OJEE MTech Biotechnology Sample Paper 03

A) Mode and Time: The exam is a Computer Based Test (CBT) lasting 120 minutes.
B) Total Questions: The exam contains 90 questions.
C) Marking Scheme & Rules:

- +4 marks for each correct answer; -1 mark for each incorrect answer.

Q1. The hydrophobic effect, which drives the folding of globular proteins, is thermodynamically characterized primarily by:

A. A large negative change in enthalpy ($\Delta H < 0$)

B. A large positive change in the entropy of water ($\Delta S_{water} > 0$)

C. A large positive change in the entropy of the protein ($\Delta S_{protein} > 0$)

D. The formation of highly stable covalent bonds

Q2. In the catalytic triad (Asp-His-Ser) of serine proteases like chymotrypsin, what is the specific role of the Aspartate residue?

A. It directly acts as the nucleophile to attack the peptide bond

B. It forms a low-barrier hydrogen bond with Histidine, stabilizing the positively charged histidine transition state

C. It forms the oxyanion hole to stabilize the tetrahedral intermediate

D. It binds tightly to the hydrophobic pocket of the substrate

Q3. An enzyme exhibits a Hill coefficient (n_H) of 0.6. This indicates which of the following regarding its binding kinetics?

A. Strong positive cooperativity

B. Independent, non-cooperative binding sites

C. Negative cooperativity

D. Irreversible covalent inhibition

Q4. When analyzing DNA topology, the intercalating agent ethidium bromide reduces the twist (T_w) of closed circular DNA. If the linking number (L_k) remains strictly constant, how does the writhe (W_r) change?

A. Writhe decreases proportionally

B. Writhe increases proportionally

C. Writhe remains unchanged

D. Writhe becomes completely relaxed to zero

Q5. Competitive inhibitors alter enzyme kinetics by increasing the apparent K_m without changing V_{max}. Which of the following best defines the inhibition constant (K_i) for a competitive inhibitor?

A. The concentration of inhibitor that halves the V_{max}

B. The dissociation constant of the enzyme-inhibitor complex

C. The concentration of substrate that outcompetes the inhibitor

D. The turnover number of the inhibited enzyme

Q6. Which specific amino acid is most likely to be found occupying the highly restricted conformational space inside the sharp β-turns of protein structures?

A. Tryptophan

B. Leucine

C. Glycine

D. Glutamate

Q7. A linear double-stranded DNA fragment is subjected to thermal denaturation. Which of the following modifications would shift its melting temperature (T_m) to a higher value?

A. Decreasing the ionic strength of the buffer

B. Increasing the A-T base pair content

C. Increasing the concentration of formamide

D. Increasing the concentration of Mg^{2+} ions

Q8. In an enzyme-catalyzed bisubstrate reaction following an ordered sequential mechanism, the Lineweaver-Burk plots of $1/v$ versus $1/[A]$ at different fixed concentrations of B will yield:

A. A set of parallel lines

B. A set of lines intersecting on the y-axis

C. A set of lines intersecting in the second or third quadrant

D. A single straight line

Q9. Suicide inhibition (mechanism-based inactivation) is distinct from competitive inhibition because the suicide inhibitor:

A. Binds to an allosteric site rather than the active site

B. Is unreactive until the enzyme chemically modifies it into a highly reactive intermediate

C. Is a transition-state analog that binds non-covalently

D. Causes denaturation of the protein tertiary structure

Q10. Glycosaminoglycans (GAGs) are essential structural components of the extracellular matrix. Which of the following GAGs is uniquely non-sulfated and not covalently attached to a core protein?

A. Chondroitin sulfate

B. Heparan sulfate

C. Hyaluronic acid

D. Keratan sulfate

Q11. During the operation of the Malate-Aspartate shuttle, which inner mitochondrial membrane transporter is strictly dependent on the proton motive force for its operation?

A. Malate-α-ketoglutarate antiporter

B. Glutamate-aspartate antiporter

C. Pyruvate-H^+ symporter

D. ATP-ADP translocase

Q12. The Warburg effect observed in many cancer cells refers to their metabolic shift toward:

A. Strict oxidative phosphorylation even in low oxygen

B. High rates of aerobic glycolysis yielding lactate despite the presence of oxygen

C. Complete reliance on β-oxidation of fatty acids

D. Downregulation of the pentose phosphate pathway

Q13. In the G-protein coupled receptor (GPCR) signaling cascade, the spontaneous intrinsic GTPase activity of the $G\alpha$ subunit acts to:

A. Amplify the signal by activating adenylate cyclase

B. Terminate the signal by converting GTP to GDP

C. Recruit β-arrestin to the receptor

D. Open voltage-gated calcium channels

Q14. Which of the following uncouplers acts as a mobile ionophore, carrying potassium ions (K^+) across the inner mitochondrial membrane and dissipating the electrical component ($\Delta\psi$) of the proton motive force?

A. 2,4-Dinitrophenol (DNP)

B. Valinomycin

C. Oligomycin

D. Rotenone

Q15. The restriction point (R-point) in the mammalian cell cycle is a critical G1 checkpoint. Progression past this point is primarily driven by the hyperphosphorylation of:

A. Cyclin B

B. p53

C. Retinoblastoma (Rb) protein

D. Cdc25 phosphatase

Q16. The secondary messenger cyclic GMP (cGMP) mediates smooth muscle relaxation (such as via Nitric Oxide signaling) primarily by activating:

A. Protein Kinase A (PKA)

B. Protein Kinase C (PKC)

C. Protein Kinase G (PKG)

D. Phospholipase C (PLC)

Q17. In gluconeogenesis, the transport of oxaloacetate from the mitochondrion to the cytosol is facilitated by its temporary conversion into:

A. Pyruvate

B. Malate

C. Citrate

D. Phosphoenolpyruvate

Q18. The F_1F_o ATP synthase complex features a rotating c-ring in its F_o sector. If an organism's ATP synthase has a c-ring composed of exactly 12 subunits, what is the theoretical H^+/ATP ratio for synthesis?

A. 3

B. 4

C. 4.5

D. 12

Q19. During the signaling of Receptor Tyrosine Kinases (RTKs), the Ras protein is activated when:

A. It undergoes dimerization

B. A Guanine nucleotide Exchange Factor (GEF) swaps its GDP for GTP

C. It is directly phosphorylated by the RTK

D. It binds to cyclic AMP

Q20. Which of the following enzymes in the TCA cycle catalyzes a substrate-level phosphorylation event, generating GTP (or ATP) directly?

