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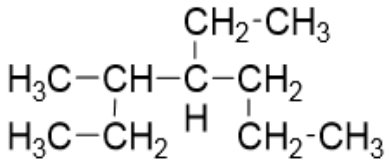
Exam questions on discipline “Molecular Biology and Bioorganic Chemistry”

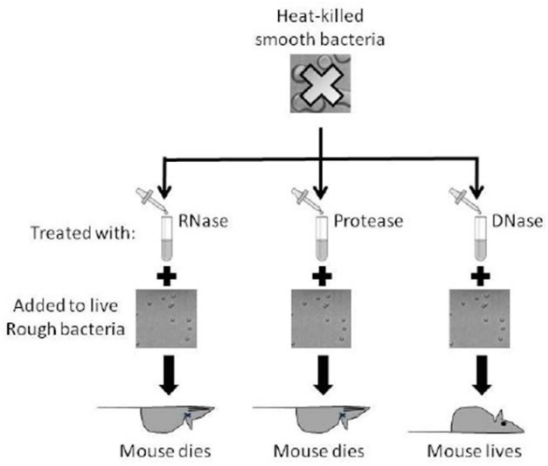
No.	Topic title	Exam question
Bioorganic chemistry		
1	**Introduction to bioorganic chemistry.**	1. Identify the general structural characteristics of organic molecules, in particular, the tetravalent nature of carbon and the different ways in which it can be expressed; 2. Define functional group - identify the functional groups in organic molecules; recognize structural (constitutional) isomers and functional group isomers; 3. Write structures of organic molecules in various ways; classify the organic compounds; 4. Name the compounds according to IUPAC system of nomenclature and also derive their structures from the given names; 5. Draw structural, condensed, and line formulas for simple chemical compounds; 6. Convert any given structural, condensed, or line formula into its corresponding alternative; 7. Plan and organize laboratory work in a correct and safe manner and carry out simpler risk and security assessments.
2	**Hydrocarbons**	1. Name hydrocarbons according to IUPAC system of nomenclature; 2. Recognise and write structures of isomers of alkanes, alkenes, and alkynes; 3. Distinguish between alkanes, alkenes, alkynes and aromatic hydrocarbons on the basis of physical and chemical properties; 4. Identify the physical properties of alkanes; determine the basic reactions of alkanes; 5. Draw the isomeric products formed during the halogenation of simple alkanes; 6. Identify a cycloalkane from its structure; 7. Name a cycloalkane given its structure and draw a cycloalkane given its name; 8. Identify the functional groups present in alkenes and alkynes; 9. Differentiate between saturated and unsaturated molecules; 10. Name a simple alkene or alkyne given its condensed or line structure; 11. Draw the condensed or line structure of an

		alkene or alkyne given its name; 12. Identify cis–trans isomers of alkenes; 13. Predict the addition products obtained when alkenes react with H2, Cl2, HCl, or H2O; identify "unsymmetrically substituted" and "symmetrically substituted" alkenes; 14. Utilize Markovnikov's rule when addition reactions to unsymmetrically substituted alkenes occur; 15. Predict what polymer forms given an alkene monomer; 16. Explain the preliminary laboratory techniques of organic chemistry; 17. Being able to perform practical chemical techniques; 18. Develop experimental skill and research potential; 19. Give the name for IUPAC and rational nomenclatures of the alkane. 
3	**Types of organic reactions**	1. Describe the reactions and properties of halogen compounds; 2. Identify an alkyl or aryl halide; 3. Identify the different types of organic reactions.
4	**Alcohols, phenols, and ethers. Properties of hydroxy compounds.**	1. Describe the structural differences between alcohols, phenols, and ethers; 2. Explain why alcohols have higher boiling points than compounds of similar molecular mass; 4. Write systematic names for simple alcohols; 5. Draw the structure of an alcohol given its name, in both condensed and line structure format; 6. Classify an alcohol as primary, secondary, or tertiary; define and identify a glycol; 7. Describe the properties of alcohols; 8. Describe hydrophobic and hydrophilic alcohols; 9. Predict the products obtained upon dehydration of an alcohol; 10. Predict the oxidation products of a primary, secondary, and tertiary alcohol; 11. Explain why alcohols and phenols are weak acids; 12. Identify an ether, distinguish between an

