Strengthening biosecurity and biosafety systems is an urgent need for continuing human existence

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A brief survey of some features of the SARS-CoV-2 virus is given, especially its ability to persist, under temperate conditions, in infectious form on surfaces, thereby contributing to prolongation of the COVID-19 pandemic. The notion of biosecurity is developed, requiring an integrated approach and global coöperation.

The interaction of viruses with humans, animals and plants and the study of their properties in the environment have always been of interest to me. As it happens, I have been studying various processes involved in this interaction for over 40 years. It was once amazing to me that viruses occupy the largest niche in the biosphere and have been around for millions of years. They are invisible, insidious killers that have been involved in millions of deaths throughout the history of humans and animals. What is their role in the COVID-19 pandemic? Already in the first year of the pandemic, humanity has been reduced by 3,073,891 people (as of 22 April 2021).

Man seems omnipotent, has already conquered space, prints any object he wants on a 3D printer, creates cyberminds and much more. We believed in our omnipotence. But it turns out that we are almost powerless against particles on the border between animate and inanimate; against the small, invisible "eye" of the virus.

Viruses are almost everywhere: in the oceans, in bacteria, in representatives of all taxonomic groups of living organisms, in glaciers, and so on. Part of my research life has

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been devoted to, among other viruses, members of the *Coronaviridae* family, animal pathogens that affect cattle, pigs and birds, namely bovine coronavirus, porcine transmissible gastroenteritis (TGE) virus and avian infectious bronchitis virus (IBV). Although they belong to the same family of viruses, they are classified into different groups, of which coronaviruses have four. These pathogens have caused and continue to cause infectious diseases in domestic animals, often resulting in their death and significant economic losses to their owners.

With the onset of the COVID-19 pandemic in 2020, it occurred to me that it was necessary to share all the knowledge I had gained in the study of animal coronaviruses, both in the development of vaccines and in the search for new chemicals, including indole derivatives and nano-objects, such as the water-soluble form of fullerene C_{60}, which can be used to help create drugs or disinfectants against coronavirus infections.[1] Of course, the biological properties of different strains of these coronavirus infections were also studied, in particular the duration of retention of infectious properties of porcine coronavirus at different temperatures during storage in liquids. The temperature resistance of the TGE coronavirus was shown to be greater than previously thought. We studied the effect of temperature: +4 °C, +25 °C, temperature difference in +31–33 °C; –13 °C, –20 °C. Both vaccine and epizoötic strains of TGE coronavirus were found to decrease infectivity after long-term storage. However, after storage, when reintroduced into susceptible biological systems (*in vitro*), they quickly regain infectivity. It was demonstrated that TGE coronavirus only partially lost its infectivity during storage for more than two years, even at –13 °C or –20 °C. These properties were restored by subsequent replication of the virus in an *in vitro* system. A similar trend was observed when the virus was stored for 8 years at +4 °C. The fastest decrease in coronavirus titre occurred at +25 °C, but the epizoötic strain of the virus was more stable under these conditions. Therefore, caution is needed when working with field isolates of coronaviruses. A general tendency for the stability time of animal and human coronaviruses to decrease with increasing temperature was found. However, we found resistance of the virus to 13-fold repeated changes in temperature (from –13.0 ± 0.5 °C to room temperature) without a complete loss of infectious properties.

Currently, researchers are also interested in "the survival time" of the pandemic coronavirus on various infected objects made of glass, vinyl, stainless steel, cotton, paper etc. materials commonly used in public places. There are currently conflicting reports on "the survival time" of SARS-CoV-2 virus, ranging from 3 to 14 days at room temperature, on the surfaces of objects made of stainless steel.[2,3] Interesting research has been conducted by Australian scientists;[4] they determined the risk of transmitting SARS-CoV-2 virus from

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1 Z. Klestova et all., Anticoronavirus activity of water-soluble pristine C_{60} fullerenes: *in silico* and *in vitro* screening. *Adv. Exp. Med. Biol.* **1352** (2021) 159–172.

2 N. van Doremalen et al., Aerosol and surface stability of SARS-CoV-2 as compared with SARS-CoV-1. *New Engl. J. Med.* **382** (2020) 1564–1567.