A. Isocitrate dehydrogenase

B. α-Ketoglutarate dehydrogenase

C. Succinyl-CoA synthetase

D. Succinate dehydrogenase

Q21. The nuclear pore complex regulates nucleocytoplasmic transport. Directionality is maintained by the Ran-GTPase cycle, where the highest concentration of Ran-GTP is maintained in the:

A. Cytosol

B. Nucleoplasm

C. Endoplasmic reticulum lumen

D. Perinuclear space

Q22. The Na^+/Ca^{2+} exchanger (NCX) in cardiac muscle cells is a critical antiport system. How does it operate to extrude calcium from the cell?

A. It uses ATP to pump 3 Na^+ out and 1 Ca^{2+} in

B. It allows 3 Na^+ to enter down their gradient to pump 1 Ca^{2+} out against its gradient

C. It allows 1 Ca^{2+} to enter to pump 3 Na^+ out

D. It cotransports 1 Na^+ and 1 Ca^{2+} outward

Q23. During intense skeletal muscle activity, the Cori cycle prevents lactic acidosis by transporting lactate to the liver, where it is primarily converted back into:

A. Alanine

B. Glycogen

C. Glucose

D. Fatty acids

Q24. Which of the following statements about the Entner-Doudoroff (ED) pathway is correct?

A. It yields more net ATP per glucose than standard glycolysis

B. It is strictly an anaerobic pathway

C. It generates unique intermediates like 2-keto-3-deoxy-6-phosphogluconate (KDPG)

D. It bypasses the formation of pyruvate entirely

Q25. Phospholipase C (PLC) cleaves phosphatidylinositol 4,5-bisphosphate (PIP_2) to produce two critical second messengers:

A. cAMP and cGMP

B. DAG and IP_3

C. Calcium and Calmodulin

D. Arachidonic acid and prostaglandins

Q26. Gram-negative bacteria possess an outer membrane containing Lipopolysaccharide (LPS). The highly toxic component of LPS responsible for endotoxin shock is:

A. O-antigen

B. Core oligosaccharide

C. Lipid A

D. Teichoic acid

Q27. In a batch microbial culture, the phase characterized by a specific growth rate (μ) equal to zero due to nutrient depletion or toxic waste accumulation is the:

A. Lag phase

B. Logarithmic (exponential) phase

C. Stationary phase

D. Death phase

Q28. In the context of the Monod growth kinetics equation, the saturation constant (K_s) is numerically equal to the substrate concentration at which:

A. The specific growth rate is zero

B. The specific growth rate is at its maximum (μ_{max})

C. The specific growth rate is exactly half of μ_{max}

D. The cell biomass concentration doubles

Q29. The nitrogenase enzyme complex is responsible for fixing atmospheric N_2. Which trace metals are essential cofactors found in the active site of the conventional MoFe protein?

A. Iron and Copper

B. Molybdenum and Iron

C. Zinc and Magnesium

D. Cobalt and Nickel

Q30. Which specialized organelle in protozoans like *Paramecium* is responsible for osmoregulation by pumping excess water out of the cell?

A. Food vacuole

B. Contractile vacuole

C. Lysosome

D. Hydrogenosome

Q31. Diauxic growth of *E. coli* in a medium containing both glucose and lactose results in a biphasic growth curve. The lag phase between the two exponential phases is primarily caused by:

A. The toxicity of lactose

B. The time required for the synthesis of the *lac* operon enzymes after catabolite repression is lifted

C. The depletion of oxygen in the medium

D. The feedback inhibition of glucose on β-galactosidase

Q32. The glyoxylate shunt allows plants and certain bacteria to bypass the CO_2-evolving steps of the TCA cycle. Which two unique enzymes are strictly required for this bypass?

A. Isocitrate lyase and malate synthase

B. Isocitrate dehydrogenase and α-ketoglutarate dehydrogenase

C. Citrate synthase and aconitase

D. Fumarase and malic enzyme

Q33. Motor proteins utilize ATP to move along cytoskeletal tracks. Which of the following correctly pairs the motor protein with its track and standard directionality?

A. Kinesin moves towards the minus-end of microtubules

B. Dynein moves towards the plus-end of actin filaments

C. Myosin moves towards the plus-end of actin filaments

D. Kinesin moves towards the plus-end of intermediate filaments

Q34. Bacterial quorum sensing often relies on the secretion and detection of autoinducers. The most common class of autoinducers utilized by Gram-negative bacteria is:

A. Oligopeptides

B. Acyl-homoserine lactones (AHLs)

C. Autoinducer-2 (AI-2) furanones

D. Cyclic di-GMP

Q35. In the C4 photosynthetic pathway, the initial fixation of carbon dioxide occurs in the mesophyll cells to form a four-carbon acid. The enzyme catalyzing this initial fixation is:

A. RuBisCO

B. PEP carboxylase

C. Malic enzyme

D. Pyruvate phosphate dikinase

Q36. Transposable elements can cause mutations when they insert into functional genes. Replicative transposons differ from conservative transposons because replicative transposons:

A. Move via an RNA intermediate

B. Always leave a copy of themselves at the original donor site

C. Require reverse transcriptase

D. Do not require the enzyme transposase

Q37. The CRISPR-Cas9 system utilizes a guide RNA (gRNA) to target specific DNA sequences. For successful cleavage, the target DNA must contain a Protospacer Adjacent Motif (PAM). In the native *Streptococcus pyogenes* system, the PAM sequence is:

A. 5'-TATA-3'

B. 5'-NGG-3'

C. 5'-GATC-3'

D. 5'-CCG-3'

Q38. Eukaryotic pre-mRNA splicing is catalyzed by the spliceosome, a massive complex of proteins and small nuclear RNAs (snRNAs). Which snRNP is responsible for binding the 5' splice site at the beginning of the process?

A. U1

B. U2

C. U4

D. U6

Q39. In *E. coli*, the mismatch repair (MMR) system relies on DNA methylation to distinguish the old template strand from the new daughter strand. Which sequence is recognized and methylated by Dam methylase?

A. 5'-CG-3'

B. 5'-GATC-3'

C. 5'-TATA-3'

D. 5'-CCGG-3'

Q40. Riboswitches are cis-acting regulatory RNA elements that control gene expression. They primarily function by:

A. Binding to specific small molecule metabolites to alter their own secondary structure

B. Acting as short interfering RNAs (siRNAs) to degrade mRNA

C. Recruiting DNA methyltransferases to the promoter

D. Serving as alternate start codons for translation

Q41. A specialized form of transduction is mediated by temperate bacteriophages that integrate into specific sites in the bacterial chromosome. The classic example is bacteriophage lambda (λ), which strictly integrates between the *gal* and *bio* operons. This integration requires the phage enzyme:

A. Transposase

B. Integrase

C. Excisionase

D. Lysozyme

Q42. In the context of population genetics, the Hardy-Weinberg equilibrium principle states that allele frequencies remain constant under certain conditions. Which of the following is NOT one of those strict conditions?

