

BITSAT Biology Sample Paper – 1

Duration: 60 Minutes

Maximum Marks: 120

Instructions

- This paper contains **40** Multiple Choice Questions (Single Correct Answer).
- Each correct answer carries **+3 marks**. Each incorrect answer carries **-1** mark. Unattempted questions carry **0** marks.
- Only **one** option is correct. Choose carefully.
- Use of mobile phones, calculators, or electronic gadgets is strictly prohibited.

Q1. Which of the following is the chief structural component of the bacterial cell wall that is absent in eukaryotic cell walls?

- (A) Cellulose
- (B) Peptidoglycan (murein)
- (C) Chitin
- (D) Lignin

Q2. Which of the following organelles is NOT a part of the endomembrane system of a eukaryotic cell?

- (A) Endoplasmic reticulum
- (B) Golgi apparatus
- (C) Lysosome
- (D) Mitochondrion

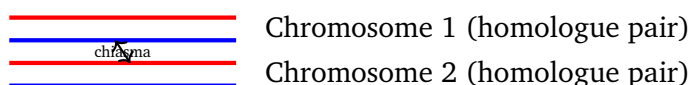
Q3. The cristae of a mitochondrion primarily function to:

- (A) Increase the inner-membrane surface area, providing more space for electron transport chain complexes



- (B) Store DNA for the cell
- (C) Synthesise ribosomal RNA
- (D) Carry out glycolysis

Q4. The diagram below shows two homologous chromosomes paired together during cell division. During which phase of meiosis is this pairing (synapsis) first established, leading to the formation of bivalents and chiasmata?



- (A) Anaphase II
- (B) Metaphase I
- (C) Prophase I (zygotene/pachytene sub-stages)
- (D) Telophase II

Q5. In Michaelis–Menten enzyme kinetics, V_{\max} represents:

- (A) The maximum rate of reaction when all enzyme active sites are saturated with substrate
- (B) The substrate concentration at half-maximum rate
- (C) The pH at which the enzyme is most active
- (D) The temperature for fastest catalysis

Q6. Mature human insulin is a globular protein consisting of:

- (A) A single polypeptide chain with one disulfide bond
- (B) A single chain with three disulfide bonds
- (C) Three polypeptide chains linked by disulfide bonds
- (D) Two polypeptide chains (A: 21 residues; B: 30 residues) linked by two interchain disulfide bonds

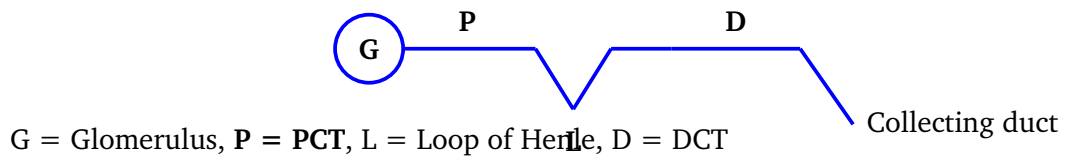


- Q7.** In Watson–Crick base pairing in a DNA double helix, the number of hydrogen bonds between guanine and cytosine is:
- (A) Two
 - (B) Three
 - (C) Four
 - (D) One
- Q8.** Which statement correctly compares glycogen and starch?
- (A) Both are linear polymers of fructose
 - (B) Starch is found only in animals
 - (C) Glycogen is more highly branched than amylopectin and is the principal storage carbohydrate in animals and fungi
 - (D) Glycogen contains β -1,4 linkages whereas starch contains α -1,4 linkages
- Q9.** Pepsin is initially secreted by gastric chief cells in an inactive zymogen form known as:
- (A) Trypsinogen
 - (B) Chymotrypsinogen
 - (C) Prorennin
 - (D) Pepsinogen (activated to pepsin by HCl in the stomach lumen)
- Q10.** Residual volume (RV) is best defined as:
- (A) The volume of air inspired during normal breathing
 - (B) The maximum volume that can be inspired forcefully
 - (C) The volume of air remaining in the lungs after a maximum forced expiration (approximately 1100–1200 mL)
 - (D) The volume exchanged during normal quiet breathing



- Q11.** The pacemaker of the human heart, which initiates each heartbeat by generating action potentials autonomously, is the:
- (A) Atrioventricular (AV) node
 - (B) Sino-atrial (SA) node, located in the wall of the right atrium
 - (C) Bundle of His
 - (D) Purkinje fibres

- Q12.** Refer to the simplified nephron diagram below. In which labelled region is approximately 65% of the glomerular filtrate (including all glucose, all amino acids, and most water and ions) reabsorbed?



- (A) P (proximal convoluted tubule)
 - (B) L (loop of Henle)
 - (C) D (distal convoluted tubule)
 - (D) Collecting duct
- Q13.** Saltatory conduction (where the action potential “jumps” from one node of Ranvier to the next, dramatically increasing conduction velocity) occurs in:
- (A) Unmyelinated nerve fibres only
 - (B) Dendrites only
 - (C) Cell bodies of neurons
 - (D) Myelinated nerve fibres (because the myelin sheath insulates the axon between nodes of Ranvier)
- Q14.** A deficiency of thyroxine (T_4) and triiodothyronine (T_3) in adults due to dietary iodine deficiency typically results in:



- (A) Simple (endemic) goitre and adult hypothyroidism (myxoedema); in iodine-deficient children it causes cretinism
- (B) Acromegaly
- (C) Diabetes insipidus
- (D) Graves' disease (hyperthyroidism)

Q15. Which of the following plant tissues is primarily responsible for the upward conduction of water and dissolved minerals from roots to leaves?

- (A) Phloem
- (B) Xylem (tracheids and vessels)
- (C) Collenchyma
- (D) Parenchyma

Q16. C_4 plants such as maize and sugarcane are characterised by a specialised leaf anatomy in which:

- (A) Mesophyll cells lack chloroplasts entirely
- (B) Stomata are absent on both leaf surfaces
- (C) Bundle sheath cells around the vascular bundles contain large chloroplasts and form a ring (Kranz anatomy), enabling efficient CO_2 concentration around RuBisCO
- (D) Photorespiration is higher than in C_3 plants

Q17. In Mendelian inheritance, the phenotypic ratio obtained in a monohybrid test cross (heterozygous tall \times homozygous recessive dwarf) is:

- (A) 1 tall : 1 dwarf
- (B) 3 tall : 1 dwarf
- (C) 9 : 3 : 3 : 1
- (D) All tall

Q18. Linkage maps (genetic maps) of chromosomes are constructed using:



- (A) Absolute physical distances in nanometres between genes
- (B) Number of chromosomes in the karyotype
- (C) Centromere positions
- (D) Recombination frequencies between gene pairs (where 1 map unit / centiMorgan = 1% recombination)

Q19. The Meselson–Stahl experiment (1958), using nitrogen isotopes ^{15}N and ^{14}N , established that DNA replication is:

- (A) Conservative
- (B) Dispersive
- (C) Semiconservative (each daughter duplex contains one parental strand and one newly synthesised strand)
- (D) Random

Q20. Eukaryotic pre-mRNA (heterogeneous nuclear RNA) undergoes which of the following post-transcriptional modifications before nuclear export?

