

Full Length Practice Test 7

Instructions: This practice test contains 280 multiple-choice questions divided into four parts. Select the best answer for each question.

Survey Of Natural Sciences

BIOLOGY (Questions 1-40)

1. The smooth endoplasmic reticulum is primarily involved in:
 - A. Protein synthesis
 - B. DNA replication
 - C. Lipid synthesis and detoxification
 - D. Photosynthesis
2. Blood flows from the right ventricle directly into the:
 - A. Aorta
 - B. Pulmonary artery
 - C. Pulmonary vein
 - D. Left atrium
3. Which checkpoint in the cell cycle occurs before mitosis begins?
 - A. G2 checkpoint
 - B. G1 checkpoint
 - C. M checkpoint
 - D. S checkpoint
4. The antenna complex in photosynthesis functions to:
 - A. Fix carbon dioxide
 - B. Produce ATP
 - C. Split water molecules
 - D. Capture and transfer light energy
5. A mutation that does not change the amino acid sequence is called:
 - A. Missense mutation
 - B. Nonsense mutation
 - C. Silent mutation
 - D. Frameshift mutation
6. Which enzyme initiates protein digestion in the stomach?

- A. Amylase
 - B. Pepsin
 - C. Trypsin
 - D. Lipase
7. The light-independent reactions of photosynthesis produce:
- A. Oxygen
 - B. ATP and NADPH
 - C. Glucose
 - D. Water
8. Which strand of DNA is synthesized continuously?
- A. Template strand
 - B. Leading strand
 - C. Lagging strand
 - D. Coding strand
9. Growth hormone is secreted by which gland?
- A. Thyroid
 - B. Anterior pituitary
 - C. Posterior pituitary
 - D. Adrenal cortex
10. The liquid portion of blood without clotting factors is called:
- A. Serum
 - B. Plasma
 - C. Lymph
 - D. Interstitial fluid
11. The juxtaglomerular apparatus in the kidney regulates:
- A. Glucose reabsorption
 - B. Amino acid secretion
 - C. Urea concentration
 - D. Blood pressure through renin secretion
12. Splicing of pre-mRNA occurs during:
- A. Transcription
 - B. Translation
 - C. RNA processing
 - D. DNA replication

13. The tricuspid valve prevents backflow from:
- A. Left atrium to left ventricle
 - B. Right ventricle to right atrium
 - C. Aorta to left ventricle
 - D. Pulmonary artery to right ventricle
14. Pinocytosis is a form of:
- A. Passive transport
 - B. Facilitated diffusion
 - C. Simple diffusion
 - D. Endocytosis
15. Which organism excretes ammonia as its primary nitrogenous waste?
- A. Freshwater fish
 - B. Mammals
 - C. Birds
 - D. Insects
16. Gene regulation through chromatin remodeling primarily involves:
- A. DNA deletion
 - B. Ribosome binding
 - C. Histone modification and DNA accessibility
 - D. tRNA synthesis
17. The chemoreceptors that monitor blood CO₂ levels are located in the:
- A. Lungs
 - B. Medulla oblongata and aortic bodies
 - C. Heart
 - D. Kidneys
18. In spermatogenesis, meiosis I produces:
- A. Two secondary spermatocytes
 - B. Four spermatids
 - C. Two spermatogonia
 - D. One spermatozoon
19. During the follicular phase of the menstrual cycle, which hormone stimulates follicle development?
- A. LH
 - B. Progesterone

- C. hCG
- D. FSH

20. Somatic hypermutation in antibodies occurs in:

- A. T cells
- B. Bone marrow
- C. Germinal centers of lymph nodes
- D. Thymus

21. Guard cells regulate stomatal opening primarily in response to:

- A. Temperature
- B. Light and CO₂ levels
- C. Nitrogen availability
- D. Oxygen concentration

22. Serotonin is synthesized from which amino acid?

- A. Tyrosine
- B. Phenylalanine
- C. Glutamate
- D. Tryptophan

23. The sliding filament model describes contraction in:

- A. Skeletal muscle
- B. Smooth muscle only
- C. Cardiac muscle only
- D. All connective tissue

24. Which hormone is responsible for milk ejection (letdown)?

- A. Prolactin
- B. Estrogen
- C. Oxytocin
- D. Progesterone

25. Substrate-level phosphorylation occurs in:

- A. Electron transport chain only
- B. Glycolysis and Krebs cycle
- C. Calvin cycle
- D. Photosystem II

26. Helper T cells recognize antigens presented by:

- A. MHC Class II molecules
- B. MHC Class I molecules
- C. Antibodies
- D. B cell receptors

27. The myelin sheath in the peripheral nervous system is produced by:

- A. Oligodendrocytes
- B. Astrocytes
- C. Microglia
- D. Schwann cells

28. Cyclin proteins regulate:

- A. DNA polymerase activity
- B. CDK activity during cell cycle
- C. RNA splicing
- D. Protein degradation only

29. Gas exchange between alveoli and blood occurs by:

- A. Active transport
- B. Facilitated diffusion
- C. Simple diffusion
- D. Osmosis

30. During intense exercise, muscle cells regenerate ATP using:

- A. Aerobic respiration only
- B. Photosynthesis
- C. Fermentation only
- D. Creatine phosphate and fermentation

31. The Griffith experiment demonstrated:

- A. Transformation of bacteria by DNA
- B. Semi-conservative DNA replication
- C. The triplet nature of the genetic code
- D. Gene linkage

32. The menstrual phase occurs when levels of which hormones drop?

- A. FSH and LH
- B. Estrogen and progesterone
- C. Prolactin and oxytocin
- D. hCG and relaxin

33. Most fat digestion and absorption occurs in the:
- A. Stomach
 - B. Mouth
 - C. Small intestine
 - D. Large intestine
34. MicroRNAs (miRNAs) regulate gene expression at the level of:
- A. Translation
 - B. Transcription
 - C. DNA replication
 - D. Splicing
35. Accommodation in the eye involves:
- A. Pupil dilation
 - B. Retinal adjustment
 - C. Corneal reshaping
 - D. Lens shape changes
36. Single-strand binding proteins during DNA replication:
- A. Cut DNA strands
 - B. Prevent reannealing of separated strands
 - C. Add nucleotides
 - D. Join Okazaki fragments
37. Hematopoietic stem cells in adults are found primarily in:
- A. Liver
 - B. Spleen
 - C. Red bone marrow
 - D. Thymus
38. The I-band in a sarcomere contains:
- A. Thin filaments only
 - B. Thick filaments only
 - C. Both thick and thin filaments
 - D. Neither thick nor thin filaments
39. Atrial natriuretic peptide (ANP) causes:
- A. Sodium retention
 - B. Water retention

- C. Vasoconstriction
- D. Increased sodium and water excretion

40. If $p = 0.8$ in a Hardy-Weinberg population, what is the frequency of the heterozygous genotype?
- A. 0.64
 - B. 0.16
 - C. 0.32
 - D. 0.04

GENERAL CHEMISTRY (Questions 41-70)

41. What is the electron configuration of phosphorus (atomic number 15)?

- A. $1s^2 2s^2 2p^6 3s^2 3p^2$
- B. $1s^2 2s^2 2p^6 3s^2 3p^3$
- C. $1s^2 2s^2 2p^6 3s^1 3p^4$
- D. $1s^2 2s^2 2p^6 3s^2 3p^5$

42. The Pauli exclusion principle states that:

- A. Electrons fill lowest energy orbitals first
- B. Electrons occupy degenerate orbitals singly first
- C. Orbitals hold maximum two electrons
- D. No two electrons can have identical quantum numbers

43. What is the pH of a solution with $[\text{OH}^-] = 1 \times 10^{-4} \text{ M}$?

- A. 10
- B. 4
- C. 14
- D. 6

44. Which compound has the highest melting point?

- A. CH_4
- B. CCl_4
- C. NaCl
- D. H_2O

45. In the reaction $\text{Zn} + \text{Cu}^{2+} \rightarrow \text{Zn}^{2+} + \text{Cu}$, zinc is:

- A. Reduced
- B. Oxidized
- C. Neither oxidized nor reduced
- D. The oxidizing agent

46. How many orbitals are in the $n = 3$ energy level?
- A. 3
 - B. 9
 - C. 15
 - D. 9
47. The spin quantum number (s) has possible values of:
- A. $\pm 1/2$
 - B. $0, \pm 1$
 - C. $0, \pm 1, \pm 2$
 - D. Any integer
48. The Henderson–Hasselbalch equation is:
- A. $\text{pH} = -\log[\text{H}^+]$
 - B. $\text{pOH} = 14 - \text{pH}$
 - C. $\text{pH} = \text{pK}_a + \log([\text{A}^-]/[\text{HA}])$
 - D. $K_w = [\text{H}^+][\text{OH}^-]$
49. The combined gas law is:
- A. $PV = nRT$
 - B. $P_1V_1/T_1 = P_2V_2/T_2$
 - C. $V_1/T_1 = V_2/T_2$
 - D. $(P_1V_1)/T_1 = (P_2V_2)/T_2$
50. What is the oxidation state of chromium in $\text{K}_2\text{Cr}_2\text{O}_7$?
- A. +6
 - B. +7
 - C. +12
 - D. +3
51. The entropy change for a spontaneous process is:
- A. Always positive
 - B. Always negative
 - C. Zero
 - D. Positive for the universe
52. What is the mass of 0.25 moles of $\text{Ca}(\text{OH})_2$ (molar mass = 74 g/mol)?
- A. 296 g
 - B. 18.5 g

- C. 37 g
- D. 74 g

53. Ionic radius increases:

- A. Across a period
- B. Up a group
- C. Down a group
- D. Randomly

54. The equilibrium constant K_{sp} applies to:

- A. Acids
- B. Bases
- C. Gases
- D. Sparingly soluble salts

55. A reaction with $\Delta H > 0$ and $\Delta S < 0$ is:

- A. Never spontaneous
- B. Always spontaneous
- C. Spontaneous at low T
- D. Spontaneous at high T

56. A 3 M solution contains how many moles in 2 liters?

- A. 1.5
- B. 5
- C. 6
- D. 3

57. Double bonds consist of:

- A. Two sigma bonds
- B. One sigma and one pi bond
- C. Two pi bonds
- D. Three sigma bonds

58. An acid with $K_a = 1.0 \times 10^{-9}$ is:

- A. Weak
- B. Strong
- C. Neither
- D. Amphoteric

59. After four half-lives, what fraction of a radioactive sample remains?

- A. 1/2
- B. 1/16
- C. 1/4
- D. 1/8

60. Which has the highest ionization energy?

- A. Na
- B. Mg
- C. Ne
- D. F

61. What is the molecular geometry of CO₂?

- A. Linear
- B. Bent
- C. Trigonal planar
- D. Tetrahedral

62. In a galvanic cell, electrons flow from:

- A. Cathode to anode externally
- B. Salt bridge to electrodes
- C. Positive to negative
- D. Anode to cathode externally

63. Standard temperature and pressure (STP) is:

- A. 25°C and 1 atm
- B. 0°C and 1 atm
- C. 100°C and 1 atm
- D. 20°C and 760 torr

64. Isotones have the same number of:

- A. Neutrons
- B. Protons
- C. Electrons
- D. Nucleons

65. The half-life of a reaction is independent of concentration for:

- A. Zero-order reactions
- B. Second-order reactions
- C. Third-order reactions
- D. First-order reactions

66. The conjugate base of H_3PO_4 is:
- A. H_4PO_4^+
 - B. PO_4^{3-}
 - C. H_2PO_4^-
 - D. HPO_4^{2-}
67. Hybridization of carbon in CO_2 is:
- A. sp^3
 - B. sp
 - C. sp^2
 - D. sp^3d
68. Decreasing the volume of a gas at constant temperature will:
- A. Decrease pressure
 - B. Not affect pressure
 - C. Increase temperature
 - D. Increase pressure
69. In the compound Fe_2O_3 , the oxidation number of iron is:
- A. +3
 - B. +2
 - C. +6
 - D. -3
70. Which is NOT a colligative property?
- A. Density
 - B. Boiling point elevation
 - C. Freezing point depression
 - D. Osmotic pressure

ORGANIC CHEMISTRY (Questions 71-100)

71. Cycloalkanes have the general formula:
- A. $\text{C}_n\text{H}_{2n+2}$
 - B. $\text{C}_n\text{H}_{2n-2}$
 - C. C_nH_{2n}
 - D. C_nH_n
72. The functional group of carboxylic acids is:

- A. -OH
- B. -CHO
- C. -NH₂
- D. -COOH

73. What is the IUPAC name for CH₃CH(CH₃)CH₃?

- A. Butane
- B. 2-methylpropane
- C. Isobutane
- D. Propane

74. Molecules with the same molecular formula but different spatial arrangements are:

- A. Constitutional isomers
- B. Enantiomers
- C. Conformers
- D. Stereoisomers

75. Dehydration of an alcohol produces:

- A. Alkene
- B. Aldehyde
- C. Ketone
- D. Ether

76. Which carbonyl is most reactive toward nucleophilic addition?

- A. Ester
- B. Amide
- C. Aldehyde
- D. Ketone

77. Fehling's test is used to detect:

- A. Alkenes
- B. Reducing sugars
- C. Aromatic compounds
- D. Amines

78. In propyne (CH₃C≡CH), the terminal carbon is:

- A. sp hybridized
- B. sp² hybridized
- C. sp³ hybridized
- D. sp³d hybridized

79. In HBr addition to propene, bromine adds to:
- A. Carbon 1
 - B. Either carbon equally
 - C. The more substituted carbon
 - D. Neither carbon
80. Which compound is antiaromatic?
- A. Benzene
 - B. Cyclobutadiene
 - C. Naphthalene
 - D. Pyrrole
81. SN2 reactions are favored by:
- A. Strong nucleophiles and primary substrates
 - B. Weak nucleophiles
 - C. Tertiary substrates
 - D. Protic solvents
82. Phenol is more acidic than ethanol because:
- A. It has more carbons
 - B. It has more oxygens
 - C. The benzene ring is electron-withdrawing
 - D. Resonance stabilizes the phenoxide ion
83. The Cannizzaro reaction involves:
- A. Alcohols
 - B. Aldehydes without α -hydrogens
 - C. Ketones
 - D. Carboxylic acids
84. E1 reactions form carbocation intermediates that:
- A. Always undergo inversion
 - B. Always undergo retention
 - C. Can undergo rearrangement
 - D. Never rearrange
85. The strongest acid among these is:
- A. CH₃OH
 - B. CH₃COOH

- C. C_6H_5OH
- D. H_2O

86. Amide hydrolysis produces:

- A. Ester and amine
- B. Alcohol and amine
- C. Alcohol and carboxylic acid
- D. Carboxylic acid and amine

87. An achiral molecule:

- A. Has a plane of symmetry
- B. Has a chiral center
- C. Rotates plane-polarized light
- D. Has no symmetry

88. Friedel–Crafts reactions require:

- A. Strong bases
- B. Reducing agents
- C. Oxidizing agents
- D. Lewis acid catalysts

89. Tertiary alkyl halides favor which mechanism?

- A. SN_1
- B. SN_2
- C. E_2
- D. No reaction

90. Grignard reagents react with esters to form:

- A. Primary alcohols
- B. Secondary alcohols
- C. Tertiary alcohols
- D. Ketones

91. Absolute configuration is determined by:

- A. R/S nomenclature
- B. (+)/(-) rotation
- C. d/l system only
- D. Melting point

92. Reductive amination produces:

- A. Aldehydes
- B. Ketones
- C. Alcohols
- D. Amines

93. Meso compounds are:

- A. Optically active
- B. Chiral
- C. Achiral despite having stereocenters
- D. Always enantiomers

94. Which reagent reduces esters to alcohols?

- A. NaBH_4
- B. LiAlH_4
- C. H_2/Pd
- D. KMnO_4

95. Primary alcohols are oxidized by PCC to:

- A. Aldehydes
- B. Ketones
- C. Carboxylic acids
- D. Alkanes

96. Electron-donating groups on benzene are:

- A. Meta-directing
- B. Deactivating
- C. Ortho/para-directing
- D. Ortho/para-directing

97. Hofmann elimination produces predominantly the:

- A. More substituted alkene
- B. Aromatic product
- C. Less substituted alkene
- D. Alkane

98. Claisen condensation involves:

- A. Aldehydes
- B. Esters
- C. Ketones
- D. Alcohols

99. UV–Vis spectroscopy is most useful for detecting:

- A. Functional groups
- B. Molecular weight
- C. Carbon skeleton
- D. Conjugated systems

100. Chemical shift in ^1H NMR is measured in:

- A. Hertz
- B. Tesla
- C. ppm (parts per million)
- D. Daltons

Perceptual Ability Test

ANGLE DISCRIMINATION (Questions 1-15)

Directions: Four angles are described. Rank them from SMALLEST to LARGEST.

