Parasites inside your body could be protecting you from disease

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Credit: AI-generated image (disclaimer)

It's fair to say parasites are generally bad for their hosts. Many cause disease and death so, like most species, we humans usually try to avoid infection at all costs. But it turns out that some parasites, although potentially harmful in isolation, can in fact help hosts to cope with more deadly infections.

Understanding when parasitism is beneficial has important implications for how we manage infectious diseases, but we currently know very little about this phenomenon. Our new study, published in Evolution Letters, tells us that parasites can readily evolve different mechanisms to defend their hosts from other infections, which suggests that host protection should be common in nature.

The idea that "the enemy of my enemy is my friend" has been around in human society for a long time but it is far from unique to human conflict. The natural world is full of examples where parasites are harmful under some conditions and helpful under others.

Bacteria that live in our gut can occasionally cause problems, but they also prevent colonisation by more harmful microbes such as *Salmonella enterica*, which causes food poisoning. Similarly, bacteria that commonly infect insects are usually costly but can provide protection against more deadly infections. And the larvae of monarch butterflies are more likely to survive infection by a parasitic fly when they are also infected by a protozoan (single-celled organism).

Parasites can also help their hosts in other ways, for example by causing more serious disease in other species. This is one of the main reasons why grey squirrels have rapidly displaced red squirrels from most of the UK. Grey squirrels are carriers of squirrel pox virus, which is usually fatal to red squirrels but is rarely harmful to greys. Likewise, some species of bacteria engage in a form of primitive biological warfare by carrying viruses to which competing bacteria are not immune.

These examples reveal that being infected is not necessarily a bad thing and in fact can sometimes be beneficial. But what they don't tell us is how and when parasites evolve to be useful to their hosts.

Recent lab experiments have shown that mildly harmful bacteria living

inside microscopic worms can evolve in just a few days to protect their hosts from a lethal infection. This striking result indicates that bacteria can rapidly evolve host protection against other infectious diseases.

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Still, very little is known about how and when such evolution occurs in nature. And if a parasite evolves to protect its host from a more deadly infection, has the enemy now become a friend?

From foe to friend

Using mathematical modelling, we explored the evolution of two forms of host protection: resistance and tolerance. Parasites that protect by

conferring resistance to their hosts reduce the likelihood that a second species will be able to infect them, such as when bacteria in the gut prevent colonisation by other microbes. In contrast, parasites that confer tolerance to their hosts reduce the harm caused by another species after it infects them, as appears to be the case with the protozoa that protect monarch butterfly larvae from parasitic flies.

We discovered that both forms of host protection evolve under a wide range of conditions even though the protective parasite may have to divert resources from its own growth or reproduction to defend the host. Protection still evolves because this cost is more than offset by the increased survival of the host (and hence the protective parasite).

But there are some notable differences between the two forms of protection. For instance, resistance usually increases the population size of the host, but tolerance can have a negative effect because it increases the overall prevalence of disease. These differences indicate that the mechanism of protection is crucial for determining whether a protective parasite is truly beneficial.

We can now combine mathematical modelling with lab experiments of evolving microbes to answer intriguing questions about how other species evolve in response to host protection. Does the host evolve to harbour the protective parasite, and is this how we developed a symbiotic relationship with some of our gut bacteria? Can more harmful parasites evolve to overcome host protection? Answering questions like these can help us find new ways to treat infectious diseases.

The results of our research shed light on a fascinating biological phenomenon about which we still know very little. Yet taken together with the growing number of examples of host protection, it is clear – at least if you're hosting a parasite – that the enemy of your enemy can indeed be your friend.