Philosophy Study, March 2021, Vol. 11, No. 3, 232-239
doi: 10.17265/2159-5313/2021.03.005

The Risks to Human Evolution Posed by World Population Growth, Environmental and Ecosystem Pollution and the COVID-19 Pandemic

Marta Toraldo
University of the Salento, Lecce, Italy
Luana Conte
University of Salento and ASL (Local Health Authority), Lecce, Italy
Domenico Maurizio Toraldo
"V. Fazzi" Hospital, Lecce, Italy

As an advanced theory of evolution, neo-Darwinism broadens the concept of Darwinism, in which natural selection intervenes to ensure that those genes that best meet the need for adaptation to the environment are conserved in the genetic background. Culture, which in human beings contributes to biological adaptation, is the sum of all the knowledge and technical innovation deriving from individual practical contributions handed down from one generation to the next, continuously influencing and changing biological life. As an unforeseen mechanism of adaptation, culture has enabled human beings to survive and to adapt to situations of environmental change and crisis. Indeed, climate change determines both cultural and genetic changes. The deterioration of the climate can have a significant impact on the spread of infectious diseases, to the point that the random mutation of a virus, such as SARS-Cov2 can easily result in a pandemic. We have violated biological ecosystems, destroying the environment and the communities that inhabit it. Spillover is what happens when an agent of disease, be it a virus or a bacterium, for any of a number of reasons, passes from one species to another, generating a zoonosis, i.e., an infectious agent that can affect human beings. The mechanisms of biological evolution act on them rapidly, generating new biological potential and transforming spillovers into pandemics. We need to invest in multidisciplinary scientific and technological research, which entails interaction between various fields of knowledge including ecological, meteorological, anthropological, cultural, medical, and environmental. All these disciplines are closely connected to each other and to the health of animals, human beings, and ecosystems, and it is only by coordinating them that we can hope to respond rapidly to the new health and environmental emergencies and provide political decision-makers with correct information that can protect the human population from decline and extinction.

Keywords: exaptation, environmental challenges, virus Sars-Cov2, spill over

Marta Toraldo, Assistant of Philosophy, Department of Philosophy, University of the Salento, Lecce, Italy.
Luana Conte, Biologist, Laboratory of Interdisciplinary Research Applied to Medicine (DReAM), University of Salento and ASL (Local Health Authority), Lecce, Italy; Laboratory of Advanced Data Analysis for Medicine (ADAM), Department of Mathematics and Physics "E. De Giorgi", University of Salento, Lecce, Italy.
Domenico Maurizio Toraldo, Medical Doctor, Respiratory Disease Specialist, Director Respiratory Unit Care, ASL Lecce, "V. Fazzi" Hospital, Lecce, Italy.

Background

The question of the origins of life on Earth was posed above all in response to the theory of evolution by natural selection, developed independently by both A. R. Wallace and C. R. Darwin in 1858, according to which all forms of life are linked by relations of common descent via ramified phylogenetic trees that lead back to a single progenitor with very simple biological characteristics. The process of evolution has continued for hundreds of millions of years and unfolds via successive events or stages, which, after numerous attempts, thanks to the intervention of natural selection, have led to progressively more complex living systems. From an analysis of a sample of Americans (Beauchamp, 2016), it emerges that neo-Darwinian natural selection has never stopped operating on our species, influencing a series of traits that are regulated by the activity of numerous genes. Moreover, the result shows that cultural change in modern societies is happening so fast as to obscure the effects of natural selection.

The question of whether neo-Darwinian natural selection is still at work on human beings is of fundamental importance for evolutionary biology, and has been the subject of fierce debate in the last few decades. Many observations demonstrate that human evolution could slow down as a result of rapid cultural and technological evolution, which is threatening the whole planet. The problem emerges even more clearly if we consider the distinctive traits of our species: Human beings have developed technology that gives them a considerable degree of power over nature, and the progress of medicine has had a profound impact on the risk of death. Thus, human beings live with reduced selective pressure. This means that the majority of infants reach adulthood and can reproduce, and environmental factors have a limited influence on this. But *how* limited? Is it possible that evolution still operates, but at a reduced speed, to the point that it is no longer evident in population studies? Can it be that the speed of cultural evolution is now greater than that of biological evolution?

