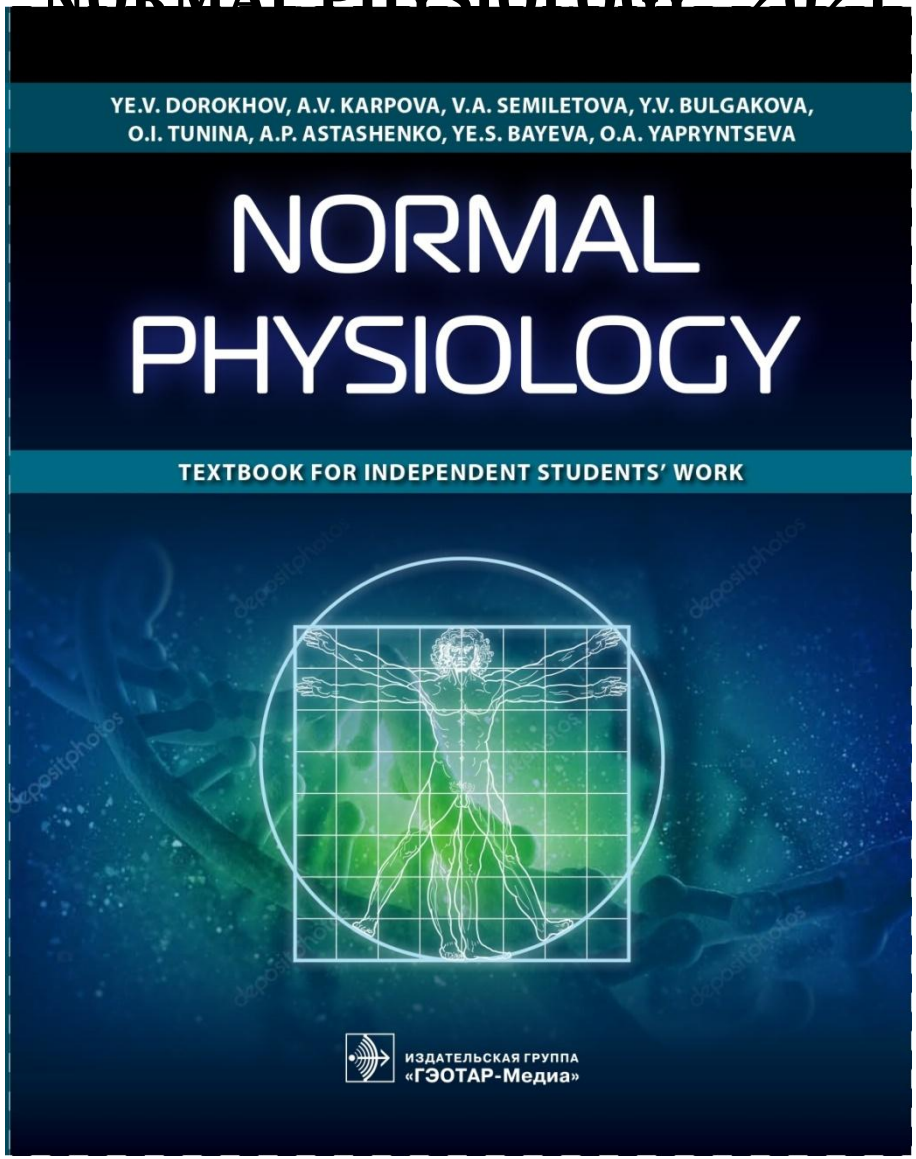
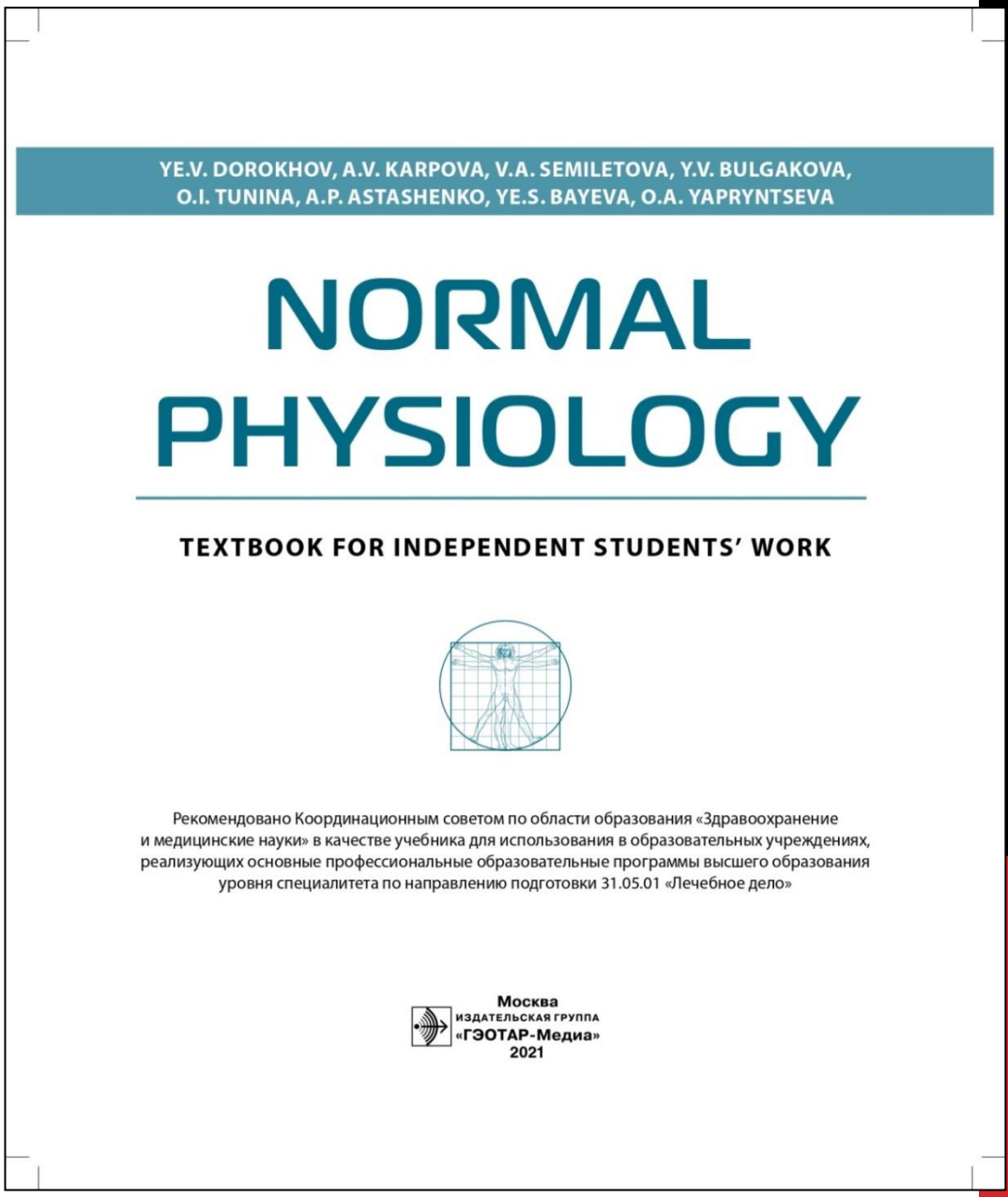
# ПРЕСС-РЕЛИЗ УЧЕБНОГО ИЗДАНИЯ “NORMAL PHYSIOLOGY” 2021



