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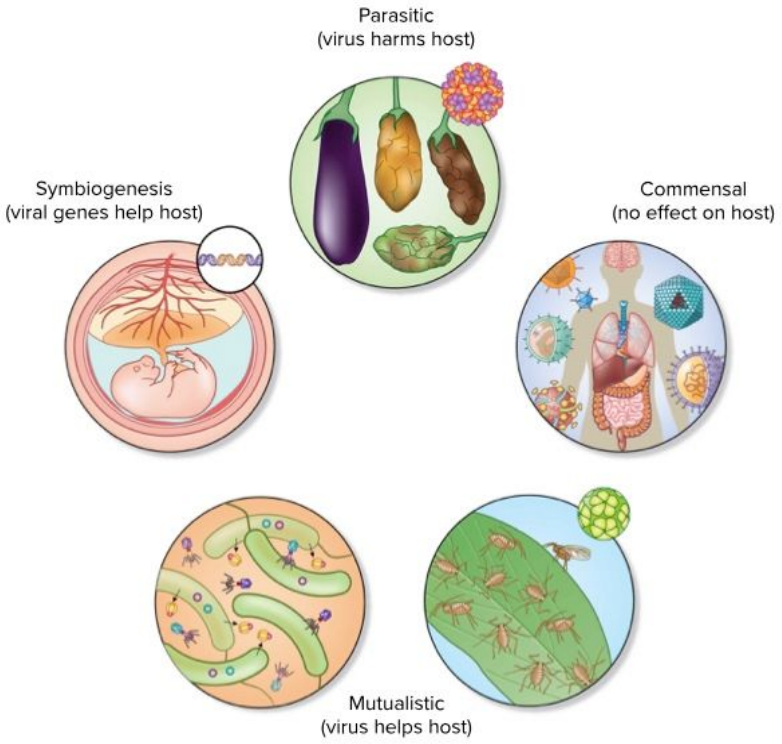
Are Viruses Beneficial, Harmful, or Ineffective?

Viruses are most commonly known to be deadly and infectious, although are they really only harmful? There are three symbiotic relationships viruses can have with their host, including parasitic, commensal, and mutualistic. Parasitic viruses harm their host, just like Ebola, a virus that killed over 11,000 people between 2014 and 2016 (Centres for Disease Control and Prevention, n.d.). Commensal relationships happen when one organism derives food or other benefits from another organism without hurting or helping it, and mutualistic is when both organisms benefit from the relation. The advantageous effects of viruses may range from obligate mutualisms (when the survival of the host depends on the virus) to benefits that only occur under specific environmental conditions (Roossinck, 2011).



(Figure 1)

It is predicted that approximately 320,000 different viruses infect mammals worldwide. Each of these viruses affect species differently, some causing more harsh and evident symptoms and some not showing any symptoms at all. So what is it that causes these viruses to be so distinctive, considering how they infect organisms in the same manner? Like humans, viruses contain genetic material, either DNA or RNA, that makes them unique.

Over the years, scientists have discovered that bacteria, prokaryotes that are known to cause infection, are in fact very beneficial to us as well. Viruses are quite similar to bacteria in this way as they are generally recognized as destructive organisms. However, this has been proven wrong in recent studies. So how have chemists used viruses to benefit society? There are many answers to this, yet a great example is the discovery of phages being capable of killing inimical bacteria leading to an alternate solution to specific infections.

Given the countless number of viruses in the world, do they play a part in our ecosystem that we are not aware of? It is confirmed that they do in fact play a major role in maintaining populations of certain microorganisms, nevertheless provide elements to other creatures, making sea life possible.

What are some other ways viruses benefit their hosts?