- (A) Transcription only; no further modification needed
- (B) Addition of a 7-methylguanosine cap at the 5' end, addition of a poly-A tail at the 3' end, and splicing out of introns
- (C) Reverse transcription into DNA
- (D) Direct translation in the nucleus

Q21. The Hardy–Weinberg equilibrium for allele frequencies in a population holds true only when all of the following conditions are met:

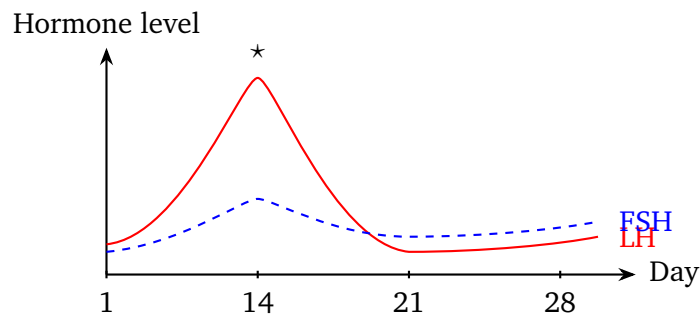
- (A) No mutation, no gene flow (migration), no genetic drift (large population), random mating, and no natural selection
- (B) Continuous mutation and strong selection pressure
- (C) Small isolated population with inbreeding
- (D) Bottleneck event followed by founder effect



Q22. The variation in beak shape and size among Darwin's finches of the Galápagos Islands is the classic illustration of:

- (A) Convergent evolution
- (B) Coevolution
- (C) Adaptive radiation (descent of multiple species from a common ancestor, each adapted to a distinct ecological niche)
- (D) Lamarckism (inheritance of acquired characters)

Q23. The graph below shows blood hormone levels during the human menstrual cycle. The sharp peak at day 14 (marked \star) that triggers ovulation is due to:



- (A) A peak in oestrogen alone
 - (B) A surge in luteinizing hormone (LH) from the anterior pituitary, induced by sustained high oestrogen via positive feedback
 - (C) A surge in progesterone
 - (D) A drop in FSH
- Q24.** Spermatogenesis in human males begins with the mitotic proliferation of:
- (A) Primary spermatocytes
 - (B) Secondary spermatocytes
 - (C) Spermatids
 - (D) Spermatogonia (diploid, $2n$) lining the seminiferous tubules



- Q25.** In a normal human pregnancy, fertilisation (sperm–ovum fusion) occurs in:
- (A) The uterine cavity
 - (B) The cervix
 - (C) The ampullary region of the fallopian tube (oviduct)
 - (D) The ovary
- Q26.** Intra-uterine devices (IUDs) such as Copper-T and LNG-IUS act primarily as contraceptives by:
- (A) Producing a local sterile inflammatory reaction and ionic changes in the uterus that prevent fertilisation/implantation; copper ions also impair sperm motility
 - (B) Suppressing ovulation by inhibiting GnRH secretion from the hypothalamus
 - (C) Surgically blocking the fallopian tubes
 - (D) Acting as physical barriers in the vagina
- Q27.** Double fertilisation, a unique reproductive feature involving the fusion of one sperm with the egg and another sperm with the central cell to form endosperm, is characteristic of:
- (A) Bryophytes
 - (B) Pteridophytes
 - (C) Gymnosperms
 - (D) Angiosperms (flowering plants)
- Q28.** Entomophilous flowers are those pollinated by:
- (A) Wind
 - (B) Insects (typically large, brightly coloured, fragrant flowers with nectar guides)



(C) Water

(D) Birds

Q29. The phenomenon of apical dominance, in which the growth of lateral (axillary) buds is suppressed by the apical (terminal) bud, is mediated chiefly by:

(A) Cytokinins synthesised in roots

(B) Gibberellins from young leaves

(C) Auxin (IAA) produced at the shoot apical meristem, which transports basipetally and inhibits lateral bud growth

(D) Abscisic acid

Q30. Short-day plants (SDPs) such as *Chrysanthemum* and *Xanthium* flower when:

(A) The continuous dark period exceeds a critical length (it is actually the length of the uninterrupted dark period, not day length, that matters)

(B) Day length exceeds 14 hours

(C) Exposed to high temperatures

(D) Subjected to drought stress

Q31. In Whittaker's five-kingdom classification (1969), Kingdom Monera includes:

(A) Single-celled eukaryotes only

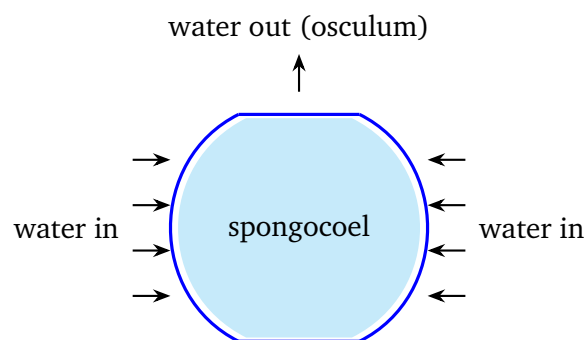
(B) All prokaryotes — both archaeobacteria and eubacteria (including cyanobacteria/blue-green algae)

(C) All photosynthetic organisms

(D) Only fungi-like microorganisms



- Q32.** According to the rules of binomial nomenclature established by Carl Linnaeus, which of the following is the CORRECT way of writing the scientific name of mango?
- (A) mangifera indica
 - (B) Mangifera Indica
 - (C) MANGIFERA INDICA
 - (D) *Mangifera indica* (genus capitalised, species lowercase, both italicised when printed or underlined when handwritten)
- Q33.** The figure below shows the body plan of an aquatic animal characterised by an internal cavity (spongocoel) lined with flagellated cells called choanocytes (collar cells) and a supporting skeleton of spicules or spongin fibres. To which phylum does this organism belong?

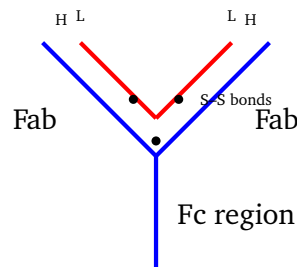


- (A) Porifera (sponges)
 - (B) Coelenterata (Cnidaria)
 - (C) Platyhelminthes
 - (D) Annelida
- Q34.** Acquired Immunodeficiency Syndrome (AIDS) is caused by HIV, a retrovirus that selectively destroys:
- (A) Erythrocytes (red blood cells)
 - (B) B-lymphocytes only
 - (C) CD4⁺ helper T-lymphocytes (causing progressive collapse of cell-mediated and humoral immunity)



(D) Platelets

Q35. The diagram below depicts a typical immunoglobulin (IgG) molecule. The Y-shaped antibody structure consists of:



- (A) One heavy and one light chain
- (B) Four identical chains, all of equal size
- (C) Three heavy chains joined at a central hinge
- (D) Two identical heavy (H) chains and two identical light (L) chains held together by disulfide bridges, forming a Y-shape with two antigen-binding Fab arms and one Fc tail

Q36. Leukaemia is best characterised as a malignant proliferation of:

- (A) Liver hepatocytes
- (B) White blood cells (leucocytes) originating from the bone marrow, leading to abnormally high circulating WBC counts
- (C) Skin keratinocytes
- (D) Smooth muscle cells

Q37. An inverted pyramid of biomass (where the standing biomass of producers is less than that of consumers) is most typically observed in:

- (A) Open ocean / pond ecosystem, where the producers are tiny short-lived phytoplankton (low standing biomass at any instant) supporting larger, longer-lived zooplankton and fish (higher standing biomass)
- (B) Tropical rainforest



- (C) Temperate grassland
- (D) Tundra

Q38. According to Lindeman's 10% law of energy transfer in an ecosystem, approximately what percentage of the energy at one trophic level is transferred to the next higher trophic level?

- (A) Approximately 50%
- (B) Approximately 25%
- (C) Approximately 10% (the rest is lost mainly as heat through respiration)
- (D) Approximately 90%

Q39. The restriction endonuclease EcoRI, isolated from *Escherichia coli*, recognises and cuts the palindromic DNA sequence:

- (A) 5'-CCGCGG-3'
- (B) 5'-GAATTC-3' (cutting between G and A to leave 5'-AATT sticky overhangs)
- (C) 5'-AAGCTT-3'
- (D) 5'-GGATCC-3'

Q40. In the polymerase chain reaction (PCR), the heat-stable DNA polymerase used to synthesise new strands during the extension step (typically at $\sim 72^{\circ}\text{C}$) is:

- (A) DNA polymerase I from *E. coli*
- (B) Reverse transcriptase
- (C) RNA polymerase
- (D) Taq polymerase, isolated from the thermophilic bacterium *Thermus aquaticus* living in hot springs



Detailed Solutions

Q1.

Solution

Concept — Cell wall composition across kingdoms: The cell wall is a defining feature of bacteria, plants, fungi and most protists, but its chemical composition differs.

