University of Tehran

College of Science

School of Biology

Description of program and course syllabi

Microbiology

Master of Science

General Course curriculum of microbiology in master's degree

Table 1. Required courses

Major: microbiology Program: Master of Science

Prerequisite	Hours			Units			Course name	No.
	Total	Practical	Theoretical	Total	Practical	Theoretical		
None	32	0	32	2	0	2	Prokaryotic Physiology	1
None	32	0	32	2	0	2	Genetics of Prokaryotes	2
None	32	0	32	2	0	2	Microbial Biotechnology	3
None	32	0	32	2	0	2	Microbial Virology	4
None	32	0	32	2	0	2	Microbial Ecosystems	5
None	32	0	32	2	0	2	Cellular Microbiology	6
–	192	0	192	2	0	12	Total	

Students are required to pass 12 units from units in table1.

Table 2. elective courses

Major: microbiology Program: Master of Science

Prerequisite	Hours			Units			Course name	No.
	Total	Practical	Theoretical	Total	Practical	Theoretical		
None	32	0	32	2	0	2	Biosafety	1
None	32	0	32	2	0	2	Bacterial Toxin and Mechanism of Action	2
None	32	0	32	2	0	2	Antimicrobial Compounds-Mechanisms of Action and Microbial Resistance	3
None	32	0	32	2	0	2	Bioinformatics	4
None	32	0	32	2	0	2	Fundamentals of Preservation of Microorganisms	5
None	32	0	32	2	0	2	Biology of Extremophiles	6
None	32	0	32	2	0	2	Molecular Immunology	7
-	224	0	224	14	0	14	Total	

Students are required to pass 10 units from units in table2.

The supervisor can set a maximum of 12 units from a lower level for the student.

Topics of required courses

Major: Microbiology

Program: Master of Science

Course title: Physiology of prokaryotes

No. of units: 2
No. of hours: 32
Unit type: theoretical
Course type: required
Prerequisites: none
Additional training: yes **Scientific expedition:** no **Workshop:** no **Lab:** no **Seminar:** yes
The overall objectives of the course:
The purpose of this course is to familiarize students with microbial cells function, including growth, metabolism and the manner of perception and response to environmental stress.

Topics of the course:

1- **Review of the eubacteria and pathogenic eukaryotic microorganisms**
2- **Study of cytoplasmic membrane in bacteria and its role in metabolism**
3- Other cellular components include: capsule, pilus and its types - and movement, structure and types of flagellum in pathogenic bacteria and its role in chemotaxis
4. The mechanism of chemotactic action as a model for studying regulatory two-component system in bacteria
5- Other types of taxis (phototaxis, aerotaxis) and their mechanism.
6- Quorum sensing and its role in pathogenesis.
7- Iron absorption mechanisms by microorganisms, Siderophores: types and function.
8. Growth and differentiation in bacteria: endospore formation, sporulation mechanism, spore molecular structure, sporulation regulation
9- Physiology of microbial biofilms: Structure and biofilm formation
10. Factors affecting the formation of biofilm, regulation and genetics of biofilm formation and their role in pathogenesis
11-Metabolism and different ways of energy acquisition in pathogenic bacteria
12. Aerobic and anaerobic metabolism
13. Studying of biosynthesis of microbial macromolecules: lipids, proteins, and polysaccharides in bacterial pathogens .
14. Specific types of metabolic pathways in bacteria
15. Cell division, regulation and role of intracellular structures
16. Growth control and various sterilization techniques.
17- Various methods of studying growth and differentiation in laboratory conditions.
18- Regulation of oxidative stress response in microorganisms.
19- Starvation, thermal, and acidity tension and response regulation to them.
20- Two component systems in bacteria.
21. The Importance of signal transduction in Regulating Pathogenicity of Bacteria

Table of assessment

Continuous evaluation	Midterm	Final exam	Project
10%	**-**	**70%- written**	**20%**

references:

-Microbial physiology. Moat, A. G., Foster, J. W., Spector, M. P. and Sector, M. P. 4th edition, Brock biology of Microorganisms. Michael T. Madigan et al. (13 th edition).