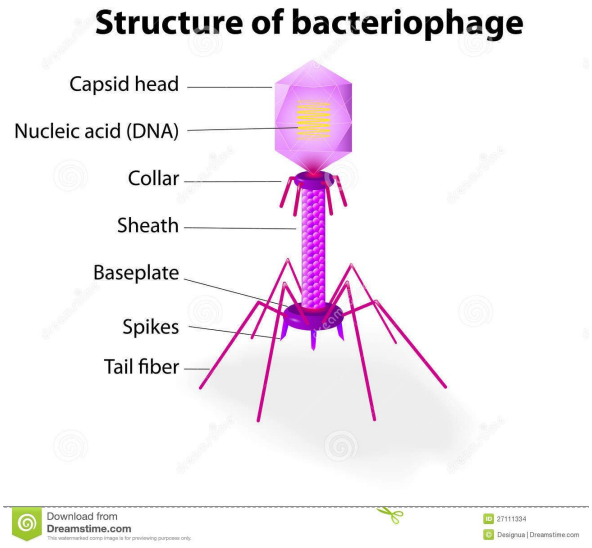
According to Knowable Magazine, any plant viruses confer drought tolerance or cold tolerance to plants (Dance, 2018). Scientists claim to not always know how this works, although have discovered that elevated sugar is very common in virus-infected plants. More sugar allows the plant cells to retain more water, protecting them from drought. This makes the plants cold-resistant since substances with excess sugar tend to freeze more slowly, meaning that these viruses are enhancing the plants' endurance (Dance, 2018).

Viruses can assist animals too, specifically in mice. Herpes viruses confer resistance against bubonic plague. Knowable Magazine says that this occurs because the herpes virus is dormant in the mouse, and turns up the mouse's immune system, making it more capable to fight the plague.

Similarly, the Hepatitis G virus that infects humans may offer some protection against AIDS (Dance, 2018). Hepatitis G is quite common and is not known to cause any disease. Yet, it does affect the immune system in various ways. If somebody is infected with Hepatitis G first, and then HIV, it takes longer for it the HIV to progress to AIDS (Dance, 2018).

Where does viral diversity come from?

According to Cell Press, viruses are classified into more than 60 distinct families, grouped depending on their genome type and gene content. Members of at least 20 of these families infect humans (Sharp, 2002). Of course, viruses also infect plants, bacteria, and other organisms, therefore making them big players in the biosphere. So, what makes all these viruses different, giving them the ability to cause a number of different diseases? According to SparkNotes, human viruses vary depending on their use of RNA or DNA as genetic material (shown in figure 2), the size of their genomes, and their lifestyles including transport routes and infection of various tissues (Viruses, n.d.). These factors mean that viruses evolve in diverse ways and rates. For instance, RNA viruses generally evolve extremely rapidly (Sharp, 2002).



(Figure 2)

Viral infection vs bacterial infection

Most people have encountered instances of being sick where they are not sure if it is a cold or the flu, or if their infection is caused by bacteria or a virus. In some cases, it may be difficult to determine whether an infection is bacterial or viral since they share a few common symptoms. An effective method to determine the type of infection is to order a blood or urine test

to help confirm a diagnosis, or a culture test of tissue is also useful in identifying bacteria or viruses (Health Direct, 2018).

When an unwanted bacterium gets into the body, it quickly begins to divide and spread, causing an infection. This is similar to how viruses reproduce because both must first enter a host, then replicate asexually. Common bacterial infections include strep throat, ear infections and, urinary tract infections, whereas viral infections are HIV/AIDS, smallpox, and Ebola (Swanson, n.d.).

The biggest difference in viral or bacterial infections involves the treatment - most bacterial infections can be cleared up with a doctor-prescribed dose of antibiotics, while a virus does not respond to antibiotics since they have different structures and replicate in a different way than bacteria (Anderson, 2017). Instead, antiviral medication can help ease the symptoms, but it's up to the strength of the body's immune system to fight off the cause of the problem. Other methods such as vaccines are used to only prevent major viruses, by training the body to fight a specific disease, without inducing any symptoms (Pappas, 2010).

How do chemists use viruses to benefit society?

It is more commonly known that some bacteria are beneficial to humans, such as the bacteria found in our gut that help us digest food. According to ScienceMag, scientists have recently discovered the usage of viruses in a positive way - helping us use them to fight against nature (Skwarecki, 2013). In an experiment lead by Jeremy Barr, a microbiologist at San Diego State University in California, scientists attempted to prove that viruses are beneficial by focusing on mucus. This slimy substance is one of humans most important lines of defense against harmful bacteria, and coats places like the inside of the mouth, nose, eyelids, and digestive tract.

