

TOPIC 3 – MULTICELLULAR ORGANISMS

Question Booklet

1.1 CELL STRUCTURE AND FUNCTION

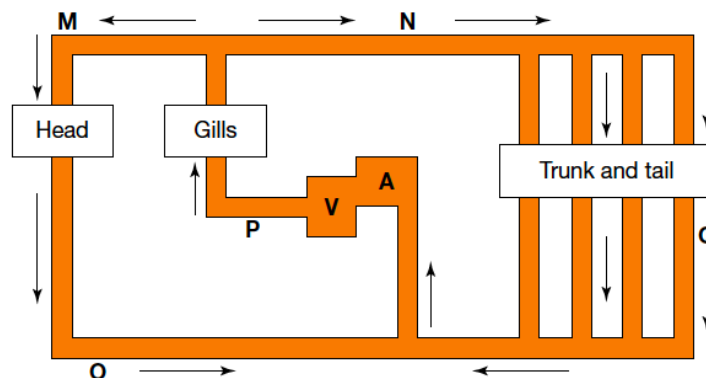
1. Explain how cells can be genetically identical, but perform completely different functions.
2. Define the term gene expression.
3. Why might stem cells be useful to someone who was born with damaged muscle tissue?
4. Why is it important for cells to differentiate?

1.2 ORGANISM STRUCTURE FOR EXCHANGE

1. Describe the main tissues in animals and plants, respectively.
2.
 - a. List the substances that a cell requires and those that a cell needs to remove.
 - b. Why do human beings need specialised exchange surfaces for these substances?
3. Identify whether each of the following statements is true or false:
 - a. An animal with a tissue level of organisation would not be expected to have organs or organ systems.
 - b. Organs are more complex in their structure than tissues.
 - c. A unicellular prokaryote could show a tissue level of organisation.
 - d. The mammalian heart is an example of a tissue.
 - e. The lining of the human bladder is an example of an epithelial tissue.
 - f. The digestive system includes many organs, for example, the pancreas.
 - g. To carry out its major function, a mammalian system depends on the operation of other systems.
4. State four characteristics of an exchange surface and explain why each of them is necessary.
5. State the three main organs of plants and describe their function.
6. Identify four organ systems that sustain the life of a mammal.
7. Classify each of the following as a tissue, organ, or organ system:
 - a. Heart, lungs, and blood vessels
 - b. Human liver
 - c. Kidneys
 - d. Layer of fat surrounding the kidney
8. Lifestyle choices can have a large impact on health. Choose two lifestyle choices and describe their positive or negative impacts on human health.
9. Give an example of each of the following:
 - a. A tissue that could be found in the stomach
 - b. An organ of the excretory system
 - c. An interaction between the skeletal system and the nervous system

1.3 MATERIAL TRANSPORT

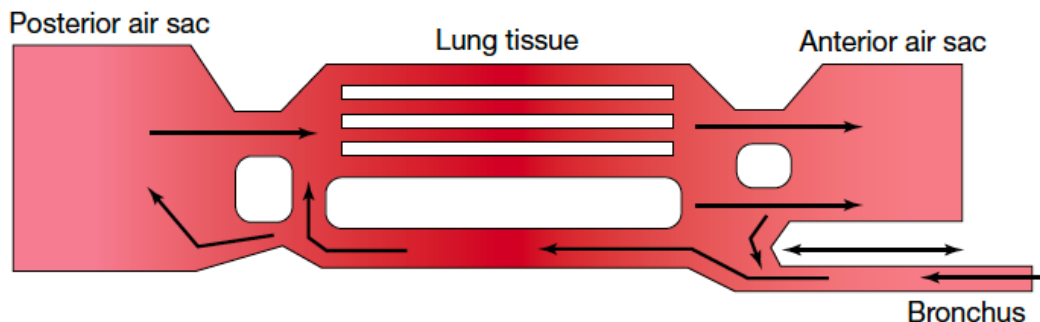
- Identify whether each of the following statements about blood capillaries and lymph capillaries is true or false:
 - Both provide a large surface area for carbon dioxide to be removed directly from the blood
 - Both provide a thin surface that increases the rate of osmosis
 - Both supply body cells with blood
 - Both supply body cells with oxygen
- What are the main components of the cardiovascular system, and what is the function of each?
- What are the main components of the lymphatic system, and what is the function of each?
- Blood and lymph are vital fluids.
 - In what ways are their chemical and cellular compositions similar?
 - In what ways are the fluids different?
 - 'Blood circulates the circulatory system but lymph does not circulate in the lymphatic system'. Explain the meaning of this statement.
- Why do arteries have thicker walls than veins?
- Describe the process of translocation in plants.
- Describe the process of material exchange at tissues. Include the molecules that are transferred between the blood and tissues in your response.
- Why are root hairs so important to the water transport system of a plant?
- By what mechanism does water reach the tops of tall trees? Use the following key words in your response: osmosis, root pressure, cohesion, transpiration.
- Explain why sugar is loaded at 'sources' and consumed at 'sinks' in plants.
- The diagram below shows the circulatory system of a fish. **A** and **V** indicate the auricle and ventricle of the heart. The arrows show the direction of flow of the blood in the system. Consider the regions **M**, **N**, **O**, **P** and **Q**.



