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Analysis of Methods for Detecting Bacteria and Fungi in Various Pathologies or Growing Environments and Their Differentiation by Main Functions

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Annotation: There are various ways of molecular communication for the development and functioning of bacteria and fungi. These bacterial-fungal interactions often alter the pathogenicity or nutritional effects of one or both partners on plants or animals, including humans. In addition, they are extremely useful for biotechnological and biogeochemical cycles. Thus, numerous biological problems in agriculture and forestry, environmental science, food production and medicine depend on the interaction of bacteria and fungi. Here we provide a structured overview of bacterial-fungal interactions with examples from many scientific fields. Scientists offer a global perspective on this developing interdisciplinary field of research, considering both the general and specific characteristics of these interactions. The researchers demonstrate that in many cases it is possible to find similarities between different situations in which bacterial-fungal interactions are important. Finally, we will talk about how new research methods can help us fight bacterial and fungal complexes, control them or use them for economic and practical purposes for the benefit of humanity, as well as change our understanding of the ecology of bacteria and fungi.

Keywords: Eukaryotic, prokaryotic, Griseofulvin, Antibiotics, peptidoglycan, chitin.

Introduction. Bacteria and fungi are found on all mucous membranes of the human body. After their discovery in the 19th century, it was long believed that diseases were associated with microbes. It was only in the second half of the 20th century, with the growing understanding of the microbial world and the increasing use of antibacterial and antifungal drugs, that people began to understand the beneficial role of microbes. For example, the first discoveries included the production of vitamin B12 by intestinal bacteria or the protective effect of vaginal lactobacilli in recurrent urinary tract infections [1,2,3]. Advances in sequencing techniques have accelerated the systematic analysis of bacterial communities in various areas of the human body. Next-generation sequencing in combination with bioinformatics tools has made it possible to identify microbes that previously could not be cultured in the laboratory. A decade and a half ago, the "human microbiome project" was launched as a result of these achievements. Soon after, the first studies of complex fungal communities known as "mycobiomes" were published [4,5,6].

Recently, the impact of microbial interactions on health and disease has become increasingly apparent. As a result, many researchers abandoned the historical division into pro- and eukaryotes and switched to the study of joint colonization and co-infection, overcoming the boundaries between kingdoms. Transferring the results of one research or experimental approach to another and, finally, to clinical practice is one of the main problems that researchers face today. In many cases, the beginning of research is to identify the links between health and diseases discovered during the study of complex microbiomes. After that, these connections are studied in more detail in less complex experimental conditions with a small number of microorganisms. To study the interaction of different species, co-cultivation in a nutrient medium, co-infection of cell cultures and the study of invertebrates and vertebrates such as mice or fish are usually used. Through the use of the so-called reductionist method, we were able to learn a lot about the nature of some interactions between fungi and bacteria. However, this method has some disadvantages [7,8,9,10,11,12].

Thus, the treyholder, consisting of fungi, bacteria and the host, determines the behavior of microbes and the overall results of their interaction with the host. The basic principle is that high-diversity communities appear to be beneficial to the host, while low-diversity communities appear to be associated with greater risk. In the future, we need to understand these interactions at the molecular level and their complexity. To solve this problem, improved methods and collaboration between clinicians, immunologists, bacteriologists and mycologists will be required. This can be the basis for individual microbiology. A deeper understanding of the fungi—bacteria—host triangle can help identify high-risk patients and improve their care through targeted exposure to the microbiota [2,7,11,14,15,16].