В издательстве **Гэотар-Медиа** вышел новый учебник **на английском языке “Normal Physiology” (2021)**, авторами которого являются преподаватели кафедры нормальной физиологии Воронежского государственного медицинского университета им. Н. Н. Бурденко.



**В издании изложены современные представления о целостных понятиях физиологической науки, обобщены и приведены в логической последовательности ее фундаментальные факты, рассмотрены молекулярные механизмы физиологических функций. В книге представлены актуальные стандарты современной физиологии – теоретический материал включает современные физиологические схемы, общепринятые в мировой практике**

***Transport function of the cell membrane.***

*Functional structure of the membrane.* The main components of the cell membrane are lipids, proteins and carbohydrates.

*Lipids* compose 30–70% of the membrane, they are mainly phospholipids (60% of all lipids), cholesterol (≈20%) and glycol lipids (≈5%).

*Phospholipids* have hydrophilic polar heads and non-polar hydrophobic tails (fatty acids) attached to the heads by glycerol. Phospholipids form a bimolecular layer, whose the polar heads are in contact with the extracellular and intracellular water compartments, and hydrophobic tails are in contact with each other on the principle of "tail to tail" (Fig. 1.2).

*Cholesterol* increases the mechanical strength of the bilayer. In addition, it inhibits the phase transitions of the membrane (gel/liquid crystal), which can occur upon a change in temperature, pH, ionic strength, leading to a sudden change in the viscosity of the bilayer associated with impairment of receptor, transport and enzymatic functions of the membrane.

*Proteins* compose 30–70% of the membrane. They determine mainly specific functions of the membrane. Proteins were detected in membranes in different forms: surface proteins weakly bound to the membrane, semi-integral proteins immersed in the membrane, and integral proteins entering the membrane. Proteins perform an enzymatic function in the plasma membrane, participate in the processes of transport as carriers, channels, and pumps, reception, cell recognition; they form intercellular contacts, ensure ion permeability and electrical conductivity of the membrane.

*Carbohydrates* compose 2–10% of the membrane. They are oligosaccharide chains attached to proteins (glycoproteins) and lipids (glycolipids) on the outer surface of the membrane by covalent bonds. Branched chains of glycolipids create a zone enriched with a carbohydrates and called glycocalyx on the outer surface of the plasma membrane. *Transport function of cell membrane.* There can be passive and active transport (Fig. 1.3).

*Passive transport* of substances occurs from the zone of higher concentration to the zone of lower concentration with a decrease in the energy of the transported substance. It involves simple and facilitated diffusion.

Simple diffusion is carried out through the lipid bilayer and ion channels. Small molecules are transferred

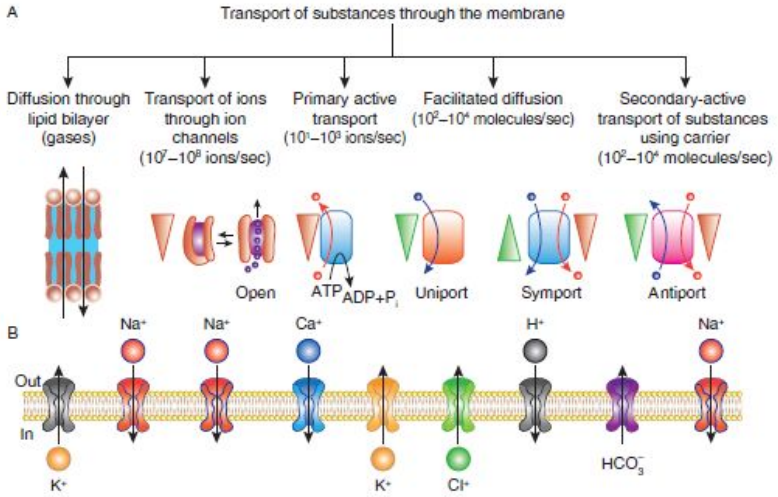



**Fig. 1.3.** Schematic representation of various types of transport through the membrane (by Kamkin A.G.) : A — the main ways of transport of substances through the membrane are demonstrated, B — various types of ion channels providing ion transport along the electrochemical gradient are shown



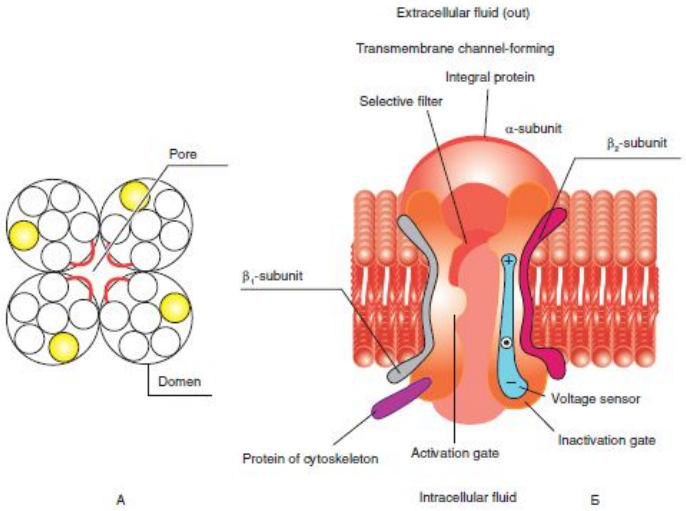



**Fig. 2.4.** Volumetric model of molecular organization of potential-gated $Na^+$ channel : A — cross-section of an ion channel, in which the four domains have six transmembrane segments, B — physiological model of a voltage-gated $Na^+$ channel (by Kamkin A.G.)

membrane, cationic (potassium, calcium, non-selective) channels, anionic channels, etc. They can create currents sufficient for a change of the electrical potential of the membrane and for activation of voltage-gated channels.

$$E = \frac{RT}{zF} \ln \frac{[\text{ion outside cell}]}{[\text{ion inside cell}]}$$

The permeability of channels can be increased or decreased as a result of the action of various substances on their proteins ($Ca^{2+}$, inositol-3-phosphate, G-protein of plasmolemma, etc.). Cell mediators and hormones operate via proteins of channels (for example, phosphorylation of amino acid residues of protein subunits of the channel changes its permeability).

