SUGGESTED ANSWERS

1.

(a) (i)

- **Observation:** After two hours (Figure 1.2), the potato chip in solution E appears swollen and firm (turgid), while the potato chip in solution F appears shrunken and soft (flaccid).
- **Explanation:** This difference is due to osmosis.
    - In solution E, the solution has a higher water potential (lower solute concentration) than the potato cells. Water moves by osmosis from the solution *into* the potato cells, causing them to swell and become turgid.
    - In solution F, the solution has a lower water potential (higher solute concentration) than the potato cells. Water moves by osmosis *out of* the potato cells into the solution, causing the cells to lose water, shrink, and become flaccid (plasmolysed).

(a) (ii) Since solution E caused the potato cells to take in water and swell, it means solution E has a lower solute concentration (higher water potential) than the potato cells. Such a solution is described as **hypotonic** relative to the cells.

(b) (i) In solution F, the potato cells lost water and shrank. The cell membrane would pull away from the cell wall. This state is called **plasmolysed** or **flaccid**.

(b) (ii) Turgor pressure, resulting from cells being full of water (turgid), provides essential mechanical support to plants. It keeps stems upright, leaves firm and spread out to maximize sunlight exposure, and helps prevent wilting.

(c)

- An **isotonic solution** is a solution that has the same water potential (or effectively, the same solute concentration) as the cell sap inside the cells placed within it.
- When cells are placed in an isotonic solution, there is no *net* movement of water across the cell membrane by osmosis (water

moves in and out at equal rates). Consequently, the cells neither swell nor shrink; they maintain their original size and shape.

2.

(a) (i)

1. **Test for Starch:** The test that gives a colour change from brown to blue/black in the presence of starch is the **Iodine test** (using Iodine solution).
2. **Nutrient tested by Emulsion test:** The Emulsion test, which produces a white precipitate (cloudy emulsion), is used to test for **Fats** or **Lipids**.
3. **Conclusion for Emulsion test:** If a white precipitate is observed, the conclusion is that **Fats are present** (or Lipids are present).
4. **Observation for Biuret test:** The Biuret test is for proteins. A positive result, confirming protein is present, is indicated by a colour change to **purple** or **violet**.

(ii)

- Kwashiorkor is a condition caused by severe **Protein** deficiency.

(iii)

- **Dietary Fibre** (or Roughage) is crucial for adding bulk to stool and preventing constipation. Water is also essential but Fibre is typically the expected nutrient answer here.

(b)

Plants can suffer from various conditions if they lack essential mineral nutrients. Here are two examples:

1. **Chlorosis:** Yellowing of the leaves, often due to a lack of magnesium (needed for chlorophyll) or nitrates (needed for proteins and chlorophyll synthesis).

2. **Stunted Growth:** Poor overall growth, often caused by a lack of nitrates, which are essential for making proteins and DNA needed for cell growth and division.

3.

(a)

- G: **Root hair**
- J: **Root cap**

(b)

- The region responsible for generating new cells through mitosis is the apical meristem, which is located just behind the root cap (J)

(c)

- **(i)**
    1. **Epidermal cells** (forming layer I)
    2. **Parenchyma cells** (making up the cortex, region H)
- **(ii)**
    1. **Xylem** (cells/vessels)
    2. **Phloem** (cells/sieve tubes)
- **(iii) Phloem** transports sugars (food) from source to sink, which can be upwards or downwards.

(d) Vascular Cambium (or simply Cambium) is the lateral meristem responsible for secondary growth (increase in thickness) in dicot roots and stems.

4.

(a)

- K: **Afferent Arteriole** (The blood vessel bringing blood *to* the glomerulus)

- L: **Bowman's capsule** (The cup-shaped structure)

(b) (i)

- The fluid in K (Afferent Arteriole) is blood, containing all blood components.
- The fluid in M (Proximal convoluted tubule) is glomerular filtrate, formed after ultrafiltration.
- Substances present in the blood (in K) but normally absent from the filtrate (in M) are:
    1. **Blood cells** (e.g., Red blood cells, White blood cells)
    2. **Large proteins / Plasma proteins** (e.g., albumin) *(Platelets are also correct)*

(b) (ii)

These substances are absent from the filtrate in M because they are normally retained in the blood during **ultrafiltration** (which happens between the glomerulus - the structure immediately after K - and the Bowman's capsule L):

1. **Molecular/Cellular Size:** Blood cells, platelets, and large plasma proteins are too large to pass through the pores and slits of the filtration barrier.
2. **Selective Filtration Barrier:** The layers of the glomerular capillaries and the Bowman's capsule wall act as a highly selective filter, preventing the passage of these large components while allowing water and small solutes to form the filtrate.