Many studies have shown that the classical division of microbiological research between bacteriologists and mycologists has led to the study of both bacteria and fungi in the laboratory. This separation does not take into account that fungi and bacteria coexist and interact in many environments. In addition, these bacterial-fungal interactions (BGV) often affect the biology of partners. Recently, the field of research has expanded and deepened significantly. Modern research has shown that fungi and bacteria often form physically and metabolically interdependent communities, each of which has its own characteristics. In addition, these studies have shown that these interactions can be useful in many fields such as agriculture, forestry, environmental protection, food processing, biotechnology, medicine and dentistry [15,16,17,18,19]. Bacteria and fungi are found in different places of the human body. In this case, they interact with each other directly or indirectly through the host's reaction. The interaction can affect the health of the host and cause diseases in both cases. This review presents the latest research on the interaction between fungi and bacteria during their symbiotic and pathogenic lifestyle. Scientists paid special attention to various mucous membranes, such as the vagina, intestines, lungs and oral cavity. We also consider the interaction of bloodstream and wound infections and possible consequences [7,9,14,18,19,20,21].

Differentiation of bacteria and fungi by structure, vital activity and basic functions.

Microbes can live in any harsh climate, so they are ubiquitous. Microbes and fungi are tiny or microscopic organisms found in almost all ecosystems. Although some microbes can be harmful, others are actively involved in critical biological cycles, playing a vital role in the ecosystem. Bacteria and fungi are different categories. Fungi are eukaryotic, and bacteria are prokaryotic. In addition to this, there are many other differences between them. For example, bacteria need a host, and they can be both autotrophs and heterotrophs. To survive, bacteria must have a host. However, since they do not grow on their own and are heterotrophic, their nutrition depends on other organisms. The two main categories of organisms are prokaryotes and eukaryotes. Prokaryotes are the most primitive single-celled organisms. Although eukaryotes originate only from prokaryotes, they are multicellular and contain all organelles. They both reproduce and are living organisms. In this article, we will look at what distinguishes bacteria from fungi [11,14,15,17].

Bacteria are microorganisms known as prokaryotes, and it is assumed that they appeared about 3.5 billion years ago. They can be heterotrophs, that is, they receive food from their host, or autotrophs, that is, they receive food through photosynthesis. Bacteria are usually spherical, rod-shaped and spiral-shaped. They reproduce asexually through binary fission or conjugation. In most cases, bacterial colonies in our intestines have a beneficial effect on us and strengthen our immune system. But, like viruses, bacteria can harm us by multiplying rapidly and killing cells in our body. Some bacteria also produce toxins that can kill cells and cause an excessive, destructive immune response. Fungi are eukaryotic organisms with unicellular or multicellular cells, like hyphae. They originated from the simplest 900 million years ago. They are usually presented in the form of gifs. After they grow, they form a dense mass called mycelium. These are heterotrophic organisms that feed on organic carbon. In addition, they produce hydrolytic enzymes. Mushrooms get their nutrients from decomposing and dead substances. They reproduce both sexually and asexually in the process of branch development, fragmentation, budding and other processes. Some fungi living in our natural environment reproduce by "spores", particles that can enter our body through our lungs or skin. When a person has a weak immune system, these fungi can spread rapidly and infect many organs, which makes them especially dangerous (Table 1) [15-21].

Table 1. Differentiation of bacteria and fungi by structure, vital activity and basic functions

№	The main indicators	Bacteria	Fungus
1.	Characteristics	Unicellular prokaryotic microorganisms without organelles	Organelles storing multicellular eukaryotic organisms
2.	Nucleus	They absent a nucleus.	The nucleus is present
3.	The content of the cell wall	The cell wall consists of peptidoglycan.	The cell wall is made up of chitin.
4.	The cell membrane	The cell membrane is located under the cell wall.	The cell membrane exists.
5.	Shape / structure	3 different shapes Round cocci Spiral – Spirella The rod-shaped wand	Mostly filamentous structures known as hyphae, but differing in shape
6.	The method of reproduction	Asexual.	It can be sexual or asexual.
7.	Mobility	They move with the help of a flagellum.	They are motionless.
8.	Power supply mode	They can be autotrophs, but	In most cases, heterotrophs

		more often heterotrophs.	drink decomposing and dead materials.
9.	Owner	They need a master to grow.	They grow on their own.
10.	An energy source.	They get their energy from sugars, proteins and fats.	They receive energy from sources used and already existing in the environment.
11.	pH of the growth environment	Neutral pH value (6.5-7.0)	Slightly acidic at pH 4-6
12.	Sensitivity	Antibiotics such as chloramphenicol, penicillin	Griseofulvin
13.	Stability	Griseofulvin	Antibiotics such as chloramphenicol, penicillin
14.	Pathogens that cause these diseases	Leprosy, Cholera, tuberculosis, tetanus	Aspergillosis, "athlete's foot", allergic bronchopulmonary aspergillosis

