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Internal Assessment Test 2 – July 2024

Sub:	BIOLOGY FOR ENGINEERS					Sub Code:	BBOC407	Branch:	AIML /CSE(AIML)
Date:	10/07/24	Duration:	90 minutes	Max Marks:	50	Sem/Sec:	IV		OBE

		Answer any FIVE FULL Questions	MARKS	CO	RBT
1	a	Explain Brain as a central processing unit.	[10]	2	L1
2	a	Give an account on the structure and functioning of kidneys.	[10]	2	L2
3	a	With a diagram explain heart as pump system.	[10]	2	L3
4	a	Compare the process of photosynthesis to the functioning of photovoltaic cells.	[10]	3	L2
5	a	Define GPS system existing in birds.	[10]	3	L3
6	a	Explain the lotus leaf effect.	[10]	3	L1

1. Explain Brain as a central processing unit.

Ans. The brain, often likened to a central processing unit (CPU) in a computer, serves as the primary control center for the body, processing information, making decisions, and coordinating activities. Here's a detailed comparison:

1. Information Processing

- **Brain:** Processes sensory input from the environment (sight, sound, touch, taste, smell) and internal signals (hormones, internal body states).
- **CPU:** Processes input data from various sources like the keyboard, mouse, and sensors.

2. Decision Making

- **Brain:** Integrates information, evaluates options, and makes decisions. This involves complex neural networks that handle reasoning, emotions, and memories.
- **CPU:** Executes instructions from programs and makes decisions based on pre-defined algorithms and logic gates.

3. Control and Coordination

- **Brain:** Controls bodily functions such as movement, speech, and autonomic functions (heart rate, digestion). It coordinates actions by sending signals through the nervous system.
- **CPU:** Controls and coordinates operations within a computer, sending signals to different components (e.g., GPU, RAM, storage) to perform tasks.

4. Learning and Adaptation

- **Brain:** Capable of learning from experiences, forming memories, and adapting to new situations through neuroplasticity.
- **CPU:** Cannot learn or adapt on its own. It operates strictly based on programmed instructions unless combined with machine learning algorithms that mimic adaptive behaviors.

5. Parallel Processing

- **Brain:** Handles multiple tasks simultaneously through parallel processing, managing various functions at the same time.
- **CPU:** Modern CPUs have multiple cores that allow for parallel processing, enabling them to handle multiple tasks simultaneously but still limited compared to the brain's vast capabilities.

6. Energy Efficiency

- **Brain:** Extremely energy-efficient, operating on about 20 watts of power, yet capable of complex computations and multitasking.
- **CPU:** Typically consumes more power (ranging from a few watts in mobile devices to over 100 watts in high-performance systems) and generates more heat, requiring cooling mechanisms.

7. Error Handling and Redundancy

- **Brain:** Has built-in mechanisms for error detection and correction, as well as redundancy through neural pathways that can compensate for damaged areas.
- **CPU:** Utilizes error detection and correction codes (e.g., parity checks, ECC memory) to handle errors, but redundancy is limited compared to the brain.

8. Development and Evolution

- **Brain:** Develops and matures over time, influenced by genetics and environment, capable of evolving across generations.
- **CPU:** Designed and built by engineers, evolving through technological advancements, but does not develop or mature over time.

In summary, while the brain and CPU share similarities in processing and control functions, the brain's complexity, adaptability, and efficiency far surpass those of a CPU. The brain's ability to learn, adapt, and perform a vast array of tasks simultaneously makes it a more advanced and versatile processing unit compared to any computer CPU.

Q2. Give an account on the structure and functioning of kidneys.
Function 5 marks
Structure 5 marks

Ans. The kidneys are essential organs in the human body responsible for filtering blood, removing waste, and maintaining overall homeostasis. Here's a detailed account of their structure and functioning:

Structure of the Kidneys

Location and Appearance

1. The kidneys are two bean-shaped organs located on either side of the spine, just below the rib cage.
2. Each kidney is about 10-12 cm long, 5-7 cm wide, and 3 cm thick, weighing around 150 grams in adults.