(c) (i)

- **Kidney failure** (also known as Renal failure)

(c) (ii)

Treatment for **Kidney failure**:

1. **Dialysis:** An artificial method to filter waste products from the blood. This includes:
    - **Hemodialysis:** Using an external 'artificial kidney' machine.

- **Peritoneal dialysis:** Using the lining of the patient's own abdomen as a filter.

2. **Kidney Transplant:** Surgically implanting a healthy kidney from a compatible donor to take over the functions of the failed kidneys. This requires the patient to take immunosuppressant drugs.

5.

(a)

- N : **Nuclear envelope**
- O : **Chromatids**

(b)

- Cell 1: The sister chromatids (labeled O) are separating and moving towards opposite poles. This stage is **Anaphase**.
- Cell 3: The chromosomes (each composed of two chromatids) are lined up along the middle/equator of the cell. This stage is **Metaphase**.

(c)

1. **Parental Phenotypes:** Husband (Blood Group A), Wife (Blood Group B)
2. **Parental Genotypes:** Husband (Heterozygous A = $I^A i$), Wife (Heterozygous B = $I^B i$)
3. **Gametes:**
   - Husband can produce: I^A and i
   - Wife can produce: I^B and i
4. **Genetic Diagram (Punnett Square):**

Gametes	I^B	i
I^A	$I^A I^B$	$I^A i$
i	$I^B i$	ii

SECTION B

6.

(a)

The movement of organic solutes, primarily sugars like sucrose, in the phloem tissue is called **translocation**. It is explained by the **Pressure Flow (or Mass Flow) Hypothesis**.

1. **Loading at the Source:** Sucrose produced during photosynthesis in source tissues (e.g., mature leaves) is actively transported into companion cells and then into sieve tube elements of the phloem. This process requires energy (ATP).
2. **Water Potential Gradient at Source:** The high concentration of sucrose inside the sieve tube elements at the source lowers their water potential. Water moves by osmosis from the adjacent xylem vessels (where water potential is higher) into the sieve tube elements.
3. **High Hydrostatic Pressure at Source:** The influx of water increases the hydrostatic pressure (turgor pressure) within the sieve tube elements at the source end.
4. **Unloading at the Sink:** In sink tissues (e.g., roots, fruits, growing tips), sucrose is actively transported out of the sieve tube elements into companion cells and then into sink cells where it is used or stored. This removal of sucrose increases the water potential within the sieve tube elements at the sink.
5. **Water Potential Gradient at Sink:** Water moves by osmosis out of the sieve tube elements (where water potential is now higher) and back into the xylem at the sink end.
6. **Low Hydrostatic Pressure at Sink:** The outflow of water decreases the hydrostatic pressure within the sieve tube elements at the sink end.
7. **Mass Flow:** The difference in hydrostatic pressure between the high pressure at the source and the low pressure at the sink creates a pressure gradient. This gradient drives the bulk flow of phloem sap

(water and dissolved solutes) from the source to the sink through the sieve tubes.

(b)

A potometer measures the rate of water uptake by a plant shoot, which is assumed to indicate the rate of transpiration.

1. **Preparation:** Select a healthy leafy shoot and cut its stem underwater to prevent air entering the xylem. Fill the potometer completely with water, ensuring no air bubbles.
2. **Assembly:** Insert the cut end of the shoot into the potometer's rubber tubing or stopper underwater, ensuring an airtight seal (Vaseline can be used). Remove the apparatus from the water and dry the outside.
3. **Measurement:** Allow the shoot to acclimatize. Introduce an air bubble into the capillary tube (e.g., by briefly lifting the end from the beaker of water or using a syringe/tap). Record the starting position of the bubble on the scale. Time how long it takes for the bubble to move a set distance, or measure the distance it moves in a set time (e.g., 5 minutes).
4. **Calculation & Reset:** The rate of water uptake is calculated from the distance moved by the bubble, the time taken, and the known radius of the capillary tube (Rate $\approx$ distance/time for comparison, or Rate = Volume/time where Volume = $\pi r^2 \times$ distance). The bubble can be reset using the reservoir tap or syringe.
5. **Precautions:** Ensure the setup is airtight and keep environmental conditions (light, temperature, humidity, wind) constant during measurement unless testing the effect of one variable.

