The Biodiversity Crisis

The health and wellbeing of humans and other organisms are intimately dependent upon biodiversity – the variety of plants, animals and microbes on the planet. The biodiversity crisis threatens this relationship.

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Storyline

Human health and wellbeing are intimately dependent upon biodiversity. Biodiversity is the variety of plant, animal, and microbiological life in the world or in a particular habitat. Biodiversity underpins functional, resilient ecosystems, sustainable development, as well as food and water security; and the links between biodiversity and human health manifest at various scales across space and time. However, we're losing biodiversity across the planet at alarming rates, which threatens ecosystems and human health. Microbes are an important facet of biodiversity (see fig. below), albeit invisible. They can be considered as the foundations of our ecosystems and play essential roles in maintaining the health of humans, and that of all other organisms. We need to conserve and restore biodiversity (including the microbes) as well as restore our emotional and cognitive connection to nature if we are to overcome the biodiversity crisis and ensure human societies are healthy and resilient in the future.

The Biodiversity Crisis

1. ***Why is biodiversity important?*** Consider the examples of 5,000 spectators in a football stadium, Saturday shoppers in a large shopping mall, holiday makers on a popular beach. We all look more or less the same. Remove 50 of us: it will not be noticed and it should not influence the outcome of the match, the sales in the shops, or the fun on the beach. However, if these 50 represent all the electricians, or the doctors, or the farmers in our society, their removal will paralyse our lives - electrical faults do not get repaired, we cannot get treatment for sickness, no-one produces food anymore, and our society slowly collapses. The reason is because of division of labour - each of us does not do everything needed to maintain a healthy society - we are all more or less specialised to do particular tasks. This is our functional diversity. And because of this, we are all interconnected: the farmer is connected to food manufacturers, who in turn are connected to transport networks, who are connected to shops, who are connected to us. Removal of one of the links in the connectedness network destroys the network and nothing works anymore. It is the same with the rest of the biosphere. Lots of insects look the same, and certainly microbes do, if we look at them through a microscope. But they also carry out different, specific and important, sometimes crucial, tasks. Although we may not perceive the functional role of a particular insect we find ugly (and perhaps are tempted to stamp on), it is very likely that it plays a significant task in biological networks, and hence is important to us. Its loss - in a particular web, or even its extinction globally - is something of great concern. This is why efforts to maintain biodiversity and conservation efforts to prevent species losses are so important to the biosphere, and thus to us.

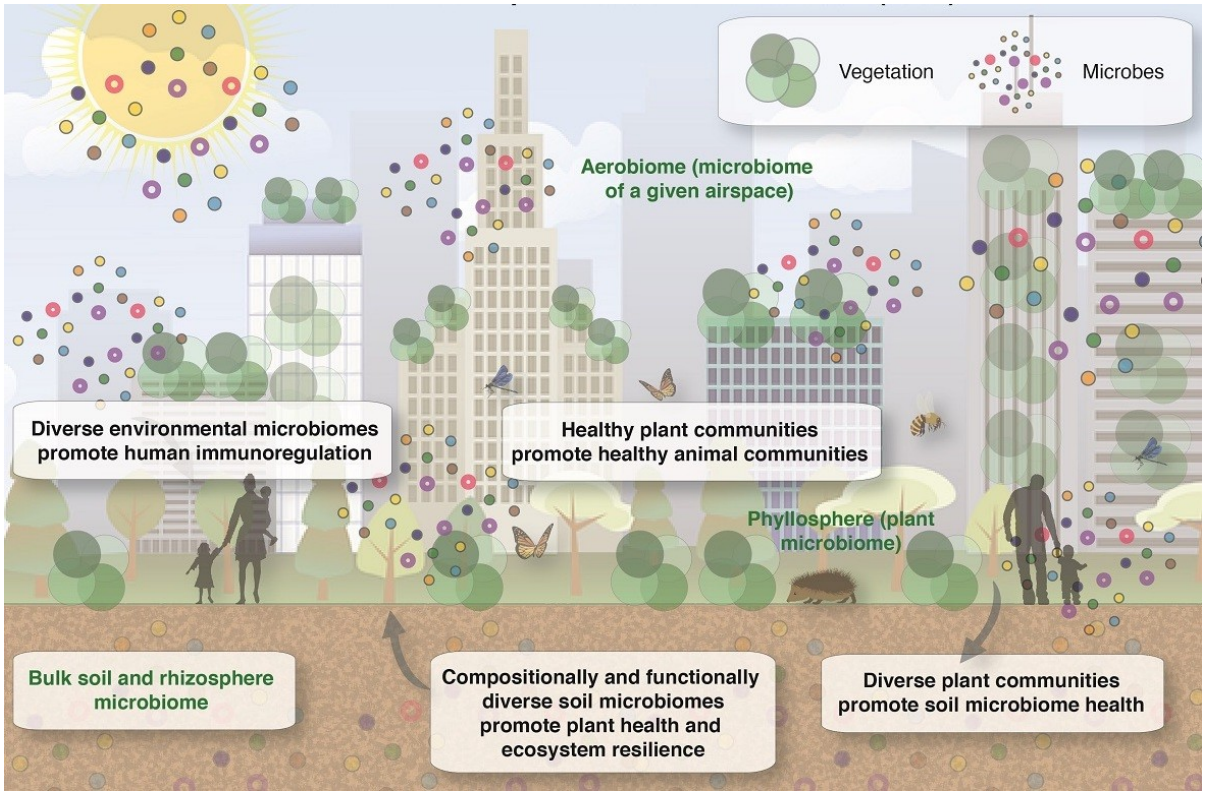
2. ***So, what is the biodiversity crisis?*** The loss of biodiversity is now recognised to be a global megatrend, with current species extinction rates estimated to be 1,000 times higher than natural background rates, and future rates are likely to increase to 10,000 times higher. This is driven, in part, by human activities and trends such as urbanisation, population growth, and associated processes including unsustainable resource exploitation (and habitat destruction), pollution and climate change. Indeed, without immediate and large-scale interventions, it is projected that by 2050, 95% of Earth's land will be affected by degradation. This is at the core of the biodiversity crisis.

