GAT B Biology

Sample Paper – 6

Duration: 23 Minutes **Maximum Marks: 15**

Instructions

- This paper contains **15** Multiple Choice Questions (Single Correct Answer), modelled on the Biology portion of **GAT B** entrance (Section A).
- Each correct answer carries **+1 mark**. There is **a deduction of 0.5 marks for each incorrect answer**.
- Only **one** option is correct. Choose carefully.
- Syllabus level: **NCERT Class 11 & 12 Biology — Cell Biology, Genetics, Plant & Human Physiology, Ecology, Evolution, and Biotechnology.**
- Use of mobile phones, calculators, or electronic gadgets is strictly prohibited.

Section A — Biology (15 Questions)

Q1. During the cell cycle, which checkpoint acts as the primary "restriction point" that prevents a cell with damaged or unreplicated DNA from advancing into the S phase (DNA synthesis phase)?

(A) Spindle assembly checkpoint

(B) G2/M checkpoint

(C) G1/S checkpoint (restriction point)

(D) Metaphase checkpoint

Q2. In a standard dihybrid cross (AaBb $\times$ AaBb), homozygous recessive alleles at the *second* locus (bb) completely mask phenotypic expression of the first locus regardless of its genotype — a phenomenon called **recessive epistasis**. What is the expected phenotypic ratio in the F_2 generation?

(A) 9 : 3 : 3 : 1

(B) 12 : 3 : 1

(C) 13 : 3

(D) 9 : 3 : 4

Q3. The liver performs numerous vital physiological functions. Which of the following is **NOT** a function of the liver?

(A) Secretion of insulin into the bloodstream

(B) Production and secretion of bile into the duodenum

(C) Detoxification of alcohol, drugs, and metabolic waste products

(D) Storage of glycogen as a glucose reserve

Q4. In rosette plants such as cabbage (*Brassica oleracea*) and mustard (*Brassica juncea*), application of which phytohormone triggers **bolting** — the dramatic rapid elongation of internodes before flowering?

(A) Auxin (IAA)

(B) Gibberellins

(C) Cytokinin

(D) Abscisic acid

Q5. Gymnosperms and angiosperms are both seed-bearing vascular plants. Which structural feature **fundamentally distinguishes** gymnosperms from angiosperms?

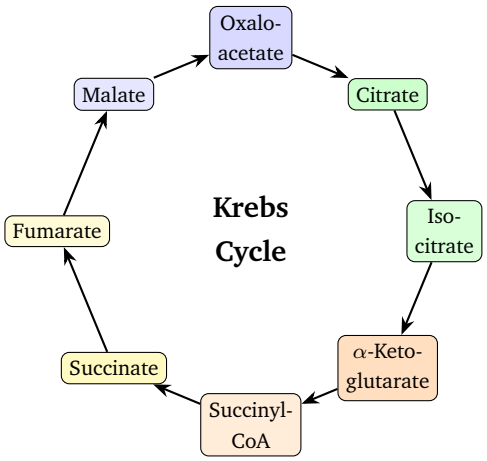
(A) Their seeds are enclosed within a ripened ovary wall (fruit)

(B) They are exclusively pollinated by water (hydrophily)

(C) Their seeds are **naked** — not enclosed within a fruit

(D) They produce true flowers with sepals, petals, stamens, and carpels

Q6. The Krebs cycle (citric acid cycle) is a central metabolic pathway in the mitochondrial matrix. The diagram below shows the eight key intermediates of the cycle.



When acetyl-CoA (2C) condenses with oxaloacetate (4C) under the action of **citrate synthase**, which compound is the **first product** of the Krebs cycle?

(A) Isocitrate

(B) Malate

(C) Succinyl-CoA

(D) Citrate

Q7. During post-transcriptional processing of a eukaryotic pre-mRNA transcript in the nucleus, which specific modification is added **to the 5′ end** of the primary RNA?

(A) A 7-methylguanosine cap (m^7G cap) linked by a 5′–5′ triphosphate bond

(B) A poly-adenylate tail (poly-A tail) of $\sim$200 adenine residues

(C) Removal of introns by the spliceosome complex

(D) An AAUAAA polyadenylation signal sequence

Q8. When blood glucose drops below the normal range (hypoglycaemia), which hormone is released by the **alpha (α) cells** of the islets of Langerhans in the pancreas, and what is its primary action?

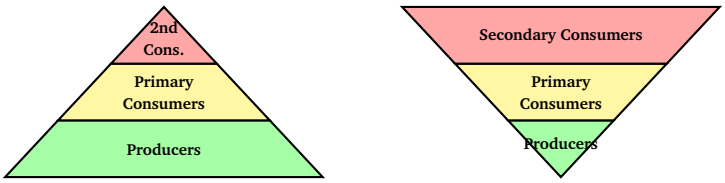
(A) Insulin — promotes glucose uptake by muscle and adipose cells, lowering blood glucose

(B) Glucagon — stimulates glycogenolysis and gluconeogenesis in the liver, raising blood glucose

(C) Somatostatin — inhibits secretion of both insulin and glucagon from the pancreas

(D) Cortisol — promotes protein catabolism and gluconeogenesis in the adrenal cortex

Q9. Ecological pyramids represent the quantitative relationship between trophic levels in an ecosystem. The diagrams below show two contrasting biomass pyramids.



Terrestrial biomass pyramid **Aquatic biomass pyramid**

Which of the following ecological pyramids is commonly observed to be **inverted** (broader at higher trophic levels than at the producer level)?

(A) Pyramid of energy in a terrestrial (grassland) ecosystem

(B) Pyramid of numbers in a grassland ecosystem

(C) Pyramid of biomass in a marine/aquatic (phytoplankton-based) ecosystem

(D) Pyramid of energy in any ecosystem

Q10. During early human pregnancy, the corpus luteum must continue secreting progesterone to maintain the uterine endometrium. Which hormone, secreted by the **trophoblast cells** of the developing placenta, prevents degeneration of the corpus luteum?

(A) Luteinizing hormone (LH) from the anterior pituitary

(B) Follicle-stimulating hormone (FSH) from the anterior pituitary

(C) Oestrogen secreted by the maturing follicle

(D) Human chorionic gonadotropin (hCG) from the trophoblast

Q11. Homologous organs share the same evolutionary origin and underlying anatomical plan, but may perform entirely different functions in different species. Which of the following pairs represents **homologous organs**?

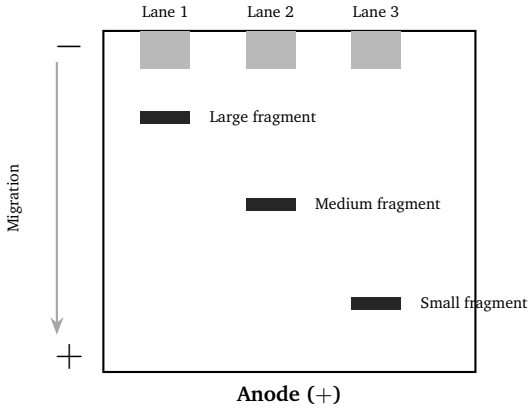
(A) Forelimb of a whale and arm of a human

(B) Wing of a butterfly and wing of a bat

(C) Flipper of a dolphin and fin of a bony fish

(D) Eye of an octopus and eye of a vertebrate

Q12. In agarose gel electrophoresis, DNA samples are loaded into wells cut near one end of the gel and an electric current is applied. Refer to the diagram below.



In which direction does negatively charged DNA migrate when the electric current is applied?

(A) Toward the negative electrode (cathode), since DNA carries positive charges

(B) Toward the positive electrode (anode), since DNA is negatively charged

(C) DNA does not migrate; separation is driven by osmotic pressure differences

(D) Randomly in all directions, depending on fragment size

Q13. CAM (Crassulacean Acid Metabolism) plants — such as cacti (*Opuntia*), agaves, and pineapple — have evolved a distinctive photosynthetic adaptation for survival in hot, arid environments. When do CAM plants open their stomata, and why?

(A) During the day, allowing direct CO_2 fixation by RuBisCO in bright sunlight

(B) Only at dawn and dusk, to avoid extreme midday temperatures

(C) Continuously (day and night), as they lack specialised water-conserving mechanisms

(D) At night, to fix CO_2 as malate and minimise water loss during the cooler dark period

Q14. The human body maintains a stable core temperature of $\approx 37^{\circ}C$ through precise homeostatic thermoregulation. Which region of the brain contains thermosensitive neurons that act as the body's primary **"thermostat,"** detecting temperature deviations and coordinating responses such as sweating, shivering, vasodilation, and vasoconstriction?

(A) Hypothalamus

(B) Cerebellum

(C) Medulla oblongata

(D) Cerebral cortex

Q15. Phylum Annelida (earthworms, leeches, polychaetes) is distinguished from Platyhelminthes (flatworms) and Nematoda (roundworms) by one key structural feature. Which characteristic is the **defining hallmark** of Annelida?

(A) Triploblastic body organisation with three germ layers

(B) Metamerism — true segmentation of the body into repeating units (metameres) separated by septa

(C) Presence of a protective cuticle on the body surface

(D) Bilateral symmetry with a defined anterior and posterior end

Solutions

Sol.1.

Solution

Concept — Cell Cycle Checkpoints: The cell cycle is monitored by surveillance mechanisms called checkpoints that detect errors and halt progression until problems are corrected. The three major checkpoints are the G1/S checkpoint, the G2/M checkpoint, and the spindle assembly checkpoint (SAC).

Step 1 — The G1/S Checkpoint (Restriction Point): The **G1/S checkpoint** sits at the boundary between G1 (first gap/growth phase) and S phase (DNA replication). Before a cell commits to DNA synthesis, this checkpoint verifies: (i) DNA integrity — if DNA damage is detected, the tumour suppressor **p53** is stabilised and transcriptionally activates **p21**, a cyclin-dependent kinase inhibitor that blocks the CDK2–Cyclin E complex, preventing Rb phosphorylation and entry into S phase; (ii) availability of growth factors and nutrients; and (iii) adequate cell size. Only after passing this checkpoint does the cell irreversibly commit to division.

Why other options are wrong:

- Option A (Spindle assembly checkpoint): Operates during M phase (metaphase), ensuring all chromosomes are attached to spindle microtubules via kinetochores before the cell proceeds to anaphase. It does not prevent entry into S phase.
- Option B (G2/M checkpoint): Operates at the G2/M boundary; it verifies that DNA replication in S phase was completed accurately and DNA damage has been repaired before the cell enters mitosis. It is upstream of mitosis, not S phase.
- Option D (Metaphase checkpoint): This is another name for the spindle assembly checkpoint; it operates within M phase to delay anaphase onset. It has no role in controlling S phase entry.

Final Answer: The G1/S checkpoint (restriction point) prevents entry into S phase when DNA is damaged $\Rightarrow$ $\boxed{\text{C}}$

Answer: (C) Go Back to Q 1

Sol.2.

Solution

Concept — Recessive Epistasis and Modified F_2 Ratios: Epistasis occurs when alleles at one gene locus mask or modify expression of a second locus. In *recessive epistasis*, the homozygous recessive genotype at locus B (bb) suppresses the phenotypic effect of both alleles at locus A.

Step 1 — Genotypic classes from AaBb × AaBb: Standard dihybrid cross yields four classes in 9:3:3:1 ratio: 9 A_B_ : 3 A_bb : 3 aaB_ : 1 aabb.

Step 2 — Applying recessive epistasis (bb masks A_):

- 9 A_B_ → **Phenotype 1** (dominant A expressed, non-masking B present)
- 3 aaB_ → **Phenotype 2** (recessive aa expressed, non-masking B)
- 3 A_bb → **Phenotype 3** (A expression masked by bb) } combined = **4**
- 1 aabb → **Phenotype 3** (aa also masked by bb)

Final phenotypic ratio: **9 : 3 : 4**

Why other options are wrong:

- Option A (9:3:3:1): Standard dihybrid ratio with *no epistasis*; obtained when both loci contribute independently to four distinct phenotypes.
- Option B (12:3:1): *Dominant epistasis* ratio — a dominant A_ allele masks locus B, merging 9 A_B_ + 3 A_bb = 12, leaving 3 aaB_ and 1 aabb.
- Option C (13:3): *Duplicate dominant epistasis* — a dominant allele at *either* locus produces one phenotype; only aabb gives the alternative: (9+3+1):3 = 13:3.

Final Answer: Recessive epistasis (bb masks A_) gives an F_2 ratio of 9:3:4 ⇒ D

Answer: (D) Go Back to Q 2

Sol.3.

Solution

Concept — Liver Functions: The liver is the largest glandular organ and performs over 500 physiological functions: bile synthesis, detoxification, glycogen storage, plasma protein synthesis, urea production, cholesterol metabolism, and more.

Step 1 — Insulin is not a liver product: **Insulin** is a polypeptide hormone syn-

thesised and secreted exclusively by the **beta (β) cells** of the **islets of Langerhans** in the **pancreas**. The liver is a *major target* of insulin action (insulin promotes hepatic glucose uptake, glycolysis, and glycogen synthesis), but hepatocytes completely lack the specialised secretory granules and regulated exocytosis machinery of pancreatic β cells. Insulin secretion is therefore NOT a liver function.

Why other options are wrong:

- Option B (Bile production): Hepatocytes continuously synthesise bile (bile salts, cholesterol, bilirubin, phospholipids), stored in the gallbladder and released into the duodenum for fat emulsification. This IS a liver function.
- Option C (Detoxification): The smooth ER of hepatocytes contains cytochrome P450 enzymes that metabolise and detoxify alcohol, pharmaceutical drugs, toxins, and metabolic by-products such as ammonia (converted to urea). This IS a liver function.
- Option D (Glycogen storage): After a carbohydrate meal, excess glucose is polymerised into glycogen in hepatocytes (glycogenesis); during fasting, hepatic glycogen is hydrolysed to maintain blood glucose (glycogenolysis). This IS a liver function.

Final Answer: Insulin is secreted by pancreatic β cells — NOT the liver $\Rightarrow$ $\boxed{\text{A}}$

Answer: (A) Go Back to Q 3

Sol.4.

Solution

Concept — Gibberellins and Bolting: Gibberellins (GAs) are diterpenoid phytohormones produced in young leaves, shoot apices, and developing seeds. They regulate multiple developmental events including seed germination, stem elongation, fruit set, and the transition to flowering.

Step 1 — Gibberellins induce bolting in rosette plants: Rosette plants grow with compressed internodes, giving a flat "rosette" form close to the ground. When **gibberellins** (particularly GA_3 and GA_1) are applied exogenously, or when vernalisation/long-day conditions trigger endogenous GA biosynthesis, they stimulate dramatic **internode elongation** by promoting cell elongation (loosening of cell walls via expansins and α-amylase activity) and cell division in the sub-apical meristem. This abrupt shoot elongation — **bolting** — precedes and is required for inflorescence formation. This response is used as a classic bioassay for gibberellin activity in genetics and plant physiology.

Why other options are wrong:

- Option A (Auxin/IAA): Auxin promotes cell elongation at shoot tips via the "acid growth" mechanism and mediates tropisms and apical dominance; it does not cause the dramatic internode elongation (bolting) seen in rosette plants.
- Option C (Cytokinin): Cytokinins promote cell division and lateral bud growth, delay leaf senescence, and maintain chloroplast function; they do not trigger bolting.
- Option D (Abscisic acid/ABA): ABA is a stress hormone that promotes stomatal closure, seed dormancy, and growth inhibition; it opposes rather than promotes bolting.

Final Answer: Gibberellins induce bolting (rapid internode elongation) in rosette plants $\Rightarrow$ B

Answer: (B) Go Back to Q 4

Sol.5.

Solution

Concept — Gymnosperm vs. Angiosperm Seed Structure: Both gymnosperm and angiosperm seeds contain an embryo and stored food, but they differ crucially in how the seed is enclosed.

Step 1 — Naked seeds in gymnosperms: The word "gymnosperm" derives from Greek *gymnos* (naked) + *sperma* (seed). In gymnosperms (e.g., *Pinus*, *Cycas*, *Ginkgo*, *Ephedra*), ovules are borne *directly on the surface* of megasporophyll (cone scale) without being enclosed by an ovary wall. After fertilisation, the seeds develop exposed ("naked") on the cone scale — they are **not enclosed within a fruit**. In angiosperms (Greek: *angeion* = vessel), the ovule is enclosed within the ovary; fertilisation triggers the ovary to develop into a fruit around the seed.

Why other options are wrong:

- Option A (Seeds enclosed within a fruit): This defines *angiosperms*, not gymnosperms. Fruit formation requires a carpel enclosing the ovule, which gymnosperms lack.
- Option B (Water pollination/hydrophily): Gymnosperms are wind-pollinated (anemophilous); they produce copious light, dry pollen shed into the air. Hydrophily (water-mediated pollination) occurs in certain aquatic angiosperms such as *Vallisneria* and *Zostera*.

- Option D (True flowers with sepals and petals): True flowers (with perianth, androecium, and gynoecium) are the defining reproductive structures of *angiosperms*. Gymnosperms produce cones (strobili), not flowers.

Final Answer: Gymnosperms bear naked seeds not enclosed within a fruit $\Rightarrow$ C

Answer: (C) Go Back to Q 5

Sol.6.

Solution

Concept — First Reaction of the Krebs Cycle: The Krebs cycle (citric acid cycle) occurs in the mitochondrial matrix and oxidises acetyl groups derived from carbohydrate, fat, and amino acid catabolism. Each full turn oxidises one 2-carbon acetyl group and regenerates the 4-carbon acceptor oxaloacetate.

Step 1 — Citrate synthase reaction: The **first** and rate-limiting step of the Krebs cycle is catalysed by **citrate synthase**: the condensation of **acetyl-CoA (2C)** with **oxaloacetate (4C)** in the presence of water to yield **citrate (6C)** and free coenzyme A:

$$\text{Oxaloacetate (4C)} + \text{Acetyl-CoA (2C)} + H_2O \xrightarrow{\text{citrate synthase}} \text{Citrate (6C)} + \text{CoA-SH}$$

In the diagram, the arrow from **Oxaloacetate** directly to **Citrate** (top to upper-right) confirms that **Citrate** is the immediate, first product.

Why other options are wrong:

- Option A (Isocitrate): Isocitrate is the *third* intermediate, formed from citrate by the enzyme aconitase (via the intermediate cis-aconitate); it is two steps away from the starting condensation.
- Option B (Malate): Malate is the *seventh* intermediate (second from last), formed from fumarate by fumarase near the end of the cycle; it is far downstream.
- Option C (Succinyl-CoA): Succinyl-CoA is the *fifth* intermediate, formed from α-ketoglutarate by the α-ketoglutarate dehydrogenase complex with release of CO_2 and reduction of NAD^+.

Final Answer: Citrate is the first product when acetyl-CoA condenses with oxaloacetate $\Rightarrow$ D

Answer: (D) Go Back to Q 6

Sol.7.

Solution

Concept — Post-Transcriptional Processing of Eukaryotic mRNA: Eukaryotic pre-mRNA undergoes three major modifications in the nucleus before export: 5′ capping, 3′ polyadenylation, and splicing. These modifications protect the mRNA, facilitate nuclear export, and enhance translational efficiency.

Step 1 — The 5′ cap (m^7G cap): Shortly after transcription begins (when the nascent transcript is only ∼20–30 nucleotides long), a **7-methylguanosine (m^7G) cap** is co-transcriptionally added to the 5′ end. The cap guanosine is connected to the 5′-terminal nucleotide of the mRNA via an unusual **5′–5′ triphosphate linkage** (not the standard 3′–5′ phosphodiester bond). The N-7 position of the guanine ring is then methylated. Functions: (i) protects mRNA from degradation by 5′ exonucleases; (ii) facilitates nuclear export via cap-binding complex (CBC); (iii) promotes ribosome binding during translation initiation via eIF4E interaction.

Why other options are wrong:

- Option B (Poly-A tail): A poly-adenylate tail of 150–250 adenine residues is added to the *3′ end* — not the 5′ end — by poly-A polymerase after endonucleolytic cleavage at the polyadenylation signal.
- Option C (Intron splicing): Introns are removed from the *interior* of the pre-mRNA by the spliceosome (snRNA–protein complexes); this is not a modification of the 5′ end specifically.
- Option D (AAUAAA signal): This hexameric sequence is the *polyadenylation signal* located in the 3′ UTR; it directs cleavage and poly-A addition to the 3′ end, not the 5′ end.

Final Answer: A 7-methylguanosine cap is added to the 5′ end of eukaryotic pre-mRNA ⇒ A

Answer: (A) Go Back to Q 7

Sol.8.

Solution

Concept — Pancreatic Hormone Secretion and Glucose Homeostasis: The islets of Langerhans in the pancreas contain three major cell types: alpha (α) cells (secrete glucagon, $\sim$25%), beta (β) cells (secrete insulin, $\sim$70%), and delta (δ) cells (secrete somatostatin, $\sim$5%). These act antagonistically to maintain blood glucose within 70–100 mg/dL.

Step 1 — Glucagon from α cells in hypoglycaemia: When blood glucose falls below $\sim$70 mg/dL, pancreatic **alpha (α) cells** release **glucagon**, a 29-amino-acid polypeptide. Glucagon binds to glucagon receptors (GPCRs) on hepatocytes, activating adenylyl cyclase and raising cAMP, which:

- Activates **glycogen phosphorylase** $\rightarrow$ **glycogenolysis** (hepatic glycogen $\rightarrow$ glucose-1-phosphate $\rightarrow$ glucose)
- Induces **gluconeogenic enzymes** $\rightarrow$ **gluconeogenesis** (amino acids, glycerol, lactate $\rightarrow$ glucose)

Both actions raise blood glucose back to normal.

Why other options are wrong:

- Option A (Insulin from alpha cells): Insulin is secreted by *beta (β) cells*, not alpha cells; insulin lowers blood glucose by promoting cellular uptake and glycogen synthesis — the opposite effect needed in hypoglycaemia.
- Option C (Somatostatin): Secreted by delta (δ) cells; acts as a paracrine inhibitor of both insulin and glucagon release; it is not the primary hormone triggering the counter-regulatory response to hypoglycaemia.
- Option D (Cortisol): A glucocorticoid from the adrenal cortex (zona fasciculata), *not* the pancreas; while cortisol promotes gluconeogenesis during prolonged stress, it is not the immediate pancreatic response to acute hypoglycaemia.

Final Answer: Alpha (α) cells secrete glucagon, raising blood glucose via glycogenolysis and gluconeogenesis $\Rightarrow$ $\boxed{\text{B}}$

Answer: (B) Go Back to Q 8

Sol.9.

Solution

Concept — Ecological Pyramids and the Inverted Biomass Pyramid: Ecological pyramids graphically represent the quantitative relationships between trophic levels. While pyramids of *energy* are always upright (due to the 10% energy transfer efficiency), pyramids of *biomass* and *numbers* can sometimes be inverted.

Step 1 — Inverted biomass pyramid in aquatic ecosystems: In open ocean (pelagic) ecosystems, producers are predominantly **phytoplankton** — microscopic algae and cyanobacteria with very high *turnover rates* (division times of hours to days). Despite high primary productivity, the **standing crop biomass** of phytoplankton at any instant is very low because they are consumed rapidly by zooplankton. Zooplankton (primary consumers) and fish (secondary consumers) have slower reproduction rates but accumulate more biomass per individual. At any given moment: phytoplankton biomass $<$ zooplankton biomass $<$ fish biomass, creating an **inverted pyramid of biomass**, as illustrated in the right diagram.

Why other options are wrong:

- Option A (Energy pyramid in grassland): Pyramids of energy are *always upright* — at each trophic level, $\sim$90% of energy is lost as metabolic heat (Lindeman's 10% rule); energy can never increase up trophic levels, in any ecosystem.
- Option B (Numbers pyramid in grassland): In a grassland, producers (grasses) vastly outnumber herbivorous insects, which outnumber carnivores — this forms an upright numbers pyramid.
- Option D (Energy pyramid in any ecosystem): The second law of thermodynamics guarantees that energy pyramids are always upright regardless of ecosystem type; the inverted energy pyramid does not exist in nature.

Final Answer: The pyramid of biomass in a marine/aquatic ecosystem is inverted due to the low standing crop of phytoplankton $\Rightarrow$ $\boxed{\text{C}}$

Answer: (C) Go Back to Q 9

Sol.10.

Solution

Concept — hCG and Corpus Luteum Maintenance: After ovulation, the ruptured follicle transforms into the corpus luteum, which secretes progesterone and estrogen to prepare and maintain the uterine endometrium. Without rescue, the corpus luteum degenerates after $\sim$14 days (causing menstruation). In pregnancy, it must be sustained until the placenta takes over steroidogenesis.

Step 1 — hCG rescues the corpus luteum: Within days of implantation, trophoblast cells of the developing embryo synthesise and secrete **human chorionic gonadotropin (hCG)**, a glycoprotein hormone sharing structural similarity with LH (both have identical α subunits; the β subunit of hCG is unique and is what pregnancy tests detect). hCG binds to **LH receptors** on the corpus luteum, mimicking the LH signal and **preventing its regression**. The corpus luteum continues secreting progesterone throughout the first trimester until the *luteo-placental shift* (weeks 8–10), after which the placenta itself produces sufficient progesterone. hCG peaks around weeks 8–10 and is the analyte detected in urine/serum pregnancy tests.

Why other options are wrong:

- Option A (LH from anterior pituitary): Maternal LH is *suppressed* during early pregnancy by the negative feedback of rising progesterone and estrogen; hCG substitutes for LH in maintaining the corpus luteum.
- Option B (FSH from anterior pituitary): FSH promotes folliculogenesis in the non-pregnant cycle; it is also suppressed during pregnancy and has no role in corpus luteum maintenance.
- Option C (Oestrogen): Oestrogen is *produced by* the corpus luteum (and later the placenta), not a signal that prevents its degeneration; it acts on uterus and breast tissue but does not rescue the corpus luteum.

Final Answer: hCG from trophoblast cells maintains the corpus luteum in early pregnancy $\Rightarrow$ $\boxed{\text{D}}$

Answer: (D) Go Back to Q 10

Sol.11.

Solution

Concept — Homologous vs. Analogous Organs: Homologous organs share the same evolutionary origin (derived from the same ancestral structure) and the same underlying anatomical plan, but may perform different functions due to adaptation to different environments (divergent evolution). **Analogous organs** perform similar functions but arose independently via convergent evolution and have entirely different structural origins.

Step 1 — Forelimb of a whale and arm of a human: Both structures are derived from the same ancestral tetrapod forelimb. Despite serving different functions (whale flipper: aquatic propulsion; human arm: manipulation and tool use), both contain *identical bones in the same sequence*: **humerus** (upper arm/flipper), **radius** and **ulna** (forearm), **carpals** (wrist), **metacarpals**, and **phalanges** (digits). This shared anatomical blueprint despite different ecological roles is classic evidence for divergent evolution from a common ancestor — a Devonian lobe-finned fish ancestor of all tetrapods.

Why other options are wrong:

- Option B (Butterfly wing & bat wing): These are *analogous* organs — both enable flight but have completely different structural origins. Butterfly wings are cuticular extensions of the exoskeleton (no internal bones); bat wings are modified tetrapod forelimbs. No common ancestral "wing" structure — convergent evolution.
- Option C (Dolphin flipper & fish fin): Fish fins lack the internal bone arrangement (humerus–radius–ulna–carpals) of tetrapod forelimbs. While both are used for aquatic locomotion (analogy), they are not derived from the same ancestral structure; this is convergent evolution.
- Option D (Octopus eye & vertebrate eye): A canonical example of *convergent evolution*: both eyes have a lens and retina and function similarly, but they evolved independently from different ancestral photoreceptive cells. Notably, the cephalopod retina is everted (photoreceptors face light) while the vertebrate retina is inverted (photoreceptors face away from light).

Final Answer: The forelimb of a whale and the arm of a human are homologous organs $\Rightarrow$ $\boxed{\text{A}}$

Answer: (A) Go Back to Q 11

Sol.12.

Solution

Concept — Gel Electrophoresis and DNA Migration: Agarose gel electrophoresis separates DNA fragments by size using an electric field. The gel matrix acts as a molecular sieve: smaller fragments thread through pores more easily and travel farther in a given time.

Step 1 — Charge of DNA and direction of migration: The **phosphodiester backbone** of DNA contains one phosphate group per nucleotide, each carrying a **negative charge** (-1) at physiological pH. DNA is therefore a highly negatively charged polyanion. When an electric field is applied, all negatively charged molecules migrate toward the **positive electrode (anode)**. As shown in the diagram: DNA is loaded into wells near the **negative electrode** $(-)$ **at the top**; upon applying current, DNA migrates **downward toward the positive electrode** $(+)$ **at the bottom**.

Step 2 — Size-based separation: Smaller fragments experience less resistance as they pass through agarose pores and therefore travel **farther** (closer to the anode) within the same time. Larger fragments are retarded by the gel matrix and remain **closer to the wells** (as illustrated: large fragment at top, small fragment near the bottom).

Why other options are wrong:

- Option A (Toward cathode/$-$): Only positively charged molecules move toward the cathode. DNA carries negative charges and therefore moves toward the anode $(+)$.
- Option C (Osmosis): Separation is driven entirely by the *electric field* acting on charged DNA molecules. Osmosis involves passive movement of water across a semipermeable membrane and plays no role in electrophoretic separation.
- Option D (Random directions): In a uniform electric field, all negatively charged DNA molecules migrate consistently in one direction — toward the positive electrode — not randomly. Size only affects *speed*, not direction.

Final Answer: DNA migrates toward the positive electrode (anode) because it is negatively charged $\Rightarrow$ $\boxed{\text{B}}$

Answer: (B) Go Back to Q 12

Sol.13.

Solution

Concept — CAM Photosynthesis (Crassulacean Acid Metabolism): CAM is an evolutionary adaptation in succulent plants of arid environments that temporally separates primary CO_2 fixation (at night) from the Calvin cycle (during the day), greatly reducing water loss through transpiration.

Step 1 — Nocturnal stomatal opening: CAM plants open their **stomata at night**, when ambient temperature is lower and humidity is higher, dramatically limiting transpirational water loss compared to daytime opening:

- **Night**: Stomata open $\rightarrow$ CO_2 enters $\rightarrow$ fixed by **PEP carboxylase** (PEP + CO_2 $\rightarrow$ oxaloacetate $\rightarrow$ malate); malate stored as **malic acid** in large vacuoles.
- **Day**: Stomata *close* (minimising water loss) $\rightarrow$ stored malate is exported from vacuoles and **decarboxylated** to release CO_2 $\rightarrow$ CO_2 is refixed by **RuBisCO** via the Calvin cycle in the same mesophyll cells.

This temporal separation (carbon fixation at night; Calvin cycle in day) in the *same cells* distinguishes CAM from C4 photosynthesis (which uses spatial separation across different cell types).

Why other options are wrong:

- Option A (Daytime opening): CAM plants keep stomata *closed* during hot days to prevent excessive water loss in arid conditions. Daytime opening defeats the entire adaptive purpose of CAM.
- Option B (Only at dawn/dusk): CAM plants open stomata *throughout the entire night* to maximise CO_2 uptake and malate storage; restricting opening to only dawn and dusk would drastically reduce carbon fixation.
- Option C (Continuously): Continuous stomatal opening would expose CAM plants to severe daytime water loss and prevent the temporal separation of carboxylation steps that defines CAM metabolism.

Final Answer: CAM plants open stomata **at night** to fix CO_2 as malate, conserving water by keeping stomata closed during the day $\Rightarrow$ $\boxed{D}$

Answer: (D) Go Back to Q 13

Sol.14.

Solution

Concept — Thermoregulation and the Hypothalamus: Mammals are homeothermic (warm-blooded) — they maintain a stable core temperature independent of the environment. This is achieved via a negative feedback control system analogous to a thermostat, with the **hypothalamus** serving as the primary control centre.

Step 1 — The hypothalamic thermostat: The **preoptic area of the anterior hypothalamus** contains two populations of thermosensitive neurons that monitor blood temperature continuously:

- **Warm-sensitive neurons**: when body temperature rises above the set point ($\sim$37°C), they activate heat-dissipating responses: cutaneous **vasodilation** (increased skin blood flow for radiative heat loss), **sweating** (evaporative cooling via eccrine glands), and behavioural responses (seeking shade, removing clothing).
- **Cold-sensitive neurons** (posterior hypothalamus): when temperature falls below set point, they activate heat-generating/conserving responses: **shivering thermogenesis** (rapid skeletal muscle contractions), **non-shivering thermogenesis** (brown adipose tissue activation via norepinephrine), and cutaneous **vasoconstriction** (reducing heat loss from skin).

The hypothalamus compares actual blood temperature with the set point and sends corrective signals to skin, muscles, and endocrine glands.

Why other options are wrong:

- Option B (Cerebellum): The cerebellum coordinates voluntary motor movements, balance, and posture; it receives proprioceptive, vestibular, and visual inputs. It has no role in temperature regulation.
- Option C (Medulla oblongata): The medulla contains autonomic control centres for heart rate, respiratory rhythm, blood pressure, swallowing, and vomiting; thermoregulation is not its primary function.
- Option D (Cerebral cortex): The cortex handles higher cognitive functions, conscious sensory perception (including temperature sensation via somatosensory cortex), language, and voluntary movement; it is not the primary thermoregulatory centre (though it contributes to behavioural thermoregulation).

Final Answer: The hypothalamus is the body's primary thermoregulatory centre (thermostat) $\Rightarrow$ $\boxed{\text{A}}$

Answer: (A) Go Back to Q 14

Sol.15.

Solution

Concept — Phylum Annelida and Metamerism: Annelida (from Latin *annellus* = little ring) are segmented worms belonging to the superphylum Lophotrochozoa. Their most distinctive feature — the innovation that separates them from other worm-like phyla — is **metamerism**.

Step 1 — Metamerism: the defining characteristic: The annelid body is divided into a linear series of repeating segments called **metameres** (somites), each separated by transverse partitions called **septa**. Each metamere is virtually a self-contained unit containing its own: pair of **nephridia** (excretory organs), pair of **nerve ganglia** connected by a ventral nerve cord, longitudinal and circular muscles, and coelomic compartment. Adaptive advantages of metamerism include: compartmentalisation of the coelom enabling independent segment movement, redundancy of vital organs, and efficient burrowing locomotion.

Platyhelminthes (flatworms) are acoelomate or pseudocoelomate with no true segmentation. **Nematoda** (roundworms) are pseudocoelomate with an unsegmented body. Neither phylum possesses the septa-separated, serially repeated metameres of Annelida.

Why other options are wrong:

- Option A (Triploblastic body): Both Platyhelminthes and Nematoda are also triploblastic (derived from ectoderm, mesoderm, and endoderm). Triploblasty is therefore shared across many animal phyla and does not uniquely distinguish Annelida.
- Option C (Cuticle): While annelids have a thin moist cuticle, *nematodes also possess a prominent cuticle* (a multi-layered collagenous structure that is moulted four times during development). Cuticle presence therefore does not uniquely identify Annelida.
- Option D (Bilateral symmetry): Bilateral symmetry is shared by Platyhelminthes and Nematoda as well as virtually all bilaterian animals; it does not distinguish Annelida from the other two phyla mentioned.

Final Answer: Metamerism (true body segmentation) is the defining characteristic of Annelida $\Rightarrow$ B

Answer: (B) Go Back to Q 15

Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	C	2	D	3	A	4	B	5	C
6	D	7	A	8	B	9	C	10	D
11	A	12	B	13	D	14	A	15	B