ZOO404 – PHYSIOLOGY

MID TERM MOST IMPORTANT QUESTIONS

1- What is microfilament?

Microfilaments assist with cell movement and are made of a protein called actin. Actin works with another protein called myosin to produce muscle movements, cell division, and cytoplasmic streaming. Microfilaments keep organelles in place within the cell.

2- Define hormones and give some examples.

Hormones

Hormones are signaling molecules produced by endocrine glands which are transported by the circulatory system to distant target organs and regulate physiology and behavior of the animal.

Properties of Hormones

- Hormones act only on specific target cells/tissues
- Hormonal action depend on the type of receptor
- Hormones are active at very low concentration
- Hormonal effects are amplified

Types of Hormones

1. ***Peptide and protein hormones***

These hormones are composed of amino acids. These hormones range in size from small peptides with as few as 3 amino acids (thyrotropin-releasing hormone, TRH) to proteins with almost 200 amino acids (growth hormone and prolactin)

2. ***Amine hormones***

Amines include the catecholamines (epinephrine and norepinephrine) and thyroid hormones (thyroxine and triiodothyronine). They are small molecules synthesized from a single amino acid tyrosine.

3. ***Steroid hormones***

Steroid hormones are synthesized from the precursor steroid cholesterol. They consist of four fused carbon rings including three cyclohexyl rings and one cyclopentyl ring combined into a single structure. They include the hormones secreted by the adrenal cortex (cortisol and aldosterone) hormones of ovaries (estrogen and progesterone) and testes (testosterone).

4. ***Prostaglandins***

Prostaglandins are cyclic unsaturated hydroxy fatty acids synthesized in membranes from 20- carbon fatty acid chains.

Examples of Hormones:

Estrogen, Progesterone, Testosterone, Insulin, Cortisol, Growth Hormones, Adrenaline, Thyroid Stimulating Hormone, Triiodothyronine, Thyroxine, Follicle Stimulating Hormone, Luteinizing hormone etc.

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3- What is Donnan effect?

Donnan equilibrium implies that if there is a nondiffusible solute in one of the solutions separated by semi-permeable membrane, the concentrations of solutions on both sides do not equalize. The concentration of the solution with nondiffusible solute remains high even at equilibrium. This is known as Donnan effect.

4- What coding of signal?

In the process of transmission of signals in the nervous system, a signal is coded alternately in graded potentials and in all-or-none action potentials. Graded potentials are produced at sensory and postsynaptic membranes where short distance conduction is required. On the other hand, all-or-none nerve impulses are generated for long-distance conduction along the axons. Signal transmission also involves the inter-conversion between electrical and chemical methods of signal conduction as it travels through the synapses.

5- What are T tubules?

T tubules are thin internal extensions of the cell membrane that are less than 0.1 μm. They innervate the cell at the level of Z disk and make branching networks around the perimeter of each myofibril.

Role of T Tubules:

The T tubule system provides the anatomic link between the surface membrane and the myofibrils deep inside the muscle fiber. When an action potential spreads over a muscle fiber membrane, a potential change also spreads along the T tubules to the deep interior of the muscle fiber.

6- What are properties of hormones?

Properties of Hormones

- Hormones act only on specific target cells/tissues: Although hormone molecules come into contact with all the tissues in the body during transport through blood, only the cells that contain receptors specific for a particular hormone are affected by it, and generate response.
- Hormonal action depend on the type of receptor: The action of a hormone depends on the nature of enzyme cascade linked to the hormone's receptor, as well as the effector molecules expressed in a particular tissue. For this reason, a hormone can act on two or more different types of tissues and generate different types of responses. For example Antidiuretic hormone stimulates water reabsorption in the nephron of kidney while the same hormone produces vasoconstriction and increases blood pressure by acting on the walls of arteries. The receptors in kidney nephron tubule and arterial receptors are different, causing the same hormone to generate different responses.
- Hormones are active at very low concentration: The amount of hormone produced by an endocrine gland is small. It is further diluted in the blood and interstitial fluid. The available concentration for the target cell lies between 10^{-8} to 10^{-12} M and the hormone is still effective at this very low concentration. The high sensitivity of hormonal signaling is due to the high affinity of target cell receptors for hormones.
- Hormonal effects are amplified: Binding of a hormone molecule to its receptor leads to a cascade of enzymatic steps that amplify the effect; thus just a few hormone molecules can influence thousands or millions of molecular reactions within a cell.

