Physiology

Sample Paper – 5

Questions:	25	**Duration:**	45 min
Total Marks:	100	**Marking:**	+4 / −1

Topics: Renal · Nervous · Endocrine · Cardiovascular · Digestive · Immune · Respiratory

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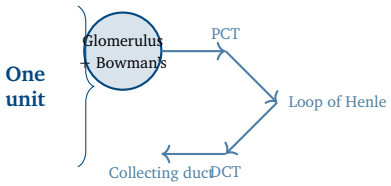
Quick Reference

Instructions

- This paper has **25 questions** carrying **100 marks**.
- Each correct answer: **+4 marks**. Each wrong answer: **−1 mark**. Unattempted: **0**.
- Suggested time: **45 minutes**. All questions are single-correct MCQs.
- Covers: Renal, Nervous, Endocrine, Cardiovascular, Digestive, Immune, Respiratory systems.
- Click a question number in the answer key to jump to its solution.

Q1. The diagram below shows a simplified nephron. The structural and functional unit of the kidney, responsible for filtration, reabsorption, and secretion of blood plasma, is the:



(A) Glomerulus only
(B) Loop of Henle
(C) Collecting duct
(D) Nephron

Q2. Olfactory receptors responsible for the sense of smell are located in the:

(A) Olfactory mucosa (nasal epithelium) of the roof of the nasal cavity
(B) Hard palate of the oral cavity
(C) Nasopharynx posterior wall
(D) Paranasal sinuses

Q3. Type 1 diabetes mellitus differs from Type 2 primarily because it is characterised by:

(A) Obesity and peripheral insulin resistance
(B) Excess glucagon secretion from alpha cells
(C) Gradual beta-cell exhaustion over decades
(D) Autoimmune destruction of pancreatic beta cells leading to absolute insulin deficiency

Q4. Normal fasting blood glucose concentration in a healthy adult is:

(A) 70–100 mg/dL (3.9–5.6 mmol/L)
(B) 120–160 mg/dL (6.7–8.9 mmol/L)
(C) 40–70 mg/dL (2.2–3.9 mmol/L)
(D) 180–220 mg/dL (10–12.2 mmol/L)

Q5. Ammonia, a toxic product of amino acid catabolism, is detoxified and converted to urea (a less toxic form) for urinary excretion by the:

(A) Liver (via the urea cycle / ornithine cycle)
(B) Kidney (via tubular secretion)
(C) Skeletal muscle (via transamination)
(D) Spleen (via haemoglobin breakdown)

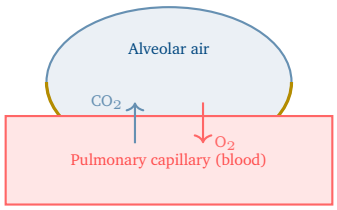
Q6. The resting membrane potential of a typical mammalian neuron is approximately:

(A) $+70$ mV (inside positive)
(B) -35 mV (slightly negative)
(C) -70 mV (inside negative)
(D) 0 mV (no electrochemical gradient)

Q7. Adrenocorticotropic hormone (ACTH), sometimes called the 'stress hormone' because it drives the cortisol stress response, is secreted by the:

(A) Anterior pituitary gland (corticotroph cells)
(B) Posterior pituitary gland (neurohypophysis)
(C) Adrenal medulla (chromaffin cells)
(D) Hypothalamus (paraventricular nucleus)

Q8. The diagram below illustrates gas exchange in an alveolus. Surfactant is produced by Type II pneumocytes and lines the alveolar surface. Its primary physiological purpose is to:



(A) Transport oxygen across the alveolar membrane via active carriers
(B) Prevent alveolar collapse (atelectasis) by reducing surface tension
(C) Destroy inhaled pathogens by antimicrobial action
(D) Increase the diffusion distance between air and blood

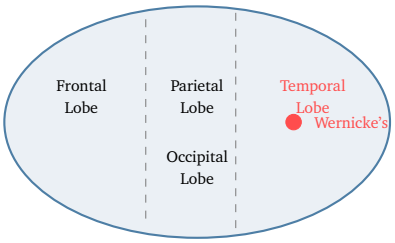
Q9. The heart sounds heard through a stethoscope — the first sound ("lubb") and the second sound ("dubb") — are produced by:

(A) Contraction of ventricular muscle generating turbulence
(B) Opening of the mitral and aortic valves respectively
(C) Closing of the atrioventricular (AV) valves (lubb) and semilunar valves (dubb)
(D) Electrical depolarisation detected at the chest wall

Q10. Intrinsic factor, an essential glycoprotein required for Vitamin B_{12} absorption in the terminal ileum, is secreted by the:

(A) Parietal cells (oxyntic cells) of the gastric mucosa
(B) Chief cells (peptic cells) of the gastric glands
(C) Goblet cells of the small intestinal villi
(D) Acinar cells of the exocrine pancreas

Q11. The diagram below shows major brain lobes. Wernicke's area, which is responsible for language comprehension (understanding spoken and written language), is located in the:



(A) Frontal lobe (motor speech area)
(B) Parietal lobe (somatosensory cortex)
(C) Occipital lobe (visual cortex)
(D) Temporal lobe (posterior superior temporal gyrus)

Q12. Phagocytosis — the process by which immune cells engulf and destroy pathogens, dead cells, and foreign particles — is carried out primarily by:

(A) Erythrocytes (red blood cells)
(B) Thrombocytes (platelets)
(C) Neutrophils and macrophages (white blood cells)
(D) Mast cells (tissue-resident immune cells)

Q13. Gallstones (cholelithiasis) form when bile components precipitate in the gallbladder. The most common type of gallstone in developed countries is primarily composed of:

(A) Calcium phosphate crystals
(B) Cholesterol
(C) Uric acid crystals
(D) Bilirubin pigment stones

Q14. Aldosterone, the main mineralocorticoid secreted by the zona glomerulosa of the adrenal cortex, acts on the distal tubule and collecting duct of the nephron to:

(A) Inhibit sodium reabsorption and promote water excretion
(B) Increase bicarbonate reabsorption and reduce H^+ secretion
(C) Stimulate glucose reabsorption from the filtrate
(D) Increase Na^+ reabsorption and K^+ excretion, thereby raising blood pressure

Q15. The bicuspid valve (also called the mitral valve) of the heart is located between the:

(A) Right atrium and right ventricle
(B) Left atrium and left ventricle
(C) Left ventricle and the aorta
(D) Right ventricle and the pulmonary artery

Q16. During skeletal muscle contraction, the rise in intracellular calcium triggers the sliding filament mechanism. Calcium ions initiate contraction by binding to:

(A) Myosin heavy chain ATPase (thick filament motor protein)
(B) Actin globular subunits directly (G-actin)
(C) Troponin C on the thin (actin) filament, exposing myosin-binding sites
(D) Titin (connectin) elastic protein in the sarcomere

Q17. When dietary protein is consumed in excess, the liver converts surplus amino acids into glucose through a process known as:

(A) Glycogenolysis (breakdown of glycogen stores)
(B) Beta-oxidation (catabolism of fatty acids)
(C) Gluconeogenesis (synthesis of new glucose from non-carbohydrate precursors)
(D) Lipogenesis (synthesis of fatty acids from acetyl-CoA)

Q18. The cranial nerve responsible for transmitting visual information from the retina to the brain is the:

(A) Olfactory nerve (CN I)
(B) Optic nerve (CN II)
(C) Oculomotor nerve (CN III)
(D) Trigeminal nerve (CN V)

Q19. Which type of immunity is characterised by antigen specificity, immunological memory (via memory B and T cells), and the ability to mount a stronger secondary response upon re-exposure?

(A) Innate (non-specific) immunity
(B) Passive immunity (transfer of pre-formed antibodies)
(C) Natural killer cell-mediated cytotoxicity
(D) Adaptive (acquired/specific) immunity

Q20. Carbonic anhydrase, the enzyme found in abundance in red blood cells, catalyses the reversible reaction that is crucial for CO_2 transport in the blood. This reaction is:

(A) $O_2 + Hb \rightleftharpoons HbO_2$ (oxyhaemoglobin formation)
(B) Glucose + $O_2 \rightarrow CO_2 + H_2O$ + ATP (aerobic respiration)
(C) $CO_2 + H_2O \rightleftharpoons H_2CO_3 \rightleftharpoons HCO_3^- + H^+$ (bicarbonate formation)
(D) Pyruvate + NADH $\rightarrow$ Lactate + NAD^+ (anaerobic glycolysis)

Q21. Blood coagulation (clotting) involves a cascade of clotting factors (Factors II, VII, IX, X) that require which fat-soluble vitamin as an essential cofactor for their synthesis in the liver?

