一、單選題 (56%)：每題 2 分，請於試卷內之「選擇題作答區」依序作答。

1. Which amino acid is most likely to be positively charged at physiological pH?
(A) Serine
(B) Histidine
(C) Glutamate
(D) Tyrosine
(E) Phenylalanine

2. Regarding Michaelis–Menten kinetics, which statement is correct?
(A) Km equals substrate concentration at Vmax
(B) Km is independent of enzyme concentration
(C) Vmax increases linearly with substrate
(D) Km applies only to allosteric enzymes
(E) Vmax is determined solely by Km

3. Which amino acid side chain most commonly participates in general acid–base catalysis?
(A) Alanine
(B) Leucine
(C) Histidine
(D) Valine
(E) Isoleucine

4. Which metabolic pathway directly produces NADPH?
(A) Glycolysis
(B) TCA cycle
(C) Pentose phosphate pathway
(D) β-oxidation
(E) Oxidative phosphorylation

5. Ribose-5-phosphate produced in the pentose phosphate pathway is mainly used for:
(A) Fatty acid synthesis
(B) Amino acid degradation
(C) Nucleotide biosynthesis
(D) ATP production
(E) Protein folding

6. Which statement about the TCA cycle is CORRECT?
(A) It occurs in the cytosol
(B) It directly consumes molecular oxygen
(C) It supplies intermediates for biosynthesis
(D) It functions only anaerobically
(E) It mainly produces NADPH

7. Which process can proceed under anaerobic conditions?
(A) TCA cycle

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(B) Electron transport chain
(C) Oxidative phosphorylation
(D) Glycolysis
(E) β-oxidation

8. Which molecule directly donates electrons to the mitochondrial electron transport chain?
(A) ATP
(B) ADP
(C) NADH
(D) CO_2
(E) Acetyl-CoA

9. In photosynthesis, ATP and NADPH are generated during:
(A) Calvin cycle
(B) Carbon fixation
(C) Light reactions
(D) Photorespiration
(E) Dark respiration

10. The ultimate source of molecular oxygen released during photosynthesis is:
(A) CO_2
(B) NADPH
(C) Glucose
(D) Water
(E) Chlorophyll

11. Which of the following represents a noncovalent interaction?
(A) Disulfide bond
(B) Peptide bond
(C) Ionic interaction
(D) Amide bond
(E) Phosphodiester bond

12. Which type of enzyme inhibitor increases Km but does not change Vmax?
(A) Noncompetitive
(B) Uncompetitive
(C) Competitive
(D) Irreversible
(E) Allosteric

13. Increased atmospheric CO_2 levels most directly affect which biological process?
(A) Glycolysis
(B) β-oxidation
(C) Photosynthetic carbon fixation
(D) Protein translation
(E) DNA replication

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14. Which of the following events is a key mitochondrial step in the intrinsic pathway of apoptosis?
(A) Activation of death receptors on the plasma membrane
(B) Release of cytochrome c from mitochondria into the cytosol
(C) Increased ATP synthesis by oxidative phosphorylation
(D) Direct activation of caspase-8 by mitochondria
(E) Complete shutdown of glycolysis

15. Many cancer cells exhibit the Warburg effect, which is characterized by:
(A) Complete suppression of glycolysis
(B) Exclusive reliance on oxidative phosphorylation
(C) Increased glycolysis even in the presence of oxygen
(D) Inactivation of mitochondrial function
(E) Absence of lactate production

16. Which molecular feature allows mitochondrial proteins encoded in the nucleus to function in energy metabolism?
(A) Presence of introns in mitochondrial DNA
(B) Random diffusion into mitochondria
(C) Targeting signals that direct proteins to mitochondria
(D) Direct translation by cytosolic ribosomes inside mitochondria
(E) Covalent attachment to ATP

17. Under low-energy conditions, cells often suppress global protein synthesis. Which metabolic reason best explains this response?
(A) Protein synthesis does not require ATP
(B) Amino acids cannot be recycled
(C) Translation is energetically expensive
(D) Ribosomes become unstable at low energy
(E) DNA transcription stops completely

18. Which statement best links nucleotide metabolism to gene expression?
(A) Nucleotides are only required for DNA replication
(B) Nucleotide synthesis is independent of cellular metabolism
(C) Availability of nucleotides can influence transcription and cell proliferation
(D) RNA synthesis does not consume energy
(E) Nucleotides function only as signaling molecules

19. What is the process of DNA synthesis using an RNA template called?
(A) Replication
(B) Translation
(C) Reverse transcription
(D) Splicing
(E) Transcription