Until a few years ago, it was widely held that human evolution had stopped between 40,000 and 50,000 years ago. In contrast, some recent studies have established that natural selection has continued to operate on human beings over the last few millennia (Byars, Ewbank, Govindaraju, & Stearns, 2010). Recent progress in molecular genetics has added more rigour to research into the effects of natural selection on human beings, because it makes it possible to directly study genetic variants in a population and their phenotypical expression, i.e., their functional and morphological traits (Courtiol, Pettay, Jokela, Rotkirch, & Lummaa, 2012). This supports the hypothesis that natural selection is still acting today, but so slowly that its effects are easily obscured by the enormous speed of cultural and technological change in modern societies. It can be concluded that human beings are still evolving, albeit slowly, above all with respect to the rapid changes seen in the last few generations due to the prevalent cultural and environmental factors (Beauchamp, 2016).

The objective of this paper is to reflect on how the history of human beings has led to this critical moment. The positive effects of natural selection on human beings in the course of the millennia have improved survival rates. And yet the increase in the world population, with the tumultuous social, technological, and environmental changes affecting modern societies is putting the very survival of human beings at risk.

The Evolution of Humans Continues

As an advanced theory of evolution, neo-Darwinism broadens the concept of Darwinism, in which natural selection intervenes to ensure that those genes that best meet the need for adaptation to the environment are

conserved in the genetic background. Neo-Darwinism thus considers the gene as the fundamental unit of cellular inheritance and at the same time the target of the evolutionary mechanism that drives natural selection. The neo-Darwinian synthesis unifies various branches of biology, especially genetics, cytology, botany, and palaeontology in support of this mechanism of natural human evolution (Gould, 2002).

The adaptation of living organisms and human beings to the environment in accordance with neo-evolutionary concepts can unfold via two integrated and closely connected biological mechanisms: (a) pre-adaptation, i.e., interaction between the individual's historic-genetic background and the external environment in which they operate, which enables the survival of the fittest; and (b) exaptation, i.e., biological-functional co-option of pre-existing traits, which is based on an unpredictable mechanism but increases the chances of survival (Gould, 2002). While exaptations refer to characters that find new uses but are not attributable to natural selection, adaptations were modelled by natural selection for their current function. Gould and Vrba acknowledged that adaptations can lead to exaptations and that any complex characteristic of living things can contain both.

Patterns of Cultural Innovation

Human beings are predisposed by their genetic make-up towards learning and communication, and thus towards cultural evolution. But there is individual variation in this predisposition and therefore, there is an individual genetic contribution to cultural evolution. The variation of certain genetic traits can influence the speed of cultural evolution. Culture is the sum of all the knowledge and technical innovation deriving from individual practical contributions handed down from one generation to the next, continuously influencing and changing everyday life. This development is made possible by the capacity for communication between individuals due to the evolution of language (Cavalli-Sforza, 1997).

In general, cultural evolution is dependent on biological evolution and thus we may speak of genetic differences that can substantially influence the evolution of culture. This means that genes can determine the culture of a people, insofar as it controls the organs that make culture possible, specifically enabling the creation of language, which is an exclusively human characteristic and is the basis for communication. However, in terms of the practical ability to intervene in reality, culture is not separate and independent from genes, and can even influence genetic evolution. Although this aspect has yet to be fully explored, the study of culture could be useful for understanding biological evolution and genetic transmission (genetic-cultural feed-back) (Cavalli-Sforza & Bormer, 1999).

In general terms, cultural evolution is determined by technical innovations and by society's response to them. The history of culture is thus the history of the succession of technical innovations that have been proposed and taken up by the population; it denotes first a social need, and subsequently a cultural one (Cavalli-Sforza & Feldman, 2003). The task of the history of culture is thus to identify the most important innovations in each epoch, to establish the place and historical context in which they were introduced and to indicate the reasons why they were proposed and/or accepted or imposed. Naturally, innovation is almost always affected by external factors (e.g., economic, social, and political), which impose more or less important cultural models. The influence of society is however always the dominant factor in that the culture is first and foremost a social process, involving exchanges of information between individual that accept the changes. Culture is achieved via a compromise between individual selfishness and the pluralist power of society. In reality, although selfishness seems to prevail, in the end it is altruism that wins (for example, the defence of

