GUJCET Biology

Sample Paper – 7

Duration: 60 Minutes **Maximum Marks: 40**

Instructions

- This paper contains **40** Multiple Choice Questions (Single Correct Answer), modelled on the Biology portion of **GUJCET** (Gujarat Common Entrance Test).
- Each correct answer carries **+1 mark**. There is a negative marking of -0.25 **marks** for each incorrect answer. Unanswered questions carry no penalty.
- Only **one** option is correct per question. Mark responses on the OMR sheet carefully.
- Syllabus level: **GSEB Class 11–12 Biology (NCERT aligned) — Human Physiology, Plant Physiology, Reproduction, Genetics, Ecology, Biotechnology.**
- Use of mobile phones, calculators, or any electronic device is strictly prohibited.

Q1. Which of the following correctly describes a function of the liver related to lipid metabolism?

A. Secretion of insulin to regulate blood glucose levels after a meal

B. Production of erythropoietin that stimulates red blood cell formation

C. Synthesis of bile salts from cholesterol, which emulsify dietary fats in the duodenum

D. Secretion of glucagon to raise blood glucose during fasting

Q2. After absorption of long-chain fatty acids and monoglycerides in the small intestinal epithelium, these lipids are reassembled and transported as:

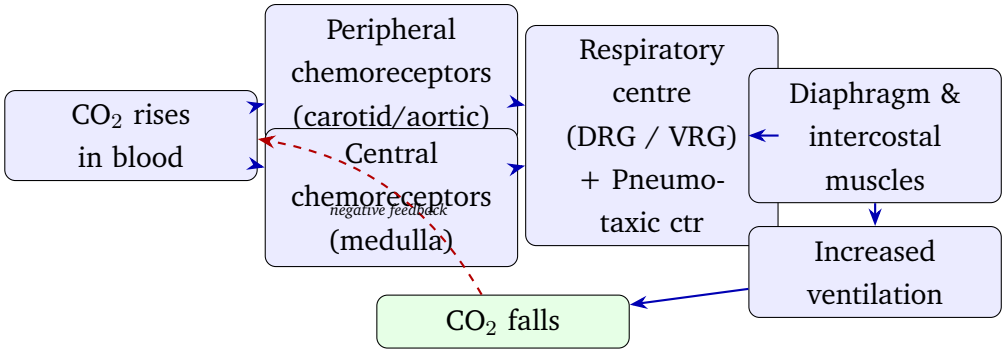
A. Free fatty acids bound to albumin directly entering the hepatic portal vein

B. Very low-density lipoproteins (VLDL) secreted directly into the intestinal capillaries

C. Micelles that pass through the thoracic duct without any protein coating

D. Chylomicrons absorbed into lacteals (lymph capillaries) and carried through the lymphatic system before entering the blood

Q3. Refer to the diagram of breathing regulation. Which statement correctly describes the role of the pneumotaxic center?



A. The pneumotaxic center (in the pons) sends inhibitory signals to the DRG, switching off inspiration and thereby limiting the duration of each breath

B. The pneumotaxic center initiates each breath by stimulating the DRG; without it, breathing stops completely

C. The pneumotaxic center responds only to blood oxygen levels and has no influence over breath duration

D. The pneumotaxic center activates the ventral respiratory group (VRG) exclusively during forced expiration

Q4. Which statement correctly distinguishes asthma from emphysema in terms of their pathophysiology?

A. Asthma involves permanent destruction of alveolar walls, leading to reduced surface area; emphysema involves reversible bronchoconstriction

B. Asthma is characterised by reversible bronchoconstriction due to hypersensitivity (often allergic); emphysema involves irreversible loss of alveolar elasticity and enlargement of air spaces

C. Both asthma and emphysema are caused by bacterial infection of the lower respiratory tract and are treated with antibiotics

D. Emphysema primarily affects the upper airways and bronchi, while asthma specifically destroys alveolar walls

Q5. Which plasma protein is primarily responsible for maintaining the colloid osmotic pressure (oncotic pressure) of blood, thereby preventing excessive fluid loss into interstitial tissues?

A. Fibrinogen, which forms a clot at vessel walls to seal osmotic leakage

B. Prothrombin, which works with platelets to maintain intravascular pressure

C. Albumin, the most abundant plasma protein that exerts the greatest oncotic pressure in blood vessels

D. Globulins, which bind to antigens and prevent osmotic imbalance via immune complexes

Q6. A patient presents with elevated eosinophil count (eosinophilia) in a complete blood count. This finding is most likely associated with:

A. Acute bacterial sepsis requiring aggressive phagocytosis by neutrophils

B. A viral infection that has activated cytotoxic T-lymphocytes and B-cell antibody production

C. A systemic autoimmune disorder in which monocytes differentiate into activated macrophages

D. An allergic reaction or helminthic (parasitic worm) infection, as eosinophils release granules toxic to parasites and mediate allergic responses

Q7. The juxtaglomerular apparatus (JGA) releases renin. Which stimulus is the PRIMARY trigger for renin secretion by JG (granular) cells?

A. A fall in blood pressure (reduced stretch of the afferent arteriole) or detection of low Na^+ concentration in tubular filtrate by the macula densa

B. A rise in blood pressure that stretches the afferent arteriole, signalling the need for greater filtration

C. High aldosterone levels in the blood stimulating JG cells via a positive feedback loop

D. Elevated blood glucose triggering osmoreceptors in the distal convoluted tubule wall

Q8. Hemodialysis removes metabolic waste products from the blood of patients with renal failure. The underlying principle is:

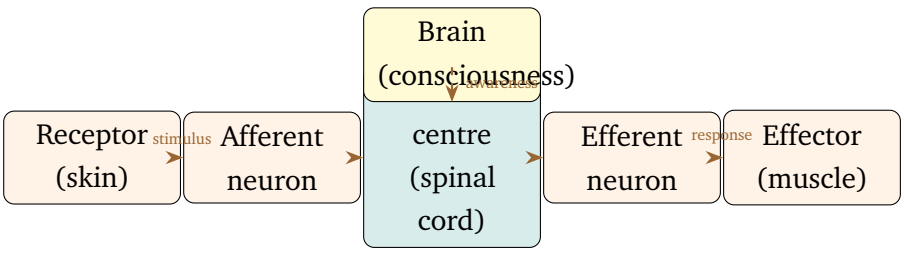
A. Active transport of urea and creatinine across the dialysis membrane using cellular ATP

B. Diffusion of waste solutes (urea, creatinine, excess ions) from the patient's blood down their concentration gradient across a semi-permeable membrane into the dialysate solution

C. Pressure filtration identical to glomerular filtration, relying on blood pressure alone

D. Osmosis of water from the dialysate into the blood to dilute toxic substances to safe levels

Q9. Refer to the reflex arc diagram. Which component of the arc carries the motor impulse from the spinal cord to the effector organ?



A. Afferent neuron, which carries sensory signals from skin to the spinal cord

B. Receptor in the skin, which detects the initial stimulus

C. Efferent neuron, which transmits motor commands from the nerve centre to the effector

D. Interneuron located entirely within the nerve centre (spinal cord)

Q10. Which of the following statements about the meninges and cerebrospinal fluid (CSF) is CORRECT?

A. The dura mater is the innermost layer of the meninges, closely adherent to the brain surface

B. CSF is produced in the subarachnoid space and circulates only around the spinal cord, not the brain

C. The pia mater is the outermost, tough fibrous layer of the meninges composed of dense connective tissue

D. CSF is secreted by the choroid plexus within the brain ventricles, circulates through the subarachnoid space, and cushions the brain against mechanical shock

Q11. Which statement about the hormones secreted by the islets of Langerhans in the pancreas is CORRECT?

A. Alpha (α) cells secrete glucagon, which raises blood glucose by stimulating glycogenolysis and gluconeogenesis in the liver

B. Beta (β) cells secrete somatostatin, which inhibits the secretion of both insulin and glucagon

C. Delta (δ) cells secrete insulin, the most important hormone for lowering blood glucose

D. Pancreatic polypeptide is secreted by alpha cells and stimulates gastric acid secretion

Q12. The middle lamella, which cements adjacent plant cells together and is solubilised during fruit ripening, is primarily composed of:

A. Cellulose microfibrils cross-linked by hemicellulose, forming a crystalline lattice

B. Calcium pectate (calcium salts of pectic acid), a gel-like polysaccharide that acts as an intercellular adhesive

C. Chitin, a nitrogen-containing polysaccharide similar to the cell walls of fungi

D. Peptidoglycan, a polymer of N-acetylglucosamine and N-acetylmuramic acid

Q13. The characteristic "9+2" arrangement of microtubules forming the axoneme is found in which of the following structures?