(A) Vitamin A (retinol)
(B) Vitamin K (phylloquinone / menaquinone)
(C) Vitamin E (tocopherol)
(D) Vitamin D (calciferol)

Q22. The ureters are muscular tubes that transport urine from the site of production to the storage organ. Ureters carry urine from the:

(A) Kidneys to the urinary bladder
(B) Urinary bladder to the urethra
(C) Renal pelvis directly to the urethra
(D) Adrenal glands to the renal pelvis

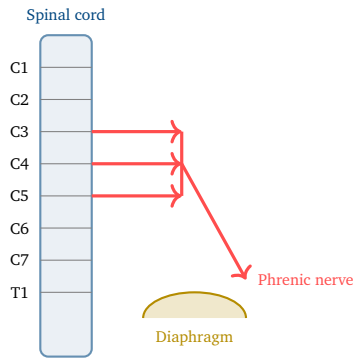
Q23. The normal total white blood cell (WBC/leukocyte) count in a healthy adult is:

(A) 4,000–11,000 per μL (4–11 $\times$ 10^9/L)
(B) 100,000–400,000 per μL (thrombocyte range)
(C) 4.5–5.5 million per μL (erythrocyte range)
(D) 1,000–3,000 per μL (severely immunocompromised range)

Q24. Leptin is a hormone secreted by adipocytes (fat cells) that acts on the hypothalamus to regulate energy balance. Its primary effect is to signal:

(A) Hunger and promote increased food intake (appetite stimulation)
(B) Satiety and suppress appetite, reducing energy intake
(C) Stress and activate the HPA axis
(D) Growth and activate IGF-1 pathways in the liver

Q25. The diagram below shows the major nerves controlling breathing. The phrenic nerve, which provides the primary motor innervation to the diaphragm and drives the rhythm of breathing, arises from spinal cord segments:



(A) C1–C2 (upper cervical)
(B) T1–T4 (upper thoracic)
(C) C7–T1 (cervicothoracic junction)

(D) C3–C5 (mid-cervical)

Answer Key — Physiology Sample Paper 5

1	D	2	A	3	D	4	A	5	A
6	C	7	A	8	B	9	C	10	A
11	D	12	C	13	B	14	D	15	B
16	C	17	C	18	B	19	D	20	C
21	B	22	A	23	A	24	B	25	D

Detailed Solutions

Solution

Q1. (D) Nephron

The **nephron** is the structural and functional unit of the kidney. Each kidney contains approximately 1 million nephrons. Each nephron consists of: glomerulus + Bowman's capsule (filtration), proximal convoluted tubule (bulk reabsorption), loop of Henle (concentration), distal convoluted tubule (fine-tuning), and collecting duct (final concentration/dilution under ADH control). Together they produce ≈1.5 L of urine daily from 180 L of filtrate.

Solution

Q2. (A) Olfactory mucosa (nasal epithelium)

Olfactory receptor neurons (ORNs) are bipolar neurons embedded in the **olfactory epithelium** lining the roof of the nasal cavity (cribriform plate region). Their cilia project into the mucus layer and bind odorant molecules. Signals travel via CN I (olfactory nerve) to the olfactory bulb and then the limbic system, which explains the strong connection between smell and memory/emotion.

Solution

Q3. (D) Autoimmune destruction of pancreatic beta cells

Type 1 DM is a T-cell-mediated autoimmune disease in which cytotoxic $CD8^+$ T cells destroy the insulin-secreting β-cells of the islets of Langerhans, leading to *absolute* insulin deficiency. Patients are dependent on exogenous insulin. Type 2 DM (Option A) involves peripheral insulin resistance and relative insulin deficiency, commonly associated with obesity. The HLA-DR3/DR4 haplotypes confer the highest genetic risk for Type 1.