(c)

Transpiration is the loss of water vapour from plant leaves, mainly through stomata. Its rate is affected by several environmental factors:

1. **Light Intensity:** Higher light intensity generally increases the rate of transpiration because light stimulates stomata to open wider for gas exchange needed for photosynthesis, allowing more water vapour to diffuse out.

2. **Temperature:** Higher temperatures increase the rate of transpiration. This is because heat increases the kinetic energy of water molecules, leading to faster evaporation from the surfaces within the leaf and faster diffusion of water vapour out. Higher temperatures also tend to lower the relative humidity of the air outside the leaf, steepening the water potential gradient.
3. **Humidity:** Higher relative humidity decreases the rate of transpiration. When the air outside the leaf is already moist, the water potential gradient between the saturated air spaces inside the leaf and the outside air is reduced, slowing down the rate of water vapour diffusion. Conversely, low humidity increases the gradient and speeds up transpiration.
4. **Wind (Air Movement):** Increased air movement generally increases the rate of transpiration. Wind blows away the layer of humid air (boundary layer) that accumulates near the leaf surface, maintaining a steep water potential gradient between the leaf interior and the surrounding air, thus promoting faster diffusion of water vapour. (Very high winds might cause stomatal closure).
5. **(Water Availability):** Although external, limited water availability in the soil will cause the plant to close its stomata (often mediated by the hormone abscisic acid) to conserve water, thus reducing the transpiration rate.

7.

(a)

The heart is a muscular organ with four internal chambers separated into right and left sides by a muscular wall called the **septum**, which prevents the mixing of oxygenated and deoxygenated blood.

1. **Chambers:**
    - **Right Atrium:** Receives deoxygenated blood from the body via the superior and inferior vena cavae.

- **Right Ventricle:** Receives deoxygenated blood from the right atrium and pumps it to the lungs via the pulmonary artery.
- **Left Atrium:** Receives oxygenated blood from the lungs via the pulmonary veins.
- **Left Ventricle:** Receives oxygenated blood from the left atrium and pumps it to the rest of the body via the aorta. The wall (myocardium) of the left ventricle is significantly thicker than the right ventricle's wall because it needs to generate higher pressure.

2. **Valves:** Ensure one-way blood flow:
   - **Atrioventricular (AV) Valves:** Located between atria and ventricles. The **tricuspid valve** (three flaps) is between the right atrium and ventricle. The **bicuspid or mitral valve** (two flaps) is between the left atrium and ventricle. These are anchored by **chordae tendineae** to **papillary muscles** in the ventricles, preventing backflow into the atria during ventricular contraction.
   - **Semilunar Valves:** Located between ventricles and major arteries. The **pulmonary valve** is between the right ventricle and pulmonary artery. The **aortic valve** is between the left ventricle and aorta. They prevent backflow into the ventricles during ventricular relaxation.

(b)

Reduced immunity means the body is less effective at fighting off pathogens, increasing susceptibility to infections. Factors include:

1. **Malnutrition:** Deficiencies in essential nutrients like proteins, vitamins (e.g., C, D), and minerals (e.g., zinc) impair the production and function of immune cells and antibodies.
2. **Chronic Stress:** Prolonged stress can suppress immune function, partly through hormones like cortisol, making individuals more vulnerable.

3. **Lack of Sleep:** Insufficient sleep negatively impacts the immune system's ability to respond effectively to threats.
4. **Certain Medical Conditions:**
    - **HIV/AIDS:** HIV specifically targets and destroys crucial immune cells (CD4 T-cells), leading to severe immunodeficiency.
    - **Chronic Diseases:** Conditions like uncontrolled diabetes can impair immune cell function.
    - **Cancers:** Especially those affecting blood and lymph (leukemia, lymphoma), and their treatments (chemotherapy, radiation), weaken immunity.
5. **Medications:** Immunosuppressant drugs (used for transplants or autoimmune diseases) and long-term corticosteroid use deliberately or incidentally reduce immune responses.
6. **Age:** The immune system is less developed in infants and tends to decline in the elderly (immunosenescence).
7. **Alcohol/Drug Abuse:** Can impair immune function.

(c)

Immunisation (vaccination) is crucial for individual and public health.

1. **Individual Protection:** Vaccines introduce weakened/inactive pathogens or their components (antigens) into the body. This triggers a primary immune response, creating specific antibodies and, crucially, **memory cells**. If the vaccinated person later encounters the actual pathogen, these memory cells mount a rapid and strong secondary immune response, preventing or greatly reducing the severity of the disease and its potential complications.
2. **Community Protection (Herd Immunity):** When a large proportion of a population is immunised, the spread of the pathogen is significantly reduced as there are fewer susceptible individuals. This **herd immunity** protects those who cannot be vaccinated (e.g., infants, immunocompromised individuals, those with allergies).
3. **Disease Control and Eradication:** Widespread immunisation programs are essential for controlling epidemics and reducing the

overall burden of infectious diseases. They have led to the eradication of smallpox and the near-eradication of diseases like polio in many parts of the world.

