

UNIT 1. GENERAL PHYSIOLOGY. PHYSIOLOGY OF CELLS AND EXCITABLE TISSUES

Lesson 1. General principles of physiology. Membrane physiology. Resting Membrane Potential. غشاء. پتانسیل آرامش

1. The object of course on physiology. Homeostasis and principles of its maintenance.
2. Biological membrane. Functions of biological membranes. The difference in the composition of intracellular and extracellular fluids.
3. Membrane transport types and their mechanisms. Types of passive transport: simple diffusion, facilitated diffusion, osmosis, filtration-absorption. Driving force for diffusion. Ion channels, their types (leakage and gated channels: voltage-gated, ligand-gated, mechanosensitive). Ion channels selectivity.
4. Types of active transport: primary and secondary, types of secondary active transport: cotransport and exchange. Role of transporters and pumps (ATPases). Role of the Na^+/K^+ -ATPase in creation and maintenance of transmembrane concentration gradients.
5. Diffusion potentials and Equilibrium potentials. The Nernst equation.
6. Resting membrane potential (RMP) پتانسیل آرامش Ionic basis of the RMP. Physiological role of the RMP.

Lesson 2. Excitable tissues. Excitability. Membrane potentials of excitable cells. Action potential. پتانسیل عمل

1. Characteristics of excitable tissues (nerve, muscle). Irritability and excitability. The excitation. Physiological properties of excitable tissues (excitability, contractility, conductivity).
2. The shift of the membrane potential in response to inward and outward currents (depolarization, hyperpolarization, repolarization). Two types of electrical potentials in excitable tissue: local (graded) and propagated (action potential)

- and their role. Threshold potential **آستانه** . Threshold, subthreshold and suprathreshold stimuli. Threshold stimulus as the measure of excitability. Properties of local response (dependence on the strength of the stimulus, propagation with/without decay, ability for summation/ refractory period).
3. The properties of action potential (AP): the all-or-none response, the strength-duration curve, propagation, refractory periods.
 4. Action potential: shape, graph, phases. Ionic mechanisms of an AP (The Hodgkin-Huxley model): fast voltage-gated sodium channels, their gates and properties; slow voltage-gated potassium channels, their gates and properties. The ionic currents, underlying ascending and descending phases of action potential). Threshold potential as equilibrium point between sodium and potassium currents. “All-or-none” law as a consequence of positive feedback in the ascending phase. Depolarizing and hyperpolarizing afterpotentials.
 5. Phase changes in the excitability of the tissue during an AP (graph, compared with the phases of an AP), their mechanism. The role of absolute and relative refractory periods.
 6. Influence of the ion permeability on threshold potential and excitability. Influence of prolonged depolarization and prolonged hyperpolarization on threshold potential and excitability. Electrical accommodation due to slowly rising current. Cathodic and anodic stimulation.

Lesson 3. Nerve Physiology. AP propagation in a nerve. The signal transmission between cells (the synapse).

1. Types of nerve fibres: myelinated and unmyelinated. Structure of myelin. Groups of nerve fibres (A, B, C).
2. Action potential propagation along the nerve fiber. Mechanism of action potential propagation along unmyelinated and myelinated fibres: role of local ionic currents. Saltatory conduction along myelinated fibres. Factors determined a speed of AP propagation: morphological (the fiber thickness and ion channels

density) and functional (amplitude and speed of depolarization, membrane excitability).

3. Bidirectional and isolated conduction along nerve fibres. Factors decreasing or blocking the AP propagation.
4. Synapse: definition, types (electrical – gap junction, chemical). Gap junctions: structure (connexons) and signal transmission (role of local currents and low electrical resistance). Functional properties of electrical synapses.
5. Chemical synapses: structure and the stages of synaptic transmission in the neuromuscular junction “end-plate” (role of action potential, calcium, neurotransmitter acetylcholine, postsynaptic receptors, postsynaptic potential).
6. Functional properties of chemical synapses.
7. The chemical classification of neurotransmitters.
8. Two types of postsynaptic receptors: ionotropic and metabotropic. Mechanism of postsynaptic potential. Pathways of neurotransmitter inactivation.
9. Synaptic transmission regulation (synaptic facilitation and synaptic depression). Regulation of neurotransmitter release and reuptake. Presynaptic receptors (auto- and heteroreceptors).

Lesson 4. Physiology of skeletal and smooth muscle.

1. Types of muscles: striated (skeletal and cardiac) and smooth. Physical and physiological properties of skeletal muscles. Functions of skeletal muscles.
2. Innervation of skeletal muscle, the motor unit. The types of muscle fibers and motor units (red and white).
3. Types of skeletal muscle contractions (single twitch and tetanus). Single muscle twitch: its phases, factors affecting the strength of contraction. Tetanus: a complete and incomplete, mechanism, factors affecting tetanic force. Isotonic and isometric contractions.

4. The structure of skeletal muscle: muscle fibers (myocytes), myofibrils, myofilaments, sarcomeres. The location and composition of thin and thick filaments (actin and myosin), Z-lines.
5. The mechanism of muscle contraction in skeletal muscle: excitation – contraction coupling/electromechanical coupling (troponin-tropomyosin complex; key role of calcium ions), the mechanism of filaments sliding (myosin bridges, the cross-bridge cycle). The role of ATP in a muscle contraction. The mechanism of skeletal muscle relaxation: the role of the calcium pump of the sarcoplasmic reticulum and elastic forces. The all-or-nothing law for a single muscle fiber.
6. Smooth muscle. The features of the smooth muscle (the morphology; innervation; automaticity; slow calcium currents, the spread of AP via gap junctions; slow, long and energy-saving contraction).
7. The mechanism of smooth muscle contraction: calcium inflow from the outside, the role of Calmodulin and Myosin Light Chains Kinase (MLCK) to increase the affinity of myosin for actin. Features of contraction: low affinity of myosin for ATP, long stay of bridges in a bound state. Features of smooth muscle relaxation: pumping calcium out, dephosphorylation of myosin by Myosin Light Chains Phosphatase (MLCP). The phenomenon of plasticity in smooth muscles.
8. Features of the regulation of smooth muscle contractions: autonomic nerves and their mediators, humoral effects, myogenic effects. A change in the concentration of calcium in the cytoplasm is a key common pathway of regulatory factors.