There is also a more socially-oriented biodiversity crisis occurring. Many humans are spending less time engaging with nature, and our knowledge of and appreciation for nature is weakening. This uncoupling of humanity from nature reduces our desire and drive to protect biodiversity, which in turn, contributes to the broader biodiversity crisis.

3. ***Why is the biodiversity crisis an issue?*** Aside from threatening the intrinsic value of biodiversity and ecosystems, which is arguably of paramount importance, the crisis also threatens the health and survival of human societies. Biodiversity underpins 'ecosystem services'. Ecosystem services are the variety of benefits to humans provided by ecosystems. Humans depend on these services which include processes like climate regulation, nutrient cycling, resource provision, and recreational and cultural services. Microbes play a central role in many of these ecosystem services, and the biodiversity crisis also threatens microbes, our exposure to them, and their ability to sustain health and wellbeing of humans and other organisms. For example, we do not enjoy snorkelling on holiday if the water is cloudy and there are no fish to discover. Microbes degrade waste products that make water cloudy – they are the great planetary purifiers - and are at the base of the food web that feeds fish and allows them to multiply; they are providing important ecosystem services! On the other hand, the processes that contribute to biodiversity loss -- such as habitat destruction -- may be increasing our exposure to emerging infectious pathogens such as novel coronaviruses. *In a human-centred sense, we are living in good times for bad microbes, and bad times for good microbes.*

4. How does microbial biodiversity benefit humans? Microbes play essential roles in carbon and nutrient cycling, climate regulation, animal and plant health, and global food

security, which we depend upon for survival. They can be viewed as the foundations of our ecosystems. Consequently, ongoing threats to communities of microbes likely poses an important threat to global biodiversity and to human societies across the planet. It is also now recognized that exposure to environmental microbiomes — the diverse network of microbes in a given environment — plays an important role in human health. Indeed, from a young age, exposure to a diverse range of environmental microbes is considered to be essential for the establishment of the human microbiome and the training and regulation of our immune system. Colonization of a stable and functional human microbiome begins following birth. Firstly, by transfer to the baby of microbes from the mother's vagina, skin and in breast milk, and later supplemented from visitors, pets, biodiverse environments, and a "normal clean" (not overly cleaned) home environment.



Microbes play essential roles in plant health, as well as human and non-human animal health.

5. ***What might happen if the biodiversity crisis continues?*** If the biodiversity crisis continues to worsen, then humans could face increasingly severe immune diseases (via lack of appropriate exposures to diverse microbes) and our ecosystems will continue to suffer. We may also have to endure more severe and frequent emerging infectious disease outbreaks. The social biodiversity crisis (lack of engagement with nature) will continue to reduce our connectedness to nature. Nature connectedness is a person's cognitive, experiential and emotional connection with the natural world. It is strongly linked to pro-ecological behaviours as well as mental and physical wellbeing. Therefore, avoiding natural environments may be detrimental to our health, and may inhibit environmental stewardship, which continues to drive the biodiversity crisis.