A. The mitotic spindle connecting centrosomes to chromosomes during metaphase

B. The sarcomere of skeletal muscle, where actin thin filaments interdigitate with myosin

C. Cilia and eukaryotic flagella, which contain 9 peripheral microtubule doublets surrounding 2 central singlets

D. The nuclear lamina that provides mechanical support to the inner nuclear membrane

Q14. Which statement correctly contrasts lysosomes and peroxisomes in eukaryotic cells?

A. Lysosomes contain catalase to break down H_2O_2; peroxisomes contain acid hydrolases for intracellular digestion

B. Peroxisomes perform autophagy by digesting damaged organelles; lysosomes carry out β-oxidation of very-long-chain fatty acids

C. Both organelles originate from the rough endoplasmic reticulum and have identical enzyme content

D. Lysosomes contain acid hydrolases and perform autophagy (digesting damaged organelles); peroxisomes contain catalase and carry out β-oxidation of fatty acids

Q15. One centimorgan (cM), also called a map unit, is defined as the genetic distance between two loci that show:

A. 1% recombination frequency between them during meiosis

B. 10% recombination frequency, representing one crossover per ten meiotic divisions

C. 0% recombination, indicating completely linked loci that never undergo crossing over

D. 50% recombination frequency, indicating independent assortment on separate chromosomes

Q16. In a dihybrid cross involving two genes where the F_2 generation shows a phenotypic ratio of 9:3:4, which type of gene interaction is responsible?

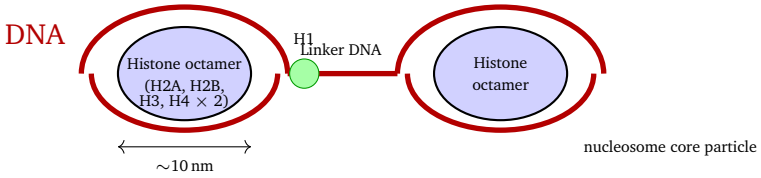
A. Dominant epistasis, producing a 12:3:1 ratio where one dominant allele masks expression of the other gene

B. Recessive epistasis, where the homozygous recessive genotype at one locus masks the phenotypic expression of the other gene

C. Duplicate dominant epistasis, where the presence of at least one dominant allele at either locus produces the same phenotype (15:1 ratio)

D. Codominance, where both alleles are simultaneously expressed in heterozygotes

Q17. Refer to the nucleosome diagram. How many times does DNA wrap around the histone octamer core in a single nucleosome core particle?



A. Exactly 1.0 turn (one complete revolution around the octamer)

B. Exactly 2.0 turns, accommodating approximately 200 base pairs

C. Approximately 1.75 turns, encompassing ∼147 base pairs of DNA

D. Exactly 0.5 turns (half a revolution), with the rest as linker DNA

Q18. Which statement about ribosomal RNA (rRNA) is CORRECT?

A. rRNA is the least abundant RNA in a cell, constituting less than 5% of total cellular RNA

B. rRNA carries specific amino acids to the ribosome during the elongation step of translation

C. rRNA is itself translated by the ribosome to produce structural ribosomal proteins

D. rRNA is the most abundant RNA type (∼80% of total RNA) and forms both the structural scaffold and the catalytic (peptidyl transferase) active site of ribosomes

Q19. In sickle cell anemia, the single point mutation in the β-globin gene causes which specific amino acid substitution?

A. Glutamic acid (hydrophilic, negatively charged) is replaced by valine (hydrophobic) at position 6 of the β-globin polypeptide chain

B. Valine is replaced by glutamic acid at position 6, making HbS more soluble than normal HbA

C. A frameshift caused by deletion of three nucleotides alters the entire β-globin reading frame

D. Insertion of an extra codon produces an elongated β-globin chain with abnormal haem-binding

Q20. Bread wheat (*Triticum aestivum*) is hexaploid (2n = 6x = 42) and is believed to have originated from crosses between three diploid ancestral species followed by chromosome doubling. This is an example of:

A. Autopolyploidy, in which all chromosome sets are derived from within the same species through non-disjunction

B. Allopolyploidy, in which chromosome sets are contributed by two or more genetically distinct ancestral species

C. Aneuploidy, involving the addition or deletion of a single chromosome from the normal diploid complement

D. Induced polyploidy, produced entirely by exposure to X-rays causing chromosome doubling

Q21. Which of the following is a necessary condition for a population to remain in Hardy-Weinberg equilibrium from generation to generation?

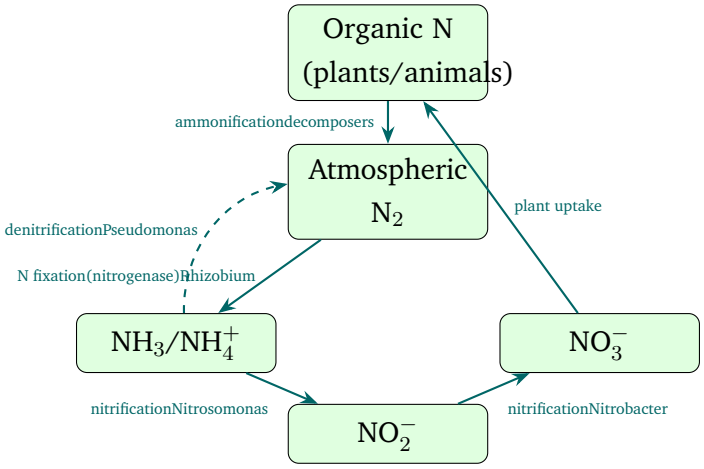
A. Strong directional natural selection favouring heterozygotes over both homozygote classes

B. A very small, isolated population subject to substantial genetic drift each generation

C. No selection, no mutation, no migration, no genetic drift, and random mating within a large population

D. High mutation rates balanced by immigration of new alleles from adjacent populations

Q22. Refer to the nitrogen cycle diagram. Which enzyme directly catalyses the conversion of atmospheric N_2 to ammonia (NH_3) during biological nitrogen fixation?



A. Nitrate reductase, an enzyme found in plant roots that reduces NO_3^- to NO_2^-

B. Nitrite reductase, converting nitrite (NO_2^-) to ammonium (NH_4^+) in plant plastids

C. Glutamine synthetase, which incorporates NH_4^+ into glutamine for amino acid biosynthesis

D. Nitrogenase, the enzyme complex in nitrogen-fixing bacteria (e.g., *Rhizobium*) that reduces N_2 to NH_3 using 16 ATP per N_2

Q23. A crop plant shows yellowing (chlorosis) that appears earliest and most severely in the older, lower leaves, while younger apical leaves remain green. Which nutrient deficiency most likely explains this pattern?

A. Nitrogen deficiency, since N is a mobile nutrient that is remobilised from older leaves to actively growing younger tissue when supply is limiting

B. Iron deficiency, which causes interveinal chlorosis that appears first in the youngest (uppermost) leaves

C. Calcium deficiency, which causes tip burn, curling, and death of young leaves because Ca is immobile in the phloem

D. Sulphur deficiency, which produces uniform yellowing of young leaves before affecting older ones

Q24. During germination of cereal (barley or wheat) grains, gibberellins secreted by the embryo stimulate the aleurone layer to synthesise and secrete which enzyme that mobilises stored starch for the growing embryo?

A. α-amylase inhibitor, which prevents premature starch hydrolysis during seed storage

B. α-amylase, which hydrolyses α-1,4-glycosidic bonds in starch, releasing maltose and glucose

C. Lipase, which breaks down triglycerides stored in the aleurone layer into fatty acids

D. Protease, which degrades gluten storage proteins in the endosperm into amino acids

Q25. The rapid folding of *Mimosa pudica* leaflets upon mechanical touch is classified as which type of plant movement?

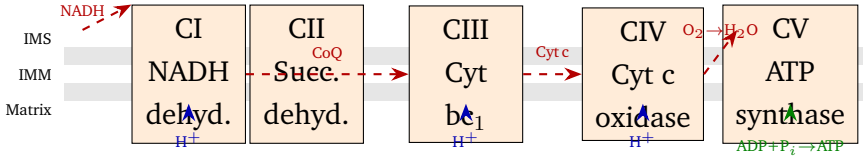
A. Phototropism, a directional growth movement in response to a light gradient

B. Thigmotropism, a directional growth response to sustained mechanical contact (as in climbing plants)

C. Seismonasty (thigmonasty), a non-directional nastic movement triggered by touch, mediated by rapid turgor changes in pulvinar cells

D. Gravitropism (geotropism), a growth response directed by the gravitational field

Q26. Refer to the electron transport chain diagram. Which complex directly catalyses the reduction of molecular oxygen (O_2) to water at the end of the electron transport chain?