3 S.B. Kasloff et al., Stability of SARS-CoV-2 on critical personal protective equipment. *Sci. Rep.* **11** (2021) 984.

4 S. Riddell et al., The effect of temperature on persistence of SARS-CoV-2 on common surfaces. *Virol. J.* **17** (2020) 145.

various contaminated typical surfaces to objects at different temperatures (20, 30 and 40 °C) and after different intervals. It was found that at 20 °C the interval during which infectious viruses could be detected ranged from 5.5 days for cotton to 9.1 days for paper banknotes. This interval was reduced to a few hours at 40 °C. At initial viral loads equivalent to the highest virus titres detected in patients with COVID-19, infectious virus was detected for 28 days at a temperature of 20 °C on surfaces such as glass, stainless steel and polymer banknotes. A study of the effect of 30 °C on the infectious virus showed that it could regain its infectious properties within 7 days of isolation from surfaces made of stainless steel, glass or polymer banknotes, and within 3 days from vinyl surfaces and cotton fabric. On paper banknotes, the infectious virus was still detectable after 21 days; on other surfaces at 30 °C, this interval ranged from 1.4 days for vinyl to 4.9 days for paper banknotes. These results show that the SARS-CoV-2 virus can remain infectious for much longer than previously thought. It has already been shown that coronaviruses are easily transmitted via contaminated skin and surfaces of objects likely to come into contact with such skin (touch screens on mobile phones, ATMs, airport check-in kiosks and self-service kiosks in supermarkets).[5] So, I have always been concerned about whether we are being too cavalier about the SARS-CoV-2 virus, given its high resilience and the possibility of transmission via the surfaces of contaminated objects and fluids containing the virus.

These results showed that the spread of SARS-CoV-2 virus occurs not only through aerosols and droplets released by human exhalation, but also through the surfaces of objects contaminated with coronavirus. The resistance of the SARS-CoV-2 virus to glass and vinyl (both common display screen materials) suggests that sensor devices may be a potential source of virus transmission. It is therefore important to consider this in the health and public transport sectors—many health centres require outpatients to check in using a touch screen. I was saddened to learn that vaccine researchers are just beginning to follow the path we took many years ago when working with the coronavirus TGE. My idea of sharing knowledge was realized in October 2020 with the publication of a scientific monograph containing important results from my research on the properties of animal coronaviruses.[6] This is not a study of the pandemic SARS-CoV-2 coronavirus, but of a model of human pathogenic coronaviruses that allows us to study their properties with greater confidence.

This makes it possible to interpret the results and draw parallels with the properties of the SARS-CoV-2 pathogen involved in the current pandemic.

So, by publishing the monograph,[5] I was happy to reveal some of the secrets of the coronavirus' properties to the general public. While the book was being distributed, I was sure that we would now overcome the virus. And, as if in response, the virus attacked me because knowledge of its secrets, both regarding the emergence of new strains, its mechanisms of long-term survival and other issues, could lead to its destruction. For almost a year of the pandemic I was healthy, and my monograph spread to libraries and research institutions, but then I was

[5] T.R. Julian et al., Virus transfer between fingerpads and fomites. *J. Appl. Microbiol.* **109** (2010) 1868–1874.

[6] Z. Klestova*, Animal Coronoviruses: The new perspectives for human coronavirus research.* Kyiv: Sprint-Service (2020).

struck by the virus—I became seriously ill with COVID-19. Hospital—reflection—treatment—reflection—oxygen therapy—reflection. Reflections on the fact that now I was experiencing the reverse side of the infection, not just laboratory experiments, experiencing it like the millions of patients who survived (not to forget the others who, unfortunately, died).

SARS-CoV-2 strains, their pathogenicity and infectivity are changing, but the ability to spread rapidly and damage human health has remained, despite seasonal and other circumstances. Most likely, humanity is condemned to coexist with this emerging pathogen for a long time to come, since it is already circulating not only among human populations, but also among fauna, especially wild animals, in different regions of the planet. The range of the virus, the material and the conditions for its evolution are therefore more than sufficient. I have analysed possible reasons for the spread of SARS-CoV-2 into new ecological niches in different fauna, which are related to several factors. One of them is the animal's body temperature, its fluctuations and the presence of specific receptors for the virus.[7]

Among other things, SARS-CoV-2 damages the genome of infected cells. Notably, it has been established that SARSCoV-2 affects DNA integrity of both somatic and germ cells.[8]

My views on combating viral aggression, as well as other biological threats that pose significant hazards, were formed under the influence of confidence in the need to strengthen the biosafety system not only in individual countries, but also by creating a single global space for biosafety and biological protection.

Science and technology have become integral to the development of society. Scientists can no longer isolate themselves from social problems. Biosafety covers a wide range of issues that affect everyone—politicians, industrialists, scientists and the general public. Biosafety concerns the life and health of humans, animals, plants and the environment. It therefore covers a wide range of issues on which the existence of life on our planet ultimately depends.