Course title: Genetics of Prokaryotes

No. of units: 2
No. of hours: 32
Unit type: theoretical
Course type: required
Prerequisites: none
Additional training: yes **Scientific expedition:** no **Workshop:** no **Lab:** no
Seminar: yes

The overall objectives of the course:
Familiarity with the principles of the genetics of prokaryotes, and the details of the molecular and genetic processes that are effective in replication, transcription and translation and their regulatory mechanisms

Topics of the course:

1. Genome structure in bacteria
2. Mutation and repair mechanisms of bacterial genome.
3. Translation and regulation of gene expression in bacteria
4. Types of horizontal transfer of genes in bacteria
5. Biology of transposons and transposable genetic elements
6. Biology of plasmids and their kinds in genetic engineering
7. Preparation of cDNA library and genomic library in bacteria
8. Composition and technology of recombinant DNA in bacteria
9. Molecular cloning in bacteria
10. Expression of recombinant gene in bacteria
11. Genetic stability in industrial prokaryotes

Table of assessment

Continuous evaluation	Midterm	Final exam	Project
10%	**-**	**70%- written**	**20%**

References:

- Molecular Genetics of Bacteria (2007) Larry Snyder and Wendy Champnes 3rd edition.ASM press.

-Gene Cloning and DNA Analysis: An Introduction. Sixth Edition (2010) T.A. Brown, Wiley-Blackwell, UK.

- Principles of Gene Manipulation and Genomics, Third Edition (2006) S.B. Primrose, S.B. and R.M. Twyman, Blackwell Publishing Company, Oxford, UK.

- Molecular Genetics of Bacteria, 4th Edition by Prof Jeremy W. Dale, Simon F. Park. Wiley, 2004

Course title: Microbial Biotechnology

No. of units: 2
No. of hours: 32
Unit type: theoretical
Course type: required
Prerequisites: none
Additional training: yes **Scientific expedition:** no **Workshop:** no **Lab:** no **Seminar:** yes

The overall objectives of the course:

The purpose of this course is to familiarize students with microbial cells function, including growth, metabolism and their application in different industrial biotechnology areas.

Topics of the course:

1. Microorganisms used in biotechnology: Properties and improvement.
2. Genetic manipulation of industrial microorganisms
3. Application of Omics in Microbial Biotechnology
4. Upstream processing
5. Fermentation technology
6. Antibiotics production
7. Production of primary metabolites: organic acids, solvents and amino acids
8. Biopolymers and microbial biosurfactants
9. Single cell proteins (SCP)
10. Microbial enzymes

Table of assessment

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10%	**-**	**70%- written**	**20%**

References:

-Microbial Biotechnology: Fundamentals of Applied Microbiology. Alexander N. Glazer and Hiroshi Nikaido (2007), Cambridge University Press.

-Microbial Biotechnology. Yuan Kun Lee (2013) World scientific.

Course title: Microbial Virology

No. of units: 2
No. of hours: 32
Unit type: theoretical
Course type: required
Prerequisites: none
Additional training: yes **Scientific expedition:** no **Workshop:** no **Lab:** no **Seminar:** yes
The overall objectives of the course:

Familiarity with the systematic principles of microbial viruses, including bacteriophages and archeal viruses and fungi. The mechanisms of growth and replication in viruses with the details and description of molecular processes are the goals of the lesson.

Topics of the course:

1. Biology and genetics of virulent phages (phages with a large DNA genome, phages with small DNA genomes, phages with the RNA genome)
2. Biology and genetic of moderate phages (Lambda Phage , Mu I Phage as the transposional model, P1 phage as a plasmid model)
3. Defective phages and phage-like structures
4. phage evolution
5. The mechanisms of infecting and the release of phages
6. DNA transfer from phage to its host
7. The role of phages in changing the host cell phenotype
8. Bacteriophages in medicine (phage therapy, antigen presenting via phage)
9. Bacteriophages in the environment
10. Bacteriophages in fermented foods
11. Relationship of bacteriophages and lactic acid bacteria
12. Toxonomy of archeal Viruses
13. Biology and mechanisms of archeal virus infection
14. Toxonomy of fungal viruses
15. Biology and mechanisms of fungal viruses infection

