

Learn these by heart before the exam. 考试前把这些内容背熟。

Chemistry of Life

Water: polar, hydrogen-bonded. Gives cohesion, adhesion, high specific heat, and ice that floats. Every property traces to the H-bond.

Hydrolysis vs dehydration synthesis 水解与脱水缩合: hydrolysis ADDS water to break a bond; dehydration synthesis removes water to form one

Four macromolecules: carbohydrates (monosaccharides), lipids (not polymers), proteins (amino acids), nucleic acids (nucleotides). Protein structure: primary sequence, secondary (H-bonds, helix/sheet), tertiary (R-group interactions), quaternary (subunits). Shape determines function. Denaturation by heat or pH breaks the 3-D shape, not the peptide bonds.

Cell Structure and Function

surface area falls as a cell grows: the reason cells stay small and divide 表面积体积比
Membrane: phospholipid bilayer, hydrophilic heads out, hydrophobic tails in. Fluid mosaic with embedded proteins.
Passive: diffusion, osmosis, facilitated diffusion (down the gradient, no ATP). Active: pumps, endo/exocytosis (against it, needs ATP).
 $\Psi = \Psi_S + \Psi_P$, $\Psi_S = -iCRT$ water moves from HIGH to LOW water potential; Ψ of pure water at atmospheric pressure is 0 水势
Hypotonic outside means water in (a plant cell becomes turgid; an animal cell bursts). Hypertonic means water out.

Cellular Energetics

Enzymes lower activation energy; they do not change ΔG . Competitive inhibitor binds the active site; allosteric binds elsewhere and changes shape.
 $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + ATP$ 细胞呼吸
Respiration: glycolysis (cytosol, 2 ATP), pyruvate oxidation, Krebs (matrix), oxidative phosphorylation (cristae, most ATP).
Chemiosmosis: the electron transport chain pumps H^+ to build a gradient; ATP synthase lets it flow back. Same principle in mitochondria and chloroplasts.
 $6CO_2 + 6H_2O \xrightarrow{\text{light}} C_6H_{12}O_6 + 6O_2$ 光合作用
Light reactions (thylakoid) make ATP and NADPH and split water. Calvin cycle (stroma) fixes CO_2 with

rubisco.
 C_4 and CAM separate fixation from the Calvin cycle in SPACE or in TIME to avoid photorespiration.
Cell Communication and Cell Cycle
Signal transduction: reception, transduction (cascade, amplifies), response. A cascade means one signal changes many molecules.
Feedback: negative restores the set point (most homeostasis); positive amplifies (childbirth, clotting).
Cell cycle: G_1 , S (DNA replicates), G_2 , M . Checkpoints at G_1 , G_2 and M verify size, DNA damage, and spindle attachment.
Mitosis makes 2 identical diploid cells. Meiosis makes 4 genetically different haploid cells.
Variation from meiosis: crossing over (prophase I), independent assortment (metaphase I), and random fertilisation.

Heredity

Punnett: 3:1 (monohybrid), 9:3:3:1 (dihybrid) 孟德尔比例
Law of segregation: alleles separate in gametes. Independent assortment: different genes assort independently, UNLESS linked.
Linked genes stay together; recombination frequency measures map distance (1% = 1 map unit).
Non-Mendelian: incomplete dominance (blend), codominance (both shown), multiple alleles, polygenic, epistasis, sex-linked.
 $\chi^2 = \sum \frac{(o - e)^2}{e}$ df = categories - 1; $p < 0.05$ means REJECT the null and the difference is significant 卡方检验

Gene Expression and Regulation

Central dogma: DNA to RNA (transcription) to protein (translation). Replication is semi-conservative.
Transcription: RNA polymerase, promoter. Eukaryotic processing adds a 5' cap, poly-A tail, and splices out introns.
Translation: ribosome reads codons; tRNA brings the amino acid. Start AUG, stop UAA/UAG/UGA.
Mutations: silent (no change), missense (one amino acid), nonsense (early stop), frameshift (insert/delete, usually worst).
Operons (prokaryote): lac is INDUCIBLE (lactose turns it on); trp is REPRESSIBLE (tryptophan turns it off).
Biotech: PCR amplifies, gel electrophoresis separates

by size (small travels furthest), CRISPR edits.

Natural Selection

$p + q = 1$, $p^2 + 2pq + q^2 = 1$ $2pq$ is the heterozygote frequency; q^2 is the homozygous recessive 哈迪-温伯格
 $H-W$ conditions: no mutation, no selection, no migration, random mating, large population. If the numbers deviate, evolution IS happening.
Selection types: directional (one extreme), stabilising (the middle), disruptive (both extremes).
Evolution mechanisms: natural selection, mutation, gene flow, genetic drift (bottleneck, founder), non-random mating.
Evidence: fossils, homologous structures (common ancestry), analogous (convergent), molecular sequences, embryology.

Ecology

$\frac{dN}{dt} = r_{\max}N$ (exponential), $\frac{dN}{dt} = r_{\max}N \frac{K - N}{K}$ (logistic) K is the carrying capacity; growth is fastest at $N = K/2$ 种群增长
Energy: about 10% passes to the next trophic level. That is why food chains are short and biomass pyramids narrow.
Interactions: competition (-/-), predation (+/-), mutualism (+/+), commensalism (+/0), parasitism (+/-).
Succession: primary starts on bare rock (no soil); secondary follows a disturbance where soil remains.
Higher biodiversity means greater resilience to disturbance.

Exam technique

Free-response verbs matter: DESCRIBE says what happens; EXPLAIN says why (give the mechanism); JUSTIFY says use the data to support the claim.
Always link structure to function, and always use the data given. A general truth with no reference to the graph earns little.
For an experiment: name the independent and dependent variables, the control, and what is held constant.