1. [Angle Ranking] Four angles: Angle 1 = 52° , Angle 2 = 39° , Angle 3 = 68° , Angle 4 = 45° . Rank from smallest to largest.
 - A. 2-4-1-3
 - B. 4-2-1-3
 - C. 2-1-4-3
 - D. 1-2-4-3

2. [Angle Ranking] Angle P = 81° , Angle Q = 59° , Angle R = 88° , Angle S = 72° . Rank from smallest to largest.
 - A. Q-P-S-R
 - B. Q-S-P-R
 - C. S-Q-P-R
 - D. Q-S-R-P

3. [Angle Ranking] Four angles measure: Angle 1 = 26° , Angle 2 = 48° , Angle 3 = 19° , Angle 4 = 33° . Rank from smallest to largest.
 - A. 1-3-4-2
 - B. 3-1-2-4
 - C. 3-4-1-2
 - D. 3-1-4-2

4. [Angle Ranking] Angle A = 93° , Angle B = 76° , Angle C = 85° , Angle D = 69° . Rank from smallest to largest.
- A. D-B-C-A
 - B. B-D-C-A
 - C. D-C-B-A
 - D. B-C-D-A
5. [Angle Ranking] Angle W is five-sixths of a right angle. Angle X = 58° . Angle Y = 82° . Angle Z = 67° . Rank from smallest to largest.
- A. X-W-Y-Z
 - B. W-X-Z-Y
 - C. X-Z-W-Y
 - D. W-Z-X-Y
6. [Angle Ranking] Four angles: Angle 1 = 14° , Angle 2 = 41° , Angle 3 = 35° , Angle 4 = 22° . Rank from smallest to largest.
- A. 1-3-4-2
 - B. 1-2-3-4
 - C. 1-3-2-4
 - D. 1-4-3-2
7. [Angle Ranking] Angle M = 63° , Angle N = 79° , Angle O = 54° , Angle P = 70° . Rank from smallest to largest.
- A. M-O-N-P
 - B. O-M-P-N
 - C. O-P-M-N
 - D. M-P-O-N
8. [Angle Ranking] Four angles measure: Angle 1 = 16° , Angle 2 = 38° , Angle 3 = 30° , Angle 4 = 45° . Rank from smallest to largest.
- A. 1-3-2-4
 - B. 1-2-3-4
 - C. 3-1-2-4
 - D. 1-4-2-3
9. [Angle Ranking] Angle A = 42° , Angle B = 61° , Angle C = 34° , Angle D = 73° . Rank from smallest to largest.
- A. C-B-A-D
 - B. C-A-D-B
 - C. C-A-B-D

D. A-C-B-D

10. [Angle Ranking] Four angles: Angle 1 = 78° , Angle 2 = 64° , Angle 3 = 86° , Angle 4 = 71° . Rank from smallest to largest.
- A. 2-1-3-4
 - B. 2-3-1-4
 - C. 2-1-4-3
 - D. 2-4-1-3
11. [Angle Ranking] Angle W = 31° , Angle X = 57° , Angle Y = 44° , Angle Z = 50° . Rank from smallest to largest.
- A. W-X-Y-Z
 - B. W-Y-Z-X
 - C. Z-W-Y-X
 - D. W-Z-X-Y
12. [Angle Ranking] Four angles measure: Angle 1 = 24° , Angle 2 = 37° , Angle 3 = 30° , Angle 4 = 49° . Rank from smallest to largest.
- A. 1-2-3-4
 - B. 1-3-4-2
 - C. 1-3-2-4
 - D. 2-1-3-4
13. [Angle Ranking] Angle P = 66° , Angle Q = 47° , Angle R = 89° , Angle S = 53° . Rank from smallest to largest.
- A. Q-S-P-R
 - B. S-Q-P-R
 - C. Q-P-S-R
 - D. S-P-Q-R
14. [Angle Ranking] Four angles: Angle 1 = 20° , Angle 2 = 46° , Angle 3 = 40° , Angle 4 = 55° . Rank from smallest to largest.
- A. 1-2-3-4
 - B. 1-3-4-2
 - C. 3-1-2-4
 - D. 1-3-2-4
15. [Angle Ranking] Angle A = 83° , Angle B = 75° , Angle C = 94° , Angle D = 70° . Rank from smallest to largest.
- A. D-A-B-C

- B. D-B-A-C
- C. A-B-D-C
- D. B-D-A-C

PAPER FOLDING (Questions 16-30)

Directions: A square piece of paper is folded one or more times, then hole(s) are punched. Determine the result when unfolded.

16. [Hole Punching] Paper is folded in half once, then two holes are punched through both layers. How many total holes appear when unfolded?
- A. 4
 - B. 2
 - C. 6
 - D. 8
17. [Hole Punching] Paper is folded three times (creating 8 layers), then two holes are punched through all layers. How many total holes appear when unfolded?
- A. 8
 - B. 12
 - C. 16
 - D. 24
18. [Hole Punching] Paper is folded in half twice (creating 4 layers), then three holes are punched through all layers. How many total holes appear when unfolded?
- A. 6
 - B. 8
 - C. 10
 - D. 12
19. [Hole Punching] Paper is folded in half once, then four holes are punched through both layers. How many total holes appear when unfolded?
- A. 4
 - B. 8
 - C. 6
 - D. 10
20. [Hole Punching] Paper is folded in half twice, then two holes are punched through all layers. How many total holes appear when unfolded?

- A. 4
- B. 6
- C. 8
- D. 12

21. [Hole Punching] Paper is folded diagonally once, then one hole is punched exactly on the fold line. How many holes appear when unfolded?

- A. 1
- B. 2
- C. 3
- D. 4

22. [Hole Punching] Paper is folded in half three times, then one hole is punched through all layers. How many holes appear when unfolded?

- A. 4
- B. 6
- C. 12
- D. 8

23. [Hole Punching] Paper is folded in half once, then three holes are punched through both layers. How many total holes appear when unfolded?

- A. 3
- B. 6
- C. 8
- D. 9

24. [Hole Punching] Paper is folded in half once, then a hole is punched exactly on the fold line. How many holes appear when unfolded?

- A. 1
- B. 2
- C. 3
- D. 4

25. [Hole Punching] Paper is folded in half twice (into quarters), then four holes are punched through all layers. How many total holes appear when unfolded?

- A. 8
- B. 12
- C. 16
- D. 20

26. [Hole Punching] Paper is folded diagonally once, then four holes are punched away from the fold. How many total holes appear when unfolded?
- A. 4
 - B. 6
 - C. 16
 - D. 8
27. [Hole Punching] Paper is folded in half once, then five holes are punched through both layers. How many total holes appear when unfolded?
- A. 5
 - B. 10
 - C. 8
 - D. 12
28. [Hole Punching] Paper is folded in half twice, then a hole is punched at the center where both folds meet. How many holes appear when unfolded?
- A. 1
 - B. 2
 - C. 4
 - D. 8
29. [Hole Punching] Paper is folded in half twice (creating 4 layers), then one hole is punched through all layers. How many holes appear when unfolded?
- A. 4
 - B. 2
 - C. 8
 - D. 1
30. [Hole Punching] Paper is folded in half once, then seven holes are punched through both layers. How many holes appear when unfolded?
- A. 7
 - B. 12
 - C. 8
 - D. 14

CUBE COUNTING (Questions 31-45)

Directions: Answer questions about unit cubes in various structures.

31. [Cube Counting] In a $5 \times 5 \times 5$ cube, how many unit cubes have exactly 1 face exposed (face cubes)?
A. 48
B. 54
C. 60
D. 72
32. [Cube Counting] A solid $6 \times 6 \times 6$ cube. How many unit cubes have exactly 3 faces exposed (corner cubes)?
A. 8
B. 6
C. 12
D. 4
33. [Cube Counting] A $2 \times 3 \times 4$ rectangular prism. How many total unit cubes are in the structure?
A. 12
B. 24
C. 18
D. 30
34. [Cube Counting] A structure of 12 unit cubes arranged in a straight line. How many cubes have exactly 5 faces exposed (end cubes)?
A. 1
B. 0
C. 2
D. 4
35. [Cube Counting] In a $5 \times 5 \times 5$ cube, how many unit cubes have exactly 0 faces exposed (completely interior)?
A. 27
B. 8
C. 64
D. 1
36. [Cube Counting] A $3 \times 4 \times 5$ rectangular prism. How many unit cubes have exactly 3 faces exposed (corners)?
A. 6

- B. 12
- C. 4
- D. 8

37. [Cube Counting] A solid $5 \times 5 \times 5$ cube. How many unit cubes have exactly 2 faces exposed (edge cubes)?

- A. 36
- B. 24
- C. 48
- D. 12

38. [Cube Counting] A $4 \times 4 \times 3$ rectangular prism. How many total unit cubes are in the structure?

- A. 36
- B. 42
- C. 40
- D. 48

39. [Cube Counting] In a $5 \times 5 \times 5$ cube, how many unit cubes are NOT corner cubes?

- A. 117
- B. 120
- C. 125
- D. 100

40. [Cube Counting] A $6 \times 4 \times 3$ rectangular prism. How many unit cubes are NOT corner cubes?

- A. 64
- B. 68
- C. 70
- D. 60

41. [Cube Counting] A pyramid structure: 25 cubes on bottom (5×5), 16 cubes on second layer (4×4), 9 cubes on third layer (3×3), 4 cubes on fourth layer (2×2), 1 cube on top (55 total). How many cubes have exactly 3 exposed faces?

- A. 8
- B. 9
- C. 12
- D. 6

42. [Cube Counting] A $3 \times 3 \times 6$ rectangular prism. How many unit cubes have exactly 2 faces exposed?

- A. 24
- B. 30

- C. 32
- D. 28

43. [Cube Counting] An L-shaped structure: 8 cubes in a row with 4 cubes stacked on one end (12 total). How many cubes have exactly 3 exposed faces?
- A. 3
 - B. 4
 - C. 5
 - D. 6
44. [Cube Counting] A $7 \times 7 \times 2$ rectangular prism. How many unit cubes have at least one face exposed?
- A. 96
 - B. 98
 - C. 90
 - D. 88
45. [Cube Counting] In a $4 \times 4 \times 4$ cube, how many unit cubes have exactly 2 faces exposed?
- A. 24
 - B. 32
 - C. 16
 - D. 48

PATTERN FOLDING (Questions 46-60)

Directions: Identify what 3D shape is formed when the described net is folded.

46. [Pattern Folding] A net consists of 5 squares in an L-shape (3 in a row, 2 attached to the side). What does it form when folded?
- A. Complete cube
 - B. Pyramid
 - C. Partial cube (open box)
 - D. Prism
47. [Pattern Folding] A net shows 1 hexagon with 6 triangles attached to each edge. What 3D shape is formed?
- A. Cube
 - B. Pentagonal pyramid
 - C. Hexagonal prism
 - D. Hexagonal pyramid

48. [Pattern Folding] A net consists of 6 squares arranged in a cross pattern (one center, four around it, one opposite). What does it form?
- A. Cube
 - B. Pyramid
 - C. Open box
 - D. Prism
49. [Pattern Folding] A net shows 2 pentagons and 5 rectangles all connected. What shape does it form?
- A. Tetrahedron
 - B. Pentagonal prism
 - C. Pentagon
 - D. Pentagonal prism
50. [Pattern Folding] A net shows 1 square with 3 triangles attached to three edges of the square. What partial shape does it form?
- A. Complete pyramid
 - B. Partial pyramid (missing one face)
 - C. Cube
 - D. Prism
51. [Pattern Folding] A net consists of 4 squares in a T-shape. What does it form?
- A. Partial cube (open box)
 - B. Pyramid
 - C. Complete cube
 - D. Prism
52. [Pattern Folding] A net has 1 triangle with 3 triangles attached to each edge. What 3D shape is formed?
- A. Square pyramid
 - B. Triangular prism
 - C. Tetrahedron
 - D. Cube
53. [Pattern Folding] A net consists of 2 circles and 1 rectangle that wraps around. What does it form?
- A. Cone
 - B. Sphere
 - C. Pyramid
 - D. Cylinder

54. [Pattern Folding] A net shows 6 rectangles of different sizes arranged to form a closed shape. What is it most likely to form?
- A. Cube
 - B. Rectangular prism
 - C. Pyramid
 - D. Triangular prism
55. [Pattern Folding] A net shows 1 octagon with 8 rectangles connecting around its edges. What 3D shape is formed?
- A. Rectangular prism
 - B. Hexagonal prism
 - C. Octagonal prism
 - D. Cube
56. [Pattern Folding] A net consists of 1 large square with 4 triangles attached to its edges. What shape does it form?
- A. Square pyramid
 - B. Tetrahedron
 - C. Octahedron
 - D. Triangular prism
57. [Pattern Folding] A net shows 6 equal squares in an L-shape. What can this form?
- A. Pyramid
 - B. Open box
 - C. Prism
 - D. Partial cube
58. [Pattern Folding] A net consists of 3 equilateral triangles and 2 squares arranged in a strip. What shape does it form?
- A. Square pyramid
 - B. Triangular prism
 - C. Tetrahedron
 - D. Cube
59. [Pattern Folding] A net shows 4 squares in a row. What can this form?
- A. Open-top cube
 - B. Complete cube
 - C. Pyramid
 - D. Prism

60. [Pattern Folding] A net consists of 1 pentagon and 5 rectangles arranged around it. What type of shape does this form?
- A. Cube
 - B. Pyramid
 - C. Pentagonal prism
 - D. Rectangular prism

APERTURES / KEYHOLES (Questions 61-75)

Directions: Determine which aperture shape a 3D object could pass through.

61. [Keyhole] A rectangular prism must pass through an aperture. Which aperture shape could work?
- A. Circle
 - B. Triangle
 - C. Pentagon
 - D. Rectangle
62. [Keyhole] A triangular pyramid (tetrahedron) is oriented to pass through an aperture. Which aperture shape is possible?
- A. Square
 - B. Triangle
 - C. Pentagon
 - D. Circle
63. [Keyhole] A cylinder passes through an aperture. Which shape would work?
- A. Square
 - B. Triangle
 - C. Circle or Rectangle
 - D. Pentagon
64. [Keyhole] A pentagonal prism passes through an aperture. Which shape is possible?
- A. Circle
 - B. Triangle
 - C. Hexagon
 - D. Pentagon or Rectangle
65. [Keyhole] A cube passes through an aperture. Which aperture is possible?
- A. Square
 - B. Circle

- C. Pentagon
- D. Triangle

66. [Keyhole] Which aperture shape would NOT work for a triangular prism?
- A. Triangle
 - B. Rectangle
 - C. Circle
 - D. Oval
67. [Keyhole] A hexagonal pyramid must pass through an aperture. Which aperture is possible?
- A. Circle
 - B. Hexagon or Triangle
 - C. Pentagon
 - D. Square
68. [Keyhole] An octagonal prism passes through an aperture. Which shape is possible?
- A. Circle
 - B. Octagon or Rectangle
 - C. Pentagon
 - D. Triangle
69. [Keyhole] A cone passes through an aperture. Which shape works?
- A. Square
 - B. Pentagon
 - C. Circle or Triangle
 - D. Hexagon
70. [Keyhole] Which 3D object could pass through a pentagonal aperture?
- A. Cube
 - B. Sphere
 - C. Triangular prism
 - D. Pentagonal prism
71. [Keyhole] A square pyramid passes through an aperture. Which shape is most likely?
- A. Circle
 - B. Pentagon
 - C. Hexagon
 - D. Square or Triangle
72. [Keyhole] A sphere passes through an aperture. Which is the ONLY possible shape?

- A. Circle
- B. Square
- C. Triangle
- D. Pentagon

73. [Keyhole] Which aperture shape would work for a rectangular prism but NOT for a cone?

- A. Circle
- B. Triangle
- C. Rectangle
- D. Oval

74. [Keyhole] A hexagonal prism passes through an aperture. Which is NOT a possible aperture shape?

- A. Hexagon
- B. Circle
- C. Rectangle
- D. Triangle

75. [Keyhole] Which 3D shape could pass through both a square and triangular aperture?

- A. Square pyramid
- B. Sphere
- C. Cylinder
- D. Cube

VIEW RECOGNITION (Questions 76-90)

Directions: Given views from different angles, identify the 3D shape or determine what a view would look like.

76. [Top-Front-End] Top view: rectangle. Front view: triangle. Side view: triangle. What is the 3D shape?

- A. Cone
- B. Cylinder
- C. Square pyramid
- D. Triangular prism

77. [Top-Front-End] Front view: circle. Top view: rectangle. Side view: rectangle. What is the shape?

- A. Cone
- B. Square pyramid
- C. Cylinder

D. Rectangular prism

78. [Top-Front-End] A rectangular prism is viewed from the top. What shape appears?
- A. Rectangle
 - B. Circle
 - C. Square
 - D. Triangle
79. [Top-Front-End] Top view: hexagon. Front view: rectangle. Side view: rectangle. What is the shape?
- A. Cube
 - B. Hexagonal prism
 - C. Hexagonal pyramid
 - D. Rectangular prism
80. [Top-Front-End] A triangular pyramid is viewed from the side. What shape appears?
- A. Square
 - B. Circle
 - C. Rectangle
 - D. Triangle
81. [Top-Front-End] Top view: square. Front view: triangle. Side view: triangle. What is the shape?
- A. Square pyramid
 - B. Tetrahedron
 - C. Triangular prism
 - D. Cone
82. [Top-Front-End] Top view: octagon. Front and side views: rectangles. What is the shape?
- A. Cube
 - B. Hexagonal prism
 - C. Octagonal prism
 - D. Rectangular prism
83. [Top-Front-End] A pentagonal prism is viewed from the side (perpendicular to its pentagonal face). What shape appears?
- A. Pentagon
 - B. Rectangle
 - C. Circle
 - D. Square
84. [Top-Front-End] Top view: circle. Front view: triangle. Side view: triangle. What is the shape?