Table of assessment

Continuous evaluation	Midterm	Final exam	Project
10%	**-**	**70%- written**	**20%**

References:

-Bacteriophage: Genetics and Molecular Biology, by Stephen Mc Grath, Douwe van Sinderen, Horizon Scientific Press, 2007

-Bacteriophages: Biology and Applications, by Elizabeth Kutter, Alexander Sulakvelidze, CRC Press, 2004

-Fields Virology, by David M Knipe, Peter Howley, Lippincott Williams & Wilkins, 2013

-Mycoviruses, by Said Ghabrial, Academic Press, 2013

Course title: Microbial Ecosystems

No. of units: 2
No. of hours: 32
Unit type: theoretical
Course type: required
Prerequisites: none
Additional training: yes **Scientific expedition:** no **Workshop:** no **Lab:** no **Seminar:** yes

The overall objectives of the course:

The study of modern molecular ecology in the microbial world, the recognition of positive and negative relationships among microbial populations, Students' acquaintance withthe sampling of various ecosystems, and learning the standard methods in order to studying microbial biodiversity

Topics of the course:

1. Water and soil sampling methods and sample processing
2. Genomic and metagenogic of water and soil environments
3. Microbial culturing techniques
4. The molecular ecology of microbes in the environment
5. Standard Methods for Microbial Biodiversity assessment
6. Chemical analysis of microbial cells
7. DNA-DNA hybridization
8. Nucleic acid analysis
9. Response of microorganisms to environmental stresses
10. cooperative Interactions between microbes in the environment
11. Relationships between microorganisms and animals
12. Relationships between microorganisms and plants

Table of assessment

Continuous evaluation	Midterm	Final exam	Project
10%	**-**	**70%- written**	**20%**

References:

- Microbial Ecology, Wiley, Barton & Northup, 2011.

- Prescott Microbiology. Willey, Sherwood, and Woolverton (2011), McGraw.Hill .

- Microbial ecology: Fundamentals and applications 4th edition, Atlas and Barta, 1997.

Course title: Cellular Microbiology

No. of units: 2
No. of hours: 32
Unit type: theoretical
Course type: required
Prerequisites: none
Additional training: yes **Scientific expedition:** no **Workshop:** no **Lab:** no **Seminar:** yes
The overall objectives of the course:
Students' acquaintance with the interaction of microorganisms with their hosts at the cellular and molecular level

Topics of the course:

1- The relationship between microbes and cells - the role of microorganisms in the evolution of animals and plants

2 - Interaction of microbes (bacteria) with animal cells

- Consequences of microbial symbiosis with animal cells
- Bacterial adhesins and cell ligands -bacterial tropism to host cells
- Interaction of bacteria with extracellular matrix in tissues
- Bacteria adhesion to the cell surface and signal transmission to the cell - the effect on the cellular skeleton
- Lipid rafts and transferring bacterial signal transmission to the cell
- The role of bacteria in the formation of granuloma
- Mechanisms of bacteria establishment on the surface or inside the cell

3 - Interaction of:

- bacteria with plant cells
- bacteria with lichens
- Bacteria with mycorrhizal fungi
- Bacteria with plant roots - nitrogen fixation
- Bacteria with plant roots - Transfer of genetic material

4- Interaction of microbes with other organisms

- Bacteria with: Arthropods - Marine organisms - extremophile organisms
- Review of the new articles

Table of assessment

Continuous evaluation	Midterm	Final exam	Project
10%	**-**	**70%- written**	**20%**

References:

-Cellular Microbiology. Cossart, P (2005). ASM Press ،9th edition.

-Life-The science of biology. Sadava D, Hillis DM, Heller HC, Berenbaum MR (2010).

