IRAN UNIVERSITY OF MEDICAL SCIENCES

School of Pharmacy

Department of Pharmacognosy and Pharmaceutical Biotechnology

Course Title: Molecular Biology and Genetics

Course code: 26

Credit: 2 (Theory)

Prerequisite: None

Second semester of 2024 -2025 School Year

Target students: Foreign Students (MPharm)

Instructors: Dr. Montazeri, Dr. Mottaghi

Responsible Instructor: Dr. Mottaghi

Course Description:

Course Objectives:

1. **Understand the Fundamental Differences Between Prokaryotic and Eukaryotic Cells**:
    - Students will learn to distinguish between prokaryotic and eukaryotic cells, including their structural and functional differences, and how these differences relate to their roles in various biological processes.
2. **Comprehend the Structure and Function of DNA, RNA, and Proteins**:
    - Students will gain a deep understanding of the molecular structures of DNA, RNA, and proteins, and their critical roles in the storage, expression, and regulation of genetic information.
3. **Analyze the Structure and Function of Nucleic Acids and Chromosomes**:
    - Students will explore the organization of nucleic acids within chromosomes and understand how this organization influences gene expression and genetic stability.
4. **Explore the Cytoskeleton and Its Role in Cell Motility**:
    - Students will examine the components of the cytoskeleton and their functions in maintaining cell shape, enabling cell movement, and facilitating intracellular transport.
5. **Investigate the Structure and Function of Cytoplasmic Membrane Systems**:

- Students will study the structure and roles of various cytoplasmic membrane systems, with a focus on their involvement in cellular transport, signaling, and membrane trafficking.

6. **Understand Mitochondrial Function and Cellular Respiration**:
   - Students will learn about the structure and function of mitochondria, with emphasis on their role in energy production through cellular respiration.
7. **Master the Mechanisms of DNA Replication**:
   - Students will understand the process of DNA replication, including the enzymes involved and the regulatory mechanisms that ensure fidelity during cell division.
8. **Examine DNA Repair Mechanisms**:
   - Students will investigate the various mechanisms by which cells repair DNA damage, ensuring the maintenance of genomic integrity.
9. **Understand Transcription and RNA Processing**:
   - Students will learn about the process of transcription and the subsequent modifications that RNA undergoes before translation, including splicing, capping, and polyadenylation.
10. **Comprehend Translation and Protein Synthesis**:
    - Students will explore the molecular mechanisms of translation, including the roles of ribosomes, tRNA, and other factors in synthesizing proteins from mRNA.
11. **Analyze the Processes of Mitosis and Meiosis**:
    - Students will understand the stages of mitosis and meiosis, their differences, and their significance in growth, development, and reproduction.
12. **Understand the Role of Telomeres and Telomerase in Cellular Aging and Cancer**:
    - Students will examine the structure and function of telomeres and the enzyme telomerase, and their roles in cellular aging, chromosomal stability, and the development of cancer.
13. **Explore the Molecular Mechanisms of Apoptosis**:
    - Students will learn about the programmed cell death process known as apoptosis, including the signaling pathways and molecular events that regulate this essential cellular function.

These objectives are designed to provide a comprehensive understanding of molecular biology and genetics, preparing students for more advanced studies or professional applications in the field.

Course Content:

1. **Fundamentally Different Classes of Cells: Prokaryotes & Eukaryotes**:
    - Overview of cellular classification
    - Structural and functional differences between prokaryotic and eukaryotic cells
    - The evolutionary significance of these differences
    - Examples of prokaryotic and eukaryotic organisms
2. **Structure and Functions of DNA, RNA, and Proteins**:
    - The chemical structure of DNA and RNA
    - The role of nucleotides in genetic information storage
    - Protein structure and the central dogma of molecular biology
    - Functions of DNA, RNA, and proteins in cellular processes
3. **Nucleic Acids and Chromosome Structure**:
    - Organization of DNA in chromosomes
    - Chromatin structure and its regulation
    - The role of histones and other proteins in chromosomal architecture
    - Chromosome condensation during cell division
4. **The Cytoskeleton and Cell Motility**:
    - Components of the cytoskeleton: microfilaments, microtubules, and intermediate filaments
    - Functions of the cytoskeleton in maintaining cell shape and enabling motility
    - The role of motor proteins in intracellular transport
    - Mechanisms of cell motility, including amoeboid movement, cilia, and flagella
5. **Cytoplasmic Membrane Systems: Structure, Function, and Membrane Trafficking**:
    - Structure and function of the endoplasmic reticulum and Golgi apparatus
    - The role of vesicles in membrane trafficking