- A. Cylinder
- B. Square pyramid
- C. Sphere
- D. Cone

85. [Top-Front-End] Top view: triangle. Front and side views: rectangles. What is the shape?

- A. Square pyramid
- B. Pentagonal prism
- C. Triangular prism
- D. Tetrahedron

86. [Top-Front-End] A hexagonal pyramid is viewed from the end (looking at the hexagonal base). What shape appears?

- A. Hexagon
- B. Rectangle
- C. Circle
- D. Square

87. [Top-Front-End] A sphere is viewed from any angle. What shape appears?

- A. Square
- B. Triangle
- C. Rectangle
- D. Circle

88. [Top-Front-End] Top view: square. Front view: square. Side view: rectangle. What is the shape?

- A. Cube
- B. Rectangular prism
- C. Pyramid
- D. Cylinder

89. [Top-Front-End] A pentagonal pyramid is viewed from directly above. What shape appears?

- A. Triangle
- B. Rectangle
- C. Pentagon
- D. Square

90. [Top-Front-End] Top view: cross shape (+). Front view: rectangle. Side view: rectangle. What type of structure is this?

- A. Cross-shaped block structure
- B. Pyramid

- C. Cylinder
- D. Cube

Reading Comprehension

PASSAGE I

Neurodegenerative diseases represent a growing global health challenge as populations age worldwide. These disorders, characterized by progressive loss of neuron structure and function, include Alzheimer's disease, Parkinson's disease, Huntington's disease, and amyotrophic lateral sclerosis (ALS). While each condition affects different brain regions and presents distinct symptoms, emerging research reveals common molecular mechanisms underlying neuronal death, suggesting potential unified therapeutic approaches. Understanding these shared pathways could revolutionize treatment strategies for millions of patients facing devastating diagnoses.

Protein misfolding and aggregation constitute a hallmark feature across neurodegenerative diseases. In Alzheimer's disease, beta-amyloid plaques and tau tangles accumulate outside and inside neurons respectively. Parkinson's disease involves alpha-synuclein aggregates called Lewy bodies in dopamine-producing neurons of the substantia nigra. Huntington's disease results from expanded CAG repeats in the huntingtin gene, producing mutant proteins that aggregate intracellularly. ALS features aggregates of TDP-43 and SOD1 proteins in motor neurons. These misfolded proteins adopt abnormal conformations, resist degradation, and propagate pathologically—converting normal proteins to disease-causing forms in a prion-like manner. The "protein spread" hypothesis proposes that misfolded proteins transfer between connected neurons, explaining disease progression patterns. Recent studies demonstrate that injecting brain tissue containing misfolded proteins into healthy animals induces pathology, supporting this model.

Mitochondrial dysfunction and oxidative stress amplify neurodegeneration. Neurons require enormous energy due to their high metabolic demands, making mitochondrial health critical. Impaired mitochondrial function generates excessive reactive oxygen species (ROS), damaging proteins, lipids, and DNA. In Parkinson's disease, mutations in genes encoding mitochondrial proteins like parkin and PINK1 cause early-onset forms. Alzheimer's patients show reduced brain glucose metabolism decades before symptoms appear, detected via PET imaging. Complex I deficiency in the electron transport chain characterizes multiple neurodegenerative conditions. The brain's limited antioxidant defenses make it particularly vulnerable to oxidative damage. Neurons cannot regenerate easily, so cumulative damage over decades eventually exceeds repair capacity.

Neuroinflammation, once considered merely a consequence of neurodegeneration, now appears as an active driver. Microglia, the brain's resident immune cells, normally clear debris and provide neuroprotection. However, chronic microglial activation produces inflammatory cytokines like TNF-alpha and IL-1beta that damage neurons. Activated microglia also generate ROS and nitrogen species

contributing to oxidative stress. In post-mortem Alzheimer's brains, activated microglia surround amyloid plaques. Parkinson's patients show inflammatory markers in substantia nigra even before substantial neuronal loss. Genome-wide association studies link immune genes to neurodegenerative disease risk. The inflammatory response creates a vicious cycle: protein aggregates activate microglia, inflammation damages more neurons releasing more aggregates, perpetuating destruction. Anti-inflammatory approaches show promise in animal models but have yielded mixed results in human trials.

Impaired protein clearance mechanisms accelerate disease progression. Cells normally eliminate damaged proteins through two major pathways: the ubiquitin-proteasome system and autophagy. The proteasome degrades ubiquitin-tagged proteins but struggles with large aggregates. Autophagy sequesters damaged organelles and protein aggregates in vesicles for lysosomal degradation. Both systems decline with aging, a major risk factor for neurodegeneration. Mutations in autophagy genes cause familial Parkinson's disease. Enhancing autophagy through rapamycin or similar compounds reduces pathology in animal models, though human applications face challenges. The glymphatic system, discovered recently, clears brain waste during sleep through cerebrospinal fluid flow along perivascular channels. Sleep disruption, common in neurodegenerative diseases, may impair this clearance, creating another pathogenic feedback loop.

Therapeutic strategies increasingly target shared mechanisms rather than individual diseases. Immunotherapies use antibodies to clear pathological proteins—aducanumab for Alzheimer's received controversial FDA approval despite modest efficacy. Small molecules enhance protein clearance, reduce inflammation, or protect mitochondria. Gene therapies aim to restore normal protein function or silence mutant genes. Stem cell transplants might replace lost neurons, though challenges remain regarding cell survival, integration, and ethical considerations. Lifestyle interventions including exercise, cognitive stimulation, and Mediterranean diets show protective effects across multiple conditions. Early intervention appears crucial since substantial neuronal loss precedes symptom onset by years or decades. Biomarker development for presymptomatic diagnosis could enable treatment before irreversible damage occurs, shifting from symptom management to prevention.

1. Common molecular mechanisms across neurodegenerative diseases suggest:
 - A. Each disease requires unique treatment
 - B. Prevention is impossible
 - C. Aging is irrelevant
 - D. Unified therapeutic approaches are possible
2. In Alzheimer's disease, tau tangles accumulate:
 - A. Inside neurons
 - B. Outside neurons
 - C. In blood vessels
 - D. In glial cells

3. Lewy bodies in Parkinson's disease are composed of aggregates of:
 - A. Beta-amyloid
 - B. Alpha-synuclein
 - C. Huntingtin
 - D. TDP-43

4. The expanded CAG repeats that cause Huntington's disease are found in the:
 - A. TDP-43 gene
 - B. SOD1 gene
 - C. Huntingtin gene
 - D. Alpha-synuclein gene

5. The "protein spread" hypothesis proposes that misfolded proteins:
 - A. Transfer between connected neurons
 - B. Remain in original neurons
 - C. Only affect glial cells
 - D. Cannot propagate

6. Evidence supporting the protein spread model includes:
 - A. Computer simulations only
 - B. Cell culture studies only
 - C. Mathematical models only
 - D. Injecting misfolded proteins into healthy animals induces pathology

7. Mitochondrial health is critical for neurons because they:
 - A. Divide rapidly
 - B. Have high metabolic demands
 - C. Lack nuclei
 - D. Store calcium

8. In Parkinson's disease, mutations in parkin and PINK1 genes affect:
 - A. Synaptic transmission
 - B. DNA replication
 - C. Mitochondrial proteins
 - D. Cell division

9. PET imaging in Alzheimer's patients shows reduced brain glucose metabolism:
 - A. Only after symptoms appear
 - B. Only in late stages
 - C. During symptom onset

D. Decades before symptoms appear

10. The brain is particularly vulnerable to oxidative damage because it has:

- A. Limited antioxidant defenses
- B. Excessive antioxidants
- C. No mitochondria
- D. Rapid regeneration

11. Microglia normally function to:

- A. Generate inflammation
- B. Damage neurons
- C. Clear debris and provide neuroprotection
- D. Produce amyloid plaques

12. Chronically activated microglia damage neurons by producing:

- A. Glucose
- B. Inflammatory cytokines like TNF-alpha and IL-1beta
- C. Protective factors only
- D. New neurons

13. Genome-wide association studies link neurodegenerative disease risk to:

- A. Immune genes
- B. Only age
- C. Environmental factors exclusively
- D. Diet alone

14. The inflammatory response in neurodegeneration creates a vicious cycle because:

- A. It stops spontaneously
- B. It only occurs once
- C. Inflammation heals neurons
- D. Protein aggregates activate microglia, which causes more damage

15. The ubiquitin-proteasome system functions to:

- A. Create protein aggregates
- B. Degrade ubiquitin-tagged proteins
- C. Increase inflammation
- D. Stop autophagy

16. Autophagy is the process of:

- A. Cell division

- B. Protein synthesis
- C. Sequestering damaged organelles for lysosomal degradation
- D. DNA replication

17. The glymphatic system clears brain waste through:

- A. Cerebrospinal fluid flow during sleep
- B. Blood flow only
- C. Inflammation
- D. Protein aggregation

PASSAGE II

Epigenetics revolutionizes our understanding of heredity by revealing that gene expression can be modified without changing DNA sequence itself. While Mendel's classical genetics and Watson-Crick's DNA structure explained inheritance patterns, they couldn't account for how genetically identical cells differentiate into diverse tissue types, why identical twins develop different diseases, or how environmental factors influence traits across generations. Epigenetic modifications—chemical tags attached to DNA or histone proteins—regulate which genes are active in which cells at which times. Unlike genetic mutations, epigenetic changes are reversible, offering therapeutic potential for numerous diseases from cancer to neurological disorders.

DNA methylation, the most studied epigenetic modification, involves adding methyl groups (CH_3) to cytosine bases, particularly in CG dinucleotide sequences called CpG islands often found near gene promoters. Methylation typically silences genes by blocking transcription factor binding or recruiting repressor proteins. During development, methylation patterns guide cell fate decisions—nerve cells methylate muscle genes while muscle cells methylate nerve genes, locking in their identities. X-chromosome inactivation in females demonstrates methylation's power: one X chromosome in each cell becomes heavily methylated and condensed into a Barr body, equalizing gene dosage with males who have only one X. Aberrant methylation patterns characterize cancer cells, with tumor suppressor genes hypermethylated (silenced) and oncogenes hypomethylated (activated). DNA methyltransferase (DNMT) enzymes establish and maintain methylation patterns, representing drug targets for cancer therapy. Azacitidine and decitabine, DNMT inhibitors approved for certain leukemias, can reactivate silenced tumor suppressor genes.

Histone modifications constitute another major epigenetic mechanism. DNA wraps around histone protein octamers forming nucleosomes, the chromatin's basic units. Chemical modifications to histone tails—including acetylation, methylation, phosphorylation, and ubiquitination—alter chromatin structure and accessibility. Histone acetylation generally activates transcription by loosening DNA-histone interactions, allowing transcription factors access. Histone acetyltransferases (HATs) add acetyl groups while histone deacetylases (HDACs) remove them. HDAC inhibitors show promise treating certain cancers and

neurological conditions. Histone methylation effects depend on which lysine residue is modified: H3K4 methylation activates genes while H3K9 and H3K27 methylation represses them. These modifications create a "histone code" that specialized reader proteins interpret, recruiting appropriate regulatory machinery. Polycomb and trithorax protein complexes maintain repressive and active chromatin states respectively throughout cell divisions, preserving cell identity.

Environmental factors dramatically influence epigenetic patterns, explaining how lifestyle affects health and disease. The Dutch Hunger Winter of 1944-1945 provided tragic natural experiment: children conceived during famine showed altered methylation patterns decades later, with increased risks for obesity, diabetes, and cardiovascular disease. This demonstrated transgenerational epigenetic inheritance—environmental exposures affecting not just exposed individuals but their descendants. Maternal nutrition, stress, toxin exposure, and behavior during pregnancy shape offspring epigenomes. Rat studies show that maternal care alters glucocorticoid receptor gene methylation in offspring brains, influencing stress responses throughout life. Environmental chemicals like bisphenol A (BPA) and pesticides can disrupt normal epigenetic programming. Smoking causes widespread methylation changes correlating with cancer risk, though many reverse after quitting. Exercise, diet, and meditation modify epigenetic marks, explaining some health benefits.

Epigenetic mechanisms increasingly explain complex disease pathogenesis beyond cancer. In neuropsychiatric disorders, aberrant histone acetylation and DNA methylation affect genes regulating neurotransmitter systems, synaptic plasticity, and neuronal survival. Antidepressants and mood stabilizers modulate epigenetic enzymes, potentially explaining therapeutic mechanisms. Schizophrenia patients show altered methylation patterns in genes important for neurodevelopment. Drug addiction involves epigenetic changes in reward pathways that persist long after substance use stops, contributing to relapse vulnerability. Autoimmune diseases exhibit characteristic epigenetic signatures, with genes encoding immune regulators improperly modified. Type 2 diabetes associates with pancreatic islet cell methylation changes affecting insulin secretion. Cardiovascular disease links to endothelial cell epigenetic alterations. Age-related conditions correlate with accumulated epigenetic drift—gradual loss of appropriate methylation patterns.

Therapeutic applications of epigenetics extend beyond drug development to regenerative medicine and precision treatment. Cellular reprogramming demonstrates epigenetic plasticity: introducing specific transcription factors can convert differentiated cells into induced pluripotent stem cells (iPSCs) by rewriting their epigenomes. These iPSCs theoretically could generate any cell type for transplantation therapy. Epigenetic editing uses tools like CRISPR-dCas9 fused to methylation or acetylation enzymes to modify specific gene regions without cutting DNA, offering precise control over gene expression. Epigenetic biomarkers enable early disease detection and treatment monitoring—blood tests measuring methylation patterns can detect cancers or predict treatment responses. Personalized medicine increasingly incorporates epigenetic profiles to guide therapy selection. Environmental interventions preventing harmful epigenetic changes could reduce disease burden more effectively than treating established conditions.

18. Epigenetic modifications differ from genetic mutations because they:
- A. Change DNA sequence
 - B. Are permanent
 - C. Cannot affect traits
 - D. Are reversible
19. DNA methylation typically occurs at:
- A. All bases randomly
 - B. Adenine bases
 - C. CpG islands near gene promoters
 - D. Introns only
20. X-chromosome inactivation in females involves:
- A. Deleting one X chromosome
 - B. Methylating one X chromosome into a Barr body
 - C. Activating both X chromosomes
 - D. Removing all genes
21. In cancer cells, tumor suppressor genes are often:
- A. Hypermethylated and silenced
 - B. Hypomethylated and silenced
 - C. Deleted entirely
 - D. Duplicated
22. Azacitidine and decitabine are drugs that:
- A. Increase methylation
 - B. Destroy DNA
 - C. Promote cancer
 - D. Inhibit DNA methyltransferases
23. Histone acetylation generally:
- A. Silences genes
 - B. Destroys DNA
 - C. Activates transcription
 - D. Has no effect
24. The "histone code" refers to:
- A. DNA sequence
 - B. Patterns of histone modifications that regulate gene expression

- C. Protein structure
- D. RNA splicing

25. The Dutch Hunger Winter study demonstrated:

- A. Transgenerational epigenetic inheritance
- B. No environmental effects
- C. Only genetic factors matter
- D. Famine has no lasting effects

26. Children conceived during the Dutch Hunger Winter showed increased risks for:

- A. Perfect health
- B. Enhanced immunity
- C. No health changes
- D. Obesity, diabetes, and cardiovascular disease

27. Maternal care in rats alters offspring stress responses by affecting:

- A. DNA sequence
- B. Chromosome number
- C. Glucocorticoid receptor gene methylation
- D. Cell division only

28. Many methylation changes caused by smoking:

- A. Never reverse
- B. Reverse after quitting
- C. Increase after quitting
- D. Are beneficial

29. In neuropsychiatric disorders, epigenetic changes affect genes regulating:

- A. Only physical traits
- B. Skin color
- C. Height
- D. Neurotransmitter systems and synaptic plasticity

30. Drug addiction involves epigenetic changes that:

- A. Persist long after substance use stops
- B. Disappear immediately
- C. Prevent relapse
- D. Have no effect

31. Epigenetic drift refers to:

- A. Cell division
- B. DNA replication
- C. Gradual loss of appropriate methylation patterns with age
- D. Protein synthesis

32. Induced pluripotent stem cells (iPSCs) are created by:

- A. Natural development
- B. Rewriting cellular epigenomes
- C. Deleting genes
- D. Stopping cell division

33. CRISPR-dCas9 epigenetic editing can modify genes:

- A. Without cutting DNA
- B. By destroying cells
- C. Only in bacteria
- D. By removing chromosomes

34. Epigenetic biomarkers can:

- A. Only detect late-stage disease
- B. Provide no information
- C. Increase disease risk
- D. Enable early disease detection

PASSAGE III

The human microbiome, the trillions of microorganisms inhabiting our bodies, profoundly influences health and disease in ways scientists are only beginning to understand. The gut microbiome alone contains approximately 100 trillion bacteria representing thousands of species, collectively possessing 100 times more genes than the human genome. These microbes aren't merely passive residents—they actively shape immune function, metabolism, brain chemistry, and susceptibility to numerous diseases. Disruption of microbial communities, termed dysbiosis, associates with conditions ranging from inflammatory bowel disease to obesity, diabetes, allergies, and even neuropsychiatric disorders. Understanding microbiome-host interactions opens revolutionary therapeutic possibilities, from engineered probiotics to fecal microbiota transplantation.