Solution

Q4. (A) 70–100 mg/dL (3.9–5.6 mmol/L)

Normal fasting blood glucose is **70–100 mg/dL**. Values of 100–125 mg/dL indicate impaired fasting glucose (pre-diabetes). Fasting glucose $\geq$126 mg/dL on two occasions confirms diabetes mellitus. Post-prandial (2-hour) glucose $\geq$200 mg/dL also confirms diabetes. Hypoglycaemia ($<$70 mg/dL) causes sweating, tremors, confusion, and in severe cases, loss of consciousness.

Solution

Q5. (A) Liver (urea cycle)

The **liver** is the sole site of the **urea cycle** (ornithine cycle), which converts toxic NH_3 (ammonia from amino acid deamination) into urea (H_2N-CO-NH_2) — a non-toxic, water-soluble compound excreted in urine. Key enzymes include carbamoyl phosphate synthetase I (mitochondrial) and argininosuccinate synthetase. Liver failure causes hyperammonaemia and hepatic encephalopathy.

Solution

Q6. (C) $-$70 mV (inside negative)

The resting membrane potential (RMP) of a neuron is approximately $-$**70 mV** (inside of the cell is negative relative to outside). This is maintained by: (1) the Na^+/K^+-ATPase pump (3 Na^+ out, 2 K^+ in), (2) high K^+ permeability via leak channels (K^+ diffuses out), and (3) large negatively charged intracellular proteins. An action potential is triggered when depolarisation reaches the threshold of ≈ -55 mV.

Solution

Q7. (A) Anterior pituitary gland (corticotroph cells)

ACTH (adrenocorticotropic hormone) is secreted by corticotroph cells of the **anterior pituitary**. The HPA (hypothalamo-pituitary-adrenal) axis: stress $\rightarrow$ hypothalamus releases CRH $\rightarrow$ anterior pituitary releases ACTH $\rightarrow$ adrenal cortex (zona fasciculata) releases cortisol. ACTH is derived from the POMC precursor protein. It also has a short-term trophic effect on the adrenal cortex. Cushing's disease is due to excess ACTH from a pituitary adenoma.

Solution

Q8. (B) Prevent alveolar collapse (atelectasis) by reducing surface tension
Pulmonary surfactant (primarily dipalmitoylphosphatidylcholine, DPPC) is secreted by Type II pneumocytes and forms a monomolecular layer on the alveolar fluid surface. It reduces surface tension according to the Law of Laplace, thereby preventing alveolar collapse (atelectasis) during expiration when alveolar radius is smallest. Surfactant deficiency in premature neonates causes Respiratory Distress Syndrome (RDS / hyaline membrane disease).

Solution

Q9. (C) Closing of the AV valves (lubb) and semilunar valves (dubb)
Heart sounds are produced by valve *closure*, not opening: **S1 ("lubb")** = simultaneous closure of the *mitral* (bicuspid) and *tricuspid* (AV) valves at the start of systole; **S2 ("dubb")** = closure of the *aortic* and *pulmonary* (semilunar) valves at the end of systole. S3 (ventricular filling) and S4 (atrial contraction into a stiff ventricle) are pathological in adults. Valve *opening* is normally silent (except in mitral stenosis where an opening snap is heard).

Solution

Q10. (A) Parietal cells (oxyntic cells) of the gastric mucosa
Parietal (oxyntic) cells in the gastric fundus and body secrete both **intrinsic factor** (IF) and hydrochloric acid (HCl). IF binds Vitamin B_{12} in the duodenum, forming the IF-B_{12} complex that is absorbed via cubam receptors in the terminal ileum. Destruction of parietal cells (e.g., autoimmune gastritis) leads to *pernicious anaemia* (B_{12} deficiency megaloblastic anaemia). Chief cells secrete pepsinogen; goblet cells secrete mucus.

