

一、單選題 (50%)：每題 2 分，請於試卷內之「選擇題作答區」依序作答。

1. Which of the following statements about the comparison between RNA and DNA synthesis processes is correct?
  - (A) During RNA synthesis, RNA polymerase requires the removal of nucleosomes to initiate transcription, whereas DNA replication does not involve nucleosome remodeling.
  - (B) RNA polymerase does not require proofreading during RNA synthesis, whereas DNA polymerase has 3'→5' exonuclease proofreading activity.
  - (C) Both RNA and DNA synthesis require the binding of DnaA protein to recognize the initiation site.
  - (D) RNA synthesis uses only dNTPs (deoxynucleotide triphosphates) as substrates, whereas DNA synthesis utilizes both NTPs (nucleotide triphosphates) and dNTPs as substrates.
  - (E) Both RNA and DNA synthesis use DNA as a template, and neither process requires any protein-assisted initiation complex formation.
2. Which of the following is NOT a product of photosynthesis?
  - (A) Glucose.
  - (B) Oxygen.
  - (C) ATP.
  - (D) NADPH.
  - (E) Water.
3. In patients with certain genetic diseases, a defect in the carnitine transporter can lead to which of the following conditions?
  - (A) Fatty acids cannot enter the mitochondria for oxidation.
  - (B) Glucose cannot enter the mitochondria for oxidation.
  - (C) Proteins cannot enter the mitochondria.
  - (D) ATP synthesis increases.
  - (E) Elevation of intracellular ketone body levels.
4. Which of the following statements regarding the functions of RNA and DNA is INCORRECT?
  - (A) DNA is primarily responsible for storing genetic information.
  - (B) mRNA carries genetic information and is used for protein synthesis.
  - (C) tRNA is involved in the process of protein translation.
  - (D) rRNA is a major component of ribosomes and participates in protein synthesis.
  - (E) miRNA can regulate gene expression but cannot degrade mRNA.
5. Under anaerobic conditions, ATP generation primarily relies on which of the following pathways?
  - (A) Electron transport chain
  - (B) Oxidative phosphorylation
  - (C) Glycolysis
  - (D) Citric acid cycle
  - (E)  $\beta$ -oxidation
6. Which of the following enzymes is directly responsible for the elongation of fatty acid chains during de novo fatty acid synthesis?
  - (A) Acetyl-CoA carboxylase.

見背面

題號： 335

國立臺灣大學 114 學年度碩士班招生考試試題

科目： 生物化學(C)

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- (B) Acyl-CoA dehydrogenase.
  - (C) Fatty acid synthase.
  - (D)  $\beta$ -ketoacyl-ACP synthase.
  - (E) Carnitine acyltransferase.
7. Which enzyme catalyzes the rate-limiting step in the citric acid cycle and is inhibited by ATP?
- (A) Citrate synthase.
  - (B)  $\alpha$ -ketoglutarate dehydrogenase complex.
  - (C) Isocitrate dehydrogenase.
  - (D) Malate dehydrogenase.
  - (E) Succinate dehydrogenase.
8. Regarding eukaryotic translation and the structure and function of tRNA, which of the following statements is correct?
- (A) During translation, the small ribosomal subunit is responsible for peptide bond formation, while the large subunit scans and pairs the ribosome with the start codon of the mRNA.
  - (B) During the recognition and attachment of the correct amino acid to tRNA, aminoacyl-tRNA synthetase verifies the side-chain structure of the amino acid and the anticodon of the tRNA to ensure specificity.
  - (C) The E-site of the ribosome is the entry site for aminoacyl-tRNA, while the P-site is the location where decoding occurs.
  - (D) Eukaryotic translation initiation requires eIF2 (eukaryotic initiation factor 2) to assist in loading the initiator tRNA into the large ribosomal subunit and directly position the start codon on the mRNA via the 5' cap structure.
  - (E) The T $\Psi$ C arm of tRNA interacts with the ribosome to help tRNA enter the ribosome, while the DHU arm is responsible for the specific recognition by aminoacyl-tRNA synthetase.
9. Which of the following substances is NOT a precursor or intermediate in cholesterol synthesis?
- (A) Acetyl-CoA.
  - (B) Acetoacetyl-CoA.
  - (C) Mevalonic acid.
  - (D) Squalene.
  - (E) Phosphatidic acid.
10. Which of the following substances is the starting material for de novo purine nucleotide synthesis?
- (A) Aspartate.
  - (B) Glycine.
  - (C) Glutamine.
  - (D) All of the above.
  - (E) None of the above.
11. Which of the following mechanisms is primarily involved in repairing double-stranded breaks in DNA?
- (A) Non-homologous end joining (NHEJ).
  - (B) Homologous recombination.
  - (C) Base excision repair (BER).
  - (D) Nucleotide excision repair (NER).
  - (E) Both A and B.