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7- Define physiology and write laws of physics and chemistry.

Animal Physiology deals with the study of functions of the tissues, organs and organ systems of animals. The ultimate goal of the study of physiology is to understand the mechanisms that operate in animals at all levels, in physical and chemical terms.

Physiological Mechanisms Obey Laws of Physics and Chemistry:
The knowledge of Physiology is firmly rooted in the laws and concepts of physics and chemistry. Following are the examples of some physical and chemical laws and concepts that relate to various physiological processes:

• Ohm's Law—applies to blood flow and pressure; ionic current; capacitance of membranes.
• Boyle's Law and the Ideal Gas Law—applies to respiration.
• Law of Gravity—applies to blood flow.
• Concepts of kinetic and potential energy—apply to muscle contraction; chest movements during inhalation and exhalation.
• Concepts of Inertia, momentum, velocity and drag—apply to animal locomotion.

8- What is Myofilament?

Myofilament is made up of thick and thin filaments.

Thick Filaments:

- Thick filaments extend the entire length of A band.
- These filaments are about 16 nm in diameter and are composed of about 300 myosin molecules.

Thin Filaments:

- The thin filaments are 7-8 nm thick and extend across the I band. 85
- They are composed chiefly of actin molecules.
- Thin filaments also overlap myosin filaments in the peripheral darker regions of the A band. In these regions, six actin filaments surround each myosin filament while each actin filament is surrounded by three myosin filaments.
- In thin filaments, actin molecules are arranged in two chains which twist around each other.
- Two strands of another protein tropomyosin twist around the actin and help to stiffen it. In a relaxed muscle fiber, they block myosin binding so that the myosin heads cannot bind to the thin filaments.
- Thin filaments also have a three polypeptide complex troponin at intervals of about 40nm along the thin filament.
- One of the troponin polypeptides (TnI) is an inhibitory subunit that binds to actin, other (TnT) binds to tropomyosin and helps position it on actin while third (TnC) binds the calcium ions.
- Both troponin and tropomyosin help control the myosin-actin interactions involved in contractions.

9- Define Acclimatization and Acclimation. Write their effects.

Acclimatization: Acclimatization is a physiological, biochemical, or anatomic change within an individual animal that results from the animal's chronic exposure to new, naturally occurring environmental conditions.

Effects:

- The lung ventilation rate will increase initially to acquire adequate oxygen.
- However, within few days, lung ventilation will begin to drop back towards normal rates as the other physiological mechanisms that facilitate gas exchange at high altitude begin to operate.
- This individual animal is said to have acclimatized to the new high-altitude conditions.

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Acclimation: Acclimation refers to the same process as acclimatization, but the changes are induced experimentally in the laboratory or field by the investigator.

Effects:

- The animal breathing rate will react in the same way as during acclimatization but we shall call that it has acclimated to the experimental conditions.

10- What is homeostasis? Give five examples?

During evolution, each species has assumed a specific set of internal environment with an ability to resist environmental changes by making adjustments to keep its internal fluctuations in a narrow range. This ability to protect internal environment from the harms of fluctuations in external environment is termed as homeostasis.

Homeostasis does not mean to keep a fixed internal environment as the changes maintained within a specific range are necessary for normal body functions.

