hand, in which the bio and the social are inseparably

entangled, foregrounds the ecological stakes. As Mbembe succinctly notes,

> Keeping the world at a distance will become the norm so as to keep risks of all kinds on the outside. But because it does not address our ecological precariousness, this catabolic vision of the world, inspired by theories of immunization and contagion, does little to break out of the planetary impasse in which we find ourselves (Mbembe 2020, 61).

Failing to appreciate more the kind of "vital–lethal" relationship (Arregui 2020) we humans have with surrounding ecologies, we are likely missing the opportunity to *become* together so that all can flourish sustainably (Voelkner 2019; Fishel et al. 2021).

In fact, ecological microbiologists have begun demonstrating the way the virus-as-disease perspective prevents scientists from appreciating the vital role that viruses play in the ecology and evolution of humans and other species (Méthot and Alizon 2014). For these microbiologists, much is still to be discovered and understood about viral "life" but most viruses are considered harmless to the human. When lecturing on whether we can live in peace with viruses, Alexander Gorbalenya, the virologist who helped classify SARS CoV-2 (Gorbalenya et al. 2020) noted already more than a decade ago: we are *all* (human and nonhuman) infected by viruses (Gorbalenya 2011). Not only are we surrounded by and comprise viruses, infection is a driving force of evolution. Indeed, half of the human genome is made up of genes from other species, for which viruses likely functioned as mediators (de Chadarevian and Raffaetà 2021, 2). Medical microbiologists and ecological thinkers have recently provided us with robust evidence that it is futile to think that humans are separate from other beings and the surrounding environment. In a similar vein, philosophers of biology Dupré and Guttinger argue, viruses are best understood not as discrete things in themselves but as processes that emerge in their interaction with their hosts and surrounding environments. Quantum microbiologists take us even further into the realm of potentialities where living bodies and environments are connected in ways not yet fully understood. Ironically, the antiviral public health measures and other infection barriers pervasive in the current pandemic work to isolate the human species from the multispecies environment, which sustains it. What if the enemy to human life is not the virus but us[1] or our flawed view of the matter[2]?

Biocultural Entanglements of Health

From a *political ecology* of health perspective, which originates from anthropology, geography, and political science, health is the result of "the biophysical, social, and cultural features of human-environment interactions" (Neely 2015, 794). Such studies, such as international relations scholars Alexander Wendt (1999) and Richard Lebow's (2008) have also suggested of international ideas manifesting "all the way down," focus on the way contemporary and historical local, national, and global "environmental, sociocultural, political and political-economic contexts, as well as the materiality of life, form health (. . .) and illness" (Neely 2015, 794). Health is a biosocial process and practice for which the *biology* of the body matters (Mansfield 2008; Guthman and Mansfield 2013): we "need to look inside bodies at the interactions among viruses, bacteria, and healthy cells to account for the physiology or biology of the human body" (Neely 2015, 794). Medical anthropologist Lock developed a comparable relational approach in the 1990s through the concept of "local biologies" (Lock 1993) to think health as the product of biology and culture "in a continuous feedback relationship of ongoing exchange, in which *both* are subject to variation" (Lock and Kaufert 2001, 503).

Scholars such as Hincliffe and Lorimer take this deep biosocial relationality of disease a step further. Health and disease are examined as multispecies conditions configured by specific socioecological "situations" (Hinchliffe et al. 2017). The concept of a disease situation foregrounds the political and ecological relations that shape the "intensities" of human–animal–microbial interaction that might lead to pathogenesis. Building on the work of feminist scholar Donna Haraway (2007), these scholars have suspended the "human exceptionalism" in medical anthropology and geography to include animals in considerations of the production of life. The anthropologist Nading and other multispecies scholars have similarly argued for a politics of disease, which foregrounds human–nonhuman relationality (Nading 2013, 2014). They have shown that people, animals, microorganisms, and spaces are entangled in ways that enable viruses or bacteria to become pathogenic to humans and other hosts. Drawing on biophilosophers Deleuze and Guattari (1987) and others (e.g., see Kirksey and Helmreich 2010; Ingold 2011), entanglement has come to refer to the nonlinear and stochastic way that "people, birds, pathogens, and spaces are connected in a process of 'mutual becoming,'" made possible by porose species borders (Nading 2013, 69) where the human "is constituted through changing relations with other animals, plants, material objects, and the like" (Ogden 2011, 2).

Taking an interdisciplinary approach and bringing this literature to bear directly on the global health strategy to control SARS CoV-2 is useful to problematize how, in construing Covid-19 as a global health threat, it not only has serious political consequences but also fails to reflect on the deep biosocial relationality of the human, the virus, and other species. Essentially, scholars arguing for a biosocial or ecological understanding of health eschew the fundamental binary opposition between the biological and the social. In this reading, the biological and health is not distinct from its surrounding ecologies and networks of relations. They challenge the distinctiveness, coherence, and agency of "the human subject." The specific notion of the human, that "index of a historically specific fantasy of mastery over the self, the earth and all its many creatures" (Frost 2016, 1), is also driving the world's current pandemic response. For Frost, not just the human but all beings including viruses are biocultural in so far as they "develop, grow, persist, and die in an environment or habitat that is the condition for their development, growth, persistence, and death" (Frost 2016, 4). Biocultural beings such as humans or viruses are mutually constituted of body and environment. The environments, within which humans, viruses, and other biocultural beings are embedded, are shaped and made meaningful by living bodies and forms of social and political subjectivity, which in turn also materially shape these bodies. In other words, humans and viruses become what they are through the (multispecies) environments, which shape them but which they also helped shape (Frost 2016, 5). In fact, considering the recent quantum challenge of nonseparability and entanglement in the subatomic realm, Frost extends biosocial studies and makes the case that at the *micro*scale,

[1] The phrase "when the enemy is us" is taken from Méthot and Alizon (2014, 755–85).