- Which of the regions would you classify as artery and which as vein?
- How would the concentration of oxygen in the blood in region **P** compare with that in regions **M** and **Q**? Explain.
- How would the blood pressure in regions **P**, **Q**, and **M** compare with each other? Explain.

1.4 GAS EXCHANGE

1. Identify whether each of the following statements is true or false:
 - a. Oxygen passes from alveoli to capillaries by diffusion.
 - b. The largest branches of the airway passages leading into the lungs are called bronchioles.
 - c. Two-way gas exchange is a means of removing nitrogen wastes in animals.
 - d. In lungs, movement in gases across the respiratory surface is by active transport.
 - e. Respiratory surfaces must be moist.
2. Explain the following statements:
 - a. Increasing your rate of exercise increases your rate of breathing.
 - b. In humans, the surface area of the lung alveoli is far greater than the surface area of the skin.
 - c. Movement of oxygen from lung alveoli into capillaries of the lungs does not require energy.
3. Identify one example of an adaptation that has enabled a plant to conserve water by reducing water loss from the leaf stomata.
4. Explain how the movement of potassium ions in and out of guard cells regulates gas exchange in plants.
5. A bird has a series of air sacs as well as two lungs. The air sacs are elastic and expand and contract rather like bellows. Gases do not diffuse through the internal surfaces of the sacs (see diagram below – arrows indicate air flow).



When a bird breathes in, air is drawn into the posterior air sacs, which expand. Some air already in the sacs is pushed towards the lungs; this causes a push on air in the lungs. When the bird breathes out, air is forced out of the anterior air sacs, into the bronchus and then out of the body. Air is drawn from the lungs into the anterior air sacs; this drawing effect results in air in the posterior sacs being drawn into the lungs.

Birds have a unique ventilating system in that air is continually pushed and drawn across the lung tissue.

- a. Explain how such a system increases the efficiency of the lungs as an excretory organ.
- b. Suggest the likely advantage of such a system for birds.

1.5 NUTRIENT EXCHANGE

1. Outline the structural components of villi that make them suitable for efficient absorption of nutrients in the small intestine.
2. How do glucose molecules, amino acids, and fat molecules move into the villi? Explain whether these molecules move to the capillary networks or lacteals in villi.
3. Identify the main role of the large intestine.
4. State four nutrients that are critical for plant survival. Explain how these nutrients are absorbed in plants.
5. How does water enter the roots of plants?
6. Briefly outline the structural features of plant roots that allow for the efficient exchange of nutrients.

1.6 WASTE REMOVAL

1.
 - a. What are nephrons and where are they located?
 - b. Describe the structure of a nephron.
 - c. What are the special features of the nephron that enable it to carry out its function efficiently?
2.
 - a. The kidneys receive a large proportion (about 20%) of the blood pumped with each heartbeat. Why is this important?
 - b. How would you expect the composition of blood in a renal vein to differ from the composition of blood in a renal artery?
 - c. Describe the terms filtration and reabsorption and state where in the nephron these processes take place.
3. Identify whether each of the following statements is true or false:
 - a. Amino acids in excess of needs cannot be stored by animals.
 - b. Reabsorption of substances occurs by both passive diffusion and active transport.
 - c. Plants remove all their waste products.
4. What is the main excretory product found in human urine?
5. How do plants remove their waste products? How do they store their waste products?

