# THE SIGNIFICANCE OF MICROORGANISMS IN HUMAN LIFE AND THE METHODOLOGY OF TEACHING THE SUBJECT

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**Abstract**
The article examines the role of microorganisms in nature and their significance in human life, particularly within the pharmaceutical industry. Central focus is given to the morphological structure of the Penicillium genus, the discovery of penicillin, and its biosynthesis process. Furthermore, the paper analyzes the challenge of antibiotic resistance and the future potential of modern genetic technologies such as CRISPR/Cas9. In the methodological section, the effectiveness of interactive teaching strategies - including "Biosynthesis Logic", the "Pharmaceutical Pyramid", and the "Microbiological Basket" is substantiated for teaching microbiology in higher education.

**Keywords**: Microbiology, Penicillium, penicillin, teaching methodology, secondary metabolites, biotechnology, antibiotic resistance, bioreactor, interactive methods..

## Introduction

As the field of microbiology advances, humanity is gaining a deeper understanding of the vital role microscopic organisms play in nature and life. Microorganisms - including bacteria, viruses, fungi, and protozoa - are ubiquitous across all layers of the biosphere. However, the most valuable "treasure" for the pharmaceutical industry lies in the secondary metabolites synthesized by these organisms. Among them, the genus Penicillium stands out due to its unparalleled therapeutic properties.

Penicillium belongs to the class Ascomycetes (sac fungi) and is one of the most widely distributed fungal genera in nature. Their mycelia are branched and may be colorless or pigmented depending on the species. The spore-producing organs—conidia—exhibit a characteristic brush-like shape. The name of the genus is derived from the Latin word “penicillus”, meaning “paintbrush”, precisely due to this morphological appearance.

Studying the morphological structure of fungi is of fundamental importance in determining their efficiency for industrial-scale applications. Specifically, indicators such as the mycelial growth rate and spore density directly influence antibiotic yield and the overall activity of the biosynthesis process [2].

**Discussion**

The discovery of this substance by Alexander Fleming in 1928 ushered in the “Golden Age” of medicine. The core nucleus of penicillin is 6-aminopenicillanic acid. Although Fleming’s discovery may appear accidental, it is the result of extensive scientific labor at the intersection of microbiology and chemistry.

The beta-lactam ring within the penicillin molecule inhibits the synthesis of peptidoglycan, which is an essential component in the construction of the bacterial cell wall (Figure 1) [1].

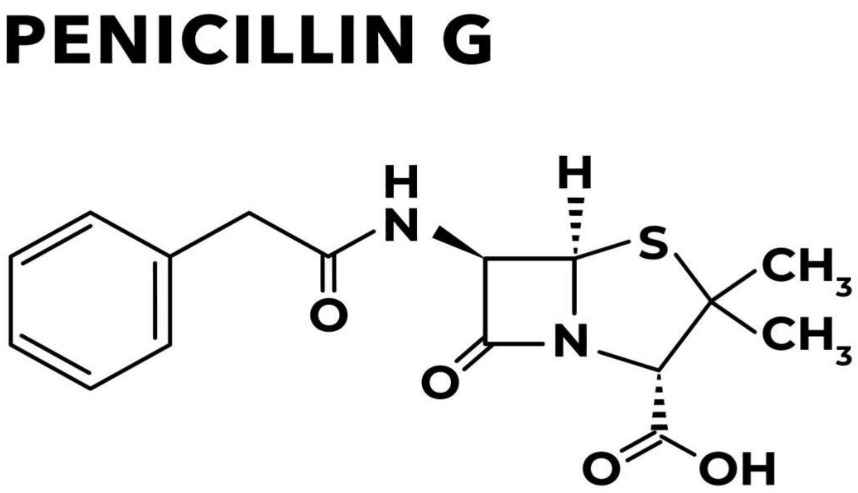


**Figure 1.** Chemical structural formula of the penicillin molecule, illustrating the lactam ring.

The production of penicillin is a complex biotechnological chain. It consists of several critical stages, beginning with strain selection, where high-yield strains of Penicillium chrysogenum are selected. Corn steep liquor, glucose, and mineral salts are utilized as the primary nutrient media.

In bioreactors, parameters such as temperature, pH, and dissolved oxygen levels are strictly monitored. In modern bioreactors, all conditions necessary for microbial growth are fully automated. During the fermentation process, maintaining the pH level at approximately 6.5 plays a decisive role in preventing the degradation of penicillin (Figure 2) [4].