[2] I thank an anonymous reviewer for suggesting to add this clarification here.

> biocultural creatures constantly undergo a frenzy of biochemical activity, transitions in energy, movements and shifts of diffusing molecules, and all manner of traffic across each and every cell membrane in the course of engaging and responding to habitats. (Frost 2016, 150)

For SARS CoV-2 viral strains as well as the humans and animals affected by the Covid-19 disease and/or the pandemic situation, this suggests examining how they came to be what they are through the underlying energetic traffic in the natural and social environments that they helped shape and that shaped them. Given the deep integration and relationality of living bodies and environments that not just scholars of biosocial studies but the postgenomic sciences are discussing and demonstrating, it also raises the question of what can be achieved in the long run beyond the pandemic politics of separation that is driving the current Covid-19 response.

Postgenomic Plasticity All the Way Down?

Biocultural studies are supported by recent advances of the postgenomic sciences of epigenetics and microbiomics in which living systems including humans are demonstrated to comprise cells derived from human as well as *symbiotic* (mutualistic, commensalistic, or parasitic) bacteria, viruses, and other microbial, lineages (Méthot and Alizon 2014; Dupré and Guttinger 2016, 109). This led anthropologist Stefan Helmreich to invoke a new figure of the human to exemplify this deep interconnectedness between the human and the microbial ecologies: *homo microbis* (Helmreich 2014). Indeed, epigenetics is redefining the genome as chromatin, a flexible macromolecule enfolding DNA, which when altered, for example, by environmental prompts, also changes the ability of proteins to read DNA sequences. In Meloni's words, the chromatin is a "regulatory architecture" on which is registered the social and biophysical environment (Meloni 2018, 21–22). This epigenetic architecture comprising DNA questions the ontological assumption of the priority and enclosure of DNA. Importantly, chromatin's three-dimensional folding also alters our understanding of biological memory as nonlinear (Meloni 2018, 21–22). Therefore, after epigenetics, biological organisms cannot be understood as predetermined and bounded; instead, they must be conceived as malleable and permeable in their *emergence* with other beings, dependent on environmental, evolutionary, and social processes. Epigeneticists have started showing the way the spatial-temporality of environmental influences such as stress, toxins, and socioeconomic status are written into the epigenome, exemplifying the way "the environment gets inside the body" (Landecker and Panofsky 2013, 339).

Indeed, after epigenetics and microbiomics, organisms can no longer be understood without reference to the spatial and temporal dimensions of the complex environment and network of relations that they comprise. The omnipresence of symbiosis and the extent of integration of organisms require revisiting substance-based accounts of life such as are pervasive in the current pandemic politics. "Boundaries between species are blurred as living systems are integrated with many organisms internal, on or external to boundaries, rendering the latter indeterminate" (Fishel et al. 2021). Recently, scores of bacteria, viruses, and other microbes have been revealed in gene sequencing to reside in, on, and around the human body. These microbes that make up the human microbiome are leading scientists to understand better, for example, the causes of infectious diseases. In contrast to the germ theory of disease, in which a specific microbe is linked to a specific disease, an ecological theory of disease understands that microbes are not essentially pathogenic (Méthot and Alizon 2014; Lorimer 2017). Rather, disease arises from complex multispecies relations of the microbial–animal environment surrounding as well as making up the human immune system, which is also influenced by specific socioecological "situations" (Hinchliffe et al. 2017). For geographer Steve Hinchcliffe, a disease situation emphasizes the political and the ecological relations shaping human–animal–microbial interactions that result in a pathogenesis, that is, the emergence of disease such as Covid-19 (Hinchliffe et al. 2017, 13–16). Lorimer reminds us that the emerging studies into the microbiome are already challenging modern biomedicine in reassessing the role of microbes in human health (Lorimer 2017).

With the new discoveries in the natural sciences, philosopher of biology Dupré and biochemist Guttinger have suggested conceiving of biological systems as processes rather than as substantive and discrete things because living systems are not just complexly interconnected with but also *dependent* on other biological systems. Organisms can be understood as the "stable eddy in the flow of interconnected biological processes" (Dupré and Guttinger 2016, 110). In this ontological understanding, viruses are not distinct individuals that proceed on their own pathogenic ways to do harm but are "vital and omnipresent constituents of the larger flow of interconnected processes that make up biological systems" (Dupré and Guttinger 2016, 110). SARS CoV-2 viral strains mix with and become part of other processes, thereby simultaneously contributing to a range of outcomes. This reading of SARS CoV-2 and the Covid-19 pandemic prompts an inquiry into the way (violent) histories and multispecies environments are folded into the coating of the genome, giving rise to the differentiated vulnerabilities to Covid-19 pathogenesis. If we take seriously Dupré and Guttinger's provocation of a processual ontology for biological systems, however, wherein all living organisms are processes and relations rather than things, then the virus and the human are not fixed substances but emerge in their relations with others.