A. No mutations

B. Random mating

C. Small population size

D. No gene flow (migration)

Q43. Epistasis occurs when the expression of one gene masks or modifies the expression of another. A dihybrid cross resulting in a 9:7 phenotypic ratio indicates:

A. Dominant epistasis

B. Recessive epistasis

C. Duplicate dominant epistasis

D. Duplicate recessive epistasis

Q44. In eukaryotic chromatin remodeling, the SWI/SNF complex activates transcription primarily by:

A. Methylating histone H3 at Lysine 9

B. Utilizing ATP to slide or eject nucleosomes, exposing promoter regions

C. Acetylating the N-terminal tails of core histones

D. Dephosphorylating RNA Polymerase II

Q45. Next-Generation Sequencing (NGS) by synthesis (e.g., Illumina technology) relies heavily on the use of modified nucleotides called:

A. Dideoxynucleotides (ddNTPs)

B. Reversible terminator nucleotides with fluorescent tags

C. Ribonucleotides with 5' caps

D. Biotinylated oligonucleotides

Q46. If a geneticist calculates a LOD (logarithm of the odds) score of 3.0 for the linkage between two loci, this statistically signifies that:

A. The odds are 3 to 1 that the genes are linked

B. The genes are separated by 3 centiMorgans (cM)

C. The odds are 1000 to 1 in favor of linkage over independent assortment

D. The genes exhibit 3% recombination frequency

Q47. During eukaryotic translation initiation, the eIF4F complex binds to the mRNA. A key component of this complex, eIF4E, specifically recognizes and binds to:

A. The Shine-Dalgarno sequence

B. The 3' Poly-A tail

C. The 5' 7-methylguanosine cap

D. The AUG start codon

Q48. Plasmids engineered as cloning vectors often contain a multiple cloning site (MCS) embedded within the *lacZ'* α-complementation gene. This setup allows for recombinant selection via:

A. Antibiotic resistance profiling

B. Blue-white screening on X-gal plates

C. Auxotrophic complementation

D. Plaque hybridization

Q49. A nonsense mutation in a gene changes an amino acid-coding codon into a stop codon. This defect can sometimes be masked by a second mutation in a completely different gene, known as a:

A. Missense suppressor mutation

B. Nonsense suppressor tRNA mutation

C. Frameshift suppressor mutation

D. Promoter up-mutation

Q50. Viral vectors are extensively used in gene therapy. Which viral vector system is highly preferred for long-term, stable transgene expression in dividing cells because it actively integrates its payload into the host genome?

A. Adeno-associated virus (AAV)

B. Adenovirus

C. Lentivirus

D. Herpes simplex virus

Q51. In the immune system, the processing of endogenous cytosolic antigens (like viral proteins) for presentation on MHC Class I molecules requires the transport of peptides into the endoplasmic reticulum via:

A. The TAP (Transporter associated with Antigen Processing) complex

B. The invariant chain (Ii)

C. The CLIP peptide

D. Phagolysosomes

Q52. The alternative pathway of the complement cascade is unique because it can be spontaneously activated on microbial surfaces without the need for:

A. C3 convertase

B. Factor B

C. Antibodies

D. Properdin

Q53. Which specialized enzyme is responsible for adding random non-templated nucleotides (N-nucleotides) to the junctions of V, D, and J segments during the recombination of B cell and T cell receptors, vastly increasing junctional diversity?

A. RAG-1/RAG-2 recombinase

B. Terminal deoxynucleotidyl transferase (TdT)

C. DNA ligase IV

D. Activation-induced cytidine deaminase (AID)

Q54. During the scale-up of a bioreactor, keeping the power input per unit volume (P/V) constant often leads to a significant increase in which of the following parameters in the larger vessel?

A. Impeller rotational speed (N)

B. Maximum shear stress at the impeller tip

C. Volumetric oxygen mass transfer coefficient (k_La)

D. Liquid mixing time

Q55. In a fed-batch bioprocess designed to produce a secondary metabolite (like an antibiotic), the feed rate is typically controlled to maintain the specific growth rate (μ) slightly below μ_{max} in order to:

A. Prevent plasmid instability

B. Avoid catabolite repression and overflow metabolism

C. Maximize the rate of biomass production

D. Decrease the heat generation rate

Q56. Resolution (R_s) is a critical parameter in chromatography, quantifying the separation between two adjacent peaks. A resolution value of $R_s = 1.5$ is generally considered to represent:

A. Baseline separation (approx. 99.7% separation)

B. Overlapping peaks

C. A failed separation

D. Theoretical plate equivalence

Q57. The use of continuous sterilization for fermentation media offers advantages over batch sterilization. A primary thermodynamic advantage is that high-temperature, short-time (HTST) processes:

A. Require significantly less steam overall

B. Result in less thermal degradation of heat-sensitive nutrients and vitamins

C. Are easier to monitor for contamination

D. Do not require heat exchangers

Q58. Monoclonal antibodies are highly specific immunological tools. In the standard production of humanized monoclonal antibodies, the engineered construct consists of:

A. Mouse variable regions grafted onto human constant regions

B. Human hypervariable (CDR) loops grafted onto a mouse antibody framework

C. Mouse hypervariable (CDR) loops grafted onto a human antibody framework

D. Entirely human sequences isolated from transgenic mice

Q59. Which downstream processing technique separates particles based strictly on their density differences by subjecting the mixture to a high centrifugal field in a gradient medium (like sucrose or cesium chloride)?

A. Differential centrifugation

B. Isopycnic (density-gradient) centrifugation

C. Rate-zonal centrifugation

D. Ultrafiltration

Q60. In a stirred tank bioreactor fitted with a Rushton turbine, the flow pattern generated is predominantly:

A. Axial flow

B. Radial flow

C. Laminar plug flow

D. Tangential flow

Q61. For a real symmetric $n \times n$ matrix A, which of the following statements regarding its eigenvalues and eigenvectors is ALWAYS true?

A. All eigenvalues are purely imaginary

B. The matrix is defective and cannot be diagonalized

C. Eigenvectors corresponding to distinct eigenvalues are mutually orthogonal

D. The determinant is always zero

Q62. Let $T : R^3 \to R^2$ be a linear transformation represented by a 2×3 matrix A. According to the Rank-Nullity Theorem, if the rank of A is 2, what is the dimension of the null space (nullity) of A?

A. 0

B. 1

C. 2

D. 3

Q63. A matrix A is considered positive definite if, for any non-zero column vector x, the quadratic form $x^T Ax$ is strictly greater than zero. What is a necessary and sufficient condition for a symmetric matrix to be positive definite?

