Insights into the New Normal from Nature and Life

Forms of Knowledge for the Post-Coronavirus Era

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Born in Tokyo in 1959. Graduated from Kyoto University. After undertaking a postdoctoral fellowship at Harvard Medical School, USA and serving as an assistant professor at Kyoto University, he took up a position as a professor in the Department of Chemistry and Biological Science at the College of Science and Engineering, Aoyama Gakuin University in 2004 and as professor in the School of Cultural and Creative Studies in 2011. He is also a guest investigator at Rockefeller University, USA. He has a doctorate in agricultural science.

He is a winner of the Suntory Prize for Social Sciences and Humanities and has published widely on the question of "what is life?" based on the idea of dynamic equilibrium, including his bestselling book *Between Organic Matters and Inorganic Matters* (Kodansha Ltd.) that sold more than 850,000 copies and *Dynamic Equilibrium* (Kirakusha, Inc.) Other books include *No Borders in the World* (Kodansha Ltd.), *Keep Changing to Prevent Changing* (Bungeishunju Ltd.), *Quiet Revolution in Life Science* (Shueisha International Inc.). Other publications include a collection of his interviews published as *Dynamic Equilibrium Dialogue* (Kirakusha, Inc.).

Interviewer
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Why We Cannot Eradicate Viruses

Takemoto: The novel coronavirus is driving changes in what constitutes the normal state of affairs. While we here at Hitachi are encouraging a flexible response to these changes that utilizes digital technology to connect the tangible and intangible, in doing so we recognize that traditional approaches to pursuing optimization on the basis of statistics and science are inadequate on their own. In the post-coronavirus era, we will need to embrace a wide variety of perspectives that also take in fields such as biology, philosophy, and social science as we consider what will constitute the "new normal."

Accordingly, we have invited Professor Shinichi Fukuoka, someone with a deep knowledge of nature and living things, to talk about what biology can tell us about this new normal. To put this in context, can you please start by telling us what attitude we should be taking toward viruses and infectious disease?

Fukuoka: I expect many people think of viruses as these invisible and unknown alien entities that are an enemy of humankind. From a biological perspective, however, viruses are a constant presence that have long co-existed with higher organisms such as ourselves. They are also very small, only visible under an electron microscope. Imagine a cell the size of a soccer ball, a virus would be no larger than a sesame seed.

If life is defined as a system of which the sole purpose is to replicate, then the ability of viruses to make copies of themselves means they are living things. If, on the other hand, you view life as being a dynamic system that exists in a precarious state of balance where it is continuously engaged in its own destruction and re-creation, which is to say, the concept I have promoted of seeing life as a condition of dynamic equilibrium, then viruses are inanimate objects, lacking metabolism and respiration. Which is to say that viruses are peculiar entities that exist in a state somewhere between the animate and the inanimate.

Why then do they exist at all? While the simple structure of viruses might suggest that they have been around since the very early stages of life, in fact they arose only after the process of evolution had advanced to higher forms of life. We know this because viruses are actually parts of our own genes that have broken off. The truth about viruses is that they were once part of our own body but wandered off on their own.

At the same time, higher organisms and viruses have maintained a form of symbiosis. Indeed, rather than viruses unilaterally attacking us, it turns out that our bodies act in ways that actively invite viruses inside. Cells are equipped with receptors to which it is easy for viruses to attach, a process that involves proteins from both sides bonding strongly to one another. Other cell proteins also assist viruses, granting them easy access into the cell. In other words, the cells that host viruses actively welcome them in.

As to why this should be, the likely answer from a biological perspective is that viruses are beneficial to the higher organism. The propagation of genes normally proceeds vertically, from parents to children and on to grandchildren. Viruses, on the other hand, carry genetic information from individual to individual, sometimes even across different species. That is, if the passing on of genetic information from parent to child is thought of as the vertical strand of evolution, the role of viruses is to provide a horizontal strand whereby such information can jump sideways.

When you think of it like that, it would not be possible to completely eliminate or eradicate viruses given that they have their own part to play in the system of life. Likewise with the novel coronavirus, our only option is to find some way of accepting and co-existing with the virus.

Suitable Caution Rather than Blind Fear

Takemoto: So declaring war on viruses is the wrong approach?
Fukuoka: Yes. Because viruses are part of nature. Meanwhile, the part of nature with which we are most intimately connected is our own body. These two aspects of nature exist in a form of dynamic equilibrium that places them in conflict with one another. While it is desirable that viruses bring genetic information to us, we do not want them to then start multiplying. As natural entities themselves, our bodies respond to this by invoking elaborate immune system mechanisms in an attempt to eliminate viruses before they can multiply. When a virus does breach these defenses and starts to replicate, our body in turn invokes a second line of defense, called acquired immunity, producing antibodies capable of binding to the virus. Viruses that have become coated with these antibodies are then eliminated by another form of immune cell called a macrophage. In other words, people with a healthy immune system are able to overcome such viruses and recover with no more than mild symptoms.