Indeed, in recent years, various experiments across a number of processes and functions of living organisms have shown that they may be better explained by quantum mechanics than classical physics (Marais et al. 2018). Quantum mechanics is the physical science of the very small, of atomic or subatomic particles, whose dynamic properties have been shown to exhibit uncertainty and complexity. For over a century, quantum mechanics mathematics was thought to not describe the macro-subject of living organisms, biology. For quantum microbiologists Trevors and Masson (2011, 43), however, since "living organisms are physical entities, it is rational and logical to examine the role of quantum mechanics in the matter and energy of living microorganisms." Today, biomedical scientists are already theorizing the potential of exploiting quantum properties to revolutionize medicine. Quantum properties have been shown to play important roles in central biological processes (Lambert et al. 2013; Marais et al. 2018; Goh, Tong, and Pusparajah 2020).

Much has been written about the way nature utilizes quantum principles to increase cell functions. Photosynthesis, for example, the vital process by which trees and other plants harvest sunlight, water, and carbon dioxide to produce oxygen and energy, existential components for almost all life on earth, has been demonstrated to involve quantum

coherent dynamics (Lambert et al. 2013). Quantum coherence is based on the complementarity principle, which indicates that a particle can have multiple contradictory properties; that is, it can be both a particle and a wave. When an object is in all possible states simultaneously both particle and wave, it is described as coherent. The potentiality of the quantum world renders it indeterminate (Barad 2007, 269). Once it is measured, however, when it is attributed a property, the object collapses to a determined or definable single state or possibility (Trevors and Masson 2011, 43). When a quantum particle such as a photon produces two particles, for example, when passing through a double-slit experiment, then both photons move simultaneously "as if they are in two places at once" (Trevors and Masson 2011, 43). This phenomenon, when one particle appears "to know" about another particle, even if they are separated by great distance, led Einstein to refer to quantum entanglement as "spooky action at a distance." Quantum phenomena are first a relation not between physical but mathematical objects that represent the states of quantum systems.

Quantum entanglement has been observed also in avian magnetoreception-some migrating species' ability to navigate utilizing the Earth's magnetic field (Lambert et al. 2013). Quantum (micro)biology is still in its infancy and remains controversial as it is still widely held among physicists and biologists that "the warm, wet, and noisy environment" in and around living organisms makes quantum effects impossible to see (Schaffer and Barreto Lemos 2019). Bridson and Gould (2000) noted, while at the macroscale, large populations of microbes "obey the rules of taxonomy," at the microscale "individual cells exhibit uncertainties (caused by mutations and fluctuating local environments) which are buried within the macro-populations." The unity of the macro-subject, however, may be a "pseudo-functional stability," since quantum uncertainties can influence the result of stress on "the death or resuscitation of cells." According to Bridson and Gould, "it is impossible to preselect which cell will die or which will survive to produce the next population" (Bridson and Gould 2000, 98).

Regardless, among scholars studying biocultural relations, the postgenomic advances led medical anthropologists Guthman and Mansfield to suggest that we are witnessing not just "the molecularization of life" but also "the environmentalization of the molecule" (Guthman and Mansfield 2013, 491) where the environment is taken to comprise a myriad of diverse natural and social elements. Indeed, Covid-19 is formative of specific socioeconomic conditions that exacerbate human–animal–microbial interactions (cf. Hinchliffe et al. 2017). The differential vulnerabilities that arise from the socioeconomic conditions that increase the risk for developing a more serious Covid-19 infection run along gender, socioeconomic, racial, and other sociopolitical lines. Thus, SARS CoV-2 as viral strains are *enabled* by the vital–lethal biocultural milieux of "ecological, institutional, social, and symbolic relations" formative of them (Frost 2016, 13). The differential biosocial processes emerging in the Covid-19 pandemic challenge not only the modern notion of viruses as the *primary* agents accountable for the Covid-19 pandemic. They also challenge the notion of the human as the master over the self and all life on earth, thereby also problematizing the efficacy of human action. This is potentially further undermined by recent discoveries of quantum (micro)biology, which, though still very much in its infancy, is beginning to theorize and demonstrate how quantum processes and dynamics play an important role in the workings across biological systems.

Quantum "Realities"

Meanwhile, the political scientist Samantha Frost sought to clarify the way the substantive binary distinction between body and environment is theoretically undermined further by considerations for the subatomic and energy traffic across human boundaries (Frost 2016). Like other new materialist scholars, hers is a theoretical proposition accounting for the fundamental liveliness of matter in the world grounded, in her case, in the dynamism in the subatomic realm. This leads Frost to develop a dynamic account of the figure of the human as constantly (de/re)composing in resonance to the environment that comprises it. Considering Frost's theorization, it is useful to explore in more depth how far quantum thought can help to think further the integration of living bodies and environments.

Quantum physics emerged from the phenomenological and transcendental currents of the early twentieth century. The product of this history of thought has revolutionized physics. Quantum theory has undergone decades of rigorous testing, shifting the classical, mechanistic and Newtonian, theory of physics toward an ever-more nonclassical understanding of physics. Quantum theory has become fundamental to understanding nature including, more recently, biology. It has shown that at the subatomic scale, light, electrons, and other quanta move and interact in entirely different ways than events and objects at the macroscopic scale, thus necessitating mathematical equations of a wholly different logic to describe subatomic movements and interactions.