A. All its eigenvalues are positive

B. Its trace is positive

C. Its determinant is equal to 1

D. It is an orthogonal matrix

Q64. In multiple calculus, the Jacobian determinant is required when changing variables in a double integral. For the transformation from Cartesian (x, y) to polar (r, θ) coordinates $(x = r\cos\theta, y = r\sin\theta)$, the absolute value of the Jacobian determinant is:

A. 1

B. r

C. r^2

D. $\sin\theta$

Q65. Stokes' Theorem equates the surface integral of the curl of a vector field over a surface S to the line integral of the vector field along the closed boundary curve C of that surface. Mathematically, $\iint_S (\nabla \times \mathbf{F}) \cdot d\mathbf{S}$ equals:

A. $\iiint_V (\nabla \cdot \mathbf{F}) dV$

B. $\oint_C \mathbf{F} \cdot d\mathbf{r}$

C. $\iint_S \mathbf{F} \cdot \mathbf{n} dS$

D. $\oint_C (\nabla f) \cdot d\mathbf{r}$

Q66. Evaluate the definite integral using integration by parts: $\int_0^{\ln 2} xe^x dx$

A. $2\ln 2 - 1$

B. $2\ln 2 - 2$

C. $\ln 2 + 1$

D. $e^2 - 1$

Q67. The Maclaurin series expansion for the function $f(x) = \ln(1 + x)$ for $-1 < x \leq 1$ is given by:

A. $\sum_{n=1}^{\infty} (-1)^{n+1} \frac{x^n}{n}$

B. $\sum_{n=0}^{\infty} \frac{x^n}{n!}$

C. $\sum_{n=1}^{\infty} \frac{x^n}{n}$

D. $\sum_{n=0}^{\infty} (-1)^n x^n$

Q68. Find the Laplace transform of the Heaviside unit step function, defined as $H(t - a) = 0$ for $t < a$ and $H(t - a) = 1$ for $t \geq a$ (where $a > 0$ and $s > 0$).

A. e^{-as}/s

B. e^{as}/s

C. $1/(s - a)$

D. $a/(s^2 + a^2)$

Q69. Consider the system of two first-order linear ordinary differential equations: $dx/dt = 3x - y$ and $dy/dt = x + y$. The trace and determinant of the coefficient matrix classify the critical point at the origin $(0, 0)$ as a:

A. Saddle point

B. Stable node

C. Unstable spiral (or node)

D. Center

Q70. For a first-order exact differential equation $M(x, y)dx + N(x, y)dy = 0$, what condition must hold identically?

A. $\partial M/\partial x = \partial N/\partial y$

B. $\partial M/\partial y = \partial N/\partial x$

C. $M(x, y) = N(x, y)$

D. $\partial^2 M/\partial x^2 = \partial^2 N/\partial y^2$

Q71. In numerical analysis, the Gauss-Seidel method is an iterative technique for solving a square system of linear equations $Ax = b$. The method is strictly guaranteed to converge for any initial guess if the matrix A is:

A. Singular

B. Symmetric

C. Orthogonal

D. Strictly diagonally dominant

Q72. The fourth-order Runge-Kutta (RK4) method is a standard technique for solving ODEs. In a single time step h, how many evaluations of the derivative function $f(t, y)$ are required?

A. 1

B. 2

C. 3

D. 4

Q73. When using the Trapezoidal Rule to approximate the integral $\int_a^b f(x)dx$, if the function $f(x)$ is strictly concave down (i.e., $f''(x) < 0$) on the interval $[a, b]$, the approximation will:

A. Overestimate the true integral

B. Underestimate the true integral

C. Be exactly equal to the true integral

D. Oscillate wildly

Q74. A rare genetic disorder occurs in 1 in 10,000 people. A diagnostic test is 99% sensitive and 99% specific. If a randomly selected person tests positive, what is the approximate probability (Positive Predictive Value) that they actually have the disorder?

A. 99.0%

B. 50.0%

C. 1.0%

D. 0.01%

Q75. If a continuous random variable X follows an exponential distribution with rate parameter $\lambda > 0$, the probability density function is $f(x) = \lambda e^{-\lambda x}$ for $x \geq 0$. What is the variance of X?

A. $1/\lambda$

B. $1/\lambda^2$

C. λ^2

D. $\sqrt{\lambda}$

Q76. In statistics, the p-value represents:

A. The probability that the null hypothesis is true

B. The probability of making a Type I error

C. The probability of observing the data, or something more extreme, assuming the null hypothesis is true

D. The probability that the alternative hypothesis is false

Q77. A discrete random variable follows a Binomial distribution $B(n, p)$. If the number of trials $n = 100$ and the probability of success $p = 0.2$, what is the standard deviation?

A. 20

B. 16

C. 4

D. 0.16

Q78. If X and Y are two independent random variables, the variance of their difference, $Var(X - Y)$, is given by:

A. $Var(X) - Var(Y)$

B. $Var(X) + Var(Y)$

C. $Var(X) - Var(Y) - 2Cov(X, Y)$

D. $Var(X)/Var(Y)$

Q79. The eigenvalues of the matrix $A = \begin{bmatrix} 4 & 1 \\ 0 & 3 \end{bmatrix}$ are:

A. 4 and 3

B. 1 and 0

C. 7 and 12

D. 2 and 1

Q80. Calculate the directional derivative of $f(x, y, z) = x^2 + y^2 + z^2$ at the point $(1, 1, 1)$ in the direction of the vector $\mathbf{v} = \langle 1, 0, 0 \rangle$.

A. 0

B. 1

C. 2

D. 3

Q81. **Analogy:** "Transcription factor" is to "Promoter" as "Signal recognition particle (SRP)" is to:

A. Ribosome

B. Endoplasmic reticulum signal sequence

C. Nuclear localization signal

D. Spliceosome

Q82. **Classification:** Find the odd one out based on their primary biological function.

A. Helicase

B. Topoisomerase

C. Primase

D. Proteasome

Q83. **Coding:** If the word "ENZYME" is coded as "FOAZNF", how will "VECTOR" be coded using the same logical shift?

A. WFDUPT

B. WFDVQS

C. UDBUNQ

D. WEDUPS

Q84. **Series:** Find the missing term in the sequence: 2, 6, 12, 20, 30, ?

A. 40

B. 42

C. 44

D. 48

Q85. **Syllogism:** Statements: All plasmids are DNA. Only a few DNA molecules are circular.
Conclusions: I. All plasmids are circular. II. Some plasmids are not circular.

A. Only I follows

B. Only II follows

C. Both I and II follow

D. Neither I nor II follows

Q86. **Venn Diagram:** Which relationship is best depicted by a large circle completely containing a medium circle, which completely contains a small circle?

A. Animals, Mammals, Bacteria

B. Eukaryotes, Fungi, Yeast

C. Proteins, Nucleic Acids, DNA

D. Organs, Tissues, Carbohydrates

Q87. **Blood Relation:** A man points to a woman and says, "Her mother is the only daughter of my mother-in-law." How is the man related to the woman?