TOPIC 3 – MULTICELLULAR ORGANISMS

Solutions

1.1 CELL STRUCTURE AND FUNCTION

1. While the DNA in all cells of an organism is identical, genes may be switched on or off through gene expression. Consequently, when particular combinations of genes are turned on or off, cells will differentiate to perform specific roles and functions.
2. Gene expression refers to the regulation of genes in an organism. Some genes may be turned off (resulting in no protein expression) or they may be turned on (resulting in protein expression). The combination of genes turned on or off give rise to differentiated cells with specific structures and functions.
3. If someone was born with damaged muscle tissue, stem cells may be used to repair the tissue as they are undifferentiated cells (able to be developed into many cells types).
4. Cells need to differentiate in order to perform specific roles and functions throughout the body.

1.2 ORGANISM STRUCTURE FOR EXCHANGE

1. The four main types of tissues in animals are: nervous tissue, muscle tissue, connective tissue and epithelial tissue. Nervous tissue is involved in transmitting information and is made up of neurons. Connective tissue connects, supports, binds or separates other tissues or organs. Muscle tissue makes up muscles. There are three types: skeletal, smooth, and cardiac muscle tissue. Epithelial tissue lines the outer surfaces of organs and blood vessels and the inner surfaces of cavities in many internal organs.

The three main types of tissues in plants are: dermal tissue, ground tissue and vascular tissue. Dermal tissue is made up of cells forming the outer surface of the leaves and young plant body. Ground tissue manufactures nutrients via photosynthesis and stores reserve nutrients. Vascular tissue is comprised of xylem and phloem. These tissues transport fluids and nutrients throughout the plant.

2.
 - a. A typical cell requires oxygen, water, glucose, minerals, and amino acids. A typical cell needs to remove urea, carbon dioxide. Plant cells will also require carbon dioxide and need to remove oxygen.
 - b. Human beings need specialised exchange surfaces for these materials in order to function most efficiently and perform the vital processes necessary for life.

- 3.
- TRUE. Organs and organ systems are more complex than tissues.
 - TRUE. Organs are comprised of multiple tissue types.
 - FALSE. A unicellular organism cannot contain tissues (as tissues are multiple cells).
 - FALSE. A heart is an example of an organ (comprised of multiple tissues).
 - TRUE. Epithelial cells line internal cavities including the bladder.
 - TRUE. Other organs in the digestive system include the stomach, and small intestine.
 - TRUE. Interdependence of organ systems is critical for survival.
4. An exchange surface must be thin so that there is less tissue for the moving molecules to pass through. Exchange surfaces are moist because molecules diffuse more efficiently through a liquid medium. If exchange surfaces were dry, cells would die and become impermeable. Having a large surface area means that there is a lot of area for molecules to pass through; aiding in the efficiency of exchange. Finally, in many animals, a rich blood supply is also essential to ensure efficient exchange across capillary beds and tissues.
5. The three main organs of plants are the root, stem and leaves. The roots physically anchor and support the plant. They absorb water and minerals from the soil and store glucose produced from photosynthesis. The stem holds the plant upright and consists of vascular tissue that transports water and glucose between roots and leaves. Leaves collect sunlight and produce glucose through photosynthesis.
6. In order to live, mammals must possess a respiratory system, circulatory system, nervous system and either the digestive system or the urinary/excretory system (both acceptable).
- 7.
- Organ system
 - Organ
 - Organ
 - Tissue
8. Any two lifestyle choices with reasonable justification acceptable.
Eg: smoking (negative impact – cancer causing, addictive, etc.)
Eg: regular exercise (positive impact – cardiovascular health, mental health, etc.)
- 9.
- Epithelial tissue
 - Kidney
 - A signal from the skeletal system via the nervous system to the brain when a bone is broken (pain)

