University of Tehran

College of Science

School of Biology

Description of program and course syllabi

Cellular and molecular biology

Ph.D.

Table 1- required - elective courses

Major: Cellular and molecular biology Program: Ph.D.

No.	Course name	Units			Hours			Prerequisite/ Corequisite
		Theoretical	Practical	Total	Theoretical	Practical	Total	
1	Molecular and Cellular Processes in Eukaryotes	3	0	3	48	0	48	None
2	Genomics and Proteomics	3	0	3	48	0	48	None
3	Special Topics in cellular& Molecular Biology	2	0	2	32	0	32	None
4	Methods for Determinational Structure of Macromolecules	2	0	2	32	0	32	None
5	RNA Biology	2	0	2	32	0	32	None
6	Molecular Biotechnology	2	0	2	32	0	32	None
7	Intracellular Receptors Involved in Proliferation and Differentiation	2	0	2	32	0	32	None
8	Epigenetics Regulation of Development	2	0	2	32	0	32	None
9	Oncogenic Transcription Factors	2	0	2	32	0	32	None
10	Systems Biology	2	0	2	32	0	32	None
11	Epigenetic in Biology and Medicine	2	0	2	32	0	32	None
12	Nano-biotechnology	2	0	2	32	0	32	None
13	Advanced Bioinformatics	2	0	2	32	0	32	None
14	Seminar	2	0	2	32	0	32	None
Total		30	0	30	480	0	480	-

Students must take 14 units from this table.

Prerequisites for Ph.D. degree in Cellular and molecular biology.

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

Topics of specialized - elective courses

Major: Cellular and molecular biology

Program: Ph.D

Course title: Molecular and cellular processes in eukaryotes
No. of units: 3
No. of hours: 48
Unit type: theoretical
Course type: specialized - elective
Prerequisites: none
Additional training: no

Scientific expedition: no **Workshop:** no **Lab:** no **Seminar:** yes

The overall objectives of the course:

Cell, genome, small RNAs, ribozymes and their mechanisms of action, cell asymmetry, gene silencing, and some molecular mechanisms of cells behavior and their molecular characteristics will be studied.

Topics of the course:

1- Intricate networks of cellular key players in cell death and immortality
2- Cell death signaling and cancer therapy
3- How do cells select their destination: The key role of p53
4- Molecular characteristics in neoplastic transformation of cells
5- Genomic instability in cancer cells
6- Cell asymmetry.
7- Specific mechanisms of genome repair from evolutionary point of view
8- Gene silencing
9- Specific regulatory mechanisms in eukaryotes
10- Small cytoplasmic and nuclear RNAs
11- Ribozymes and their mechanisms of action

Table of assessment

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

References:

- Annual Review of Biochemistry, Mc Graw Hill New york.
- Annual Review of cell and developmental Biology, McGrowHill New York**.**

Course title: Genomics and proteomics
No. of units: 3
No. of hours: 48
Unit type: theoretical
Course type: specialized - elective
Prerequisites: none
Additional training: no
Scientific expedition: no **Workshop:** no **Lab:** no **Seminar:** yes
The overall objectives of the course:
The study of genomics and proteomics science and genomic map in various types of organisms, methods for protein sequencing and determining phosphorylation sites, and the study of protein complexes.
Topics of the course:

1- Structural genomics: genome organization, determining genomic maps and sequencing of genome.
2- Functional genomics: the role of genome in genes expression, comparative bacterial genomics, *Arabidopsis* genome.
3- Comparative genomics of mouse, rat, chicken, human and chimpanzee.
4- Proteomics: separation and identification methods including chromatography and electrophoresis techniques.
5- Amino acid analysis and introducing protein sequencing methods including chemical or enzymatic digestion of proteins, mass spectrometry approaches for determining mass and sequence of proteins and post translational modifications.
6- Various types of engineered peptides and proteins and the effects of that engineering on improving these molecules.
7- Post translational phosphorylation and acetylation modifications, determination of position and impacts of those modifications in different proteins and on proteins function.
8- Various types of protein complexes, methods of their identification and how they change.

