University of Tehran

College of Science

School of Biology

Description of program and course syllabi

Microbiology

Ph.D.

Table 1- required - elective courses

Major: Microbiology Program: Ph.D.

No.	Course name	Units			Hours			Prerequisite
		Theoretical	Practical	Total	Theoretical	Practical	Total	
1	Advanced Bacteriology	2	0	2	32	0	32	None
2	Biology of Archaea	2	0	2	32	0	32	None
3	Microbial Genetic Engineering	2	0	2	32	0	32	None
4	Molecular virlogy	2	0	2	32	0	32	None
5	Advanced Microbial Biotechnology	2	0	2	32	0	32	None
6	Marine Microbiology	2	0	2	32	0	32	None
7	Interaction Between Parasite and Host	2	0	2	32	0	32	None
8	Protocols in Microbiology	2	0	2	32	0	32	None
9	Evolution of Microorganisms	2	0	2	32	0	32	None
10	Immunopathogenesis of Microbial Infections	2	0	2	32	0	32	None
11	Biology of Anaerobes	2	0	2	32	0	32	None
12	Polyphasic Taxonomy	2	0	2	32	0	32	None
13	Bioinformatics	2	0	2	32	0	32	None
14	Seminar	2	0	2	32	0	32	None
Total		28	0	28	448	0	448	-

Students must take 14 units from this table.

Prerequisites for Doctorate of Philosophy degree in Microbiology.

The student's supervisor requires the student to take up to 6 units of lower level courses.

Topics of Specialized-Elective courses

Major: Microbiology

Program: Ph.D.

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

Students become familiar with principles of Bacterial Pathogenesis including mechanism of pathogenicity and virulence factors.

Topics of the course:

1- Methods for study of bacterial pathogenicity
2- Methods of detection of bacterial pathogenic genes
3- Genetic factors in bacterial pathogenicity
4- Bacterial adhesins: Fimbria
5- Bacterial adhesins: Non fimbria
6- Bacterial biofilms
7- Effective bacterial toxins on host plasma membrane.
8- Effective bacterial toxins on host intracellular structures.
9- Mechanism of bacterial entry to host cells.
10- The bacterial life in host cell's vacuole.
11- The bacterial life in host cell's cytosol.
12- Bacterial use of host's nutrients
13- Escape of bacteria from complement system.
14- Resistance of bacteria to antibacterial peptides.
15- Bacteria-induced host cell death

Table of assessment

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

References:

-Bacterial Pathogenesis: Molecular and Cellular Mechanisms, Camille Locht, Michel Simonet- 2012

Course title: Biology of Archaea
No. of units: 2
No. of hours: 32
Unit type: theoretical
Course type: Specialist-Elective
Prerequisites: none
Additional training: yes
Scientific expedition: no**Workshop:** no**Lab:** no**Seminar:** yes
The overall objectives of the course:
Archaea bacteria are third domain of life. The goals of this course are understanding physiology, metabolism and growth, genomic structure and genomic compatibility mechanisms in this domain. Archaea according to special physiologic properties usually live in harsh environment. The main objectives of this course are mechanisms of motility, getting energy, interaction with other microbial groups and intracellular signaling. Also, cellular structure and genome organization, replication and transcription system are discussed in this course.

Topics of the course:
1- Archaebacterial domain.
2- Structure and Ultrastructure of Archaea.
3- Archaebacterial Cell wall Structure and S layer structure.
4- Catabolism and anabolism in Archaea.
5- Glycolytic pathway in Archaea.
6- Methanogens: production pathways of methane and getting energy.
7- Lipid biosynthesis and function.
8- Inorganic sulfur metabolism.
9- Solutes transportation systems.
10- Chemotaxy
11- DNA replication and life cycle.
12- DNA repair systems.
13- Transcription: mechanism and regulation
14- Translation mechanism and protein synthesis.

Table of assessment

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

References:
- Archaea, Molecular and Cellular biology. R. Cavicchioli. (2008). ASM press.

- Archaea, Evolution, physiology and molecular biology. R.A. Garrett and H-P Klenk. (2007). Blackwell publishing. UK.

Course title: Microbial Genetic Engineering
No. of units: 2
No. of hours: 32
Unit type: theoretical
Course type: Specialist-Elective
Prerequisites: none
Additional training: yes
Scientific expedition: no**Workshop:** no**Lab:** no**Seminar:** yes
The overall objectives of the course:
Understanding the principles of genetic engineering, detailed description of molecular processes and practical genetics in gene manipulation, genetic modifications and production of recombinant structures are goals of this course.
Topics of the course:

1- Extraction and purification of DNA.
2- Vector systems (restriction enzymes, plasmids, bacteriophages, prokaryotes and eukaryotes expression vector).
3- DNA transformation.
4- Selecting systems for recombinant gene
5- Gene cloning (PCR cloning, shotgun cloning, cDNA cloning).
6- Types of restriction enzymes and their restriction sites.
7- Gene and genome sequencing.
8- Techniques for studying gene expression and their applications.
9- Gene cloning and producing recombinant protein.
10- Application of genetic modifications in gene by direct mutation and protein engineering.
11- Cloning in gram negative bacteria except*E. coli*
12- Cloning in gram positive bacteria.
13- Cloning in *Saccharomyces cerevisiae*.
14- Applications of genetic engineering in medicine.
15- Applications of genetic engineering in agriculture.
16- Genetic engineering in animals (Knockouts and knockin).

Table of assessment

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

References:
-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 (2007) Larry Snyder and Wendy Champnes 3rd edition.ASM press.

Course title: molecular virology
No. of units: 2
No. of hours: 32
Unit type: theoretical
Course type: Specialist-Elective
Prerequisites: none
Additional training: yes
Scientific expedition: no**Workshop:** no**Lab:** no**Seminar:** yes
The overall objectives of the course:
To understand the principles molecular virology and mechanisms of virus's growth and proliferation with detail, description of molecular processes and types of proliferation and replication mechanisms in viruses, are main objectives of this course.
Topics of the course:

1- Structure and symmetry of capsid and viral morphogenesis
2- Binding of virus to cell and reciprocal cellular response.
3- Viral entry into host cell mechanism.
4- Transportation of virus into host cell.
5- Viral structure and complexity of genome.
6- RNA virus replication and transcription mechanism.
7- RNA virus reverse transcription mechanism.
8- DNA virus transcription mechanism.
9- DNA virus replication mechanism.
10- Regulation of translation and gene expression mechanisms in virus.
11- Mechanism of Viral self-assembly
12- Mechanism of Viral maturation and release from host cell

Table of assessment

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

References:
-Fields Virology, David M. Knipe , Peter Howley , Lippincott Williams & Wilkins; 6th edition.

-Principles of Molecular Virology, Alan J. Cann, Academic Press; 5th edition.

-Principles of Virology, S. Jane Flint, L. W. Enquist, Vincent R. Racaniello, ASM Press; 3rd edition.

Course title: Advanced Microbial Biotechnology
No. of units: 2
No. of hours: 32
Unit type: theoretical
Course type: Specialist-Elective
Prerequisites: none
Additional training: yes
Scientific expedition: no**Workshop:** no**Lab:** no**Seminar:** yes
The overall objectives of the course:
Getting to know the ability of different subgroups of microbes, bacteria, molds, yeasts and archaea for introduction to industry and biotechnological processes. Indentifying microorganisms role and different functions in pharmaceutical industries, environmental applications, agriculture, mine and medicine as well as understanding biotechnological ability of extremophiles are main goals of this course.
Topics of the course:
1- Beneficial microorganisms in biotechnology.
2- Genetic manipulation of microorganisms.
3- Omic applications in microbial biotechnology.
4- Archaea and their applications.
5- Recombinant protein production in bacteria and fungi.
6- Antibiotics production and process.
7- Production of primary metabolites: organic acids and amino acids.
8- Microbial biopolymers and biosurfactants.
9- Microbial energy transformation.
10- Microbial biomass as products.
11- Microbial biotransformation.
12- Microbial bioremediation and biodegradation.
13- Role of microbes in agricultural biotechnology.
14- Biomining and bioleaching.
15- Biotechnological application of marine microorganism.
16- Extremophiles and their applications in biotechnology.
17- Microbial vaccines.
Table of assessment