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12. Which of the following substances can activate phosphofructokinase-1 (PFK-1) and stimulate glycolysis?
- (A) ATP.
  - (B) Citrate.
  - (C) AMP.
  - (D) Fatty acid.
  - (E) Acetyl-CoA.
13. Which of the following statements about cyclin-dependent kinases is INCORRECT?
- (A) Different types of cells regulate the cell cycle through distinct CDK complexes with specific cyclins.
  - (B) CDK activity fluctuates depending on the stage of the cell cycle.
  - (C) CDK activity is controlled by mechanisms such as gene expression, phosphorylation, and protein degradation.
  - (D) Cyclins are essential regulators of CDK activity.
  - (E) CDKs regulate proteins that drive cell cycle progression.
14. Which of the following reactions is common to both gluconeogenesis and glycolysis?
- (A) Phosphoenolpyruvate to pyruvate.
  - (B) Glucose-6-phosphate to fructose-6-phosphate.
  - (C) Fructose 1,6-bisphosphate to glyceraldehyde 3-phosphate and dihydroxyacetone phosphate.
  - (D) Dihydroxyacetone phosphate to glyceraldehyde 3-phosphate.
  - (E) Pyruvate to oxaloacetate.
15. How is the electron transport chain related to oxidative phosphorylation?
- (A) The electron transport chain serves as the electron donor for oxidative phosphorylation.
  - (B) Oxidative phosphorylation provides protons as the electron acceptor for the electron transport chain.
  - (C) These two processes are entirely separate.
  - (D) Both processes occur simultaneously in the cytoplasm.
  - (E) None of the above.
16. The pentose phosphate pathway plays a dual role in cellular metabolism. It generates \_\_\_\_ for anabolic reactions and \_\_\_\_ as a precursor for nucleotide biosynthesis. Which of the following correctly fills in the blanks?
- (A) ATP; fructose-6-phosphate.
  - (B) NADPH; fructose-1,6-bisphosphate.
  - (C) NADPH; ribose-5-phosphate.
  - (D) NADH; glyceraldehyde-3-phosphate.
  - (E) NADH; ribulose-5-phosphate.
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  - (D) Both processes occur simultaneously in the cytoplasm.
  - (E) None of the above.