		ether and an alcohol.
5	**Aldehydes and ketones**	1. Identify a carbonyl group and describe its polarity and shape; 2. Name and draw simple aldehydes and ketones given a structure or a name; 3. Describe the polarity, hydrogen bonding, and water solubility of aldehydes and ketones; 4. Identify the products of the reduction of aldehydes and ketones; 5. Identify the differences between hemiacetals, hemiketals, acetals, and ketals; 6. Predict the products of hemiacetal, hemiketal, acetal, and ketal formation and their hydrolysis.
6	**Carboxylic acids and their derivatives. Properties of carbonyl-containing compounds.**	1. Compare and contrast the structures, reactions, hydrogen bonding, water solubility, boiling points, and acidity or basicity of carboxylic acids, esters, and amides; 2. Name simple carboxylic acids, esters, and amides given a structure and write a structure given a name; 3. Describe the acidity of different carboxylic acids and predict the products obtained when they react with strong bases; 4. Describe how esters and amides are formed from carboxylic acids.
7	**Aromatic and aromatic heterocyclic compounds**	1. Identify the structures of aromatic compounds; 2. Explain the importance and function of resonance in aromatic compounds; 3. Name simple monosubstituted or disubstituted aromatic compounds; 4. Predict the products obtained when aromatic compounds react with concentrated HNO3, CL2, Br2, or concentrated H2SO4; 5. Define and recognize aromatic compounds and the importance of resonance and aromaticity; 6. Explain Huckel's Rule; 7. Name the chemical properties of heterocyclic compounds; 8. Formulate conclusions about the possible products of chemical reactions of heterocyclic compounds; 9. Describe the nomenclature, structure and properties of heterocyclic compounds.
8	**Stereochemistry and chirality**	1. Identify a chiral carbon; differentiate chiral and achiral molecules; 2. Identify the stereocenters in a molecule and assign the configuration as R or S; 3. Explain the relationships between enantiomers and their specific rotations.

9	**Introduction to spectral methods**	1. Describe the principles of structure determination for organic molecules using the tools of ultraviolet-visible spectroscopy, infrared spectroscopy, nuclear magnetic resonance spectroscopy, and mass spectrometry; 2. Explain the basis of IR, NMR, UV and mass spectra methods of determination the structures of aromatic compounds.
10	**Amines and amino acids**	1. Describe and recognize the 20 alpha amino acid structures and their side chains; 2. Identify and classify an amine as primary, secondary, or tertiary; 3. Name a simple amine given its structure or draw an amine given its name; 4. Describe amine properties such as hydrogen bonding, solubility, boiling point, and basicity; 5. Identify a quaternary ammonium ion and describe its properties; 6. Define what is meant by alpha-amino acids, isoelectric point for amino acids, L-configuration for natural amino acids and the "zwitterion" nature of amino acids.
11	**Peptides and proteins**	1. Describe the different functions of proteins and give an example for each function; 2. Identify a peptide bond, and explain how it is formed; 3. Draw and name a simple protein structure given its amino acid sequence; 4. Identify the amino-terminal end and the carboxyl-terminal end of a simple protein (peptide) structure given its amino acid sequence; 5. Define primary protein structure and explain how primary structures are represented; 6. Describe the planar sections of the primary sequence, their influence on the shape of the protein backbone, and identify these sections given a drawing of the primary sequence; 7. Give an example of how the change in primary sequence can change the function of a protein; 8. Identify the a-helix and b-sheet structures and give an example of a protein that contains primarily helix and one that contains primarily sheet secondary structure; 9. Describe the specific hydrogen bonding responsible for secondary structures; 10. Distinguish between fibrous and globular proteins.
12	**Carbohydrates**	1. Classify carbohydrates by functional group and number of carbon atoms and label them

		accordingly; 2. Identify D and L enantiomers and any diastereomers of a monosaccharide from the Fischer projection; 3. Draw the Fischer projection for a monosaccharide; 4. Convert five- and six-carbon monosaccharides from the Fischer projection to the Haworth projection; 5. Identify the anomeric carbon and the alpha (a) or beta (b) form of the monosaccharide and describe the role of mutarotation in cyclic structure; 6. Identify by name and structure the common monosaccharides, their sources and uses; 7. Predict the products of oxidation and reduction reactions on monosaccharides; 8. Predict the products of reactions between monosaccharides and alcohols; 9. Recognize and predict the products of hydrolysis reactions of polysaccharides and phosphorylation reactions of monosaccharides; 10. Predict the results of some common reactions of simple carbohydrates such as oxidation, reduction, osazone formation, etc.; 11. Describe glycosidic bond formation as a type of dehydration reaction; 12. Identify by name and structure the common disaccharides, the subunits and the bond between them, their sources and uses; 13. Recognize common polysaccharides and identify where each polysaccharide is found in nature and its function; 14. Identify the monomers and type of bond present in each polysaccharide; 15. Identify the modified monosaccharides found in naturally occurring polysaccharides and identify the functions of these polysaccharides.
13	**Lipids**	1. Describe the chemical structures and general properties of fatty acids, waxes, sterols, fats, and oils; 2. Describe the characteristics of fatty acids and fatty acid esters; 3. List the physical properties of fats and oils and explain why they are different; 4. Describe hydrogenation and hydrolysis reactions of triacylglycerols, and, given the reactants, predict the products; 5. Recognize phospholipids and glycolipids and describe their functions; 6. Identify sterols and their derivatives and describe their structures and roles.