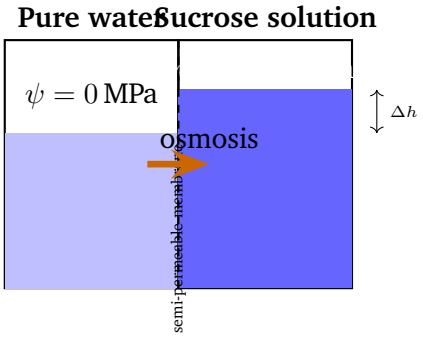
A. Complex I (NADH dehydrogenase), which accepts electrons from NADH at the start of the chain

B. Complex II (succinate dehydrogenase), which feeds electrons from $FADH_2$ into the chain via CoQ

C. Complex III (cytochrome bc_1), which transfers electrons from reduced CoQ to cytochrome c

D. Complex IV (cytochrome c oxidase), which accepts electrons from cytochrome c and transfers them to O_2, forming H_2O

Q27. Refer to the osmosis diagram. If the sucrose solution in the right compartment has an osmotic potential (ψ_s) of $-0.8\,\text{MPa}$ and the pressure potential (ψ_p) is zero, what is the water potential (ψ) of that solution?



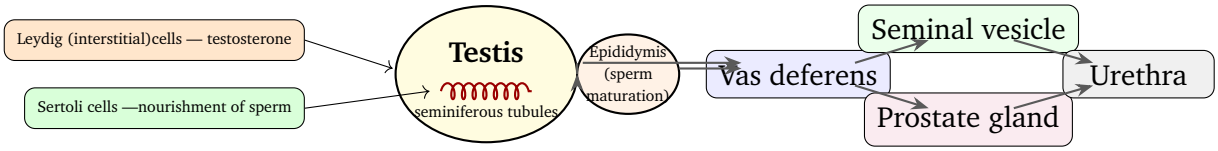
A. -0.8 MPa, because $\psi = \psi_s + \psi_p = -0.8 + 0 = -0.8$ MPa

B. $+0.8$ MPa, because pressure potential adds in the opposite direction to osmotic potential

C. 0 MPa, because the two potentials cancel each other at equilibrium

D. -1.6 MPa, because osmotic and pressure potentials are both negative and therefore additive

Q28. Refer to the simplified diagram of the male reproductive system. Which cells are located *between* the seminiferous tubules (in the interstitium) and are the primary source of testosterone?



A. Sertoli cells, which are located inside the seminiferous tubules and nurse developing spermatids

B. Leydig (interstitial) cells, which reside between the seminiferous tubules and secrete testosterone in response to LH stimulation

C. Spermatogonia, which are stem cells on the basement membrane undergoing mitotic divisions

D. Primary spermatocytes, which undergo the first meiotic division to form secondary spermatocytes

Q29. During which phase of the menstrual cycle does the mid-cycle LH surge occur, triggering ovulation of the secondary oocyte from the mature Graafian follicle?

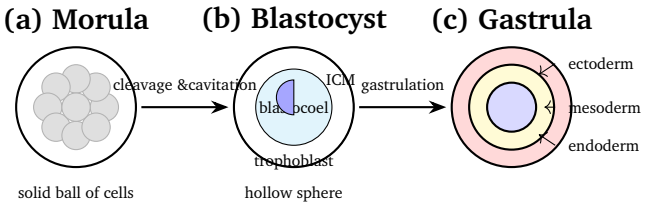
A. Menstrual phase (days 1–5), when declining oestrogen and progesterone cause endometrial shedding

B. Luteal phase (days 15–28), when the corpus luteum secretes progesterone and oestrogen to maintain the endometrium

C. Ovulatory phase (≈day 14), when the LH surge causes follicle rupture and release of the secondary oocyte into the fallopian tube

D. Follicular phase (days 1–13), when FSH stimulates follicle growth and increasing oestrogen causes endometrial proliferation

Q30. Refer to the early embryonic development diagram. Which stage, labelled in the diagram, is characterised by a hollow sphere with a distinct inner cell mass (ICM) on one pole and a surrounding trophoblast layer, and is the stage that implants in the uterine endometrium?



A. Morula, a solid ball of 16–32 blastomeres produced by cleavage of the zygote

B. Gastrula, which shows three primary germ layers and has already completed implantation

C. Zygote, the single-celled stage immediately after fertilisation before any cleavage division

D. Blastocyst, which forms after the morula undergoes cavitation, showing the ICM and trophoblast, and implants into the endometrium

Q31. In which assisted reproductive technology (ART) are unfertilised oocytes

and sperm collected and then placed together directly into the fallopian tube, allowing fertilisation to occur *in vivo*?

A. Gamete Intrafallopian Transfer (GIFT), where both oocytes and sperm are transferred to the fallopian tube for natural in-vivo fertilisation

B. Zygote Intrafallopian Transfer (ZIFT), where fertilised eggs (zygotes) are transferred to the fallopian tube after in-vitro fertilisation

C. Intrauterine Insemination (IUI), where processed sperm alone are deposited into the uterine cavity near the time of ovulation

D. In Vitro Fertilisation and Embryo Transfer (IVF-ET), where fertilisation occurs outside the body in a culture dish and the embryo is transferred to the uterus

Q32. According to the internationally accepted criteria, a region qualifies as a global biodiversity hotspot if it meets which two requirements?

A. Contains $>$500 endemic vertebrate species AND has lost more than 50% of its original primary vegetation

B. Harbours at least 1,500 endemic vascular plant species AND has already lost more than 70% of its original primary habitat

C. Has a recorded species richness exceeding 10,000 species AND supports at least one IUCN-listed critically endangered mammal

D. Covers an area $>$100,000 km^2 AND contains at least 5% of the world's endemic bird species

Q33. Which of the following is an example of *ex-situ* (off-site) conservation of biodiversity?

A. Declaring a wildlife sanctuary where animals are legally protected within their natural habitat

B. Establishing a biosphere reserve that includes a core zone, buffer zone, and transition area around an ecosystem

C. Storing seeds of crop varieties and wild relatives at low temperature and low humidity in a seed bank, such as the Svalbard Global Seed

Vault

D. Designating a national park where human habitation, grazing, and exploitation are prohibited

Q34. Which international agreement, adopted in 1987 in Montreal, specifically established legally binding controls on the production and use of chlorofluorocarbons (CFCs) and other ozone-depleting substances (ODS)?

A. Kyoto Protocol (1997), which set binding greenhouse gas emission reduction targets for developed countries

B. Paris Agreement (2015), which aims to limit global average temperature rise to well below 2°C above pre-industrial levels

C. Stockholm Convention (2001), which restricted the production and use of persistent organic pollutants (POPs)

D. Montreal Protocol (1987), which established phase-out schedules for CFCs, halons, and other ODS responsible for stratospheric ozone depletion

Q35. In the global carbon cycle, which process is primarily responsible for the long-term removal of atmospheric CO_2 and its conversion into stable organic carbon compounds in terrestrial ecosystems?

A. Photosynthesis by green plants and algae, which fixes CO_2 into carbohydrates using solar energy via the Calvin cycle

B. Cellular respiration by all living organisms, which oxidises organic compounds back to CO_2 and H_2O

C. Decomposition by bacteria and fungi, which releases CO_2 and methane from dead organic matter

D. Combustion of fossil fuels, which releases geologically sequestered carbon rapidly back into the atmosphere

Q36. The pest-resistance trait in transgenic Bt cotton is conferred by which of the following genetic modifications?

A. Overexpression of the cotton plant's own protease inhibitor genes, activated via jasmonic acid signalling upon insect attack

B. Integration of *cry* genes from *Bacillus thuringiensis* that encode Cry proteins (Bt toxins), which are specifically toxic to lepidopteran larvae (e.g., cotton bollworm) but harmless to mammals

C. Introduction of a viral coat protein gene that triggers RNA-silencing of the bollworm's essential genes

D. Transfer of the *Bt* toxin gene from a related *Gossypium* species via conventional hybridisation and backcrossing

Q37. The first clinically successful application of gene therapy in humans involved correction of which inherited disorder?