1.3 MATERIAL TRANSPORT

1.
 - a. FALSE. Lymph vessels do not take up carbon dioxide.
 - b. TRUE. Water moves via osmosis in both capillary and lymphatic vessels.
 - c. FALSE. Lymph vessels do not supply the body with blood.
 - d. FALSE. Lymph vessels do not supply the body with oxygen.
2. The cardiovascular system is composed of the heart and blood vessels (arteries, arterioles, capillaries, venules, veins). The heart is responsible for pumping blood around the body. Blood vessels carry the blood to and from vital organs.
3. The lymphatic system is composed of lymph nodes and lymph vessels (among many other components not discussed!). Lymph nodes act as a filter to foreign substances (involved in the immune response). Lymph vessels carry the lymph fluid in one direction towards the heart.
4.
 - a. Both blood and lymph contain water.
 - b. Blood contains other essential molecules including amino acids, glucose, minerals and oxygen. Lymph contains immune cells but no other essential molecules.
 - c. Blood constantly circulates the body via the heart and the lungs. Lymph, on the other hand, exists in a series of projections, not a closed, circular system. The lymphatic system works to circulate fluid back into the circulatory system.
5. Arteries experience an increase in pressure as blood is pumped from the heart. Veins circulate deoxygenated blood back to the heart under much lower pressure. These pressure differences account for the different thicknesses of each blood vessel.
6. Translocation refers to the movement of nutrients around a plant. It involves phloem vessels to transport sugars and organic compounds from sources to sinks. Translocation is bidirectional, meaning nutrients are transported up and down the plant via phloem vessels. This process requires energy. Sugar is loaded at sources (green leaves and the stem) and consumed at sinks (roots and growing shoots).
7. As blood from arteries arrives at tissues, it is forced into capillaries under pressure, increasing cell 'leakiness'. Small nutrient molecules such as glucose, amino acids, oxygen, ions and water, and waste molecules such as carbon dioxide and urea are exchanged via diffusion. Initially, nutrient molecules move into the surrounding tissue spaces, then fluid leaks out of the capillary and bathes the surrounding tissues. 90% of this fluid is returned to the capillary, along with waste substances. 10% of the leaked fluid is collected by lymph vessels.
8. Root hairs are so important because they increase the surface area to volume ratio of the roots, making for efficient exchange; particularly important when absorbing water and nutrients from the soil.

9. Water reaches the tops of trees via transpiration. This process involves xylem vessels to transport water and minerals from the roots to the leaves of the plant. Water moves into the roots via osmosis. Then, root pressure produces a force that drives fluid upward into xylem vessels. The transpiration stream is the movement of water up the stem. During this process, water bonds via both cohesion and adhesion. Once water from the xylem reaches the plant leaves, it exits from the stomata into the air space via transpiration.
10. Sources produce glucose via photosynthesis, while sinks consume glucose for growth (root or shoot growth) (hence their names).
11.
 - a. Artery = **M, N, P**. Vein = **O, Q**.
 - b. The concentration of oxygen at point **P** and **Q** would be similar, and much lower than at point **M**. This is because oxygen is collected from the gills, meaning **M** would contain oxygen-rich blood. Meanwhile, at point **Q** material exchange would have occurred at tissues, depleting the oxygen supply in the blood.
 - c. The blood pressure at **M** would be much higher than at point **P** or **Q** because materials will be exchanged at the head, so the blood will be put under high pressure as it is forced into thin, small capillary networks. At point **P**, the blood is in an artery, meaning it is higher pressure than at point **Q** (a vein), but still not as high as at point **M**.

