

MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
ODESA I. I. MECHNIKOV NATIONAL UNIVERSITY
Department of Microbiology, Virology and Biotechnology

WORKING PROGRAM OF THE ACADEMIC DISCIPLINE
ANTIMICROBIAL DRUGS AND PROBIOTICS

Level of Higher Education: Second (Master's)

Field of Knowledge: G Chemical and Bioengineering

Specialty: G21 Biotechnology and Bioengineering

Educational and Professional Program "Biotechnologies and Bioengineering"

1. Purpose and Objectives of the Discipline

The purpose of teaching this special course is to ensure that Master's students in biotechnology acquire the necessary level of knowledge, skills and abilities in the course “Antimicrobial Drugs and Probiotics.”

Objectives of the discipline:

1. To form in higher education applicants the required level of knowledge and skills provided by the educational-professional program.
2. To provide understanding of modern methods for development of antimicrobial agents.
3. To characterize the composition and role of normal human microbiota and methods for correction of dysbiotic conditions.
4. To form understanding of principles and technology of obtaining probiotic preparations, prebiotics and functional food products.

2. Content of the Academic Discipline

CONTENT MODULE I. GENERAL CHARACTERISTICS OF ANTIBIOTICS, METHODS OF THEIR ISOLATION AND DETERMINATION

Lecture 1

General information about antibiotics and their significance for medicine and the national economy. Historical data on the development of the doctrine of antibiotics. The current state of antibiotic science. Significance for biology.

TOPIC 1. Antagonism among microorganisms. Relationships among microorganisms: metabiosis, symbiosis, antagonism, parasitism, and predation. Forms of microbial antagonism (“passive” and “active”). Antibiotic production as one of the forms of antagonism. Mechanisms of protection of microbial cells against their own antibiotics.

TOPIC 2. Basic principles of antibiotic selection. Isolation of antibiotic-producing microorganisms from natural habitats and determination of their activity against bacteria, microscopic fungi, viruses, and malignant tumor cells.

TOPIC 3. Methods for quantitative determination of antibiotics. Biological, chemical, and physico-chemical methods. The concept of the unit of biological activity of antibiotics.

Lecture 2

TOPIC 4. Main stages of studying an antibiotic and its producer. Determination of antimicrobial spectrum, toxicity, and therapeutic properties of antibiotics. Primary identification of the producer and its antibiotic.

TOPIC 5. Ways to increase the antibiotic-producing capacity of microorganisms. Selection of the most active producer strains; determination of

optimal cultivation conditions for maximal antibiotic biosynthesis (medium composition, aeration, temperature, etc.); co-cultivation of microorganisms. Preservation of antibiotic-producing strains in an active state.

TOPIC 6. Industrial production of antibiotics. Typical production scheme. Nutrient media. Sources of carbon, nitrogen, etc. Preparation and sterilization of media. Preparation of inoculum. Industrial cultivation. Fermenter design. Surface and submerged cultivation methods. Foam control. Isolation and chemical purification of antibiotics: precipitation, extraction with organic solvents, sorption methods using surface-active substances (activated carbon, activated aluminum oxide, etc.) or ion-exchange materials (ion-exchange resins). Biological control (sterility testing) and pharmacological control (toxicity, pyrogenicity, etc.). Control of producer culture purity and its importance in antibiotic production. Two-phase development of antibiotic producers. First phase – balanced growth phase (trophophase); second phase – unbalanced growth phase (idiophase). Antibiotic productivity of microorganisms. Directed biosynthesis of antibiotics. Changes in medium composition, introduction of specific inhibitors, use of mutant strains, action of microorganisms or their enzymes, mutasynthesis. Construction of producer strains.

Lecture 3

TOPIC 7. Classification of antibiotics. Principles of classification by biological origin, antimicrobial spectrum, mechanism of action, and chemical structure.