A. Cystic fibrosis, by delivering a functional *CFTR* gene to lung epithelial cells via an adenoviral vector

B. Haemophilia A, by inserting the Factor VIII gene into hepatocytes using a retroviral vector

C. Adenosine deaminase (ADA) deficiency (a form of severe combined immunodeficiency, SCID), by introducing a functional *ADA* gene into the patient's T-lymphocytes

D. Sickle cell anemia, by correcting the HbS point mutation using CRISPR-Cas9 base editing

Q38. Which causative agent and its associated sexually transmitted infection (STI) are correctly matched?

A. *Neisseria gonorrhoeae* causes syphilis, presenting initially as a painless chancre at the site of infection

B. *Treponema pallidum* causes gonorrhoea, characterised by purulent urethral or cervical discharge

C. HIV causes genital herpes, producing recurrent painful vesicular lesions due to DNA virus replication

D. *Treponema pallidum* causes syphilis, which progresses through primary (chancre), secondary (skin rash, systemic), and tertiary stages (gummas, cardiovascular/neurological damage)

Q39. Heroin (diacetylmorphine) is derived from which plant source and belongs to which pharmacological class of drugs?

A. Derived from the dried latex of *Papaver somniferum* (opium poppy); classified as an opioid narcotic that acts on opioid receptors in the CNS to produce analgesia and euphoria

B. Derived from the leaves of *Cannabis sativa*; classified as a cannabinoid with mixed stimulant and depressant properties

C. Derived from the leaves of *Erythroxylum coca*; classified as a coca alkaloid stimulant that blocks dopamine reuptake

D. A fully synthetic compound with no botanical origin; classified as a barbiturate CNS depressant

Q40. In the life cycle of ferns (pteridophytes), the heart-shaped, independently photosynthetic structure called the *prothallus* represents which stage of the life cycle?

A. The diploid sporophyte generation, which produces spores by meiosis within sporangia

B. The haploid gametophyte generation, which bears archegonia (female) and antheridia (male) organs for sexual reproduction

C. A specialised nutrient-storage tissue found exclusively in gymnosperm seeds (endosperm)

D. The sporangium cluster (sorus) on the underside of the sporophyte frond where meiosis produces haploid spores

Detailed Solutions

Q1.

Solution

Concept — Liver functions in metabolism:

The liver is the largest gland in the body and performs diverse metabolic roles: glycogen storage (glycogenesis/glycogenolysis), detoxification of drugs and alcohol, deamination of amino acids, synthesis of plasma proteins (albumin, fibrinogen), and crucially, **synthesis of bile**. Bile salts are produced from cholesterol in hepatocytes and stored in the gallbladder; they are released into the duodenum to emulsify dietary fats, increasing surface area for lipase action.

Why other options are wrong:

Option A: Insulin is secreted by the β cells of the islets of Langerhans in the pancreas, not by the liver.

Option B: Erythropoietin (EPO) is produced primarily by the kidneys (peritubular cells), not the liver (fetal liver is an exception).

Option D: Glucagon is secreted by α cells of the pancreatic islets, not by the liver; the liver responds to glucagon but does not produce it.

Answer: (C) ← Go back to Q1

Q2.

Solution

Concept — Fat absorption and chylomicrons:

Long-chain fatty acids and monoglycerides, after re-esterification to triglycerides in intestinal epithelial cells (enterocytes), are packaged with cholesterol, phospholipids, and apoproteins (ApoB-48) into **chylomicrons**. These are too large to enter blood capillaries, so they are absorbed into the **lacteals** (lymphatic capillaries) within each villus. They travel through the thoracic duct into the bloodstream, bypassing the hepatic portal system initially.

Why other options are wrong:

Option A: Short- and medium-chain fatty acids do enter the portal vein directly, but long-chain fats travel via lymphatics as chylomicrons.

Option B: VLDL is assembled in the liver, not in enterocytes; enterocytes produce chylomicrons.

Option C: Micelles are transient emulsification structures used for digestion, not for transport across the epithelium into circulation.

Answer: (D) ← Go back to Q2

Q3.

Solution

Concept — Neural regulation of respiration: pneumotaxic center:
The respiratory rhythmicity center in the medulla consists of the **dorsal respiratory group (DRG)** (drives inspiration) and the **ventral respiratory group (VRG)** (active in forced breathing). The **pneumotaxic center** in the pons continuously sends inhibitory signals to the DRG, limiting the duration of inspiration and thus regulating breathing rate and depth. Without this inhibition, inspiration would be abnormally prolonged (apneusis).

Why other options are wrong:
Option B: The pneumotaxic center does not initiate breathing; the DRG sets the basic rhythm autonomously. Loss of the pneumotaxic center causes slow, deep breathing (apneustic breathing), not apnea.
Option C: Peripheral chemoreceptors (carotid and aortic bodies) respond to O_2, CO_2, and pH; the pneumotaxic center's action is independent of blood gas sensing.
Option D: The VRG recruits accessory muscles during forced breathing, but the pneumotaxic center primarily modulates the DRG (inspiratory off-switch), not the VRG exclusively.

Answer: (A) ← Go back to Q3

Q4.

Solution

Concept — Respiratory disorders: asthma vs emphysema:
Asthma is a chronic inflammatory airway disease characterised by **reversible bronchoconstriction**, increased mucus secretion, and airway hyperresponsiveness, usually triggered by allergens, exercise, or cold air. **Emphysema** involves **irreversible destruction of alveolar walls**, loss of elastic recoil, and enlargement of air spaces distal to the terminal bronchioles, leading to a reduced surface area for gas exchange. It is strongly linked to smoking.

Why other options are wrong:
Option A: This reverses the definitions; it is emphysema that has permanent alveolar destruction and asthma that is reversible.
Option C: Neither asthma nor emphysema is primarily caused by bacterial infection; asthma is immune/hypersensitivity-mediated and emphysema is mostly due to smoking.
Option D: This also reverses the anatomical sites; emphysema involves the alveoli (air sacs), while asthma involves the bronchi and bronchioles.

Answer: (B) ← Go back to Q4

Q5.

Solution

Concept — Plasma proteins: albumin and oncotic pressure:

Albumin is the most abundant plasma protein (∼55–60% of total plasma protein) and is the principal contributor to the colloid osmotic (oncotic) pressure of blood (∼25–28 mmHg). This pressure opposes the hydrostatic pressure that drives fluid out of capillaries and is critical for retaining fluid within vessels. Low albumin (hypoalbuminemia) causes oedema.

Why other options are wrong:

Option A: Fibrinogen participates in blood clotting (converted to fibrin by thrombin), not primarily in oncotic pressure maintenance.

Option B: Prothrombin is a clotting factor; it does not contribute significantly to oncotic pressure.

Option D: Globulins contribute to oncotic pressure but their primary roles are immune function (immunoglobulins) and transport (transferrin, ceruloplasmin). Albumin is the main determinant.

Answer: (C) ← Go back to Q5

Q6.

Solution

Concept — WBC types: eosinophils:

Eosinophils are granulocytes that normally constitute 2–4% of circulating leucocytes. They are characteristically elevated in **type I hypersensitivity reactions (allergies)** and in **parasitic (helminthic) infections**. Eosinophils release cytotoxic granule proteins (major basic protein, eosinophil peroxidase) against parasites and participate in the late-phase allergic response.

Why other options are wrong:

Option A: Bacterial infections primarily elevate **neutrophils** (the first responders to bacterial invasion via phagocytosis); neutrophilia, not eosinophilia, is expected.

Option B: Viral infections activate T and B lymphocytes; lymphocytosis (elevated lymphocytes) is the typical finding.

Option C: Autoimmune disorders are more often associated with elevated monocytes/macrophages and lymphocytes, not specifically eosinophils.

Answer: (D) ← Go back to Q6

Q7.

Solution

Concept — Juxtaglomerular apparatus: renin secretion:

The **juxtaglomerular apparatus** comprises JG (granular) cells in the wall of the afferent arteriole and the **macula densa** (specialised cells of the distal tubule).

Renin is released when: (1) blood pressure falls, reducing stretch of the afferent arteriole; (2) the macula densa detects a low NaCl concentration in the tubular filtrate; or (3) sympathetic (adrenergic) stimulation occurs. Renin initiates the renin-angiotensin-aldosterone system (RAAS) to raise blood pressure.

Why other options are wrong:
Option B: A *rise* in blood pressure would *inhibit* renin secretion (via stretch-mediated suppression of JG cells), not stimulate it.
Option C: Aldosterone acts on the collecting duct to promote Na^+ reabsorption; high aldosterone itself does not stimulate renin — in fact, RAAS involves negative feedback where aldosterone-mediated correction reduces renin secretion.
Option D: Blood glucose sensing is the role of pancreatic β cells, not the macula densa or JG cells.