one's offspring and the sharing of food and resources in terms of both production and reproduction). To each stage of cultural evolution corresponds a new selective advantage. Often altruism and selfishness play complimentary roles, the former representing the winning strategy within the group as a whole, and the latter dominating relations between individuals. For this reason, human social and cultural relations result from the dynamic equilibrium between cooperation and competition, between acting together and acting against each other. Both attitudes serve human evolution, with reference to the defence of territory, common prosperity and the management of assets. That human culture oscillates between conflicts and alliances is a constant of human societies. Evolution devises fundamental stratagems to generate increasingly complex forms of social cooperation that expand social functioning and adapt it to the environment (Wilson, 2019). Genetic factors among human populations determine cultural mutations that can alter human and social adaptation. In fact, there exists a form of natural selection by cultural evolution which however acts on two fronts at the same time: biological/genetic and cultural. The first stage is "cultural selection" or "cultural drift", which consists of the human decision to accept or reject an innovation. This then leads to a biological change that we may call "genetic shift" (Li et al., 2008). Cultural evolution thus accelerates biological evolution. The increase in social functions and dimensions corresponds to the increase in genetic functions and social advancement.

Human Evolution and Environmental Degradation: Healthy People and a Healthy Planet Are Not Mutually Exclusive

The search for better conditions of life in the process of cultural adaptation has prompted human beings to seek growing dominion over the natural environment, in order to adapt it to its own needs. The use of fossil fuels in a range of activities has considerably increased the concentration of CO_2 in the atmosphere. A close correlation has been found between this concentration and the average temperature of the planet, which has increased by about 0.7°C in the last hundred years (temperatures have been systematically measured since 1866). This is the result of CO_2 and other gases preventing part of the heat of the sun from being reflected back into space. This is the "greenhouse effect", the physical phenomenon that normally maintains the average temperature of the Earth's surface at about 15°C. The carbon dioxide that accumulates in the atmosphere forms a sort of blanket that slows heat exchange between the Earth's crust and surrounding space. The inevitable result of increasing the amount of CO_2 in the air (primarily a consequence of the burning of fossil fuels) is a higher temperature on Earth, which sets off a cascade of effects with biological consequences that are incalculable. The direct effect is the melting of glaciers and polar ice caps, which in turn leads to global sea level rise. Chris Thomas, a biologist at the Centre for Biodiversity and Conservation of the University of Leeds (UK), has published a catastrophic prediction in the scientific periodical Nature (Thomas & Williamson, 2012): from 15 to 37% of living species (more than a million) may disappear from the Earth by 2050 due to climate change and the greenhouse effect (Moritz & Agudo, 2013). In addition, another million living species might disappear by the end of this century—a unique event in the history of the planet. Indeed, such a large mass extinction in such a short time has never happened before. Another researcher has offered even worse data, presented at the conference of the United Nations Environment Programme (UNEP), declaring that climate change is the most serious and urgent threat to humanity (Blois, Zarnetske, Fitzpatrick, & Finnegan, 2013; Ceballos, Ehrlich, & Dirzo, 2017).

The damage to the planet is so grave as to threaten human health and short-term survival. The alarm comes from another study by 250 UN scientists which warns that if environmental protection in the cities and

regions of Asia, the Middle East and Africa is not increased, there could be millions of deaths by 2050 (Lozano et al., 2018). The report warns that industrial and domestic pollutants can alter freshwater conservation systems and this could become one of the main causes of death and large-scale human migration (Myers, 2002).

In another recent study published in the Lancet, the WHO estimates that in 2015, almost one million children below the age of five years died as a result of infections of the lower respiratory tract (LRIs). Atmospheric pollution has a big impact on mortality from LRI, especially in combination which malnutrition and inadequate healthcare. Mortality due to atmospheric pollution began to be estimated in 2015 (especially in children below five years of age) in order to assess the effect of exposure to this risk factor on life expectancy in various parts of the world. Overall, in 2015, 4.55 million deaths (95% CI from 3.41 million to 5.56 million) were attributable to atmospheric pollution, of which 727,000 (573,000 to 865,000) were due to *Ambient Air Pollution-induced-Lower Respiratory Tract Infections* (AAP-LRIs). It has been estimated that AAP-LRIs caused about 237,000 (192,000 to 277,000) excess deaths among infants in 2015 (Lelieveld, Haines, & Pozzer, 2018). It has been estimated that in sub-Saharan Africa, atmospheric pollution reduces average life expectancy by four to five years. In Asia, mortality for all age groups increased by about 10% between 2010 and 2015, while infant mortality due to AAP-LRI fell by almost 30% in the same period. According to the United Nations Environment Programme (UNEP)'s Sixth Global Environment Outlook 2019 (GEO-6), the health of the planet is deteriorating rapidly, with serious direct and indirect impacts on human health and well-being (Intergovernmental Panel on Climate Change 2018). The direct impacts include those of polluted air on people's lungs, while the indirect impacts include the impoverishment of the soil and the consequences for food security. Therefore, environmental protection will also have substantial benefits for human health and well-being. This document argues however that change will not come without political will. It calls on humanity to overcome social and political inertia and focus its attention on the environment. Investing in the environment generates advantages for human health and the economy. Politicians must use scientific knowledge to radically change the political, economic, social, and cultural trajectory of humanity in order to guarantee well-being to the planet and make people healthier (Ekins & Gupta, 2019) (see Figure 1).