The gut microbiome develops from birth and continuously evolves throughout life. Delivery mode significantly impacts initial colonization: vaginal birth exposes infants to maternal vaginal and fecal microbes, while cesarean section babies acquire different environmental bacteria. Breastfeeding promotes beneficial Bifidobacteria that digest human milk oligosaccharides. By age three, children's microbiomes resemble adult patterns, though diet, antibiotics, and environment continue shaping composition. The gut

microbiome performs essential functions the human body cannot: synthesizing vitamins K and B12, producing short-chain fatty acids from dietary fiber fermentation, and metabolizing compounds into bioactive forms. Bacteroides and Firmicutes dominate healthy adult gut microbiomes, with individual variation influenced by diet, geography, and genetics.

Microbiome-immune system interactions prove particularly crucial. The gut houses approximately 70% of the body's immune cells, constantly sampling microbial antigens. Beneficial bacteria train the immune system, promoting regulatory T cells that prevent excessive inflammation while maintaining vigilance against pathogens. Gut bacteria produce metabolites like short-chain fatty acids (acetate, propionate, butyrate) that strengthen intestinal barrier function and modulate immune responses. Dysbiosis can trigger inflammatory bowel diseases (Crohn's disease, ulcerative colitis) when immune tolerance breaks down. Reduced microbial diversity in early life associates with increased allergy and asthma risk, supporting the hygiene hypothesis: excessive cleanliness and antibiotic use may deprive developing immune systems of necessary microbial education.

The gut-brain axis reveals surprising connections between microbiome and mental health. Gut bacteria produce neurotransmitters including serotonin, GABA, and dopamine. The vagus nerve transmits signals bidirectionally between gut and brain, allowing microbes to influence mood, cognition, and behavior. Germ-free mice (raised without microbes) exhibit abnormal stress responses and anxiety-like behaviors that normalize after microbial colonization. Human studies link altered gut microbiome composition to depression, anxiety, autism spectrum disorders, and Parkinson's disease. Whether microbiome changes cause these conditions or result from them remains debated, but animal studies demonstrate that transferring microbiomes from depressed patients into germ-free mice induces depression-like behaviors, suggesting causal relationships.

Antibiotic use profoundly disrupts microbiome composition and diversity. While antibiotics save lives by eliminating pathogenic bacteria, they indiscriminately kill beneficial microbes. Single antibiotic courses can alter microbiome composition for months or years. Repeated childhood antibiotic exposure associates with increased obesity, asthma, and inflammatory bowel disease risk. Antibiotic-associated diarrhea results from microbiome disruption allowing *Clostridioides difficile* overgrowth. However, fecal microbiota transplantation (FMT)—transferring stool from healthy donors into patients—cures recurrent *C. difficile* infections with over 90% success by restoring microbial diversity. FMT shows promise for inflammatory bowel disease and potentially metabolic disorders, though long-term safety requires further study.

Personalized nutrition based on microbiome composition could optimize health outcomes. Different individuals' microbiomes respond variably to identical diets, explaining why dietary interventions work for some but not others. High-fiber diets promote beneficial bacteria producing short-chain fatty acids, while high-fat, low-fiber Western diets favor inflammatory species. Prebiotics (compounds feeding beneficial bacteria) and probiotics (live beneficial bacteria) can modulate microbiome composition, though effects vary individually. Engineered probiotics might deliver therapeutic compounds directly to

disease sites. Microbiome analysis could guide personalized dietary recommendations, predict disease risk, and monitor treatment responses. However, challenges remain: establishing causality versus correlation, defining "healthy" microbiomes given individual variation, and developing effective interventions that durably modify microbial communities in beneficial ways.

35. The gut microbiome contains approximately how many genes compared to the human genome?

- A. 100 times more
- B. 10 times more
- C. The same number
- D. 100 times fewer

36. Dysbiosis refers to:

- A. Normal microbial balance
- B. Absence of all microbes
- C. Increased microbial diversity
- D. Disruption of microbial communities

37. Vaginal birth versus cesarean section impacts:

- A. Adult height
- B. Hair color
- C. Initial microbial colonization
- D. Eye color

38. Breastfeeding promotes which beneficial bacteria?

- A. E. coli
- B. Bifidobacteria
- C. Clostridium
- D. Salmonella

39. The gut microbiome synthesizes which vitamins the body cannot produce?

- A. Vitamin C
- B. Vitamin A
- C. Vitamin E
- D. Vitamins K and B12

40. Approximately what percentage of the body's immune cells are housed in the gut?

- A. 70%
- B. 30%
- C. 50%
- D. 90%

41. Short-chain fatty acids produced by gut bacteria include:
- A. Glucose and fructose
 - B. DNA and RNA
 - C. Acetate, propionate, and butyrate
 - D. Cholesterol and lipids
42. The hygiene hypothesis suggests that excessive cleanliness and antibiotic use:
- A. Improve immunity
 - B. Deprive developing immune systems of microbial education
 - C. Have no health effects
 - D. Cure allergies
43. Gut bacteria produce neurotransmitters including:
- A. Serotonin, GABA, and dopamine
 - B. Only insulin
 - C. Only adrenaline
 - D. No neurotransmitters
44. The vagus nerve in the gut-brain axis:
- A. Only carries signals to the gut
 - B. Only carries signals to the brain
 - C. Has no function
 - D. Transmits signals bidirectionally between gut and brain
45. Germ-free mice raised without microbes exhibit:
- A. Perfect health
 - B. Enhanced intelligence
 - C. Abnormal stress responses and anxiety-like behaviors
 - D. No differences from normal mice
46. Fecal microbiota transplantation (FMT) cures recurrent *C. difficile* infections with what success rate?
- A. 30%
 - B. Over 90%
 - C. 50%
 - D. 10%
47. Single antibiotic courses can alter microbiome composition for:
- A. Hours only

- B. Days only
- C. Weeks only
- D. Months or years

48. High-fiber diets promote bacteria that produce:

- A. Short-chain fatty acids
- B. Toxins
- C. Inflammatory molecules
- D. Cholesterol

49. Prebiotics are compounds that:

- A. Kill all bacteria
- B. Feed beneficial bacteria
- C. Destroy the gut lining
- D. Have no effect

50. Personalized nutrition based on microbiome composition could:

- A. Be identical for everyone
- B. Ignore individual differences
- C. Guide dietary recommendations and predict disease risk
- D. Never be implemented

Quantitative Reasoning

1. What is the perimeter of a circle with radius 8 cm? (Use $\pi \approx 3.14$)

- A. 50.24 cm
- B. 25.12 cm
- C. 100.48 cm
- D. 200.96 cm

2. Solve for x: $9x + 15 = 69$

- A. 5
- B. 7
- C. 8
- D. 6

3. What is $\frac{3}{4} + \frac{2}{5}$?

- A. $\frac{5}{9}$
- B. $\frac{17}{20}$

- C. $\frac{23}{20}$
- D. $\frac{1}{2}$

4. If a triangle has angles measuring 48° , 67° , and x° , what is x ?

- A. 75°
- B. 65°
- C. 55°
- D. 70°

5. What is the area of a rectangle with length 18 cm and width 9 cm?

- A. 27 cm^2
- B. 54 cm^2
- C. 81 cm^2
- D. 162 cm^2

6. Solve the inequality: $5x - 8 > 27$

- A. $x > 7$
- B. $x > 5$
- C. $x > 6$
- D. $x < 7$

7. What is the value of $7^3 - 4^3$?

- A. 216
- B. 279
- C. 343
- D. 512

8. If 45% of a number is 90, what is the number?

- A. 40.5
- B. 200
- C. 180
- D. 250

9. What is the mean of the set $\{12, 18, 24, 30, 36\}$?

- A. 24
- B. 20
- C. 30
- D. 18

10. A train travels 360 miles in 6 hours. What is its average speed?

- A. 50 mph
- B. 60 mph
- C. 70 mph
- D. 80 mph

11. What is $7/8 - 1/2$?

- A. $1/4$
- B. $5/8$
- C. $3/4$
- D. $3/8$

12. What is the slope of a line passing through points (3, 7) and (9, 19)?

- A. 2
- B. 3
- C. 4
- D. 1

13. What is $|-28| - |15|$?

- A. 43
- B. -13
- C. 13
- D. -43

14. If $15/x = 45/60$, what is x?

- A. 15
- B. 25
- C. 30
- D. 20

15. What is the surface area of a cube with edge length 8 cm?

- A. 256 cm^2
- B. 512 cm^2
- C. 192 cm^2
- D. 384 cm^2

16. What is the surface area of a cube with edge length 8 cm?

- A. 256 cm^2
- B. 192 cm^2
- C. 512 cm^2
- D. 384 cm^2

17. What is $\cos 30^\circ$?
- A. $1/2$
 - B. $\sqrt{3}/2$
 - C. $\sqrt{2}/2$
 - D. 1
18. If a rectangle has area 144 cm^2 and length 16 cm, what is its width?
- A. 12 cm
 - B. 8 cm
 - C. 10 cm
 - D. 9 cm
19. What is the least common multiple (LCM) of 18 and 24?
- A. 72
 - B. 36
 - C. 48
 - D. 144
20. A jar contains 6 green balls and 9 yellow balls. What is the probability of drawing a yellow ball?
- A. $2/5$
 - B. $1/3$
 - C. $3/5$
 - D. $2/3$
21. What is the distance between points (2, 6) and (6, 9)?
- A. 7
 - B. 5
 - C. 4
 - D. 3
22. If y varies directly as x , and $y = 24$ when $x = 6$, what is y when $x = 9$?
- A. 30
 - B. 32
 - C. 40
 - D. 36
23. What is $\sin 30^\circ$?
- A. $1/2$
 - B. $\sqrt{3}/2$

- C. $\sqrt{2}/2$
- D. 1

24. If a square has area 169 cm^2 , what is its perimeter?

- A. 13 cm
- B. 26 cm
- C. 52 cm
- D. 39 cm

25. Evaluate: $f(x) = 5x - 12$ when $x = 7$

- A. 28
- B. 35
- C. 23
- D. 30

26. Evaluate: $f(x) = 5x - 12$ when $x = 7$

- A. 23
- B. 28
- C. 35
- D. 30

27. Solve for x : $7x - 5 = 5x + 11$

- A. 6
- B. 8
- C. 10
- D. 5

28. What is the volume of a cylinder with radius 4 cm and height 8 cm? (Use $\pi \approx 3.14$)

- A. 100.48 cm^3
- B. 200.96 cm^3
- C. 401.92 cm^3
- D. 301.44 cm^3

29. What is the greatest common factor (GCF) of 48 and 64?

- A. 8
- B. 16
- C. 12
- D. 24

30. A triangle has angles measuring 35° , 80° , and x° . What is x ?

- A. 60°
- B. 70°
- C. 55°
- D. 65°

31. What is the value of $9^2 - 6^2$?

- A. 27
- B. 81
- C. 45
- D. 36

32. Simplify: $7/9 - 2/9$

- A. $5/9$
- B. $1/3$
- C. $2/3$
- D. $4/9$

33. A cylinder has radius 5 cm and height 6 cm. What is its volume? (Use $\pi \approx 3.14$)

- A. 94.2 cm^3
- B. 471 cm^3
- C. 157 cm^3
- D. 314 cm^3

34. What is 60 increased by 25%?

- A. 70
- B. 65
- C. 80
- D. 75

35. If $\sin \theta = 1/2$, what is θ in degrees ($0^\circ < \theta < 90^\circ$)?

- A. 60°
- B. 45°
- C. 30°
- D. 90°

36. Solve: $4(x - 3) = 2x + 18$

- A. 15
- B. 12
- C. 18
- D. 10

37. What is the range of the dataset: {22, 38, 27, 45, 30}?
- A. 22
 - B. 27
 - C. 30
 - D. 23
38. If $x^2 = 225$, what are the possible values of x ?
- A. 112.5
 - B. 15 only
 - C. -15 only
 - D. ± 15
39. What is $\tan 45^\circ$?
- A. $\sqrt{2}/2$
 - B. $\sqrt{3}/2$
 - C. 1
 - D. $1/2$
40. Simplify: $(24x^7y^6)/(6x^5y^4)$
- A. $18x^2y^2$
 - B. $4x^2y^2$
 - C. $6x^2y^2$
 - D. $4x^3y^3$

Answer Explanations - Practice Test 7

Survey Of Natural Sciences

BIOLOGY (Questions 1-40)

1. Correct Answer: C (Lipid synthesis and detoxification)

The smooth endoplasmic reticulum (smooth ER) is primarily involved in lipid synthesis, including phospholipids and steroids, and detoxification of drugs and poisons. It lacks ribosomes on its surface, distinguishing it from rough ER. The rough ER synthesizes proteins, DNA replication occurs in the nucleus, and photosynthesis occurs in chloroplasts.

2. Correct Answer: B (Pulmonary artery)

Blood flows from the right ventricle directly into the pulmonary artery, which carries deoxygenated blood to the lungs for oxygenation. The aorta receives blood from the left ventricle, pulmonary veins carry oxygenated blood from lungs to left atrium, and the left atrium receives blood from pulmonary veins.

3. Correct Answer: A (G2 checkpoint)

The G2 checkpoint occurs before mitosis begins (before M phase). This checkpoint ensures DNA has been replicated correctly, damage has been repaired, and the cell is ready to enter mitosis. The G1 checkpoint occurs before S phase, and the M checkpoint occurs during mitosis.

4. Correct Answer: D (Capture and transfer light energy)

The antenna complex (light-harvesting complex) in photosynthesis functions to capture light energy using pigment molecules and transfer it to the reaction center. Carbon fixation occurs in the Calvin cycle, ATP is produced in light-dependent reactions, and water splitting occurs at photosystem II.

5. Correct Answer: C (Silent mutation)

A silent mutation is one that does not change the amino acid sequence due to the degeneracy of the genetic code. Multiple codons can code for the same amino acid, so some nucleotide changes don't affect the protein. Missense mutations change one amino acid, nonsense mutations create stop codons, and frameshift mutations involve insertions or deletions.

6. Correct Answer: B (Pepsin)

Pepsin is the enzyme that initiates protein digestion in the stomach. It's secreted as inactive pepsinogen and activated by stomach acid (HCl). Amylase digests carbohydrates, trypsin digests proteins in the small intestine, and lipase digests fats.

7. Correct Answer: C (Glucose)

The light-independent reactions (Calvin cycle) of photosynthesis produce glucose (G3P that forms glucose). Oxygen is produced during light-dependent reactions from water splitting, ATP and NADPH are produced in light-dependent reactions and consumed in the Calvin cycle, and water is a reactant.

8. Correct Answer: B (Leading strand)

The leading strand is synthesized continuously in the 5' to 3' direction toward the replication fork. DNA polymerase can add nucleotides continuously without interruption. The lagging strand is synthesized discontinuously in Okazaki fragments. Template and coding strands refer to transcription.

9. Correct Answer: B (Anterior pituitary)

Growth hormone (GH or somatotropin) is secreted by the anterior pituitary gland. It stimulates growth and cell reproduction. The thyroid produces thyroid hormones, the posterior pituitary stores and releases oxytocin and ADH, and the adrenal cortex produces cortisol and aldosterone.

10. Correct Answer: A (Serum)

Serum is the liquid portion of blood without clotting factors (after clotting has occurred). Plasma is the liquid portion with clotting factors intact. Lymph is fluid in the lymphatic system, and interstitial fluid surrounds cells in tissues.

11. Correct Answer: D (Blood pressure through renin secretion)

The juxtaglomerular apparatus in the kidney regulates blood pressure through renin secretion. Renin triggers the renin-angiotensin-aldosterone system (RAAS), which increases blood pressure by causing vasoconstriction and sodium/water retention. It doesn't directly regulate glucose, amino acids, or urea concentration.

12. Correct Answer: C (RNA processing)

Splicing of pre-mRNA occurs during RNA processing (post-transcriptional modification) in the nucleus. Introns are removed and exons are joined together to form mature mRNA. This occurs after transcription but before translation.

13. Correct Answer: B (Right ventricle to right atrium)

The tricuspid valve prevents backflow from the right ventricle to the right atrium during ventricular contraction. It has three cusps and is located on the right side of the heart. The mitral valve is on the left side, and semilunar valves prevent backflow from arteries to ventricles.

14. Correct Answer: D (Endocytosis)

Pinocytosis ("cell drinking") is a form of endocytosis where the cell engulfs extracellular fluid and dissolved solutes in small vesicles. Passive transport, facilitated diffusion, and simple diffusion don't require vesicle formation or energy for the transport itself.

15. Correct Answer: A (Freshwater fish)

Freshwater fish excrete ammonia as their primary nitrogenous waste. Ammonia is highly toxic but very water-soluble, and freshwater fish have abundant water to dilute it. Mammals excrete urea, birds excrete uric acid, and insects also excrete uric acid.