This means our attitude toward viruses should be one of suitable caution. Rather than fearing or worrying about them, we should rather treat them with due respect. While hand washing and avoiding closed spaces, crowded places, and close-contact settings remain crucial, I believe it is also important that we avoid over-reacting and instead respect viruses as part of nature, putting our faith in the immune system with which nature has endowed us.

Unfortunately, cool judgement can be hard to maintain in the midst of a pandemic as we are right now. It is particularly difficult to take the long view when people around us are dying or suffering serious illness. Nevertheless, therapeutic drugs or vaccines will no doubt be developed in due course and the time will come when we are able to make a dispassionate assessment of the current turmoil. Indeed, we continue to go about our public lives in the presence of influenza viruses that cause the same flu-like symptoms as the novel coronavirus despite knowing that the vaccines and therapeutic drugs for these are not always entirely effective. I expect that in due course we will come to accept the novel coronavirus too as an endemic virus that continues to pose a certain level of risk to the public.

What Forms of "Literacy" are Needed in the Post-Coronavirus Era?

Takemoto: Why then has the novel coronavirus been such a big deal?
Fukuoka: One reason can be found in how we describe the novel coronavirus as "novel." As with new strains of influenza or Creutzfeldt-Jakob disease, dubbing these conditions as something new gives people the impression of an unknown disease running rampant, causing them to overreact. Along with the rapid spread of viruses due to globalization and how the widespread use of polymerase chain reaction (PCR) testing allows us to quickly produce maps of infection, this provokes people into a state of fear. In other words, what we have is an "infodemic" in which panic has been spread by means of information. This is nothing other than a man-made disaster.
Takemoto: As you say, the accurate conveying and assimilating of information is more important than ever in this era of information overload. Even the naming of things has an important role to play. Finding ways of appropriately filtering all this information is in itself something that we appear to need.
Fukuoka: That is right. Now in particular, we are getting tangled up in a steady stream of anecdotal and unsubstantiated data. In a case of the bad driving out the good, it is the fake or sensationalized news that spreads more easily. In other words, it is not just viruses about which we should be "suitably cautious," but information as well. I believe we need to improve the "literacy" of those who convey and assimilate information, together with the technology to support this.

An important prerequisite for this is to adopt an intellectual attitude of self-skepticism. Recognizing that various biases may predispose us to believe certain information, it is essential that we treat our own views with caution. Moreover, in order to acquire this skeptical attitude, we should from an early age be cultivating an intellectual attitude of not indiscriminately accepting what other people say. Likewise, what is called for in the post-coronavirus era is the intellectual humility of being quick to correct ourselves when our views turn out to be wrong. I believe that self-skepticism and integrity will both be crucial survival skills in the information society of the future.

Recognizing the Structure of "*Physis* vs *Logos*"

Takemoto: As we grope our way toward the new normal, I believe that life science and biology, together with your concept of dynamic equilibrium, will have an important role to

play over and above the past emphasis on science, technology, engineering, and mathematics (STEM).

Fukuoka: One way of looking at this is in terms of the idea of "*physis* vs *logos*." I spoke earlier of how our own bodies are the part of nature to which we are most intimately bound. While many of us think of our living bodies as something that belongs to us, the truth is that our bodies are not amenable to our own control. We can neither know nor control the timing of our birth, when we will fall ill and with what diseases, or how we will eventually die. Nature is intrinsically fickle and unpredictable and not something we can control. "*Physis*," the Ancient Greek word for nature, expressed this inherent characteristic.

On the other hand, the only animal ever to exert a degree of control over nature and achieve some comfort in terms of food, clothing, and shelter is *homo sapiens*, in other words ourselves. What made this possible was that we developed the capacity for speech and reason, namely "*logos*." Humans have built civilized societies, having devised such things as language, logic, algorithms, and technology.

The sole objective of *physis* is the continuity of the species. The value of individual lives is extremely low, serving only as tools for perpetuating the species. Humans, however, have developed *logos*, putting greater value on the lives of individuals than on the continued existence of the species as a whole. We have also made commitments in the form of conferring basic human rights. That is, we have surrounded our *physis* existence as biological entities with the social contracts and commitments of *logos*, taking forms such as laws, social norms, morality, and religion. In this way humans have come to live in a state that is poised part way between *physis* and *logos*. Obviously it is not possible to use *logos* to take in everything and to predict or control it. Nevertheless, when you look at what is happening with things like artificial intelligence (AI), the impression you get from modern society is that we have placed great faith in *logos*. So long as we exist in essence as part of nature, however, it will remain all but impossible for us to reach the singularity where all human thinking is handed over to computers. This is because of the impossibility of ever completely transforming a life of *physis* into pure *logos*.

