My Word

Why should biomedical scientists care about biodiversity?

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Biodiversity is now being lost at a rate unprecedented in human history and this loss, rather than slowing, is most likely accelerating [1]. Biomedical scientists are aware of biodiversity loss, but so far have failed to mobilise the full potential of their research skills and scientific influence to address the issue. This view is poignantly exposed by an eminent biomedical scientist who asked one of us at a party '*we all know that species are in trouble, but why does this matter?*'

There may be two reasons why some biomedical scientists might think this is a perfectly valid question. Firstly, biomedical scientists predominantly work with model organisms; species that are well suited to address a particular molecular, cellular, developmental or genetic issue, or that can be used to understand fundamental physiological or health-threatening processes that occur in humans and domesticated animals. Understandably, if someone has a constant supply of *Caenorhabditis elegans*, *Drosophila melanogaster* and *Mus musculus*, then the loss of Yangtze River dolphin *Lipotes vexillifer*, the golden toad *Incilius periglenes* in Costa Rica, or the *Partula* snails in French Polynesia does not seem to be of immediate concern.

Secondly, by working with model organisms in the lab, the research of many biomedical scientists is detached from nature. Few biomedical scientists investigate the organisms in their natural habitats, and this is important because working with a species in nature often makes transparent how badly an organism's habitat or the organism's population is deteriorating. Without these first-hand experiences from wild populations, lab-based scientists are easily lured into the 'business as usual' attitude.

The ecological tradition is different: ecologists emphasise the diversity of their organisms, and many ecologists would argue that their organism is 'unique' since it exhibits adaptations to its environment. This uniqueness is encapsulated in the Linnaean binomial nomenclature: this label, by definition, establishes that a group of organisms is distinct enough from their relatives. Sticking the correct label on an organism can be important, for instance the discovery that the medicinal leech is not *Hirudo medicinalis*, rather *H. verbena*[2], may lead to new research in natural populations of *H. medicinalis* for compounds that are more effective anticoagulant, painkiller and anti-inflammatory drugs than the existing ones.

But conservation biologists are also to blame for failing to embrace biomedical research. Conservation biology focuses on ecological processes, and rarely brings in tools, approaches and results from the vast biomedical literature. This perspective is now beginning to change, with recent reviews emphasising the biodiversity resources that benefitted biomedical science, and the significance of healthy ecosystems in hampering spread of pathogens and infectious diseases [3-4] and also recently demonstrated by the re-naming of the former Wildlife Trust in the United States as the EcoHealth Alliance. Biodiversity can have immense impact on health, social life and finances of humans, and when research agencies need to justify their spending as being relevant to human well-being, the biomedical use of plants, microbes and animals is one of the underutilised justifications.

Only a fraction of the Earth's species has been named, let alone studied in detail. The majority of the undescribed organisms comprise the bacteria, Achaea, microeukaryotes (fungi, nematodes, algae and others) and arthropods, many of which could be of great practical importance for humans. At the present rate of discovery and description, however, many species will vanish before they are discovered. Therefore biomedical scientists have an immense task of joining systematists, evolutionary biologists and ecologists discovering the processes underpinning the tree of life.

There are many reasons why humans should care about biodiversity and its loss: species and their genes, communities and ecosystems provide vital support for humans (direct and indirect economic values), and they have immense intrinsic ethical and spiritual value [5]. Beyond these general justifications, we see seven fundamental reasons why the biomedical scientist community should be more involved in biodiversity conservation.

Resources to study the mechanistic bases of evolutionary diversity. How much of evolutionary diversity can be explained using the candidate gene approach based on biomedical model systems? With fewer species remaining on the planet, we will have less understanding. Of course, it can be argued that we do not need to understand everything; we just need to study sufficient examples to understand the principles. Nevertheless, with the prediction that many species may go extinct before they have even been described, there is an immense risk of losing key, informative examples.

Resources to understand the emergence of new human pathogens. The importance of anthropologically-altered ecologies in the emergence of new human pathogens is just beginning to be recognised [4]. For example, the transmission of

HIV-1 and Ebola viruses to humans, and thus the origin of AIDS and Ebola haemorrhagic fever, has been linked to the hunting of apes and bats as bushmeat [6]. Here epidemiology provides a strong warning of the risks of the uncontrolled and short-sighted exploitation of the natural world.