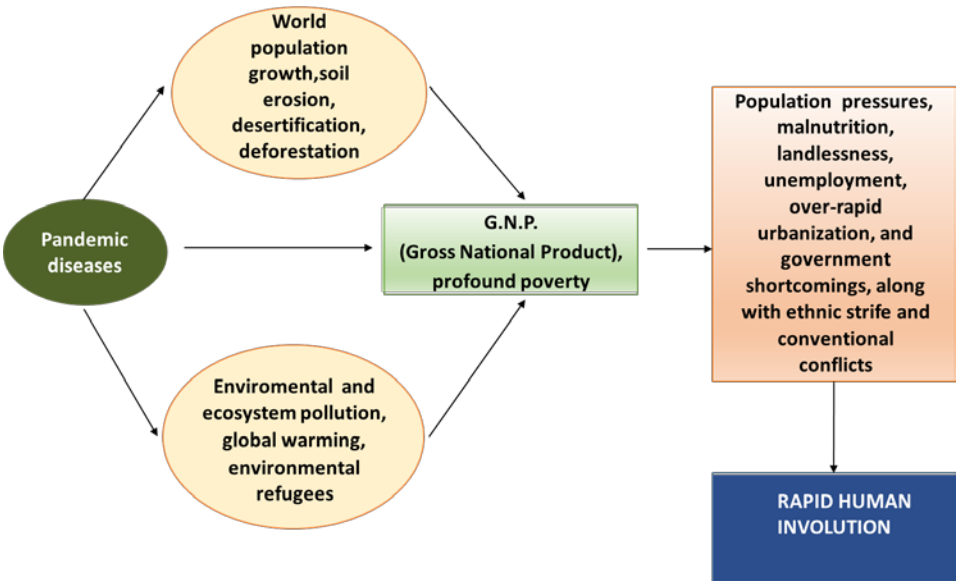

Figure 1. There is a new phenomenon in the global arena: the cumulative impacts of human behavior adversely affect ecosystems, human health and evolution on the planet.

The Novel Coronavirus (SARS-Cov2) Pandemic

Towards the end of December 2019, from a market in Wuhan began a new, unstoppable epidemic, now known as COVID-19 (Read, Bridgen, Cummings, Ho, & Jewell, 2014). The health of the environment is closely linked to the health of human beings. COVID-19 is yet another demonstration of the degree to which human survival on the planet depends on the safeguard of nature, the biosphere and the environment (Coker et al., 2011).

A few years ago a group of scientists discussed the possibility of humanity being hit by a serious viral pandemic, for which it was essential to prepare. They hypothesised a planetary catastrophe, in that the biology of the virus was unknown (Allen et al., 2017). As a response, scientists guided by a multidisciplinary approach provided a predictive model for monitoring possible hot spots from which spillovers (the migration of a virus from one species to another) could originate, causing a zoonosis that was lethal to human beings. These hot spots on the planet, at greater risk of catastrophe, are tropical regions where the biodiversity of wild flora and fauna is high and the soil can be affected by sudden changes due to pollution. Quammen (2012) analysed the causes of pandemics in detail. Once the world population exceeds six billion, humanity begins to approach environmental incompatibility. The world population is currently 7.8 billion (https://www.worldometers.info/world-population/) and is growing by 70 million a year. Human beings have populated all corners of the Earth, disrupting remote and ancient ecosystems. One consequence of this is environmental devastation and the activation of hitherto silent bacteria and viruses. The growth of the human population, together with the environmental disruption caused by pollution, makes it seem as if the end of the planet is near. The mechanism that set off the pandemic is a “spillover”, in this case the passage of a virus from bats to human beings. When a virus or a bacterium, for causes that are not yet clear, passes from an animal species to human beings, it generates a zoonosis, i.e., a contagious disease that strikes human beings but comes from the animal world and subsequently can be transmitted from person to person. This is what happened in 2019 with the SARS-Cov2 virus, which causes the disease known as COVID-19. The spillover is the fruit of inappropriate interaction between human beings and nature. The same authorpoints out that the genetic mutation rate of RNA viruses (such as SARS-Cov2) is about 1,000 times that of the DNA viruses, and the genetic mutation rate of SARS-Cov2 is 30 times that of other RNA viruses. In a short time, the SARS-Cov2 virus produces in the body of the infected human host an immense swarm of viral particles that prevent an effective immunity response. The random mutations of these viruses are frequent and the multiplication of strains makes it harder to create a vaccine (Gollakner & Capua, 2020).