In a classical system, the separate parts/agents interact in ways describable by classical physics' laws of motion and thermodynamics that render them predictable (Wendt 2015; Zanotti 2019). In a quantum system, the particles are never entirely separate from each other but emerge in the *interaction* of parts with each other and with the system. For early quantum physicist Bohr, "quantum phenomena" described the position and momentum of particles in a quantum system arranged, for example, in a clearly defined experimental apparatus. Thus, quantum dynamics cannot be thought without reference to the observer's influence. For the quantum physicist David Bohm, on the other hand, an arrangement of quantum objects constituted an indivisible whole, the "undivided universe" in which the positions of the particles are guided by a wave function associated with the field guiding the trajectories of the particles-irrelevant whether there be an observer or not (Bohm and Hiley 1993; Bohm 2002). Notwithstanding these different interpretations of the relation between wholes and parts, it is useful to consider the underlying *ontological holism*, which comes into play and fundamentally distinguishes these quantum physics accounts from classical accounts.

Physics of whatever theory engages first with questions of motions, forces, causality, interactions, and changes in physical systems through mathematical equations (Schaffer and Barreto Lemos 2019, 11). In the metaphysical realism of classical physics, reality exists independent of the observer who is accorded with its objective investigation. Things, facts, and phenomena are out there to be investigated, independent of the subjects who are observing and theoretically reflecting or *re*-presenting this reality through theoretical (or mathematical) concepts (Pris n.d.). The concepts and formulars used to describe reality are a priori or predetermined, leading to a description that confirms the theory. Importantly,

> (…) we can conceive of the entities and substances and species of the "external" world independently of

> any of the empirical beliefs and theories we hold or might hold in the future. (Ebbs 1997, as quoted in Pris n.d.)

The quantum mechanical reality, however, cannot be described by a metaphysical reality of static and ahistorical substances located in an external world that is independent of the observers' beliefs and theorizations.

Rather, the *subatomic* world of electrons, photons, gravitons, and so on is imagined in physics as a world of relational becomings whose theorization is one of mathematical probabilities and potentialities. While this constitutes a radically different ontological understanding of what makes up the universe that departs from the normalized, substance-based ontology of modernity, a process-based metaphysics was not new at the time. Grove has noted that quantum thinking was influenced by historically prior relational philosophies of monism, continuity, panpsychism, and process (Grove 2020, 5). Process philosophies also constitute some of the oldest philosophies in the world, including religious thought as pertains to Christianity, Buddhism, Daoism, and Islam as well as indigenous thought (Scheper-Hughes and Lock 1987; Ling 2013).

The mathematics of a quantum state such as entanglement represents "matrices (sets of possible values of physical quantities together with the corresponding probabilities" (Pris n.d.). For the quantum physicist Heisenberg, as Pris notes, rather than being things or facts, subatomic particles constitute a realm of possibilities (Pris n.d.).

Quantum theory cannot define what an electron is or what a wave function means. This requires interpretation, that is, "a set of philosophical commitments associating the terms in quantum mechanics equations, and the phenomena observed in laboratories, with specific meanings" (Schaffer and Barreto Lemos 2019, 8).

The act of measurement demonstrates this. Measuring collapses the dynamism of the subatomic, giving the physical quantity of a quantum state a definite value that is reproducible in the classical sense. In Fierke and Mackay's words, measuring a quantum state such as an entanglement means breaking this entanglement (Fierke and Mackay 2020) insofar as the process relationality between particles themselves, the experimental apparatus, and observer, in sum the physical phenomenon, interferes with the relational process that is being observed. In the interaction between the investigated object and the investigator, "it is as though both become (. . .) inseparable from each other" (Pris n.d.), the subject and object dissolve into another. They co-emerge. The act of measuring actualizes one of many other possibilities.

Quantum theory offers a probabilistic idealization of many possibilities describing the subatomic world. Indeed, there are multiple quantum interpretations of what makes up the universe. Yet, while

> nobody knows for sure why these recipes work, nor how to talk about the relationship between the mathematical operations and the underlying physical nature of the electron itself. The point is that it does work. (Schaffer and Barreto Lemos 2019, 7)

Scientific phenomena, as a number of scholars have argued, are generated within frames of knowledge and experimenting that are subjective (cf. Latour and Woolgar 2008). The physicist Pris and others have suggested to resolve the measurement problem in quantum mechanics by reading this through the metaphysics of Heidegger and his conceptualization of *Dasein* and Wittgenstein's notion of a language game (Pris n.d.). Heisenberg and Heidegger were frequent interlocutors in the early twentieth century. For Wittgenstein, applying a rule is a language game, which brings forth one form of life over another. In this way, quantum concepts have normative implications. In relation to *How Science Comes to Matter*, Rouse has argued that the normative and material are co-constitutive in science (Rouse 2002). Consequently, Pris concludes, "quantum concepts function rather as rules for forming a new reality, not as notions for describing a pre-existing metaphysical reality which is independent from the observer in the absolute sense" (Pris n.d.).