6. ***What can we do to address the biodiversity crisis?*** Perhaps the most important thing we can do to address the biodiversity crisis is to learn to appreciate the biodiversity –– both the

visible and the invisible –– that surrounds us. As mentioned, biodiversity is essential to humans and other organisms, and microbial biodiversity is the foundation of our ecosystems.

To enhance our appreciation of biodiversity, we can aim to spend more time engaging with the natural world. This means regularly visiting the green and blue spaces around us –– the woodlands, parks, lakes –– which has been shown to enhance our 'nature connectedness'. Studies show that enhancing our nature connectedness can also enhance our mental wellbeing and foster pro-ecological behaviours. A recent study shows that engaging with nature more often may also improve our attitudes towards microbes.

Engaging with the natural world also means learning about its biotic members (plants, animals, microbes) and their relationships and interactions. The natural world is fascinating and can inspire long-term reciprocity if we are willing to learn and engage. Biodiversity underpins the ecosystem services we depend upon for survival, and microbes play a pivotal role in these.

With a greater appreciation of biodiversity, we can become better stewards of those parts of the biosphere we personally influence, and more effectively exercise our stakeholder rights to help steer and scrutinise the development and implementation of relevant local, regional and international policies and regulations, and hold the policy makers and implementing agencies to account.

Relevance for Sustainable Development Goals and Grand Challenges

Because biodiversity underpins our ecosystems and sustainable development, the biodiversity crisis could potentially impact all of the SDGs:

- **Goal 1. No poverty.** The biodiversity crisis could be detrimental to the status of global poverty by reducing quality and access to essential resources. Biodiversity underpins our health and economy.
- **Goal 2. Zero hunger.** Biodiversity provides food and water for billions of people. Any risk to this is a risk to the 'zero hunger' sustainable development goal.
- **Goal 3. Good health and wellbeing.** The biodiversity crisis could be detrimental to health and wellbeing by reducing our exposure to health-promoting aspects of nature such as immune system-regulating microbes. Biodiversity also provides many ecosystem services, which are the precursor to favourable health.
- **Goal 4. Quality education.** Biodiversity provides the resources required in educational settings. Quality education must also include learning about the natural world. Any crisis that threatens this, threatens education.
- **Goal 5. Gender equality.** Biodiversity loss is disproportionately felt by poorer communities, but there are also disparities along gender lines. Biodiversity loss affects gender equality and education e.g. by increasing the time spent by women and children in performing certain tasks, such as collecting valuable resources.
- **Goal 6. Clean water and sanitation.** Protecting biodiversity is essential to ensure clean water and sanitation is accessible for all.
- **Goal 7. Affordable and clean energy.** Humans acquire their energy from biodiversity and use biodiversity to acquire it. Threats to biodiversity are therefore threats to clean and fairly distributed energy.
- **Goal 8. Decent work and economic growth.** Biodiversity underpins our economy, through resource extraction, trade and use. The biodiversity crisis is a major threat to sustainable economies.

- **Goal 9. Industry, innovation and infrastructure.** Without biodiversity there would be no industry or infrastructure.
- **Goal 10. Reduced inequalities.** Biodiversity loss is disproportionately felt by poorer communities. Therefore, biodiversity must be protected, and resources fairly distributed, if inequalities are to be reduced.
- **Goal 11. Sustainable cities and communities.** To achieve sustainable communities, we need to protect natural environments. If we avoid natural environments and do not learn about and from them, our environmental stewardship is reduced, and this could have important implications for sustainability.
- **Goal 12. Responsible consumption and production.** Irresponsible consumption of biodiversity directly contributes to the biodiversity crisis and therefore works against this sustainable development goal.
- **Goals 13. Climate action.** Protecting biodiversity is essential if we are to take meaningful and long-term action to help mitigate the effects of climate change.
- **Goal 14. Life below water.** Life is biodiversity, and biodiversity is life. Our waters are an important reservoir of biodiversity and require protection and appreciation.
- **Goal 15. Life on land.** As above, we need to promote a deeper appreciation for nature (on land and below water) in order to address the biodiversity crisis.
- **Goal 16. Peace, justice, and strong institutions.** As with our economies and industries, biodiversity is foundational to our ability to establish strong institutions, and justice must include addressing ecological (in)justice and access to safe, biodiverse environments for all.
- **Goal 17. Partnerships for the goals.** Partnerships must include those between people, and those between people and nature. Reciprocity is key to a sustainable future.