When you think of it in those terms, the current pandemic can be interpreted as *physis* delivering a shake-up to a modern society that has become a place of excessive *logos*. *Physis* has given us a sharp reminder that we cannot rely on *logos* to control everything.

Takemoto: So what attitude should we adopt toward *physis*?

Fukuoka: We should keep in mind the impossibility of completely controlling nature, including our own lives. Obviously, it is still a good idea to use technology for our own benefit to control those parts that can be controlled to some extent. However, this technology is a means of expanding human capabilities beyond ourselves and we need to take care when it comes to technologies that control us on the inside.

Areas where special care is needed include those technologies relating to reproduction and gene editing that control human life. This is because they equate to a mechanistic approach to living things (*physios*) that oversimplifies their fickle and complex nature. Used carelessly, they have the potential to unexpectedly backfire.

Takemoto: So it is important to think in terms of both internal and external. As with drugs, using them the wrong way is dangerous.

Fukuoka: First of all, pharmaceuticals do not work by guiding our *physios* existence in a favorable direction. Rather they block or interrupt certain processes to snap us into a different state where we forget our pain or where discomforting symptoms are alleviated, but without healing our body in a fundamental way. In response to such interventions, our *physios* bodies and our existence in a state of dynamic equilibrium change how we react in ways that counteract these effects. As a result, ongoing use of pharmaceuticals causes their efficacy to fade or brings side effects.

Takemoto: Which goes to show how remarkable we are in terms of our *physios*.

Fukuoka: That's right. The processes of life are amazing, such that simple interventions that may be beneficial at the time have negative consequences when considered from a long-term perspective. It is dangerous to see *physios* as something that can be addressed by technology. Technologies that help us move around or communicate more easily are all very well, but we need to be careful about using technical means to control the internal aspects of human life.

Altruism Holds Key to the New Normal

Takemoto: My first exposure to your idea of dynamic equilibrium left me feeling quite blown away. Dynamic equilibrium is a state of order that persists despite existing in a condition of continuous change where it is endlessly being destroyed. You have spoken of life being such an ongoing process in a state of dynamic equilibrium. In other words, the process of life continues despite the fact that we are being continuously replaced at a physical level, forever coming apart and being rebuilt at the molecular scale. It is through this process that life is able to overcome the law of entropy.

One of the key elements in this concept of dynamic equilibrium is the idea of complementarity. Complementary

interactions at a molecular level are an essential part of maintaining biological activity. While it is not a well-known term, I suspect that this idea of complementarity can help show the way when considering the new normal.

Fukuoka: That's right. The pandemic has taught us that the ecosystem as a whole is in a state of dynamic equilibrium. Moreover, it is complementarity that sustains this dynamic equilibrium. Complementarity describes a relationship in which different elements support one another to their mutual benefit like the pieces of a jigsaw puzzle. For example, if one piece is thrown away, the location of this missing piece is not lost so long as the surrounding pieces are still present. In this way, order is retained. Similarly, life retains a state of order without an increase in entropy as it continuously swaps pieces (molecules) around and refreshes itself.

This is true also of ecosystems as a whole. Relationships that appear to be based on the principle of eat or be eaten are not in fact a case of one-sided exploitation, but rather a form of mutual support and balance. In other words, they are complementary. Viruses, too, form part of this complementarity. As I talked about earlier, viruses are not selfish entities with the sole task of replicating themselves, but rather altruists that bring benefits to higher organisms, which is to say they are complementary to those higher organisms.

What we can take from this, as explained in the book *The Selfish Gene* by the British evolutionary biologist Richard Dawkins, is a way of living that, rather than a selfish existence that has its own replication as the sole goal, it takes the form of altruistic coexistence that benefits others. Such altruism will also be one of the keys to the new normal.

While altruism may conjure up images of self-denial or charity, that is not what it means. Rather than giving away 10 of something when you need 100 of them to live, altruism means sharing out any excess when it is available. Life's condition of dynamic equilibrium is constantly subject to disturbances that lead to ups and downs in production. So, when you were able to produce 110 of the item concerned, altruism says you should give the extra 10 to others.