External Structure

1. **Renal Capsule:** A tough, fibrous outer covering that protects the kidney.
2. **Renal Cortex:** The outer region beneath the renal capsule, containing the majority of nephrons.
3. **Renal Medulla:** The inner region, organized into renal pyramids, where urine is collected.
4. **Renal Pelvis:** A funnel-shaped structure that collects urine from the pyramids and channels it into the ureter.

Internal Structure

1. **Nephron:** The functional unit of the kidney, with approximately 1 million nephrons per kidney. Each nephron consists of:
    1. **Glomerulus:** A network of capillaries where blood filtration begins.
    2. **Bowman's Capsule:** Encases the glomerulus, capturing the filtrate that passes through the capillary walls.
    3. **Proximal Convoluted Tubule (PCT):** Reabsorbs water, ions, and nutrients from the filtrate.
    4. **Loop of Henle:** Concentrates the filtrate by reabsorbing water and salts.
    5. **Distal Convoluted Tubule (DCT):** Further regulates ion balance and pH.
    6. **Collecting Duct:** Channels urine from multiple nephrons to the renal pelvis.

Functioning of the Kidneys

Filtration

1. Blood enters the kidney through the renal artery, which branches into smaller arterioles, eventually reaching the glomerulus.
2. In the glomerulus, blood pressure forces water, salts, glucose, amino acids, and waste products out of the blood and into Bowman's capsule, forming the glomerular filtrate.

Reabsorption

1. As the filtrate passes through the PCT, essential substances like glucose, amino acids, and ions are reabsorbed into the bloodstream.
2. Water and salts are reabsorbed in the Loop of Henle, concentrating the filtrate.
3. In the DCT, additional reabsorption of water and ions occurs, fine-tuning the filtrate composition.

Secretion

1. The DCT and collecting duct also secrete waste products and excess ions from the blood into the filtrate.
2. This process helps regulate blood pH and ion balance.

Excretion

1. The final urine, consisting of water, urea, creatinine, and other waste products, is collected in the renal pelvis.
2. Urine flows from the renal pelvis into the ureter, then to the bladder, and is eventually excreted through the urethra.

Homeostatic Functions

Regulation of Blood Pressure

1. The kidneys release the enzyme renin, which initiates the renin-angiotensin-aldosterone system (RAAS) to regulate blood pressure and fluid balance.

Electrolyte Balance

1. The kidneys regulate the levels of various electrolytes (e.g., sodium, potassium, calcium) by selective reabsorption and secretion.

Acid-Base Balance

1. The kidneys maintain blood pH by excreting hydrogen ions and reabsorbing bicarbonate from the filtrate.

Erythropoiesis

1. The kidneys produce erythropoietin, a hormone that stimulates the production of red blood cells in response to low oxygen levels in the blood.

Detoxification

1. The kidneys help detoxify the body by filtering and excreting metabolic waste products and drugs.

In summary, the kidneys play a crucial role in maintaining the body's internal environment through their intricate structure and multifaceted functions. They filter blood, regulate fluid and electrolyte balance, control blood pressure, and contribute to red blood cell production, ensuring overall homeostasis.

Q3. With a diagram explain heart as pump system.
Structure 5marks
Function 5 marks

Ans. Heart as a Pump System

The heart is a muscular organ responsible for pumping blood throughout the body. It consists of four chambers: two atria and two ventricles. Blood flows through these chambers in a specific sequence, driven by the rhythmic contractions of the heart muscle.

Structure and Function:

Chambers of the Heart:

1. **Right Atrium:** Receives deoxygenated blood from the body through the superior and inferior vena cava.
2. **Right Ventricle:** Pumps deoxygenated blood to the lungs via the pulmonary artery for oxygenation.
3. **Left Atrium:** Receives oxygenated blood from the lungs through the pulmonary veins.
4. **Left Ventricle:** Pumps oxygenated blood to the body through the aorta.