The interaction between bacteria and fungi. Bacteria and fungi interact with each other in a variety of conditions and ways. In this section, we will begin by describing the general characteristics of interactions between bacteria and fungi, considering the various physical connections of the two partners. Next, we will look at interactions between bacteria and fungi, including anti-bacterial and signaling interactions and genetic exchange. Finally, we will discuss how interactions between bacteria and fungi can affect the development and life cycles of these organisms. Although our examples are not exhaustive, we have intentionally selected them from various contexts in order to emphasize the diversity of BFI and make readers think about other systems that may be related to their own field of activity [11,12,13,14]. To create a basis for further conversation about the effects of inter-microbial interactions, we describe here the "conversation" or communication that takes place between a bacterium and a fungus. Several recent reviews suggest further discussion of these processes, especially in the context of clinical studies where the interaction of *Candida albicans* and *Pseudomonas aeruginosa* is used as a model. When bacteria and fungi can establish a connection, it is very harmful to both organisms. In this section, we consider the main consequences of the interaction of bacteria and fungi related to changes in the physiology, life cycles and survival of partners. [20,21,22]. Bacteria and fungi live side by side and interact with each other in many places and environments, and many similarities can be found between some of these diverse interactions. Undoubtedly, the variety of mechanisms of antagonism and cooperation that manifest themselves during the interaction between bacteria and fungi reflects the continuous interaction between bacteria and fungi throughout evolution. There is probably much more interaction between bacteria and fungi, especially in natural environments such as the ocean, which are poorly understood by microbiology. Despite the fact that more and more people are learning about the wide range of effects that BFI has, there are many interesting aspects that require further study, and advances in technology help in this [2,3,4,16,17,18].

Discussion. Fungi and bacteria do not have the same physiological characteristics. Their macroecology is necessary for the functioning of ecosystems, such as the carbon cycle. However, few studies have yet been conducted on the biogeography of bacteria and fungi and the underlying mechanisms. In many studies, the scientists combined the CLM-Microbe model, which takes into account microorganisms, with data on the biomass of fungi (FBC) and bacteria (BBC) at 34 NEON points to study the macroecology of bacteria and fungi. The FBC, BBC distributions and FBC: BBC ratios were well modeled at various sites, with variations of 99% ($P < 0.001$), 97% ($P < 0.001$) and 99% ($P < 0.001$). All these variations were explained by the CLM-Microbe model. Scientists have found that the biogeographic patterns of the FBC are more pronounced than the BBC in the United States. The turnover rates of bacteria and fungi demonstrated the same latitudes [1,5,8,9,11]. However, the latitudinal trends of the constituent fluxes, such as carbon assimilation, respiration, and necromass production, differed in fungi and bacteria. In bacteria, latitudinal trends decrease exponentially, and in fungi, reverse unimodal trends. Vegetation productivity and the average annual temperature for bacteria and fungi determine carbon asymmetry. Soil conditions affect fungi, and the average annual temperature affects bacteria. To understand how the metabolism of microorganisms and biogeochemical processes in the soil are related to each other, it is necessary to understand the macroecology of fungi and bacteria. Differences in the macroecology of fungi and bacteria affect the ecosystem of microorganisms, in particular, the structure of microbial communities and their relationship with the carbon cycle in spatial ecosystems [8,14,15,17].