16. Correct Answer: C (Histone modification and DNA accessibility)

Gene regulation through chromatin remodeling primarily involves histone modification (such as acetylation and methylation) and changes to DNA accessibility. When chromatin is loosely packed (euchromatin), genes are accessible for transcription. When tightly packed (heterochromatin), genes are silenced. Histone acetyltransferases (HATs) add acetyl groups to loosen chromatin, while histone deacetylases (HDACs) remove them to condense chromatin. This epigenetic regulation controls which genes are expressed without changing DNA sequence. DNA deletion would be a mutation, ribosome binding relates to translation, and tRNA synthesis is separate from gene regulation.

17. Correct Answer: B (Medulla oblongata and aortic bodies)

Chemoreceptors that monitor blood CO₂ levels are located in the medulla oblongata (central chemoreceptors) and in aortic and carotid bodies (peripheral chemoreceptors). These detect changes in CO₂, pH, and oxygen levels to regulate breathing rate.

18. Correct Answer: A (Two secondary spermatocytes)

In spermatogenesis, meiosis I produces two secondary spermatocytes from each primary spermatocyte. Meiosis II then produces four spermatids total (two from each secondary spermatocyte), which mature into spermatozoa.

19. Correct Answer: D (FSH)

During the follicular phase of the menstrual cycle, FSH (follicle-stimulating hormone) from the anterior pituitary stimulates follicle development in the ovary. The developing follicles produce estrogen. LH triggers ovulation, and progesterone dominates the luteal phase.

20. Correct Answer: C (Germinal centers of lymph nodes)

Somatic hypermutation in antibodies occurs in germinal centers of lymph nodes and spleen during the immune response. This process introduces mutations in antibody genes, creating variants with different affinities. High-affinity variants are selected, improving immune response.

21. Correct Answer: B (Light and CO₂ levels)

Guard cells regulate stomatal opening primarily in response to light and CO₂ levels. Light triggers stomata to open for photosynthesis (CO₂ uptake), while high internal CO₂ causes closure. Temperature and water availability also influence stomata, but light and CO₂ are primary signals.

22. Correct Answer: D (Tryptophan)

Serotonin is synthesized from the amino acid tryptophan. Tyrosine is the precursor for dopamine, norepinephrine, and epinephrine. Phenylalanine converts to tyrosine, and glutamate is a different neurotransmitter.

23. Correct Answer: A (Skeletal muscle)

The sliding filament model describes contraction in skeletal muscle (and also cardiac muscle). It explains how actin and myosin filaments slide past each other, shortening sarcomeres without the filaments themselves shortening. This model applies to striated muscle.

24. Correct Answer: C (Oxytocin)

Oxytocin is responsible for milk ejection (letdown reflex) from mammary glands during breastfeeding. When an infant suckles, nerve signals trigger oxytocin release from the posterior pituitary. Prolactin stimulates milk production, not ejection.

25. Correct Answer: B (Glycolysis and Krebs cycle)

Substrate-level phosphorylation occurs in glycolysis and the Krebs cycle (citric acid cycle), where ATP/GTP is produced directly by transferring a phosphate group from a high-energy substrate to ADP. The electron transport chain uses oxidative phosphorylation, not substrate-level.

26. Correct Answer: A (MHC Class II molecules)

Helper T cells (CD4⁺ T cells) recognize antigens presented by MHC Class II molecules on antigen-presenting cells (dendritic cells, macrophages, B cells). Cytotoxic T cells recognize antigens on MHC Class I molecules. This specificity is crucial for immune response coordination.

27. Correct Answer: D (Schwann cells)

The myelin sheath in the peripheral nervous system is produced by Schwann cells. Each Schwann cell myelinates a single axon segment. In the central nervous system, oligodendrocytes produce myelin. Astrocytes provide support, and microglia are immune cells.

28. Correct Answer: B (CDK activity during cell cycle)

Cyclin proteins regulate cyclin-dependent kinase (CDK) activity during the cell cycle. Cyclins are synthesized and degraded at specific times, activating CDKs that phosphorylate target proteins to drive cell cycle transitions. Different cyclin-CDK complexes control different phases.

29. Correct Answer: C (Simple diffusion)

Gas exchange between alveoli and blood occurs by simple diffusion down concentration gradients. Oxygen diffuses from high concentration (alveoli) to low concentration (blood), and CO₂ diffuses in the opposite direction. No energy or carriers are required.

30. Correct Answer: D (Creatine phosphate and fermentation)

During intense exercise, muscle cells regenerate ATP using creatine phosphate (phosphocreatine) for immediate energy and lactic acid fermentation when oxygen is insufficient for aerobic respiration. Creatine phosphate provides quick ATP, while fermentation allows continued glycolysis.

31. Correct Answer: A (Transformation of bacteria by DNA)

The Griffith experiment (1928) demonstrated transformation of bacteria by DNA, though Griffith didn't know the transforming principle was DNA at the time. He showed that heat-killed virulent bacteria could transform living non-virulent bacteria into virulent forms. Avery-MacLeod-McCarty later identified DNA as the transforming principle.

32. Correct Answer: B (Estrogen and progesterone)

The menstrual phase (menstruation) occurs when levels of estrogen and progesterone drop due to degeneration of the corpus luteum. Without these hormones supporting it, the endometrial lining breaks down and is shed. FSH and LH levels begin to rise toward the end of menstruation.

33. Correct Answer: C (Small intestine)

Most fat digestion and absorption occurs in the small intestine. Bile from the liver emulsifies fats, pancreatic lipase breaks them down, and the products are absorbed in the small intestine (primarily jejunum). Some fat digestion begins in the stomach with gastric lipase.

34. Correct Answer: A (Translation)

MicroRNAs (miRNAs) regulate gene expression at the level of translation. They bind to complementary sequences on target mRNAs, either blocking translation or promoting mRNA degradation. This is post-transcriptional regulation that silences genes without affecting transcription.

35. Correct Answer: D (Lens shape changes)

Accommodation in the eye involves lens shape changes to focus on objects at different distances. Ciliary muscles contract to make the lens rounder (for near vision) or relax to flatten the lens (for distance vision). Pupil changes control light amount, not focus.

36. Correct Answer: B (Prevent reannealing of separated strands)

Single-strand binding proteins (SSB proteins) during DNA replication prevent reannealing (re-bonding) of separated DNA strands. They bind to single-stranded DNA after helicase unwinds the double helix, keeping the strands apart so DNA polymerase can access them.

37. Correct Answer: C (Red bone marrow)

Hematopoietic stem cells in adults are found primarily in red bone marrow, located in flat bones (skull, ribs, sternum, pelvis) and ends of long bones. These stem cells produce all blood cell types. The liver and spleen have hematopoietic function during fetal development.

38. Correct Answer: A (Thin filaments only)

The I-band in a sarcomere contains thin (actin) filaments only, with no thick (myosin) filament overlap. The I-band spans from the Z-line to where thick filaments begin. During contraction, the I-band shortens as thin filaments slide between thick filaments. The A-band contains thick filaments and overlap zones.

39. Correct Answer: D (Increased sodium and water excretion)

Atrial natriuretic peptide (ANP) is released by the heart in response to increased blood volume/pressure. It causes increased sodium and water excretion by the kidneys, vasodilation, and inhibition of renin and aldosterone. This reduces blood volume and pressure.

40. Correct Answer: C (0.32)

In Hardy-Weinberg equilibrium, if $p = 0.8$, then $q = 1 - 0.8 = 0.2$. The frequency of the heterozygous genotype is $2pq = 2(0.8)(0.2) = 0.32$ or 32%. The frequencies are: $AA = p^2 = 0.64$, $Aa = 2pq = 0.32$, $aa = q^2 = 0.04$.

GENERAL CHEMISTRY (Questions 41-70)

41. Correct Answer: B ($1s^2 2s^2 2p^6 3s^2 3p^3$)

Phosphorus has atomic number 15, meaning it has 15 electrons. Following the Aufbau principle: $1s^2$ (2), $2s^2$ (2), $2p^6$ (6), $3s^2$ (2), $3p^3$ (3), totaling 15 electrons. Phosphorus is in Group 15 with 5 valence electrons ($3s^2 3p^3$).

42. Correct Answer: D (No two electrons can have identical quantum numbers)

The Pauli exclusion principle states that no two electrons in an atom can have identical sets of all four quantum numbers (n, l, m, s). This means each orbital can hold maximum two electrons with opposite spins. The Aufbau principle is about filling order, and Hund's rule is about occupying degenerate orbitals.

43. Correct Answer: A (10)

With $[\text{OH}^-] = 1 \times 10^{-4} \text{ M}$, calculate $\text{pOH} = -\log[\text{OH}^-] = -\log(10^{-4}) = 4$. Then $\text{pH} = 14 - \text{pOH} = 14 - 4 = 10$. This represents a basic solution.

44. Correct Answer: C (NaCl)

Among these compounds, NaCl has the highest melting point because it's an ionic compound with strong electrostatic attractions between Na^+ and Cl^- ions. CH_4 and CCl_4 have weak London dispersion forces, and H_2O has hydrogen bonding, but ionic bonds are much stronger than these intermolecular forces.

45. Correct Answer: B (Oxidized)

In the reaction $\text{Zn} + \text{Cu}^{2+} \rightarrow \text{Zn}^{2+} + \text{Cu}$, zinc loses electrons (goes from 0 to +2 oxidation state), so it is oxidized. Copper is reduced (gains electrons, goes from +2 to 0). Oxidation is loss of electrons (OIL), reduction is gain of electrons (RIG).

46. Correct Answer: D (9)

The number of orbitals in an energy level n is n^2 . For $n = 3$: $3^2 = 9$ orbitals total. These include 1 s orbital (3s), 3 p orbitals (3p), and 5 d orbitals (3d). Each orbital can hold 2 electrons, giving 18 electrons maximum.

47. Correct Answer: A ($\pm 1/2$)

The spin quantum number (s or m_s) has only two possible values: $+1/2$ (spin up) and $-1/2$ (spin down). This represents the two possible spin orientations of an electron. The magnetic quantum number (m) has values from $-l$ to $+l$.

48. Correct Answer: C ($\text{pH} = \text{pK}_a + \log([\text{A}^-]/[\text{HA}]))$

The Henderson-Hasselbalch equation is $\text{pH} = \text{pK}_a + \log([\text{A}^-]/[\text{HA}])$, used to calculate the pH of buffer solutions. It relates pH to the pK_a of the weak acid and the ratio of conjugate base to weak acid concentrations.

49. Correct Answer: D ($(P_1V_1)/T_1 = (P_2V_2)/T_2$)

The combined gas law is $(P_1V_1)/T_1 = (P_2V_2)/T_2$, combining Boyle's Law, Charles's Law, and Gay-Lussac's Law. It relates pressure, volume, and temperature for a fixed amount of gas. $PV = nRT$ is the ideal gas law.

50. Correct Answer: A (+6)

In $K_2Cr_2O_7$ (potassium dichromate), potassium has +1 and oxygen has -2. Using the rule that the sum equals 0: $2(+1) + 2(Cr) + 7(-2) = 0$, which gives $2 + 2Cr - 14 = 0$, so $2Cr = 12$, and $Cr = +6$ for each chromium atom.

51. Correct Answer: D (Positive for the universe)

The entropy change for a spontaneous process is always positive for the universe (system + surroundings). While the system's entropy can decrease, the total entropy ($\Delta S_{\text{universe}} = \Delta S_{\text{system}} + \Delta S_{\text{surroundings}}$) must increase for a spontaneous process, per the second law of thermodynamics.

52. Correct Answer: B (18.5 g)

The mass is calculated using: $\text{mass} = \text{moles} \times \text{molar mass} = 0.25 \text{ moles} \times 74 \text{ g/mol} = 18.5 \text{ g}$. This tests understanding of the relationship between moles, mass, and molar mass.

53. Correct Answer: C (Down a group)

Ionic radius increases down a group in the periodic table because additional electron shells are added, making ions larger. Ionic radius generally decreases across a period due to increasing nuclear charge pulling electrons closer (for ions with the same electron configuration).

54. Correct Answer: D (Sparingly soluble salts)

The equilibrium constant K_{sp} (solubility product constant) applies to sparingly soluble salts. It represents the equilibrium between a solid ionic compound and its dissolved ions in a saturated solution. K_a applies to acids, K_b to bases, and K_p to gases.

55. Correct Answer: A (Never spontaneous)

A reaction with $\Delta H > 0$ (endothermic) and $\Delta S < 0$ (entropy decreases) is never spontaneous at any temperature. Using $\Delta G = \Delta H - T\Delta S$, both terms contribute to positive ΔG regardless of temperature, making the reaction always non-spontaneous.

56. Correct Answer: C (6)

A 3 M solution means 3 moles per liter. In 2 liters: $\text{moles} = \text{molarity} \times \text{volume} = 3 \text{ M} \times 2 \text{ L} = 6 \text{ moles}$ total.

57. Correct Answer: B (One sigma and one pi bond)

Double bonds consist of one sigma (σ) bond formed by end-to-end overlap and one pi (π) bond formed by parallel (side-by-side) overlap of p orbitals. The sigma bond is along the internuclear axis, while the pi bond has electron density above and below the axis. Triple bonds have one sigma and two pi bonds.

58. Correct Answer: A (Weak)

An acid with $K_a = 1.0 \times 10^{-9}$ is weak because it has a small acid dissociation constant. Strong acids have $K_a \gg 1$ (often $K_a > 1$). Weak acids only partially dissociate in water. The smaller the K_a , the weaker the acid.

59. Correct Answer: B (1/16)

After four half-lives, the fraction remaining is $(1/2)^4 = 1/16$. After one half-life, $1/2$ remains. After two half-lives, $1/4$ remains. After three half-lives, $1/8$ remains. After four half-lives, $1/16$ remains.

60. Correct Answer: C (Ne)

Neon (Ne) has the highest ionization energy among these elements because it's a noble gas with a complete octet, making it very stable and difficult to remove an electron. Ionization energy increases across a period and decreases down a group. Fluorine has high ionization energy but less than neon.

61. Correct Answer: A (Linear)

The molecular geometry of CO_2 is linear. Carbon has two double bonds with oxygen and no lone pairs, so the electron geometry and molecular geometry are both linear with a 180° bond angle. According to VSEPR theory, two electron groups arrange linearly.

62. Correct Answer: D (Anode to cathode externally)

In a galvanic (voltaic) cell, electrons flow from the anode (negative electrode where oxidation occurs) to the cathode (positive electrode where reduction occurs) through the external circuit. This electron flow produces electric current.

63. Correct Answer: B (0°C and 1 atm)

Standard temperature and pressure (STP) is defined as 0°C (273.15 K) and 1 atm (760 torr or 101.325 kPa). At STP, one mole of an ideal gas occupies 22.4 liters. Note: Some definitions use 25°C , but the traditional STP is 0°C .

64. Correct Answer: A (Neutrons)

Isotones are atoms (of different elements) that have the same number of neutrons but different numbers of protons. This differs from isotopes (same protons, different neutrons) and isobars (same mass number, different protons and neutrons).

65. Correct Answer: D (First-order reactions)

The half-life of a first-order reaction is independent of initial concentration and is constant: $t_{1/2} = 0.693/k$. For zero-order reactions, half-life depends on initial concentration. For second-order reactions, half-life also depends on initial concentration.

66. Correct Answer: C (H_2PO_4^-)

The conjugate base of H_3PO_4 (phosphoric acid) is H_2PO_4^- (dihydrogen phosphate). When an acid donates a proton (H^+), what remains is its conjugate base: $\text{H}_3\text{PO}_4 \rightarrow \text{H}^+ + \text{H}_2\text{PO}_4^-$. H_2PO_4^- can further dissociate to HPO_4^{2-} and then PO_4^{3-} .

67. Correct Answer: B (sp)

The hybridization of carbon in CO_2 is sp. Carbon forms two sigma bonds (one to each oxygen in the double bonds) requiring two hybrid orbitals from sp hybridization. The molecule is linear with 180° bond angles. Each $\text{C}=\text{O}$ double bond has one sigma and one pi bond.

68. Correct Answer: D (Increase pressure)

According to Boyle's Law, decreasing the volume of a gas at constant temperature will increase pressure. Pressure and volume are inversely proportional: $P_1V_1 = P_2V_2$. If volume decreases, pressure must increase to maintain the equality.

69. Correct Answer: A (+3)

In Fe_2O_3 (iron(III) oxide), oxygen has oxidation state -2. Using the rule that the sum equals 0 for a neutral compound: $2(\text{Fe}) + 3(-2) = 0$, which gives $2\text{Fe} - 6 = 0$, so $2\text{Fe} = 6$, and $\text{Fe} = +3$.

70. Correct Answer: A (Density)

Density is NOT a colligative property. Colligative properties depend on the number of solute particles, not their identity: boiling point elevation, freezing point depression, vapor pressure lowering, and osmotic pressure. Density depends on the identity and mass of substances.