Examples:

- Water availability may fluctuate tremendously in the external environment, from abundant supply to almost dry conditions.
- The quantity of water in the body i.e. internal environment may vary, but in a narrow range, in response to either abundant supply in dry condition.
- It means that the homeostatic control systems would not let the body flooded with water in abundant supply and also not let it to dehydrate in dry conditions.
- Homeostasis maintains the temperature of healthy human body near 37oC, inspite of environmental temperature variations.
- The pH of blood and interstitial fluid is maintained at 7.4 with a fluctuation range of only 0.1 pH unit.
- The concentration of glucose in the bloodstream is regulated near the range of 90 mg per 100 ml of blood even if one is fasting or full stomach.
- Similar homeostatic regulations apply to osmotic pressure, oxygen level and various ion concentrations.

11- How does acetylcholine acts at slow neurotransmitter?

Acetylcholine acts as a slow neurotransmitter by binding to muscarinic receptors, which are G-protein coupled receptors. This triggers a series of intracellular signaling events that result in slower and longer-lasting changes in neuronal excitability, synaptic plasticity, and other cellular responses.

12- Write functions of triad.

Function of Triads: Triads form the anatomical basis of excitation-contraction coupling, due to which a stimulus excites the muscle and causes it to contract. It is due to the close proximity of T tubules and sarcoplasmic reticulum at the triads that an AP in T tubule causes the SR to release Ca2+.

13- Discuss types of feedback system.

Types of Feedback Loops:

Feedback circuits/loops may follow negative or positive pathways.

Negative Feedback: The secretory activities of most endocrine tissues, especially those involved in maintaining homeostasis, are modulated by negative feedback. In this type of feedback, the hormone

itself or products resulting from its action tend to suppress its further release. Negative feedback mechanisms ensure a proper level of hormone activity at the target tissue and prevent its over-activity by over-secretion.

Positive Feedback: In this type of feedback, the secretion of a hormone leads directly or indirectly to its increased secretion. This happens when an extremely rapid or strong response is required. Positive feedback is also common in the early phases of response in most cases of hormonal action.

14- Define negative feedback system with examples.

There are many negative feedback pathways in biological systems, including:

- Temperature regulation.
- Blood pressure regulation.
- Blood sugar regulation.
- Thyroid regulation.
- Photosynthesis in response to increased carbon dioxide.
- Predator/prey population dynamic.

15- Write features of Cardiac muscles.

Features of Cardiac Muscles:

- A cardiac muscle cell (myocyte) contains one nucleus, whereas skeletal muscle cells are multinucleate.
- Skeletal muscle fibers are individually innervated by an excitatory motor axon, whereas cardiac muscle fibers are innervated only diffusely by neurons of the sympathetic (excitatory) and parasympathetic (inhibitory) nervous system.
- The cardiac innervation is modulatory only and does not produce discrete postsynaptic potentials. Its actions are to increase or decrease the strength of spontaneous myogenic contractions, which are induced by the electrical activity within the pacemaker region of the heart.
- Cardiac muscle cells are connected electrically by intercalated disks so that an AP initiated in the pacemaker region spreads rapidly from cell to cell, through fast-conducting pathways to all muscle cells within the heart.

16- Explain transmission of neurosignals in detail.

- **Signal Reception and Integration:** A nerve cell receives input signals through its dendrites and the membrane of its soma. The soma integrates messages from all inputs and determines whether the signal should be transmitted to the next neuron passively or actively through action potential.
- **Spread of Information through a Neuron:** The information received by a neuron is in the form of a stimulus-generated local depolarization. The depolarization spreads through the neuron, away from its point of origin, by two basic mechanisms:
  i. Passive electrotonic conduction—in nonspiking, local-circuit neurons
  ii. Active regenerative APs—in neurons with functional voltage-gated ion channels
- **Nonspiking, Local circuit Neurons** Many small neurons lack the voltage-gated ion channels and have only the resting K+ ion channels. They are incapable of producing APs and are referred to as nonspiking neurons or local-circuit neurons. Their conductance depends only on the passive electrical properties of the membrane i.e. capacitance and resistance, also known as the cable properties.