-Plant microbiology. Gillings M, Holmes A (2004). Garland Science /Bios Scientific publishers

Course title: Biosafety

No. of units: 2
No. of hours: 32
Unit type: theoretical
Course type: required
Prerequisites: none
Additional training: yes **Scientific expedition:** no **Workshop:** no **Lab:** no
Seminar: yes
The overall objectives of the course:
Learning how to work with chemical and biological substances, laboratory equipment, or regarding the principles of safety during incident or sampling in natural environments, as well as the correct disposal of laboratory wastes.

Topics of the course:

An introduction to Biosafety, working in research labs and basis of classifying potentially dangerous biological agents.

1. **Safety principles of working with chemicals. storage of chemicals, working with gases and explosive chemicals and providing MSDS**
2. **Safety principles of working with chemicals. labeling of chemicals, solvents, volatile substances, warning signs and labeling principles**
3. **Safety principles of working with chemical, acquaintance with liquid and gas refrigerants , explosive materials, safety with acids and alkalis, corrosive and irritating substances, incompatible chemicals and reactive substances, and inflammable chemicals.**
4. **Radiation safety principles. Basic principles of radiation safety, biological effects of ultraviolet radiation and how to protect against it.**
5. **Safety principles of working with biomaterials and biological quaternary levels 1, 2, 3 and 4**
6. **Safety and personal protective equipment, type I laboratories, second and third level laboratories, essentials, symptoms and abbreviations**
7. **Safety considerations of recombinant DNA technology and biological expression systems, risk assessment of genetically modified organisms**

8. **Biological ethics, biological safety for working with common materials in genetic laboratories and genetic engineering**
9. **Principles of transportation of biological materials, its international laws, decontamination and going against discarding chemical and biological substances**
10. **safety tips when working in the field or when sampling**
11. **Good Laboratory Practice and Standard Laboratory Practice (SOP)**
12. **Dealing with the risk and manner of risk reporting, decontamination and opposing chemical and biological disposal, discarding bio-wastes.**
13. **Essential relief supplies / materials in laboratories and first aid in the event of biological science labs accidents**
14. **Principles of calibration and maintenance of devices, regulations on safety signs in laboratories**

Table of assessment

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References:

-Laboratory Biosafety Manual. 2004; 3rd ed; WHO; Geneva; Switzerland.

-Biological Safety Manual. 2007; University of Pennsylvania; Pennsylvania; USA.

-Seiler J. P. (2005) Good Laboratory Practice – the Why and the How. Springer

-Guidance on Regulations For the Transport of Infectious Substances; 2007–2008; WHO; USA.

Course title: Bacterial Toxins and Mechanism of Action

No. of units: 2
No. of hours: 32
Unit type: theoretical
Course type: elective
Prerequisites: none
Additional training: yes **Scientific expedition:** no **Workshop:** no **Lab:** no
Seminar: yes
The overall objectives of the course:
After completing this course, students can describe different types of microbial toxins and their functions and roles in pathogenesis.

Topics of the course:

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1. The position of microbial toxins in microbial sciences and technologies, pathogenicity, genetics and other pathogenic factors
2. Biogenesis of Toxins: membrane transport
3. Secretory systems in bacteria and their roles in toxin transport
4. classification of toxins (based on the structure and mechanism of action)
5. A complete study of the enterotoxin produced by *Vibrio cholerae* as a model for adenylate cyclase toxins: structure, receptors, mechanism of action and genetic regulation
6. Study of cholera-like enterotoxins, regarding of structural and mechanical differences (Escherichia coli toxins)
7. study of Shigella toxin produced by Shigella spp and Shigella-like toxins: structure, receptors, mechanism of action and pathogenesis, their relationship with other inhibitory toxins of ribosomes
8. pertussis toxin and other toxins produced by *Bordetella pertussis*
9. anthrax toxin and other toxins produced by *Bacillus anthracis*
10. Diphtheria toxins and similar toxins
11. Neurotoxins: tetanus and botulism
12. host cell membrane damaging toxins classification, structure and mechanism of action
13. Bacteriocins: A study of several models such as E. coli Bacteriocins
14. Fungal Toxins: Types, structure, toxic effects, stability, International standards

15. Laboratory methods to Identify and investigate the effects of toxins

16. Use of toxins in biology, treatment and vaccines production

Table of assessment

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References:

-Bacterial Protein Toxins, Drusilla L . Burns & al. American Society for Microbiology (last edition).