Mucus is also home to bacteriophages, which are viruses that infect and kill bacteria. Skwarecki states that, "They can be found wherever bacteria reside, but Barr and his colleagues noticed that there were even more phages in mucus than in mucus-free areas just millimeters

away," (2013, para. 5). The team hypothesized that the bacteriophages were protecting the host, so to carry on their hypothesis they grew human lung tissue in the lab since it is "one of the body surfaces that is protected by mucus" (Skwarecki, 2013, para. 6). The researchers also had a sample of the lung cells that were no longer capable of making mucus. Both samples were left overnight to incubate with bacterium Escherichia coli in them, the results showed that about half the cells in each culture died. Thus, the mucus made no difference to their survival. But when the researchers added a phage that targets E. coli to the cultures, survival rates rose for the mucus-producing cells. Barr states that this disparity shows that phages can kill harmful bacteria, but it's not yet clear whether they help or hurt beneficial bacteria (Skwarecki, 2013).

Viruses and Biotechnology

Lodish, Berk, and Zipursky have stated that, "since bacteriophages are natural predators of bacteria, they are utilized efficiently in modern Biotechnology," (2000). According to the National Centre for Biotechnology Information, they have been proposed as alternatives to antibiotics for many antibiotic-resistant bacterial strains. Bacteriophages are a diverse group of viruses that are easily manipulated, and thus have potential uses in research and therapeutics (Lodish, Berk, and Zipursky, 2000). Therefore, not only are viruses naturally beneficial, but also aid in the research of chemists today.

Do viruses play a part in our ecosystem?

Surprising to most, viruses are important in leading global biogeochemical cycles, meaning that they play critical roles in the cycling of nutrients and carbon in oceans. How do they do this? According to Rohwer, Prangishvili, and Lindell (2009) about half of the world's oceans contain organic matter produced by photosynthesis that supports the production of new heterotrophic microbes. Viruses and protists then kill roughly identical amounts of these. The lysed cells become dissolved organic matter, which may later be used by other heterotrophic bacteria. This results in increases in net respiration, the release of CO2 and nutrient recycling in the oceans (Rohwer, Prangishvili, and Lindell, 2009). This may not sound impressive but is very critical as it keeps organisms like phytoplankton thriving, which happen to be at the bottom of the food chain, making them essential for sea life. Kingdon states that, "photosynthesis by

marine algae and phytoplankton is responsible for over half the oxygen on the planet." (Kingdon, 2017). Hence viruses perform a scale of services that are beneficial to all life.

Viruses help maintain marine biodiversity by stabilizing microbes such as bacteria and algae. Lumen states that microorganisms compose more than 90% of the sea's biomass. It is estimated that viruses kill approximately 20-30% of this biomass each day and that there are 15 times as many viruses in the oceans as there are bacteria and archaea. Thus, viruses play a huge role in the destruction of these harmful microorganisms, which may kill other marine life (Lumen, n.d.).

It is concluded that, although viruses are most often studied as pathogens, many are beneficial to their hosts, some even necessary for life on earth. They can be beneficial to a variety of species including bacteria, insects, plants, fungi, and mammals. Although it cannot be denied that viruses have caused extensive disease and suffering for countless organisms, there are many viruses that are clearly mutualistic. Viruses can range from being essential for the survival of their hosts, to giving their hosts a fighting edge in the competitive world of nature.

This paper discussed where viral diversity comes from, as well as compared viral and bacterial infections. It is critical to know the difference between the two since it determines the method by which the infection will be treated. Researchers have discovered how viruses like bacteriophages are beneficial to humans since they kill the bad bacteria in our bodies. This discovery will conceivably lead to even further ways viruses could be used usefully, such as perchance being an alternative way to approach bacterial infections.

Lastly, this paper examined how viruses contribute to the environment in ways such as cycling carbon in oceans and maintaining certain populations. Hence, viruses account for a very significant part in our ecosystem, and most people are oblivious to this. This leads us to wonder, what will be the next discovery of viruses, and how will it help us?

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