Bacteria and fungi live in different places. Their interaction is important for animal and plant health, as well as for many other ecosystem functions. Numerous families of bacteria and fungi interact with each other in complex interactions that can lead to significant changes in the behavior of microorganisms, from antagonism to mutualism. The combination of various approaches such as molecular biology, genomics, geochemistry, chemical and microbial ecology, biophysics and environmental modeling is the result of a dynamic and interdisciplinary field of research on bacterial-fungal interactions (BFI) in environmental science, medicine and biotechnology [16,17,20,21].

Conclusions. Recently, the impact of microbial interactions on health and disease has become increasingly apparent. As a result, many researchers abandoned the historical division into pro- and eukaryotes and moved on to the study of joint colonization and co-infection, overcoming the boundaries between kingdoms.Transferring results from one research or experimental approach to another and, finally, into clinical practice is one of the main problems that researchers face today.

From the point of view of biotechnology, knowledge about metabolic interactions during BFI has great potential for use in many areas. However, this knowledge has so far been little studied outside of food technology research. In addition, the metabolic impact of bacterial and fungal communities on the environment is of great interest in relation to bioremediation, climate change and the development of new antimicrobial drugs and treatments.

Currently, our understanding of global ecology, evolution, trophic relationships, and the functioning of these and other BFI is at an early stage of development, making it difficult to develop such applications. Nevertheless, fungal endobacteria can be an excellent approach to creating easy-to-use "stabilized" BFI in which modified bacteria are located inside fungal hyphae. Our understanding of the biology and ecology of bacteria and fungi will change significantly as a result of research aimed at solving these problems.

References.

1. He, L., Viovy, N., & Xu, X. (2023). Macroecology differentiation between bacteria and fungi in topsoil across the United States. Global Biogeochemical Cycles, 37, e2023GB007706. https://doi.org/10.1029/2023GB007706

2. Frey-Klett P, Burlinson P, Deveau A, Barret M, Tarkka M, Sarniguet A. Bacterial-fungal interactions: hyphens between agricultural, clinical, environmental, and food microbiologists. Microbiol Mol Biol Rev. 2011 Dec;75(4):583-609. doi: 10.1128/MMBR.00020-11.

3. Burns, K. N., Bokulich, N. A., Cantu, D., Greenhut, R. F., Kluepfel, D. A., O'Geen, A. T., et al. (2016). Vineyard soil bacterial diversity and composition revealed by 16S rRNA genes: Differentiation by vineyard management. Soil Biology and Biochemistry, 103, 337–348. https://doi.org/10.1016/j.soilbio.2016.09.007

4. The difference between bacteria and fungi. https://www.toppr.com/guides/biology/difference-between/bacteria-and-fungi/#:~:text=Bacteria%20and%20Fungi%20both%20come,autotrophs%20as%20well%20as%20heterotrophs.