In the state of physiological rest, leak channels mainly determine the permeability of the membrane (P). The permeability is very low for $Na^+$, medium for $Cl^-$, and high for $K^+$. If $PK^+$ is taken as 1, then $PK^+$: $PCl^-$ : $P\,Na^+$=1:0.4:0.04.

## 2.3. Mechanisms of resting membrane potential formation

*Diffusion of $K^+$ from the cell* through the leak channels up to the equilibrium potential ($E_{K^+}$=–94 mV) is the main mechanism of formation *of resting membrane potential* ($K^+$ as a polarizing ion). The equilibrium potential ($E_{eq}$) for $K^+$ is the potential at which an equilibrium of two forces occurs: the force of ion movement following the chemical concentration gradient and the electrostatic force with an opposing direction. If these forces are equal, diffusion of the ion stops. The diffusion of $K^+$ from the cell following electrostatic force (difference of charge) is accompanied by diffusion of cytosolic anions (proteins, phosphates). These anions stop near the inner surface of the cell, which is a membrane impermeable to them, and they form a negative membrane potential.

The equilibrium potential is calculated using the Nernst equation, where: R is the universal gas constant

**Комплексная физиологическая информация учебника “Normal Physiology” структурирована и представлена поэтапно; графические иллюстрации и таблицы нумеруются в соответствии с главами текста. В конце каждой главы авторы предлагают читателям ответить на контрольные вопросы и решить клинические ситуационные задачи, позволяющие понять значение изученного материала для практики врача. В конце учебника представлены ответы на данные задачи**

## CONTENTS

## Profile materials

*For students of the general medicine faculty*

*A change in reflex activity after the age of 60* is manifested in: a decrease in strength and an increase in the latent time of the reflex reaction (for example, Achilles, abdominal, conjunctival reflexes); a decrease in the cortical control of reflexes (appearance of a positive proboscis lip reflex, a decrease or absence of plantar reflex and disinhibition of the Babinski reflex); a decrease in concentration of nervous processes and an increase in inhibition processes in the nerve centers; a compensatory increase in the sensitivity of the nerve centers to humoral effects (by increasing the permeability of the blood-brain barrier and increasing the sensitivity of receptors to bioactive substances).

*Features of integrative mechanisms of the central nervous system* after the age of 60 include weakening of subordination effects in the central nervous system due to the weakening of cortical control; a change in the nature of feedback information arriving at the centers ("misinformation" of the centers on the state of the periphery), limiting the flow of information directed to the objects of regulation; enhanced discrepancy between central programs and their outcomes due to unamended "errors" in the activity of the body.

*Changes in EEG after the age of 60 manifest as* a decrease in the frequency of alpha rhythm to 7 Hz, as well as its amplitude to 30 mV; a decrease in the frequency of beta rhythm and its amplitude to less than 14 Hz and 10 mV respectively; a decrease in the amplitude of theta and Delta rhythms to 30 mV. Changes in EEG in the elderly are associated with changes in metabolism and hypoxia, due to a decrease in cerebral blood flow and oxygen saturation of the blood. They are manifested by a decrease in neuron lability (narrowing the range of assimilable rhythms) and a shift of neurodynamic processes towards inhibition. In the evoked potentials, their latent period increases, and amplitude decreases.

## Control questions

1. What is a reflex, what are its components, what are reflex types?
2. What are excitatory and inhibitory neural circuits?
3. What are the general characteristics and properties of nerve centers?
4. What is inhibition of excitation and occlusion of excitation? What is plasticity of nerve centers?
5. What are the mechanisms and forms of interaction of nerve centers (pathway, switching, feedback, reciprocal action, etc.)?
6. What is dominance and what are the properties of a dominant center?
7. What is a functional system and what are its components?
8. What is an electroencephalogram, what functional characteristic do its basic rhythms show?
9. What are cortical evoked potentials and what is the source of early, medium, and late waves?
10. What is functional magnetic resonance imaging, what is the principle of the method and its possibilities?
11. What is positron emission tomography, what is the principle of the method and its possibilities?