Table of assessment

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

References:

- Gibsom, Aprimer of Genomes Science 2nd edition simaues Assoc.
- Brown TA, Genomes John Willey and Sons.
- Gffraser, Tdrod and Nelson, Microbial Genomes Human Press.
- Lander ES et al., Initial Sequencing and analysis of the human genome Nature 406: 860-921.
- Venteral JC, The sequences of the human genomes science 241: 1304-1351.

Course title: Special topics in cellular & molecular Biology

No. of units: 2
No. of hours: 32
Unit type: theoretical
Course type: specialized - elective
Prerequisites: none

Additional training: no
Scientific expedition: no **Workshop:** no **Lab:** no **Seminar:** yes

The overall objectives of the course:
Teaching new topics in the field of cellular and molecular biology

Topics of the course:

1- Using the most recent topics from reliable journals.

Table of assessment

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

References:
- Reliable journals in the field of cellular and molecular biology.

Course title: Methods for determinational structure of macromolecules
No. of units: 2
No. of hours: 32
Unit type: theoretical
Course type: specialized - elective
Prerequisites: none
Additional training: no
Scientific expedition: no **Workshop:** no **Lab:** no **Seminar:** yes
The overall objectives of the course:
Familiarization with methods used for studying of molecules and their interactions.
Topics of the course:

1- The study of structure of macromolecules with X-ray crystallography.
2- Crystals, their preparation and characteristics, the electromagnetic waves and X-ray diffraction.
3- Bragg's law, Fourier transform and scattering factors.
4- Phase 1 matter of determination of three dimensional structure, resolution
5- The study of structure of macromolecules with NMR spectroscopy, theoretical fundamentals of nuclear magnetic resonance.
6- All types of spin interactions, comfort phenomenon
7- An introduction to one and two dimensional spectrums.
8- Various types of two dimensional spectrums and analysis of them.
9- Experimental image formation.
10- The study of structure of macromolecules with cryo-electron microscopy
11- An introduction to cryo-electron microscopy.
12- Preparation of two dimensional crystals and formation of three dimensional structure
13- Measuring the conformational stability of proteins by hydrogen exchange.
14- Thermodynamic relationships between structure and stability.
15- Other methods of studying structure of macromolecules such as CD and light scan
16- Seminars and discussion about recent articles.

Table of assessment

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

References:

- Vans, Biomelecular NMR spectroscopy.
- Cavanaugh, Protein NMR spectroscopy.
- Murphy, protein structure, stability and folding.
- Glasel , (Introduction to biophysical methods for protein and nucleic and Research.
- Cantor,Biophysical chemistry.

Course title: RNA Biology
No. of units: 2
No. of hours: 32
Unit type: theoretical
Course type: specialized - elective
Prerequisites: none
Additional training: yes
Scientific expedition: no **Workshop:** no **Lab:** no **Seminar:** yes
The overall objectives of the course:
Student's familiarization with RNA biology
Topics of the course:

1- An introduction to RNA molecule, the history of important discoveries, various types and importance of non-coding RNAs.
2- The RNA world hypothesis and riboswitches.
3- The RNA structure and processing (capping, splicing and spliceosome, polyadenylation), RNA editing, RNase P, ScaRNA, SnoRNA, snRNA and RNaseMRP
4- Non coding RNAs involved in protein synthesis (translation) and ribosome biogenesis, rRNA, tRNA, 7SL RNA
5- Antisense RNAs and their role in regulation of gene expression and chromatin structure (eukaryotes and prokaryotes)
6- RNA and chromatin structure, paramutation, X inactivation and Xist RNA
7- Genomic imprinting and non coding RNAs
8- The role of RNA in gene expression regulation, 7SK RNA, microRNA, CRISPR, competing endogenous RNAs (ceRNAs)
9- Non coding RNAs and DNA replication, RNA telomerase, Y RNA, RNaseMRP in triggering mitochondrial DNA transcription, genome rearrangement using RNA.
10- Genomic defense and control of transposons, piRNA and endosiRNA
11- RNA stability and degradation
12- Non coding RNAs and disease, cancer, Prader-Willi syndrome, Alzheimer, autoimmune diseases
13- Laboratory methods to study RNA and RNAomics
14- Calculation sources and bioinformatics of RNA