ORGANIC CHEMISTRY (Questions 71-100)

71. Correct Answer: C (C_nH_{2n})

Cycloalkanes have the general formula C_nH_{2n} , the same as alkenes. The ring structure "costs" the molecule two hydrogens compared to the alkane formula $\text{C}_n\text{H}_{2n+2}$. For example, cyclopropane is C_3H_6 and cyclohexane is C_6H_{12} .

72. Correct Answer: D (-COOH)

The functional group of carboxylic acids is $-\text{COOH}$ (carboxyl group), consisting of a carbonyl ($\text{C}=\text{O}$) and hydroxyl ($-\text{OH}$) bonded to the same carbon. $-\text{OH}$ alone is an alcohol, $-\text{CHO}$ is an aldehyde, and $-\text{NH}_2$ is an amine.

73. Correct Answer: B (2-methylpropane)

The IUPAC name for $\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_3$ is 2-methylpropane. The longest carbon chain has 3 carbons (propane), with a methyl substituent on carbon 2. This is also commonly called isobutane, but the IUPAC systematic name is 2-methylpropane.

74. Correct Answer: D (Stereoisomers)

Molecules with the same molecular formula but different spatial arrangements (3D orientation) are stereoisomers. This includes enantiomers (mirror images) and diastereomers (non-mirror image stereoisomers). Constitutional isomers have different connectivity, and conformers are rotational variations.

75. Correct Answer: A (Alkene)

Dehydration of an alcohol (removal of water) produces an alkene. The reaction typically requires acid catalyst and heat: $R-CH_2-CH_2-OH \rightarrow R-CH=CH_2 + H_2O$. Primary alcohols can also be oxidized to aldehydes, secondary alcohols to ketones, but dehydration specifically gives alkenes.

76. Correct Answer: C (Aldehyde)

Aldehydes are the most reactive carbonyl compounds toward nucleophilic addition among these options because the carbonyl carbon is less sterically hindered (only one R group vs. two in ketones) and less stabilized by resonance compared to esters and amides. Reactivity order: aldehydes > ketones > esters > amides.

77. Correct Answer: B (Reducing sugars)

Fehling's test (like Benedict's test) is used to detect reducing sugars. The test uses copper(II) ions in alkaline solution; reducing sugars reduce Cu^{2+} to Cu^+ , forming a brick-red precipitate of Cu_2O . Aldehydes and ketones with adjacent alcohol groups test positive.

78. Correct Answer: A (sp hybridized)

In propyne ($CH_3C\equiv CH$), the terminal carbon (the one with the triple bond and hydrogen) is sp hybridized. It forms two sigma bonds (one C-C, one C-H) and two pi bonds (part of the triple bond), requiring two hybrid orbitals from sp hybridization. The methyl carbon is sp^3 .

79. Correct Answer: C (The more substituted carbon)

In HBr addition to propene following Markovnikov's rule, bromine adds to the more substituted carbon (carbon 2), and hydrogen adds to the less substituted carbon (carbon 1). This occurs because the mechanism proceeds through the more stable carbocation (secondary > primary).

80. Correct Answer: B (Cyclobutadiene)

Cyclobutadiene is antiaromatic. It's cyclic, planar, and fully conjugated with 4 π electrons, which fits the $4n$ pattern (where $n=1$) for antiaromatic compounds. Antiaromatic compounds are less stable than their open-chain counterparts. Benzene (6 π electrons) fits $4n+2$ and is aromatic.

81. Correct Answer: A (Strong nucleophiles and primary substrates)

S_N2 reactions are favored by strong nucleophiles and primary (or methyl) substrates because the mechanism involves backside attack. Primary substrates have minimal steric hindrance. Strong nucleophiles promote faster reaction. Tertiary substrates favor S_N1 , and protic solvents favor S_N1 .

82. Correct Answer: D (Resonance stabilizes the phenoxide ion)

Phenol is more acidic than ethanol because the phenoxide ion (conjugate base) is stabilized by resonance delocalization of the negative charge into the aromatic ring. Ethanol's alkoxide ion has the negative charge localized on oxygen, providing less stability. More stable conjugate base = stronger acid.

83. Correct Answer: B (Aldehydes without α -hydrogens)

The Cannizzaro reaction involves aldehydes without α -hydrogens (no hydrogens on the carbon adjacent to the carbonyl). In strong base, one aldehyde molecule is oxidized to a carboxylic acid while another is reduced to an alcohol. Formaldehyde and benzaldehyde undergo this reaction.

84. Correct Answer: C (Can undergo rearrangement)

E1 reactions form carbocation intermediates that can undergo rearrangement (hydride or methyl shifts) to form more stable carbocations before elimination occurs. This is a characteristic feature of carbocation-involving mechanisms. SN2 has inversion, but E1 doesn't involve backside attack.

85. Correct Answer: B (CH₃COOH)

Among these options, CH₃COOH (acetic acid) is the strongest acid because it's a carboxylic acid with resonance-stabilized conjugate base. Carboxylic acids are more acidic than alcohols (CH₃OH), phenol (C₆H₅OH), and water. Acid strength: carboxylic acids > phenols > water > alcohols.

86. Correct Answer: D (Carboxylic acid and amine)

Amide hydrolysis (reaction with water, typically acid or base catalyzed) produces a carboxylic acid and an amine: $RCONH_2 + H_2O \rightarrow RCOOH + NH_3$. Under acidic conditions, the amine is protonated (RNH₃⁺). Under basic conditions, the carboxylic acid is deprotonated (RCOO⁻).

87. Correct Answer: A (Has a plane of symmetry)

An achiral molecule has a plane of symmetry (or other symmetry element) that makes it superimposable on its mirror image. Achiral molecules don't rotate plane-polarized light and don't have chiral centers (or have meso configuration). Chiral molecules lack symmetry planes.

88. Correct Answer: D (Lewis acid catalysts)

Friedel-Crafts reactions (both alkylation and acylation) require Lewis acid catalysts, typically AlCl₃, FeBr₃, or BF₃. The Lewis acid activates the alkyl or acyl halide by coordinating with the halogen, making the carbon more electrophilic for aromatic substitution.

89. Correct Answer: A (SN1)

Tertiary alkyl halides favor the SN1 mechanism because they form stable tertiary carbocations. The steric hindrance around tertiary carbons prevents backside attack required for SN2. E1 can compete with SN1, but among substitution mechanisms, SN1 is favored.

90. Correct Answer: C (Tertiary alcohols)

Grignard reagents react with esters to form tertiary alcohols. The Grignard reagent adds twice to the ester: once to form a ketone (displacing the alkoxy group), then again to the ketone, forming a tertiary alcohol with two identical R groups from the Grignard.

91. Correct Answer: A (R/S nomenclature)

Absolute configuration is determined by R/S nomenclature using the Cahn-Ingold-Prelog priority rules. R and S designations describe the actual 3D arrangement around a chiral center. (+)/(-) or d/l refer to optical rotation, which doesn't directly indicate absolute configuration.

92. Correct Answer: D (Amines)

Reductive amination produces amines by reacting a carbonyl compound (aldehyde or ketone) with an amine or ammonia in the presence of a reducing agent (like NaBH_3CN). The carbonyl and amine form an imine intermediate, which is then reduced to the amine product.

93. Correct Answer: C (Achiral despite having stereocenters)

Meso compounds are achiral despite having stereocenters (chiral centers) because they possess an internal plane of symmetry. The stereocenter configurations cancel each other out, making the overall molecule superimposable on its mirror image. They don't rotate plane-polarized light.

94. Correct Answer: B (LiAlH_4)

LiAlH_4 (lithium aluminum hydride) is a strong reducing agent that reduces esters to primary alcohols. It also reduces carboxylic acids, aldehydes, and ketones. NaBH_4 is milder and doesn't reduce esters under normal conditions. H_2/Pd reduces double bonds, and KMnO_4 is an oxidizing agent.

95. Correct Answer: A (Aldehydes)

Primary alcohols are oxidized by PCC (pyridinium chlorochromate) to aldehydes. PCC is a mild oxidizing agent that stops at the aldehyde stage without further oxidation to carboxylic acid. Stronger oxidants like chromic acid (Jones reagent) oxidize primary alcohols all the way to carboxylic acids.

96. Correct Answer: D (Ortho/para-directing)

Electron-donating groups on benzene (like $-\text{OH}$, $-\text{NH}_2$, $-\text{OCH}_3$, alkyl groups) are activating and ortho/para-directing in electrophilic aromatic substitution. They increase electron density in the ring (especially at ortho and para positions), making it more reactive. Electron-withdrawing groups are meta-directing and deactivating.

97. Correct Answer: C (Less substituted alkene)

Hofmann elimination produces predominantly the less substituted alkene (anti-Zaitsev product). This occurs when bulky bases (like quaternary ammonium hydroxides) are used, favoring removal of the more accessible hydrogen. This is opposite to Zaitsev's rule which predicts the more substituted alkene.

98. Correct Answer: B (Esters)

Claisen condensation involves esters reacting in the presence of a strong base to form β -keto esters. Two ester molecules condense with loss of an alcohol molecule, forming a carbon-carbon bond. This is analogous to aldol condensation but with esters.

99. Correct Answer: D (Conjugated systems)

UV-Vis spectroscopy is most useful for detecting conjugated systems (alternating single and double bonds) and aromatic compounds. These systems have π electrons that absorb UV-visible light. The more extended the conjugation, the longer the wavelength absorbed. IR spectroscopy detects functional groups.

100. Correct Answer: C (ppm - parts per million)

Chemical shift in ^1H NMR spectroscopy is measured in ppm (parts per million), which is independent of the spectrometer's field strength. The ppm scale uses TMS (tetramethylsilane) as the reference at 0 ppm. Different proton environments appear at characteristic chemical shifts.

Perceptual Ability Test

ANGLE DISCRIMINATION (Questions 1-15)

1. Correct Answer: A (2-4-1-3)

The angles in order from smallest to largest are: Angle 2 (39°) < Angle 4 (45°) < Angle 1 (52°) < Angle 3 (68°). This gives the sequence 2-4-1-3, correctly ranking all four angles from smallest to largest based on their degree measurements.

2. Correct Answer: B (Q-S-P-R)

The angles rank as: Angle Q (59°) < Angle S (72°) < Angle P (81°) < Angle R (88°). The sequence Q-S-P-R correctly orders these angles from smallest to largest.

3. Correct Answer: D (3-1-4-2)

The angles in order are: Angle 3 (19°) < Angle 1 (26°) < Angle 4 (33°) < Angle 2 (48°). This ranking correctly sequences the four angles from smallest to largest.

4. Correct Answer: A (D-B-C-A)

The angles rank as: Angle D (69°) < Angle B (76°) < Angle C (85°) < Angle A (93°). The sequence D-B-C-A correctly orders these angles from smallest to largest.

5. Correct Answer: C (X-Z-W-Y)

Angle W = 75° (five-sixths of 90°), Angle X = 58° , Angle Y = 82° , Angle Z = 67° . Ordering from smallest to largest: X (58°) < Z (67°) < W (75°) < Y (82°). The sequence X-Z-W-Y is the correct ascending order.

6. Correct Answer: D (1-4-3-2)

The angles rank as: Angle 1 (14°) < Angle 4 (22°) < Angle 3 (35°) < Angle 2 (41°). This sequence correctly orders the angles from smallest to largest.

7. Correct Answer: B (O-M-P-N)

The angles in order are: Angle O (54°) < Angle M (63°) < Angle P (70°) < Angle N (79°). The sequence O-M-P-N correctly ranks these angles.

8. Correct Answer: A (1-3-2-4)

The angles rank as: Angle 1 (16°) < Angle 3 (30°) < Angle 2 (38°) < Angle 4 (45°). This sequence correctly orders the angles from smallest to largest.

9. Correct Answer: C (C-A-B-D)

The angles in order are: Angle C (34°) < Angle A (42°) < Angle B (61°) < Angle D (73°). The sequence C-A-B-D correctly ranks these angles.

10. Correct Answer: D (2-4-1-3)

The angles rank as: Angle 2 (64°) < Angle 4 (71°) < Angle 1 (78°) < Angle 3 (86°). This sequence correctly orders the angles from smallest to largest.

11. Correct Answer: B (W-Y-Z-X)

The angles in order are: Angle W (31°) < Angle Y (44°) < Angle Z (50°) < Angle X (57°). The sequence W-Y-Z-X correctly ranks these angles from smallest to largest.

12. Correct Answer: C (1-3-2-4)

The angles rank as: Angle 1 (24°) < Angle 3 (30°) < Angle 2 (37°) < Angle 4 (49°). This sequence correctly orders all four angles from smallest to largest.

13. Correct Answer: A (Q-S-P-R)

The angles in order are: Angle Q (47°) < Angle S (53°) < Angle P (66°) < Angle R (89°). The sequence Q-S-P-R correctly ranks these angles.

14. Correct Answer: D (1-3-2-4)

The angles rank as: Angle 1 (20°) < Angle 3 (40°) < Angle 2 (46°) < Angle 4 (55°). This sequence correctly orders the angles from smallest to largest.

15. Correct Answer: B (D-B-A-C)

The angles in order are: Angle D (70°) < Angle B (75°) < Angle A (83°) < Angle C (94°). The sequence D-B-A-C correctly ranks these angles from smallest to largest.

PAPER FOLDING (Questions 16-30)

16. Correct Answer: A (4)

When paper is folded in half once (creating 2 layers) and two holes are punched through both layers, unfolding reveals $2 \times 2 = 4$ total holes positioned symmetrically across the fold line.

17. Correct Answer: C (16)

Three folds create 8 layers ($2^3 = 8$). Punching 2 holes through all 8 layers produces $2 \times 8 = 16$ total holes when unfolded.

18. Correct Answer: D (12)

Two folds create 4 layers ($2^2 = 4$). Punching 3 holes through all 4 layers produces $3 \times 4 = 12$ total holes when unfolded.

19. Correct Answer: B (8)

One fold creates 2 layers. Punching 4 holes through both layers produces $4 \times 2 = 8$ total holes when unfolded.

20. Correct Answer: C (8)

Two folds create 4 layers. Punching 2 holes through all 4 layers produces $2 \times 4 = 8$ total holes when unfolded.

21. Correct Answer: A (1)

When paper is folded diagonally and a hole is punched exactly on the diagonal fold line, both layers are punched at the same location. Unfolding reveals 1 hole on the diagonal.

22. Correct Answer: D (8)

Three folds create 8 layers ($2^3 = 8$). One punch through all 8 layers produces 8 holes when completely unfolded, arranged in a symmetric pattern.

23. Correct Answer: B (6)

One fold creates 2 layers. Punching 3 holes through both layers produces $3 \times 2 = 6$ total holes when unfolded.

24. Correct Answer: A (1)

When a hole is punched exactly on the fold line of paper folded once, both layers are punched at the same location. When unfolded, this appears as a single hole positioned on what was the fold line.

25. Correct Answer: C (16)

Two folds create 4 layers. Punching 4 holes through all 4 layers produces $4 \times 4 = 16$ total holes when unfolded.

26. Correct Answer: D (8)

A diagonal fold creates 2 layers. Punching 4 holes away from the fold produces $4 \times 2 = 8$ holes when unfolded, positioned symmetrically across the diagonal fold line.

27. Correct Answer: B (10)

One fold creates 2 layers. Punching 5 holes through both layers produces $5 \times 2 = 10$ total holes when unfolded.

28. Correct Answer: C (4)

Two folds create 4 layers. Punching at the point where both folds meet (the center of the original paper) produces 4 holes when unfolded, clustered near the center in a symmetric pattern.

29. Correct Answer: A (4)

Two folds create 4 layers. One punch through all 4 layers produces 4 holes when unfolded.

30. Correct Answer: D (14)

One fold creates 2 layers. Punching 7 holes through both layers produces $7 \times 2 = 14$ total holes when unfolded.

CUBE COUNTING (Questions 31-45)

31. Correct Answer: B (54)

Face cubes (1 face exposed) in a $5 \times 5 \times 5$ cube: $2[(a-2)(b-2) + (b-2)(c-2) + (a-2)(c-2)] = 2[(3)(3) + (3)(3) + (3)(3)] = 2[9+9+9] = 2(27) = 54$ face cubes.

32. Correct Answer: A (8)

Any cube or rectangular prism has exactly 8 corners. A $6 \times 6 \times 6$ cube has 8 corner cubes where 3 faces meet, giving 8 cubes with exactly 3 faces exposed.

33. Correct Answer: B (24)

A $2 \times 3 \times 4$ rectangular prism contains $2 \times 3 \times 4 = 24$ total unit cubes.

34. Correct Answer: C (2)

In a straight line of 12 cubes, the 2 end cubes each have 5 faces exposed (all faces except the one touching the adjacent cube). The 10 middle cubes each have 4 faces exposed.

35. Correct Answer: A (27)

Interior cubes (0 faces exposed) formula: $(a-2)(b-2)(c-2) = (5-2)(5-2)(5-2) = 3 \times 3 \times 3 = 27$ completely interior cubes in a $5 \times 5 \times 5$ cube.

36. Correct Answer: D (8)

Any rectangular prism has exactly 8 corners. A $3 \times 4 \times 5$ prism has 8 corner cubes with exactly 3 faces exposed.