## Situational tasks

***Task 4.1.*** What happens if in the Renshaw cell synapses of the spinal motor center glutamate is released instead of glycine? Justify your answer.

***Task 4.2.*** At a lecture, students demonstrated the effect of electrical stimulation of cerebral motor centers on muscle contraction of the limbs. Once, the laboratory assistant who had forgotten to have the fed animal walk beforehand, introduced it into the experiment. To the surprise of the physiologist, in response to irritation, the dog did not have a contraction of the limb muscles, but an act of defecation. Irritation of the same area of the brain earlier caused a contraction of limb muscles. What new principle of cerebral activity coordination was discovered in these experiments? Justify your answer.

***Task 4.3.*** In the functional system when afferent synthesis is blocked, a decision block is follows. Which nerve circuit mainly ensures the formation of a decision block? Justify your answer.

***Task 4.4.*** Which neural circuit has not only a direct connection from the input neuron to the output (from the neuron circuit), but also the feedback from the output neuron to input neuron? What is the main significance of feedback in the neural circuit? Justify your answer.

Данное издание предназначено как для студентов медицинских вузов, изучающих физиологию, так и для специалистов, работающих в области теоретической и прикладной физиологии. Книга может быть использована как учебник или как основной источник в интегрированных или проблемных учебных программах по изучению медицины, создавая физиологическую основу для овладения фармакологией и патофизиологией.

CHAPTER 6

# BASIC NON-INVASIVE METHODS OF STUDYING THE CNS IN HUMAN



## 6.1. Computed tomography

Tomography (*tomos*, the Greek for section, *grapho*, write,) is a method of layer-by-layer study of the structure and function of human organs and tissues. The founder of tomography in medicine is the great Russian surgeon N.I. Pirogov, who developed a new science called topographic anatomy in the mid-19th century using the method of layer-by-layer study in three projections of the organs of frozen corpses. Modern tomography, as a non-invasive method of research, began its development in the mid-20th century from X-ray machines with a tomography attachment. Modern tomography obtaining an image of human body sections using complex devices (tomographs) as a result of interaction of three elements: a radiation source, detectors of its reception and the object itself (while two of them move while the third is motionless). The image is constructed using a computer. Depending on the radiation source (X-ray tube, protons of hydrogen nuclei in a magnetic field, administered radioactive isotopes, etc.), several types of computed tomography are distinguished: X-ray, magnetic resonance, positron emission, etc.

***X-ray computed tomography (CT).*** The method is based on transmitting x-ray radiation through the human body and fixing the degree of its attenuation to various structures of the studied section of the body by using hypersensitive detectors (layer thickness of about 1 mm). For a quantitative assessment of the degree of attenuation, the Hounsfield scale is used, in which water attenuation is taken as 0 units, a lower degree of attenuation is expressed in negative units (for example, fat — 120 units, air — 1000 units), a higher degree of attenuation in comparison with water positive units (e.g., soft tissue +40 units, bones +400 units). The degree of attenuation (radiodensity) is displayed on a computer monitor in various shades of gray, whose amount depending on the tomograph can be from several hundred to a thousand. Tomography is performed using software packages (both a standard package and specialized programs), which makes the study more focused and reduces radiation exposure. Thus, X-ray computed tomography yields a layered image of various body structures, which allows us to determine their shape and size, as well as pathological processes accompanied by a change in radiodensity. Cerebral tissues with excessive density are hematomas, calcification sites, meningeal tumors, denser areas of ischemia, cysts, glial, and metastatic tumors.

CT was the first technique that allowed visualizing brain tissue, its white and gray matter, studying its structure at the level of various sections, cerebral ventricle system, its subarachnoid spaces, and diagnosing hemorrhage in the brain, its cysts and tumors. However, with CT, images of brain sections can only be obtained in one direction transverse to the body axis, that is the image is not three-dimensional. An improvement in CT in recent decades is spiral tomography.

***Spiral X-ray computed tomography.*** Spiral CT is performed by rotating the X-ray tube around the patient's body which is at this time moved continuously along the longitudinal axis, while the tube follows

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