Step 1 — Composition by kingdom:

- Bacteria (Monera): **peptidoglycan** (also called murein) — a polymer of NAG and NAM cross-linked by short peptide bridges.
- Plants: cellulose (β -1, 4-linked glucose).
- Fungi: chitin (β -1, 4 N-acetylglucosamine).
- Archaea: pseudopeptidoglycan or S-layers (no true peptidoglycan).

Step 2 — Clinical/medical significance: The bacterial peptidoglycan layer is the target of penicillin and related β -lactam antibiotics, which inhibit transpeptidase enzymes and thus selectively kill bacteria without harming eukaryotic host cells.

Why other options are wrong:

- **Cellulose:** plant cell walls, not bacterial.
- **Chitin:** fungi and arthropod exoskeletons.
- **Lignin:** a secondary thickening in xylem and sclerenchyma of plants; not in bacteria.

Final Answer: Peptidoglycan (murein) is the chief bacterial cell-wall polymer \Rightarrow

B

Answer: (B) [Go Back to Q1](#)



Q2.

Solution

Concept — The endomembrane system: A coordinated set of membrane-bound organelles whose functions are physically and functionally linked through vesicle trafficking.

Step 1 — Components of endomembrane system: Endoplasmic reticulum (ER) → Golgi apparatus → lysosomes, vacuoles, and the plasma membrane, with vesicles shuttling material between them. The nuclear envelope is also considered part of this system.

Step 2 — Why mitochondrion is excluded: Mitochondria (and chloroplasts) have their own double membrane, their own circular DNA, and their own 70S ribosomes. They are believed to have evolved from free-living prokaryotes by endosymbiosis (Margulis, 1967). They do NOT exchange material with the ER/Golgi via vesicles, so they are NOT part of the endomembrane system.

Why other options are wrong:

- **ER, Golgi, lysosome:** all classically defined parts of the endomembrane system; protein and lipid traffic flows between them via budding vesicles.

Final Answer: Mitochondrion is the exception ⇒

[Go Back to Q2](#)



Q3.

Solution

Concept — Mitochondrial ultrastructure: A mitochondrion has two membranes: a smooth outer membrane (permeable to small molecules via porins) and a highly folded inner membrane.

Step 1 — Function of cristae: The inner membrane is thrown into shelf-like folds called **cristae**. These folds vastly increase the surface area on which the four electron transport chain complexes (I, II, III, IV) and ATP synthase (Complex V) are embedded.

Step 2 — Why surface-area matters: More cristae \Rightarrow more ETC complexes per mitochondrion \Rightarrow higher rate of oxidative phosphorylation \Rightarrow more ATP. Cells with high energy demand (cardiac muscle, hepatocytes) have densely packed cristae.

Why other options are wrong:

- **Store DNA:** mitochondrial DNA exists, but it is housed in the matrix, not in the cristae folds themselves.
- **Synthesise rRNA:** ribosomal RNA synthesis occurs in the nucleolus.
- **Glycolysis:** glycolysis takes place in the cytosol, not in mitochondria.

Final Answer: Cristae increase inner-membrane surface area for the ETC \Rightarrow

[Go Back to Q3](#)



Q4.

Solution

Concept — Meiosis I prophase substages: Meiosis I prophase is unusually long and is subdivided into five substages: **leptotene** → **zygotene** → **pachytene** → **diplotene** → **diakinesis**.

Step 1 — Where synapsis happens:

- **Zygotene:** homologous chromosomes begin to pair (synapsis), aided by the synaptonemal complex. The paired structure is a **bivalent** (or tetrad, as each homologue has 2 sister chromatids).
- **Pachytene:** synapsis is complete; **crossing-over** occurs between non-sister chromatids of homologues, mediated by recombination nodules. The points of exchange are visible later as chiasmata.
- **Diplotene:** chromosomes start to separate but remain joined at chiasmata.

Step 2 — Why prophase I, not other phases: At metaphase I, bivalents are already formed and align at the equator. At anaphase II, sister chromatids (not homologues) separate. At telophase II, daughter nuclei reorganise. Only prophase I (zygotene/pachytene) shows synapsis and bivalent formation.

Why other options are wrong:

- **Anaphase II:** sister chromatids separate, not homologues.
- **Metaphase I:** bivalents are already formed; this phase is alignment, not pairing.
- **Telophase II:** no synapsis; nuclei reform.

Final Answer: Prophase I (zygotene/pachytene) ⇒

[Go Back to Q4](#)



Q5.

Solution

Concept — Michaelis–Menten kinetics: The rate equation is $v = \frac{V_{\max}[S]}{K_m + [S]}$.

Step 1 — Meaning of V_{\max} : V_{\max} is the rate when essentially all enzyme molecules are in the ES (enzyme-substrate) form — i.e. the enzyme is saturated with substrate. Adding more substrate cannot increase the rate further because all active sites are occupied.

Step 2 — Meaning of K_m : K_m (Michaelis constant) is the substrate concentration at which $v = V_{\max}/2$. A low K_m means high enzyme–substrate affinity. K_m is not asked here but is a common distractor.

Why other options are wrong:

- **[S] at half-max rate:** this is K_m , not V_{\max} .
- **Optimum pH/temperature:** these are physical conditions, not kinetic parameters.

Final Answer: Maximum rate at enzyme saturation \Rightarrow

Answer: (A) [Go Back to Q5](#)



Q6.

Solution

Concept — Quaternary structure of insulin: Insulin is synthesised as a single-chain pre-pro-insulin, but the mature, functional, secreted hormone is processed differently.

Step 1 — Processing:

- Pre-pro-insulin → signal peptide removed → pro-insulin (single chain with A, B, C segments).
- Pro-insulin → C-peptide cleaved out → mature insulin.
- Mature insulin has **two chains**: A-chain (21 amino acids) and B-chain (30 amino acids), linked by **two interchain disulfide bonds**; A-chain also has an intra-chain disulfide.

Step 2 — Clinical relevance: The C-peptide, although discarded for biological activity, is co-secreted with insulin in equimolar amounts and is measured clinically to assess endogenous insulin production (distinguishing type 1 from type 2 diabetes).

Final Answer: Two chains (A and B) linked by disulfide bonds ⇒

[Go Back to Q6](#)



Q7.

Solution

Concept — Watson–Crick base pairing: In a B-form DNA double helix, the two complementary strands are held together by hydrogen bonds between bases.

Step 1 — Number of H-bonds per pair:

- A–T pair: 2 hydrogen bonds.
- G≡C pair: 3 hydrogen bonds.

Step 2 — Practical significance: DNA regions rich in G–C content are more thermally stable (higher melting temperature T_m) than A–T-rich regions, because 3 H-bonds require more energy to break than 2. This is why thermophiles often have GC-rich genomes.

Why other options are wrong:

- 2 **bonds:** characteristic of A–T pair, not G–C.
- 1 or 4 **bonds:** simply incorrect; not consistent with Watson–Crick geometry.

Final Answer: G≡C has 3 H-bonds ⇒

[Go Back to Q7](#)



Q8.

Solution

Concept — Storage polysaccharides: Both starch (plants) and glycogen (animals/fungi) are polymers of α -D-glucose linked by α -1,4 glycosidic bonds with α -1,6 branch points. They differ in degree of branching.

Step 1 — Structural comparison:

Feature	Starch	Glycogen
Source	Plants (amyloplasts)	Animals (liver, muscle), fungi
Components	Amylose (linear, 20%) + Amylopectin (branched, 80%)	Single branched polymer
Branch every	\sim 24–30 residues (amylopectin)	\sim 8–12 residues
Branching enzyme	α -1,6 glucan branching	Same; more active

Step 2 — Why higher branching matters: Frequent branches give glycogen many non-reducing ends, allowing rapid simultaneous release of glucose by glycogen phosphorylase — crucial for muscle bursts and liver glucose homeostasis.

Why other options are wrong:

- **Fructose polymer:** neither — both are glucose polymers (fructans like inulin are made of fructose).
- **Starch only in animals:** starch is in plants; glycogen in animals.
- **β -1,4 in glycogen:** both starch and glycogen have α -glycosidic bonds; β -1,4 links characterise cellulose.

Final Answer: Glycogen is more branched and is the animal storage carbohydrate

\Rightarrow C

Answer: (C) [Go Back to Q8](#)



Q9.

Solution

Concept — Zymogens (inactive enzyme precursors): Proteolytic enzymes are secreted in inactive forms (zymogens) to prevent autodigestion of the gland or duct.

Step 1 — Activation of pepsinogen: Pepsinogen $\xrightarrow{\text{HCl/active pepsin}}$ Pepsin + small peptide. HCl (secreted by parietal cells) provides the acidic pH and triggers cleavage of the N-terminal portion of pepsinogen, exposing the active site. Once formed, pepsin autocatalytically activates more pepsinogen.

Step 2 — Parallel examples:

- Trypsinogen \rightarrow Trypsin (activated by enterokinase in the small intestine).
- Chymotrypsinogen \rightarrow Chymotrypsin (activated by trypsin).
- Procarboxypeptidase \rightarrow Carboxypeptidase.

Final Answer: Pepsinogen is the inactive precursor of pepsin \Rightarrow

[Go Back to Q9](#)



Q10.

Solution**Concept — Lung volumes and capacities:**

- **Tidal volume (TV):** air moved during normal breathing (~ 500 mL).
- **Inspiratory reserve volume (IRV):** extra air inhaled forcibly (~ 3000 mL).
- **Expiratory reserve volume (ERV):** extra air exhaled forcibly (~ 1100 mL).
- **Residual volume (RV):** air remaining after forced maximum expiration (~ 1200 mL).

Step 1 — Why RV cannot be exhaled: Lungs are kept slightly inflated by negative intrapleural pressure and surface tension reduced by surfactant. Even on maximum exhalation, ~ 1200 mL stays behind — this is the residual volume.

Step 2 — Functional residual capacity: $FRC = ERV + RV \approx 2300$ mL — the air in the lungs at the end of a normal expiration.

Why other options are wrong:

- Tidal volume: normal breathing volume, not residual.
- IRV: maximum forced inspiration, not residual.
- Tidal volume during normal breathing: same as TV.

Final Answer: Air remaining after maximum forced expiration \Rightarrow

[Go Back to Q10](#)



Q11.

Solution

Concept — Cardiac conduction pathway: The heart generates its own action potentials autonomously (myogenic). The conduction sequence is: SA node → AV node → Bundle of His → Right/Left bundle branches → Purkinje fibres → ventricular muscle.

Step 1 — Why SA node is the pacemaker: SA node cells have the fastest intrinsic firing rate (~ 70–80 impulses/min). They depolarise first, and this depolarisation spreads to the rest of the heart, ensuring all heart chambers contract in synchrony.

Step 2 — If SA node fails: The AV node takes over (40–60/min); if both fail, ventricular tissue self-pacemakes at ~ 20–40/min. Artificial pacemakers are inserted when these intrinsic rhythms are inadequate.

Why other options are wrong:

- AV node: backup pacemaker, slower rate.
- Bundle of His and Purkinje fibres: conduct impulses but do not normally initiate them.

Final Answer: SA node in the right atrium ⇒ **B**

Answer: (B) [Go Back to Q11](#)



Q12.

Solution

Concept — Tubular reabsorption in the nephron: ~ 180 L of glomerular filtrate forms per day, but only ~ 1.5 L of urine is excreted. The bulk of reabsorption happens in the PCT.

Step 1 — PCT reabsorbs:

- $\sim 65\%$ of filtered water (passive, follows solutes osmotically).
- 100% of filtered glucose and amino acids (via Na^+ -coupled symporters — secondary active transport).
- $\sim 65\%$ of Na^+ , K^+ , Cl^- , HCO_3^- .
- $\sim 90\%$ of filtered HCO_3^- (acid–base regulation).

Step 2 — Why PCT is the major site: PCT cells have abundant microvilli (brush border) facing the lumen \rightarrow huge absorptive surface area. They also have many mitochondria for active transport.

Step 3 — Roles of other segments:

- **Loop of Henle:** concentrates urine via the counter-current mechanism (impermeable to water in ascending limb; sets up medullary osmotic gradient).
- **DCT:** fine ionic regulation (Na^+/K^+ exchange, Ca^{2+} reabsorption under PTH).
- **Collecting duct:** water reabsorption under ADH control.

Final Answer: Most reabsorption occurs in the PCT (region P) \Rightarrow

Answer: (A) [Go Back to Q12](#)



Q13.

Solution

Concept — Saltatory conduction in myelinated fibres: Myelin sheath (made by Schwann cells in PNS, oligodendrocytes in CNS) wraps around the axon at intervals, leaving gaps called **nodes of Ranvier**.

Step 1 — Why myelin speeds up conduction: Myelin is a lipid insulator \Rightarrow ion flow through the axonal membrane is blocked under the sheath. Voltage-gated Na^+/K^+ channels are concentrated only at the nodes of Ranvier. The action potential therefore “jumps” from node to node — saltation (Latin *saltare*, to leap).

Step 2 — Quantitative impact: Unmyelinated fibres: $0.5\text{--}2\text{ m s}^{-1}$. Myelinated fibres: up to 120 m s^{-1} .

Step 3 — Pathology: In multiple sclerosis (MS), the immune system attacks myelin in the CNS, severely slowing nerve conduction and causing motor and sensory deficits.

Final Answer: Myelinated nerve fibres permit saltatory conduction \Rightarrow

[Go Back to Q13](#)



Q14.

Solution

Concept — Iodine deficiency and thyroid: Iodine is essential for synthesising the thyroid hormones T_3 (triiodothyronine) and T_4 (thyroxine).

Step 1 — Hormonal feedback loop: Low T_4 → low negative feedback on hypothalamus and pituitary → increased TSH (thyroid-stimulating hormone) → thyroid gland enlarges as it tries to compensate → visible swelling in the neck = **goitre**.

Step 2 — Other clinical manifestations:

- **Adults:** myxoedema — weight gain, cold intolerance, slowed reflexes, dry skin, mental sluggishness.
- **Children:** cretinism — impaired physical and mental development, stunted growth, intellectual disability.
- **Pregnant women:** risk of foetal cretinism — a major reason for iodised salt programmes globally.

Why other options are wrong:

- **Acromegaly:** GH excess in adults; not thyroid.
- **Diabetes insipidus:** ADH deficiency, not thyroid.
- **Graves' disease:** hyperthyroidism due to autoantibodies stimulating the TSH receptor — exactly the opposite of iodine deficiency.

Final Answer: Goitre / hypothyroidism (cretinism in children) ⇒

[Go Back to Q14](#)



Q15.

Solution

Concept — Plant vascular tissues: Two complex permanent tissues form the plant vascular system:

- **Xylem:** conducts water and minerals upward from roots to aerial parts. Cells: tracheids, vessels (both dead, lignified), xylem parenchyma, xylem fibres.
- **Phloem:** conducts food (sucrose, amino acids) bidirectionally from sources (leaves) to sinks (roots, fruits, growing tissues). Cells: sieve tube elements (alive, lack nucleus), companion cells, phloem parenchyma, phloem fibres.

Step 1 — Mechanism of xylem transport: Water moves upward by the cohesion–tension theory: transpiration at the leaves creates negative pressure (tension); cohesion (H-bonds between water molecules) keeps the column unbroken; adhesion to xylem walls helps the column climb. Trees as tall as 100 m (*Sequoia*) transport water this way.

Why other options are wrong:

- **Phloem:** transports food, not water primarily.
- **Collenchyma/parenchyma:** mechanical or general functions; not conducting.

Final Answer: Xylem ⇒

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Q16.

Solution

Concept — C_4 photosynthesis (Hatch–Slack pathway): C_4 plants (maize, sugarcane, sorghum, amaranth) fix CO_2 initially into a 4-carbon compound (oxaloacetate) using the enzyme PEP carboxylase in mesophyll cells, then transport the C_4 acid to bundle sheath cells where CO_2 is released and re-fixed by RuBisCO in a C_3 cycle.

Step 1 — Kranz anatomy (key adaptation): Bundle sheath cells in C_4 plants form a tight ring around vascular bundles. They contain large agranal chloroplasts (no grana, no O_2 -evolving photosystem II), creating a high- CO_2 , low- O_2 environment around RuBisCO.

Step 2 — Advantage: By concentrating CO_2 around RuBisCO, C_4 plants suppress photorespiration (where RuBisCO mistakenly fixes O_2). This makes C_4 photosynthesis more efficient in hot, dry, high-light environments where photorespiration would otherwise be severe.

Step 3 — Comparison with C_3 : C_3 plants (wheat, rice) lack Kranz anatomy and have substantial photorespiratory losses ($\sim 25\%$ of fixed carbon) at high temperatures.

Final Answer: Bundle sheath cells with large chloroplasts (Kranz anatomy) \Rightarrow

Answer: (C) [Go Back to Q16](#)

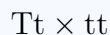


Q17.

Solution

Concept — Test cross: A test cross involves crossing an unknown phenotype (here, the heterozygous dominant) with a known homozygous recessive (tt) individual to reveal the genotype of the unknown.

Step 1 — The cross:



Gametes from Tt: T and t (each 50%). Gametes from tt: only t.

Step 2 — Punnett square:

	T	t
t	Tt (tall)	tt (dwarf)

Step 3 — Result: 50% Tt (tall) : 50% tt (dwarf) \Rightarrow 1 : 1 phenotypic and genotypic ratio.

Why other options are wrong:

- 3 : 1: this is the F_2 ratio of a monohybrid self-cross ($Tt \times Tt$), not a test cross.
- 9 : 3 : 3 : 1: dihybrid F_2 ratio.
- **All tall:** would result only if the unknown were homozygous dominant ($TT \times tt$).

Final Answer: 1 : 1 ratio \Rightarrow A

Answer: (A) [Go Back to Q17](#)



Q18.

Solution

Concept — Genetic (linkage) maps: Two genes on the same chromosome are linked. The frequency of recombination between them reflects the physical distance separating them: the farther apart, the more often crossing-over produces recombinant gametes.

Step 1 — Map unit: 1 centiMorgan (cM) = 1% recombination frequency (recombinants/total progeny). 50% recombination indicates the two loci are unlinked (either on different chromosomes or so far apart on the same chromosome that crossing-over occurs in essentially every meiosis).

Step 2 — Pioneer: A. H. Sturtevant (1913), working in T. H. Morgan's lab, constructed the first linkage map of *Drosophila* X chromosome from recombination frequencies in three-point test crosses.

Why other options are wrong:

- **Physical distance in nm:** that is the physical map (sequence-based, modern).
- **Number of chromosomes:** unrelated to linkage maps.
- **Centromere positions:** used for cytological mapping, not classical linkage mapping.

Final Answer: Recombination frequencies \Rightarrow

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Q19.

Solution

Concept — Modes of DNA replication: Three models were proposed before the mechanism was settled:

- **Conservative:** the original duplex remains intact; both new strands form a brand-new duplex.
- **Dispersive:** new and old DNA are interspersed in patches throughout both daughter duplexes.
- **Semiconservative:** each parental strand serves as a template; each daughter duplex contains one old + one new strand.

Step 1 — The Meselson–Stahl experiment (1958):

- *E. coli* grown for many generations in ^{15}N (heavy nitrogen) medium → all DNA is heavy.
- Cells transferred to ^{14}N (light) medium and harvested after one and two generations.
- DNA analysed by CsCl density gradient centrifugation:
 - Generation 1: single intermediate band (half-heavy, half-light).
 - Generation 2: two bands — one intermediate, one light.

Step 2 — Conclusion: The intermediate band at generation 1 rules out conservative (which would give two bands). The two bands at generation 2 rule out dispersive (which would maintain a single intermediate band). Result: **semiconservative replication**, just as predicted by Watson & Crick from the double-helix model.

Final Answer: Semiconservative ⇒

[Go Back to Q19](#)



Q20.

Solution

Concept — Post-transcriptional processing of eukaryotic mRNA: Eukaryotic genes contain coding sequences (exons) interrupted by non-coding sequences (introns). The primary transcript (hnRNA / pre-mRNA) must be processed before it can leave the nucleus and be translated.

Step 1 — Three modifications:

- **5' capping:** a 7-methylguanosine cap (m^7G) is added to the 5' end in an unusual 5'-5' triphosphate linkage. Functions: protects from 5' exonucleases; recruits ribosomes.
- **3' poly-A tailing:** after the transcript is cleaved at a polyadenylation signal (AAUAAA), ~ 200 – 300 adenine residues are added by poly-A polymerase. Functions: stability, nuclear export, translation efficiency.
- **Splicing:** introns are removed and exons ligated by the spliceosome (snRNPs + proteins). Alternative splicing of the same pre-mRNA can yield multiple mature mRNAs, vastly expanding proteome diversity.

Step 2 — Contrast with prokaryotes: Bacterial mRNAs do not contain introns, are not capped or polyadenylated (in most cases), and translation begins on the nascent transcript while transcription is still in progress.

Why other options are wrong:

- **No modification:** would make eukaryotic mRNA non-functional.
- **Reverse transcription:** this is the action of reverse transcriptase on RNA viral genomes, not normal mRNA processing.
- **Translation in nucleus:** translation occurs in the cytoplasm in eukaryotes, on ribosomes either free or attached to ER.

Final Answer: 5' cap + poly-A tail + splicing \Rightarrow **B**

Answer: (B) [Go Back to Q20](#)



Q21.

Solution

Concept — Hardy–Weinberg equilibrium: In a population at equilibrium, allele and genotype frequencies remain constant from generation to generation, satisfying:

$$p^2 + 2pq + q^2 = 1 \quad \text{where} \quad p + q = 1$$

(p and q are the frequencies of two alleles).

Step 1 — Five required conditions:

- No mutation (alleles do not change).
- No gene flow (no migration in or out).
- No genetic drift (population is large \rightarrow no random sampling effects).
- Random mating (no assortative mating).
- No natural selection (all genotypes equally fit).

Step 2 — Significance: The HW principle serves as a **null hypothesis**: any deviation of observed genotype frequencies from $p^2 : 2pq : q^2$ indicates that one or more evolutionary forces is acting. Real populations rarely satisfy all five conditions simultaneously, which is why allele frequencies change over time and evolution occurs.

Why other options are wrong:

- **Continuous mutation/selection:** these are the very forces HW excludes.
- **Small inbred population:** violates the large-population and random-mating conditions.
- **Bottleneck/founder:** forms of genetic drift; explicitly excluded by HW.

Final Answer: No mutation, no gene flow, large population, random mating, no selection \Rightarrow

Answer: (A) [Go Back to Q21](#)



Q22.

Solution

Concept — Adaptive radiation: Adaptive radiation is the rapid diversification of an ancestral lineage into multiple new species, each adapted to a distinct ecological niche, typically following colonisation of a new habitat or the appearance of new ecological opportunities.

Step 1 — Darwin's finches as the classic example: On the Galápagos Islands (visited by Darwin in 1835), ~ 15 closely related species of finches (now called Geospizinae) are found, all derived from a single mainland ancestor. They differ chiefly in beak shape and size, each suited to a distinct diet: large seed-cracking beaks, small insect-catching beaks, woodpecker-like probing beaks, even blood-drinking beaks (vampire finch).

Step 2 — Why this isn't convergent evolution: Convergent evolution = unrelated species evolve similar features (e.g. wings in birds and bats). The finches' diversification is the opposite: closely related forms diverge — this is divergent evolution, of which adaptive radiation is the most dramatic kind.

Other classic examples: Australian marsupials (single mammalian lineage radiating into many niches), Hawaiian honeycreepers, African cichlid fishes.

Final Answer: Adaptive radiation \Rightarrow

Answer: (C) [Go Back to Q22](#)



Q23.

Solution

Concept — Hormonal control of the menstrual cycle: The cycle is regulated by an interplay of four hormones: FSH and LH from the anterior pituitary, and oestrogen and progesterone from the ovary.

Step 1 — Pre-ovulatory phase (days 1–13):

- FSH stimulates growth of a Graafian follicle.
- The maturing follicle secretes rising amounts of oestrogen.
- Oestrogen has biphasic effect: at low levels it gives negative feedback on the hypothalamus/pituitary, but at sustained high levels (just before ovulation) it switches to **positive feedback**.

Step 2 — The LH surge (day ~ 14): Positive feedback from peak oestrogen causes a massive, sharp release of LH (and a smaller FSH surge). The LH surge triggers:

- Final maturation of the oocyte (completion of meiosis I).
- Rupture of the Graafian follicle and release of the ovum (ovulation).
- Transformation of the remaining follicle into the corpus luteum, which then secretes progesterone.

Step 3 — Clinical use: LH detection in urine (home ovulation predictor kits) is used to time conception or natural family planning.

Why other options are wrong:

- **Oestrogen alone:** oestrogen drives the LH surge but does not itself cause ovulation directly.
- **Progesterone surge:** progesterone rises *after* ovulation (corpus luteum phase), not before.
- **FSH drop:** FSH does not drop at day 14; it actually has a small concurrent peak.

Final Answer: LH surge from anterior pituitary ⇒

[Go Back to Q23](#)



Q24.

Solution

Concept — Stages of spermatogenesis: Spermatogenesis occurs in the seminiferous tubules of the testes after puberty and yields four haploid spermatozoa from each diploid spermatogonium.

Step 1 — Cell lineage:

- **Spermatogonia ($2n$):** stem cells lining the basement membrane of the seminiferous tubule. Divide mitotically throughout the male's life.
- **Primary spermatocyte ($2n$):** formed when a spermatogonium grows. Enters meiosis I.
- **Secondary spermatocyte (n):** two formed per primary spermatocyte. Enter meiosis II.
- **Spermatid (n):** four formed per primary spermatocyte.
- **Spermatozoon (n):** the mature sperm, formed by spermiogenesis (morphological transformation: condensation of nucleus, formation of acrosome, growth of flagellum, loss of cytoplasm).

Step 2 — Time course: \sim 64–74 days from spermatogonium to mature sperm in humans. About 200–300 million sperm are produced per day in healthy adult males.

Final Answer: Spermatogonia (diploid stem cells) \Rightarrow D

Answer: (D) [Go Back to Q24](#)



Q25.

Solution

Concept — Site of fertilisation: Fertilisation must occur in the upper one-third of the fallopian tube, specifically in the **ampulla** (the widest segment near the ovary).

Step 1 — Why the ampulla?

- After ovulation, the secondary oocyte is captured by the fimbriae of the fallopian tube.
- Sperm deposited in the vagina swim up through the cervix and uterus and reach the fallopian tube.
- Sperm and ovum meet in the ampullary region, where fertilisation occurs.

Step 2 — Subsequent events: The fertilised zygote begins cleavage as it travels down the tube towards the uterus, reaching the uterus as a 16-cell morula at ~ 4 days, and implanting as a blastocyst at ~ 6–7 days post-fertilisation.

Step 3 — Pathological correlates:

- **Ectopic pregnancy:** if the zygote implants in the tube instead of the uterus, this is a medical emergency. Most ectopic pregnancies are tubal.
- **Tubectomy/ligation:** surgical sterilisation by cutting/tying the fallopian tubes prevents sperm-ovum encounter.

Final Answer: Ampulla of the fallopian tube ⇒ C

Answer: (C) [Go Back to Q25](#)



Q26.

Solution

Concept — Mechanism of action of IUDs: IUDs are small T-shaped devices inserted into the uterine cavity. Two main types are in use:

Step 1 — Non-medicated/copper IUDs (Copper-T, Multiload-375):

- Cause a sterile inflammatory reaction in the endometrium (a foreign-body response). Activated macrophages, leucocytes and increased prostaglandins create a hostile uterine environment.
- Released copper ions are toxic to sperm (impair motility) and zygote (prevent implantation).

Step 2 — Hormonal IUDs (LNG-IUS, Mirena): Slowly release progestin (levonorgestrel) which thickens cervical mucus (blocks sperm), thins the endometrium, and sometimes suppresses ovulation.

Step 3 — Why option B is correct: The classic mechanism of action emphasised in NCERT Biology is the local inflammatory reaction and ionic changes preventing fertilisation/implantation, with copper specifically impairing sperm motility.

Why other options are wrong:

- **Suppressing ovulation via GnRH:** this is the mechanism of oral contraceptive pills, not IUDs.
- **Tubal blockade:** that is surgical tubectomy.
- **Vaginal barrier:** describes diaphragm/condom, not an IUD.

Final Answer: Local inflammatory reaction + copper toxicity to sperm ⇒ A

Answer: (A) [Go Back to Q26](#)



Q27.

Solution

Concept — Double fertilisation, an angiosperm hallmark: The pollen tube delivers **two** male gametes into the embryo sac of the ovule. Both fuse with different cells of the female gametophyte, hence “double”.

Step 1 — The two fusions:

- **Syngamy (true fertilisation):** one sperm (n) + egg (n) \rightarrow zygote ($2n$) \rightarrow embryo.
- **Triple fusion:** one sperm (n) + two polar nuclei ($n + n$) \rightarrow primary endosperm nucleus ($3n$) \rightarrow triploid endosperm tissue, which nourishes the developing embryo.

Step 2 — Why unique to angiosperms:

- Gymnosperms: only single fertilisation; the female gametophyte (haploid tissue) serves as nutritive tissue — no triple fusion.
- Bryophytes and pteridophytes: motile sperm reach egg through external water; no double fertilisation.

Step 3 — Discoverer: Sergei Nawaschin (1898), in lily and *Fritillaria*.

Final Answer: Angiosperms (flowering plants) \Rightarrow

[Go Back to Q27](#)



Q28.

Solution**Concept — Types of pollination by agent:**

- **Anemophily:** pollination by wind (e.g. grasses, maize, pine). Flowers small, dull, no nectar, large pollen output.
- **Hydrophily:** pollination by water (e.g. *Vallisneria*, *Zostera*). Rare.
- **Entomophily:** pollination by insects. The most common type.
- **Ornithophily:** pollination by birds (e.g. *Bombax*, sunbird-pollinated flowers).
- **Chiropterophily:** pollination by bats (e.g. *Kigelia* sausage tree, baobab).

Step 1 — Characteristics of entomophilous flowers:

- Large, brightly coloured petals to attract insects.
- Fragrant, often with nectar guides (UV-visible patterns visible to bees).
- Sticky, sculptured pollen that adheres to insect bodies.
- Nectaries that secrete sugar-rich nectar as a reward.
- Co-evolution with specific pollinators (e.g. *Yucca-Tegeticula* moth, fig-fig wasp).

Final Answer: Entomophily = insect pollination ⇒ [Go Back to Q28](#)

Q29.

Solution

Concept — Auxin and apical dominance: Auxin (chiefly indole-3-acetic acid, IAA) is synthesised in the shoot apical meristem and young leaves, then transported basipetally (downward) through parenchyma cells by an active polar transport system.

Step 1 — Inhibition of lateral buds: High auxin levels suppress the growth of axillary (lateral) buds, keeping the plant tall and single-stemmed. The closer a lateral bud is to the apex, the more strongly it is suppressed.

Step 2 — Practical demonstration: When a gardener pinches off the apical bud (“decapitation”), auxin supply to the lower stem drops → axillary buds break dormancy and grow into lateral branches ⇒ a bushier plant. This is the basis of pruning in horticulture (roses, tea, coffee).

Step 3 — Interaction with cytokinins: Cytokinins (made in roots) antagonise auxin and promote lateral bud growth. The auxin/cytokinin ratio at each bud decides whether it remains dormant (high auxin) or grows (high cytokinin).

Why other options are wrong:

- **Cytokinin:** promotes lateral growth, opposite effect.
- **Gibberellins:** cause stem elongation but not apical dominance.
- **Abscisic acid:** causes dormancy and stomatal closure; not the apical dominance signal.

Final Answer: Auxin (IAA) ⇒ C

Answer: (C) [Go Back to Q29](#)



Q30.

Solution

Concept — Photoperiodism and the critical dark period: Photoperiodism is the response of plants to relative durations of light and dark periods, especially for flowering.

Step 1 — Classification of plants:

- **Short-day plants (SDPs):** flower when day length is shorter than a critical maximum (e.g. *Chrysanthemum*, *Xanthium*, rice, soybean).
- **Long-day plants (LDPs):** flower when day length exceeds a critical minimum (e.g. spinach, wheat, radish).
- **Day-neutral plants:** flower regardless of photoperiod (e.g. tomato, cucumber, sunflower).

Step 2 — The crucial discovery (the “dark period” rule): Hamner and Bonner (1938) showed that what really matters is not day length but **the continuous, uninterrupted dark period**.

- In SDPs: flowering occurs only if the dark period exceeds a critical length. A brief flash of red light during the dark period (night break) prevents flowering.
- In LDPs: flowering occurs only if the dark period is shorter than a critical length.

Step 3 — The photoreceptor: Phytochrome ($Pr \leftrightarrow Pfr$) measures the dark period. The night-break experiment is one of the most elegant demonstrations of phytochrome’s role.

Step 4 — Florigen: Leaves perceive the photoperiod; the signal (now identified as the FT protein, “florigen”) travels through phloem to the shoot apex, where it induces flowering.

Final Answer: SDPs flower when the continuous dark period exceeds a critical length \Rightarrow

Answer: (A) [Go Back to Q30](#)



Q31.

Solution

Concept — Whittaker's five-kingdom classification (1969): Replaced the older two-kingdom (Plantae/Animalia) and three-kingdom systems, recognising the fundamental differences between prokaryotes and various groups of eukaryotes.

Step 1 — The five kingdoms:

- (a) **Monera:** all prokaryotes (true bacteria + archaea + cyanobacteria).
- (b) **Protista:** unicellular eukaryotes (*Amoeba*, *Paramecium*, *Euglena*, diatoms).
- (c) **Fungi:** multicellular (or unicellular like yeast) heterotrophic decomposers; cell wall of chitin.
- (d) **Plantae:** multicellular photoautotrophs; cell wall of cellulose.
- (e) **Animalia:** multicellular heterotrophs; no cell wall.

Step 2 — Five criteria used: Cell type (pro/eukaryotic), cell wall presence/chemistry, body organisation, mode of nutrition (auto/heterotrophic), phylogenetic relationships.

Step 3 — Modern modification: Today, the three-domain system (Carl Woese, 1990) is widely used: Bacteria, Archaea, Eukarya — splitting Whittaker's Monera into two domains based on rRNA differences.

Final Answer: Monera = all prokaryotes ⇒

[Go Back to Q31](#)



Q32.

Solution

Concept — Rules of binomial nomenclature (Linnaeus, 1753, *Species Plantarum*):

Step 1 — The five conventions:

- Each name has **two parts**: genus (generic name) and species (specific epithet). E.g. *Mangifera indica* = mango.
- The **genus** starts with a capital letter; the **species** starts with a small letter.
- Both names are written in **italics** (in print) or **underlined separately** (when handwritten).
- The name should be in Latin or Latinised.
- The name of the author who first described the species is sometimes appended (not italicised): e.g. *Mangifera indica* L. (L. = Linnaeus).

Step 2 — Governing code: International Code of Botanical Nomenclature (ICBN, now ICN), International Code of Zoological Nomenclature (ICZN), International Code of Nomenclature of Bacteria (ICNB).

Why other options are wrong:

- lowercase genus / capital species / all caps:** all violate the conventions.

Final Answer: *Mangifera indica* (capitalised genus, lowercase species, italicised)

⇒ D

Answer: (D) [Go Back to Q32](#)



Q33.

Solution

Concept — Phylum Porifera (sponges): The simplest multicellular animals; mostly marine, sedentary, with a body that operates as a filter pump.

Step 1 — Diagnostic features:

- Cellular grade of organisation (no tissues, organs or organ systems).
- Body bears **ostia** (incurrent pores) and an **osculum** (excurrent pore). Water enters through ostia, passes through the central cavity (**spongocoel**) and exits through the osculum.
- Inner lining of **choanocytes** (collar cells with a flagellum encircled by a microvillar collar) drives water current and traps food.
- Skeletal support: **spicules** (calcareous or siliceous) or **spongin** fibres (protein).
- Reproduction: sexual (hermaphrodite, monoecious) and asexual (budding, fragmentation, gemmules).
- Examples: *Sycon*, *Spongilla* (freshwater), *Euspongia* (bath sponge).

Step 2 — Distinguishing from other phyla:

- **Coelenterata:** tissue grade; nematocysts (stinging cells); polyp/medusa body forms (*Hydra*, jellyfish).
- **Platyhelminthes:** dorso-ventrally flattened, bilateral, acoelomate (planaria, tapeworm).
- **Annelida:** segmented (metameric) coelomates (earthworm, leech).

Step 3 — Identification cues in the question: “Spongocoel”, “choanocytes”, “spicules” — all uniquely pinpoint Porifera.

Final Answer: Porifera (sponges) ⇒

[Go Back to Q33](#)



Q34.

Solution

Concept — HIV and the CD4⁺ T-helper cell: HIV (Human Immunodeficiency Virus) is a retrovirus belonging to the Lentivirus family. It has an RNA genome and uses reverse transcriptase to copy itself into DNA.

Step 1 — Target cell: HIV's surface glycoprotein **gp120** binds specifically to the **CD4 receptor** on T-helper lymphocytes (also expressed at lower levels on macrophages and dendritic cells). gp41 then mediates membrane fusion.

Step 2 — Why CD4⁺ T-helper cells matter: T-helper cells are central coordinators of adaptive immunity. They secrete cytokines that activate cytotoxic T-cells, B-cells, and macrophages. Their progressive destruction (in untreated HIV: $\sim 50\text{--}100$ cells μL^{-1} /year decline) causes immune collapse.

Step 3 — Progression to AIDS: AIDS is diagnosed when CD4 count drops below 200 cells μL^{-1} or an opportunistic infection appears (e.g. *Pneumocystis jirovecii* pneumonia, oral candidiasis, Kaposi's sarcoma, tuberculosis).

Step 4 — Treatment: ART (Antiretroviral Therapy) combines drugs against reverse transcriptase, integrase, and protease. It does not cure HIV but suppresses viral replication, allowing CD4 counts to recover.

Final Answer: CD4⁺ helper T-lymphocytes \Rightarrow

Answer: (C) [Go Back to Q34](#)



Q35.

Solution

Concept — Structure of immunoglobulins (Y-shaped antibody): An immunoglobulin monomer (the basic IgG, IgD, IgE structure) is a tetrameric protein.

Step 1 — Four chains:

- **2 heavy (H) chains:** \sim 440 amino acids each.
- **2 light (L) chains:** \sim 220 amino acids each.
- Joined by interchain disulfide bonds: one between each H-L pair and one or more between the two H chains in the hinge region.
- Both H and L chains have variable (V) and constant (C) regions.

Step 2 — Two functional regions:

- **Fab (Fragment antigen-binding):** the two “arms” of the Y, each formed by one $V_L + V_H$ pair, contain the antigen-binding sites (hypervariable / CDR loops).
- **Fc (Fragment crystallisable):** the “stem” of the Y, made of the constant regions of the heavy chains. Binds Fc receptors on macrophages, neutrophils, NK cells; also activates complement (classical pathway).

Step 3 — Antibody classes (isotypes):

- IgG (most abundant; can cross placenta).
- IgM (pentamer; first response).
- IgA (mucosal secretions; dimer at mucosa).
- IgE (allergy, parasites; binds mast cells).
- IgD (B-cell receptor function).

Why other options are wrong:

- **One H + one L:** a half-antibody, not the complete molecule.
- **Four identical chains:** chains differ — H is much heavier (\sim 50 kDa) than L (\sim 25 kDa).
- **Three heavy chains:** no such immunoglobulin structure.