Table of assessment

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

References:
- Human molecular genetics, Strachan and Read, 2013, Bios
- RNA biology, Gunter Meister, 2011, Wiley
- Molecular Biology of RNA, David Elliot and Michael Ladomery, 2010, Oxford University Press

Course title: Molecular biotechnology
No. of units: 2
No. of hours: 32
Unit type: theoretical
Course type: specialized - elective
Prerequisites: none
Additional training: no
Scientific expedition: no **Workshop:** no **Lab:** no **Seminar:** yes
The overall objectives of the course:
To consider a living organism as a template for fabrication of a nature friendly technology without polluting the environment
Topics of the course:

1- An introduction to biotechnology, fermentation and fermantors, various types and applications.
2- Plant biotechnology, methods of gene delivery into plants (Agrobacterium, electroporation and shutgun)
3- Examples of transgenic plants (resistant to insects, viruses, herbicides, and fungi, salinity and drought stresses)
4- Use of plants as bioreactors for production of antibodies and multifunctional pharmaceutical proteins)
5- Clinical biotechnology: production of recombinant somatostatin, growth factor and insulin hormones
6- Cytokines like interleukin-2 and interferons
7- Synthesis of antitrypsin and tPA
8- Monoclonal antibodies, cloning based synthesis of HBSAg vaccine
9- Production of coagulating VIII and IX factors
10- Gene therapy: abiotic (chemical and physical) and biotic methods for gene delivery
11- Prenatal diagnosis of genetic abnormalities using molecular approaches
12- Transgenic animals and use of them as bioreactors
13- Production of cloned animals
14- Production of DNase I and phenylalanine ammonia lyase enzymes
15- Production of polysaccharide biopolymers such as alginate, xanthan, dextran
16- Seminars

Table of assessment

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

References:

- Alca. E, DNA technology Last Edition

- Glick and Pasternak Molecular Biotechnology. Last Edition

- Primrose S.B. et al., Principles of Gene Manipulation. Black well sciences. Last Edition

- Watson et al Recombinant DNA sc. Am, books. Last Edition

Course title: Intracellular receptors in proliferation and differentiation
No. of units: 2
No. of hours: 32
Unit type: theoretical
Course type: specialized - elective
Prerequisites: none
Additional training: no
Scientific expedition: no **Workshop:** no **Lab:** no **Seminar:** yes
The overall objectives of the course:
Student's familiarity with the structure and function of estrogen receptors, study of intracellular pathways related to estrogen receptors and their relation with diseases like cancer or control of differentiation processes. Learning these topics will be helpful in understanding of routes of design and synthesis of anticancer drugs or drugs that are effective in tissue differentiation.
Topics of the course:
1- Estrogen hormone, its receptors, the relation between estrogen receptors and breast cancer
2- Structure and function of ER-α36 receptor, scaffold proteins and activation of STAT transcription factor
3- NF-κB pathway, the relation between nuclear receptor of estrogen hormone and NF-κB transcription factor, molecular mechanism of NF-κB factor inhibition mediated by estrogen receptor, inhibition of NF-κB DNA binding by estrogen receptor, regulation of IκB protein by estrogen receptor
4- Effects of estrogen receptor on interaction of NF-κB with co-activators, other impacts of estrogen receptor on NF-κB factor, the relation of estrogen receptor and NF-κB factor with breast cancer
5- An introduction to estrogen cell surface receptors (GPR30/GPER1), structure and cellular localization of GPR30 receptor, GPR30 receptor in tumors, GPR30 receptor and induction of cancer cell growth, GPR30 receptor as a novel therapeutic target, GPR30 target genes.
6- EGFR signaling pathway, insulin like growth factor signaling pathway, relationship between histone deacetylases and estrogen receptor, HOXB7 protein
7- DNA repair signals in breast cancer, estrogen hormone and regulation of apoptosis, estrogen induced apoptosis
8- Tamoxifen and PKC, tamoxifen and reactive oxygen species (ROS), ROS and AMPK enzyme, ROS and JNK enzyme, tamoxifen and Erk1/2 enzyme
9- Estrogen receptors signaling pathway and cardiac and bronchial diseases, role of estrogen receptors in sell differentiation
10- Crosstalk between estrogen receptors and Wnt signaling constitutes
11- Role of α strogen receptors signaling pathway in osteoblast differentiation
12- α strogen receptors signaling pathway and IGF-1 in brain
13- Seminars