When you look at the ecosystem as a whole you find that altruistic behavior is occurring all the time. Plants are a prime example. If plants were to photosynthesize no more than needed to satisfy their own growth and protect their seeds, animals along with the microorganisms and worms in the soil would no longer be able to share in the benefits of their leaves and fruit. But because they do, when the productivity of plants is high they generously make their leaves and fruit available to other living things.

When you think of it like this, it is only humans who try to hoard what we have, such that on acquiring 110 of a thing we want 120, and if we get that 120 we now want 130. I believe that freeing ourselves from this trait and behaving altruistically will be one of the principles of the new normal.

Resiliency that Mimics Life

Takemoto: In your book *No Borders in the World* (Kodansha Ltd.), you make the point that, while one needs to break life down to the micro level to understand its mechanisms, because everything is connected to everything else, the true nature of life does not become apparent until you consider these connections. I see altruism as being at the heart of this idea.

Fukuoka: It is. Obviously, if we are to understand the world, there are many elements that we first need to break down and analyze. Science has largely advanced by breaking things down in this way. However, this on its own does not tell us everything because there are also the interactions between the different component parts that function on the principles of altruism and complementarity. In other words, it is only by putting things back together again after taking them apart that we can understand their true nature.

This applies to AI and other technologies as well as to life and it is not enough to only target things like optimization and efficiency. As we have seen with the novel coronavirus pandemic, it is a characteristic of ecosystems that a lack of surpluses and flexibility leaves them vulnerable to collapse in response to adverse events. For this reason, I hope that future AIs will incorporate algorithms that encourage altruism to facilitate the distribution of surpluses when they occur.

Takemoto: Clearly Hitachi needs to consider the interconnectivity of things and to take on the ideas of complementarity and altruism in the digital transformation it is undertaking. It will become more important than ever that we identify the relationships between different types of data, assign meaning to it, and discern attributes.

In recent years, you have sought to further address the world of *physis* while making skillful use of *logos* (language), including by writing a book on the philosophy of Kitarō Nishida. What is it you are trying to accomplish by nurturing this way of looking at things and passing it on to others?

Fukuoka: The more you specialize, the more you find yourself scaling a peak from which you tend to view the world at an elevated perspective. Unfortunately for the learners of the future, being handed down such messages from above does not foster understanding. Accordingly, my aspiration is to adopt a stance of being highly cognizant of the process I have gone through to learn the things I have and to express matters in terms of that timeline, sort of like climbing the mountain from its base. As a consequence, whatever the field, it is important to study its history.

Likewise, the liberal arts, an area of renewed attention recently, can be thought of as a way to forge your own timeline. In their literal sense of offering ways of finding freedom, the liberal arts are meaningless if they equate to no more than stuffing yourself with knowledge. Rather, you need to keep reviewing your knowledge based on an awareness of your own progression over time. I believe this reciprocal approach to learning will be especially important in the post-coronavirus era.

This applies also to the solutions and systems we spoke of earlier and the need to put them back together again based on knowing what the various component parts are and understanding how they interact. In doing so, more than ever, we will find ourselves asking what philosophy is behind the solution.

The emphasis in the past has been on optimization in the engineering sense of maximizing output per unit of time and we have already talked about how that is insufficient on its own. In the context of biology, for example, optimization happens over very long time spans that are measured not in hours or days, but in years or centuries.

There are also phenomena that appear to serve no purpose but in fact facilitate survival. You have probably heard of how populations of ants invariably include a certain proportion of idlers. While this appears inefficient, in fact colonies would eventually fail if they were made up entirely of diligent workers. When events like the current crisis occur, which might happen only once in a hundred years, it is the organizations with reserves to call on that prove resilient. While it might seem inefficient, because we are living instances of *physis*, I suspect that in the future, more than ever, we will seek to learn from examples in nature.

Takemoto: It is certainly important that we take onboard the insights into resiliency offered to us by the natural world. You have had many very valuable things to say today. Thank you for participating.

Interview Conclusion

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The books of Professor Fukuoka are both highly instructive and very accessible. Though a layperson when it comes to biology, I find myself nodding in agreement as I read. I found the experience to be quite remarkable. When I had the nerve to ask the professor how he came to be so multi-talented, he replied that he never set out with such a goal but merely followed the trail of his own interests.

So what are his interests? I continued to ponder this question after the interview was over. My understanding is that their source lies in an homage to what life has become through its four-billion-year history.

His passionate desire to understand the complex and elaborate processes of life have borne fruit in the form of exceptional ideas and books. At this time when STEM is in the ascendency, I also believe that the results of his work offer extremely valuable guidance. As part of Hitachi, I hope that I will be able to help create a better society by making practical use of these lessons that I find so fascinating.