18. Which of the following inhibitors can have its inhibitory effect overcome by increasing substrate concentration?
- (A) Competitive inhibitor.
  - (B) Non-competitive inhibitor.
  - (C) Uncompetitive inhibitor.
  - (D) Irreversible inhibitor.
  - (E) None of the above.
19. Which of the following statements about CRISPR-Cas9 is FALSE?
- (A) CRISPR-Cas9 can be used to introduce specific mutations in a precise manner.
  - (B) Off-target effects, where unintended DNA sequences are edited, are a potential concern with CRISPR-Cas9.
  - (C) CRISPR-Cas9 is primarily limited to editing the genomes of simpler organisms such as bacteria and yeast.
  - (D) gRNA directs the Cas9 protein to a complementary target DNA sequence for cleavage.
  - (E) CRISPR-Cas9 has the potential to treat genetic diseases by repairing or correcting disease-causing mutations.
20. Which of the following statements about nitrogen metabolism in biological systems is INCORRECT?
- (A) The enzyme glutamine synthetase catalyzes the ATP-dependent conversion of glutamate and ammonia to glutamine, serving as a key regulatory point in nitrogen assimilation.
  - (B) The urea cycle is the primary pathway for nitrogen excretion in most terrestrial vertebrates, converting ammonia into urea for safe excretion.
  - (C) Nitrogen fixation by nitrogenase requires ATP and is inhibited by molecular oxygen due to the enzyme's oxygen sensitivity.
  - (D) Nitrate reductase and nitrite reductase are exclusively found in prokaryotes and play a critical role in reducing nitrate to ammonia for assimilation.
  - (E) Aminotransferases (transaminases) use pyridoxal phosphate (PLP) as a cofactor to transfer amino groups between amino acids and  $\alpha$ -keto acids, linking amino acid metabolism with the citric acid cycle.
21. Which of the following statements correctly describes the roles of insulin and glucagon in glucose homeostasis?
- (A) Insulin promotes glycogenolysis and gluconeogenesis in the liver, while glucagon promotes glycolysis and glycogenesis.
  - (B) Insulin stimulates glucose uptake in muscle and adipose tissues by upregulating GLUT4 transporters, whereas glucagon primarily acts on the liver to increase glucose production.
  - (C) Insulin inhibits lipogenesis and enhances  $\beta$ -oxidation of fatty acids, whereas glucagon stimulates lipogenesis and inhibits  $\beta$ -oxidation.
  - (D) Both insulin and glucagon act through receptor tyrosine kinases to mediate their effects on target tissues.
  - (E) Insulin and glucagon are secreted by pancreatic  $\beta$ -cells in response to high glucose levels.
22. Which of the following statements about oncogenes and tumor suppressor genes is INCORRECT?
- (A) Oncogenes are typically derived from proto-oncogenes through activating mutations, which lead to a gain of function and promote uncontrolled cell proliferation.

- (B) Tumor suppressor genes usually require both alleles to be inactivated by mutations or deletions to lose their function, a concept described by the "two-hit hypothesis."
- (C) Mutations in oncogenes are often dominant, while mutations in tumor suppressor genes are typically recessive.
- (D) Oncogenes are involved in processes such as apoptosis and DNA repair, whereas tumor suppressor genes primarily regulate growth and cell division.
- (E) The p53 protein, a tumor suppressor, plays a key role in the DNA damage response by inducing cell cycle arrest or apoptosis.

23. Which of the following hormones or neurotransmitters is NOT derived from an amino acid?

- (A) Serotonin.
- (B) Thyroxine (T4).
- (C) Dopamine.
- (D) Testosterone.
- (E) Epinephrine.

24. Which of the following organelles plays a crucial role in the modification and sorting of secretory proteins?

- (A) Endoplasmic reticulum.
- (B) Lysosome.
- (C) Autophagosome.
- (D) Golgi apparatus.
- (E) Peroxisome.

25. Which enzyme is deficient in phenylketonuria?

- (A) Phenylalanine hydroxylase.
- (B) Tyrosine hydroxylase.
- (C) Phenylalanine transaminase.
- (D) Phenylalanine deaminase.
- (E) Tyrosine kinase.