Answer: (A) ← Go back to Q7

Q8.

Solution

Concept — Hemodialysis principle:
Hemodialysis removes metabolic wastes (urea, creatinine, excess K^+, phosphate) by passing the patient's blood through a **dialyser** containing a semi-permeable membrane. The dialysate (on the other side) is maintained at low waste concentrations. Waste solutes move by **simple diffusion** down their concentration gradient from blood into the dialysate. The membrane is impermeable to large molecules (proteins, blood cells), so these are retained.

Why other options are wrong:
Option A: Active transport requires cellular ATP pumps; the dialysis membrane is an artificial inert membrane with no metabolic activity.
Option C: Glomerular filtration is driven by hydrostatic pressure in living nephrons; hemodialysis membranes are not equivalent to the glomerular basement membrane, and the primary mechanism is diffusion, not pressure filtration.
Option D: Osmosis moves water (solvent), not waste solutes; while ultrafiltration in dialysis does remove some water, the principal waste removal mechanism is diffusion.

Answer: (B) ← Go back to Q8

Q9.

Solution

Concept — Reflex arc: efferent neuron:
The reflex arc consists of five sequential components: (1) **Receptor** detects stimulus; (2) **Afferent (sensory) neuron** carries impulse to the CNS; (3) **Nerve centre**

(spinal cord interneurons) integrates the signal; (4) **Efferent (motor) neuron** carries the motor command from the spinal cord to the effector; (5) **Effector** (muscle/gland) produces the response. The branch to the brain provides conscious awareness but is not part of the reflex arc proper.

Why other options are wrong:
Option A: The afferent neuron carries impulses *toward* the CNS (sensory/centripetal), not away from it to the effector.
Option B: The receptor detects the initial stimulus; it does not transmit impulses to the effector.
Option D: The interneuron (in the nerve centre) processes the signal between afferent and efferent neurons; it does not directly contact the effector organ.

Answer: (C) ← Go back to Q9

Q10.

Solution

Concept — Meninges and CSF:
The three meningeal layers (outer to inner) are: **dura mater** (tough, outermost), **arachnoid mater** (middle, web-like), and **pia mater** (thin, innermost, closely adherent to brain). **CSF** is produced by the **choroid plexus** within the lateral, third, and fourth ventricles. It circulates through the ventricular system and **subarachnoid space** (between arachnoid and pia mater), providing buoyancy, cushioning, and immune protection for the brain and spinal cord.

Why other options are wrong:
Option A: The dura mater is the *outermost* (not innermost) meningeal layer; it is the tough, fibrous layer lining the inner skull.
Option B: CSF is produced in the choroid plexus of the *ventricles* and circulates around both brain and spinal cord in the subarachnoid space.
Option C: The *pia mater* is the innermost, thin, delicate layer; the dura mater is the outermost, tough layer.

Answer: (D) ← Go back to Q10

Q11.

Solution

Concept — Pancreatic islet hormones:
The islets of Langerhans contain four cell types: α **(alpha) cells** (∼25%), which secrete **glucagon** (raises blood glucose by stimulating glycogenolysis and gluconeogenesis in the liver); β **(beta) cells** (∼60%), which secrete **insulin** (lowers blood glucose); δ **(delta) cells** (∼10%), which secrete **somatostatin** (inhibits both insulin and glucagon secretion); and **PP cells** (F cells), which secrete pancreatic

polypeptide.

Why other options are wrong:
Option B: Somatostatin is secreted by *delta* cells, not beta cells; beta cells secrete insulin.
Option C: Insulin is secreted by *beta* cells, not delta cells; delta cells secrete somatostatin.
Option D: Pancreatic polypeptide is secreted by *PP cells* (F cells), not by alpha cells; alpha cells secrete glucagon.

Answer: (A) ← Go back to Q11

Q12.

Solution

Concept — Plant cell wall: middle lamella:
The **middle lamella** is the first layer deposited during cell division (at the cell plate). It is composed primarily of **calcium pectate** (calcium and magnesium salts of pectic acid), a gel-like polysaccharide. It acts as an intercellular cement binding adjacent cells. During fruit ripening, pectinase enzymes solubilise calcium pectate, softening the tissue.

Why other options are wrong:
Option A: Cellulose microfibrils form the *primary cell wall*, deposited after the middle lamella; cellulose is not the main component of the middle lamella.
Option C: Chitin is the structural polysaccharide of *fungal* cell walls and insect exoskeletons, not plant middle lamellae.
Option D: Peptidoglycan is found in *bacterial* cell walls (murein); it is absent in plant cells entirely.

Answer: (B) ← Go back to Q12

Q13.

Solution

Concept — Cytoskeleton: 9+2 axonemal arrangement:
The **axoneme** of eukaryotic **cilia and flagella** consists of **nine peripheral doublet microtubules** surrounding **two central singlet microtubules** (the "9+2" arrangement). Each outer doublet has A and B tubules with dynein arms that generate the sliding force. This arrangement is absent in primary (non-motile) cilia, which have a 9+0 pattern.

Why other options are wrong:
Option A: The mitotic spindle consists of kinetochore microtubules, astral microtubules, and interpolar microtubules, but they are not organised in a 9+2 pattern.

Option B: Muscle sarcomeres contain actin (thin) and myosin (thick) filaments, not microtubules in a 9+2 arrangement; actin filaments are microfilaments (7 nm), not microtubules (25 nm).
Option D: The nuclear lamina is composed of intermediate filaments (lamins A, B, C), not microtubules.

Answer: (C) ← Go back to Q13

Q14.

Solution

Concept — Lysosomes and peroxisomes: contrasting functions:
Lysosomes are membrane-bound organelles (derived from the Golgi apparatus) containing approximately 50 types of **acid hydrolases** (proteases, lipases, nucleases, glycosidases) active at pH ∼5. They perform **autophagy** (digesting worn-out organelles) and heterophagy. **Peroxisomes** are self-replicating organelles that contain **catalase** (converts H_2O_2 to H_2O + O_2) and enzymes for **β-oxidation of very-long-chain fatty acids**.

Why other options are wrong:
Option A: This reverses the enzymes; catalase is in peroxisomes and acid hydrolases are in lysosomes, not vice versa.
Option B: Autophagy is a function of *lysosomes*, not peroxisomes; β-oxidation of very-long-chain fatty acids occurs in *peroxisomes*.
Option C: Lysosomes arise from the Golgi apparatus (trans-Golgi network), not the rough ER; peroxisomes replicate by fission and their membrane proteins are imported post-translationally.

Answer: (D) ← Go back to Q14

Q15.

Solution

Concept — Genetic mapping: centimorgan (map unit):
A **centimorgan (cM)** or **map unit** is the unit of genetic distance defined as the distance between two gene loci that produces **1% recombinant offspring** (i.e., 1% recombination frequency) in a testcross. It was named after T.H. Morgan. Genes >50 cM apart show independent assortment (even if physically on the same chromosome), as multiple crossovers randomise allele combinations.

Why other options are wrong:
Option B: 10% recombination frequency corresponds to 10 cM, not 1 cM.
Option C: 0% recombination indicates completely linked genes (0 cM); this is the definition of the same locus, not 1 cM.
Option D: 50% recombination frequency corresponds to independent assortment;

genes this far apart are unlinked and cannot be mapped relative to each other using recombination frequency alone.

Answer: (A) ← Go back to Q15

Q16.

Solution

Concept — Epistasis: 9:3:4 ratio (recessive epistasis):

When a dihybrid F_2 shows a **9:3:4 ratio**, this indicates **recessive epistasis**: the homozygous recessive genotype at one locus (e.g., *aa*) masks the expression of the other locus regardless of its genotype. This collapses the normal 9:3:3:1 ratio: 9 A_B_ + 3 A_bb + (3 aaB_ + 1 aabb) = 9:3:4. Example: Labrador retriever coat colour (locus B determines pigment type; locus E determines pigment deposition; *ee* is epistatic, producing yellow regardless of B locus).

Why other options are wrong:

Option A: Dominant epistasis produces a **12:3:1** ratio, where one dominant allele at a locus masks the other gene.

Option C: Duplicate dominant epistasis (complementary or duplicate genes where at least one dominant allele at *either* locus suffices) gives a **15:1** ratio.

Option D: Codominance does not affect the 9:3:3:1 ratio between genes; it affects heterozygote phenotype expression within a single locus.

Answer: (B) ← Go back to Q16

Q17.