- Mechanisms of endocytosis and exocytosis
- Membrane fusion and its significance in cellular processes

6. **Mitochondria and Cellular Respiration**:
    - Structure of mitochondria and their evolutionary origins
    - The role of mitochondria in ATP production through cellular respiration
    - The electron transport chain and oxidative phosphorylation
    - The role of mitochondria in apoptosis and cellular metabolism
7. **DNA Replication**:
    - The process of DNA replication and the role of enzymes like DNA polymerase
    - The significance of replication origins and replication forks
    - Mechanisms ensuring the accuracy and fidelity of replication
    - Differences in replication between prokaryotic and eukaryotic cells
8. **DNA Repair**:
    - Types of DNA damage and their causes
    - Mechanisms of DNA repair
    - Connection between DNA repair mechanisms and diseases like cancer
9. **Transcription and Processing of RNA**:
    - The process of transcription in prokaryotes and eukaryotes
    - RNA polymerases and transcription factors
    - Post-transcriptional modifications: capping, polyadenylation, and splicing
10. **Translation and Protein Synthesis**:
    - The structure and function of ribosomes in protein synthesis
    - The role of tRNA and the genetic code in translation
    - Steps of translation: initiation, elongation, and termination
11. **Mitosis**:
    - The stages of mitosis
    - The role of the mitotic spindle and centrosomes in chromosome segregation
    - Significance of mitosis in growth, development, and tissue repair

12. **Meiosis**:
    - The stages of meiosis I and meiosis II
    - Processes of homologous chromosome pairing and crossing over
    - Reduction of chromosome number and the formation of haploid gametes
    - The role of meiosis in genetic diversity and sexual reproduction
13. **Telomeres and Telomerase**:
    - Structure and function of telomeres in chromosome protection
    - The role of the enzyme telomerase in maintaining telomere length
    - Telomere shortening and its implications for aging and cell senescence
    - The connection between telomere biology and cancer
14. **Apoptosis**:
    - The molecular mechanisms of programmed cell death
    - The role of caspases and Bcl-2 family proteins in apoptosis
    - Signaling pathways that trigger apoptosis

This course content outline is designed to systematically cover the essential topics in molecular biology and genetics, ensuring a comprehensive understanding of both the theoretical and practical aspects of the subject.

Specific Course Learning Objectives

By the end of this course, students will be able to:

1. **Fundamentally Different Classes of Cells: Prokaryotes & Eukaryotes**
    - Identify and describe the key structural differences between prokaryotic and eukaryotic cells.
    - Explain how these differences influence cellular function and organization.
    - Compare the evolutionary significance of prokaryotic and eukaryotic cells.
2. **Structure and Functions of DNA, RNA, and Proteins**
    - Illustrate the molecular structure of DNA, RNA, and proteins.
    - Explain the roles of DNA and RNA in storing and transmitting genetic information.
    - Describe the process of protein synthesis and the functions of proteins in cellular activities.
3. **Nucleic Acids and Chromosome Structure**
    - Explain the organization of DNA into chromosomes.

- Describe the structure and function of chromatin and its role in gene regulation.
- Analyze how chromosomal structure impacts genetic stability and gene expression.

4. **The Cytoskeleton and Cell Motility**
    - Identify the components of the cytoskeleton and describe their functions in the cell.
    - Explain the mechanisms of cell motility and the role of the cytoskeleton in these processes.
    - Discuss the importance of motor proteins in intracellular transport and cell movement.
5. **Cytoplasmic Membrane Systems: Structure, Function, and Membrane Trafficking**
    - Describe the structure and function of key cytoplasmic membrane systems, including the ER and Golgi apparatus.
    - Explain the processes of membrane trafficking, including endocytosis and exocytosis.
    - Discuss the role of membranes in cellular signaling and transport.
6. **Mitochondria and Cellular Respiration**
    - Describe the structure and function of mitochondria.
    - Explain the process of cellular respiration and the role of the electron transport chain.
    - Discuss the involvement of mitochondria in apoptosis and metabolic regulation.
7. **DNA Replication**
    - Explain the molecular mechanisms of DNA replication, including the roles of key enzymes.
    - Describe how replication fidelity is maintained and the consequences of replication errors.
    - Compare the differences in DNA replication between prokaryotes and eukaryotes.
8. **DNA Repair**
    - Identify the various types of DNA damage and the mechanisms by which they are repaired.
    - Explain the importance of DNA repair in maintaining genomic stability.

