Mini Review Article

A Mini Review on Exploring the Role of Beneficial Viruses

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Abstract | Most people hold the belief that all viruses are harmful. However, this idea is incorrect, and requires correction. In this review article, we mentioned numerous examples of beneficial viruses to demonstrate their existence. Moreover, we aim to dispel the notion that all viruses are harmful, based on our understanding of them. So, what is a virus? The term "virus" is derived from the Latin word for poison (1). Viruses are microscopic obligate intracellular parasites that depend entirely on their host cells to replicate and propagate, by exploiting the host cell machinery (2, 3). They come in various shapes, sizes, and levels of complexity. The structure of viruses is relatively simple; they typically consist of an icosahedral or helical protein coat that encloses the viral genome, which may be either DNA or RNA (4). Some viruses have genomes that are extremely small, consisting of only two genes (5). Due to their small size and complete dependence on their host cells, viruses can infect a variety of organisms, including bacteria, plants, and mammals (6). Viruses occupy a unique place in the world, somewhere between living and non-living entities (7). Unlike living beings, viruses do not metabolize or grow, but instead assemble in their mature form inside their host cells (8).

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Introduction

We previously mentioned a brief overview of viruses. In 1892, Russian scientist Dmitry Ivanovsky pioneered the discovery of viruses. He demonstrated that a filtrate from diseased plants contained a Tobacco mosaic virus that was capable of passing through a filter that was known to be impermeable to bacteria. Initially, Ivanovsky believed that bacterial toxins might have caused plant disease. However, further research proved that viruses could pass through a filter, infect their hosts, and replicate within cells. This demonstration was later confirmed by Martinus Bejerinck, Wendall Stanley, and Friedrich Loeffler (9). The second half of the twentieth century saw the golden age of virus discovery, during which many species of animal, plant, and bacterial viruses were discovered (10).

Do you think that all viruses are destructive and harmful?
The viruses are inherently harmful, pathogenic, and dangerous organisms is deeply ingrained in our minds

and beliefs. This belief is often reinforced by the news, which frequently reports on viruses that pose a threat to human health, such as COVID-19, AIDS, influenza, and polioviruses. However, this belief is not entirely accurate, as there are also beneficial viruses that exist alongside harmful ones (11).

In fact, our bodies contain several protective viruses that help defend against pathogenic bacteria and other harmful viruses (12). Beneficial viruses can also be found in various hosts, including bacteria, insects, plants, fungi, and other microbial eukaryotes, as well as mammals (11). To illustrate this point, we will provide examples of beneficial viruses that challenge the idea that all viruses are harmful. For instance, some plant viruses can increase a plant›s ability to withstand drought and cold stresses. In a previous study, four acute plant viruses were used to infect various plants, including the *Chenopodium amaranticolor* plant infected with the Cucumber mosaic virus. The study showed that these plants had increased their tolerance to drought stress due to their infection with the acute plant viruses. Additionally, plant Pararetroviruses are involved in protecting plants against pathogenic viruses (13). These examples demonstrate that beneficial viruses are not limited to plants; they can also be found in mammals, insects, fungi, and other beneficial microbial eukaryotes (14).

In conclusion, while harmful viruses are undoubtedly a significant threat to human health, it is essential to recognize that not all viruses are harmful. Beneficial viruses play a crucial role in protecting hosts from pathogenic bacteria and viruses, increasing resistance to environmental stresses, and promoting host health in various ways. By understanding the existence of beneficial viruses, we can correct our thinking that all viruses are harmful and appreciate the complexity and diversity of these microscopic entities.

In some instances, infection with mammalian viruses can provide protection against other serious diseases. For example, in a previous study, mice infected with lymphotropic viruses were found to be protected against type 1 diabetes. Similarly, mice infected with latent herpes virus were protected against severe bacterial infections, such as *Listeria monocytogenes* and *Yersinia pestis* (11). Another study involving newborn hamsters showed that infection with adeno-associated virus reduced the incidence of cancerous tumors caused by human adenovirus type 12 (15). Long-term studies have also reported that patients infected with HIV-1 progressed to full-blown AIDS more slowly when also infected with the non-pathogenic hepatitis G virus, which is common in humans (16, 17). Additionally, it has been noted that the human cytomegalovirus can suppress HIV-1 infection (18), while infection with the hepatitis A virus suppresses superinfection with the hepatitis C virus (19). Mammalian retroviruses have played a crucial role in the evolution of the placenta (20).

An example of a beneficial insect virus is the polydna virus, which is necessary for the survival and development of parasitoid wasp eggs. This virus has genes that can suppress the immune system of the caterpillars and is found in wasps, deposited along with their eggs (21, 22). The hypovirus of *Chryphonectaria parasitica*, the causal agent of Chestnut blight, is an example of a beneficial fungal virus. Trees infected with the chestnut blight fungus *Cryphonectria parasitica* can recover and survive when the fungus is also infected with the Hypovirus (23). Furthermore, there are several other examples of beneficial viruses, such as parvoviruses required for the development of aphid wings (24), yeast viruses that allow the suppression of competitors (25), fungal viruses which known as Pestalotiopsis theae chrysovirus-1 (PtCV1) that can confer thermal tolerance to fungal endophytes and their plant hosts (26), and bacteriophages that can enable the invasion of new territories by killing off competitors and facilitating the invasion of mammalian hosts (14).

There are also other examples of beneficial viruses, such as those infect and kill their hosts, which can act as catalysts for biogeochemical cycling. These viruses contribute to element cycling by liberating essential nutrients, including calcium (Ca), carbon (C), and phosphorus (P), thereby playing a significant role in ecosystem functioning (27, 28). Additionally, the human genome carries viral DNA integrated into our genetic material, with approximately 8.3% consisting of long terminal repeat (LTR) retrotransposons, specifically human endogenous retroviruses (HERVs) (29, 30). These elements have been incorporated into our genome over evolutionary time and may influence gene regulation and immune responses (30).

Another notable example of a beneficial virus is the Curvularia thermal tolerance virus (ChThTV), which forms a mutualistic symbiosis with the endophytic fungus Curvularia protuberata. This fungus resides in the grass plant Dichanthelium lanuginosum, which can thrive in extreme temperatures of around 55°C. The presence of ChThTV enhances the fungus's ability to assist the plant in tolerating these high temperatures, demonstrating the virus's role in promoting plant resilience under stress conditions (31).

In the field of virology, the term "virome" is used to describe the collection of viruses found within the human body, analogous to the term "microbiome" used for microorganisms (32, 33). This concept highlights the importance of understanding the diverse viral populations that coexist with humans and their potential impacts on health and disease.

With more research on beneficial viruses, it may be possible to prevent or attenuate many human, plant, and animal diseases. Therefore, these examples illustrate that not all viruses are harmful, and some can be beneficial.

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Novelty Statement

This mini review provides a comprehensive overview of beneficial viruses across various biological domains, a topic that is often overlooked in virology. The article highlights recent findings and provides updated examples that challenge the common misconception that all viruses are harmful.

Author's Contribution

E.M.H. conducted the literature review and initial drafting of the manuscript. W.S.E. supervised the study, revised the manuscript critically for important intellectual content, and finalized the manuscript for submission. Both authors approved the final version.

Conflict of interest

The authors have declared no conflict of interest.

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