Table of assessment

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

References:

- Estrogen Receptors: Mechanisms, Structure and Role in Diseases (2012), George Chen ed., Nova Science Publishers

Course title: Epigenetic regulation of development
No. of units: 2
No. of hours: 32
Unit type: theoretical
Course type: specialized - elective
Prerequisites: none
Additional training: yes
Scientific expedition: no **Workshop:** no **Lab:** no **Seminar:** no

The overall objectives of the course:

Nowadays, role of epigenetic mechanisms in different biologic processes such as development, cancer, autoimmune diseases, and etc is well known. Among various processes that are affected by epigenetic events, development is the most significant ones. The objective of this course is the understanding of important epigenetic events that occur during development.

Topics of the course:

1- An introduction to epigenetics, epigenetic mechanisms including: chromatin modifications, histone variants, chromatin remodelers, non coding RNAs, polycomb and trithorax proteins)
2- Reprogramming of epigenome in zygote after fertilization and in embryo, demethylation of genome, chromatin organization
3- Epigenetic of stem cells, transcription and chromatin factors, bivalent domains
4- Paternal X chromosome activation, random inactivation of X chromosome, escaping of X chromosome from inactivation
5- Epigenetic modifications during differentiation of pluripotent stem cells
6- Reprogramming of epigenome in primordial germ cells (PGCs), active demethylation and genome inactivation
7- Imprinted genes, mechanisms of imprinting, paternal X chromosome imprinting
8- Epigenetic control of lymphopoiesis, the role of epigenetic in differentiation of multipotent cells (such as hematopoietic stem cells, HSCs)
9- Epimutation, trans-generational and inter-generational epigenetic inheritance
10- Epigenetic of induced stem cells
11- Seminars

Table of assessment

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

References:

- Tollefsbol, T. (2011). Handbook of epigenetics, Academic Press.

- Allis, D. et al (2008) Epigenetics, Cold Spring Harbor Laboratory Press

- Orkin, S. and Hochedlinger, K. (2011) Chromatin connections to pluripotency and cellular reprogramming, Cell *145*, 835-850

- Saladi, S.V. and De la Serna, I.L. (2010) ATP dependent chromatin remodeling enzymes in embryonic stem cells. Stem Cell Review 6(1): 62-73

- Surani, M.A. et al (2007) Genetic and epigenetic regulators of pluripotency, Cell *128*, 747-762

Course title: Oncogenic transcription factors
No. of units: 2
No. of hours: 32
Unit type: theoretical
Course type: specialized - elective
Prerequisites: none
Additional training: no
Scientific expedition: no **Workshop:** no **Lab:** no **Seminar:** yes

The overall objectives of the course:
Student's familiarity with one of the most important stages of genetic expression with emphasis on control of transcription factors activity in cell homeostasis and change in their activity in the beginning and developing of carcinogenesis. Passing this course would be useful for students whose thesis is defined in the field of regulation of genetic expression and help them in designing experiments and analysis of results.

Topics of the course:
1- An introduction to DNA transcription, regulatory elements in DNA and DNA binding elements in transcription factors.
2- Experimental assays for evaluation of transcription factors activity (*in vivo* or *in vitro*)
3- Steroid hormone receptors
4- Homeodomain transcription factors
5- E2F protein
6- p53 protein
7- TCF/LEF proteins family
8- NF-κB protein
9- STAT proteins
10- c-Myc protein
11- c-Jun and c-Fos (AP1) proteins
12- Transcription factors as good targets for therapeutic studies
13- Seminars

Table of assessment

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

References:

- Bruce Alberts Molecular Biology of the Cell,. 5th edition (2008). Garland Science

- F Weaver Robert Molecular Biology, , 5th edition, (2012) McGraw Hill

- Scott F Gilbert Developmental Biology, 6th edition (2000). Sinauer Associates

Course title: Systems biology
No. of units: 2
No. of hours: 32
Unit type: theoretical
Course type: specialized - elective
Prerequisites: none
Additional training: no
Scientific expedition: no **Workshop:** no **Lab:** no **Seminar:** yes
The overall objectives of the course:
Student's familiarity with systemic study in the biology, use of the results of these studies and their application in the cellular and molecular sciences

Topics of the course:
1- Biological systems
2- Mathematical modeling
3- Static network models
4- The Mathematics of Biological Systems
5- Parameter estimation
6- Gene systems
7- Protein systems
8- Metabolic systems
9- Signal systems
10- Population systems
11- Integrated analysis of genomic, protein and metabolic data.