1.4 GAS EXCHANGE

1.
 - a. TRUE. Gas exchange is a passive process.
 - b. FALSE. The largest branches are called bronchi.
 - c. FALSE. Two-way gas exchange removes carbon dioxide from the body.
 - d. FALSE. Gas exchange is a passive process.
 - e. TRUE. Dry surfaces would become impermeable – preventing exchange.
2.
 - a. An increased rate of exercise means more energy is used by muscles undergoing aerobic and anaerobic respiration. As a result of this process, carbon dioxide is produced as a by-product, resulting in a need for breathing rate to increase to expel the additional waste products produced.
 - b. Alveoli are little air sacks that fill the lungs for efficient gas exchange. The small and convoluted size significantly increase their surface area (making it larger than the skin surface area).
 - c. Blood flow in capillaries at the lungs is de-oxygenated, meaning the concentration of oxygen in the alveoli is much greater than that in the blood. This allows oxygen to follow the concentration gradient and diffuse across to the blood passively.
3. Cacti plants have adapted to the extreme heat in their environment by keeping their stomates closed during the day to limit moisture loss through transpiration. At night, when it's cooler, they open their stomata to facilitate gas exchange and minimise water lost. They then perform photosynthesis during the day using the gasses stored from the previous night.
4. Explain how the movement of potassium ions in and out of guard cells regulates gas exchange in plants.

5.
 - a. In air is continually being pushed and drawn across the lung tissue, this allows for continual exchange of carbon dioxide and oxygen gases, making an incredibly efficient process.
 - b. As birds spend a large proportion of their time flying, they will naturally be undergoing more aerobic and anaerobic respiration, resulting in a larger production of carbon dioxide. By allowing continual blood flow over the lungs, more carbon dioxide will be able to be expelled from the bird, allowing for quicker recovery time in the air.

1.5 NUTRIENT EXCHANGE

1. The villi are small structures that contain a lining of cells with microvilli to increase the surface area. They are also thin and moist. Together, these properties allow for very efficient exchange.
2. Glucose and amino acids move into the capillary network of villi via facilitated diffusion or active transport, and active transport, respectively. Fat molecules diffuse into the lacteal of villi with the assistance of bile salts.
3. The main role of the large intestine is to reabsorb water and electrolytes.
4. Nitrogen, phosphorus, magnesium and potassium are essential for plant survival. They enter the plant roots via diffusion.
5. Water enters plant roots via osmosis following the movement of essential nutrients such as nitrogen, phosphorus, magnesium and potassium.
6. Some plants have a fibrous, highly branching root system which increases the surface area available for absorption. Other plants have a main tap root with lateral branches, which can penetrate the soil to access deeper water reservoirs. Often roots have extensions called root hairs, which further increase the overall surface area for absorption.

1.6 WASTE REMOVAL

1.
 - a. Nephrons are the functional unit of the kidney and are located in the kidney between the cortex of the kidney.
 - b. The nephron holds a capillary network (glomerulus) in a cell 'cup' (Bowman's capsule). The Bowman's capsule is connected to a tubule and accompanying capillary network for efficient material exchange. The tubule connects to a collecting duct that transports waste to the bladder for excretion.
 - c. The nephron is thin, moist, has a high surface area to volume ratio and has access to a rich blood supply, making exchange incredibly efficient.

2.
 - a. This is important as blood needs to be regularly filtered for toxin removal to avoid inefficient exchange/functioning in the body.
 - b. A renal vein would contain blood without urea and some water and mineral ions, whereas a renal artery would contain these molecules as the artery directs blood into the kidney for filtering.
 - c. Filtration occurs in the glomerulus. During the process, blood enters the glomerulus under pressure. This forces small molecules from the blood into the tubule. The small molecules filtered include glucose, amino acids, urea, minerals and water. Selective reabsorption occurs when useful molecules move from the tubule back into the capillary network. Glucose, amino acids and minerals move by diffusion then active transport. Some water is reabsorbed and some is secreted as urine. Materials, like urea, that are not reabsorbed travel to the collecting duct and then to the bladder for secretion.
3. Identify whether each of the following statements is true or false:
 - a. TRUE. Excess amino acids are destroyed or converted to glucose.
 - b. TRUE. All useful substances want to be retained, hence the use of active processes to retain all materials.
 - c. FALSE. Some waste materials are stored in vacuoles or soon-to-be-dead leaves.
4. Urea is the main excretory product in humans.
5. Plants remove their waste including carbon dioxide and oxygen via the stomata. Other waste products can be stored in large vacuoles or organs destined to fall off or die.