Solution

Concept — Chromatin packaging: nucleosome DNA wrapping:

The **nucleosome core particle** consists of ∼147 base pairs of DNA wrapped approximately **1.75 times (1 3/4 turns)** around an **octameric histone core** (two copies each of H2A, H2B, H3, and H4). The linker histone **H1** binds at the entry/exit point of DNA on the nucleosome to stabilise the 30-nm chromatin fibre. Adjacent nucleosomes are connected by linker DNA of variable length (∼20–80 bp).

Why other options are wrong:

Option A: One complete turn (360) would accommodate only ∼84 bp; the actual wrapping is ∼1.75 turns (∼147 bp).

Option B: Two complete turns would require ∼168 bp and is not the correct value for the nucleosome core particle.

Option D: Half a turn (0.5 turns) would accommodate only ∼42 bp; the DNA does not merely half-wrap; it wraps nearly twice around the histone octamer.

Answer: (C) ← Go back to Q17

Q18.

Solution

Concept — Types of RNA: rRNA:

rRNA (ribosomal RNA) is the **most abundant** RNA in a cell, constituting approximately 80% of total cellular RNA. It forms both the structural backbone of ribosome subunits (small subunit: 16S/18S rRNA; large subunit: 23S/28S and 5S/5.8S rRNA) and provides the **catalytic (ribozyme) activity** of the peptidyl transferase centre that forms peptide bonds during translation.

Why other options are wrong:

Option A: rRNA is the *most* abundant RNA (∼80%), not the least; tRNA is next (∼15%), and mRNA is the least (∼5%) by mass.

Option B: *tRNA* (transfer RNA) carries amino acids to the ribosome via its 3' CCA-amino acid attachment site; rRNA does not carry amino acids.

Option C: rRNA is *not translated*; it is a structural/catalytic component of ribosomes. Ribosomal proteins are encoded by nuclear DNA, translated by cytoplasmic ribosomes, and imported post-translationally.

Answer: (D) ← Go back to Q18

Q19.

Solution

Concept — Sickle cell anemia: molecular basis:

Sickle cell anemia is caused by a **point mutation** (single nucleotide substitution: GAG $\rightarrow$ GTG) in the sixth codon of the β-globin gene. This changes the amino acid at position 6 from **glutamic acid** (hydrophilic, charged) to **valine** (hydrophobic). The substitution causes HbS to polymerise under low-oxygen conditions, deforming RBCs into sickle shapes that obstruct capillaries.

Why other options are wrong:

Option B: This is the reverse; HbS has *less* solubility (not more) than HbA under deoxygenated conditions because valine is hydrophobic and promotes polymer formation.

Option C: A frameshift from a 3-nucleotide deletion would cause a thalassemia-like syndrome altering many codons, not sickle cell anemia (which is a specific missense point mutation).

Option D: An elongated β-globin chain occurs in haemoglobin Constant Spring (a stop codon mutation), not in sickle cell anemia.

Answer: (A) ← Go back to Q19

Q20.

Solution

Concept — Polyploidy: allopolyploidy in wheat:

Allopolyploidy occurs when polyploidy arises in a hybrid between **two or more distinct species**, with each contributing a different genome set. Bread wheat (*Triticum aestivum*; 2n = 6x = 42; genomes AABBDD) is believed to have originated through two successive allotetraploidisation events involving *T. urartu* (AA), *Aegilops speltoides* (BB), and *Aegilops tauschii* (DD). This is the basis of crop improvement through wide hybridisation.

Why other options are wrong:

Option A: Autopolyploidy involves duplication of the *same species'* chromosome set (e.g., 4x watermelon or 4x potato); wheat has three *distinct* ancestral genomes (A, B, D) from different species.

Option C: Aneuploidy is the gain or loss of individual chromosomes (e.g., trisomy 21), not the multiplication of complete genome sets.

Option D: Radiation-induced polyploidy is artificial and experimental; bread wheat arose through natural hybridisation and chromosome doubling over millennia.

Answer: (B) ← Go back to Q**20**

Q21.

Solution

Concept — Hardy-Weinberg principle: conditions:

The **Hardy-Weinberg equilibrium** states that allele and genotype frequencies in a population remain constant from generation to generation, provided: (1) **random mating**, (2) **no natural selection**, (3) **no mutation**, (4) **no gene flow (migration)**, (5) **no genetic drift** (infinitely large population). The equation $p^2 + 2pq + q^2 = 1$ describes genotype frequencies at equilibrium.

Why other options are wrong:

Option A: Strong natural selection is one of the primary forces that *disrupts* Hardy-Weinberg equilibrium by changing allele frequencies.

Option B: A small, isolated population is subject to *genetic drift*, which is one of the five conditions that disrupts HWE; HWE requires an infinitely large population.

Option D: High mutation rates are one of the conditions that *violate* HWE; HWE requires no mutation (or that mutation rates are negligibly low).

Answer: (C) ← Go back to Q**21**

Q22.

Solution

Concept — Biological nitrogen fixation: nitrogenase:
Nitrogenase is the enzyme complex (comprising dinitrogenase and dinitrogenase reductase) that reduces atmospheric N_2 to NH_3 in nitrogen-fixing organisms. The reaction requires **16 ATP** and 8 electrons per N_2 fixed: $N_2 + 8H^+ + 8e^- + 16$ ATP $\rightarrow 2NH_3 + H_2 + 16$ ADP $+ 16$ P_i. **Leghemoglobin** in root nodules maintains low O_2 levels to protect nitrogenase from inactivation.

Why other options are wrong:
Option A: Nitrate reductase (in plant roots) reduces NO_3^- *to* NO_2^- — this is part of nitrate assimilation, not N_2 fixation.
Option B: Nitrite reductase converts NO_2^- to NH_4^+ in plastids — again part of assimilation, not atmospheric N_2 fixation.
Option C: Glutamine synthetase incorporates *already-fixed* NH_4^+ into glutamine — it acts after nitrogenase has produced ammonia, not in fixing N_2 directly.

Answer: (D) ← Go back to Q**22**

Q23.

Solution

Concept — Mineral deficiency: mobile vs immobile nutrients:
Nitrogen is a highly **mobile** nutrient in the phloem. When N is deficient, the plant remobilises N from older (lower) leaves to younger, actively growing tissue. This produces **chlorosis (yellowing) that progresses from older to younger leaves**. In contrast, **iron** and **calcium** are immobile in the phloem, so their deficiency symptoms appear first in **young leaves**: Fe deficiency causes interveinal chlorosis of young leaves; Ca deficiency causes tip burn and death of young tissue.

Why other options are wrong:
Option B: Iron deficiency causes interveinal chlorosis of *young* (not old) leaves because Fe is phloem-immobile and cannot be remobilised from older tissue.
Option C: Calcium is immobile in the phloem, so Ca deficiency affects *youngest* tissues (growing tips, young leaves); it causes tip burn, blossom-end rot, and failure of young cells to form proper walls.
Option D: Sulphur is also relatively immobile; S deficiency typically causes yellowing of *young* leaves first, similar to Fe and Ca, not old leaves.

Answer: (A) ← Go back to Q**23**

Q24.

Solution

Concept — Gibberellins and seed germination: α-amylase induction:
During cereal grain germination, **gibberellins (GA)** secreted by the scutellum of

the embryo diffuse to the **aleurone layer** (a single layer of protein-rich cells surrounding the starchy endosperm). GA_3 induces transcription and secretion of α-**amylase**, which breaks α-1,4 glycosidic bonds in starch to release maltose and glucose. These sugars are absorbed by the scutellum and used for embryo growth. This is a classic example of hormonal induction of enzyme synthesis.

Why other options are wrong:
Option A: α-amylase *inhibitors* are storage proteins that prevent starch hydrolysis during dormancy; gibberellins promote amylase *production*, not its inhibition.
Option C: Lipases hydrolyse fats; they are induced in oil-storing seeds, not primarily by gibberellins in the aleurone layer of cereal grains.
Option D: Proteases degrade gluten proteins; while proteolytic activity occurs during germination, the hallmark gibberellin-induced enzyme in cereal aleurone is specifically α-amylase.

Answer: (B) ← Go back to Q24

Q25.

Solution

Concept — Plant movements: nastic vs tropic movements:
Plant movements are classified as **tropic** (directional, growth-based) or **nastic** (non-directional, turgor-based). The *Mimosa pudica* response to touch is **seismonasty** (also called thigmonasty): a rapid, **non-directional** movement mediated by sudden loss of turgor in **pulvinar cells** at the base of leaflets and petiolules. Action potentials propagate along the plant, causing K^+ and water efflux from motor cells, leading to collapse and folding.