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- **Cable properties:** The passive electrical properties make axons comparable to electric wires, thus are known as cable properties. The cable properties affect the speed and distance of transmission of electrical signals through the axon. One important implication of these properties is that any current flowing longitudinally along an axon decays with distance. This decay happens because of resistance of cytoplasm and cell membrane to the flow of electrical signals. Moreover, there is no insulation surrounding the axonal membrane. So the current (that is in the form of K+ ions flow) decreases as it can leak out of the cell across the plasma membrane at every point as it travels down longitudinally.
- **Passive Electrotonic Conduction of Signals in Local-circuit neurons:** Local-circuit neurons are only few millimeters in length, so the graded signals can be transmitted through passive, electrotonic conduction to the axon terminals without the aid of APs. The amplitude of the signals in these neurons is attenuated as they spread through the cell, but the signals are still large enough at the terminals to modulate the release of a neurotransmitter.
- **Neurons Conducting APs** The neurons with functional voltage-gated ion channels in the axonal membranes have active electrical properties. They carry electrical signals without decrement through regenerative action potentials. Usually the neurons with relatively longer axons generate action potentials and transmit signals to long distances.

17- Define membrane potential.

Membrane potentials: All electrical phenomena in the cells and particularly neurons depend on transmembrane potential difference, generally called as membrane potential, Vm. This potential difference is electrochemical in nature. This potential difference is the basis of generation of signals which are used by neurons in communication and muscles in contraction. Membrane potential arises from two features found in all eukaryotic cells:

1. The concentrations of several ions inside the cell are different from their concentrations in the fluids outside the cell. These concentration gradients are maintained at the expense of metabolic energy.
2. The ion channels in the membrane are selectively permeable to different ionic species.

18- How action potential generated in muscles?

Action potentials in muscles are generated through a process known as excitation- contraction coupling, which involves the coordinated activation of electrical and chemical signals. Here's a simplified explanation of how action potentials are generated in muscles:

1. Motor Neuron Stimulation: When you want to move a muscle, a signal is sent from your brain or spinal cord to the motor neurons that innervate the specific muscle. These motor neurons release a neurotransmitter called acetylcholine at the neuromuscular junction, which is the point of contact between the motor neuron and the muscle fiber.
2. Depolarization of Muscle Fiber: The acetylcholine released at the neuromuscular junction binds to receptors on the muscle fiber's membrane, causing the membrane to become permeable to sodium ions (Na+). Sodium ions rush into the muscle fiber, depolarizing the membrane and generating an electrical impulse known as an action potential.
3. Propagation of Action Potential: The action potential generated at the neuromuscular junction propagates along the muscle fiber's membrane in a wave-like fashion, rapidly spreading across the entire muscle fiber.
4. Release of Calcium Ions: As the action potential travels down the membrane of the muscle fiber, it reaches specialized structures called T-tubules. These T-tubules are in close proximity to a network of membranous structures called the sarcoplasmic reticulum, which stores and releases calcium ions

(Ca2+). The action potential causes the sarcoplasmic reticulum to release calcium ions into the surrounding cytoplasm of the muscle fiber.

5. Muscle Contraction: The released calcium ions bind to specific proteins called troponin, which are located on the thin filaments within the muscle fibers. This binding causes a conformational change in the troponin, which then allows another protein called myosin to interact with the actin filaments of the muscle. The interaction between myosin and actin leads to the sliding of actin filaments over the myosin filaments, resulting in muscle contraction.
6. Repolarization and Relaxation: After the action potential is generated and the muscle contracts, the muscle fiber repolarizes and relaxes. This is achieved through the removal of calcium ions from the cytoplasm back into the sarcoplasmic reticulum, which allows the troponin to return to its original conformation and ends the interaction between myosin and actin. The sodium-potassium pump restores the normal distribution of ions across the muscle fiber's membrane, preparing it for the generation of another action potential.

19- What is myofibril?

Myofibrils are long contractile fibres, groups of which run parallel to each other on the long axis of the myocytes (long single multinucleated cells that combine to form the muscle). The myocytes run parallel to each other on the long axis of the cell.

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