A. Father

B. Brother

C. Uncle

D. Grandfather

Q88. **Seating:** A, B, C, D, E, and F are sitting in a straight line facing North. C is sitting immediately between A and E. D is not at the end. B is sitting to the immediate right of E. F is at the far right end. Who is sitting at the far left end?

A. A

B. C

C. D

D. E

Q89. **Data Interpretation:** A bacterial growth curve shows an exponential phase where the cell number increases from 10^4 to 10^8 in exactly 4 hours. What is the approximate generation (doubling) time?

A. 18 minutes

B. 30 minutes

C. 45 minutes

D. 60 minutes

Q90. **Logical Deduction:** You have three unlabelled microtubes containing enzyme, substrate, and buffer. Tube 1 does not contain buffer. Tube 2 does not contain enzyme. Tube 3 contains substrate. If all statements are true, which tube contains the enzyme?

A. Tube 1

B. Tube 2

C. Tube 3

D. Cannot be determined

Solutions

1. Answer: B
Explanation: When hydrophobic residues pack into the core of a protein, the ordered clathrate (cage-like) water structures surrounding them break down. This results in a massive, thermodynamically favorable increase in the entropy of the bulk water ($\Delta S_{water} > 0$).

2. Answer: B
Explanation: The Aspartate residue is buried and negatively charged. It forms an unusually short and strong low-barrier hydrogen bond with Histidine, stabilizing the Histidine's positive charge when it extracts a proton from Serine to make Serine a potent nucleophile.

3. Answer: C
Explanation: The Hill coefficient (n_H) measures cooperativity. A value of $n_H = 1$ means no cooperativity. A value of $n_H > 1$ implies positive cooperativity. A value of $n_H < 1$ (like 0.6) indicates negative cooperativity, where binding decreases affinity for subsequent ligands.

4. Answer: B
Explanation: According to $L_k = T_w + W_r$, if the linking number is constant (the DNA backbone is unbroken), any forced decrease in the twist (T_w) by an intercalator must be mathematically compensated by an equal increase in writhe (W_r) to maintain the equation.

5. Answer: B
Explanation: The inhibition constant (K_i) represents the equilibrium dissociation constant of the enzyme-inhibitor complex ($EI \rightleftharpoons E + I$). A lower K_i indicates a higher binding affinity of the inhibitor for the enzyme's active site.

6. Answer: C
Explanation: Beta-turns involve tight reversals in the polypeptide chain. Glycine is the smallest amino acid (having only a hydrogen atom as a side chain), giving it unmatched conformational flexibility, allowing it to easily adopt the extreme dihedral angles required in these tight turns.

7. Answer: D
Explanation: Increasing the concentration of divalent cations like Mg^{2+} highly stabilizes the DNA double helix. The positively charged magnesium ions effectively shield the electrostatic repulsion between the negatively charged phosphate backbones, thus raising the melting temperature (T_m).

8. Answer: C
Explanation: In sequential bisubstrate mechanisms (both ordered and random), the binding of the first substrate affects the binding affinity of the second. This mutual dependence creates an intersecting pattern in Lineweaver-Burk plots, typically in the second or third quadrant.

9. Answer: B
Explanation: A suicide inhibitor binds to the active site as a normal substrate. However, the normal catalytic mechanism of the enzyme chemically converts the inhibitor into a highly reactive intermediate that covalently, and irreversibly, bonds

to the active site, destroying it.

10. Answer: C
Explanation: Hyaluronic acid (hyaluronan) is the only glycosaminoglycan that is totally non-sulfated. Furthermore, unlike other GAGs (which form proteoglycans), it is synthesized directly at the plasma membrane and is not covalently linked to any core protein.

11. Answer: B
Explanation: The glutamate-aspartate antiporter exchanges mitochondrial aspartate for cytosolic glutamate accompanied by a proton (H^+). The inward movement of the proton makes this specific antiport driven entirely by the electrical and pH gradients of the proton motive force.

12. Answer: B
Explanation: The Warburg effect describes how cancer cells, even under fully normoxic (oxygen-rich) conditions, aggressively upregulate glycolysis and convert most pyruvate into lactate, rather than shuttling it into the mitochondria for oxidative phosphorylation.

13. Answer: B
Explanation: The activated $G\alpha$-GTP subunit acts as a molecular timer. Its intrinsic GTPase activity eventually hydrolyzes the bound GTP back to GDP. This causes the $G\alpha$ subunit to detach from its effector and reassociate with the $G\beta\gamma$ dimer, terminating the signal.

14. Answer: B
Explanation: Valinomycin is a classic lipophilic ionophore. It selectively wraps around K^+ ions and physically ferries them across the inner mitochondrial membrane, collapsing the electrical potential ($\Delta\psi$) of the proton motive force without necessarily affecting the pH gradient.

15. Answer: C
Explanation: At the G1 restriction point, G1-CDK complexes progressively hyperphosphorylate the Retinoblastoma (Rb) protein. This causes Rb to release the E2F transcription factor, which then drives the expression of genes required to commit to S-phase (DNA replication).

16. Answer: C
Explanation: Nitric Oxide (NO) diffuses into smooth muscle cells and activates soluble guanylate cyclase, producing cGMP. cGMP then acts as the specific secondary messenger to allosterically activate Protein Kinase G (PKG), triggering downstream relaxation pathways.

17. Answer: B
Explanation: Oxaloacetate is produced in the mitochondrion but must reach the cytosol for gluconeogenesis. Because the inner membrane lacks an oxaloacetate transporter, it is reduced to malate, exported via the malate transporter, and re-oxidized to oxaloacetate in the cytosol.

18. Answer: B
Explanation: One full 360° rotation of the c-ring always produces exactly 3 ATP molecules via the F_1 head. If the ring has 12 c-subunits, 12 protons must pass

through to cause one full rotation. Therefore, 12 H^+/3 ATP = exactly 4 H^+ required per ATP synthesized.

19. Answer: B
Explanation: Ras is a small monomeric G-protein. It is activated when a recruited Guanine nucleotide Exchange Factor (GEF), such as SOS, binds to it and induces a conformational change that forces Ras to release GDP and bind the abundant intracellular GTP.

20. Answer: C
Explanation: Succinyl-CoA synthetase (also called succinate thiokinase) cleaves the high-energy thioester bond of succinyl-CoA. The significant energy released is coupled directly to the substrate-level phosphorylation of GDP to GTP (or ADP to ATP, depending on the isozyme).

21. Answer: B
Explanation: Ran-GEF (which swaps GDP for GTP on Ran) is strictly tethered to the chromatin inside the nucleus, creating a high concentration of Ran-GTP in the nucleoplasm. Conversely, Ran-GAP is in the cytosol, ensuring Ran-GDP dominates there, driving directional transport.

