Integrating Biodiversity Infrastructure into Pathogen Discovery and Mitigation of Emerging Infectious Diseases

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The global human suffering, economic damage, and social disruption we are currently experiencing from the COVID-19 pandemic stem from inadequate preparedness and ineffective response to emerging pathogens. At its core, the COVID-19 pandemic is a consequence of our fundamental ignorance of our planet's natural ecosystems and the effects of our encroachment on them. Our reactive approaches to the emergence of zoonotic pathogens, which are responsible for approximately 75% of all new emerging infectious disease outbreaks, are too often based on limited knowledge of the origin, pathogenicity, and basic biology of the wild host and pathogen coupled with poor communication among relevant stakeholders. Others have pointed to this ignorance of viral diversity and offered solutions (Andersen et al. 2020), but a broad, fully integrative discussion of how to leverage existing infrastructure and to build new resources has been missing. In the present article, we call for the development of alternative tactics that are aimed at proactively meeting the daunting challenges to humanity posed by emerging zoonotic pathogens.

The potential role of natural history specimens in pathogen discovery and mitigation is recognized in the museum world (DiEuliis et al. 2016, Dunnum et al. 2017) and by at least some disease ecologists (e.g., Mills and Childs 1998). However, relatively few in the One Health community (e.g., Kelly et al. 2020) embrace the value of leveraging existing biodiversity infrastructure (i.e., natural history collections, biorepositories, and their associated expertise and informatics resources) to more fully understand zoonotic pathogen emergence and reemergence. This concept is not new; in the early 1900s, the American Museum of Natural History created the Department of Public Health (Brown 2014). Although a lack of funding put an early end to the initiative, the Department of Public Health made extensive progress, from clever exhibitions for the public to assembling a living collection of bacterial cultures (Brown 2014). Renewed efforts to align pathobiology with biodiversity discovery initiatives are critical. Moreover, linking both biodiversity infrastructure and building capacity closer to zoonotic pathogen surveys in biodiverse countries would substantially improve proactive responses to pandemics before they once again wreak havoc across the globe.

Biodiversity science as a tool in biomedical research and response

Earth's biodiversity is connected through a single evolutionary tree of life, and pathogens (whether viruses, bacteria, or eukaryotes) and their hosts represent millions of years of evolutionary interactions. Medical researchers have long used this knowledge to advance our understanding of how certain microbes cause disease in humans. For example, because fundamental aspects of malaria parasitism are extremely difficult to study in humans, New World monkeys—particularly, owl monkeys in the genus *Aotus*—have been important models for studying strains of malaria to develop vaccines, some of which are now in clinical trials. Taxonomic research based on museum specimens (Hershkovitz 1983) demonstrated that geographically separated species of owl monkeys have varying tolerance to the parasite and that the failure to recognize these taxonomic differences can hamper research. We have only begun to understand how widespread and diverse coronaviruses are in nature, and important gaps in regional and phylogenetic coverage persist (Anthony et al. 2017). Understanding their functional interactions with host cells and developing the most effective strategies to combat pathogenic coronaviruses will require documenting genetic relationships of the virus and among the wild hosts (Andersen et al. 2020). Archiving these associations in accessible and curated specimen databases is crucial now and into the future (e.g., www.globalbioticinteractions.org). Building on a solid foundation of knowledge of evolutionary and ecological relationships of hosts and pathogens enables scientists to possibly predict the emergence of future zoonotic diseases and to respond to novel outbreaks more rapidly and efficiently (Brooks et al. 2019).

The need to strengthen biodiversity infrastructure and increase discovery

The detection and description of novel pathogens usually requires large numbers of host samples because of low