

The Eternal Arms Race: The Constant Battle between Pathogens and the Immune System

Throughout history, countries have directed resources toward staying ahead of their enemies. Weapons are among the most important of those resources. People debate the ethics and economics of these efforts. However, if a country fails to protect its borders and population, it might cease to exist. The same is true in the battle between pathogens and the immune system.

For a pathogen to survive, it must reproduce, often destroying cells. During that reproduction and the immune system's response, the infection's symptoms arise. However, if the immune system fails to control the pathogen, the person may not survive. Because of these powerful forces of natural selection, the most successful methods for both the pathogen's survival and the immune system's response will be passed on to future generations. Each will continually outsmart the other in an "arms race" — leading to an evolutionary impasse. So how do pathogens try to overcome our immune systems? Pathogens choose different approaches:

- Find new people to infect
 - If a pathogen does not have someone to infect, it cannot survive. This fact explains why high vaccination rates are effective in stemming outbreaks of diseases.
- Change its appearance
 - Pathogens can employ genetic changes to look different. They can change the proteins on their surface, so the immune system has trouble identifying the pathogens. For example, human immunodeficiency virus (HIV) changes so fast that an infected person typically has many types of HIV circulating in his or her body.
- Survive long-term in one person
 - Some pathogens live in our bodies for a long time. They either continue to replicate at low levels without causing outward signs of disease, or they live silently until a time when the immune system is weak. Hepatitis B is an infection in which viral replication is ongoing. Varicella zoster virus first shows up as chicken pox. It then lies dormant after the person gets well. At the right moment, it reawakens, again reproducing, and causing shingles.
- Affect the immune system
 - Some pathogens infect particular immune cell types crippling the immune response. HIV infects helper T cells, which help coordinate the immune system. Other pathogens confuse the immune system. For example, human cytomegalovirus (CMV) makes a protein like one found on healthy cells. The immune system thus ignores cells infected with CMV.

The nature of the adaptive immune system response depends on the type of pathogen and the pathogen's specific methods for survival. If the immune system did not respond to the pathogen's specific approach, we would quickly lose this crucial, eternal arms race.