**Figure 2.** A modern bioreactor

Other Microorganisms in the Pharmaceutical Industry. Beyond Penicillium, various other microbes play a critical role in the drug industry:

- Streptomyces: The primary source of streptomycin and tetracycline.
- Bacillus: Producers of peptide antibiotics such as bacitracin.
- Saccharomyces cerevisiae: Utilized for the synthesis of vitamins and recombinant proteins.

Ecological and industrial roles of Fungi. In nature, fungi act as decomposers (sanitarians), breaking down complex compounds such as cellulose and lignin. In the dairy industry, Penicillium roqueforti and P. camemberti serve not only as flavoring agents but also as natural preservatives that protect the product from contaminating microorganisms [2].

Antibiotic Resistance. Due to the misuse of antibiotics, bacteria are increasingly developing resistance. For instance, some bacteria produce the beta-lactamase enzyme, which degrades the penicillin molecule. As antibiotic resistance levels rise, diseases that were once easily treated are becoming dangerous again. This situation necessitates the pharmaceutical industry to develop a new generation of semi-synthetic penicillins [5].

Future Perspectives. Today, it is possible to edit the Penicillium genome using CRISPR/Cas9 technology. By editing the genomes of microorganisms, we can produce not only natural antibiotics but also synthetic molecules that do not occur in nature and are effective against highly resistant "superbugs" [3].

Pedagogical methods in teaching Microbiology and Virology

We shall examine the application of specific methods related to the subject:

**The "Biosynthesis Logic" Method (Chain Analysis)**

Technological Concept. This method involves a sequential analysis of the molecular stages of penicillin, from the laboratory environment to the final dosage form. Each link relies on the biological outcome of the preceding process.



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**Chain of inquiry:**

Genetic activation. Under what conditions are the genes responsible for antibiotic synthesis "awakened" in the Penicillium chrysogenum mycelium?

Precursor assembly. How do the amino acids L-cysteine and L-valine form a tripeptide chain?

Ring formation. Which enzymes catalyze the formation of the beta-lactam ring?

Extraction and purification. How is therapeutic activity preserved when the substance is isolated from the solution?

Objective. To develop students' ability to perceive complex biotechnological processes as an integrated system.

**The Pharmaceutical Pyramid Method**

Technological concept. Information is arranged hierarchically. The base represents the biological nature of the microbe, while the apex represents its global benefit to humanity.

Apex. Global epidemiological control and an 80% reduction in mortality rates.

Middle layer. The beta-lactam mechanism that blocks bacterial cell wall synthesis.

Base. The metabolism of the Penicillium fungus within the nutrient medium and the secretion of secondary metabolites.

Advantage. It systematizes data, helping students realize that high-level results (drug production) cannot be achieved without mastering fundamental science (fungal biology).

**The Bio-technological Scheme Method (Graphical Modeling)**

Technological concept. This focuses on depicting the industrial production line as a graphical flowchart or algorithm.

Task. Arrange the following stages in logical order: Strain selection – Inoculation into the bioreactor – Controlled fermentation – Liquid filtration – Chemical purification – Lyophilization (freeze-drying) – Medical packaging.

Objective. To bridge theoretical knowledge with industrial manufacturing and foster "engineering thinking".

**The Microbiological Basket (Knowledge Sorting)**

Technological Concept: An interactive method requiring the grouping of terms based on their roles in life and industry.

Basket 1 (Medical/Pharmaceutical). Penicillin G, Vaccines, Insulin, Streptomycin.

Basket 2 (Industrial/Food): P. roqueforti, Cheese fermentation, Vitamin B12, Citric acid.

**Conclusion**

The study of the microbial world, particularly the genus Penicillium, has opened a new chapter in the history of human civilization. Alexander Fleming's serendipitous discovery not only provided penicillin—the first antibiotic that saved millions of lives - but also laid a solid foundation for modern pharmaceutical and industrial microbiology.

As explored in this research, the significance of Penicillium extends beyond medicine. They play an incomparable role in the food industry, agriculture, and maintaining the matter cycle in nature. However, the relationship between microbes and humanity faces a new challenge: antibiotic resistance. Methodological approaches such as "Molecular Logic" and the "Pharmaceutical Pyramid" demonstrate that the key to future medicine is not the domination of microorganisms, but cooperation through a deep understanding of their biological mechanisms.

The advancement of CRISPR/Cas9 and synthetic biology is expanding the potential of these "living factories", paving the way for next-generation drugs against cancer and other severe diseases. Our relationship with the microbial world is a constantly shifting balance; penicillin remains the greatest scientific tool that tipped this balance in favor of humanity [4].

## Summary

In conclusion, studying microorganisms is not merely about scientific advancement; it is about ensuring biological security and enhancing the quality of life. The primary task for future scientists is to find more rational and responsible ways to utilize these "invisible helpers" of nature.

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