(De/Re)Composing Biocultural Creatures

Samantha Frost takes quantum theory's blurring of the distinction between matter (bio) and form (social) as a starting point to think further the figure of the human and other beings in a world where the biological and the social can no longer be thought as separate (Frost 2016, 25). Studying the potential dynamics in the quantum realm and the traffic of biochemicals constituting carbon, membranes, proteins, and oxygen—upon which life is understood to be based—leads Frost to argue that all living organisms are formed of a dynamism of (de/re)composition in resonance with the environments they inhabit. "Culture," in Frost's understanding, incorporates the material, social, political, aesthetic, economic, and symbolic worlds as well as the chemical, spatial, thermal, viral, bacteriological, and nutritional, which make up the conditions through which biocultural beings become subjects. In the process of *culturing*, then, living (biological) matter can be conceived as *cultured* by their habitats in both social and political, symbolic, and (bio)physical and chemical ways. Essentially biocultural beings, human and nonhuman, are not discrete individuals separate or detached from their biocultural surroundings. On the contrary, for Frost, they are enmeshed in and permeable to the energetic environment within which they are embedded and through which they emerge. In this way, bodies, selves, and the environment do not stand opposed but are constitutive of each other, that is, they are entangled.

Before elaborating on the way Frost connects quantum physics with biology and the social world, however, it is worth noting that, while quantum thought has revolutionized physics, it is only now becoming more apparent that organic/biological processes cannot be interpreted by classical physics alone. Quantum principles must be involved too. Renowned physicist Erwin Schrödinger argued this already in 1943 (Schrödinger and Penrose 2012). In his Dublin lectures on "What is life?," he suggested, quantum processes are implicated in the atomic and subatomic constitutions of matter in microbial, for example, viral, metabolism, and structures, as well as the organic, genetic information code of DNA and RNA. Recent technological advances have revealed that the living system requires a variety of processes that depend on a sensitive interplay between classical *and* quantum physical effects. Yet, quantum mechanistic explanations usually fail when confronted with biological processes and the problem of environment:

> Any time we are discussing complex structures of quanta (like complex chemical structures, or biological structures), long-distance entanglement effects are suppressed to the point of being irrelevant, simply because of constant interactions between quanta and their neighbors. (Schaffer and Barreto Lemos 2019, 17)

Although quantum mechanisms including quantum entanglement have been shown to take place in living cells, these have been observed only under conditions unsustainable to processes of complex biological environments.

In physics and chemistry, Frost clarifies, "matter" is understood as energy. In the quantum and chemical realm, the dynamism and interaction of quanta (e.g., electrons) can be conceived as bits of energy in a field that is indeterminate, unstable, and unpredictable. Studying the uncertain dynamics constituting carbon, however, leads Frost to propose that matter can be conceived as "*effect(s)* and *manifestations* of energy under constraint," that is, energy takes form as matter through its constrained self-relation (Frost 2016, 25). In this way, matter and fleshy bodies are not just inert objects but can be understood as having "some kind of agent-like force or capacity" (Frost 2016, 31). Instead of an "undifferentiated mass of substance,"

> matter is a broad array of atomic elements (a conglomeration of energy) each of which is composed quite differently and specifically, as elements whose very specificity has a profound effect on how each behaves. (Frost 2016, 32)

Like two magnets pulling and pushing each other, the interaction of electrically charged quanta inadvertently generates, with their different (subatomic and quantum component parts) forms of energy that constrain each other, the chemical elements that constitute matter (Frost 2016, 34). Constraints on the relation of energy to itself, Frost explains, ultimately give form to the perimeters of atoms (Frost 2016, 42) and constitute chemical reactions, and molecules that form the basis of life. Carbon atoms, she notes, "form the backbone or the scaffolding that structures the molecules that together make life possible" (Frost 2016, 49). While it may be that at the quantum level processes are indeterminant and of infinite potential, at the atomic, cellular, and organismic levels,

> the constraints through which energy relates to itself make it congeal in fairly stable form, not to an extent that it never changes – because it does, and often – but rather in such a manner that we cannot really say that there is a "a radical openness" or "an infinity of possibilities." (Frost 2016, 51)

This is important in debates about the scalability of quantum ontology. Frost attempts to reconcile the possibility of quantum microscopic dynamisms and macroscopic biological forms, that is, there are multiple ontologies at work in giving shape to biocultural beings. As Gunnarsson remarks, "there is nothing about dynamism as such that is at odds with structuredness" (as quoted in Frost 2016, 51; Gunnarsson 2013, 8). Indeed, while Frost acknowledges the potential energetic dynamics at the quantum level, unlike Wendt (2015), she does not equate "quantum" in a synonymous way to "organic," that is, a part of an organism and/or living system in a wholesale way. Rather, her understanding suggests that living systems are dealing with multiple ontologies (Frost 2016, 150).

For Frost, the important point is, the energetic traffic of quanta and biochemicals such as oxygen renders living organisms permeable and forever (de/re)composing in resonance to their different habitats. Living bodies and environments are thus not substances separated by rigid boundaries but compose each other. Insofar as "culture" is the process of culturing through biocultural environments, living matter can be conceived as *cultured* all the way down (see also Wendt 1999, 2015) influencing also our conduct toward other (quasi-)species and matter and shaping ethical and political behavior (Lebow 2008). In focusing on the energetics and manifestations of matter and living processes that give rise to carbon, the chemical basis of life as we know it, Frost does not need to engage with the debate on whether quantum is scalable to the macroscopic world of biology.