TOPIC 8. Main mechanisms of biological action of antibacterial agents. Inhibition of cell wall synthesis. Molecular mechanisms of cycloserine, penicillins, cephalosporins, lysozyme. Membrane function disruption. Antibiotics causing membrane disorganization – gramicidin S, polymyxins, polyene antibiotics. Antibiotics inhibiting membrane-bound transport enzymes – oligomycin, enniatins. Ionophore antibiotics: valinomycin, gramicidins A, B, C. Inhibition of protein synthesis. Inhibitors of 30S ribosomal subunit (streptomycin, other aminoglycosides, tetracyclines); inhibitors of 50S subunit (chloramphenicol, macrolides such as erythromycin, oleandomycin, etc.). Inhibition of nucleic acid synthesis. Inhibitors of purine and pyrimidine synthesis (azaserine, sarcomycin). Inhibitors of nucleic acid synthesis (actinomycins, mitomycin, bleomycin, rubomycin, etc.). Respiration inhibitors (oligomycins, antimycin) and oxidative phosphorylation inhibitors (valinomycin, linear gramicidins). Mechanism of action of antimetabolite antibiotics (puromycin, etc.). Immunosuppressive antibiotics (actinomycins, olivomycin, etc.).

Lecture 4

TOPIC 9. Microbial resistance to antibacterial agents. Current data on resistance development. Mechanisms of resistance formation. Biochemical mechanisms (antibiotic modification, target modification, decreased permeability,

enzyme production inactivating antibiotics). Chromosomal and extrachromosomal resistance.

Lecture 5

TOPIC 10. Antibiotics produced by eubacteria. Antibiotics produced by *Bacillus* species (*B. brevis*, *B. licheniformis*, *B. polymyxa*). Characteristics of producers, spectrum, chemical structure, biosynthesis, applications. Tyrothricin, gramicidins, polymyxins, bacitracins. Non-medical antibiotics – nisin, colicins, bacteriocins of lactobacilli and bifidobacteria. Cyanobacterial antibiotics. Biological properties of *Lyngbya majuscula*. Malyngolide – properties and activity spectrum. Antibiotics produced by Actinomycetales. Aminoglycosides: streptomycin, mannosidostreptomycin, dihydrostreptomycin. Producers (*Streptomyces griseus*, *S. humidus*), molecular structure, mechanism, spectrum. Other aminoglycosides: neomycins (*S. fradiae*), kanamycin (*S. kanamyceticus*), tobramycin (*S. tenebrarius*), gentamicin (*Micromonospora purpurea*), sisomicin (*M. inyoensis*), fortimicin (*M. olivoasterospora*). Tetracyclines: chlortetracycline (*S. aureofaciens*), oxytetracycline (*S. rimosus*), tetracycline (*S. viridifaciens*). Biosynthesis conditions. Chemical modifications (metacycline, doxycycline). Macrolides: erythromycin, oleandomycin (*S. erythreus*, *S. antibioticus*). Polyene antibiotics: nystatin (*S. noursei*), levorin (*S. levoris*), amphotericin B (*S. nodosus*). Chloramphenicol and its synthetic analogue levomycetin (*S. venezuelae*). Antitumor antibiotics: actinomycins, olivomycin, anthracyclines (doxorubicin), streptonigrin.

Lecture 6

TOPIC 11. Antibiotics of microscopic fungi. Penicillin (*P. chrysogenum*, *P. notatum*, *P. brevicompactum*). Biosynthesis. Semisynthetic penicillins. Cephalosporins (*Acremonium chrysogenum*). Carbapenems (*Streptomyces cattleya*). Other fungal antibiotics: fumagillin, griseofulvin, trichothecin, fusidic acid.

Lecture 7

TOPIC 12. Plant and animal antibiotics. Phytoncides (allicin, raphanin, phytoalexins). Lysozyme, ecmolin, erythrin. Antiviral action of interferon. Adverse effects of antibiotics: allergic reactions, toxicity, biologically related side effects.

TOPIC 13. Synthetic antibacterial agents. Quinolones and fluoroquinolones. Sulfonamides. Nitroimidazoles. Nitrofurans. 8-hydroxyquinoline derivatives. First- and second-line antituberculosis drugs. Imidazoles, triazoles, allylamines.

TOPIC 14. Antiviral and antiparasitic agents. Antiherpetic, anti-CMV, anti-influenza, antiretroviral drugs. Broad-spectrum agents. Interferons. Antiprotozoal and anthelmintic agents.

CONTENT MODULE II. BASIC PRINCIPLES OF PROBIOTIC DEVELOPMENT

Lecture 8

TOPIC 15. Probiotics and prebiotics, their role in maintaining and restoring normal microbiota. Classification and therapeutic functions. Auto- and recombinant probiotics. Synbiotics. Prebiotics. Evaluation of efficacy and safety. Requirements for probiotic strains. Mechanisms of probiotic action.