Why other options are wrong:
Option A: Phototropism is a *directional growth* movement toward or away from light, mediated by auxin redistribution; *Mimosa* closure is neither directional nor growth-based.
Option B: Thigmotropism is a *directional growth* response to sustained mechanical contact (as in tendrils of climbers); *Mimosa* closure is non-directional and non-growth-based.
Option D: Gravitropism (geotropism) is the directional growth response to gravity; *Mimosa* leaflet closure has no relationship to gravity direction.

Answer: (C) ← Go back to Q25

Q26.

Solution

Concept — Electron transport chain: Complex IV and oxygen reduction:
Complex IV (*cytochrome c oxidase*) is the terminal enzyme of the mitochondrial electron transport chain. It accepts electrons one at a time from **cytochrome c** (a mobile carrier in the intermembrane space) and transfers them to $\mathbf{O_2}$, reducing it to **water** ($2H_2O$ per O_2). Complex IV contains haem groups and copper centres (Cu_A and Cu_B) that facilitate this four-electron reduction. The energy released drives pumping of $4H^+/O_2$ into the IMS.

Why other options are wrong:
Option A: Complex I (NADH dehydrogenase) accepts electrons from NADH and passes them to ubiquinone (CoQ); it does not reduce O_2.
Option B: Complex II (succinate dehydrogenase) accepts electrons from $FADH_2$ (formed in the TCA cycle) and reduces CoQ; it does not pump protons and does not reduce O_2.
Option C: Complex III (cytochrome bc_1) transfers electrons from reduced CoQ (ubiquinol) to cytochrome c, pumping H^+ via the Q-cycle; it does not reduce O_2.

Answer: (D) ← Go back to Q**26**

Q27.

Solution

Concept — Water potential: $\psi = \psi_s + \psi_p$:
Water potential (ψ) describes the tendency of water to move from one region to another. It is calculated as:

$$\psi = \psi_s + \psi_p$$

where ψ_s = osmotic (solute) potential (always negative, lowers ψ) and ψ_p = pressure potential (positive in turgid cells; zero in a solution in an open container). For the sucrose solution: $\psi = -0.8 + 0 = -0.8\,\text{MPa}$. Water moves from higher ψ (pure water, $\psi = 0$) to lower ψ (sucrose solution, $\psi = -0.8$), i.e., from left to right across the membrane.

Why other options are wrong:
Option B: Pressure potential does not become negative in a simple open solution; it is 0 MPa in an open container. $+0.8\,\text{MPa}$ is incorrect.
Option C: $\psi = 0$ would only occur if $\psi_s = 0$ (pure water) or if positive pressure potential exactly cancelled the negative osmotic potential; neither is the case here.
Option D: There is no reason to add the two values as $-1.6\,\text{MPa}$; only one component ($\psi_s = -0.8$) applies here, and $\psi_p = 0$.

Answer: (A) ← Go back to Q**27**

Q28.

Solution

Concept — Male reproductive system: Leydig cells:

The testis contains **seminiferous tubules** (where spermatogenesis occurs) and the **interstitium** between tubules. The interstitium contains **Leydig (interstitial) cells**, which are stimulated by **LH (luteinising hormone)** from the anterior pituitary to synthesise and secrete **testosterone**. Testosterone is essential for spermatogenesis, development of secondary sexual characteristics, and maintenance of male reproductive structures. **Sertoli cells** are located *inside* the seminiferous tubules and support developing sperm.

Why other options are wrong:

Option A: Sertoli cells are located *inside* the seminiferous tubules (not between them); their function is to nourish, support, and regulate spermatogenic cells, and to produce inhibin and androgen-binding protein (ABP) — not testosterone.

Option C: Spermatogonia are the spermatogenic stem cells on the basement membrane of the seminiferous tubules; they undergo mitosis and do not produce testosterone.

Option D: Primary spermatocytes are in the seminiferous tubules undergoing meiosis I; they are germ cells, not endocrine cells.

Answer: (B) ← Go back to Q**28**

Q29.

Solution

Concept — Menstrual cycle: LH surge and ovulation:

The menstrual cycle is divided into: **menstrual phase** (days 1–5, endometrial shedding), **follicular phase** (days 1–13, FSH-driven follicle maturation and oestrogen rise), **ovulatory phase** (day ∼14, mid-cycle LH surge triggered by peak oestrogen levels acts on the mature Graafian follicle, causing its rupture and release of the secondary oocyte), and **luteal phase** (days 15–28, corpus luteum secretes progesterone/oestrogen to maintain endometrium).

Why other options are wrong:

Option A: The menstrual phase is when oestrogen and progesterone *fall*, causing endometrial shedding; the LH surge does not occur during this phase.

Option B: The LH surge occurs at the *end* of the follicular phase / beginning of the ovulatory phase (∼day 14), not during the luteal phase (days 15–28); the luteal phase follows after ovulation.

Option D: The follicular phase is when FSH stimulates follicle development and oestrogen *rises*; the LH surge comes only *at the end* of this phase (day ∼14), transitioning into the ovulatory phase.

Answer: (C) ← Go back to Q**29**

Q30.

Solution

Concept — Early embryonic development: blastocyst:
After fertilisation, the zygote undergoes **cleavage** (rapid mitotic divisions without growth) to form the **morula** (solid ball of 16–32 blastomeres). The morula undergoes **cavitation** (fluid accumulates centrally) to form the **blastocyst**: a hollow sphere with an outer **trophoblast** layer (will form placenta) and an inner **inner cell mass (ICM)** or embryoblast (will form the embryo proper). The blastocyst **implants** into the endometrium ∼6–10 days post-fertilisation. Subsequently, gastrulation forms three primary germ layers.

Why other options are wrong:
Option A: The morula is a *solid* ball of cells with no cavity and no ICM; the hollow structure with ICM first appears at the blastocyst stage.
Option B: The gastrula has three germ layers but it arises *after* implantation; the blastocyst is the stage that implants, not the gastrula.
Option C: The zygote is the single-celled fertilised egg before any division; it has no hollow cavity or ICM.

Answer: (D) ← Go back to Q30

Q31.

Solution

Concept — Assisted reproductive technologies: GIFT:
Gamete Intrafallopian Transfer (GIFT) involves collecting oocytes from the ovaries (after ovarian stimulation) and retrieving sperm, then **transferring both unfertilised oocytes and sperm directly into the fallopian tube** via laparoscopy. Fertilisation occurs naturally *in vivo* within the fallopian tube. GIFT is suitable when the woman has at least one functional fallopian tube.

Why other options are wrong:
Option B: **ZIFT** (Zygote Intrafallopian Transfer) involves fertilisation *in vitro* first, and then the resulting *zygote* (not unfertilised gametes) is transferred to the fallopian tube.
Option C: **IUI** (Intrauterine Insemination) places only *sperm* into the uterus (not oocytes), and only into the uterine cavity (not the fallopian tube).
Option D: **IVF-ET** (In Vitro Fertilisation and Embryo Transfer) involves fertilisation entirely outside the body in a laboratory dish, and the embryo (not gametes) is transferred to the uterus.

Answer: (A) ← Go back to Q31

Q32.

Solution

Concept — Biodiversity hotspots: criteria:

A region is designated a **biodiversity hotspot** based on two mandatory criteria established by Norman Myers and refined by Conservation International: (1) it must contain **at least 1,500 endemic vascular plant species** (i.e., species found nowhere else on Earth); and (2) it must have **lost more than 70% of its original primary habitat** (reflecting the threat level). Currently, 36 recognised biodiversity hotspots cover only 2.5% of Earth's land surface but support more than 50% of endemic plant species.

Why other options are wrong:

Option A: The correct threshold is 1,500 endemic *vascular plant* species (not 500 vertebrate species) and $>$70% habitat loss (not 50%).

Option C: Total species count is not the criterion; endemism is; and 10,000 species with one endangered mammal is not the defined threshold.

Option D: Area size alone is not a criterion; small areas can qualify as hotspots if they meet the endemic plant and habitat loss thresholds.

Answer: (B) ← Go back to Q32

Q33.

Solution

Concept — Ex-situ vs in-situ conservation:

Ex-situ conservation involves preserving species **outside their natural habitat**: gene banks, seed banks, cryopreservation of embryos/gametes, zoological parks, botanical gardens, and culture collections. The **Svalbard Global Seed Vault** (Norway) stores seeds of $>$1 million crop varieties at -18C as a backup against catastrophic loss. **In-situ conservation** protects species within their natural habitat: national parks, wildlife sanctuaries, biosphere reserves, and sacred groves.