She develops a theory of biocultural beings in which matter is revealed as plastic and porose. For Frost,

> humans are constituted through a matrix of biological and cultural processes that shape one another over various time scales in such a way that neither one nor the other can be conceived as distinct (Frost 2016, 18).

Frost developed the concept of the biocultural creature to both reassert the *bio*logical and living animality of the human and to culture. All beings on earth, including the human, are biocultural in that they develop, grow, persist, and die in an environment or habitat that is the condition of their development, growth, persistence, and death (Frost 2016, 4). Infectious diseases such as Covid-19, then, emerge also from within the environment insofar as viruses or other pathogens become pathogenic to other "messmates" as they develop, grow, persist, and die in that multispecies environment (e.g., see Thorpe, Clark, and Brice 2021).

The permeability of the body has variously been theorized as a socionatural, biosocial, or biocultural hybrid to denote the sum of biophysical (material) and sociocultural forces and factors, which constitute all life on earth. The deep reciprocal shaping of living organisms and environments has led to an eschewing of the conjunction of "and" in grammatically binding the body and the environment since this presumes two a priori distinct phenomena coming together (Frost 2016, 18). To counter the tendency to think there is a gap between body/environment, quantum physicist and critical feminist theorist Karen Barad spoke of intra-acting *naturecultures*. Matter and meaning are constituted in their entanglement. She writes,

> To be entangled is not simply to be intertwined with another, as in the joining of separate entities, but to lack an independent, self-contained existence. Existence is not an individual affair. Individuals do not preexist their interactions; rather, individuals emerge through and as part of their entangled *intra-relating*. (Barad 2007)

Barad's (quantum) conception of entanglement professes a deeply relational ontology in which everything, human–animal–microbial–mineral is ontologically enfolded. We are ethically accountable in our "becoming with each other." Frost too professes that the human must "own up to and take collective responsibility" for "social and ecological devastation" (Frost 2016, 2–3). Agency in the biocultural world, however, is entangled with the possibilities arising from the environment comprising a multiplicity of overlapping entanglements across time and space. As such, it is "agency in context" (Ling 2013) or intra-actions (e.g., see Barad 2012).

Agency in Context: Toward Healthy (Dis)Entanglements

Quantum mechanics equations, Schaffer and Barreto Lemos remind us, "make no unambiguous references to the structure or form of physical reality prior to specific measurements. Rather, the interpretation of the things that are represented by the equations is "a set of philosophical commitments associating the terms in quantum mechanics equations, and the phenomena observed in laboratories,

with specific meanings" (Schaffer and Barreto Lemos 2019, 8). Indeed, key quantum physicists Bohr, Bohm, and others subscribed to an ontological holism in their interpretations of quantum processes (Healey 1991, 2009). His work on quantum mechanics even led Bohm to assert that any collection of quanta, i.e., any quantum system, constitutes an indivisible whole. More specifically, for Bohm, a description of the whole required not just listing all constituent parts and their positions but also the field's wave function that guides the particles' trajectories (Bohm and Hiley 1993). Quantum field theory (QFT) is the theoretical framework that approaches quanta as excited states, which interact vis-à-vis the underlying quantum field. The quantum field (the whole) is treated as more than the particle (part) it comprises. QFT is subscribed to by Barad (2007) in her quantum critique of the reductionist dualism of nature/cultures. Her holistic interpretation forms the basis on which Frost developed her theory of *biocultural creatures* (Frost 2016).

What, then, is at stake in the politics of separation in the current Covid-19 pandemic if we take seriously the embeddedness of *biocultural* processes all the way down to the subatomic quanta? Whether we take seriously the notion of biocultural emergence beginning with the smallest parts? As I argued further up, the securitized and martial language of the worldwide Covid-19 response mostly understands the SARS CoV-2 virus as the primary agent of the pandemic. The virus is singled out as the main entity responsible for the pandemic. It is acted upon as a discrete and pathogenic machine whose pathways are determined to infect and mess about with the internal mechanisms of the host organism's system.

What this mechanistic view detracts from is the way in which the viruses are not distinct individuals that proceed on their very own pathogenic pathways to cause harm but can also be understood as vital and pervasive constitutive members of the larger flow of interconnected processes (Dupré and Guttinger 2016). As such, they are stages in living processes that mix with other processes to contribute to a number of results. Viruses are complexly interconnected "quasi-species" that give rise to viral swarms or clouds comprising different species bodies and other matter, human rationality, and subjectivities (Lowe 2010) that emerge bioculturally. The (quantum) plasticity of biological systems including the virus and the human body as theorized by Frost makes it further conceivable the way the environment gets into the body and the body gets into the environment from which the virus and the disease both emerged and that both also influenced. The postgenomic sciences including quantum microbiology are confirming what biocultural social scientists have argued since the 1980s, namely the deep embeddedness of all beings and nonbeings in the world. This radical relationality is more in line with non-Western cosmologies such as Daoism and Buddhism (Scheper-Hughes and Lock 1987; Voelkner 2019) and alter-modernistic ontologies as endorsed by posthumanism (Barad 2007; Frost 2016; Meloni 2018; Bennett 2020).