Potential Implications for Decisions

1. Individual

a. Should I avoid spending time in nature, or can I spend more time exploring different natural environments, and more regularly?
b. Should I participate in activities that help to protect biodiversity for myself, my family, friends, and future generations?
c. Should I learn about the different roles microbes (invisible biodiversity) play in making sure the human body is healthy?
d. Should I learn about the different roles microbes play in sustaining functional ecosystems, and all other life on Earth?

2. Community policies

a. Local education and campaigns about the importance of biodiversity including microbes and their roles in human health and ecosystem functionality.
b. Campaigns aimed at increasing people's time spent engaging with nature and all of its biodiversity, and exposure to diverse microbial communities.
c. Campaigns aimed at providing an ecological education and helping nature thrive in the local community.

3. National policies

a. National education and campaigns about the importance of biodiversity including microbes and their roles in human health and ecosystem functionality.

b. Declaring microbial literacy and access to safe biodiverse environments a national priority
c. Taxes and other incentives/disincentives to protect biodiversity
d. Consider a National Service for Nature scheme – requiring everyone to spend several weeks/months on restoration and conservation initiatives.

Pupil Participation

1. ***Class discussion of the issues associated with the biodiversity crisis***, and the importance of spending time in and engaging with nature
    a. Approximately how much time and how often do you spend in natural environments (such as parks, woodlands, lakes etc.)?
    b. The next time you visit a natural environment, note down three ways in which you think microbes contribute to the environment, and bring these to the next session.
    c. The next time you visit a natural environment, note down three good things you see in nature and bring these to the next session.

2. ***Pupil reflection on microbes and their engagement with natural environments***
    a. What is your opinion about microbes?
    b. Do you think some microbes are beneficial to humans and if so, in what ways?
    c. Do you think some microbes are beneficial to ecosystems and other animals/plants, and if so, in what ways?

The Evidence Base, Further Reading and Teaching Aids

Useful resources/groups

- Biodiversity-focused Teaching Resources:
- https://www.countrysideclassroom.org.uk/resources/781
- UN Decade on Ecosystem Restoration: https://www.decadeonrestoration.org/
- The Healthy Urban Microbiome Initiative (HUMI): https://www.humicity.org/about
- Microbes and Social Equity Working Group: https://sueishaqlab.org/microbes-and-social-equity-working-group/
- Professor Graham Rook and the Old Friends Hypothesis: http://www.grahamrook.net/
- Conversation Article: 'Biodiversity Loss Could be Making Us Sick: Here's Why' https://theconversation.com/biodiversity-loss-could-be-making-us-sick-heres-why-143627
- The Schoolrun.com Microorganisms: https://www.theschoolrun.com/homework-help/micro-organisms
- Society for Ecological Restoration: https://www.ser.org/

Videos:

- FEMS Microbiology Ecology Webinar on Ecology of Soil Microorganisms: https://www.youtube.com/watch?v=nvRiEPi3SC0
- Prof. John Cryan TEDMED: Food for thought: how gut microbes change your mind: https://www.youtube.com/watch?v=vKxomLM7SVc

- Dr Tim Spector: What role does our microbiome play in a healthy diet? https://www.youtube.com/watch?v=-LUuqxQSaFQ

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Glossary

Biodiversity: the variety of plant, animal, and microbial life in the world or in a particular habitat

Biodiversity crisis: human-caused biodiversity loss via activities such as habitat destruction, pollution, resource exploitation, and associated climate change.

Blue spaces: natural or semi-natural environments that comprise aquatic (water-based) habitats such as ponds, lakes, rivers, the sea, etc.

Green spaces: natural or semi-natural environments that comprise terrestrial (land-based) habitats such as woodlands, grasslands, shrubs, etc.

Ecosystem: a biological community of interacting organisms and their physical environment
Ecosystem restoration: The science and practice of restoring degraded ecosystems
Microbe: a microscopic organism, which could be bacteria, algae, archaea, fungi, protozoa
Microbiome: the collection of microorganisms in a given environment and their theatre of activity
Nature connectedness: a person's emotional, cognitive and experiential connection with the natural world
Pathogen: any disease-causing organism, for example certain viruses, bacteria, protozoa, fungi, algae, worms, etc.