

Questions from Medical biology and Genetics
in acad. year 2025/2026
for 1st year General Medicine

I. The cell

1. Microscopy techniques and their utilization in biology.
2. Types, shapes, and sizes of the cells.
3. Prokaryotic cells, their structure and reproduction.
4. Differences between prokaryote and eukaryote cells.
5. Molecular structure of the biological membranes.
6. Cell transport.
7. Cell junctions - structure and function.
8. Types of intercellular communications (endocrine, paracrine, autocrine, and neural).
9. Types and function of signal molecules, first and second messengers, amplification of signal.
10. Membrane receptors - structure and function.
11. Cytoplasm - structure and function.
12. Cell nucleus – structure and function.
13. Nuclear envelope and nuclear pores (structure and function).
14. Nuclear matrix – structure and function (lamins, transcriptosomes, replicosomes), regulatory proteins.
15. The nucleolus – types and function.
16. Ribosomes – structure and function.
17. Endoplasmic reticulum - types, structure and function.
18. Entry of newly synthesized protein into the endoplasmic reticulum and post-translational modification.
19. Golgi complex, its structure, metabolic and distribution function.
20. Lysosomes as a part of the intracellular digestive system. Proteasomes – structure and function.
21. Peroxisomes – structure and function.
22. Structure and function of mitochondria, endosymbiotic theory.
23. Cytoskeleton - types of its structures, function.
24. Cell cycle - phases, regulatory molecules, checkpoints (overview).
25. Structure of and function of centromere and kinetochore of eukaryotic chromosomes (DNA, proteins).
26. Processes taking part in cell cycle regulation, examples.
27. Cyclins, cyclin-dependent kinases – types, function, activation, inactivation, inhibition.
28. Mitosis as a part of the cell cycle (overview).
29. G1 checkpoint of the cell cycle – principle, key molecules.
30. Factors facilitating G1/S transition in the cell cycle.
31. Initiation of S-phase, origin of replication complex (participating proteins).
32. G2 checkpoint of the cell cycle, key proteins.
33. Factors performing G2/M transition in the cell cycle – principle.
34. Mitotic checkpoint, molecular mechanism of its regulation.
35. Meiosis – stages and biological significance.
36. Spermatogenesis and oogenesis in humans.
37. Cell and tissue cultures, their significance in biology and medicine.
38. Extracellular vesicles and their significance in medicine.
39. In vitro biological evaluation of cells (viability, proliferation and metabolic activity).
40. Stem cells (definition, types and utilization in biology and medicine).

41. Tissue engineering and regenerative medicine.
42. Apoptosis - programmed cell death (telomeric sequences).
43. Mechanism of apoptosis activation through death receptors.
44. Mechanism of apoptosis activation through mitochondrial pathway.
45. Mechanism of apoptosis activation through endoplasmic reticulum.
46. Methods detecting cell death.
47. Viruses as an independent group of organisms and their taxonomy.
48. Viruses according to the character of their nucleic acids, RNA viruses.
49. Viruses according to the character of their nucleic acids, DNA viruses.
50. Reproduction of viruses (lysogenic and lytic cycle, molecular mechanism – retroviruses (HIV).
51. Mutations and recombinations of viruses (influenza, retroviruses), reasons and consequences.
52. Mechanisms of reverse transcription (cDNA synthesis), origin of HIV provirus.
53. Oncoproteins of DNA viruses (HPV, SV40, EBV) in malignant transformation of cell (overview).
54. Evidence of evolutionary interaction of retroviruses and eukaryotic genomes (HERV and other sequences).
55. Acute and non-acute transforming retroviruses, mechanism of action.
56. Interactions between micro – and macroorganisms.

II. Chromosomes, genes, genome, inheritance, malignancy, mutagenesis

1. Basic methods of human genetics
2. Chromosomal basis of inheritance, types of chromosomes, human karyotype.
3. Ultrastructure of chromosome – nucleosome, non-histone proteins, chromatin and mechanisms of its remodeling.
4. Classical cytogenetics, indications for cytogenetic testing. Methods of chromosome staining.
5. Identification of chromosomes in interphase nucleus, principle, and utilization.
6. Molecular cytogenetic methods (overview).
7. Disorders of mitotic and meiotic division (non-disjunction, anaphase lag) and their consequences.
8. Numerical aberrations of chromosomes – types, mechanisms of origin.
9. Spectrum of chromosomal aberrations in miscarriages, newborns, and in the adult population.
10. The most common numerical chromosomal aberrations in neonatal population (Down sy., Turner sy.) – compare the mechanism of origin.
11. Specific chromosomal aberrations of tumors.
12. X-chromosome inactivation, reasons, mechanisms and consequences.
13. Gene dose effect, consequences of allele amplification.
14. Mosaicism – definition, origin, the influence on the clinical signs.
15. Structural chromosomal aberrations - classification, origin, prognosis.
16. Mechanisms causing deregulation of cell cycle and its consequences.
17. Oncogenesis, molecular characteristics of gradual malignant transformation of cell.
18. Relation between protooncogene - oncogene, types of oncogenes.
19. Mechanisms of changing protooncogene to oncogene.
20. Protooncogenes - by localization of their products, function in organism, system of their expression control.
21. Non-viral and viral mechanisms of protooncogenes deregulation, possibilities of their detection.
22. Tumor-suppressor genes and proteins – types, function, significance in cell cycle regulation.
23. Mechanisms of tumor-suppressor genes (proteins) deregulation and consequences for cell cycle regulation.