- Microbial Toxins: Current Research and Future Trends, Edited by Thomas Proft, 2009 Caister Academic Press, Norfolk, UK.

-Virulence Mechanisms of Bactrial Pathogens James A. Roth: ASM Press-1995 (2th Edition) and the same by Kim A. Brogden, ASM press-2007.

Course title: Antimicrobial Compounds-Mechanisms of Action and Microbial Resistance

No. of units: 2
No. of hours: 32
Unit type: theoretical
Course type: elective
Prerequisites: none
Additional training: yes **Scientific expedition:** no **Workshop:** no **Lab:** no
Seminar: yes
The overall objectives of the course:
acquaintance with the history of antibiotics discovery, the importance of antibiotics production in microbial populations, their application in treatment and importance of microbial resistance

Topics of the course:

1.Introduction - The History of Antibiotics' discovery
2.Antibiotic-producing bacteria - The mechanism of immunity against self antibiotics
3.Induction of antibiotic production in antibiotic producing bacteria
4.Classification of antibiotics based on target molecule
5.The mechanism of the antibiotics' effect on bacteria
6.The bacterial resistance mechanisms against antibiotics
7. Classification of antibiotics according to their effect on extracellular or intracellular bacteria
8.Classification of antibiotics according to their effect on extracellular or intracellular bacteria
9. Efflux pumps.
10. The role of transposable genetic elements in spreading antibiotic resistance within bacterial population
11. Anti-fungal antibiotics.
12. Anti-parasite antibiotics.
13. The role of foods and humans' modern life style in the spread of antibiotic-resistant bacteria.
14. New antibiotics - Overcoming the resistance of microbes.

15. Review of the new articles

Table of assessment

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10%	**-**	**70%- written**	**20%**

References:

-Antibiotics - Mechanism of action and development of resistance. Walsh, C (2003), ASM Press.

- Antimicrobial agents- Antibacterials and antifungals B.ryskier, A (2005).

- Antibiotics, Current innovations and future trends. Sergio Sanchez and Arnold L. Demain .2015. Caister Academic Press.

Course title: Bioinformatics

No. of units: 2
No. of hours: 32
Unit type: theoretical
Course type: elective
Prerequisites: none
Additional training: yes **Scientific expedition:** no **Workshop:** no **Lab:** no **Seminar:** yes
The overall objectives of the course:
Students' acquaintance with biological databases and phylogeny trees analysis to determine the position of microbial species in the evolutionary tree of life and gene prediction in prokaryotes and eukaryotes.

Topics of the course:

1. **Introduction including the history and importance of bioinformatics**
2. **Information databases including bibliography, first type databases such as protein and nucleotide databases**
3. **Second type databases such as Blocks, Prosite**
4. **Pair alignment of sequences including scoring matrices**
5. **Global and local alignment**
6. **Multiple alignment of sequences including methods of scoring such as progressive and iterative methods**
7. **Phylogeny trees that include distance-based and maximum-likelihood methods**
8. **Predicting the Secondary RNA Structure**
9. **Genome analysis including gene prediction in prokaryotes and eukaryotes**
10. **Protein classification and prediction of spatial structure of protein**
11. **Special issues**

Table of assessment

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10%	**-**	**70%- written**	**20%**

References:

-Bioinformatics. Mount D.W.(2004) .Cold spring Harbor Laboratory Press.

-Structural ,Bioinformatics. Borne P. and T. Weissiny, (2003). Wiley Publishing.

-Basic Bioinformatics. Ignaamathu S. (2004). Alpha Science International,Ltd.

-Bioinformatics and molecular evolution. Higgs P. and T. Attwood, (2005). Blackwell Publishing.UK.