Continuous evaluation	Midterm	Final exam	Project
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: Marine Microbiology
No. of units: 2
No. of hours: 32
Unit type: theoretical
Course type: Specialist-Elective
Prerequisites: none
Additional training: yes
Scientific expedition: no**Workshop:** no**Lab:** no**Seminar:** yes
The overall objectives of the course:
To understand ecology, biodiversity, function, physiology, metabolism and growth of marine microorganism growth, and to understand marine microorganism biotechnological ability are main objectives of this course.
Topics of the course:

1- Marine ecosystems and environmental factors.
2- Marine food chain.
3- Microorganisms in seas and oceans
4- Archaeal and bacterial biodiversity in sea.
5- Energy cycle in marine ecosystems.
6- Interactions between microbes in marine ecosystems.
7- Production of primary metabolites: organic acids and amino acids
8- Carbon cycle in marine ecosystems.
9- Nitrogen cycle in sea.
10- Phosphor and sulfur cycle in marine ecosystems.
11- Methods for studying activity and biodiversity of microorganisms in oceans.
12- Marine viruses.
13- Photosynthesis in sea.
14- Biotechnological application of marine microorganisms.

Table of assessment

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

References:

1. Prescott's Microbiology. Willey et al., (2012). McGraw hill international.

2. Marine Microbiology and Application. Colin Munn, (2003). Humana Press.

3. Microbial ecology of the Ocean. David L. Kirchman, (2010). John Wiley and Son.

Course title: Interaction between Parasite and Host
No. of units:2
No. of hours:32
Unit type: theoretical
Course type: Specialist-Elective
Prerequisites: none
Additional training: yes
Scientific expedition: no **Workshop:** no **Lab:** no **Seminar:** yes
The overall objectives of the course:
Students become acquainted with the evolutionary process involved in the emergence of intracellular microorganisms.
Topics of the course:
1- Emergence of intracellular organism and colonization of special habitats
2- Parasites and intracellular symbionts
3- Host genetic status and intracellular symbionts –gene transfer
4- Phagocytosis- recognizing particles and phagocytosis- phagosome formation.
5- Different models for studying phagosome formation.
6- Impact of pathogens on phagosome formation.
7- Antibiotic treatment of intracellular infections.
8- Immune response to intracellular pathogens.
9- Bacterial pathogens that live in vacuole- *Salmonella, Brucella, Chlamydia, Legionella* and *Mycobacterium.*
10- **Bacterial pathogens** that live in cytosol- *Burkholderia, Francisella, Listeria, Shigella, Rickettsia*.
11- Endosymbiotic bacteria of plants.
12- Endosymbiotic cyanobacteria and algae.
13- Endosymbiotic bacteria of Insects.
14- Endosymbiotic parasites and fungi.

Table of assessment

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

References:
-Intracellular niche of microbes, Ulrich E.Schaible and Albert Hass, 2009. John Wiley & Sons

Course title: Protocols in Microbiology
No. of units: 2
No. of hours: 32
Unit type:theoretical
Course type: Specialist-Elective
Prerequisites: none
Additional training: yes
Scientific expedition: no **Workshop:** no **Lab:** no **Seminar:** yes
The overall objectives of the course:
Student will become familiar with new and advanced methods in microbiology.
Topics of the course:

1- Absolute quantitative real time PCR, relative quantitative real time PCR and reverse transcriptase PCR.
2- Touch down/up PCR
3- Multiplex PCR, PCR-Based Methods for Mutation Detection (ARMS), intracellular PCR.
4- over lap PCR reaction and study of genome methylation based on PCR.
5- Cell line and Primary cell culture.
6- Flow cytometry method and cell sorting
7- Primer design.
8- Principle of fermentation.
9- Types of sequencing methods – part 1.
10- Types of sequencing methods – part 2.
11- Immunologic methods in bacteria diagnosis- part 1.
12- Immunologic methods in bacteria diagnosis- part 2.
13- Purification and identification of proteins with antibody (Immunoprecipitation, Affinity chromatography, western blot).
14- Immunofluorescence and immunohistochemistry.
15- Producing of monoclonal antibodies and human antibodies.
16- Electronic microscope.

Table of assessment

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

References:

-Advanced techniques in diagnostic microbiology , Yi-wei tang et.al, 2012, springer.

-Current protocols in microbiology, Richard Coico, 2005, Wiley InterScience.

Course title: Evolution of Microorganisms
No. of units: 2
No. of hours: 32
Unit type: theoretical
Course type: Specialist-Elective
Prerequisites: none
Additional training: yes
Scientific expedition: no **Workshop:** no **Lab:** no **Seminar:** yes
The overall objectives of the course:
Students get to know the evolutionary processes involved in emergence of microorganisms
Topics of the course:

1- Prokaryotes: emergence and classification
2- Diversity of microorganisms.
3- Gene reduction and condensation of microorganisms- Mosaic genomes and new microbial generations.
4- Ribosomal Evolution - role of 16s rRNA in the study of microbial evolution
5- Role of gene transfer in the evolution of microorganisms.
6- Evolution of archaea.
7- Evolution of viruses and phages.
8- Evolution of bacteria.
9- Flagella and evolution.
10- Microbial populations in industrial environments- antibiotic resistance in natural environments.
11- Role of pathogenicity islands in bacteria.
12- Evolution of pathogens in soil.
13- Evolution of *Streptococci* and *Staphylococci*.
14- Evolution of intestinal pathogens.
15- Evolution of *Mycobacterium*.
16- Evolution of pathogenic fungi.

Table of assessment

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

References:
Evolution of Microbial pathogens, H. Steven Seifert and Victor J. Dirita, 2006

Course title: Immunopathogenesis of Microbial Infections.
No. of units: 2
No. of hours: 32
Unit type: Specialist-Elective
Course type:elective
Prerequisites: none
Additional training: yes
Scientific expedition: no **Workshop:** no **Lab:** no **Seminar:** yes

The overall objectives of the course:

Understanding of biological process of infection and microbial mechanisms for causing infection. In addition, understanding the balance between microbes, human host and interference environment interaction in determining the result of infection.

Topics of the course:

1- Host factors in infection.
2- Immune response (innate immunity/adaptive immunty).
3- Molecular mechanisms of microbial pathogenicity.
4- Microbial adhesion and entry into host cell.
5- Microbial growth after entry into host cell.
6- Escape from host innate immune systems.
7- Encounter with phagocytes.
8- Microbial toxins.
9- Regulation of pathogenicity.
10- Tissue invasion and tissue tropism.
11- Interaction between parasite and host in urinary tract infections / genital tract infections.
12- Interaction between parasite and host in respiratory tract infections (upper/lower).
13- Interaction between parasite and host in gastrointestinal infections.
14- Immunopathogenesis of microbial infections of central nervous system (CNS)
15- Sepsis immunopathogenesis.
16- Host response.
17-

Table of assessment

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

References:

- Douglas and Bennett's principal and practice of infectious diseases, Mandell GL, Bennet JE, Dolin R. Mandell, 7th edition 2010, Churchill Livingstone, Elsevier, USA.

- Virulence mechanisms of bacterial pathogens. Brogden K. A., Roth J. A., Stanton T.B., et al. ASM Press, Washington DC.

Course title: Biology of Anaerobes
No. of units: 2
No. of hours: 32
Unit type: theoretical
Course type: Specialist-Elective
Prerequisites: none
Additional training: yes
Scientific expedition: no **Workshop:** no **Lab:** no **Seminar:** yes
The overall objectives of the course:
Understanding of physiology, biochemistry of metabolites and genetics of anaerobes
Topics of the course:

1- Anaerobes' habitats
2- Microbiology, physiology and ecology of phototrophic bacteria.
3- Molecular mechanism of bacterial photosynthesis.
4- Denitrification ecology and reduction of nitrate to ammonium.
5- Reduction of nitrogen oxide compounds.
6- Microbial reduction of Manganese and Iron.
7- Anaerobic decomposition of cellulose, lignin and lignin-derived mono-aromatics
8- **Anaerobic** fermentation and hydrolysis of lipids and proteins.
9- Osteogenesis.
10- Microbiology of sulfate and Sulfur-reducing bacteria.
11- Methanogenic bacteria and biochemistry of methanogenesis.
12- Principles and restrictions of anaerobic decomposition (environmental and technologic aspects).
13- Important **anaerobic** bacteria in medicine.

Table of assessment

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

References:

1-Biochemistry and Physiology of Anaerobic Bacteria Springer; 2003 edition, by Lars G. Ljungdahl , Michael W. Adams , Larry Barton , James G. Ferry, Michael K. Johnson

2-Genetics and Molecular Biology of Anaerobic Bacteria, Springer-Verlag New York, By Madeleine Sebald.

3-Medical Microbiology, By Samuel Baron.

Course title: Polyphasic Taxonomy
No. of units: 2
No. of hours: 32
Unit type: Theoretical
Course type: Specialist-Elective
Prerequisites: none
Additional training: yes
Scientific expedition: no **Workshop:** no **Lab:** no **Seminar:** yes
The overall objectives of the course:
Students get to know methods of identification of polyphasic microorganism according to their phenotype property, phylogeny analysis and chemotaxonomy.
Topics of the course:

1- Introduction including history and importance of taxonomy.
2- Classification based on phenotype, phylogenetics and genotype.
3- Methods of microbial classification and phylogenetics.
4- Phenotypic methods of identification including morphological, physiological, metabolic and ecological properties.
5- Chemotaxonomy methods.
6- Determination of peptidoglycan structure, respiratory quinone.
7- Determination of polar lipids and analysis of fatty acids.
8- Transfer of genetic material and profile of plasmid.
9- C nucleic acid content and nucleic acid hybridization.
10- Genomic fingerprinting.
11- Phylogenic trees.
12- Whole genome sequencing.
13- Minimum standards of microorganism identification.
14- Standards for nomenclature of microorganisms.

Table of assessment

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

References:
-Whitmann W.B. (2015) Bergey's manual of systematic Archaea and Bacteria. Wiley Press.

Course title: Bioinformatics
No. of units: 2
No. of hours: 32
Unit type: Theoretical
Course type: Specialist-Elective
Prerequisites: none
Additional training: yes
Scientific expedition: no **Workshop:** no **Lab:** no **Seminar:** yes

The overall objectives of the course:
Students understand biological data bases and analysis of phylogenic trees for identifying microbial species in evolutionary tree and prediction of gene in prokaryotes and eukaryotes.

Topics of the course:

1- Introduction including history and importance of bioinformatics.
2- Data bases including bibliography, primary data bases like proteins, nucleotide
3- Secondary data bases like Prosite, Blocks.
4- Pairwise sequence alignment including scoring matrices.
5- Global and local sequence alignment.
6- Multiple sequence alignment including scoring methods and progressive and iterative methods
7- Phylogenetic trees including distance- based algorithm and maximum-likelihood.
8- RNA secondary structure prediction.
9- Genome analysis including gene prediction in Prokaryotes and Eukaryotes.
10- Proteins classification and spatial structure of proteins prediction.
11- Special Issues.

Table of assessment

Continuous evaluation	Midterm	Final exam	Project
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.