24. Tumor-suppressor gene Rb1, characteristics and biological function.
25. Tumor-suppressor gene TP53, characteristics and biological function.
26. Tumor-suppressor genes BRCA1 & BRCA2, characteristics and biological function.
27. Examples of oncological diseases with the significant portion of heredity (retinoblastoma, sy. Li-Fraumeni).
28. Translocations of chromosomes in etiology of Burkitt lymphoma and chronic myeloid leukemia.
29. Detection of mistakes in DNA, activation of ATM/ATR and its consequences.
30. DNA repair mechanisms – types, function.
31. Failure of reparatory mechanisms – syndromes with spontaneous instability of chromosomes.
32. Autosomal dominant inheritance, criteria, most common diseases with autosomal dominant inheritance, new mutations, selection against them.
33. Autosomal recessive inheritance, criteria, most common diseases with autosomal recessive inheritance, selection, detection of recessive alleles.
34. X-chromosome linked inheritance, most common diseases with this type of inheritance.
35. AB0 system, inheritance, antigen and antibody, compatibility, rules of transfusion.
36. Rh factor and hemolytic disease of newborns – mechanism of origin and prevention.
37. Multifactorial and polygene inheritance, criteria (continual and discontinual variability).
38. Normal variation in population, tendency to average values, traits with threshold effect (oro-facial clefts and neural tube defects).
39. Most common diseases with multifactorial inheritance (pyloric stenosis, civilization diseases), mechanism of origin, prognosis for subsequent pregnancy.
40. Hardy-Weinberg law, gene frequencies in population, gene pool of population, consanguinity - influence on allele frequency in population.
41. Mutagenesis – molecular base, types of mutations.
42. Mutagens – characteristics, types, mechanisms of action, possibilities of their detection.
43. Somatic and gametic mutations, consequences.
44. Congenital developmental defects – characteristics, incidence in human population, possibilities of study.
45. Molecular mechanisms governing embryogenesis (SHH, HOX, PAX).
46. Apoptosis in embryogenesis.
47. Prenatal genetic diagnosis, its methods (examination of amniocytes, chorionic villi sampling, chromosomal analysis, DNA analysis).

III. Molecular genetics

1. Composition, function and structure of DNA.
2. Complementarity of bases and its importance. Watson-Crick model of DNA (alpha helix).
3. Genetic code and its degeneration.
4. Enzymes and other proteins taking part in semiconservative replication of DNA.
5. Initialization of semiconservative replication of DNA (ORI, replication fork, direction).
6. Elongation and termination of semiconservative replication of DNA.
7. Central dogma of molecular genetics, flow of genetic information (Crick, Temin-Baltimore).
8. Structure of eukaryotic gene (regulatory, coding, and non-coding regions).
9. Regulatory sequence of gene (characterize region of promoter and order of regulatory proteins binding in the gene expression).
10. Regulation of gene expression – principles, mechanisms.
11. Characteristics of the human nuclear genome, types of sequences in DNA.
12. Mitochondrial genome. Comparison between nuclear and mitochondrial genome.

13. The Human Genome Project (HGP) and follow-up projects (Human Genome Diversity Project, the 1000 Genome Project, ENCODE, Earth BioGenome), significance for medical practice.
14. Initiation of mRNA synthesis, participating factors.
15. Post-transcriptional modification of pre-mRNA.
16. Translation – origin of initiation complex and active ribosome, elongation and termination.
17. Differences of protein synthesis between prokaryotic and eukaryotic cell.
18. Inhibition of protein synthesis, mechanism of antibiotics action.
19. RNA types in eukaryotic cell (overview), their characteristics and function.
20. rRNA - structure, place of synthesis in cell, localization of genes, maturation.
21. tRNA structure and function, its synthesis in cell.
22. Non-coding RNA – types and function.
23. Types of non-coding DNA in human genome (Alu, mini and microsatellite DNA).
24. Transposable elements (transposons) and other retroelements (SINEs, LINEs), distinction from proviruses.
25. Instable repetitions of trinucleotides, FRAXA, Huntington chorea, myotonic dystrophy - molecular diagnostics.
26. Gene families (hemoglobin genes, HOX) – mechanism of origin, characteristics.
27. DNA binding regulatory proteins, characteristics, function, cis and trans activation.
28. Alternative use of a cell's genetic information (promoters, splicing, RNA editing, polyadenylation) in cell differentiation.
29. Forms of alien DNA entry into the cell – conjugation, transduction, transformation, transfection.
30. Principles of DNA isolation from biological material.
31. Restrictive endonucleases, characteristics and function of enzymes, utilization in practice.
32. DNA recombinant techniques, principles, utilization.
33. DNA cloning in vitro, principles, utilization.
34. Genetic vectors – types, characteristics.
35. Genetically modified organisms.
36. Fluorescent in situ hybridization (FISH), principle, utilization.
37. DNA polymorphisms – examples and utilization (VNTR, RFLP), possibilities of identification.
38. DNA fingerprint method and its practical application.
39. DNA sequencing, principles, utilization.
40. Gel electrophoresis, Southern blot, Northern blot, principles, utilization.
41. PCR – principle of method and its utilization in diagnostics.
42. DNA - DNA hybridization and its practical application.
43. Principles, advantages and limits of gene therapy.
44. Types of vectors used in gene therapy.
45. Transgenes types and methods of insertion in patients.
46. Approved products and diseases using gene therapy.
47. The importance of CRISPR/Cas in medicine.

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