Bacteriophage Therapy

Perhaps the greatest medical crisis that faces humanity is that of antibiotic-resistant bacteria. Such bacteria threaten to eliminate much of the progress made by humans in the past century with regards to health and medicine and return humanity to an era when infections were death sentences. If we do not come up with a new way to kill bacteria, humans, particularly in developing nations, will see a drastic decline in life expectancy. One of the most viable solutions to the problem of antibiotic-resistant bacteria are bacteriophages, or viruses that kill bacteria. Bacteriophages attacking a bacterial cell are shown in Figure A. The science and study of bacteriophages is a rapidly evolving field, and while great strides have been made in it, there is still a great deal of work to be done before bacteriophages can be used as routine treatments. However, once they have been more fully researched and developed, they will help to avert the crisis posed by antibiotic-resistant bacteria.

Antibiotic-resistant bacteria arise by natural selection. Certain bacteria have mutations which lend them greater resistance to antibiotics and thus they survive while their less fortunate fellow bacteria lacking in those mutations are killed by the antibiotics. The bacteria with the mutations then reproduce to fill the space left by the destroyed bacteria, resulting in most of the bacteria being at least somewhat resistant to the antibiotic. Multiple repetitions of the process of selective proliferation of the bacteria with the most resistance eventually leads to a population of bacteria which is mostly resistant to the antibiotic. The mutation can also be transferred between bacteria by the transfer of DNA by viruses which infect bacteria or by the bacteria themselves during a DNA-swapping process called conjugation. This process has already occurred for a great deal of antibiotics, and there are many strains of bacteria that are resistant to multiple antibiotics. In the past, doctors have used less common antibiotics on resistant bacteria. However, there have been several recent cases of resistance to even these antibiotics of last resort due to their overuse in factory farms where large numbers of livestock are raised in relatively small areas. These farms tend to use antibiotics extensively in their livestock, which can create breeding grounds for resistant bacteria.
Given that antibiotics will become less and less useful as tools to fight bacteria, the world has a dire need for a new way to treat bacterial infections in order to prevent a return to a time when death from bacterial infection was commonplace. Bacteriophages are our best option here. They solve several problems related to bacterial resistance. Firstly, while bacteria can evolve to defend against bacteriophages, bacteriophages can also evolve. Thus, they can adapt to counter the bacteria and maintain their ability to kill the bacteria even if the bacteria evolve to resist them. This is a key difference from antibiotics, which cannot evolve to counter the bacteria and thus must be improved by humans or substituted in favor of a new antibiotic to which the bacteria have not developed resistance. Secondly, bacteriophages generally do not have side effects for people. One would think that introducing a virus into a person would have dire consequences. However, the structure of viruses is such that each can only infect certain hosts. Bacteriophages are structured to infect bacteria, not humans or any other animal. Thus, bacteriophages cannot and will not infect a human once introduced. In this respect, they are again superior to antibiotics, which can have harmful side effects on the humans and their microbiomes, communities of beneficial bacteria that live on and in humans. This specificity has a downside though, as it is difficult to find the right phage for a given infection as a given phage generally only infects a few types of bacteria. Bacteriophages also may provide a less expensive alternative to antibiotics as they can be grown and require less chemical infrastructure to produce. Given these characteristics, bacteriophages are not a perfect solution, but are a viable alternative to antibiotics and may give us a constantly evolving weapon that will forever end the danger of bacterial infection.

Bacteriophages must be developed further before they can be used on a large scale against bacteria. That being said, they have already been used in several cases. For example, there was a case in San Diego in which a patient, a 15-year-old girl, had a bacterial infection that was resistant to all types of antibiotics that doctors tried, and who would surely have died had nothing been done. The doctors decided to use bacteriophages as a last resort. The bacteriophages killed the bacteria and cured the patient. Such cases will only become more commonplace as bacterial resistance continues to spread and bacteriophages become more widely used to kill resistant bacteria. Bacteriophages will continue to change the future of the world as they avert the potential apocalypse that could result from antibiotics, which have nearly eliminated death from bacterial infection in developed nations, becoming useless as bacteria evolve to resist them.

A helpful and fun video about bacteriophages and their potential clinical use:

Articles on the use of bacteriophages to cure an infected person: