A Living Planet
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Earth is a living planet. But how much life is there, and what is it doing? We will discuss the distribution of biomass on Earth, and compare the effects of microbes, wild animals, domesticated animals. The aim of this lecture is to provide concrete examples of how life is woven in with the rest of the planetary engine, expanding the importance of biodiversity from sentiment alone to a matter of survival for both whole ecosystems and our own civilisation

What, where, when?

The diversity of life on Earth is stunning, ranging from microbes that can survive hellish conditions near deep sea vents to fragile hummingbirds and huge predators like orcas and polar bears. There are strong moral arguments for caring about all this diversity for its own sake, and for appreciating and preserving every species possible in its natural habitat. But our focus in this lecture is to zoom out from individual animals or species to see the big picture, and to consider how all those organisms interact with their surroundings, and how they are woven into Earth as a planetary system.

We now have global surveys of how much life there is, and what types there are. The perhaps surprising conclusion for most humans is that this is not a planet of animals, but a planet where the biomass is dominated by plants, bacteria and archaea (a class of single-celled ancient organisms that is separate from bacteria). Even within the tiny fraction of that biomass that is made up by animals, the most significant fraction are insects. But a more telling insight is found in the bottom right of the famous figures by Bar-On *et al* in their 2018 paper. The total mass of humans on Earth is bigger than the total mass of all wild mammals by a factor of 10, and the mass of our domestic livestock (cows, pigs, sheep etc) is greater even than the humans. This is where human civilisation has come to dominate life on Earth: at the largest sizes.

We live in a microbial world, and the example of vitamin B12 shows just how deep that biochemical dependence goes. We could not exist without the microbes, and they are working in the background to do a huge number of biochemical jobs that multi-cellular organisms are not capable of. But the bigger animals still have a huge influence in shaping our world. All animals have two fundamental tasks: to extract enough energy from their surroundings and to harvest the atoms they need to carry on the functions of life. Each one is locally focussed on those tasks. But the outcome at a global scale is a world that is a complicated web of interdependencies. No organism can exist by itself, and all organisms influence many others.

What is it all doing?

There isn't enough time in this lecture to do a comprehensive survey of the whole web of interactions, so we will focus on a handful of examples of the types of actions that have an impact.

Parrotfish are a distinctive family of tropical fish that have a large "beak" – very hard fused teeth that are made from the stiffest material known in the animal kingdom. They feed by rasping away algae and coral, and their second set of teeth grinds up the hard coral to produce sand. This produces an estimated 85% of the white sand beaches in the Maldives (for example), with similar proportions on other tropical islands.

The compound responsible for “the smell of the sea”, is called dimethylsulphide or DMS. There are a few different chemical responsible for that smell, but they are almost all derived from DMS. Many ocean phytoplankton produce DMS when they are stressed, and the small proportion of this natural chemical that gets into the atmosphere forms sulphur aerosols. These dominate marine cloud production, so phytoplankton have a large indirect effect on our climate.

The Pacific ocean has very little fixed nitrogen, an essential nutrient. One significant source for remote islands like Hawaii is the arrival of migrating whales from thousands of miles away. They feed in nutrient-rich waters to the north, and come to Hawaii to give birth and rest. Their urea delivers a very significant dose of fixed nitrogen to these waters, far more than is provided by physical processes like upwelling.

What is changing?

We have all heard that there is a biodiversity crisis, but how do we measure it and what are the impacts? The famous IUCN “Red List” is very useful for tracking potential extinctions, but it does not provide a real measure of the health of species or ecosystems. There are some proposals to change this, by adding a “green status” list, but progress is limited to date. We end by briefly considering the impact of humans on our planet, using the same measures as for the other animals. Overall, the living part of our planetary life support system is facing a very uncertain future, because of human actions, but we will not be able to address this crisis unless we see life on Earth as a completely interconnected life support system, rather than a collection of individual species that we deal with individually.

References and Further Reading

What, how much and where?

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