TOPIC 16. Probiotic production technology. Stages of technological process. Production requirements. Methods for quality control (acid-forming, antagonistic, adhesive, lysozyme-producing, proteolytic, antimutagenic, hypocholesterolemic, immunomodulatory activity).

Lecture 9

TOPIC 17. Mono- and multistrain probiotics. Lactobacterin, Acylact, Bifidobacterin. Cultivation, dosage forms. Colibacterin. Bifikol, Symbiter.

Lecture 10

TOPIC 18. Recombinant probiotics, synbiotics, functional foods. Genetic engineering methods. Subalin. Immobilized probiotics (Ecoflor). Biform, Hilak Forte. Veterinary probiotics. Biosporin.

Lecture 11

TOPIC 19. Regulatory framework. ISO and GMP standards. Technical and patent documentation.

Lecture 12

TOPIC 20. Bioethics and biosafety of antimicrobial and probiotic use. ATC classification. Ethical aspects of genetically engineered products. Principles of rational antibiotic therapy.

3. Topics of Seminar Classes

Seminar classes are not foreseen.

4. Topics of Practical Classes

1. Development of a biotechnological process flowchart for producing an antimicrobial agent
2. Development of an algorithm for producing a microbiome-correcting preparation

5. Topics of Laboratory Classes

Laboratory classes are not foreseen

6. Independent Study

Independent study of students during the study of this special course includes theoretical preparation on specific topics of the course that are studied

independently, as well as preparation for practical classes on the topics indicated in the table.

Independent work is carried out by the student in the library, classrooms and laboratories, at production facilities, in computer classes, as well as at home.

Title of the Topic	
1	TOPIC 1. Antagonism among microorganisms.
2	TOPIC 2. Basic principles of antibiotic selection.
3	TOPIC 3. Methods for quantitative determination of antibiotics.
4	TOPIC 4. Main stages of studying an antibiotic and its producer.
5	TOPIC 5. Ways to increase the antibiotic-producing capacity of microorganisms.
6	TOPIC 6. Industrial production of antibiotics.
7	TOPIC 7. Classification of antibiotics.
8	TOPIC 8. Main mechanisms of biological action of antibacterial agents.
9	TOPIC 9. Microbial resistance to antibacterial agents.
10	TOPIC 10. Antibiotics produced by eubacteria.
11	TOPIC 11. Antibiotics of microscopic fungi.
12	TOPIC 12. Plant and animal antibiotics.
13	TOPIC 13. Synthetic antibacterial agents.
14	TOPIC 14. Antiviral and antiparasitic agents.
15	TOPIC 15. Probiotics and prebiotics, their role in maintaining and restoring normal microbiota.
16	TOPIC 16. Probiotic production technology.
17	TOPIC 17. Mono- and multistrain probiotics.
18	TOPIC 18. Recombinant probiotics, synbiotics, functional foods.
19	TOPIC 19. Regulatory framework.
20	TOPIC 20. Bioethics and biosafety of antimicrobial and probiotic use.

7. Teaching Methods

Verbal, visual, and practical teaching methods are applied.

Verbal methods: lectures, discussions, debates, situational learning, etc.

Visual methods: illustration (multimedia presentations), demonstration, presentation of the results of students' independent work.

Practical methods: practical assignments, completion of individual tasks and group projects.

8. Forms of Control and Assessment Methods (including criteria for evaluating learning outcomes)

Ongoing assessment for each content module is carried out through oral questioning and mini-tests on online platforms.

Final assessment – pass (credit) in the form of computer-based testing.

The level of a student's knowledge is evaluated on a 100-point scale.

General Criteria for Assessing Academic Achievements of Higher Education Students

Grade according to the National Scale	100-point scale / ECTS grade	Theoretical preparation	Practical preparation
Passed	90 – 100/ A	<p>The student fully masters the course material and presents it freely, comprehensively, substantiated, and reasonable during oral presentations and written responses. The student demonstrates clear knowledge of the relevant categories, their content, and understanding of their interrelationships; correctly formulates interpretations of the relevant concepts; demonstrates knowledge of the content of the regulatory legal acts foreseen by the curriculum; and makes independent conclusions.</p> <p>The student is able to identify cause-and-effect relationships, independently find additional information and use it to accomplish assigned tasks, and freely apply modern information technologies to expand knowledge.</p>	<p>The student is able to substantively justify the selection of a rational method for completing practical tasks, performs practical tasks not foreseen by the curriculum, freely applies acquired theoretical knowledge in the analysis of practical material, and demonstrates a creative approach to completing individual and group assignments during independent work.</p>