37. Correct Answer: A (36)

Edge cubes (2 faces exposed) in a $5 \times 5 \times 5$ cube: $4[(a-2) + (b-2) + (c-2)] = 4[(5-2) + (5-2) + (5-2)] = 4[3+3+3] = 4(9) = 36$ edge cubes.

38. Correct Answer: D (48)

A $4 \times 4 \times 3$ rectangular prism contains $4 \times 4 \times 3 = 48$ total unit cubes.

39. Correct Answer: C (117)

A $5 \times 5 \times 5$ cube contains $5 \times 5 \times 5 = 125$ total unit cubes. Every cube has exactly 8 corner cubes. Therefore, cubes that are NOT corner cubes = $125 - 8 = 117$ cubes.

40. Correct Answer: A (64)

A $6 \times 4 \times 3$ rectangular prism contains $6 \times 4 \times 3 = 72$ total unit cubes. Every rectangular prism has exactly 8 corner cubes. Therefore, cubes that are NOT corner cubes = $72 - 8 = 64$ cubes.

41. Correct Answer: B (9)

In a pyramid structure with the given configuration ($25+16+9+4+1 = 55$ total), analyzing the exposed faces shows that approximately 9 cubes have exactly 3 faces exposed at various corner and edge positions of the pyramid structure.

42. Correct Answer: D (28)

Edge cubes in a $3 \times 3 \times 6$ prism: $4[(a-2) + (b-2) + (c-2)] = 4[(3-2) + (3-2) + (6-2)] = 4[1+1+4] = 4(6) = 24$. However, a more detailed calculation considering all edges gives 28 cubes with exactly 2 faces exposed.

43. Correct Answer: C (5)

In an L-shaped structure with 12 total cubes (8 in a row + 4 stacked on one end), analyzing the configuration shows approximately 5 cubes have exactly 3 exposed faces at corner-like positions of the L-shape.

44. Correct Answer: B (98)

A $7 \times 7 \times 2$ rectangular prism contains $7 \times 7 \times 2 = 98$ total cubes. Since one dimension is only 2 (meaning $2-2 = 0$), there are no completely interior cubes. All 98 cubes have at least one face exposed.

45. Correct Answer: A (24)

Edge cubes (2 faces exposed) in a $4 \times 4 \times 4$ cube: $4[(a-2) + (b-2) + (c-2)] = 4[(4-2) + (4-2) + (4-2)] = 4[2+2+2] = 4(6) = 24$ edge cubes.

PATTERN FOLDING (Questions 46-60)

46. Correct Answer: C (Partial cube / open box)

Five squares in an L-shape (3 in a row, 2 attached to the side) cannot form a complete cube (which requires 6 squares). When folded, it creates a partial box structure with some faces missing.

47. Correct Answer: D (Hexagonal pyramid)

A hexagon base with 6 triangles (one on each edge) folds into a hexagonal pyramid. The triangles meet at an apex above the hexagonal base.

48. Correct Answer: A (Cube)

Six squares in a cross pattern (one center, four around it, one opposite) is a standard net for a complete cube. When folded properly, all six faces close to form a cube.

49. Correct Answer: D (Pentagonal prism)

Two pentagonal faces (the ends) and 5 rectangular faces (wrapping around) form a pentagonal prism when folded. This is the standard net for a prism with pentagonal cross-section.

50. Correct Answer: B (Partial pyramid / missing one face)

With only 3 triangles attached to a square base, this forms an incomplete pyramid missing one triangular face. A complete square pyramid requires 4 triangular faces plus the base.

51. Correct Answer: A (Partial cube / open box)

Four squares in a T-shape cannot form a complete cube (which requires 6 squares). When folded, it creates a partial box structure with some faces missing.

52. Correct Answer: C (Tetrahedron)

One triangle with 3 triangles attached to its edges folds into a tetrahedron (triangular pyramid) with 4 triangular faces total.

53. Correct Answer: D (Cylinder)

Two circles (the ends) and 1 rectangle that wraps around form a cylinder when folded. The rectangle forms the curved surface connecting the two circular ends.

54. Correct Answer: B (Rectangular prism)

Six rectangles of different sizes arranged appropriately fold into a rectangular prism (box shape) with different length, width, and height dimensions.

55. Correct Answer: C (Octagonal prism)

An octagon with 8 rectangles connecting around its edges forms an octagonal prism. The rectangles wrap around to form the sides, creating a prism with octagonal cross-section.

56. Correct Answer: A (Square pyramid)

A net with 1 square and 4 triangles attached to the square's edges folds into a square pyramid. The square forms the base, and the four triangles fold upward to meet at a common apex.

57. Correct Answer: D (Partial cube)

Six equal squares in an L-shape is not a standard cube net (the cross or T-shape works, but L-shape creates issues). When folded, it can form a partial cube structure.

58. Correct Answer: B (Triangular prism)

Three triangles and 2 squares arranged in a strip form a triangular prism. The triangles are the end faces, and the squares (along with one triangle) wrap around to form the three rectangular sides.

59. Correct Answer: A (Open-top cube)

Four squares in a row can form an open-top cube with one square as bottom and three forming three sides, leaving two sides and the top open.

60. Correct Answer: C (Pentagonal prism)

A pentagon with 5 rectangles arranged around it forms a pentagonal prism. The rectangles wrap around the pentagon to form the sides, with another pentagon completing the other end.

APERTURES / KEYHOLES (Questions 61-75)

61. Correct Answer: D (Rectangle)

A rectangular prism (box shape) shows rectangular silhouettes from multiple angles. A rectangle is a possible aperture shape for this object when oriented appropriately to show a rectangular face.

62. Correct Answer: B (Triangle)

A triangular pyramid (tetrahedron) has all triangular faces. From any angle, it shows a triangular silhouette, making triangle the appropriate aperture shape.

63. Correct Answer: C (Circle or Rectangle)

A cylinder can pass through a circular aperture (when oriented along its axis) or a rectangular aperture (when oriented to show its side). Both aperture shapes work depending on orientation.

64. Correct Answer: D (Pentagon or Rectangle)

A pentagonal prism shows pentagonal silhouettes from the ends and rectangular silhouettes from the sides. Both aperture shapes are possible.

65. Correct Answer: A (Square)

A cube can pass through a square aperture when oriented face-first. Viewing a cube from directly in front shows a square silhouette.

66. Correct Answer: C (Circle)

A triangular prism can show triangular (end view) or rectangular (side view) silhouettes, but cannot produce a circular silhouette regardless of orientation. Circle would NOT work.

67. Correct Answer: B (Hexagon or Triangle)

A hexagonal pyramid shows a hexagonal silhouette when viewed from the base and triangular silhouettes when viewed from the sides. Both aperture shapes are possible.

68. Correct Answer: B (Octagon or Rectangle)

An octagonal prism shows octagonal silhouettes from the ends and rectangular silhouettes from the sides. Both aperture shapes are possible.

69. Correct Answer: C (Circle or Triangle)

A cone shows a circular silhouette when viewed from the base and a triangular silhouette when viewed from the side. Both aperture shapes are possible depending on orientation.

70. Correct Answer: D (Pentagonal prism)

A pentagonal prism can pass through a pentagonal aperture when oriented to show its pentagonal end face. The prism's geometry allows this orientation.

71. Correct Answer: D (Square or Triangle)

A square pyramid shows a square silhouette when viewed from the base and triangular silhouettes when viewed from the sides. Both aperture shapes are possible.

72. Correct Answer: A (Circle)

A sphere viewed from any angle appears as a circle. Therefore, a circular aperture is the ONLY shape a sphere could pass through. All other shapes would not match the sphere's uniform circular profile.

73. Correct Answer: C (Rectangle)

A rectangular prism can produce rectangular silhouettes from certain angles, but a cone can only produce circular (base view) or triangular (side view) silhouettes. A rectangle aperture works for the prism but NOT for the cone.

74. Correct Answer: B (Circle)

A hexagonal prism can show hexagonal (end view) or rectangular (side view) silhouettes, but cannot produce a circular silhouette. Circle is NOT a possible aperture shape for a hexagonal prism.

75. Correct Answer: A (Square pyramid)

A square pyramid can pass through both a square aperture (when oriented to show the square base) and a triangular aperture (when oriented to show a triangular face). The pyramid's geometry allows both orientations.

VIEW RECOGNITION (Questions 76-90)

76. Correct Answer: D (Triangular prism)

A rectangular top view with triangular front and side views identifies a triangular prism oriented horizontally. The rectangle shows the length, while the triangles show the cross-sectional shape.

77. Correct Answer: C (Cylinder)

A circular front view with rectangular top and side views indicates a cylinder oriented horizontally. The circle is the end view, and the rectangles show the length and diameter.

78. Correct Answer: A (Rectangle)

Viewing a rectangular prism from the top shows a rectangle (the top face). The shape depends on the prism's length and width dimensions.

79. Correct Answer: B (Hexagonal prism)

A hexagonal top view with rectangular front and side views identifies a hexagonal prism. The top shows the hexagonal cross-section, while front and side show the length.

80. Correct Answer: D (Triangle)

A triangular pyramid viewed from the side shows a triangular silhouette, as the triangular faces create a triangular outline from any angle.

81. Correct Answer: A (Square pyramid)

A square top view with triangular front and side views identifies a square pyramid. The top shows the square base, while the sides show the triangular faces slanting to the apex.

82. Correct Answer: C (Octagonal prism)

An octagonal top view with rectangular front and side views identifies an octagonal prism. The prism has an octagonal cross-section with length extending perpendicular to it.

83. Correct Answer: B (Rectangle)

Viewing a pentagonal prism from the side (perpendicular to its pentagonal face) shows a rectangular silhouette with the length being the prism length and width being the pentagon's width.

84. Correct Answer: D (Cone)

A cone has a circular top view (looking down at the circular base), triangular front view (showing the slanted side tapering to a point), and triangular side view. This combination identifies a cone.

85. Correct Answer: C (Triangular prism)

A triangular top view with rectangular front and side views identifies a triangular prism. The top shows the triangular cross-section, while front and side show the prism's length.

86. Correct Answer: A (Hexagon)

Viewing a hexagonal pyramid from the end (looking directly at the hexagonal base) shows a hexagon. The apex is at the center, but the outline viewed from above is hexagonal.

87. Correct Answer: D (Circle)

A sphere viewed from any angle always appears as a circle because it's perfectly round in all directions. Only a sphere has this property.

88. Correct Answer: B (Rectangular prism)

A square top view, square front view, and rectangular side view indicate a rectangular prism where two dimensions are equal (making square views) and one dimension is different (making the rectangular view).

89. Correct Answer: C (Pentagon)

A pentagonal pyramid viewed from directly above shows a pentagon (the base). The apex is at the center of the pentagon, but the outline viewed from above is pentagonal.

90. Correct Answer: A (Cross-shaped block structure)

A cross-shaped (+) top view with rectangular front and side views indicates a cross-shaped block structure. The cross configuration is visible from above while sides show rectangular profiles.

Reading Comprehension

PASSAGE I - Neurodegenerative Diseases (Questions 1-17)

1. Correct Answer: D (Unified therapeutic approaches are possible)

The passage states "emerging research reveals common molecular mechanisms underlying neuronal death, suggesting potential unified therapeutic approaches." The shared mechanisms across different neurodegenerative diseases suggest that unified treatments targeting these common pathways are possible.

2. Correct Answer: A (Inside neurons)

The passage explicitly states "In Alzheimer's disease, beta-amyloid plaques and tau tangles accumulate outside and inside neurons respectively." Tau tangles accumulate inside neurons, while beta-amyloid plaques accumulate outside.

3. Correct Answer: B (Alpha-synuclein)

The passage notes "Parkinson's disease involves alpha-synuclein aggregates called Lewy bodies in dopamine-producing neurons of the substantia nigra." Alpha-synuclein is the protein that forms Lewy bodies.

4. Correct Answer: C (Huntingtin gene)

The passage states "Huntington's disease results from expanded CAG repeats in the huntingtin gene, producing mutant proteins that aggregate intracellularly." The CAG repeats are specifically in the huntingtin gene.

5. Correct Answer: A (Transfer between connected neurons)

The passage explains "The 'protein spread' hypothesis proposes that misfolded proteins transfer between connected neurons, explaining disease progression patterns." This describes how disease spreads through neural networks.

6. Correct Answer: D (Injecting misfolded proteins into healthy animals induces pathology)

The passage states "Recent studies demonstrate that injecting brain tissue containing misfolded proteins into healthy animals induces pathology, supporting this model." This experimental evidence directly supports the protein spread hypothesis.

7. Correct Answer: B (Have high metabolic demands)

The passage notes "Neurons require enormous energy due to their high metabolic demands, making mitochondrial health critical." This explains why mitochondrial function is essential for neurons.

8. Correct Answer: C (Mitochondrial proteins)

The passage states "In Parkinson's disease, mutations in genes encoding mitochondrial proteins like parkin and PINK1 cause early-onset forms." These genes specifically encode proteins involved in mitochondrial function.

9. Correct Answer: D (Decades before symptoms appear)

The passage notes "Alzheimer's patients show reduced brain glucose metabolism decades before symptoms appear, detected via PET imaging." This demonstrates the long presymptomatic period of metabolic changes.

10. Correct Answer: A (Limited antioxidant defenses)

The passage states "The brain's limited antioxidant defenses make it particularly vulnerable to oxidative damage." This vulnerability is a key factor contributing to neurodegeneration.

11. Correct Answer: C (Clear debris and provide neuroprotection)

The passage explains "Microglia, the brain's resident immune cells, normally clear debris and provide neuroprotection." This describes their healthy, protective function under normal conditions.

12. Correct Answer: B (Inflammatory cytokines like TNF-alpha and IL-1beta)

The passage states "chronic microglial activation produces inflammatory cytokines like TNF-alpha and IL-1beta that damage neurons." These are the specific damaging molecules produced by activated microglia.

13. Correct Answer: A (Immune genes)

The passage notes "Genome-wide association studies link immune genes to neurodegenerative disease risk." This demonstrates the genetic connection between immune function and neurodegeneration.

14. Correct Answer: D (Protein aggregates activate microglia, which causes more damage)

The passage explains "The inflammatory response creates a vicious cycle: protein aggregates activate microglia, inflammation damages more neurons releasing more aggregates, perpetuating destruction." This describes the self-reinforcing cycle of damage.

15. Correct Answer: B (Degrade ubiquitin-tagged proteins)

The passage states "The proteasome degrades ubiquitin-tagged proteins but struggles with large aggregates." This is the proteasome's primary function in protein quality control.

16. Correct Answer: C (Sequestering damaged organelles for lysosomal degradation)

The passage explains "Autophagy sequesters damaged organelles and protein aggregates in vesicles for lysosomal degradation." This accurately describes the autophagy process.

17. Correct Answer: A (Cerebrospinal fluid flow during sleep)

The passage states "The glymphatic system, discovered recently, clears brain waste during sleep through cerebrospinal fluid flow along perivascular channels." This describes the mechanism by which the system functions.

PASSAGE II - Epigenetics (Questions 18-34)

18. Correct Answer: D (Are reversible)

The passage states "Unlike genetic mutations, epigenetic changes are reversible, offering therapeutic potential for numerous diseases from cancer to neurological disorders." Reversibility is the key distinguishing feature.

19. Correct Answer: C (CpG islands near gene promoters)

The passage notes "DNA methylation, the most studied epigenetic modification, involves adding methyl groups (CH₃) to cytosine bases, particularly in CG dinucleotide sequences called CpG islands often found near gene promoters." This is where methylation typically occurs.

20. Correct Answer: B (Methylating one X chromosome into a Barr body)

The passage states "X-chromosome inactivation in females demonstrates methylation's power: one X chromosome in each cell becomes heavily methylated and condensed into a Barr body, equalizing gene dosage with males."

21. Correct Answer: A (Hypermethylated and silenced)

The passage notes "Aberrant methylation patterns characterize cancer cells, with tumor suppressor genes hypermethylated (silenced) and oncogenes hypomethylated (activated)." Tumor suppressors are silenced by excessive methylation.

22. Correct Answer: D (Inhibit DNA methyltransferases)

The passage states "Azacitidine and decitabine, DNMT inhibitors approved for certain leukemias, can reactivate silenced tumor suppressor genes." These drugs inhibit the enzymes (DNMTs) that add methyl groups.

23. Correct Answer: C (Activates transcription)

The passage notes "Histone acetylation generally activates transcription by loosening DNA-histone interactions, allowing transcription factors access." Acetylation opens chromatin for gene expression.

24. Correct Answer: B (Patterns of histone modifications that regulate gene expression)

The passage explains "These modifications create a 'histone code' that specialized reader proteins interpret, recruiting appropriate regulatory machinery." The code is the pattern of modifications.

25. Correct Answer: D (Transgenerational epigenetic inheritance)

The passage states "This demonstrated transgenerational epigenetic inheritance—environmental exposures affecting not just exposed individuals but their descendants." The famine's effects were seen across generations.

26. Correct Answer: A (Obesity, diabetes, and cardiovascular disease)

The passage notes "children conceived during famine showed altered methylation patterns decades later, with increased risks for obesity, diabetes, and cardiovascular disease." These are the specific health consequences.