Why other options are wrong:

Option A: A wildlife sanctuary protects animals *within* their natural habitat — this is **in-situ** conservation.

Option B: A biosphere reserve protects entire ecosystems with human communities included — this is **in-situ** conservation.

Option D: A national park is the highest level of *in-situ* conservation, with strict prohibition of human activities; it is not ex-situ.

Answer: (C) ← Go back to Q33

Q34.

Solution

Concept — Ozone depletion: Montreal Protocol:

The **Montreal Protocol on Substances that Deplete the Ozone Layer** (adopted 1987, entered into force 1989) is an international treaty under which countries agreed to phase out the production and use of CFCs, halons, hydrochlorofluorocarbons (HCFCs), and other ODS. CFCs release chlorine radicals in the stratosphere (by UV photolysis), which catalytically destroy ozone: $Cl\cdot + O_3 \rightarrow ClO\cdot + O_2$ (one Cl atom can destroy $\sim$100,000 ozone molecules). The Antarctic ozone hole was a major impetus for the Protocol.

Why other options are wrong:

Option A: The **Kyoto Protocol** (1997) targeted *greenhouse gas* emissions (CO_2, CH_4, N_2O, HFCs, PFCs, SF_6) for climate change mitigation, not ozone-depleting substances.

Option B: The **Paris Agreement** (2015) also addresses climate change (temperature targets), not ozone depletion.

Option C: The **Stockholm Convention** (2001) restricts *persistent organic pollutants (POPs)* such as DDT and PCBs, not ODS.

Answer: (D) ← Go back to Q**34**

Q35.

Solution

Concept — Carbon cycle: photosynthesis as carbon fixation:

Photosynthesis by photoautotrophs (plants, algae, cyanobacteria) is the primary mechanism for removing CO_2 from the atmosphere and converting it into stable organic carbon compounds (glucose, carbohydrates) using solar energy. The overall reaction is: $6CO_2 + 6H_2O \xrightarrow{\text{light}} C_6H_{12}O_6 + 6O_2$. Forests act as major **carbon sinks**, sequestering carbon in biomass and soil organic matter.

Why other options are wrong:

Option B: Cellular respiration *releases* CO_2 back into the atmosphere; it is the reverse process and does not remove atmospheric CO_2.

Option C: Decomposition by bacteria and fungi also *releases* CO_2 (and CH_4 under anaerobic conditions); it is part of carbon release, not long-term removal.

Option D: Combustion of fossil fuels releases CO_2 from geological carbon stores into the atmosphere; it is the opposite of carbon sequestration.

Answer: (A) ← Go back to Q**35**

Q36.

Solution

Concept — Transgenic organisms: Bt cotton:

Bt cotton is genetically modified to express ***cry* genes** (crystal protein genes) from the soil bacterium *Bacillus thuringiensis*. The **Cry proteins** (delta-endotoxins) are produced as inactive protoxins; in the alkaline gut of lepidopteran larvae, they are cleaved to the active toxin, which binds to specific receptors in the gut epithelium, forming pores that cause cell lysis and larval death. The toxin is harmless to mammals, birds, and beneficial insects not bearing the receptor.

Why other options are wrong:

Option A: Protease inhibitors are an alternative plant defence strategy (activated by jasmonic acid), but Bt cotton specifically uses *bacterial Cry proteins*, not over-expressed plant protease inhibitors.

Option C: Viral coat protein genes confer resistance to *plant viruses* (e.g., virus-resistant papaya); this is not the mechanism in Bt cotton.

Option D: The Bt toxin gene was transferred from *Bacillus thuringiensis* (a bacterium), not from a related *Gossypium* species; and it was introduced via *Agrobacterium*-mediated transformation, not conventional hybridisation.

Answer: (B) ← Go back to Q**36**

Q37.

Solution

Concept — Gene therapy: ADA deficiency:

In 1990, the first approved human gene therapy trial treated a child with **adenosine deaminase (ADA) deficiency**, a rare autosomal recessive disorder causing **severe combined immunodeficiency (SCID)** because accumulation of deoxyadenosine is toxic to lymphocytes. The therapy involved isolating the patient's T-lymphocytes, introducing a functional *ADA* gene using a retroviral vector (*ex vivo* approach), and reinfusing the corrected cells. This was a landmark in **somatic gene therapy**.

Why other options are wrong:

Option A: Gene therapy for cystic fibrosis has been attempted but has not achieved clinical success; adenoviral vectors to lung epithelium faced immune rejection and transient expression problems.

Option B: Haemophilia A gene therapy (Factor VIII delivery) showed clinical success only in the 2020s via AAV vectors; it was not the *first* gene therapy case in 1990.

Option D: CRISPR-Cas9-based sickle cell therapy is a recent advance (approved 2023); it was not the first gene therapy case, which occurred in 1990.

Answer: (C) ← Go back to Q**37**

Q38.

Solution

Concept — STIs: causative agents:

Syphilis is caused by the spirochaete bacterium *Treponema pallidum*. It progresses through: **Primary syphilis** (painless chancre at the infection site); **Secondary syphilis** (generalised skin rash, mucous membrane lesions, systemic involvement); and **Tertiary syphilis** (gummas, cardiovascular syphilis, neurosyphilis). It is transmitted sexually and vertically (congenital syphilis).

Why other options are wrong:

Option A: *Neisseria gonorrhoeae* causes *gonorrhoea*, characterised by purulent urethral/cervical discharge and pelvic inflammatory disease — not syphilis with its characteristic chancre.

Option B: *Treponema pallidum* causes syphilis, not gonorrhoea; this option reverses the organisms and diseases.

Option C: HIV causes *AIDS* (acquired immunodeficiency syndrome), not genital herpes; genital herpes is caused by *Herpes simplex virus type 2 (HSV-2)*, a DNA virus, not HIV (an RNA retrovirus).

Answer: (D) ← Go back to Q**38**

Q39.

Solution

Concept — Drug abuse: heroin as an opioid:

Heroin (diacetylmorphine) is a semi-synthetic **opioid** derived by acetylation of morphine, which is itself extracted from the dried latex (opium) of *Papaver somniferum* (opium poppy). Heroin acts on μ, κ, and δ opioid receptors in the CNS, producing intense analgesia and euphoria. It causes both **physical dependence** (withdrawal syndrome: sweating, cramps, rhinorrhoea) and **psychological dependence**. Tolerance develops rapidly.

Why other options are wrong:

Option B: *Cannabis sativa* is the source of cannabinoids (marijuana, hashish — Δ^9-THC); these are not opioids. Cannabinoids have mixed CNS effects via endocannabinoid receptors (CB1, CB2).

Option C: *Erythroxylum coca* is the source of cocaine (a tropane alkaloid / coca alkaloid), which is a *stimulant* that blocks monoamine reuptake; it is not an opioid.

Option D: Heroin is *not* fully synthetic; it is derived from a natural plant alkaloid (morphine from opium poppy). Barbiturates (e.g., phenobarbital) are synthetic CNS depressants; they act on GABA-A receptors, not opioid receptors.

Answer: (A) ← Go back to Q**39**

Q40.

Solution

Concept — Pteridophytes: prothallus as gametophyte:

Ferns exhibit **alternation of generations**. The familiar leafy fern plant is the **diploid sporophyte**; it is the dominant generation. The **prothallus** is the tiny (few mm), heart-shaped, independent photosynthetic structure that represents the **haploid gametophyte generation**. The prothallus bears male **antheridia** (producing flagellate sperms) and female **archegonia** (producing eggs). Fertilisation requires water for sperm motility, and the resulting diploid zygote grows into a new sporophyte on the prothallus.

Why other options are wrong:

Option A: The diploid sporophyte is the large, leafy fern plant that produces *spores* by meiosis within sporangia on the undersides of fronds (in sori); the prothallus is the haploid *gametophyte*, not the sporophyte.

Option C: The prothallus is found in *pteridophytes*, not exclusively gymnosperms; gymnosperms have a reduced, non-free-living gametophyte. Endosperm is found in angiosperm seeds.

Option D: The *sorus* (plural: sori) is the cluster of *sporangia* on the sporophyte frond where meiosis occurs; it is part of the sporophyte generation, not the gametophyte (prothallus).

Answer: (B) ← Go back to Q40

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	C	14	D	15	A
16	B	17	C	18	D	19	A	20	B
21	C	22	D	23	A	24	B	25	C
26	D	27	A	28	B	29	C	30	D
31	A	32	B	33	C	34	D	35	A
36	B	37	C	38	D	39	A	40	B