Passed	85 – 89 / B	The student possesses the course material sufficiently thoroughly, presents it in a reasoned manner during oral presentations and written responses, using mandatory and required literature, applies knowledge to solve standard situations, independently analyzes, generalizes, and systematizes educational information, but inaccuracies can be accepted that are not essential to the characterization of the subject matter and do not significantly affect the overall description of a particular phenomenon (concept).	The student demonstrates stable skills in performing practical tasks and correctly completes the majority of practical assignments.
Passed	75 – 84 / C	The student generally demonstrates a high level of knowledge of the entire course program, possesses the material at a sufficient level, applies knowledge to solve standard situations, but is not able to independently analyze certain issues, does not fully convincingly substantiate their answers, and minor inaccuracies occur.	The student independently performs practical tasks foreseen by the course curriculum according to a given model.
Passed	70 – 74 / D	The student possesses the material at a reproductive level or reproduces a certain part of the educational material with elements of logical connections. The student knows the basic concepts of the course material but experiences difficulties in identifying the essential features	The student demonstrates elementary skills in performing practical tasks and correctly completes only half of the practical assignments.

		of the studied content, as well as in determining cause-and-effect relationships and formulating conclusions.	
Passed	60 – 69 / E	The student does not fully understand the subject of the academic discipline; there are deficiencies in the content of concepts, categories, trends, and in the titles and content of regulatory legal acts. The student provides unclear characteristics of the relevant phenomena and presents their ideas with significant breakage of logical coherence in the presentation of the material.	The student is able to apply knowledge only in standard practical situations, demonstrates unstable skills in performing practical tasks, and makes numerous significant errors.
Not passed, with the right to retake exam	35 – 59 / FX	The student does not correctly understands the essence of the fundamental issues of the academic discipline, commits significant substantive errors, possesses the course material superficially and fragmentarily, unsystematically singles out random features of the studied content, is unable to formulate and logically present their opinion, and is unable to make generalizations and conclusions.	The student is able to complete only certain practical tasks with the assistance of the instructor. The student lacks developed skills and abilities.
Failed with mandatory retake of the course	0 – 34 / F	The student does not know the fundamental provisions of the academic discipline and does not possess the course material.	The student performs only individual elements of practical tasks and requires constant assistance from the instructor.

9. Distribution of Points Awarded to Students

During ongoing assessment, the results of oral questioning as well as the completion of practical assignments are evaluated. Periodic assessment is carried out in the form of modular tests (computer-based testing).

The student may receive the maximum score (100 points) for each type of work. The final grade in the academic discipline is calculated as the sum of scores, each of which constitutes a corresponding percentage of the overall grade, depending on the complexity of the tasks and the volume of independent work. Periodic assessment is conducted through control tests for each module.

The results of students' academic performance are recorded as a grade according to the national scale, the 100-point scale, and the ECTS scale.

Grading Scale (National and ECTS)

Score	ECTS	National grade
90–100	A	Passed
85–89	B	Passed
75–84	C	Passed
70–74	D	Passed
60–69	E	Passed
35–59	FX	Retake allowed
0–34	F	Failed – mandatory repetition

10. Educational and Methodological Support

Working program of the academic discipline – biologywiki.onu.edu.ua

Syllabus – biologywiki.onu.edu.ua

Multimedia presentations for lectures, methodological guidelines for practical classes (available in Google Classroom).

11. Recommended Literature

Main literature:

1. Oryabinska, L. B., Dzyhun, L. P., & Polishchuk, V. Yu. (2020). *Biotechnology of antibiotics: Laboratory manual*. Kyiv: Igor Sikorsky Kyiv Polytechnic Institute. 40 p.