At the heart of the epidemiology of viruses is their marked tendency to mutate, triggering changes in their surface proteins that enable them to avoid the barrier posed by acquired immunity in the human population. For viruses, exaptation of traits generated randomly by mutation is a continuous mechanism that enables them to multiply. It unfolds in various ways, including the recruitment and exploitation of a defective virus, from which the virus acquires numerous individual proteins that can result in a new adaptation with new functions (Koonin & Krupovic, 2018). Exaptations are managed by transposable elements (TEs), which are mobile parts of the external capsule of the virus that act as powerful agents of adaptation. By means of exaptation, TEs contribute to the evolution of the viral genome and enable the virus to replicate and transform itself in new hosts by giving rise to a range of phenotypical benefits. TEs are known to contribute to vital functions and can facilitate the biological equilibrium of the virus (Schrader & Schmitz, 2019). Viral exaptation could facilitate adaptive

responses to environmental changes and this mechanism could be particularly important in the generation of invasive and pathogenic strains (Schrader & Schmitz, 2019). Transposable Elements are known to facilitate changes in the virus in the environment by means of exaptation, but our understanding of the function of TEs is limited (Joly-Lopez & Bureau, 2018).

Conclusion

Cultural dynamics are interfering with biological evolution in increasingly significant ways. Neo-Darwinian biological dynamics, based on genetic mutation and natural selection, are driving the adaptation of human populations to the new cultural changes in human life on the planet. The COVID-19 pandemic has brought about a profound cultural and social crisis. The virus has transformed itself into a dangerous killer for humanity. We propose a scientific approach to tackling and resolving the risk linked to the points of contact between the environment, the animal ecosystem, and the evolution of human beings.

References

Allen, T., Murray, K. A., Zambrana-Torrelio, C., Morse, S. S., Rondinini, C., Di Marco, M., ... Daszak, P. (2017). Global hotspots and correlates of emerging zoonotic diseases. *Nature Communications, 8*(1). Retrieved from https://doi.org/10.1038/s41467-017-00923-8

Beauchamp, J. P. (2016). Genetic evidence for natural selection in humans in the contemporary United States. *Proceedings of the National Academy of Sciences of the United States of America, 113*(28), 7774-7779. Retrieved from https://doi.org/10.1073/pnas.1600398113

Blois, J. L., Zarnetske, P. L., Fitzpatrick, M. C., & Finnegan, S. (2013). Climate change and the past, present, and future of biotic interactions. *Science, 341*(6145), 499-504. Retrieved from https://doi.org/10.1126/science.1237184

Byars, S. G., Ewbank, D., Govindaraju, D. R., & Stearns, S. C. (2010). Natural selection in a contemporary human population. *Proceedings of the National Academy of Sciences of the United States of America, 107*(Suppl. 1), 1787-1792. Retrieved from https://doi.org/10.1073/pnas.0906199106

Cavalli-Sforza, L. L. (1997). Genes, peoples, and languages. *Proceedings of the National Academy of Sciences of the United States of America, 94*(15), 7719-7724. Retrieved from https://doi.org/10.1073/pnas.94.15.7719

Cavalli-Sforza, L. L., & Bormer, W. (1999). *The genetics of human population* (2nd ed.). San Francisco: Freeman/Mineola: Dover Publications.