The notion of biocultural emergence leads the way to understand how socioeconomic relations such as modern intensive agriculture intensify human–animal–microbe *intra-actions* that contribute to the emergence and/or (pandemic) spread of SARS CoV-2 and Covid-19. To make sense of the different spatiotemporal scales and multiple ontologies involved in how matters of disease take form, appreciating (quantum) nonseparability and entanglement in biocultural becoming further strengthens understanding the pandemic as a crises of interspecies relationality arising from complex relations across global multispecies biocultures.

I suggest that the art of caring for what matters pandemically, for what becomes in our relation with other species and environments to the crises point, begins with cultivating attentiveness toward multispecies relations (van Dooren, Kirksey, and Münster 2016). It further involves appreciating others in their otherness, such as viruses in how they become pathogenic in their entanglements with other species including humans or humans in how they become vulnerable to Covid-19 due to their socioeconomic status. It also involves attending to the "entities, practices, and ways of being that are foreclosed when other entangled realities are realised" by *dis*entangling connections (Giraud 2019). All this is necessary to prevent future pandemics from emerging. Rather than silencing others and associated ontologies, it also means taking seriously ontological plurality and otherness in how we approach and organize life with others on earth (e.g., see Yates, Harris, and Wilson 2017). Essentially, it involves eschewing "universal translation of evaluation and verification" (van Dooren, Kirksey, and Münster 2016; Zanotti 2019). Ethics cannot apply the same to all without discernment as particular contexts matter. Indeed, the cascade effect of minuscule interventions or entangled agencies in becoming with others may yield changes to the status quo of a habitat toward a more healthy and sustainable multispecies future.

Attentiveness to Multispecies Entanglements

RNA virus outbreaks such as the Covid pandemic are first and foremost processes of multispecies and biosocial infections and reassortments "that are coincidental, responsive, opportunistic, and often irrational," suggests Lowe (2010, 644). In his account of the emergence of Covid-19, multispecies scholar Eben Kirksey has highlighted the transformations of SARS CoV-2 viral strains in their adaptive interactions with the animal host's immune systems and associated ecological communities, as well as with the "human institutions, infrastructures and behaviors that facilitate their spread" (Kirksey 2020, 12). Like many other EIDs, Covid-19 is a zoonotic disease or zoonosis. Zoonoses are infectious diseases that occur when a pathogen such as a virus species transmits from an animal host to humans, and thereafter between humans. When pathogens move from their host species to another host species, this is referred to as interspecies spillovers. This occurs between microbe and human, but it also happens between wildlife and livestock. If the new host population is immunologically naïve, that is, the host immune system has not encountered a particular virus strain, such spillovers can generate significant illness (morbidity) and death (mortality) in both human populations and wildlife and livestock. It can also have a significant economic impact on agricultural industries, as could be seen throughout the 1980s and 1990s in the United Kingdom when dealing with the mad cow disease (bovine spongiform encephalopathy, BSE) outbreak. The outbreak generated export restrictions and had significant reductions in productivity. Four million cows were culled to break further livestock and human disease transmission. As a result, human intervention into nature in the form of livestock industries redirected human–animal intra-actions such that the risk of new infectious diseases emerging is increased (Voelkner 2021).

At the time of writing, SARS CoV-2 outbreaks have also been registered in mink farms. Already in April 2020, the European Centre for Disease Control and Prevention (ECDC) reported a spillover from humans to minks and a spillback from minks to humans in the Netherlands and

thereafter also in Italy, Sweden, Spain, Denmark, Greece, and the United States (ECDC 2020). In late 2020, a spillback was recorded by Denmark, which increased the risk that in the process of transmitting from human to mink back to human, SARS CoV-2 viral strains mutated such that the spike protein gene essential for vaccine efficacy was altered. Although the mutations of SARS CoV-2 strains were of small scale and proved of little effect, seventeen million minks in Denmark were culled on order of the Danish government (Koopmans 2021). Consequently, interventions by humans into nature such as through modern livestock farming contribute to infectious diseases emerging. It also accelerates the trend to increasing immunity of bacteria and viruses to antimicrobials such as antibiotics and antivirals developed to protect humans from pathogenesis.

Deforestation and displacing natural vegetation to make way for modern crop development and agriculture is increasingly accepted as having an altering influence on the environment. Natural habitats have fragmented as a consequence, leading to an increase in the likelihood of zoonoses. Scientists examining the link between veterinary epidemiology, economics, and public health have suggested that agricultural intensification and structural changes to the environment impact on the structure and habits of migrating wildlife populations (Jones et al. 2013). Zoonoses have recently been traced back to wildlife. Livestock and humans interact with wildlife in ways that raise the potential of a spillover of disease-inducing microbes. In modern livestock farming, large numbers of animals crowd in smaller spaces such as in wired cages that produce a lot of dust, increasing the risk of pathogenesis, as in the case of farmed minks (Koopmans 2021). In that way, livestock are intermediate or amplifying hosts by way of which viruses mutate and transmit to humans. However, wildlife also infects humans directly or other organisms such as insects that are vectors for disease to humans (Childs, Richt, and Mackenzie 2007). In addition, population expansion and advances in economics and technologies are changing human behavior leading to higher demands in consumption, which necessitates agricultural intensification (Jones et al. 2013) but that also contributes to further EID outbreaks.