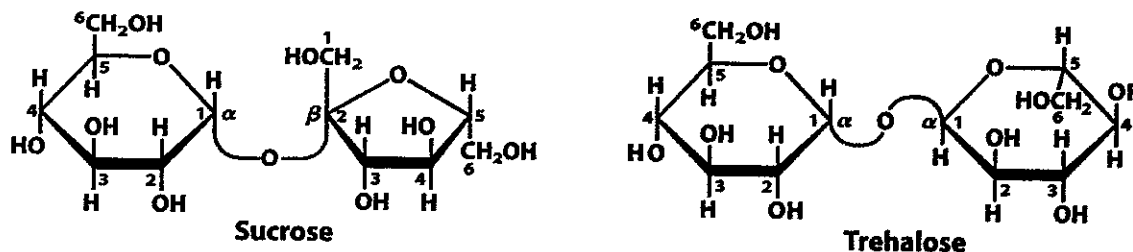
二、問答題 (50%)：分數標示於各題，請於試卷內之「非選擇題作答區」標明題號依序作答。

1. The typical amino acid has a chiral carbon. Please draw the side chains (R groups) of methionine, lysine, tyrosine, leucine, and serine. (10%)
2. Please answer the questions about myoglobin and hemoglobin.
  - (A) How do they bind oxygen? (2%)
  - (B) Please describe the pH effect on O<sub>2</sub> binding to hemoglobin. (2%)
  - (C) Please describe the allosteric regulation modulated by 2,3-bisphosphoglycerate for regulating O<sub>2</sub> binding to hemoglobin. (2%)
  - (D) What is the major secondary structure of myoglobin? (2%)
  - (E) Please describe the sickle-cell anemia which is caused by a mutation in hemoglobin. (2%)

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3. Please answer the following questions about sugars.

(A) Sucrose and trehalose are consisted of what kinds of monosaccharides, respectively? (2%)



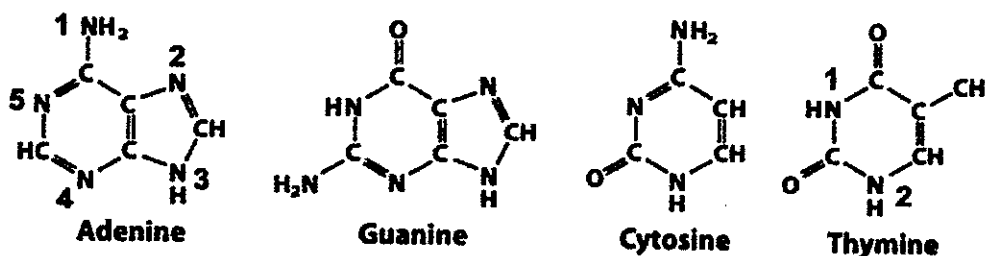
(B) What is the definition of reducing sugar? (2%)

(C) Are sucrose and trehalose all reducing sugars? Please explain. (2%)

(D) Please describe the molecular linkages of glycogen and amylose which are composed of glucose units, respectively. (2%)

(E) Please draw a D-ribose and use it as the example to describe the cyclization of monosaccharide to form a beta-D-ribofuranose. (2%)

4. The molecular structures of adenine, guanine, cytosine, and thymine are shown as below. Please answer the following questions.



(A) In the DNA molecule, which nitrogen atoms of adenine and thymine are connected to the deoxyribose, respectively? Please use numbers beside the N atoms to answer this question. (2%)

(B) Which molecule is NOT found in RNA? (2%)

(C) Which molecule can be found in coenzyme A? (2%)

(D) Please draw the hydrogen bonds between guanine and cytosine. (4%)

5. Lipids have several diverse forms and play versatile functions in cells. Please answer the questions about lipids.

(A) Please draw the molecular structure of *cis*-, *cis*-, *cis*-9,12,15-octadecatrienoic acid. (2%)

(B) Please describe the structural features of sterols. (2%)

(C) Eicosanoids are most frequently derived from which polyunsaturated fatty acid? (2%)

(D) Which fat-soluble vitamin is required for the enzymatic reaction of the formation of active prothrombin? (2%)

(E) Sphingolipids play the important roles in cell recognition. The blood groups are determined in part by the type of sugars attached on the head groups of glycosphingolipids. Sphingolipids are degraded in which cellular organelle? (2%)

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