Cavalli-Sforza, L. L., & Feldman, M. W. (2003). The application of molecular genetic approaches to the study of human evolution. *Nature Genetics, 33*, 266-275. Retrieved from https://doi.org/10.1038/ng1113

Ceballos, G., Ehrlich, P. R., & Dirzo, R. (2017). Biological annihilation via the ongoing sixth mass extinction signaled by vertebrate population losses and declines. *Proceedings of the National Academy of Sciences of the United States of America 114*(30), E6089-96. Retrieved from https://doi.org/10.1073/pnas.1704949114

Coker, R., Rushton, J., Mounier-Jack, S., Karimuribo, E., Lutumba, P., Kambarage, D., ... Rweyemamu, M. (2011). Towards a conceptual framework to support one-health research for policy on emerging zoonoses. *The Lancet Infectious Diseases, 11*(4), 326-331. Retrieved from https://doi.org/10.1016/S1473-3099(10)70312-1

Courtiol, A., Pettay, J. E., Jokela, M., Rotkirch, A., & Lummaa, V. (2012). Natural and sexual selection in a monogamous historical human population. *Proceedings of the National Academy of Sciences of the United States of America, 109*(21), 8044-8049. Retrieved from https://doi.org/10.1073/pnas.1118174109

Ekins, P., & Gupta, J. (2019). *Perspective: A healthy planet for healthy people.* Cambridge: Cambridge University Press. Retrieved from https://doi.org/10.1017/sus.2019.17

Gollakner, R., & Capua, I. (2020). Is COVID-19 the first pandemic that evolves into a panzootic? *Veterinaria Italian, 56*(1), 11-12. Retrieved from https://doi.org/10.12834/VetIt.2246.12523.1

Gould, S. J. (2002). *The structure of evolutionary theory.* Cambridge, Massachusetts and London, England: The Belknap press of Harvard University Press.

Joly-Lopez, Z., & Bureau, T. E. (2018). Exaptation of transposable element coding sequences. *Current Opinion in Genetics and Development, 49*, 34-42. Retrieved from https://doi.org/10.1016/j.gde.2018.02.011

Koonin, E. V., & Krupovic, M. (2018). The depths of virus exaptation. *Current Opinion in Virology, 31*, 1-8. Retrieved from https://doi.org/10.1016/j.coviro.2018.07.011

Lelieveld, J., Haines, A., & Pozzer, A. (2018). Age-dependent health risk from ambient air pollution: A modelling and data analysis of childhood mortality in middle-income and low-income countries. *The Lancet Planetary Health, 2*(7), e292-300. Retrieved from https://doi.org/10.1016/S2542-5196(18)30147-5

Li, J. Z., Absher, D. M., Tang, H., Southwick, A. M., Casto, A. M., Ramachandran, S., ... Myers, R. M. (2008). Worldwide human relationships inferred from genome-wide patterns of variation. *Science, 319*(5866), 1100-1104. Retrieved from https://doi.org/10.1126/science.1153717

Lozano, R., Fullman, N., Abate, D., Abay, S. M., Abbafati, C., Abbasi, N., ... Murray C. J. L. (2018). Measuring progress from 1990 to 2017 and projecting attainment to 2030 of the health-related sustainable development goals for 195 countries and territories: A systematic analysis for the global burden of disease study 2017. *The Lancet, 392*(10159), 2091-2138. Retrieved from https://doi.org/10.1016/S0140-6736(18)32281-5

Moritz, C., & Agudo, R. (2013). The future of species under climate change: Resilience or decline? *Science, 341*(6145), 504-508. Retrieved from https://doi.org/10.1126/science.1237190

Myers, N. (2002). Environmental refugees: A growing phenomenon of the 21st century. *Philosophical Transactions of the Royal Society B: Biological Sciences, 357*(1420), 609-613. Retrieved from https://doi.org/10.1098/rstb.2001.0953

Quammen, D. (2012). *Spillover: Animal infections and the next human pandemic* (Reprint ed.). New York: W.W. Norton &. Company, Inc.

Read, J. M., Bridgen, J. R. E., Cummings, D. A. T., Ho, A., & Jewell, C. P. (2014). Novel Coronavirus 2019-NCoV: Early estimation of epidemiological parameters and epidemic predictions. *Antimicrobial Agents and Chemotherapy, 58*(12), 7250-7257. Retrieved from https://doi.org/10.1101/2020.01.23.20018549

Schrader, L., & Schmitz, J. (2019). The impact of transposable elements in adaptive evolution. *Molecular Ecology, 28*(6), 1537-1549. Retrieved from https://doi.org/10.1111/mec.14794

Thomas, C. D., & Williamson, M. (2012). Extinction and climate change. *Nature, 482*, E4-E5. Retrieved from https://doi.org/10.1038/nature10858.

Wilson, E. O. (2019). *Genesis: The deep origin of societies.* UK: Penguin.