Molecular biology		
14	**Introduction to molecular biology**	1. Describe the Chargaff, Griffith, Avery-macleod-mccarty, Hershey-Chase experiments and explain their significance; 2. Explain informational properties of macromolecules; 3. Explain the central dogma of molecular biology; 4. Briefly discuss the role of molecular biology in medicine; 5. In 1944, three Canadian and American researchers, Oswald Avery, Maclyn McCarty, and Colin MacLeod, set out to identify Griffith's "transforming principle."  What conclusion can be drawn from these data?
15	**Nucleotides and nucleic acids**	1. Describe, identify, and draw the components of nucleosides and nucleotides; 2. Describe and identify nucleic acid chains in DNA and RNA.
16	**DNA replication**	1. Describe the three hypotheses of DNA replication; 2. Describe the Meselson-Stahl experiment and explain its significance; 3. Explain the molecular mechanism of semiconservative DNA replication; 4. Explain the role of main enzymes implicated in the replication process; 5. Explain proofreading mechanisms and error correction during DNA replication.
17	**DNA repair**	1. Explain what a mutation is and its importance for evolution of life; 2. Explain the importance of dna repair; 3. Explain the mechanisms of base excision, nucleotide excision, homologous recombination, non-homologous end joining modes of repair.
18	**Transcription of genetic information**	1. Define the terms: transcription, promoter,

		enhancer, terminator; 2. Describe prokaryotic and eukaryotic RNA-polymerases' structure and functions; 3. Describe phases of transcription, explain the processes happening at each phase and their importance; 4. Explain the process, importance and difference of Rho-independent and Rho-dependent termination.
19	**Post-transcriptional RNA modifications**	1. Explain mechanisms of polyadenylation, its importance; 2. Describe the cap structure, its synthesis and functions; 3. Describe the mechanism of splicing and its importance; 4. Explain the effect of splicing on gene expression.
20	**Translation of genetic information**	1. Explain the ribosome cycle and fidelity of translation; 2. Define the genetic code, tRNA, mRNA, codon, anticodon; 3. Describe the structure of tRNA and the mechanism of its charging; 4. Explain the scanning model of translation; 5. Explain the mechanism of translation and its phases; describe the structure of ribosomes and polysomes.
21	**Post-translational protein modifications and folding**	1. Draw a functional connection between primary structure and higher-order spatial organization of polypeptides; 2. Explain the auxiliary role of chaperones in protein folding; 3. Give detailed examples of human disorders linked with protein misfolding.
22	**Regulation of gene expression in prokaryotes**	1. Define the terms: operon, cistron, promoter; 2. Explain the functioning and regulation of the following operons: lac, ara, trp, gal; 3. Explain positive and negative controls of operons; 4. Differentiate between constitutive and inducible promoters.
23	**Regulation of gene expression in eukaryotes**	1. Explain the mechanism of transcriptional regulation in eukaryotes; 2. Describe promoter structure: TATA-,GC-boxes; 3. Explain functions of enhancers and silencers; 4. Describe the roles of transcription factors and transcription activators in transcription regulation; 5. Describe structure and significance of DNA-

		binding domains and transcription activation domains; 6. Explain translational regulation.
24	**Epigenetics**	1. Explain the importance of epigenetic regulation and its role in heritability of cellular traits; 2. Explain the role of DNA methylation in regulation of gene expression; Explain the mechanism of RNAi; 4. Describe chromatin structure at the levels of organization: nucleosome, 30-nm fiber, chromosome; 5. Explain the effects of histones on transcription; 6. Explain how transcription is affected by: nucleosome positioning, histone acetylation and methylation, chromatin remodeling; 7. Describe the mechanisms and major players of above mentioned processes.
25	**Mobile genetic elements**	1. Describe DNA transposons, retrotransposons, retroviral integration; 2. Provide examples of human diseases triggered by transposable elements; 3. Discuss the usage of transposable elements in medicine.
26	**Modern techniques in medicine**	1. Describe recombinant DNA technology; 2. Discuss about perspectives and dangers of creating the genetically modified organisms; 3. Explain the principles of CRISPR-Cas9 technology; 4. Discuss the perspectives of genomic technologies in medicine; 5. Explain the Sanger, Maxam-Gilbert, NGS and other methods of genome sequencing; 6. Discuss Human Genome Project and the application of genomic data in personalized medicine; 7. Describe EMBL-EBI, DDJB, NCBI, PIR, MIPS, NBRF, SwissProt, UniProt and other bioinformatical databases; 8. Discuss about future perspectives and applications of genomics and bioinformatics.