22. Answer: B
Explanation: The NCX is a secondary active antiporter. It utilizes the massive inward sodium electrochemical gradient (maintained by the Na^+/K^+ pump) to forcefully drive one calcium ion out of the cell against its gradient for every three sodium ions allowed in.

23. Answer: C
Explanation: The Cori cycle is a metabolic cooperation. Skeletal muscles ferment glucose to lactate during intense exercise. This lactate enters the blood and goes to the liver, where the liver expends ATP to run gluconeogenesis, converting the lactate back into glucose.

24. Answer: C
Explanation: The ED pathway is an alternative to glycolysis used by many soil bacteria. It yields only 1 net ATP per glucose (worse than glycolysis). Its distinguishing biochemical feature is the formation and cleavage of the unique 6-carbon intermediate KDPG.

25. Answer: B
Explanation: Activated PLC cleaves the membrane phospholipid PIP_2 into two separate second messengers: Diacylglycerol (DAG), which stays in the membrane to activate PKC, and Inositol 1,4,5-trisphosphate (IP_3), which diffuses to the ER to release calcium.

26. Answer: C
Explanation: Lipopolysaccharide (LPS) consists of the O-antigen, core polysaccharide, and Lipid A. Lipid A is the highly conserved hydrophobic anchor embedded in the membrane. It is explicitly recognized by TLR4 receptors and is the toxic moiety that triggers endotoxic shock.

27. Answer: C
Explanation: In the stationary phase, the environment can no longer support

exponential growth due to exhausted nutrients or accumulated toxic metabolites. The rate of cell division equates to the rate of cell death, rendering the net specific growth rate (μ) essentially zero.

28. Answer: C
Explanation: The Monod equation is $\mu = (\mu_{max} \cdot S)/(K_s + S)$. When the substrate concentration S is exactly equal to the saturation constant K_s, the equation simplifies to $\mu = (\mu_{max} \cdot K_s)/(2K_s)$, which equals $\mu_{max}/2$.

29. Answer: B
Explanation: The standard nitrogenase enzyme complex consists of two parts: the Fe protein (dinitrogenase reductase) and the MoFe protein (dinitrogenase). The active site where N_2 binds and is reduced contains a complex iron-molybdenum cofactor (FeMoco).

30. Answer: B
Explanation: Freshwater protozoans are hypertonic to their environment, causing water to constantly enter the cell via osmosis. The contractile vacuole acts as a biological bilge pump, accumulating this excess water and actively expelling it to prevent the cell from bursting.

31. Answer: B
Explanation: As long as glucose is present, catabolite repression keeps the *lac* operon shut down via low cAMP levels. When glucose depletes, cAMP rises, activating CAP. The lag phase represents the time required for the cell to transcribe and translate the new lactose-digesting enzymes.

32. Answer: A
Explanation: The glyoxylate shunt bypasses the two decarboxylation steps of the TCA cycle to conserve carbon for gluconeogenesis. It utilizes two specific enzymes not found in the TCA cycle: isocitrate lyase (cleaving isocitrate into succinate and glyoxylate) and malate synthase.

33. Answer: C
Explanation: Kinesin generally moves towards the plus-end of microtubules (anterograde), dynein moves towards the minus-end of microtubules (retrograde), and most classes of myosin are motor proteins that travel towards the plus-end (barbed end) of actin microfilaments.

34. Answer: B
Explanation: Gram-negative bacteria typically use Acyl-homoserine lactones (AHLs) for intraspecies quorum sensing. These small, hydrophobic molecules easily diffuse across membranes. Gram-positive bacteria typically use modified oligopeptides, and AI-2 is for interspecies communication.

35. Answer: B
Explanation: In C4 plants, atmospheric CO_2 is first converted to bicarbonate and fixed to Phosphoenolpyruvate (PEP) by the highly efficient enzyme PEP carboxylase in the mesophyll cells. This produces the 4-carbon acid oxaloacetate, bypassing the oxygenase activity of RuBisCO.

36. Answer: B
Explanation: Replicative transposons employ a "copy and paste" mechanism,

utilizing a cointegrate intermediate. They actively replicate their sequence during transposition, leaving the original copy intact at the donor site while inserting the new copy at the target site.

37. Answer: B
Explanation: For the widely used SpCas9 (from *S. pyogenes*) to cleave DNA, the target 20-nucleotide sequence must be immediately followed by the Protospacer Adjacent Motif (PAM). For SpCas9, the specific PAM requirement is 5'-NGG-3' on the non-target strand.

38. Answer: A
Explanation: Splicing is highly ordered. The U1 snRNP is the first to act, base-pairing via its snRNA to the highly conserved 5' splice site (GU) of the intron. Subsequently, U2 binds the branch point, and the U4/U6-U5 tri-snRNP joins to form the active spliceosome.

39. Answer: B
Explanation: Dam methylase specifically recognizes the palindromic tetranucleotide sequence 5'-GATC-3' and methylates the N6 position of the adenine. Because there is a lag in methylation after replication, the mismatch repair system uses the transiently unmethylated strand to identify errors.

40. Answer: A
Explanation: Riboswitches are segments of mRNA (usually in the 5' UTR) that bind directly to specific small molecules (like vitamins, amino acids, or SAM) without needing a protein intermediate. This binding alters the RNA's 3D structure, causing early termination or blocking the ribosome.

41. Answer: B
Explanation: Lysogeny by phage lambda requires site-specific recombination between the *attP* site on the phage DNA and the *attB* site on the bacterial chromosome. This exact recombination event is catalyzed by the phage-encoded λ Integrase enzyme.

42. Answer: C
Explanation: The Hardy-Weinberg principle assumes an *infinitely large* population size to prevent genetic drift (random fluctuations in allele frequencies). Small populations violate this assumption. The other rules are no mutations, random mating, no gene flow, and no natural selection.

43. Answer: D
Explanation: A 9:7 ratio occurs in duplicate recessive epistasis (complementary gene action). The presence of homozygous recessive alleles at *either* of the two loci completely masks the dominant phenotype. Thus, the 3:3:1 classes of a normal 9:3:3:1 cross all show the recessive trait.

44. Answer: B
Explanation: The SWI/SNF complex is an ATP-dependent chromatin remodeler. It uses the energy of ATP hydrolysis to alter the physical contacts between DNA and histones, sliding nucleosomes along the DNA or ejecting them entirely to expose regulatory promoter sequences.

45. Answer: B

Explanation: Illumina NGS relies on sequencing-by-synthesis. It uses specialized nucleotides that possess a fluorescent fluorophore and a chemical blocking group at the 3'-OH. They terminate synthesis temporarily ("reversible terminators") until the block and dye are chemically cleaved off.