4. **Public Health Benefits:** Reduces illness, disability, and death from preventable diseases, lowering healthcare costs and improving overall population health and productivity.

8.

(a)

Wind Dispersal (Anemochory): This method relies on wind to carry seeds or fruits away from the parent plant. Adaptations often involve being lightweight and having structures to catch the wind or increase air resistance.

- **Wings:** Some fruits or seeds develop wing-like structures that act like propellers or gliders, slowing descent and allowing the wind to carry them further.
    - *Example:* **Sycamore** or **Maple** fruits (samaras) have prominent wings that cause them to spin as they fall.
    - *Example:* **Jacaranda** seeds are flattened and surrounded by a thin, papery wing.
- **Plumes/Hairs (Parachutes):** Seeds or fruits possess feathery hairs or plumes that increase surface area and buoyancy, allowing them to float on air currents.
    - *Example:* **Dandelion** fruits have a 'parachute' of fine hairs (pappus) attached to the seed by a stalk, enabling long-distance travel.
    - *Example:* **Cottonwood** seeds are embedded in cotton-like fluff that catches the wind easily.
- **Censer Mechanism:** Small, light seeds are held within a capsule on a long stalk. Wind shakes the stalk, and seeds are sprinkled out through pores or openings, similar to a pepper shaker.

- *Example:* **Poppy** capsules develop pores below the stigma through which seeds are released when shaken by the wind.

Animal Dispersal (Zoochory): Animals transport seeds or fruits either externally (attached to their bodies) or internally (after consumption).

- **External Dispersal (Epizoochory):** Fruits or seeds have hooks, barbs, spines, or sticky surfaces that attach to an animal's fur, feathers, or skin. They are carried away and later fall off or are groomed off.
  - *Example:* **Burdock** fruits possess hooked bracts that cling tenaciously to fur and clothing.
  - *Example:* **Black-jack** (Bidens pilosa) fruits have barbed awns that readily attach to passing animals or clothing.
- **Internal Dispersal (Endozoochory):** Plants produce fleshy, often colourful and nutritious fruits that attract animals. The animal eats the fruit, and the seeds, which are resistant to digestion, pass through the digestive tract and are deposited in faeces, often far from the parent plant and with natural fertiliser.
  - *Example:* **Berries** (like tomatoes, guavas, or wild berries) are eaten by birds and mammals, and the seeds are defecated later.
  - *Example:* **Mangoes** or **cherries** (drupes) have fleshy parts eaten, and the hard stone containing the seed may be swallowed and passed, or the fruit carried away and the stone discarded after eating the flesh.
- **Scatter-Hoarding:** Animals like squirrels collect nuts and acorns, burying them in various locations (caches) as a food store. Many caches are forgotten, allowing the seeds to germinate.
  - *Example:* **Oak** acorns are frequently buried by squirrels.

(b) Explain the importance of fruit and seed dispersal. [4]

Fruit and seed dispersal is crucial for the survival and success of plant species for several reasons:

1. **Reduces Competition:** It prevents overcrowding near the parent plant. By moving seeds away, seedlings avoid competing intensely

with the parent and siblings for vital resources like sunlight, water, soil nutrients, and physical space.

2. **Colonisation of New Habitats:** Dispersal allows plants to reach and establish in new, potentially more suitable locations. This expands the species' range and increases the chance of finding favourable growing conditions.
3. **Avoidance of Pests and Diseases:** Pathogens and seed predators can build up in high concentrations around established parent plants. Dispersing seeds away reduces the risk of seedlings being attacked by these specialised pests or diseases.
4. **Increases Genetic Diversity/Gene Flow:** Spreading seeds allows for the mixing of genes between different populations when dispersed plants establish and reproduce. This gene flow increases genetic diversity, enhancing the species' ability to adapt to environmental changes and resist widespread disease outbreaks.

9.

(a)

(i) Thyroxine

- **Source:** Produced by the thyroid gland.
- **Functions:**
    - Regulates the body's **basal metabolic rate (BMR)**, controlling the speed at which cells use energy at rest.
    - Essential for normal **growth and development**, particularly of the brain and skeleton in children.
    - Increases cellular respiration, oxygen consumption, and **heat production** (thermogenesis).
    - Influences heart rate and protein synthesis.