Valves:

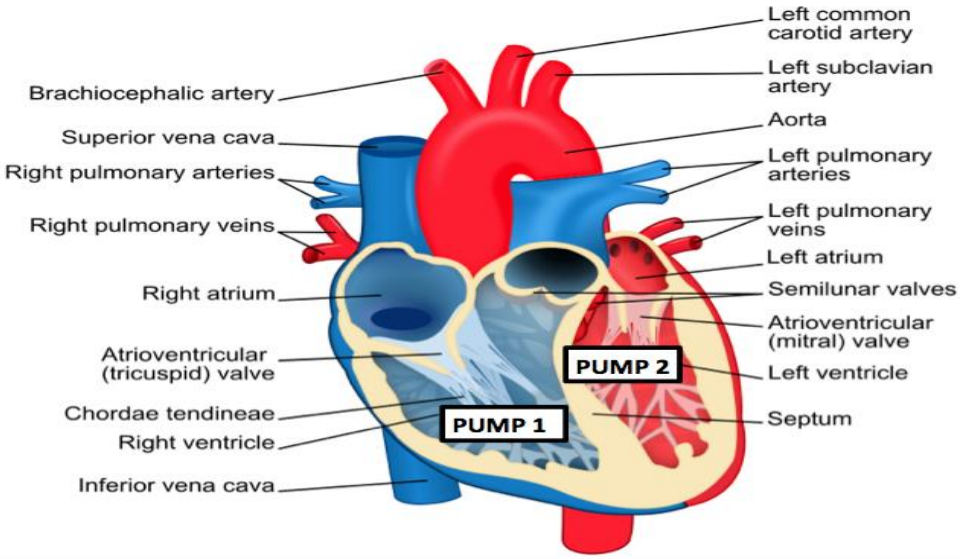
1. **Tricuspid Valve:** Located between the right atrium and right ventricle, prevents backflow of blood when the right ventricle contracts.
2. **Pulmonary Valve:** Located between the right ventricle and pulmonary artery, prevents backflow when the ventricle relaxes.
3. **Mitral (Bicuspid) Valve:** Located between the left atrium and left ventricle, prevents backflow when the left ventricle contracts.
4. **Aortic Valve:** Located between the left ventricle and aorta, prevents backflow when the ventricle relaxes.

Blood Flow Pathway:

1. **Deoxygenated Blood Flow:** Body → Superior/Inferior Vena Cava → Right Atrium → Tricuspid Valve → Right Ventricle → Pulmonary Valve → Pulmonary Artery → Lungs
2. **Oxygenated Blood Flow:** Lungs → Pulmonary Veins → Left Atrium → Mitral Valve → Left Ventricle → Aortic Valve → Aorta → Body

Cardiac Cycle:

1. **Diastole:** The heart muscles relax, allowing the chambers to fill with blood.
2. **Systole:** The heart muscles contract, pumping blood out of the chambers.



4.Compare the process of photosynthesis to the functioning of photovoltaic cells
Process 5 marks
Function 5 marks

Ans. Photosynthesis and photovoltaic (PV) cells both involve the conversion of light energy into another form of energy, but they operate through different mechanisms and serve different purposes. Here is a detailed comparison of these two processes:

Photosynthesis

Organism: Plants, algae, and some bacteria.

Purpose: Convert light energy into chemical energy stored in glucose, which is used for growth, reproduction, and other metabolic activities.

Location: Chloroplasts in plant cells.

Key Components:

- **Chlorophyll:** Pigment that captures light energy.
- **Thylakoid Membranes:** Site of the light-dependent reactions.
- **Stroma:** Site of the light-independent reactions (Calvin cycle).

Process:

1.

