Introduction into Cell Metabolism 1

Differences between prokaryotic and eukaryotic cell. Organelles of eukaryotic cells and their functions. Biochemically important organic reactions.

Cells

1. Characterize the principal differences between prokaryotic and eukaryotic cell:

Feature	Prokaryotic cell	Eukaryotic cell
Organisms	bacteria and cyanobacteria, mostly unicellular	protozoa, fungi, plants, animals, mostly multicellular
Cell size (μm)		
Separated nucleus	YES / NO	YES / NO
Subcellular compartmentation	YES / NO	YES / NO
Character of chromosomes		
Ribosome size		
Presence of cytoskeleton	YES / NO	YES / NO
Cell division		
DNA	…….. not connected with histones	linear connected with histones
Protein synthesis events		
Location of respiratory enzymes	in plasmatic membrane	

2. Cells of certain tissues or organs often have specialized functions in multicellular organisms. Complete where the given processes occur in the human body:

Glycogen synthesis ..…….....…….

Haemoglobin oxygenation …….....

Epinephrine synthesis …….....

Urea synthesis …….....

Lipids storage …….....

Actin and myosin synthesis …….....

Insulin synthesis …….....

Conjugation of toxic compounds …….....

Subcellular Compartmentation of Metabolism

3. In the table, assign the following processes to the corresponding cell compartments:

- transport of ions and small molecules,
- RNA synthesis,
- steroid synthesis,
- detoxification reactions,
- respiration,
- metabolism of glucose,
- protein biosynthesis,
- ATP synthesis,
- export of proteins,
- intracellular digestion,
- fatty acid oxidation,
- DNA synthesis,
- RNA processing,
- receptors for small molecules of hormones,
- modification and sorting of proteins,
- hydrogen peroxide degradation.

Compartment	**Metabolic process**
Cell membrane	
Cytoplasm	
Mitochondria	
Nucleus	
Rough ER	
Smooth ER	
Golgi apparatus	
Lysosome	
Proteasome	
Peroxisome	

Enzyme Markers of Subcellular Fractions

The purity of subcellular fractions is assessed by the determination of enzyme activity of organelles. Enzyme markers are enzymes that are located specifically within certain cell fractions and are specific for this organelle.

4. Fill in the functions of enzymes that serve as markers into the table:

Fraction	**Enzyme**	**Enzyme function**
Cell membrane	Na^+/K^+-ATPase	
Nucleus	DNA polymerase	
	RNA polymerase	
ER	Glucose-6-phosphatase	
	Cytochrome b_5 reductase	Fatty acid desaturation
Golgi apparatus	Galactosyl transferase	
Lysosomes	Acid phosphatase	
	β-Glucuronidase	Proteoglycan cleavage
Mitochondria	Succinate dehydrogenase	
	Cytochrome c oxidase	
Peroxisomes	Catalase	
Cytosol	Lactate dehydrogenase	
	Glucose-6-phosphate dehydrogenase	Pentose phosphate cycle

5. Write the equation of glucose-6-phosphate cleavage by the action of glucose-6-phosphatase.
6. Write the equation of a reaction catalyzed by succinate dehydrogenase.
7. Write the equation of a reaction catalyzed by lactate dehydrogenase.
8. Which compound is a cofactor in both above-mentioned reactions?
9. What is the function of cytochrome c oxidase? Do you know some inhibitors of it?
10. The criterion of subcellular fractions purity is specific activity of enzymes, expressed as enzyme activity per unit of protein mass. How is changed this value with increasing fraction purity?
11. Draw the structure of a compound that is formed from D-glucopyranose by the action of glucose-6-phosphate dehydrogenase.

Nucleus

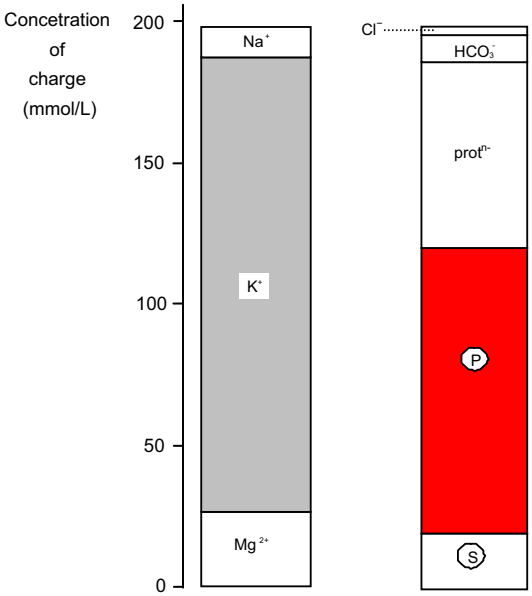
12. Characterize the arrangement of DNA in the nucleus of eukaryotic cells.
13. What processes does mRNA undergo after its synthesis?
14. How does the processed mRNA penetrate from nucleus to cytosol?