Global geopolitical, geo-ecological and climatic, epidemiological and epizoötic changes, biological terrorism and the rapid development of bio- and nanotechnologies (and indeed bionanotechnologies) have raised biosafety issues not only at national but also at global level.[9] The emergence of new infections that did not exist before (emergent infections—such as COVID-19, Ebola) and those that are returning although thought to have been eradicated (re-emergent infections) require new approaches to prevention and control. Unfortunately, new diseases are emerging for which no prevention or treatment has been developed and which pose serious risks to humanity as a whole. It is therefore very important to identify possible sources of these biological hazards and the ways in which they can spread.[10]

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[7] Z. Klestova, Possible spread of SARS-CoV-2 in domestic and wild animals and body temperature role. *Virus Res.* **327** (2023) 199066.

[8] Z. Klestova, Towards SARS-COV-2 effects on the genetic apparatus of target cells. *Acta Sci. Microbiol.* **6** (2023) 9–21.

[9] Z. Klestova and A. Golovko, Biosecurity forecasting system—the key to biological security. *J. Veterinary Med. Ukraine* **224** (2014) 9–14.

[10] Z. Klestova, A. Makarenko and E. Samorodov, Local origin and global spread of viruses. Possible pathogenic viruses distribution from an example of Antarctic study. *Intl J. Agric. Biol. Sci.* **3** (2019) 51–61.

We therefore need new approaches to diagnosis[11] and a system for the development, use and control of immunobiological agents (including vaccines) that will prevent the spread of pathogenic strains of microörganisms among susceptible populations. We also need rapid methods for detecting viruses in different environments. One of these methods was developed by me and colleagues based on the phenomenon of surface plasmon resonance using a nanosensor. The method allowed the detection of coronaviruses in liquids, including biological fluids.[12, 13]

Various approaches have been used to develop vaccines to prevent COVID-19. Different countries use different vaccines and vaccination schemes in different populations, but unfortunately, due to insufficient clinical trials of immunobiological drugs rapidly developed on the basis of the pathogen or its components, including genetic, we cannot yet guarantee their safety and efficacy; we do not yet have sufficient data, and in particular there are no data on the consequences of vaccines including long-term consequences.

Biosafety and bioterrorism are now important factors affecting the overall security of many countries. This can be explained by the fact that the use of pathogens of various human and animal diseases as biological weapons, or sabotage of companies involved in biotechnological production or the maintenance of reference collections of strains of microörganisms, can lead to unintended consequences. Factors contributing to the emergence and spread of biological threats include social and economic instability (especially in the context of pandemics such as COVID-19), mass migration, lack of coördination of interagency and interregional coöperation on biological threats and interregional coöperation on biosafety, the low scientific and industrial potential of some countries, the failure to respect global ethical principles and double standards in the conduct of research involving biological objects, and the inappropriate development of biological weapons and inappropriate use of the results.

In addition, we cannot be sure that the accidental release of pathogens from laboratories, the spread of pathogens in war zones and civil wars, and the use of inferior (ineffective) vaccines will not lead to uncontrollable situations around the world.

We should therefore use the term "biosecurity" in the future. Biosafety refers to the successful minimization of risks of deliberate or accidental use of certain results, not only of laboratory-based biological sciences, but also of natural sources of biological hazards and dual-use goods and knowledge that could harm humans, animals, plants and the environment. Some advances in modern biotechnology create goods that may be dual-use in nature. It is therefore important to use the public information space to improve understanding of potential risks to society in order to minimize biological risks.

Biosecurity requires a strategic and integrated approach that encompasses scientific knowledge, policy strategies and regulatory frameworks that analyse and manage biological risks related to food safety, human and animal life, animal and plant health, as well as

[11] Z. Klestova et al., Experimental and theoretical substantiation of the express method development for detection of enteroviruses in water by surface plasmon resonance method. *Innovative Biosyst. Bioengng* **3** (2019) 52–60.

[12] Z. Klestova et al., Aspects of "antigen–antibody" interaction of chicken infectious bronchitis virus determined by surface plasmon resonance. *Spectrochim. Acta A* **264** (2021) 120236.

[13] A. Yushchenko, G. Dorozhynskyi, Y. Dremuch, Y. Ushenin, Z. Klestova, S. Kravchenko, V. Maslov, N. Gavrasieva and O. Blotskaya, Detection of antibodies in animal serum samples using surface plasmon resonance biosensor. *ALTEX Proc.* (LINZ 2018–EUSAAT 2018) **7** (2018) 191 (p. 259).

environmental risks associated with biological agents, including those used for ostensibly benign purposes such as pest control.

As agricultural production, including organic production and pharmaceutical production, increases, this has an impact on transport systems and foreign trade relations. New challenges arise in terms of the risk of substances, biological pathogens and new threats, including the contamination of laboratory personnel through the accidental release of pathogenic microörganisms from laboratories. The sustainable development of countries requires efforts to address global biosafety issues in the context of intergovernmental coöperation.