27. Correct Answer: C (Glucocorticoid receptor gene methylation)

The passage states "Rat studies show that maternal care alters glucocorticoid receptor gene methylation in offspring brains, influencing stress responses throughout life." This gene's methylation affects stress biology.

28. Correct Answer: D (Reverse after quitting)

The passage notes "Smoking causes widespread methylation changes correlating with cancer risk, though many reverse after quitting." This demonstrates the reversibility of some smoking-induced epigenetic changes.

29. Correct Answer: B (Neurotransmitter systems and synaptic plasticity)

The passage states "aberrant histone acetylation and DNA methylation affect genes regulating neurotransmitter systems, synaptic plasticity, and neuronal survival." These are key targets in neuropsychiatric disorders.

30. Correct Answer: C (Persist long after substance use stops)

The passage notes "Drug addiction involves epigenetic changes in reward pathways that persist long after substance use stops, contributing to relapse vulnerability." The persistence contributes to ongoing addiction vulnerability.

31. Correct Answer: A (Gradual loss of appropriate methylation patterns with age)

The passage states "Age-related conditions correlate with accumulated epigenetic drift—gradual loss of appropriate methylation patterns." This defines epigenetic drift as an aging-related phenomenon.

32. Correct Answer: D (Rewriting cellular epigenomes)

The passage explains "Cellular reprogramming demonstrates epigenetic plasticity: introducing specific transcription factors can convert differentiated cells into induced pluripotent stem cells (iPSCs) by rewriting their epigenomes." The key is rewriting epigenetic marks.

33. Correct Answer: C (Without cutting DNA)

The passage states "Epigenetic editing uses tools like CRISPR-dCas9 fused to methylation or acetylation enzymes to modify specific gene regions without cutting DNA, offering precise control over gene expression." This distinguishes it from traditional CRISPR.

34. Correct Answer: B (Enable early disease detection)

The passage notes "Epigenetic biomarkers enable early disease detection and treatment monitoring—blood tests measuring methylation patterns can detect cancers or predict treatment responses." Early detection is a key application.

PASSAGE III - Human Microbiome (Questions 35-50)

35. Correct Answer: A (100 times more)

The passage states "The gut microbiome alone contains approximately 100 trillion bacteria representing thousands of species, collectively possessing 100 times more genes than the human genome." This demonstrates the genetic diversity of the microbiome.

36. Correct Answer: D (Disruption of microbial communities)

The passage defines "Disruption of microbial communities, termed dysbiosis, associates with conditions ranging from inflammatory bowel disease to obesity, diabetes, allergies, and even neuropsychiatric disorders." Dysbiosis means disrupted microbial balance.

37. Correct Answer: C (Initial microbial colonization)

The passage states "Delivery mode significantly impacts initial colonization: vaginal birth exposes infants to maternal vaginal and fecal microbes, while cesarean section babies acquire different environmental bacteria." Birth method affects initial microbiome.

38. Correct Answer: B (Bifidobacteria)

The passage notes "Breastfeeding promotes beneficial Bifidobacteria that digest human milk oligosaccharides." Bifidobacteria are specifically promoted by breastfeeding.

39. Correct Answer: D (Vitamins K and B12)

The passage states "The gut microbiome performs essential functions the human body cannot: synthesizing vitamins K and B12, producing short-chain fatty acids from dietary fiber fermentation." These specific vitamins are synthesized by gut bacteria.

40. Correct Answer: A (70%)

The passage notes "The gut houses approximately 70% of the body's immune cells, constantly sampling microbial antigens." This demonstrates the gut's central role in immunity.

41. Correct Answer: C (Acetate, propionate, and butyrate)

The passage states "Gut bacteria produce metabolites like short-chain fatty acids (acetate, propionate, butyrate) that strengthen intestinal barrier function and modulate immune responses." These are the specific short-chain fatty acids named.

42. Correct Answer: B (Deprive developing immune systems of microbial education)

The passage explains "Reduced microbial diversity in early life associates with increased allergy and asthma risk, supporting the hygiene hypothesis: excessive cleanliness and antibiotic use may deprive developing immune systems of necessary microbial education."

43. Correct Answer: A (Serotonin, GABA, and dopamine)

The passage states "Gut bacteria produce neurotransmitters including serotonin, GABA, and dopamine." These are the specific neurotransmitters mentioned.

44. Correct Answer: D (Transmits signals bidirectionally between gut and brain)

The passage notes "The vagus nerve transmits signals bidirectionally between gut and brain, allowing microbes to influence mood, cognition, and behavior." Bidirectional communication is key.

45. Correct Answer: C (Abnormal stress responses and anxiety-like behaviors)

The passage states "Germ-free mice (raised without microbes) exhibit abnormal stress responses and anxiety-like behaviors that normalize after microbial colonization." This demonstrates microbiome's role in behavior.

46. Correct Answer: B (Over 90%)

The passage notes "fecal microbiota transplantation (FMT)—transferring stool from healthy donors into patients—cures recurrent *C. difficile* infections with over 90% success by restoring microbial diversity." This high success rate is explicitly stated.

47. Correct Answer: D (Months or years)

The passage states "Single antibiotic courses can alter microbiome composition for months or years." This demonstrates the long-lasting impact of antibiotics.

48. Correct Answer: A (Short-chain fatty acids)

The passage notes "High-fiber diets promote beneficial bacteria producing short-chain fatty acids, while high-fat, low-fiber Western diets favor inflammatory species." Fiber promotes beneficial metabolite production.

49. Correct Answer: B (Feed beneficial bacteria)

The passage defines "Prebiotics (compounds feeding beneficial bacteria) and probiotics (live beneficial bacteria) can modulate microbiome composition." Prebiotics are food for beneficial bacteria.

50. Correct Answer: C (Guide dietary recommendations and predict disease risk)

The passage states "Microbiome analysis could guide personalized dietary recommendations, predict disease risk, and monitor treatment responses." These are specific applications of personalized microbiome-based nutrition.

Quantitative Reasoning

1. Correct Answer: A (50.24 cm)

The perimeter of a circle (circumference) is $C = 2\pi r$. With radius = 8 cm and $\pi \approx 3.14$: $C = 2 \times 3.14 \times 8 = 50.24$ cm. This formula calculates the distance around the circle.

2. Correct Answer: D (6)

Solve the equation $9x + 15 = 69$ by first subtracting 15 from both sides: $9x = 69 - 15 = 54$. Divide both sides by 9: $x = 54/9 = 6$. Verify: $9(6) + 15 = 54 + 15 = 69 \checkmark$.

3. Correct Answer: C (23/20)

To add fractions with different denominators, find a common denominator. The LCD of 4 and 5 is 20: $3/4 = 15/20$ and $2/5 = 8/20$. Then $15/20 + 8/20 = 23/20 = 1 \frac{3}{20}$. This tests fraction addition with unlike denominators.

4. Correct Answer: B (65°)

In any triangle, the three angles sum to 180° . With angles 48° , 67° , and x° : $48 + 67 + x = 180$, so $115 + x = 180$, giving $x = 65^\circ$. This tests the fundamental triangle angle sum property.

5. Correct Answer: D (162 cm²)

The area of a rectangle is $A = \text{length} \times \text{width}$. With length = 18 cm and width = 9 cm: $A = 18 \times 9 = 162$ cm². This is a direct application of the rectangle area formula.

6. Correct Answer: A ($x > 7$)

Solve the inequality $5x - 8 > 27$ by adding 8 to both sides: $5x > 35$. Divide both sides by 5: $x > 7$. The inequality direction remains the same because we divided by a positive number.

7. Correct Answer: C (279)

Calculate $7^3 - 4^3$: First, $7^3 = 7 \times 7 \times 7 = 343$. Then, $4^3 = 4 \times 4 \times 4 = 64$. Finally, $343 - 64 = 279$. This tests exponent evaluation and subtraction.

8. Correct Answer: B (200)

If 45% of a number equals 90, set up the equation: $0.45 \times N = 90$. Divide both sides by 0.45: $N = 90/0.45 = 200$. Alternatively, recognize that $45\% = 9/20$, so if $9/20$ of $N = 90$, then $N = 90 \times (20/9) = 200$.

9. Correct Answer: A (24)

The mean (average) is calculated by summing all values and dividing by the count: $(12 + 18 + 24 + 30 + 36)/5 = 120/5 = 24$. This tests understanding of calculating the arithmetic mean.

10. Correct Answer: B (60 mph)

Average speed = distance \div time = 360 miles \div 6 hours = 60 miles per hour. This straightforward calculation tests understanding of the distance-rate-time relationship.

11. Correct Answer: D (3/8)

To subtract fractions with different denominators, find a common denominator. The LCD of 8 and 2 is 8: $1/2 = 4/8$. Then $7/8 - 4/8 = 3/8$. This tests fraction subtraction with unlike denominators.

12. Correct Answer: A (2)

The slope formula is $m = (y_2 - y_1)/(x_2 - x_1)$. With points (3, 7) and (9, 19): $m = (19 - 7)/(9 - 3) = 12/6 = 2$. A slope of 2 means the line rises 2 units vertically for every 1 unit horizontally.

13. Correct Answer: C (13)

The absolute value of -28 is 28, and the absolute value of 15 is 15. Therefore, $|-28| - |15| = 28 - 15 = 13$. Absolute value represents distance from zero, always positive or zero.

14. Correct Answer: D (20)

Solve $15/x = 45/60$ by first simplifying the right side: $45/60 = 3/4$. So $15/x = 3/4$. Cross-multiply: $15 \times 4 = 3 \times x$, giving $60 = 3x$, so $x = 20$. Verify: $15/20 = 3/4 \checkmark$.

15. Correct Answer: D (384 cm²)

The surface area of a cube is $SA = 6s^2$ where s is the edge length. With $s = 8$ cm: $SA = 6 \times 8^2 = 6 \times 64 = 384$ cm². A cube has 6 identical square faces, each with area s^2 .

16. Correct Answer: C (512 cm³)

The surface area of a cube is $SA = 6s^2$ where s is the edge length. With $s = 8$ cm: $SA = 6 \times 8^2 = 6 \times 64 = 384$ cm². However, if we're looking for the volume instead: $V = s^3 = 8^3 = 512$ cm³. Given the answer key shows C (512), this question likely asks for volume, not surface area.

17. Correct Answer: B ($\sqrt{3}/2$)

The cosine of 30° is a standard trigonometric value: $\cos 30^\circ = \sqrt{3}/2$. This can be derived from a 30-60-90 triangle with sides in ratio $1:\sqrt{3}:2$, where $\cos 30^\circ = \text{adjacent/hypotenuse} = \sqrt{3}/2$. This is a value worth memorizing.

18. Correct Answer: D (9 cm)

If a rectangle has area 144 cm² and length 16 cm, use $A = l \times w$: $144 = 16 \times w$. Divide by 16: $w = 144/16 = 9$ cm. Verify: $16 \times 9 = 144 \checkmark$.

19. Correct Answer: A (72)

The least common multiple (LCM) of 18 and 24 can be found using prime factorization: $18 = 2 \times 3^2$, $24 = 2^3 \times 3$. The LCM uses the highest power of each prime: $LCM = 2^3 \times 3^2 = 8 \times 9 = 72$.

20. Correct Answer: C (3/5)

With 6 green balls and 9 yellow balls, there are 15 total balls. The probability of drawing a yellow ball is (number of yellow)/(total) = $9/15 = 3/5$. This tests basic probability calculation.

21. Correct Answer: B (5)

The distance formula is $d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$. With points (2, 6) and (6, 9): $d = \sqrt{[(6-2)^2 + (9-6)^2]} = \sqrt{[4^2 + 3^2]} = \sqrt{[16 + 9]} = \sqrt{25} = 5$. This represents the 3-4-5 Pythagorean triple.

22. Correct Answer: D (36)

For direct variation, $y = kx$ where k is constant. When $y = 24$ and $x = 6$: $24 = k(6)$, so $k = 4$. When $x = 9$: $y = 4(9) = 36$. In direct variation, the ratio y/x remains constant.

23. Correct Answer: A (1/2)

The sine of 30° is a standard trigonometric value: $\sin 30^\circ = 1/2$. This can be derived from a 30-60-90 triangle with sides in ratio $1:\sqrt{3}:2$, where $\sin 30^\circ = \text{opposite/hypotenuse} = 1/2$. This is a value worth memorizing.

24. Correct Answer: C (52 cm)

If a square has area 169 cm^2 , then $s^2 = 169$, so $s = 13 \text{ cm}$ (side length). The perimeter is $P = 4s = 4 \times 13 = 52 \text{ cm}$. This tests connecting area and perimeter formulas for squares.

25. Correct Answer: C (23)

Evaluate $f(x) = 5x - 12$ at $x = 7$ by substitution: $f(7) = 5(7) - 12 = 35 - 12 = 23$. This tests function evaluation by substituting the given value into the function.

26. Correct Answer: A (23)

This is the same calculation as question 25. Evaluate $f(x) = 5x - 12$ at $x = 7$: $f(7) = 5(7) - 12 = 35 - 12 = 23$.

27. Correct Answer: B (8)

Solve $7x - 5 = 5x + 11$ by subtracting $5x$ from both sides: $2x - 5 = 11$. Add 5 to both sides: $2x = 16$. Divide by 2: $x = 8$. Verify: $7(8) - 5 = 56 - 5 = 51$, and $5(8) + 11 = 40 + 11 = 51 \checkmark$.

28. Correct Answer: C (401.92 cm³)

The volume of a cylinder is $V = \pi r^2 h$. With $r = 4 \text{ cm}$, $h = 8 \text{ cm}$, and $\pi \approx 3.14$: $V = 3.14 \times 4^2 \times 8 = 3.14 \times 16 \times 8 = 3.14 \times 128 = 401.92 \text{ cm}^3$. This tests applying the cylinder volume formula.

29. Correct Answer: B (16)

The greatest common factor (GCF) of 48 and 64 can be found using prime factorization: $48 = 2^4 \times 3$ and $64 = 2^6$. The GCF uses the lowest power of each common prime: $2^4 = 16$.

30. Correct Answer: D (65°)

In any triangle, the three angles sum to 180° . With angles 35° , 80° , and x° : $35 + 80 + x = 180$, so $115 + x = 180$, giving $x = 65^\circ$. This tests the fundamental triangle angle sum property.

31. Correct Answer: C (45)

Calculate $9^2 - 6^2$: First, $9^2 = 81$. Then, $6^2 = 36$. Finally, $81 - 36 = 45$. Alternatively, use the difference of squares formula: $a^2 - b^2 = (a+b)(a-b) = (9+6)(9-6) = 15 \times 3 = 45$.

32. Correct Answer: A (5/9)

To subtract fractions with the same denominator, simply subtract the numerators: $7/9 - 2/9 = (7-2)/9 = 5/9$. This tests basic fraction subtraction with like denominators.

33. Correct Answer: B (471 cm³)

The volume of a cylinder is $V = \pi r^2 h$. With $r = 5$ cm, $h = 6$ cm, and $\pi \approx 3.14$: $V = 3.14 \times 5^2 \times 6 = 3.14 \times 25 \times 6 = 3.14 \times 150 = 471$ cm³. This tests applying the cylinder volume formula.

34. Correct Answer: D (75)

To increase 60 by 25%, calculate 25% of 60 and add: $0.25 \times 60 = 15$, so $60 + 15 = 75$. Alternatively, 60 increased by 25% = $60 \times 1.25 = 75$.

35. Correct Answer: C (30°)

If $\sin \theta = 1/2$, then $\theta = 30^\circ$ (in the range $0^\circ < \theta < 90^\circ$). This occurs in a 30-60-90 triangle where $\sin 30^\circ = \text{opposite/hypotenuse} = 1/2$. This is a standard trigonometric value worth memorizing.

36. Correct Answer: A (15)

Solve $4(x - 3) = 2x + 18$ by first distributing: $4x - 12 = 2x + 18$. Subtract $2x$ from both sides: $2x - 12 = 18$. Add 12 to both sides: $2x = 30$. Divide by 2: $x = 15$. Verify: $4(15 - 3) = 4(12) = 48$, and $2(15) + 18 = 30 + 18 = 48$ ✓.

37. Correct Answer: D (23)

Range equals maximum minus minimum. In the dataset $\{22, 38, 27, 45, 30\}$, the maximum is 45 and minimum is 22. Range = $45 - 22 = 23$. This tests understanding of range as a measure of spread.

38. Correct Answer: D (± 15)

If $x^2 = 225$, then $x = \pm\sqrt{225} = \pm 15$. Both positive and negative 15 are solutions because $(15)^2 = 225$ and $(-15)^2 = 225$. Always consider both positive and negative square roots when solving $x^2 = \text{constant}$.

39. Correct Answer: C (1)

The tangent of 45° is a standard trigonometric value: $\tan 45^\circ = 1$. This occurs in a 45-45-90 triangle where opposite and adjacent sides are equal, so their ratio equals 1. This is a value worth memorizing.

40. Correct Answer: B ($4x^2y^2$)

Simplify $(24x^7y^6)/(6x^5y^4)$ by dividing coefficients and subtracting exponents for like bases. For the coefficient: $24/6 = 4$. For x: $x^7/x^5 = x^{(7-5)} = x^2$. For y: $y^6/y^4 = y^{(6-4)} = y^2$. The result is $4x^2y^2$.