Table of assessment

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

References:

- A First Course in Systems Biology, E. O. Voit (2012), Garland Science.

- An Introduction to Systems Biology, U. Alon (2006), Chapman and Hall/CRC.

- Systems Biology, E. Klipp (2009), WILEY-BLACK WELL.

Course title: Epigenetic in biology and medicine
No. of units: 2
No. of hours: 32
Unit type: theoretical
Course type: specialized - elective
Prerequisites: none
Additional training: no
Scientific expedition: no **Workshop:** no **Lab:** no **Seminar:** no
The overall objectives of the course:
Learning epigenetic processes that have essential roles in the embryonic development, chromosomes organization, genomic defense, traits inheritance, genes expression and development

Topics of the course:

1- The main concepts of epigenetic and the methods of epigenetic studies have been integrated enough that some call it as 'modern genetics', because every day declare that many of biologic processes are caused not by gene mutations but mediated by epigenetic modifications such as DNA methylation and various and widespread histone variations. Due to the extent of concepts and continuous developments of epigenetic, paying attention to these concepts as a course is required in the graduate studies. In this course, with emphasis on recent credible review articles, in addition to familiarizing with basic concepts of epigenetic, the importance of epigenetic variations in health and disease pathogenesis will be reviewed. Familiarization with the concepts and related mechanisms will be helpful in analysis and understanding of genetic regulation events.

Table of assessment

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

References:

- Allis, Jenuwein, Reinberg, eds. Epigenetics, , CSHL Press, 2007

- Tollefsbol, Handbook of Epigenetics. AP, 2011.

- Ferguson-Smith, Greally, Martienssen Eds. Epigenomics, Springer, 2009.

Course title: Nano biotechnology
No. of units: 2
No. of hours: 32
Unit type: Theoretical
Course type: specialized - elective
Prerequisites: none
Additional training: no
Scientific expedition: no **Workshop:** no **Lab:** no **Seminar:** yes

The overall objectives of the course:
Student's familiarity with nanobiotechnology

Topics of the course:
1- What is nanobiotechnology?
2- Quantum physics
3- Mesoscopic physics
4- Size related characteristics
5- Electron gaff related characteristics
6- Surface plasmon resonance related characteristics
7- Allotropes of carbon
8- Non-carbonic nanomaterials (metals, ceramics, nanoporous)
9- Bio-nanomaterial
10- Observation methods in nanobiotechnology
11- Delivery methods in nanobiotechnology
12- Production methods in nanobiotechnology
13- Nanobiotechnology applications in diagnosis and treatment
14- Nanobiotechnology applications in agriculture and food industry
15- Nanobiotechnology applications in environment and industries
16- The safety concerns of nanobiotechnology

Table of assessment

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

References:
- C.A. Mirkin Nanobiotechnology I, Wiley-VCH, 2013.

- C.A. Mirkin, C.M. Niemeyer. Nanobiotechnology II: More concepts and applications hardcover. Wiley-VCH, 2007/

- C.M. Niemeyer, C.A. Mirkin. Nanobiotechnology: Concepts, Applications and Perspectives Hardcover. Wiley-VCH, 2004

- O. Shoseyov, I. Levy. NanoBioTechnology. Human Press 1ed 2008

Course title: Advanced bioinformatics
No. of units: 2
No. of hours: 32
Unit type: Theoretical
Course type: specialized - elective
Prerequisites: none
Additional training: no
Scientific expedition: no **Workshop:** no **Lab:** no **Seminar:** yes

The overall objectives of the course:

Topics of the course:
1- H

Table of assessment

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

References:
- S