Solution

Q11. (D) Temporal lobe (posterior superior temporal gyrus)
Wernicke's area (Brodmann area 22) is located in the **posterior superior temporal gyrus** of the dominant (usually left) hemisphere. It is essential for language comprehension. Damage causes *Wernicke's aphasia*: fluent but nonsensical speech ("word salad"), poor comprehension, and impaired repetition. *Broca's area* (inferior frontal gyrus) is for speech production; its damage causes non-fluent (Broca's) aphasia with good comprehension but poor output.

Solution

Q12. (C) Neutrophils and macrophages

Phagocytosis is the process of engulfing and destroying particles $> 0.5\ \mu$m. Key phagocytes: **neutrophils** (first responders, short-lived, most abundant WBC, 60–70% of WBCs) and **macrophages** (derived from monocytes, long-lived tissue residents, also present antigens). Steps: chemotaxis $\rightarrow$ opsonisation (IgG/C3b coating) $\rightarrow$ engulfment $\rightarrow$ phagosome formation $\rightarrow$ fusion with lysosome (phagolysosome) $\rightarrow$ killing by ROS and proteases.

Solution

Q13. (B) Cholesterol

Cholesterol gallstones account for $\approx$80% of gallstones in Western populations. They form when bile becomes supersaturated with cholesterol (e.g., excess cholesterol secretion, reduced bile salts, reduced gallbladder motility). Risk factors: the "5 Fs" — Fat, Female, Forty, Fertile, Fair. *Pigment stones* (bilirubin) occur in haemolytic anaemias and cirrhosis. Gallstone pain (biliary colic) is severe right upper quadrant/epigastric pain radiating to the right shoulder.

Solution

Q14. (D) Increase Na^+ reabsorption and K^+ excretion

Aldosterone acts on principal cells of the distal nephron via mineralocorticoid receptors (nuclear receptors), stimulating the synthesis of ENaC (epithelial Na^+ channels) and Na^+/K^+-ATPase. Net result: Na^+ and water reabsorption $\uparrow$ (expanding plasma volume, raising BP) and K^+ and H^+ excretion $\uparrow$. Excess aldosterone causes *Conn's syndrome* (hypertension + hypokalaemia). Regulated by the renin-angiotensin-aldosterone system (RAAS) and plasma K^+.

Solution

Q15. (B) Left atrium and left ventricle

The **bicuspid (mitral) valve** has two leaflets (cusps) and guards the **left atrioventricular orifice** — i.e., between the left atrium and left ventricle. It opens during diastole (when left atrial pressure exceeds left ventricular pressure) to allow oxygenated blood to fill the left ventricle, and closes at the start of systole to prevent backflow. The tricuspid valve (3 cusps) is on the right side. Mitral stenosis and mitral regurgitation are common cardiac valve pathologies.

Solution

Q16. (C) Troponin C on the thin (actin) filament

The **troponin-tropomyosin complex** on actin thin filaments normally blocks myosin-binding sites at rest. When intracellular Ca^{2+} rises (released from sarcoplasmic reticulum via ryanodine receptors), Ca^{2+} binds to **Troponin C**, causing a conformational change that moves tropomyosin aside, exposing the actin-myosin binding sites. Myosin heads then attach, undergo power strokes, and the filaments slide. Relaxation occurs when Ca^{2+} is pumped back by SERCA.

Solution

Q17. (C) Gluconeogenesis

The liver converts excess amino acids to glucose via **gluconeogenesis** (literally "making new glucose"). First, amino acids are deaminated (amino group removed as NH_3), leaving carbon skeletons (e.g., pyruvate, oxaloacetate, α-ketoglutarate). These enter gluconeogenesis (essentially reverse glycolysis with bypass enzymes: pyruvate carboxylase, PEPCK, fructose-1,6-bisphosphatase, glucose-6-phosphatase). Gluconeogenesis also uses lactate (Cori cycle), glycerol, and alanine as substrates.

Solution

Q18. (B) Optic nerve (CN II)

The **optic nerve (CN II)** carries visual information from retinal ganglion cells to the brain. The two optic nerves partially decussate at the *optic chiasm*: nasal fibres cross to the opposite side while temporal fibres remain ipsilateral. Signals then travel via the optic tracts to the lateral geniculate nucleus (LGN) of the thalamus, and then via the optic radiations to the primary visual cortex (V1) in the occipital lobe. CN I = olfaction; CN III = eye movement; CN V = facial sensation.