20. Which chromatin feature is most strongly associated with euchromatin?
(A) High levels of DNA methylation
(B) Enrichment of H3K9me3

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(C) Enrichment of HP1 protein
(D) Dense packing and late replication timing
(E) Open chromatin structure with histone acetylation

21. Which of the following is NOT required for a polymerase chain reaction (PCR) using a thermophilic DNA polymerase?
(A) A DNA template
(B) ATP
(C) A primer
(D) Four 2′-deoxynucleoside triphosphates (dNTPs) or their analogues
(E) Magnesium (Mg^{2+}) or manganese (Mn^{2+}) ions

22. Which of the following best describes the function of telomerase?
(A) Repairs DNA double-strand breaks
(B) Methylates cytosines in CpG islands
(C) Removes RNA primers during replication
(D) Introduces negative supercoils into DNA
(E) Extends telomeres using an RNA template

23. Which of the following enzymes catalyzes the synthesis of tRNA molecules and certain small RNAs in the eukaryotic nucleus?
(A) AMV reverse transcriptase
(B) RNA polymerase I
(C) RNA polymerase II
(D) RNA polymerase III
(E) T7 RNA polymerase

24. In which of the following situations does the polymerase chain reaction (PCR) occur naturally?
(A) During replication of mitochondrial DNA
(B) When a thermophilic bacterium replicates its DNA
(C) During replication of HIV
(D) In ancient DNA
(E) None of the above

25. Which of the following statements about the CRISPR–Cas9 system is TRUE?
(A) Cas9 recognizes target DNA solely by binding to histones.
(B) Guide RNA provides sequence specificity for DNA cleavage.
(C) CRISPR–Cas9 can only be used in bacterial cells.
(D) DNA repair after Cas9 cleavage always occurs by homologous recombination.
(E) CRISPR–Cas9 does not require any specific sequence motif near the target site.

26. Which of the following statements is FALSE?
(A) Proteins in a mixture may be separated analytically in polyacrylamide gels as negatively charged complexes with the detergent SDS. Complexes are resolved roughly according to their molecular mass/size.
(B) In a Western blot, you transfer protein from an electrophoresis gel to a membrane, then visualize a specific protein on the membrane with a specific reagent such as an antibody.
(C) In a Northern blot, you transfer RNA from an electrophoresis gel to a membrane, then visualize a specific RNA on the

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membrane by hybridization with an antibody.
(D) In a Southern blot, you transfer DNA from an electrophoresis gel to a membrane, then visualize a DNA by its hybridization to a labelled DNA probe.
(E) Double-stranded DNA fragments of different sizes can be separated by agarose gel electrophoresis.

27. In human cells, which of the following is NOT a sequence-specific DNA element where transcription factors bind to regulate gene expression?
(A) A Shine–Dalgarno sequence
(B) A TATA box
(C) An enhancer
(D) A kappa B element (κB element)
(E) An AP-1 site (e.g. ATGAGTCA)

28. Which of the following statements about DNA replication is FALSE?
(A) DNA synthesis occurs in the 5′ → 3′ direction.
(B) RNA primers are required to initiate DNA synthesis.
(C) Okazaki fragments are synthesized on the leading strand.
(D) DNA ligase joins adjacent DNA fragments.
(E) DNA polymerases require a template strand.

二、問答題 (44%)：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. Protein structure underlies biological function, and proper folding is essential for enzymatic activity, molecular recognition, and cellular regulation.
   (a) Define primary, secondary, and tertiary protein structures. (4%)
   (b) Explain how amino acid side-chain properties influence protein folding. (4%)
2. Central metabolic pathways are tightly interconnected to ensure efficient energy production and metabolic flexibility in living cells.
   (a) Explain how glycolysis, the TCA cycle, and oxidative phosphorylation are metabolically linked. (5%)
   (b) What happens to cellular metabolism when oxygen supply is limited? (3%)
3. Biological membranes play essential roles in compartmentalizing and regulating metabolic processes.
   (a) Explain how membrane transporters or channels influence cellular metabolism. (4%)
   (b) Describe why membrane integrity and composition are important for mitochondrial function. (3%)
4. Amino acids serve not only as building blocks of proteins but also as key metabolic intermediates.
   (a) Describe two metabolic fates of amino acids in cells. (3%)
   (b) Explain how amino acid metabolism is linked to energy production or biosynthesis. (3%)
5. How was the lamb 'Dolly' cloned? Describe the technique used. (4%)
6. Outline the general structure of the nucleosome. What experimental evidence supports this model? (5%)
7. Compare microRNAs (miRNAs) and small interfering RNAs (siRNAs) in terms of their origin, function and effector complex. (6 %)

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