Final Answer: 2 heavy + 2 light chains in Y-shape, joined by disulfide bridges \Rightarrow

D

Answer: (D) [Go Back to Q35](#)



Q36.

Solution

Concept — Leukaemia (cancer of WBCs): Leukaemia is a malignancy of blood-forming (haematopoietic) cells in the bone marrow, resulting in uncontrolled proliferation of abnormal white blood cells that crowd out normal blood cell production.

Step 1 — Classification: Leukaemias are classified along two axes:

- **Cell lineage:** myeloid vs lymphoid.
- **Onset:** acute (rapid, blast cells dominate) vs chronic (slower, more mature cells).

This gives four main types: AML, ALL, CML, CLL.

Step 2 — Pathophysiology:

- Abnormal WBC count: often very high ($> 50,000 \text{ cells } \mu\text{L}^{-1}$), sometimes low.
- Crowding out of red blood cells \rightarrow anaemia, fatigue.
- Crowding out of platelets \rightarrow bleeding, bruising.
- Crowding out of normal WBCs \rightarrow recurrent infections.

Step 3 — Important example — CML and the Philadelphia chromosome: A reciprocal translocation $t(9;22)(q34;q11)$ creates the BCR-ABL fusion gene encoding a constitutively active tyrosine kinase. This was the first cancer-causing chromosomal abnormality identified (1960). The drug imatinib (Gleevec) targets it — a landmark in personalised cancer therapy.

Why other options are wrong:

- **Hepatocytes:** hepatocellular carcinoma.
- **Keratinocytes:** squamous cell carcinoma or basal cell carcinoma of skin.
- **Smooth muscle:** leiomyoma (benign) or leiomyosarcoma (malignant).

Final Answer: White blood cells originating in bone marrow \Rightarrow **B**

Answer: (B) [Go Back to Q36](#)



Q37.

Solution

Concept — Ecological pyramids of biomass: A pyramid of biomass plots the total dry weight (or carbon content) of organisms at each trophic level. In most terrestrial ecosystems, biomass decreases from producers → herbivores → carnivores — an upright pyramid.

Step 1 — Why oceans are inverted:

- Producers in the open ocean are **phytoplankton**: microscopic, short-lived (~days), with rapid turnover.
- Consumers are zooplankton, small fish, large fish: longer-lived, accumulate more biomass.
- At any single instant, the standing biomass of phytoplankton is less than that of the consumers feeding on them.
- However, productivity (rate of biomass generation over time) is still highest at the producer level — a pyramid of productivity in oceans is upright.

Step 2 — Other inverted examples:

- Tree-based ecosystems where “producers” counted differently: e.g. a single tree (one organism, large biomass) supports thousands of caterpillars (huge biomass when summed); this can give pyramids of number (not biomass) that are inverted.

Step 3 — General principle: Pyramids of energy are always upright (energy is lost as heat at each transfer — second law of thermodynamics). Pyramids of biomass may be inverted under conditions of high turnover. Pyramids of number can be inverted.

Final Answer: Open ocean / pond ecosystem ⇒

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Q38.

Solution

Concept — Lindeman's 10% law of energy transfer: Raymond Lindeman (1942) formulated the foundational principle of trophic dynamics from his study of Cedar Bog Lake (Minnesota).

Step 1 — The principle: Only about 10% of the energy at one trophic level is incorporated into biomass at the next higher level. The remaining ~ 90% is dissipated as:

- Heat from respiration (largest loss; second law of thermodynamics).
- Undigested matter (egesta) passed in faeces.
- Excretion of nitrogenous wastes.
- Not all biomass at one level is consumed; some is decomposed.

Step 2 — Consequence — short food chains: Because energy attenuates by ~ 10× at each step, food chains rarely exceed 4–5 trophic levels — there isn't enough energy left to support a fifth or sixth consumer.

Step 3 — Worked example: If producers fix 10,000 kJ of energy/m²/year, herbivores can support ~ 1,000 kJ, primary carnivores ~ 100 kJ, secondary carnivores ~ 10 kJ. By the fourth trophic level, the available energy is too small to sustain a population.

Step 4 — Variation in real ecosystems: The 10% figure is approximate. Actual ecological efficiencies range from ~ 2% (mammalian endotherms) to ~ 20% (ectotherms like fish), reflecting metabolic strategies. The 10% rule is a useful approximation.

Final Answer: ~ 10% energy transfer ⇒

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Q39.

Solution

Concept — Restriction endonucleases: Restriction enzymes are bacterial defence proteins that cut foreign (typically viral) DNA at specific palindromic recognition sequences. They are key tools in recombinant DNA technology, enabling precise cutting and pasting of DNA fragments.

Step 1 — EcoRI specifics:

- Source: *Escherichia coli* strain R(Y13).
- Recognition site (palindromic): 5'-G↓AATTC-3' / 3'-CTTAA↑G-5'.
- Cuts between G and A on each strand, leaving 5'-AATT single-stranded overhangs ("sticky ends").

Step 2 — Why "palindromic"? A DNA palindrome reads the same 5' → 3' on both strands: GAATTC on top is matched by GAATTC on the bottom (when read 5' → 3'). This palindromic symmetry allows the enzyme (which works as a homodimer) to recognise the sequence in either direction.

Step 3 — Use in cloning:

- Both the gene of interest and the cloning vector (e.g. plasmid pBR322) are cut with the same enzyme (here EcoRI).
- Complementary AATT sticky ends allow base pairing.
- DNA ligase seals the nicks → recombinant DNA.

Step 4 — Other common restriction enzymes:

- BamHI: 5'-G↓GATCC-3'.
- HindIII: 5'-A↓AGCTT-3'.
- SacII: 5'-CCGC↓GG-3'.

Final Answer: EcoRI cuts 5'-GAATTC-3' ⇒

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Q40.

Solution

Concept — Polymerase Chain Reaction (PCR): PCR amplifies a specific DNA segment exponentially through repeated cycles of three temperature-controlled steps, performed in a thermal cycler.

Step 1 — The three steps per cycle:

- (a) **Denaturation** ($\sim 94\text{--}95^\circ\text{C}$): double-stranded DNA template separates into two single strands.
- (b) **Annealing** ($\sim 50\text{--}65^\circ\text{C}$): short oligonucleotide primers (~ 20 bases, flanking the target region) bind to their complementary sequences on each single strand.
- (c) **Extension** ($\sim 72^\circ\text{C}$): a heat-stable DNA polymerase synthesises new DNA, extending from the 3' end of each primer using the template strand.

Step 2 — Why Taq polymerase: Ordinary *E. coli* DNA polymerase I would denature (be destroyed) at the high temperatures used in PCR. Taq polymerase, isolated from the bacterium *Thermus aquaticus* (living in hot springs at $70\text{--}75^\circ\text{C}$), is thermostable and retains activity through repeated heating cycles.

Step 3 — Exponential amplification: After n cycles, the number of copies of the target region is $\sim 2^n$. After 30 cycles: $2^{30} \approx 10^9$ -fold amplification — enough to detect or sequence DNA from minute starting samples (single cell, ancient DNA, forensic sample).

Step 4 — Inventor and applications: Invented by Kary Mullis (1983; Nobel Prize 1993). Used in:

- Disease diagnosis (HIV, tuberculosis, COVID-19 RT-PCR).
- DNA fingerprinting (forensics, paternity).
- Gene cloning and mutation analysis.
- Ancient DNA research (mammoths, Neanderthals).

Final Answer: Taq polymerase from *Thermus aquaticus* \Rightarrow D

Answer: (D) [Go Back to Q40](#)



Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	B	2	D	3	A	4	C	5	A
6	D	7	B	8	C	9	D	10	C
11	B	12	A	13	D	14	A	15	B
16	C	17	A	18	D	19	C	20	B
21	A	22	C	23	B	24	D	25	C
26	A	27	D	28	B	29	C	30	A
31	B	32	D	33	A	34	C	35	D
36	B	37	A	38	C	39	B	40	D

