**Symbiotic Science through a Shared Language**

Many scientific concepts are applicable to multiple disciplines and across spatial scales, from the microscopic to the global. As such, scientists from different disciplines must communicate effectively – through a shared scientific language – for effective collaboration and scientific advancement. With this aim, Dr Laura Tipton of Chaminade University and her colleagues from the University of Hawai’i investigate the history of ecological terminology, in order to work towards building a common lexicon that bridges ecology and microbiome science.

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What we can see is only a tiny fraction of the life that exists all around us. From the soil below our feet, to the most extreme environments on Earth, and even covering our own bodies, microscopic organisms live out their lives. These microbes, which include bacteria, archaea [ar-kay-ah], viruses, fungi and other tiny organisms, can have a seemingly disproportionate impact on their environment. For example, the microbes inside our intestines play key roles in digestion. Without them, we are unable to properly process our food.

Studying microbes is therefore a rich and fruitful scientific discipline that can help us to better understand the world around us, and even solve some of society’s biggest challenges. Microbes have already provided us with medicines, gene therapy, and methods of breaking down waste products.

Theoretical frameworks from other scientific disciplines – including computer science, molecular biology, statistics, medicine, and ecology – can be applied to microbes and their communities. Ecological theory can be particularly valuable, as it offers methods of studying organisms interacting with each other and their environment. However, a lack of consistency in terminology across disciplines hinders collaboration. Using different definitions for common terms allows miscommunication and misunderstanding to arise.

Thus, a well-defined, universal lexicon could advance scientific disciplines, and allow new concepts to emerge. To achieve this goal, Dr Laura Tipton of Chaminade University and her colleagues from the University of Hawai’i in Honolulu define concepts and terminology used in ecology and studies of microbe communities, and suggest definitions where discrepancies occur.

The researchers divided ecological concepts into four broad frameworks with an associated lexicon: ONE – biomes [by-omes]; TWO – diversity; THREE – symbiosis; and FOUR – succession. To identify appropriate universal definitions, they investigated the historical contexts of the terms, and how and where definitions diverged among disciplines.

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The term ‘biome’ originated in the 1930s to encompass plant and animal communities, and the environments where they live and interact. Despite this longstanding use within ecology, applying the term to microbial communities has not been straightforward. The term ‘microbiome’ – now in common use – has attracted controversy over its definition. Dr Tipton discovered that this boils down to a single question: does the word microbiome derive from the suffix ‘-ome’ meaning ‘all of’, or is it a portmanteau of the words ‘microbe’ and ‘biome’? Consensus favours the latter. Thus, the ‘microbiome’ is all the microbes within a community and the environment in which they live.

Confusingly, the terms ‘bacteriome’ [bak-tear-ee-ome], ‘mycobiome’ [my-koh-buy-ome], and ‘virome’ [vy-rome] have arisen to refer to the genetic material of the bacteria, fungi, and viruses within a community. Although ecology does not traditionally separate biomes based on taxonomic groupings, for example by referring only to a plant biome or an animal biome, a larger proportion of microbiome studies do focus on just one or two types of microbes. So, an argument could be made for retaining these terms.

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The simplest definition of ‘diversity’ is variation within a group. But the term ‘diversity’ is not used uniformly across ecology.

Some ecologists argue that a simple count of the number of species within a group – also referred to as ‘species richness’ – is not a sufficient measure of diversity, and that ‘evenness’ must also be included. Dr Tipton illustrates evenness with an example of two groups, A and B, each with a count of three species.

In group A, one species accounts for 99% of the observations, while in group B, each of the three species is equally abundant. Group A has a low evenness, and group B has a high evenness. So even when richness is the same, considering evenness can alter the level of diversity. However, many ecologists and microbiome scientists use the term ‘diversity’ interchangeably, and a consensus has yet to be reached.

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There has been historic disagreement among biologists on the proper usage and definition of the term ‘symbiosis’. The word itself is derived from the Greek ‘syn’ [sin] – meaning together – and ‘bios’ – meaning life. Originally scientists used ‘symbiosis’ to refer to all types of interactions between species, from ‘parasitism’ – where the parasitic species benefits at the other species’ expense, to ‘mutualism’ – where both species benefit.

Over time, however, the term ‘symbiosis’ became synonymous with the concept of ‘mutualism’, with few scientists still using the term with its intended definition. It was only in the late 20th century that the term’s original definition came into common usage again.

The discipline of microbiology is expanding the concept of symbiosis, with relationships only seen at the microbial scale. But alas, the term remains incorrectly used in microbiology, often referring exclusively to ‘mutualism’. Equally, a flurry of new terminology in ecology and medical literature has added to inconsistencies between disciplines.

Dr Tipton suggests that a solution is to use the term ‘symbiosis’ in its broadest sense with the addition of a modifier to express the specific relationship being referred to – for example, ‘mutualistic symbiosis’ or ‘parasitic symbiosis’.

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In ecology, the concept of ‘succession’ is important for understanding how the species composition of communities changes over time in disturbed environments, such as by a fire or a landslide. Historically, succession was thought to be an ordered sequence of communities with a pre-determined end or climax community, dictated by environmental factors.

Scientists now recognise that several stable climax communities are possible for a given environment, dependent on numerous factors, such as the order in which species join a community. Positive feedback within established communities helps to build resilience to maintain the climax community that has developed. Just like in these larger biomes, microbiomes can also exist in alternative stable states.

Ecologists investigating succession use several techniques to try to predict future community composition. However, applying the concept of succession to microbiome studies is difficult because of the rapid turnover of microbes. Dr Tipton suggests that evaluating succession within a microbiome can be achieved though, by examining microbial communities by strain, rather than by species.

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Developing a universal scientific lexicon is an ongoing effort. Dr Tipton’s work in defining the concepts shared by ecology and microbiome science is great for improving cross-talk between these disciplines. Perhaps more importantly, their effort demonstrates that a consensus on terminology shared between scientific disciplines is both possible and vital for future collaboration.

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