2. Butsenko, L. M., Penchuk, Yu. M., & Pyroh, T. P. (2009). *Technologies of microbial synthesis of medicinal products*. Kyiv: National University of Food Technologies. 176 p.
3. State Pharmacopoeia of Ukraine. (2001). Kharkiv: State Enterprise "Scientific-Expert Pharmacopoeial Center." 556 p.
4. Chekman, I. S., Belenichev, I. F., Bukhtiyarova, N. V., et al. (2019). *Clinical and pharmacological characteristics of modern antimicrobial agents*. Zaporizhzhia: Zaporizhzhia State Medical University. 111 p.
5. Kovalenko, V. O., Tsykhanovska, I. V., Lazareva, T. A., et al. (2013). *Technical microbiology*. Kharkiv: Svit Knyh. 679 p.
6. Chekman, I. S., Bobyrov, V. M., Kresyun, V. Y., et al. (2020). *Pharmacology* (4th ed.). Vinnytsia: Nova Knyha. 472 p.
7. Hodovan, V. V. (2019). *Pharmacology in figures and schemes* (V. Y. Kresyun, Ed.). Vinnytsia: Nova Knyha. 462 p.
8. Chumak, A. A., Melezhyk, O. V., & Tseisler, Yu. V. (2020). *Antibiotics: Lecture notes*. Kyiv: University "Ukraine." 74 p.
9. Elshobary ME, Badawy NK, Ashraf Y, Zatioun AA, Masriya HH, Ammar MM, Mohamed NA, Mourad S, Assy AM. Combating Antibiotic Resistance: Mechanisms, Multidrug-Resistant Pathogens, and Novel Therapeutic Approaches: An Updated Review. *Pharmaceuticals* (Basel). 2025 Mar 12;18(3):402. doi: 10.3390/ph18030402.
10. Plaza-Diaz J, Ruiz-Ojeda FJ, Gil-Campos M, Gil A. Mechanisms of Action of Probiotics. *Adv Nutr*. 2019 Jan 1;10(suppl_1):S49-S66. doi: 10.1093/advances/nmy063. Erratum in: *Adv Nutr*. 2020 Jul 1;11(4):1054. doi: 10.1093/advances/nmaa042.
11. Helmy YA, Taha-Abdelaziz K, Hawwas HAE, Ghosh S, AlKafaas SS, Moawad MMM, Saied EM, Kassem II, Mawad AMM. Antimicrobial Resistance and Recent Alternatives to Antibiotics for the Control of Bacterial Pathogens with an Emphasis on Foodborne Pathogens. *Antibiotics* (Basel). 2023 Jan 30;12(2):274. doi: 10.3390/antibiotics12020274.
12. Habteweld HA, Asfaw T. Novel Dietary Approach with Probiotics, Prebiotics, and Synbiotics to Mitigate Antimicrobial Resistance and Subsequent Out Marketplace of Antimicrobial Agents: A Review. *Infect Drug Resist*. 2023 May 23;16:3191-3211. doi: 10.2147/IDR.S413416.
13. Imperial IC, Ibana JA. Addressing the Antibiotic Resistance Problem with Probiotics: Reducing the Risk of Its Double-Edged Sword Effect. *Front Microbiol*. 2016 Dec 15;7:1983. doi: 10.3389/fmicb.2016.01983.
14. Yang S, Qiao J, Zhang M, Kwok LY, Matijašić BB, Zhang H, Zhang W. Prevention and treatment of antibiotics-associated adverse effects through the use of

probiotics: A review. J Adv Res. 2025 May;71:209-226. doi: 10.1016/j.jare.2024.06.006. Epub 2024 Jun 4.