46. Answer: C
Explanation: The LOD score is the $\log_{10}$ of the odds ratio that two loci are genetically linked rather than unlinked. A LOD score of 3.0 means $10^3 = 1000$. This signifies the data is 1,000 times more likely to have occurred under linkage than under independent assortment.

47. Answer: C
Explanation: In eukaryotes, the eIF4F complex is critical for cap-dependent translation. Its specific subunit, eIF4E, is the cap-binding protein that chemically recognizes and binds to the 5' 7-methylguanosine cap structure of mature mRNA, recruiting it to the 40S ribosome.

48. Answer: B
Explanation: The MCS is placed inside the *lacZ'* gene (which encodes the α-peptide of β-galactosidase). Insertion of a foreign DNA fragment interrupts the gene, causing a loss of β-galactosidase activity. These recombinant colonies cannot cleave X-gal and appear white instead of blue.

49. Answer: B
Explanation: A nonsense suppressor mutation typically occurs in a tRNA gene. The tRNA's anticodon mutates so that it recognizes the premature stop codon in the mRNA and successfully inserts an amino acid, allowing translation to continue and suppressing the nonsense mutation.

50. Answer: C
Explanation: Lentiviral vectors (derived from retroviruses like HIV) are heavily favored because they possess the integration machinery to stably insert their therapeutic transgene into the host genome, allowing long-term expression even as the target cells divide.

51. Answer: A
Explanation: Endogenous proteins are degraded by the cytosolic proteasome into small peptides. These peptides are then actively pumped into the lumen of the Endoplasmic Reticulum (ER) by the TAP transporter, where they are loaded onto newly synthesized MHC Class I molecules.

52. Answer: C
Explanation: Unlike the classical pathway (which strictly requires antibodies bound to antigen) or the lectin pathway, the alternative complement pathway activates spontaneously via the continuous "tick-over" hydrolysis of C3, which binds directly to unprotected foreign microbial surfaces.

53. Answer: B
Explanation: While RAG1/2 makes the DNA breaks, Terminal deoxynucleotidyl transferase (TdT) is a specialized DNA polymerase that adds random, non-templated nucleotides to the single-stranded ends before they are ligated, creating massive junctional diversity in the CDR3 regions.

54. Answer: B
Explanation: Because power relates to the impeller diameter to the fifth power (D^5), keeping P/V constant during scale-up usually requires a larger impeller spinning slower. However, the sheer size of the larger impeller vastly increases the tip speed, greatly increasing maximum shear stress.

55. Answer: B
Explanation: If the feed rate provides excess carbon, the specific growth rate hits μ_{max}, which triggers overflow metabolism (like the Crabtree effect) and represses the transcription of secondary metabolite genes. Keeping μ slightly restricted avoids this and maximizes product yield.

56. Answer: A
Explanation: In chromatography theory, a resolution (R_s) of 1.5 indicates that the distance between two peak centers is exactly enough to cover their base widths. This equates mathematically to baseline separation, representing about 99.7% purity between the two components.

57. Answer: B
Explanation: The destruction kinetics of microorganisms are highly temperature-dependent, much more so than the chemical degradation of vitamins or proteins. High-Temperature Short-Time (HTST) sterilization kills spores instantly while sparing heat-sensitive media components.

58. Answer: C
Explanation: To reduce immunogenicity in humans, therapeutic antibodies are "humanized." Only the hypervariable Complementarity Determining Regions (CDRs) from the original mouse antibody are grafted onto an otherwise completely human antibody framework sequence.

59. Answer: B
Explanation: In isopycnic (density-gradient) centrifugation, particles migrate through a gradient medium until they reach a position where the medium's density exactly equals their own buoyant density. They stop moving regardless of run time, separated purely by density.

60. Answer: B
Explanation: A Rushton turbine is a standard disk-style flat-blade impeller designed primarily for dispersing gases in aerobic fermentations. It thrusts the fluid outward directly against the vessel walls, generating a predominantly radial flow pattern.

61. Answer: C
Explanation: The Spectral Theorem states that any real symmetric matrix is guaranteed to have real eigenvalues, is always diagonalizable, and its eigenvectors corresponding to distinct eigenvalues are always orthogonal to one another.

62. Answer: B
Explanation: The Rank-Nullity Theorem states: $Rank(A) + Nullity(A) = n$, where n is the number of columns in the matrix. Here, matrix A is 2×3, so it has 3 columns. Since $Rank(A) = 2$, $Nullity(A) = 3 - 2 = 1$.

63. Answer: A

Explanation: For a symmetric matrix, it is positive definite if and only if all of its eigenvalues are strictly positive. (Note: A positive trace or determinant is necessary but not sufficient on its own, as two negative eigenvalues give a positive determinant).

64. Answer: B

Explanation: The Jacobian matrix is $J = \begin{bmatrix} \partial x/\partial r & \partial x/\partial \theta \\ \partial y/\partial r & \partial y/\partial \theta \end{bmatrix} = \begin{bmatrix} \cos\theta & -r\sin\theta \\ \sin\theta & r\cos\theta \end{bmatrix}$. The determinant is $(r\cos^2\theta) - (-r\sin^2\theta) = r(\cos^2\theta + \sin^2\theta) = r$.

65. Answer: B

Explanation: Stokes' Theorem equates the flux of the curl of a vector field across a surface to the circulation (line integral) of the vector field around the boundary of the surface: $\iint_S (\nabla \times \mathbf{F}) \cdot d\mathbf{S} = \oint_C \mathbf{F} \cdot d\mathbf{r}$.

66. Answer: B

Explanation: Let $u = x, dv = e^x dx$. Then $du = dx, v = e^x$. The integral is $xe^x|_0^{\ln 2} - \int_0^{\ln 2} e^x dx = (\ln 2 \cdot e^{\ln 2} - 0) - (e^{\ln 2} - e^0) = (\ln 2 \cdot 2) - (2 - 1) = 2\ln 2 - 1$. Wait, option is missing my math. Ah: $(2\ln 2) - (2 - 1) = 2\ln 2 - 1$. The answer is A, sorry. Let me re-verify. Yes, A. My provided answer key was wrong in drafting, it is A. Let me correct the output to A. (Output is A).

Correction: The answer is A. **67. Answer: A**

Explanation: By integrating the geometric series $1/(1+x) = 1 - x + x^2 - x^3...$, we get the Maclaurin series for $\ln(1+x) = x - x^2/2 + x^3/3 - x^4/4...$, which is concisely represented as $\sum_{n=1}^{\infty} (-1)^{n+1} \frac{x^n}{n}$.

68. Answer: A

Explanation: The Laplace transform is defined as $\int_0^{\infty} e^{-st} f(t) dt$. For $H(t-a)$, the integral evaluates from a to ∞ because the function is 0 before a. $\int_a^{\infty} e^{-st}(1) dt = [-e^{-st}/s]_a^{\infty} = 0 - (-e^{-as}/s) = e^{-as}/s$.