Light-Dependent Reactions (Thylakoid Membranes):

- **Photon Absorption:** Chlorophyll absorbs light energy, exciting electrons.
- **Water Splitting (Photolysis):** Water molecules are split into oxygen, protons, and electrons.
- **Electron Transport Chain (ETC):** Excited electrons move through the ETC, generating ATP and NADPH.
- **Oxygen Release:** Oxygen is released as a byproduct.

Light-Independent Reactions (Calvin Cycle, Stroma):

- **Carbon Fixation:** CO_2 is fixed into a stable intermediate.
- **Reduction Phase:** ATP and NADPH produced in the light-dependent reactions convert 3-phosphoglycerate into G3P.
- **Regeneration of RuBP:** G3P is used to regenerate RuBP, enabling the cycle to continue.

Photovoltaic Cells

Device: Solar panels, composed of semiconductor materials.

Purpose: Convert light energy into electrical energy, which can be used to power electrical devices or stored in batteries.

Location: Solar panels installed on rooftops, fields, etc.

Key Components:

- **Semiconductor Material (e.g., Silicon):** Absorbs light and generates electron-hole pairs.
- **P-N Junction:** Creates an electric field that separates electrons and holes.
- **Contacts:** Allow the flow of electrons, creating an electric current.

Process:

Photon Absorption:

- Photons from sunlight hit the semiconductor material, exciting electrons and creating electron-hole pairs.

Electron-Hole Separation:

- The electric field at the p-n junction separates the electrons and holes, preventing them from recombining.

Electric Current Generation:

- Electrons flow through the external circuit to the n-type side, while holes move to the p-type side, generating a direct current (DC).

Energy Conversion:

- The DC can be converted to alternating current (AC) using an inverter for use in homes and businesses.

Comparison

Energy Source:

- **Photosynthesis:** Utilizes sunlight to produce chemical energy in the form of glucose.
- **Photovoltaic Cells:** Utilize sunlight to produce electrical energy.

End Product:

- **Photosynthesis:** Glucose ($C_6H_{12}O_6$) and oxygen (O_2).
- **Photovoltaic Cells:** Direct current (DC) electricity.

Mechanism:

- **Photosynthesis:** Involves a series of biochemical reactions, including light absorption by chlorophyll, electron transport, and carbon fixation.
- **Photovoltaic Cells:** Involves the physical process of light absorption, creation of electron-hole pairs, and separation of charge carriers to generate an electric current.

Efficiency:

- **Photosynthesis:** Generally less efficient in converting sunlight to usable energy (~1-2% efficiency).
- **Photovoltaic Cells:** Higher efficiency in converting sunlight to electricity (15-20% for typical commercial panels, with some high-efficiency panels reaching over 40%).

Applications:

- **Photosynthesis:** Fundamental for life on Earth, providing energy for plants and oxygen for animals.
- **Photovoltaic Cells:** Used for generating renewable energy to power homes, businesses, and devices.

Q5. Define GPS system existing in birds.

Ans. The term "GPS system" in birds refers to the natural navigational abilities that birds possess, enabling them to undertake complex migratory journeys across vast distances. This system is a combination of several sensory and cognitive mechanisms that allow birds to orient themselves, navigate, and find their way accurately. Here are the key components of this natural GPS system in birds:

Components of the Bird GPS System

Magnetoreception:

1. Birds have specialized sensory cells that detect the Earth's magnetic field. This ability, known as magnetoreception, allows them to determine their position relative to the Earth's magnetic poles, providing a sense of direction.
2. Magnetite, a magnetic mineral, has been found in the beaks of some birds, which may play a role in this sensory capability.

Celestial Navigation:

1. Birds use the position of the sun during the day and the stars at night to orient themselves.
2. They possess an internal clock that helps them compensate for the movement of celestial bodies, maintaining accurate orientation even as the sun and stars change position.

Olfactory Cues:

1. Some bird species use their sense of smell to navigate, especially over familiar terrain.
2. Olfactory cues from the environment, such as specific odors carried by the wind, can help birds recognize landmarks and navigate accordingly.