- Discuss the connection between defects in DNA repair mechanisms and the development of diseases like cancer.

9. **Transcription and Processing of RNA**
    - Describe the process of transcription and the role of RNA polymerase in gene expression.
    - Explain the post-transcriptional modifications of RNA and their significance.
    - Analyze the regulation of gene expression at the transcriptional and post-transcriptional levels.
10. **Translation and Protein Synthesis**
    - Explain the process of translation and the roles of mRNA, tRNA, and ribosomes.
    - Describe the stages of protein synthesis.
11. **Mitosis**
    - Describe the stages of mitosis and the events that occur in each stage.
    - Explain the role of the mitotic spindle in chromosome segregation.
12. **Meiosis**
    - Describe the stages of meiosis and the key differences between meiosis I and meiosis II.
    - Explain the processes of homologous chromosome pairing and crossing over.
    - Discuss the role of meiosis in generating genetic diversity and its importance in sexual reproduction.
13. **Telomeres and Telomerase**
    - Describe the structure and function of telomeres in chromosome stability.
    - Explain the role of telomerase in maintaining telomere length and its implications for cellular aging.
14. **Apoptosis**
    - Describe the molecular mechanisms of apoptosis and the key players involved, such as caspases.
    - Explain the signaling pathways that regulate apoptosis.

These specific learning objectives are designed to guide students in understanding and mastering the key concepts, mechanisms, and processes in molecular biology and genetics, ensuring they achieve a deep and practical understanding of the subject matter

Course Schedule for Molecular Biology and Genetics

Course Schedule for Molecular Biology and Genetics

(Monday 10-12)

Session	Date (1403-2024)	Topic	Teaching Method	Instructor(s)
1	18 Farvardin 1404 07 Apr 2025	Fundamentally Different Classes of Cells: Prokaryotes & Eukaryotes	PowerPoint/Lecture	Dr. Montazeri
2	25 Farvardin 1404 14 Apr 2025	Structure and functions of DNA, RNA, and Proteins	PowerPoint/Lecture	Dr. Montazeri
3	01 Ordibehesht 1404 21 April 2025	Nucleic Acids and Chromosome Structure	PowerPoint/Lecture	Dr. Montazeri
4	08 Ordibehesht 1404 28 April 2025	The Cytoskeleton and Cell Motility	PowerPoint/Lecture	Dr. Montazeri
5	15 Ordibehesht 1404 05 May 2025	Cytoplasmic Membrane Systems: Structure, Function, and Membrane Trafficking	PowerPoint/Lecture	Dr. Montazeri
6	22 Ordibehesht 1404 12 May 2025	Mitochondria and cellular respiration	PowerPoint/Lecture	Dr. Montazeri
7	29 Ordibehesht 1404 19 May 2025	DNA Replication	PowerPoint/Lecture	Dr. Montazeri
8	05 Khordad 1404 26 May 2025	DNA Repair	PowerPoint/Lecture	Dr. Mottaghi
9	12 Khordad 1404 02 June 2025	Transcription and Processing of RNA	PowerPoint/Lecture	Dr. Mottaghi
10	19 Khordad 1404 09 June 2025	Translation and Protein Synthesis	PowerPoint/Lecture	Dr. Mottaghi
11	26 Khordad 1404 16 June 2025	Mitosis	PowerPoint/Lecture	Dr. Mottaghi
12	02 Tir 1404 23 June 2025	Meiosis	PowerPoint/Lecture	Dr. Mottaghi
13	09 Tir 1404 30 June 2025	Telomers and Telomerase	PowerPoint/Lecture	Dr. Mottaghi
14	16 Tir 1404 07 July 2025	Apoptosis	PowerPoint/Lecture	Dr. Mottaghi
Final Exam	-	Written and Descriptive Test	-	Dr. Mottaghi & Dr. Montazeri

References:

1. **Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2014). Molecular Biology of the Cell (6th ed.)**. Garland Science.

- A comprehensive textbook covering all aspects of cell and molecular biology, including the structure and function of cells, DNA, RNA, proteins, and the mechanisms of cell division and gene expression.