Course title: Fundamentals of Preservation of Microorganisms

No. of units: 2
No. of hours: 32
Unit type: theoretical
Course type: elective
Prerequisites: none
Additional training: yes **Scientific expedition:** no **Workshop:** no **Lab:** no
Seminar: yes
The overall objectives of the course:
Isolation, identification and maintenance of microorganisms and ultimately storage in microbial banks is an useful act in the interest of biodiversity conservation. necessity of stable and sustainable bio-materials maintenance is one of the basic requirements in the biosciences, medicine, agriculture and biotechnology.

Topics of the course:

1. **. necessity of stable and sustainable bio-materials maintenance**
2. History of the formation and development of biological resources collections.
3. conservation of microorganisms in an inactive state
4. conservation of microorganisms at low temperatures and effective factors in keeping them at ultracold temperature
5. Protective factors in the cold
6. Storage of biological samples in liquid nitrogen
7. Lyophilization - Methods and Applications
8. Activation of Lyophilized ampoules
9. Quality control processes for stored biological samples
10. Quality control during and after the storage of biological samples

Table of assessment

Continuous evaluation	Midterm	Final exam	Project
10%	**-**	**70%- written**	**20%**

References:

-Preservation and Maintenance of Microbial Cultures. S. Kumar, P. Kashyap, R. Singh, A. K. Srivastava (2013). Springer.

Course title: Biology of Extremophiles

No. of units: 2
No. of hours: 32
Unit type: theoretical
Course type: elective
Prerequisites: none
Additional training: yes **Scientific expedition:** no **Workshop:** no **Lab:** no **Seminar:** yes
The overall objectives of the course:
Determination of Extreme environments, the role of Extremophile microorganisms in biotechnology, and understanding the compatibility of Extremophile microorganisms with harsh environmental conditions

Topics of the course:

1. **Extremophiles and the origin of life**
2. **Warm environments and biodiversity**
3. **Functional genomes in thermophilic microorganisms**
4. **Biology and biodiversity of cold-adapted microorganisms**
5. **Biodiversity in high salinity environments**
6. **Molecular compatibility in high salinity environments**
7. **Physiology and ecology of acidophilic Microorganisms**
8. **Peripheral genomic of acidophiles**
9. **Biodiversity, Taxonomy and environmental diversity of alkaliphiles**
10. **Microbial adaptation at high pressures**
11. **Astrobiology and search for life in the universe**
12. **Biology of other extremophile groups**
13. **Biotechnology of extremophile Microorganisms**

Table of assessment

Continuous evaluation	Midterm	Final exam	Project
10%	**-**	**70%- written**	**20%**

References:

-Extremophiles Handbook, Horikosh: et al, 2011.

-Physiology and biochemistry of Extremophiles Gerday & Glans DDrff, 2007**.**

Course title: Molecular Immunology

No. of units: 2
No. of hours: 32
Unit type: theoretical
Course type: elective
Prerequisites: none
Additional training: yes **Scientific expedition:** no **Workshop:** no **Lab:** no **Seminar:** yes
The overall objectives of the course:
Students' acquaintance with the innate and adaptive immune system responses to germs, the manner in which microbes escape from host defenses as well as vaccine design.

Topics of the course:

1. General features of immune responses to the germs

2. Immune responses to the extracellular bacteria

3. Innate immune responses to the extracellular bacteria

4- Adaptive immune responses to the extracellular bacteria

5. Escape of extracellular bacteria from immune mechanisms

6. Immune responses to the intracellular bacteria

7. Innate immune responses to the intracellular bacteria

8. Adaptive immune responses to the intracellular bacteria

9. Escape of intracellular bacteria from immune mechanisms

10. innate and adaptive immune responses to fungi

11. Immune responses to viruses

12. Innate immune responses to viruses

13. Adaptive immune responses to viruses

14. Virus escape from immune mechanisms

15. Immune responses to the parasites

16. Innate immune responses to parasites

17. Adaptive immune responses to parasites

18. Parasite escape from immunity mechanisms

19. Strategies for vaccine design

Table of assessment

Continuous evaluation	Midterm	Final exam	Project
10%	**-**	**70%- written**	**20%**

References:

-Cellular and molecular immunology. Abbas A.K. and Lichtman A.H., 6th edition, 2010