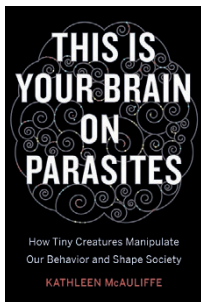


Disgusting parasites?



This is Your Brain
on Parasites

by Kathleen McAuliffe

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In support of the UN's Millennium Development Goals (<http://www.un.org/millenniumgoals/>), we as a global society have taken some major steps towards curbing the scourge of infectious disease. For example, the annual incidence of malaria has dropped, antiretroviral drugs are now available to many for whom they would have been previously prohibitively expensive, and integrated country-wide programmes are being developed for the mass treatment of hundreds of millions of individuals exposed to a range of chronic infections such as trachoma and schistosomiasis. For those of us who work on infectious diseases, the mortality, chronic morbidity and developmental impairment caused by these infections are major driving forces behind our efforts to better understand and address these problems, and are sufficient to justify additional investment in infectious disease research and interventions in endemic areas.

In *This is Your Brain on Parasites* Kathleen McAuliffe asks us to step back from this view of host–pathogen interactions, setting out the argument that our evolutionary relationship with pathogens goes beyond disease and their classical interactions with the immune system. She presents evidence for a ‘behavioural immune system’, one that influences our perceptions of others and our sense of morality, one that may ultimately affect our governance, our law and even geopolitical stability.

McAuliffe begins with weird and wonderful descriptions of pathogens manipulating their hosts: helminths that drive ants to cling onto blades of grass (ready to be eaten by passing sheep) and crickets to jump into ponds and the awaiting mouths of their predators. She then explains that the hairworms that cause the suicidal behaviour in crickets may be the life support of an endangered trout species, and that *Plasmodium*, the parasite that causes malaria, manipulates the feeding patterns of

its mosquito host, aiding the transmission of one of our most deadly infectious diseases.

We, as vertebrates, are not immune to parasite manipulation. One of the most cohesive chapters of the book is on *Toxoplasma gondii*, previously the subject of a widely read article by McAuliffe in *The Atlantic* (<http://go.nature.com/3VQoU5>). Here, she sets out experimental evidence and human study data for manipulation by this widespread infectious agent. For example, dopamine levels are increased in the neurons of infected rats, and localized inflammation around cysts in the brain alter the signalling of a range of neurotransmitters. In humans, *T. gondii* is quoted as causing rash behaviour, with a higher incidence of car crashes amongst those infected than in the general population. There is also epidemiological evidence for increased suicidal thoughts amongst those infected, and an increased prevalence in people with schizophrenia. McAuliffe stresses that these findings do not necessarily infer causality, but are worthy of attention.

If it is not hard to imagine manipulation of our brain by pathogens that reside there, McAuliffe ramps this up to discuss distal manipulation of our reasoning by microorganisms, concentrating on the effects of the gut microbiome. She states that 90% of the information passing between our enteric nervous system and our brain originates from the gut, not vice versa. The balance of our microbiome, she continues, may influence our state of happiness and reactivity to stress. Here, I think she misses a trick, in omitting the evidence for a complex three-way interaction between ourselves, our microbiome and the pathogens that take up residence in our gut. If the evidence that our microbiome influences our mental well-being stacks up, could the hygiene hypothesis be extended to our mental as well as our physical health?

From here, McAuliffe turns towards the behavioural immune system, setting out a series of animal behaviours that protect them from pathogens, before emphasizing parallels displayed by humans. She presents evidence that a strong element of our behavioural immune system is our sense of disgust, describing how we are inherently programmed by this emotion to avoid disease transmission. In humans, this sense of disgust stretches to mistrust and ostracization of those who appear as ‘other’; as unknown, they may carry infections

or bear the scars. McAuliffe presents an evolutionary argument for this behaviour, but also reflects on the potential insidious effects, as disgust may underlie racism or discrimination against the disabled. She, and the academics she interviewed, are emphatic that this evolutionary argument is no excuse for such discrimination, as our reasoning capabilities should allow us to counter these innate reactions. Deeply wired into us, this disgust may though have wide reaching effects. For example, it is argued that our ‘disgust sensitivity’ may alter how we perceive defendants in a court of law, affect how we interpret evidence, or how we decide the degree of retribution a crime deserves. Individuals who score highly on disgust sensitivity are, on a population scale, more conservative in their views, so the influence of this sense of disgust may stretch to our governance.

McAuliffe also discusses the geographical distribution of disgust sensitivity, describing how it is elevated in areas where people are exposed to the highest degrees of parasite stress, hot zones of infectious disease. Furthermore, countries under severe parasite stress tend to score poorly on indexes of freedom and equality. Therefore, the parasite-stress model suggests that infection induces protectionism of your own, which promotes fractures between sectors of society and civil disruption. This implies that if you wish to engender more liberal societies, development strategies should first and foremost promote infectious disease control and eradication.

The book, although slightly disjointed as it moves from direct host manipulation to the parasite-stress model, is always enjoyable to read and the role disgust may play in our societal development is an intriguing subject. Although I doubt many of us will step away from the biological arguments for our research towards defending the societal benefits that may result from controlling infectious diseases, if the highly controversial parasite-stress model is correct, we may yet see additional benefits to society as we slowly progress towards the aims of Millennium Development Goal 6 (Combat HIV/AIDS, malaria and other diseases) and its successor within the Sustainable Development Goals for 2030. □

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