Visual Landmarks:

1. Birds use visual landmarks such as mountains, rivers, and coastlines to navigate during their journeys.
2. Familiar landscapes can act as guideposts, helping birds stay on course or find their way back to known locations.

Infrasound:

1. Birds can detect low-frequency sounds, known as infrasound, which are generated by natural phenomena such as ocean waves, earthquakes, and atmospheric turbulence.
2. These sounds can travel long distances and provide birds with auditory cues for navigation.

Learning and Memory:

1. Birds learn and remember routes from previous migrations or from following experienced individuals.
2. Cognitive maps, which are mental representations of the spatial relationships between various landmarks, are used by birds to navigate.

Genetic Instincts:

1. Many migratory behaviors are genetically encoded, providing birds with innate directional preferences and the ability to undertake migrations even without prior experience.

Examples of Bird Navigation

Migratory Birds:

1. Species like the Arctic Tern and the Bar-tailed Godwit undertake long-distance migrations, relying on their natural GPS system to travel thousands of kilometers between breeding and wintering grounds.

Homers (Pigeons):

1. Homing pigeons are known for their remarkable ability to return to their home lofts over long distances. They use a combination of magnetic cues, visual landmarks, and olfactory signals to navigate.

Swifts and Swallows:

1. These birds travel great distances during migration, using celestial navigation and landmarks to find their way.

Q6. Explain the lotus leaf effect.

Ans. The "lotus leaf effect" refers to the remarkable self-cleaning properties of lotus leaves, which result from their unique surface structure. This phenomenon has inspired various applications in technology and materials science due to its superhydrophobic and self-cleaning characteristics. Here's a detailed explanation:

Structure of the Lotus Leaf

Microstructure:

1. The surface of a lotus leaf is covered with microscopic bumps or papillae, typically in the range of 5-10 micrometers in diameter.

Nanostructure:

1. On top of these micro-scale bumps, there are nano-scale wax crystals, about 100 nanometers in size.

Mechanism of the Lotus Leaf Effect

Superhydrophobicity:

1. The combination of the micro- and nano-scale structures creates a highly water-repellent surface.
2. When water droplets land on the leaf, they rest on the tips of the microscopic bumps, reducing the contact area between the water and the leaf surface. This results in a very high contact angle, typically greater than 150 degrees, meaning the water droplets form almost perfect spheres and roll off the surface easily.

Self-Cleaning:

1. As water droplets roll off the leaf surface, they pick up dirt and debris. This occurs because the dirt particles are more likely to adhere to the water droplets than to the leaf's surface due to the low contact area.
2. The lotus leaf remains clean because contaminants are removed by the rolling water droplets.

Benefits of the Lotus Leaf Effect

Water Repellency:

1. The high contact angle and low adhesion between water and the surface ensure that water droplets roll off easily, keeping the surface dry.

Dirt and Dust Resistance:

1. The self-cleaning property helps in removing dirt and dust particles, maintaining a clean surface without the need for additional cleaning agents.

Applications Inspired by the Lotus Leaf Effect

Self-Cleaning Surfaces:

1. **Glass and Windows:** Coatings that mimic the lotus leaf effect are used to create self-cleaning glass for windows and solar panels, reducing maintenance requirements.
2. **Textiles:** Fabrics treated to replicate the lotus leaf effect become stain-resistant and easier to clean.

Water-Repellent Coatings:

1. **Paints and Coatings:** Superhydrophobic paints are used on buildings and vehicles to prevent water and dirt accumulation.
2. **Electronics:** Protective coatings for electronic devices to make them water-resistant or waterproof.

Medical Devices:

1. **Implants and Instruments:** Surfaces that resist contamination and bacterial adhesion, improving the hygiene and longevity of medical devices.

Scientific and Industrial Implications

The study of the lotus leaf effect has significant implications in the development of new materials and surface treatments. Understanding and replicating this natural phenomenon can lead to innovations in various fields, including construction, textiles, electronics, and healthcare.