The risk of zoonotic diseases to human health as a consequence of the intensification of human–livestock–wildlife interactions is also harming farming economies. As Arregui notes, during this pandemic and when Hubei went into lockdown, the African Swine Fever Virus (ASFV), another viral strain, moved largely unhindered through pig communities because veterinarians were quarantined, leaving ASFV uncontrolled. ASFV is deadly to domesticated and wild pigs, significantly affecting farming economies and ecologies in Asia (Arregui 2020). As not only with BSE but also with highly pathogenic H5N1 avian influenza, for example, the SARS-CoV-2 infection and Covid-19 outbreaks in mink farms around the world have a severe effect on international economies. In response to avian influenza, for example, millions of chickens, ducks, turkeys, and geese died or were culled as a containment measure.

Caring For What Matters

We do not know yet the origins of SARS CoV-2 (Kirksey 2020), but we do know that human interventions into nature are increasingly leading to new infectious diseases. Newly appeared infections, for example, Covid-19, Zika, and SARS, or existing infections that gain in incidence or geographical spread, such as HIV/AIDS, are categorized as EIDs. Scholars have argued that demography, environment, and ecology facilitate the emergence of an infectious disease. This is because these three factors are understood to bring humans into closer contact with pathogens unfamiliar to them, thus leading to a viral spillover from an animal to a human (Morse 1995; Jones et al. 2008). As such, the conditions favorable to a spillover are "not 'natural' but can be directly attributed to economic and political decisions" (Voelkner 2021).

Interventions by humans into nature have historically affected the extent of human disease, its geographical spread, and pathogen types. As human populations spread around the globe, their relationship to nature changed, leading to new or unknown infectious diseases. At the beginning of agriculture and livestock herding some 10,000 years ago, from early agrarian settlements to the commercial and military interactions between early Eurasian civilizations and European imperialism, each historical transition led to the exchange of dominant infections between peoples and between the natural world. European colonization since the Middle Ages led to the transoceanic transmission of often lethal infectious diseases. Mostly unwittingly, measles, smallpox, and influenza spread in Amerindian populations (McMichael 2004). In the twentieth century, hygiene and nutrition improved, and vaccines and antimicrobials helped to cut down the burden of human infectious diseases. Yet, global trade and travel, and staggering global health inequalities have accelerated the spread of infectious diseases globally. The scale, speed, and impact of the current Covid-19 pandemic affecting mainly socially and economically vulnerable regions and peoples demonstrate this.

The growing global population puts a strain on food and health demands. To meet these increasing demands, sustainable agricultural food systems that reduce the risk of infectious disease emergence but preserve biodiversity are necessary (Jones et al. 2013). Indeed, the genealogy of SARS CoV-2 invites a new kind of interspecies empathy in which, as multispecies scholar Eben Kirksey has argued, "it is possible to respond with a sense of biophilia, or love for other forms of life," rather than react with biophobia (a fear of other beings) (Kirksey 2020, 15).

Conclusion

This paper considered what is at issue in the current global politics of Covid-19 if we take seriously the multispecies relationality all the way down to the subatomic and atomic levels. Starting from a perspective of biocultural emergence, I began by problematizing the securitized language of the worldwide Covid-19 response in which the SARS CoV-2 virus strains are taken to be the core agent of the current pandemic. I argued that this stance led to a failure of appreciating the socioeconomic relations that, in exacerbating the energetic interactions between human–animal–microbial living matter, helped to make possible the pandemic in the first place. It also cannot sufficiently capture the ways the pandemic may be *un*made, for example, by working together globally, or prevent another pandemic in the making.

To understand better the energetic interactions between a multiplicity of species that make possible the emergence of new infectious diseases of pandemic proportion, I delved deeper into Samantha Frost's political theory of biocultural creatures. Frost's analytics contribute to a better understanding of the way we can conceive living matter, human and nonhuman including infected animals and SARS CoV-2 viral strains, as *cultured* all the way down. Understanding matter as effects of energy under constraint that is

cultured through its interaction or rather intra-action and transformation with the natural/cultured environment allows us to understand the way the human and nonhuman animal as well as other species are constituted in a constant dynamic of composing, decomposing, and recomposing in response to matter's engagement with its lively biocultural surrounding. Thus, bodies and the environment do not stand opposed but are constitutive of each other. To answer to the lively debate about the ontological difference between quantum dynamics at the subatomic level and the substance-based dynamics at the macroscopic level:

> at the gross spatial and temporal scale of the organism, the creature, the human individual, the macro-adjustments and transformations might not be made manifest until they accumulate sufficiently so as to affect the larger scale function and behaviour. (Frost 2016, 150)

Starting out from the porosity or permeability of biocultural beings to their habitats, the article analyzed the multispecies enmeshment in the making of the Covid-19 pandemic. Caring for what matters in this pandemic involves an attunement to human–animal–microbial intra-actions. This does not entail casting aside a substance-based biomedical perspective on health. This would be futile in disavowing the achievements gained for the health of many through biomedical approaches. Rather, it suggests shifting away from a logic that has tragically ignored, in Lily Ling's words (Ling 2013), "stasis of hegemony, hierarchy, and violence" toward more-than-human relations to a multispecies and ontologically plural approach in the global politics of disease.

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