Solution

Q19. (D) Adaptive (acquired/specific) immunity

Adaptive immunity is characterised by: (1) antigen specificity (via clonal selection of B and T cells with unique receptors), (2) *immunological memory* (memory cells persist after the primary response), (3) clonal expansion, and (4) self/non-self discrimination. The primary response takes 7–14 days; the secondary (memory) response is faster and stronger. B cells $\rightarrow$ antibodies (humoral); T cells $\rightarrow$ cell-mediated immunity. In contrast, innate immunity is rapid, non-specific, and has no memory.

Solution

Q20. (C) $CO_2 + H_2O \rightleftharpoons H_2CO_3 \rightleftharpoons HCO_3^- + H^+$

Carbonic anhydrase (CA) catalyses the hydration of CO_2 to carbonic acid (H_2CO_3), which rapidly dissociates to bicarbonate (HCO_3^-) and H^+. This reaction is 13,000× faster with CA. ≈70% of CO_2 is transported as bicarbonate in plasma (chloride shift: HCO_3^- exits RBC in exchange for Cl^-); ≈23% binds haemoglobin as carbamino-haemoglobin; ≈7% dissolved in plasma. This reaction reverses in the lungs to re-generate CO_2 for exhalation.

Solution

Q21. (B) Vitamin K

Vitamin K (phylloquinone K_1 from plants; menaquinone K_2 from bacteria) is essential for the γ-carboxylation of glutamate residues in clotting factors **II** (prothrombin), **VII**, **IX**, and **X**, as well as Proteins C and S. Carboxylation is required for Ca^{2+}-dependent membrane binding, activating the coagulation cascade. Vitamin K deficiency or warfarin therapy (which antagonises vitamin K) prolongs the PT/INR. Newborns receive prophylactic Vitamin K injection.

Solution

Q22. (A) Kidneys to the urinary bladder

The **ureters** are paired muscular tubes (≈25–30 cm long) that carry urine from the renal pelvis of each kidney to the urinary bladder. They enter the bladder obliquely (vesicoureteric junction), creating a valve mechanism that prevents reflux of urine back up to the kidney during micturition. Ureteric peristalsis (smooth muscle contractions) propels urine downward. Urinary tract infections (UTIs) can ascend from bladder via ureters to kidney (pyelonephritis).

Solution

Q23. (A) 4,000–11,000 per μL

Normal total WBC (leukocyte) count is **4,000–11,000/μL** (4–11 × 10^9/L). Differential: neutrophils 60–70%, lymphocytes 20–40%, monocytes 2–8%, eosinophils 1–4%, basophils <1%. *Leukocytosis* (>11,000) indicates infection, inflammation, or leukaemia. *Leukopenia* (<4,000) suggests bone marrow failure, viral infections, or immunosuppression. Note: erythrocyte count is ≈4.5–5.5 million/μL and platelet count is 150,000–400,000/μL.

Solution

Q24. (B) Satiety and suppress appetite

Leptin (from Greek *leptos* = thin) is produced by adipocytes in proportion to fat mass. It acts on leptin receptors (LepR) in the **hypothalamic arcuate nucleus** to: suppress *NPY/AgRP* (orexigenic/appetite-stimulating) neurons and activate *POMC/α-MSH* (anorexigenic/appetite-suppressing) neurons. Net effect: *satiety*, reduced food intake, increased energy expenditure. *Leptin resistance* (not deficiency) underlies most human obesity. *Ghrelin* (from the stomach) is the main orexigenic (appetite-stimulating) hormone.

Solution

Q25. (D) C3–C5 (mid-cervical)

The **phrenic nerve** arises predominantly from the **C3, C4, and C5** ventral rami (mnemonic: "C3, 4, 5 keeps the diaphragm alive"). It descends through the neck and thorax to innervate the diaphragm (motor) and the central diaphragmatic pleura and pericardium (sensory). Cervical spine injuries at or above C3–C5 can paralyse the diaphragm and require mechanical ventilation. In addition to the phrenic nerve, intercostal muscles (T1–T11) assist in breathing.