Cell Membrane

15. Which components are contained in cell membrane?
16. Draw examples of such structures.
17. Which intermolecular interactions exist in the inner part of a membrane?
18. What is the function of proteins in cell membrane?
19. What is glycocalix?
20. Which amino acids occur in the intramembrane part of membrane proteins?

Cytoplasm

Main components of intracellular fluid (ICF)



21. What is the main cation of intracellular fluid?
22. What are main anions of intracellular fluid?
23. Why are proteins counted among the anions?
24. Which ions included in the diagram have buffering effect?

25. Glycolysis and gluconeogenesis are located in cytoplasm. Glyceraldehyd-3-phosphate, dihydroxyacetone phosphate, phosphoenolpyruvate, and 1,3-bisphosphoglycerate are intermediates of these processes. Draw the structural formulas of these compounds.
26. Fatty acids are converted to acyl-CoA after they enter the cell. What type of bond is formed between the fatty acid and coenzyme A? Draw a general formula.
27. How is metabolized ethanol in cytoplasm? What enzymes are involved?

Mitochondria

28. Characterize a structure of mitochondria. What is the difference between the two mitochondrial membranes?
29. Does DNA occur in mitochondria? What is its function?
30. Why is oxygen needed in mitochondria? Write the main oxygen reaction in mitochondria.
31. Electrons are transported via system of redox cofactors in the respiratory chain. What are the values of standard redox potentials of these cofactors?
32. Citric acid cycle (CAC) is located in the mitochondrial matrix. Write the first reaction of CAC.
33. Which cofactors take part in dehydrogenation reactions of CAC? Characterize their structures.
34. Characterize ATP structure. What type of bond is cleaved during the conversion of ATP to ADP?
35. The ketone bodies are formed in mitochondrial matrix. Give their names and structures.

Endoplasmic Reticulum (ER)

36. Characterize the structure of ER. What is the difference between rough and smooth ER?
37. What is the role of cytochrome P450 in the ER?
38. How is called ER in muscle cells? Which cation is accumulated here?
39. Fatty acids are desaturated in ER. Which types of desaturases are present in human liver cells?

Golgi Apparatus (GA)

40. Characterize Golgi apparatus structure. What is the difference between *cis*- and *trans*-GA?
41. What is the role of GA in the cell? Give examples.

Peroxisomes

42. Characterize peroxisome structure and function.
43. Enzyme catalase catalyzes both peroxide decomposition and reactions utilizing peroxide for oxidation of substrate. Complete the equations:

    a) ... H_2O_2 → … ..... + … O_2

    b) … RH_2 + … H_2O_2 → … ..... + … .....
44. Complete the equation of ethanol degradation in peroxisomes of liver cell:

    … H_2O_2 + … ethanol → … ……. + … ……

Lysosomes

45. What is the role of lysosomes in cells?
46. What is the pH in lysosomes?
47. What is the difference between the primary and secondary lysosomes?
48. How macromolecules enter lysosomes?
49. Which enzyme class do lysosomal enzymes belong to?
50. Draw general formulas of phosphoester, amide, peptide, *O*- and *N*-glycoside.
51. In the table, complete the bond types cleaved by the given enzymes:

Enzyme	**Type of bond**
α-Glucosidase	
β-Galactosidase	
Hyaluronidase	
Arylsulfatase	
Lysozyme	
Cathepsin	
Collagenase	
Elastase	
Ribonuclease	
Lipase	
Phosphatase	
Ceramidase	

Cytoskeleton

52. Cytoskeleton is composed of three types of filamentous structures. Complete the table:

Type of filament	**Main protein**	**Main function**
		Maintenance of cell shape, intracellular transport processes (e.g. movement of chromosomes), migration of cells ...
		Cell division, endocytosis, exocytosis, maintenance of cell shape ...
	Desmin (muscle cells) Vismetin (fibroblasts) Keratin (epithelial cells) Neurofilaments (neurons)	Unknown

53. Which of cytoskeleton fibres are longest?
54. Which cytoskeleton filaments does colchicine bind to? What is its effect?
55. What is the role of kinesin and dynein in the cell?

Non-Covalent Interactions

56. Integrity of cell and its compartments, interactions between individual molecules, interactions between signal molecules and receptors, substrate and enzyme, etc., are based on the existence of non-covalent interactions. Characterize these interactions by completion of the table:

Non-covalent interaction	Principle of the interaction
Hydrogen bonds	
Electrostatic	
Hydrophobic	

Occurrence of Non-Covalent Interactions in Cells

57. Complete prevailing type of non-covalent interactions, stabilising the structure/system in cell.

Structure / System	Prevailing type of interaction
Proteins – secondary	
Proteins – tertiary	
Proteins – quaternary	
DNA	
Phospholipid bilayer	
Enzyme – substrate	
Antibody – antigen	