Standing up to infectious disease

Despite major advances in dissecting how pathogens cause disease and the development of treatments to combat infection, infectious diseases remain a major cause of death today. This month's issue includes a special 'Focus on Infectious Disease', which highlights efforts to develop new ways to prevent, detect and treat infections.

Whether attributed to unbalanced energies, exposure to poisonous miasmas, or the consequence of some supernatural punishment, infectious diseases have been humanity's constant companion since time immemorial, decimating populations through epidemics and everyday infections alike. Since the first discovery of 'animalcules' by Antoine van Leeuwenhoek and the subsequent demonstration by Robert Koch and contemporaries that certain microorganisms are the cause of major human diseases, we have made enormous strides in understanding how pathogens cause disease and in developing treatments to prevent and treat infection. Such revolutionary therapeutic approaches include improvements in hygiene, developing vaccines to prevent infection, creating pathogen-specific tests to diagnose disease and designing antimicrobials to then treat patients. As a result, the human burden of infectious disease has been significantly reduced, and we have been able to fully eradicate smallpox and the animal disease rinderpest, with polio set to hopefully follow.

Despite such successes, infectious disease remains a major cause of morbidity and mortality today, accounting for over 8 million deaths in 2016 (https://go.nature.com/2PZ9fDn). And, over the past few decades, we have seen the emergence of new diseases (for example, SARS, MERS), increased spread of known pathogens (for example, Ebola virus, Zika virus), increasing drug resistance that makes our current antimicrobials ineffective (for example, multidrug-resistant tuberculosis), and even the re-emergence of diseases for which we had controlled due to lapses in public health coverage (for example, measles). Combatting infectious diseases thus remains a high priority in the twenty-first century and requires multi-pronged approaches that leverage new ways to track, prevent, diagnose and ultimately treat infection. In this month's issue, we are publishing a special 'Focus on Infectious Diseases' that highlights some of the exciting new avenues being pursued.

A cornerstone of public health is our ability to track the spread of infectious disease, so that we can mitigate risk and prevent further transmission. Over 150 years after John Snow (the oft-cited father of modern epidemiology) used medical records and spatiotemporal surveys to identify a waterborne transmission route for cholera, new technologies are providing us with ever greater resolution to address these epidemiological questions. In our first Review Article, Grubaugh et al. discuss how high-throughput sequencing is helping us tackle the growing problem of zoonotic viral epidemics. Real-time, public availability of such genomic information enables earlier recognition of epidemics, better reconstruction of transmission chains, and provides us with an evolutionary view of disease that helps identify genomic changes associated with increased virulence or resistance in particularly worrisome pathogen lineages.

Notably, many of the diseases discussed in Grubaugh et al. are spread by arthropods, which not only serve as vectors for human transmission but are also biological amplifiers of pathogen numbers. As human-associated activities can be associated with increased vector dissemination, it is imperative that infectious disease control includes approaches to target arthropod vectors. As Shaw and Catteruccia discuss, we are now developing a diverse arsenal of approaches to both reduce vector abundance and also make them less susceptible to pathogen infection. For example, the release of sterilized insects has been used for decades to promote abortive mating and thus decrease disease transmission, as in the case of combatting sleeping sickness. Today, new approaches include using hormone-like compounds to reduce vector fecundity and infection by the endosymbiont *Wolbachia* to prevent successful mating. *Wolbachia*, as well as other members of the insect microbiota, can also be used to enhance vector immunity and make them less susceptible to a suite of pathogens, an effect that can also be recapitulated through direct genome engineering of the vector.

Once disease manifests, it is imperative that patients are quickly treated with effective therapeutics. This requires the ability to identify the pathogen responsible through the use of accurate and affordable diagnostics, especially at the point-of-care. For example, the HIV rapid test has revolutionized our ability to screen entire populations, expedite antiretroviral treatment, and ultimately reduce transmission, while newer technologies such as sequence-based tests have enabled simultaneous TB detection and identification of important resistance mutations. However, developing diagnostics for resource-limited settings remains difficult, and Land et al. give us their perspective on the factors contributing to the success of recent diagnostics, as well as continuing challenges for developing new tests and overcoming logistical and monetary hurdles. The authors also propose new functionalities that may be incorporated into new diagnostics for resource-limited settings, which include greater connectivity with public health institutions and alternative formats compatible with more accessible human clinical samples.

Finally, Libertucci and Young review how our understanding of the mammalian microbiome may be leveraged against infectious disease. Given the recent successes of using faecal microbiota transplantation as a highly efficacious treatment for recurrent *Clostridium difficile* infection, there is great interest in translating microbiome knowledge into therapeutics, which may take the form of living probiotic strains that encode functionalities to prevent infection, prebiotic compounds that help alter microbiome community function to promote pathogen clearance, or a combination of the two (synbiotics). However, much work remains to clarify the mechanisms by which microbiota affect the host, and bridging this gap will be increasingly important as we attempt to utilize microbiome products to combat infectious disease.

Of course, there are a myriad of other exciting areas being investigated to help fight infectious diseases that are not covered in the Focus, including vaccine and anti-infective drug development and efforts to overcome antibiotic resistance. Simultaneous advances in all of these areas will be needed, and we at *Nature Microbiology* look forward to publishing these new exciting developments in the coming years. ❐

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