(ii) Glucagon

- **Source:** Produced by the alpha cells in the islets of Langerhans within the pancreas.
- **Functions:**
    - **Increases blood glucose levels** (counteracting the effect of insulin).
    - Stimulates the liver to convert stored **glycogen back into glucose** (glycogenolysis) and release it into the blood.
    - Promotes the synthesis of glucose from other sources like amino acids in the liver (gluconeogenesis).

(b) Explain the causes of short sight and how it can be corrected.

- **Cause:** Short sight (myopia) occurs when light rays from distant objects are focused *in front of* the retina, instead of directly on it. This can be because the eyeball is too long, or the cornea/lens is too curved (refracts light too strongly).
- **Correction:** It is corrected using a **concave (diverging) lens** (in spectacles or contact lenses), which spreads out the light rays slightly before they enter the eye, allowing the eye's lens system to focus the image correctly on the retina.

(c)

Deafness (hearing loss) can often be prevented through various measures:

1. **Protect Hearing from Loud Noise:** Avoid prolonged exposure to loud sounds (e.g., loud music, industrial noise). Use hearing protection like earplugs or earmuffs in noisy environments. Keep volume on personal listening devices at safe levels.
2. **Immunisation:** Get vaccinated against diseases known to cause hearing loss, such as measles, mumps, rubella (MMR), and bacterial meningitis.
3. **Prompt Treatment of Ear Infections:** Treat middle ear infections (otitis media) quickly and effectively, especially in children, to prevent complications that can damage hearing.

4. **Avoid Ototoxic Substances/Medications:** Be cautious with medications known to potentially damage hearing (ototoxic drugs), using them only under medical supervision when necessary. Avoid inserting objects into the ear canal that could cause injury.
5. **(Good Prenatal Care):** Preventing certain infections (like rubella) during pregnancy can protect the hearing of the developing baby.

10.

(a)

(i) Habitat:

- A habitat is the specific natural place or environment where an organism or species normally lives. It encompasses the physical and biological characteristics of that area, providing the resources (like food, water, shelter, appropriate temperature range) the organism needs to survive and reproduce.
    - *Example:* A freshwater pond is the habitat for a water lily; a tropical rainforest canopy is the habitat for a toucan.

(ii) Community:

- A community consists of all the different populations of various species (plants, animals, fungi, microorganisms) living and interacting with one another within a specific geographical area or habitat at a particular time. It focuses only on the living (biotic) components and their interactions (e.g., predation, competition).
    - *Example:* The community of a savanna could include grasses, acacia trees, zebras, lions, giraffes, termites, vultures, and various bacteria.

(iii) Niche:

- An organism's niche describes its functional role or "profession" within its ecosystem. It includes not just its habitat, but also its feeding habits (what it eats, what eats it), its interactions with other species, its activity patterns (e.g., nocturnal/diurnal), the resources it utilizes, and how it influences its environment.

- *Example:* The niche of an earthworm involves burrowing through soil (aerating it), consuming decaying organic matter (decomposer role), and being a food source for birds.

(b) (i)

- A food chain is a linear sequence showing how energy and nutrients are transferred from one organism to another through feeding. It starts with a producer (which makes its own food, usually via photosynthesis) and moves through successive levels of consumers (organisms that eat other organisms).
  - *Example:* **Maize Plant (Producer) → Locust (Primary Consumer) → Lizard (Secondary Consumer) → Hawk (Tertiary Consumer)**. In this chain, the maize plant produces energy, the locust eats the maize, the lizard eats the locust, and the hawk eats the lizard.

(b) (ii)

1. **Initial Source:** Energy primarily enters the food chain from sunlight, captured by producers (like plants) through photosynthesis and converted into chemical energy stored in organic matter.
2. **Unidirectional Flow:** Energy flows in one direction along the food chain, from producers to primary consumers, then to secondary consumers, and so on, as organisms are eaten.
3. **Energy Loss:** The transfer of energy between trophic levels is very inefficient. Only about 10% of the energy from one level is typically incorporated into the next level. The remaining 90% is lost primarily as:
   - Heat during metabolic processes (respiration).
   - Energy used for life processes (movement, growth, etc.).
   - Energy in uneaten parts or indigestible materials.
   - Energy in waste products (excreta).
4. **Limited Length:** Due to this significant energy loss at each step, the amount of energy available decreases dramatically at higher trophic

levels, which limits the length of most food chains (usually to 4 or 5 levels).