MOLECULAR CELL BIOLOGY I

Institute of Biochemistry and Molecular Biology
Department of Molecular Biology
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Credit: 4
Number of lessons per week: lectures: 2; practicals: 2
Subject code: **AOKMBT795_1A**

The subject provides the foundations of modern molecular medicine, emphasizing points of interest for diagnostics, intervention and therapeutic applications. It serves as a base for several fields in medicine, such as molecular pathology, molecular diagnostics, pharmacology, gene therapy and medical biotechnology.

Prerequisites for subject registration:
Successful exams in Medical Chemistry as well as in Medical Biochemistry I.

Lectures:

1. Introduction to molecular cell biology
2. Structure and function of nucleotides and nucleic acids. Packaging of DNA into chromatin
3. DNA packaging in pro- and eukaryotic cells; the role of topoisomerases
4. Structure of the human genome 1
5. Structure of the human genome 2
6. Principles of DNA replication. Replication in prokaryotes
7. Replication in eukaryotes
8. DNA repair
9. Transcription in prokaryotes 1
10. Transcription in prokaryotes 2
11. Transcription in eukaryotes, mRNA processing
12. Regulation of transcription
13. Alternative ways to regulate eukaryotic gene expression
14. Nuclear receptors. Transcriptional factors, DNA-binding domains
15. MicroRNAs
16. Epigenetics
17. The genetic code, translation 1
18. The genetic code, translation 2
19. The genetic code, translation 3
20. Posttranslational modification of proteins
21. Protein folding
22. Quality control
23. Protein targeting into metabolic compartments 1
24. Protein targeting into metabolic compartments 2
25. Proteostasis, the ubiquitin–proteasome system
26. Mechanisms of autophagy
27. Molecular biology of viruses 1
28. Molecular biology of viruses 2

Practicals: *(4x45 min every other week):*

1. Introduction, Biuret test, Ellmann’s reaction, consultation
2. Cell fractions I
3. Cell fractions II
4. Consultation
5. Regulation of beta-galactosidase expression
6. Purification of a bacterially expressed protein by affinity chromatography
7. SDS-PAGE and western blot

Acknowledgment of the semester:
Attendance of at least 75% of the practical lessons is prerequisite of acknowledging the semester. In case of more than two missed labs the semester cannot be acknowledged and the student is not going to be allowed to sit for the terminal exam. Missed practicals can be made up only in the same week with another group; certificate of participation issued by the host teacher has to be presented by the student to his/her own teacher.Students can collect “practical points” during the labs. These points are taken into account at the Molecular cell biology II. final exam at the end of the academic year.

Examination and grading system:

The oral exam is based on the topic list announced in the beginning of the semester, and it takes place before a committee of two (examiner and co-examiner). Students pick three random questions from the DNA, RNA and Protein group of the following topic list. The exam can be passed if all three topics are sufficiently answered.

Topic list:

I. DNA

1. Chemical structure of nucleotides; primary and secondary structures of nucleic acids (DNA and various RNAs)
2. Condensation levels of DNA in the eukaryotic cells; the role of topoisomerases and chromatin proteins
3. Structure of the human genome: coding and gene regulatory sequences; non-coding genomic sequences: introns, pseudogenes, repetitive sequences
4. Principles of the semiconservative DNA replication; replication fork, leading and lagging strand
5. DNA replication in the pro- and eukaryotic cells; comparison of the enzymes, proteins involved
6. The telomere; function and significance of the telomerase
7. Common types of DNA damage and repair mechanisms; DNA lesions versus mutations
8. Repair of DNA deamination
9. Formation and repair of thymine dimers
10. Formation and repair of DNA mismatch
11. Formation of spontaneous point mutations; DNA polymorphism; possible effects of point mutations on the encoded proteins

II. RNA

12. Structure and function of RNA polymerase of *E. coli*; initiation of transcription in prokaryotes; the prokaryotic transcription unit
13. Termination of transcription in prokaryotes; post-transcriptional RNA modifications in prokaryotic cells
14. Regulation of transcription in prokaryotes
15. The eukaryotic transcription unit; initiation and termination of transcription in the eukaryotic cells
16. Regulation of transcription in eukaryotes
17. Maturation of mRNA
18. Regulation of the eukaryotic gene expression by proteins binding to UTR segments of mRNA
19. Formation and regulatory functions of microRNAs in eukaryotic cells
20. Significance of DNA methylation and histone modifications
21. Modulation of eukaryotic mRNA maturation, and subsequent sequence modifications in mRNA – their roles in the control of gene expression
22. DNA-binding proteins and their characteristic structural motifs with examples
23. Structure and function of nuclear receptors; steroid-thyroid receptors and the aryl hydrocarbon receptor

III. Proteins

24. The genetic code; codon-anticodon interaction; function and role of aminoacyl-tRNA synthetases
25. Structure and function of the ribosome; the ribosome cycle; role of tRNA in translation
26. Initiation of translation in pro- and eukaryotic cells
27. Regulation of eukaryotic translation; the role of eIF2α phosphorylation
28. Elongation and termination of translation in pro- and eukaryotic cells; pharmacological inhibitors of translation
29. Post-translational modifications of proteins, characteristic modifications in the endoplasmic reticulum
30. Maturation and quality control of proteins; ERAD
31. Protein targeting within the secretory pathway; targeting to peroxisome or mitochondrion; entry of lysosomal proteins and substrates to be degraded into the lysosome
32. The concept of proteostasis; possible modes of intracellular protein degradation
33. Structure, function and inhibition of the proteasome; TAP
34. Different types of autophagy; role of the lysosomes
35. The lytic replication cycle of bacteriophages; strategies of bacteria and phages to distinguish foreign DNA from their own
36. The lysogenic cycle of bacteriophages; regulation of gene expression in the prophage; phage induction
37. Classification of animal viruses according to their replication mechanism; structure and replication of retroviruses

Recommended textbook

Lodish: Molecular Cell Biology (8th edition)