

Introduction to environmental microbiology

Environmental microbiology is a branch of microbiology that studies microorganisms present in various natural environments such as water, soil, air, and even living organisms. These microorganisms include bacteria, viruses, fungi, and protozoa, among others. It studies the role of microorganisms within different ecosystems as well as their impact on human, animal, and environmental health. It emphasizes the involvement of microorganisms in the biogeochemical cycles of elements such as carbon, nitrogen, phosphorus, and sulfur. Furthermore, it actively investigates bioremediation by examining the mechanisms of degradation of environmental contaminants like hydrocarbons and heavy metals.

I. Basic concepts

Ecology, derived from the Greek words "oikos" (habitat) and "logos" (science), is the discipline that studies living organisms and their interactions with their environment.

An *ecosystem* is defined as a dynamic system composed of a large number of individuals living in the same environment, which is maintained and regulated through numerous relationships among its components. It includes a community of organisms as well as their environment. Among its components, two inseparable aspects are distinguished:

- **Biocenosis**: the biotic component of the ecosystem, including living beings such as animals, plants, and microorganisms. This biocenosis is generally divided into three functional categories: producers (which produce organic matter through photosynthesis), consumers (which feed on producers or other consumers), and decomposers (which break down dead organic matter into mineral elements).
- **Biotope**: the abiotic component of the ecosystem, consisting of the physical and chemical environment with its specific characteristics such as temperature, humidity, and climate.

Together, these two components form the ecosystem as a whole.

Habitat refers to the physical environment in which an organism lives. It is the geographic or spatial location where the organism is capable of surviving and reproducing. Every organism has at least one associated habitat.

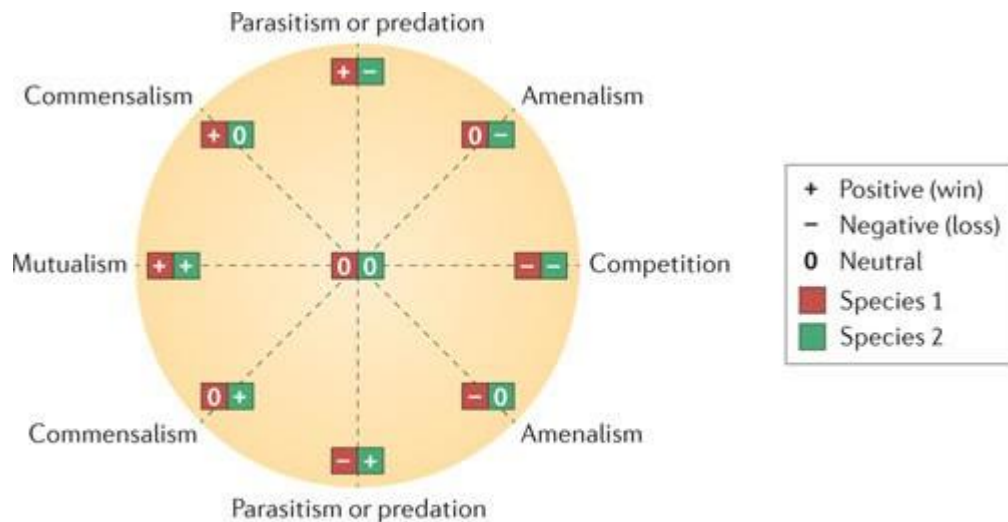
Niche, on the other hand, is a more complex and abstract concept. It encompasses how an organism interacts with its environment and other species within its community. The niche of an organism defines its functional role in the ecosystem, including its interactions with other organisms and its use of available resources. This includes its position in environmental gradients such as temperature, humidity, pH, and other relevant ecological factors.

In summary, the habitat refers to where an organism lives, while the niche describes its functional role and interactions within its environment.

II. Microbial interactions

Microbial interactions play a crucial role in the establishment and maintenance of biological communities. They encompass a range of processes that can influence the structure and dynamics of ecosystems. These interactions include:

- **Physicochemical changes:** Microorganisms alter their physical and chemical environment through processes such as chemical production, pH alteration, and nutrient availability modification.
- **Metabolite exchange:** Microorganisms can exchange metabolites with each other or with other organisms in their environment. This may include processes such as metabolic cooperation or competition for resources.
- **Metabolite conversion:** Microorganisms can transform metabolites present in their environment into other chemical forms, which can impact the elemental cycle and the availability of nutrients for other organisms.
- **Signaling:** Microorganisms can communicate with each other via chemical signals, enabling them to coordinate their metabolic and behavioral activities. This is important for processes such as biofilm formation, defense against predators, or other functions.
- **Genetic exchange:** Microorganisms can exchange genes with each other through mechanisms such as conjugation, transformation, and transduction. This can lead to the acquisition of new metabolic capabilities or resistance to antibiotics, for example.



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Fig. 1: Different types of microbial interactions

III. Microbial Diversity

Microorganisms represent the most diverse and abundant component of the biosphere, forming what could be called the "microbial world." Their diversity is exceptional, with a remarkable variety of cellular metabolisms, physiologies, morphologies, habitats, and ecological functions. Furthermore, their structure, expression, and genomic evolution present considerable diversity. Environmental parameters such as temperature, pH, pressure, and other environmental conditions significantly influence the composition and diversity of microbial communities. Likewise, growth requirements such as oxygen, light, and the availability of organic matter play a crucial role in determining microbial communities specific to a given environment. In extreme environments, one environmental factor may often predominate, dictating the composition of microbial communities. For example, in salt lakes, halophiles (microorganisms adapted to salt-rich environments) are predominant.