5. Buyer, J. S., & Sasser, M. (2012). High throughput phospholipid fatty acid analysis of soils. Applied Soil Ecology, 61, 127–130. https://doi.org/10.1016/j.apsoil.2012.06.005
6. Chen, D., Mi, J., Chu, P., Cheng, J., Zhang, L., Pan, Q., et al. (2015). Patterns and drivers of soil microbial communities along a precipitation gradient on the Mongolian Plateau. Landscape Ecology, 30(9), 1669–1682. https://doi.org/10.1007/s10980-014-9996-z
7. French, K. E., Tkacz, A., & Turnbull, L. A. (2017). Conversion of grassland to arable decreases microbial diversity and alters community composition. Applied Soil Ecology, 110, 43–52. https://doi.org/10.1016/j.apsoil.2016.10.015
8. Difference Between Bacteria and Fungi. https://byjus.com/neet/difference-between-bacteria-and-fungi/
9. Robert Starke, Rubén López Mondéjar, Zander Rainer Human, et al. Niche differentiation of bacteria and fungi in carbon and nitrogen cycling of different habitats in a temperate coniferous forest: A metaproteomic approach, Soil Biology and Biochemistry, Volume 155, 2021, 108170, https://doi.org/10.1016/j.soilbio.2021.108170.
10. Gomez, J. D., Denef, K., Stewart, C. E., Zheng, J., & Cotrufo, M. F. (2014). Biochar addition rate influences soil microbial abundance and activity in temperate soils. European Journal of Soil Science, 65(1), 28–39. https://doi.org/10.1111/ejss.12097
11. Hamdi, S., Moyano, F., Sall, S., Bernoux, M., & Chevallier, T. (2013). Synthesis analysis of the temperature sensitivity of soil respiration from laboratory studies in relation to incubation methods and soil conditions. Soil Biology and Biochemistry, 58, 115–126. https://doi.org/10.1016/j.soilbio.2012.11.012
12. He, L., Lai, C.-T., Mayes, M. A., Murayama, S., & Xu, X. (2021). Microbial seasonality promotes soil respiratory carbon emission in natural ecosystems: A modeling study. Global Change Biology, 27(13), 3035–3051. https://doi.org/10.1111/gcb.15627
13. Kampe, T. U., Johnson, B. R., Kuester, M. A., & Keller, M. (2010). NEON: The first continental-scale ecological observatory with airborne remote sensing of vegetation canopy biochemistry and structure. Journal of Applied Remote Sensing, 4(1), 043510. https://doi.org/10.1117/1.3361375
14. Kao, R. H., Gibson, C. M., Gallery, R. E., Meier, C. L., Barnett, D. T., Docherty, K. M., et al. (2012). NEON terrestrial field observations: Designing continental-scale, standardized sampling. Ecosphere, 3(12), 1–17. https://doi.org/10.1890/es12-00196.1
15. Metzger, S., Ayres, E., Durden, D., Florian, C., Lee, R., Lunch, C., et al. (2019). From NEON field sites to data portal: A community resource for surface–atmosphere research comes online. Bulletin of the American Meteorological Society, 100(11), 2305–2325. https://doi.org/10.1175/bams-d-17-0307.1
16. National Ecological Observatory, N. (2021a). Soil microbe biomass (DP1.10104.001).
17. National Ecological Observatory Network (NEON). ousk, J., Brookes, P. C., & Bååth, E. (2010b). Investigating the mechanisms for the opposing pH relationships of fungal and bacterial growth in soil. Soil Biology and Biochemistry, 42(6), 926–934. https://doi.org/10.1016/j.soilbio.2010.02.009
18. Rousk, J., Brookes, P. C., & Bååth, E. (2010b). Investigating the mechanisms for the opposing pH relationships of fungal and bacterial growth in soil. Soil Biology and Biochemistry, 42(6), 926–934. https://doi.org/10.1016/j.soilbio.2010.02.009
19. Waldrop, M. P., Holloway, J. M., Smith, D. B., Goldhaber, M. B., Drenovsky, R. E., Scow, K. M., et al. (2017). The interacting roles of climate, soils, and plant production on soil microbial

communities at a continental scale. Ecology, 98(7), 1957–1967. https://doi.org/10.1002/ecy.1883

20. Wickham, H., & Chang, W. (2016). ggplot2: Create elegant data visualisations using the grammar of graphics, R package version 2.1. Retrieved from https://CRAN.R-project.org/package=ggplot2
21. Xu, X., Schimel, J. P., Janssens, I. A., Song, X., Song, C., Yu, G., et al. (2017). Global pattern and controls of soil microbial metabolic quotient. Ecological Monographs, 87(3), 429–441. https://doi.org/10.1002/ecm.1258
22. Aurélie Deveau, Gregory Bonito, Jessie Uehling, et al. Bacterial–fungal interactions: ecology, mechanisms and challenges, FEMS Microbiology Reviews, Volume 42, Issue 3, May 2018, Pages 335–352, https://doi.org/10.1093/femsre/fuy008