Resources for bioprospecting. Species that have never been named let alone investigated provide vast resources within which to search for drugs, protective agents for food crops and domesticated animals. Bioprospecting is flourishing, and by cutting branches off the tree of life, we may miss fundamentally new solutions to human-focused problems. For instance, the denning behaviour of certain bear species and the associated physiological processes suggest this unlikely group as being a treasure-trove for finding cures for osteoporosis, renal diseases and diabetes[3]. Fasting polar bears *Ursus maritimus* are six times more obese than any human, yet they show none of the symptoms of cardiac diseases. By working out the mechanisms by which polar bears escape cardiovascular disease, medical science may benefit millions of obese people. Uncharted species therefore can provide new physiological pathways and new drugs, although these treasure-troves are rapidly shrinking: for instance eight bear species, including the polar bear, are red-listed.

The importance of prospecting new species for drugs cannot be overemphasised; for example, the majority (116 out of 158) of new small-molecule drugs that were licensed in the US during the period 1998-2002 can be traced back to natural origins [3]. Our current understanding extends to only a tiny range of the diverse life-styles found in nature. In particular, extreme environments such as high pressure and cold and hot temperatures demand special adaptations, and yet we are only beginning to name and explore physiologically the species that exists under these environments (e.g. in hydrothermal vents [7]).

Resources for identifying new tools for biomedical science. Biomedical science has been enormously enriched for tools by drug discovery programmes, including cyclopamine, tetracycline, and taxol. Indeed, many drug leads that have to be abandoned at late stages because of toxicity issues nevertheless remain useful as tools for dissecting genetic and physiological mechanisms. Countless further tools doubtless await discovery, if we preserve biodiversity long enough to screen for them.

Identification of novel approaches to medicine. Exploration of biodiversity can open up new biomedical possibilities. For example, study of mice *M. musculus* and human medicine would have resulted in dismissal of the possibility of regenerative medicine for many purposes, such as limb replacement, or spinal cord injuries. However, study of other species, especially amphibians and fish, has identified substantial powers of natural regeneration that give hope that regeneration might be coaxed out of mammalian tissues [8]. Other prospective treatments might be revealed by study of non-model organisms.

Opportunities for collaborative research between ecologists and biomedical scientists. Understanding the processes by which alien species infect and infest natural systems, or microbes like the chytrid fungus *Batrachochytrium dendrobatidis* spread and kill vast numbers of amphibians, need tools and approaches only biomedical scientists can provide. Epidemiologists, mycologists and other biomedical scientists should join conservation biologists to combat the fungus. As well as opportunity for a new research area, urgent efforts in this direction have a further importance for biomedical scientists: since amphibians harbour potential medicines and bioactive peptides and are frequently used in studies of embryonic development, the likely loss of tens of hundreds of amphibian species in the near future may hurt advances in biomedical science [3, 9].

Sources of new research opportunities. All the biomedical model organisms used so successfully today were carefully selected for their suitability for studying a specific problem. For example, both zebrafish *Danio rerio* and the nematode worm *C. elegans* were chosen initially as having a suite of characters making them ideal for understanding the development and function of the nervous system. This selection resulted from comparative studies examining diverse candidate organisms for their key traits, selected against a list of desirable features. The selection of model organisms used in current biomedical research is understandably biased towards organisms that will do well in a lab environment – hardy, fast breeding, fecund; they may well therefore not be the most appropriate models to identify candidate genes and physiological processes to model certain human diseases.

Some key biological topics are not served well by the current model species, for instance sociality, vocal learning and pair-bonding. To study these, new organisms will need to be identified and explored. For instance, many birds have complex repertoires of up to several 1000 songs, and among songbirds (Oscines) the songs are learnt from conspecifics [10]. Songbirds are therefore great model systems to work out *how* and *when* complex vocalisations are learnt, and identify the neural substrate that facilitates vocal learning. Similarly, small rodents, Microtine voles, proved to be great systems to reveal the neurogenetics of pair bonding and mate preference [10]. A thorough understanding of the earth's biomes, and their conservation in a healthy state, will be necessary if we are to identify organisms best suited to these questions.

In conclusion, we urge biomedical scientists to engage more in biodiversity conservation — for the sake of our scientific discipline and for the benefit of society. Biomedical scientists can make crucial contributions to combating the loss of diversity and improving the health of our planet. Conversely, biodiversity offers untapped resources for biomedical science. With support from the full community of biological scientists, conservation initiatives will be enriched and the benefits our species draws from protected biodiversity will be so much greater. Given the massive environmental problems humankind faces in the 21st century, there is an urgent need for joint initiatives by biomedical scientists and conservation biologists.

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