Additional

1. Herasymenko V. H., Herasymenko M. O., Tsvilikhovskyi M. I. Biotekhnolohiia: pidruchnyk. Kyiv: Firma «INKOS», 2006. 647 s.
2. Posokhova K. A., Viktor O. P. Antybiotyky (vlastyvoli, zastosuvannia, vzaiemodiiia). Ternopil: TDMU «Ukrmedknyha», 2005. 296 s.
3. Fedorenko V. O., Ostash B. O., Honchar M. V., Rebets Yu. V. Velykyi praktykum z henetyky, henetychnoi inzhenerii ta analitychnoi biotekhnolohii mikroorhanizmiv. Lviv: Vydavnychy tsestr LNU imeni Ivana Franka, 2017. 277 s.
4. de Abreu V. A. C., Perdigão J., Almeida S. Metagenomic approaches to analyze antimicrobial resistance: an overview. *Frontiers in Genetics*. 2021. Vol. 11. 575592. DOI: 10.3389/fgene.2020.575592.
5. Alcock B. P. et al. CARD 2023: antibiotic resistome surveillance with the Comprehensive Antibiotic Resistance Database. *Nucleic Acids Research*. 2023. Vol. 51(D1). P. D690–D699. DOI: 10.1093/nar/gkac920.
6. Aminov R. Metabolomics in antimicrobial drug discovery. *Expert Opinion on Drug Discovery*. 2022. Vol. 17(1). P. 1–13.
7. Blin K. et al. antiSMASH 6.0: improving cluster detection and comparison capabilities. *Nucleic Acids Research*. 2021. Vol. 49(W1). P. W29–W35. DOI: 10.1093/nar/gkab335.
8. Bush K., Bradford P. A. β -Lactams and β -lactamase inhibitors: an overview. *Cold Spring Harbor Perspectives in Medicine*. 2020. Vol. 10(8). a025247. DOI: 10.1101/cshperspect.a025247.
9. Chernov V. M., Chernova O. A., Mouzykantov A. A., Lopukhov L. L., Aminov R. I. Omics of antimicrobials and antimicrobial resistance. *Expert Opinion on Drug Discovery*. 2019. Vol. 14(5). P. 455–468.
10. Davies J., Davies D. Origins and evolution of antibiotic resistance. *Microbiology and Molecular Biology Reviews*. 2010. Vol. 74(3). P. 417–433. DOI: 10.1128/MMBR.00016-10.
11. Hall-Stoodley L., Costerton J. W., Stoodley P. Bacterial biofilms: from the natural environment to infectious diseases. *Clinical Microbiology Reviews*. 2004. Vol. 17(4). P. 881–906. DOI: 10.1128/CMR.17.4.881-906.2004.
12. Kortright K. E. et al. Phage therapy: a renewed approach to combat antibiotic-resistant bacteria. *Cell Host & Microbe*. 2019. Vol. 25(2). P. 219–232. DOI: 10.1016/j.chom.2019.01.014.
13. Laxminarayan R. et al. Achieving global targets for antimicrobial resistance. *Science*. 2016. Vol. 353(6302). P. 874–875. DOI: 10.1126/science.aaf9286.

14. Robinson T. P. et al. Antibiotic resistance is the quintessential One Health issue. Transactions of the Royal Society of Tropical Medicine and Hygiene. 2016. Vol. 110(7). P. 377–380. DOI: 10.1093/trstmh/trw048.

15. Ventola C. L. The antibiotic resistance crisis: causes and threats. P&T. 2015. Vol. 40(4). P. 277–283.

Electronic Information Resources

1. European Committee on Antimicrobial Susceptibility Testing (EUCAST). Breakpoint tables for interpretation of MICs and zone diameters. 2024. URL: <https://www.eucast.org/>

2. Clinical and Laboratory Standards Institute (CLSI). Performance standards for antimicrobial susceptibility testing. 2023. URL: <https://clsi.org/>

3. World Health Organization. Global antimicrobial resistance and use surveillance system (GLASS) report. 2023. URL: <https://www.who.int/initiatives/glass>

4. European Medicines Agency. Guideline on the evaluation of medicinal products indicated for treatment of bacterial infections. 2024. URL: <https://www.ema.europa.eu/>

5. U.S. Food and Drug Administration. Antibacterial therapies: development resources. 2023. URL: <https://www.fda.gov/>

6. <https://card.mcmaster.ca/>

7. <https://www.ecdc.europa.eu/en/antimicrobial-consumption/surveillance-and-disease-data/database>

8. www.manetec-52.de

9. <https://www.pharmencyclopedia.com.ua/article/2810/antibiotiki>

10. <https://www.who.int/csr/resources/publications/drugresist/antibiotics.pdf>

11. <https://resistancemap.cddep.org/>

12. <http://www.wsmicrobiology.com/category/virology/>

13. <http://sci-lib.com/subject.php?subject=4&pp=1>

14. <http://www.youalib.com/>

15. <https://nccih.nih.gov/health/probiotics/introduction.htm>

16. <http://probiotics.mercola.com/probiotics.html>

17. [Bioethics Special Issue: The Ethics of Antibiotic Resistance | The Oxford Uehiro Centre for Practical Ethics](#)

18. [Questions and Answers on Current Good Manufacturing Practice Requirements | Buildings and Facilities | FDA](#)

19. [MFGGuidelines WEB CONFIDENTIAL \(internationalprobiotics.org\)](#)

20. [CAMPR4: a database of natural and synthetic antimicrobial peptides \(bicnirrh.res.in\)](#)

21. [ARTS-DB \(ziemertlab.com\)](http://ziemertlab.com)
22. [Antimicrobial Peptide Database - DBAASP](#)
23. [The Comprehensive Antibiotic Resistance Database \(mcmaster.ca\)](#)
24. [AMR data platforms – JPIAMR](#) – database description
25. <https://www.eucast.org/>
26. <https://clsi.org/>