69. Answer: C

Explanation: The matrix $A = \begin{bmatrix} 3 & -1 \\ 1 & 1 \end{bmatrix}$. Trace $T = 4$, Determinant $D = 3(1) - (-1)(1) = 4$. The characteristic equation roots are $(T \pm \sqrt{T^2 - 4D})/2 = (4 \pm \sqrt{16 - 16})/2 = 2$. Repeated positive real roots ($T > 0, T^2 = 4D$) means unstable node. My provided option was Unstable spiral/node.

70. Answer: B

Explanation: A differential equation of the form $M(x,y)dx + N(x,y)dy = 0$ is exact if there exists a potential function $f(x,y)$ such that $\partial f/\partial x = M$ and $\partial f/\partial y = N$. According to Clairaut's theorem on mixed partials, this requires $\partial M/\partial y = \partial N/\partial x$.

71. Answer: D

Explanation: The Gauss-Seidel iterative method is guaranteed to converge for any starting vector x_0 if the coefficient matrix A is strictly diagonally dominant, meaning the absolute value of the diagonal entry in each row is strictly greater than the sum of the absolute values of the other entries in that row.

72. Answer: D

Explanation: The classical RK4 method calculates four different intermediate slopes (k_1, k_2, k_3, k_4) across a single step h. This explicitly requires the function

$f(t, y)$ to be evaluated exactly 4 times per iteration to achieve its $O(h^4)$ global accuracy.

73. Answer: B
Explanation: The Trapezoidal Rule connects points on a curve with straight lines. If the function is concave down (bowing upward), the straight line drawn between any two points will strictly lie below the curve, resulting in an underestimation of the area.

74. Answer: C
Explanation: Using Bayes: Prev = 0.0001. Sens = 0.99. Spec = 0.99. False Positive Rate = 0.01. $P(Pos) = (0.0001 \times 0.99) + (0.9999 \times 0.01) \approx 0.0101$. $PPV = (0.0001 \times 0.99)/0.0101 \approx 0.0098$, which is roughly 1%. The rarity of the disease heavily outweighs the test accuracy.

75. Answer: B
Explanation: For an exponential distribution defined by rate parameter λ, the expected value (mean) is $E[X] = 1/\lambda$. Through integration of the second moment, the variance is calculated to be exactly $Var(X) = 1/\lambda^2$.

76. Answer: C
Explanation: The p-value does not measure the probability that a hypothesis is true or false. It strictly measures the probability of observing a test statistic at least as extreme as the one computed from the sample, assuming the null hypothesis is perfectly true.

77. Answer: C
Explanation: For a Binomial distribution, the variance is given by $\sigma^2 = n \cdot p \cdot (1-p)$. Here, $\sigma^2 = 100 \times 0.2 \times 0.8 = 16$. The standard deviation (σ) is the square root of the variance, which is $\sqrt{16} = 4$.

78. Answer: B
Explanation: The general rule is $Var(X-Y) = Var(X) + Var(Y) - 2Cov(X, Y)$. Because X and Y are explicitly stated to be independent, their covariance ($Cov(X, Y)$) is exactly 0. Thus, the equation simplifies to $Var(X) + Var(Y)$.

79. Answer: A
Explanation: Because A is an upper triangular matrix (the entry below the main diagonal is 0), its eigenvalues are simply the entries lying directly on its main diagonal. Therefore, the eigenvalues are 4 and 3.

80. Answer: C
Explanation: The gradient is $\nabla f = \langle 2x, 2y, 2z \rangle$. At $(1, 1, 1)$, $\nabla f = \langle 2, 2, 2 \rangle$. The vector $\mathbf{v} = \langle 1, 0, 0 \rangle$ is already a unit vector. The directional derivative is the dot product $\nabla f \cdot \mathbf{v} = (2 \times 1) + (2 \times 0) + (2 \times 0) = 2$.

81. Answer: B
Explanation: A transcription factor binds directly to a specific target sequence (Promoter) on DNA. Analogously, the Signal Recognition Particle (SRP) specifically recognizes and binds to an ER signal sequence emerging from a translating ribosome.

82. Answer: D
Explanation: Helicase, Topoisomerase, and Primase are all nuclear enzymes strictly

involved in DNA replication and topology. The proteasome is a massive cytosolic protein complex tasked with degrading unneeded or damaged proteins.

83. Answer: A
Explanation: The code adds 1 to the alphabet position of each letter (+1 shift). E → F, N → O, Z → A, Y → Z, M → N, E → F. Applying this to VECTOR: V → W, E → F, C → D, T → U, O → P, R → S, giving WFDUPT.

84. Answer: B
Explanation: The series represents $n^2 + n$. ($1^2 + 1 = 2$; $2^2 + 2 = 6$; $3^2 + 3 = 12$; $4^2 + 4 = 20$; $5^2 + 5 = 30$). The next term for $n = 6$ is $6^2 + 6 = 36 + 6 = 42$. Alternatively, the differences are +4, +6, +8, +10, so the next difference is +12 ($30 + 12 = 42$).

85. Answer: D
Explanation: "Only a few DNA are circular" means Some DNA are circular and Some DNA are NOT circular. Plasmids are completely inside DNA. However, the exact intersection of Plasmids with the "circular" part of DNA is unknown. Neither conclusion strictly follows based *only* on the statements.

86. Answer: B
Explanation: All Yeast are Fungi, and all Fungi are Eukaryotes. Thus, Yeast is completely inside Fungi, which is completely inside Eukaryotes. (Animals/Mammals/Bacteria fails because Bacteria are not Mammals. Proteins/Nucleic Acids fails as they don't encompass each other).

87. Answer: A
Explanation: The man's "mother-in-law's only daughter" is the man's wife. The woman's mother is the man's wife. Therefore, the woman is the man's daughter, making the man the father of the woman.

88. Answer: A
Explanation: C is between A E (A-C-E or E-C-A). B is to the immediate right of E (E-B). Combining yields A-C-E-B. F is far right. Since D is not at the end, D must be before F. The arrangement is A-C-E-B-D-F. The person at the far left is A.

89. Answer: A
Explanation: Using the formula $N_t = N_0 \cdot 2^n$. $10^8 = 10^4 \cdot 2^n$. Therefore, $2^n = 10^4 = 10000$. Taking $\log_2$, $n \approx 13.3$ generations. 4 hours = 240 minutes. Generation time = $240/13.3 \approx 18.04$ minutes.

90. Answer: A
Explanation: We know each tube has exactly one unique substance. Tube 3 has the substrate. This leaves enzyme and buffer for tubes 1 and 2. Tube 2 does not have the enzyme, so Tube 2 must have the buffer. This logically leaves the enzyme in Tube 1. (Tube 1 also doesn't have buffer, matching the premise).