2. **Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A., & Scott, M. P. (2021). Molecular Cell Biology (9th ed.)**. W. H. Freeman.
    - This book provides an in-depth exploration of molecular cell biology, focusing on the molecular mechanisms that underlie cellular processes and their regulation.
3. **Watson, J. D., Baker, T. A., Bell, S. P., Gann, A., Levine, M., & Losick, R. (2013). Molecular Biology of the Gene (7th ed.)**. Pearson.
    - A classic text that offers detailed explanations of the principles of molecular biology, including DNA replication, repair, transcription, translation, and gene regulation.
4. **Cooper, G. M., & Hausman, R. E. (2019). The Cell: A Molecular Approach (8th ed.)**. Sinauer Associates.
    - This textbook is well-suited for understanding the molecular basis of cell structure and function, with a focus on cellular processes and their roles in health and disease.
5. **Karp, G. (2018). Cell and Molecular Biology: Concepts and Experiments (8th ed.)**. Wiley.
    - Karp's book is known for its clear explanations of key concepts in cell and molecular biology, making it an excellent resource for students new to the field.
6. **Klug, W. S., Cummings, M. R., Spencer, C. A., Palladino, M. A., & Killian, D. J. (2019). Concepts of Genetics (12th ed.)**. Pearson.
    - A foundational text in genetics, this book covers the principles of heredity, molecular genetics, and the genetics of populations.
7. **Lewin, B. (2010). Genes X**. Jones & Bartlett Learning.
    - A highly regarded text that delves into the molecular biology of genes, including gene structure, function, and regulation.
8. **Pollard, T. D., & Earnshaw, W. C. (2017). Cell Biology (3rd ed.)**. Saunders.
    - This book covers the fundamental concepts of cell biology, with a focus on the molecular mechanisms that drive cellular processes.
9. **Gilbert, S. F. (2013). Developmental Biology (10th ed.)**. Sinauer Associates.

- Although primarily a developmental biology textbook, this resource provides valuable insights into the processes of mitosis, meiosis, and apoptosis.

10. **Campbell, N. A., & Reece, J. B. (2017). Biology (11th ed.)**. Pearson.
    - This widely used general biology textbook provides a broad overview of biological principles, including essential concepts in molecular biology and genetics.
11. **Articles from Peer-Reviewed Journals**:
    - Selected readings from journals such as *Nature*, *Science*, *Cell*, and *The Journal of Molecular Biology* will be assigned to supplement textbook material and provide insights into current research in molecular biology and genetics.
12. **Supplementary Online Resources**:
    - Access to online databases and resources such as PubMed, NCBI, and the Protein Data Bank (PDB) will be provided for further reading and research.

These references will provide students with a solid foundation in molecular biology and genetics, supporting the course's learning objectives and enhancing their understanding of the subject matter.

Student Responsibilities and Expectations

Students are expected to adhere to the following responsibilities throughout the course:

- **Regular Attendance**: Students must attend all classes regularly and punctually. The absence hours of a student should not exceed 4/17 of the sessions. Otherwise, the score for the course will be considered as zero. Note: Allowed absences are accepted provided students bring in documents for that and the related professor approves it. Acting against absences (excused or not) will be the professor's decision and the college's agreement. For each session missed, 0.25 points will be deducted from the final grade. However, if students provide a summary of the topics covered during the missed session, the 0.25-point deduction will be waived, but the absence will still be recorded.
- **Timely Completion of Assignments**: Students are required to complete and submit all assignments by the specified deadlines.
- **Study Assigned Materials**: Students should thoroughly study all the recommended textbooks, articles, and other resources provided during the course.
- **Active Participation**: Students are encouraged to actively participate in class discussions, activities, and any other scheduled programs.

Additional Note on Final Examination

- **Final Exam Policy**: The final examination will consist of multiple-choice and descriptive questions. There will be no opportunity to retake the final exam for students who do not achieve a passing grade. Students are strongly advised to prepare diligently and manage their study time effectively to perform well. Requests for grade adjustments or exam retakes will not be entertained. It is imperative to approach the course with seriousness and commitment to meet the academic standards set forth.

Class Location

- **Class Venue**: All classes will be held in Besarati (Eastern 7) Street, North Shahin Boulevard

Evaluation Criteria and Grade Distribution

Percentage of Total Grade	Evaluation Basis
80%	Final Exam
-	Midterm Exam or Quiz
10%	Class Participation
10%	Assignments

This table provides a clear breakdown of how the students will be assessed throughout the course and the weightage of each component in the final grade.