Changing the Hydration of Proteins of the Cytoskeleton of the Neuron - Mechanism of Formation and Motion of the Nerve Impulse

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ABSTRACT

Previously proposed mechanism of cells ripple was used based on changes in the hydration of proteins of the cytoskeleton. Ripples are necessary to maintain cell homeostasis, entry into the cell nutrient and cleaning cell from products of metabolism. In this study we show that the ripples are also the basis of curves of depolarization and repolarization, define mechanisms of overshoot and promote the nerve impulse along the axon. The aim of the study is to theoretically justify the need of studies of the aqueous component of neuroplasm and especially the interaction of protein molecules with water molecules for further development of neurophysiology.

Key words: Hydration, Hydrolysis, Ripple, Axon, Nodes of Ranvier, Resting potential, Aactivations, Nerve impulse.

INTRODUCTION

Mechanism of cells ripple was proposed in which changes in the hydration of proteins of the cytoskeleton play the main role. Heated in the water muscle fibers are contracted when the temperature is 44^{0}C (Ukhtomskiy, 1952). From this it is concluded that until this temperature there is spontaneously increasing hydration of cytoskeleton proteins, which causes an increase in its length and above it there is a spontaneously attenuation of hydration, as a consequence, reduction in the length of the protein molecules (Yashkichev, JSW, 2014). In increasing hydration cell volume increases. The resultant pressure difference between the cytoplasm and the tissue fluid provides nutrients coming into the cell and facilitates access of oxygen molecules into the cell. However homeostasis of cells disturbs as sodium ions enter into the cell sent together with the pressure differential by gradients of concentration and capacity. But sodium ions activate the enzyme sodium – ATP-ase. ATP hydrolysis begins, the heat of which raises the temperature of the cytoplasm to a value, where spontaneous dehydration of the proteins becomes. The cell compresses a pressure difference between the cytoplasm and the tissue fluid expels from the cell sodium ions, the excess water molecules and metabolic products. Since in the mechanism of pulsations ATP hydrolysis plays an important role and therefore it requires replenishment of these molecules, it becomes clear the continuous need for cells in oxygen. Rhythmic allocation and absorption of heat in the nerve established experimentally, and the amount of released heat is 20% more than absorbed (Leontyeva, 1972). Changing the hydration of motor proteins used to explain the conversion of thermal energy into mechanical and the mechanism of actin motion (Yashkichev, LSJ, 2014) in theory of the muscles work by Huxley was offered. (Huxley, 1975). In the study using the ripples the origin of depolarization and repolarization curves is explained, the formation of the nerve impulse (e.g. overshoot, since sodium ions, no matter how many additional channels are opened, will not be able to enter the axon against such obstacle as the membrane potential), as well as a mechanism of the action potential motion along the axon. For these processes additional mechanisms are needed that are cell ripples.

METHOD

In this study there is an attempt to examine the mechanism of formation of the nerve impulse and its motion along the axon, taking into account the basic laws of diffusion in the aquatic environment (Vdovenko *et al*., 1966), (Goncharov *et al*., 1968), taking into account the structure of water (Eisenberg H., & Kauzmann W, 1975) and water solutions (Samoilov, 1957.), and above all in the presence of potential and concentration gradients of sodium ions - the carriers of the action potential. It was found that depolarization and repolarization curves describing the dependence of the membrane potential from time are determined by the ripples and at the same time provide a description of the nerve cells ripples in the coordinates of potential - time. The study examines the role of the same ripples in the coding of the nerve impulse and participation of the ripples in the motion of the nerve impulse along the axon. Ripple moving along the nerve fiber has a constant amplitude. It is a short stereotypical electrical phenomenon which lasts about 1 ms. It quickly moves along the nerve from one end to the other. Ripple is also called an action potential. Stronger ripples induce ripple discharge at a higher frequency. For example, sensory nerve responds to the stretching of a muscle discharges with a frequency proportional to the degree of stretching (Kuffler and Nichols, 1976, pp. 23-25).

RESULTS

As with all the cells in the nerve cell ripples remain ion homeostasis, play an important role in the delivery of oxygen to cells and nutrients, cells purified from the metabolic products. Cell expansion during ripple and accordingly the entrance of sodium ions the ascending branch of depolarization causes. For nerve cells the potential increases from approximately -70 mV (resting potential) to -40 mV (potential activation) (Kuffler and Nichols, 1976 pp. 23-35). Cell compression at the ripple and exit from it sodium ions at the same time the descending branch of repolarization causes, which is going gently than depolarization curve, since the concentration gradient and the potential slow down the movement of sodium ions out of the cell by the action of the compression cell during ripples. All cells pulse including living plant cells (Zholkevich, 2001, pp. 21-25), but the amplitude of ripples of nerve cells is by far larger and therefore more than potential and the potential activation module resting. This made it possible to apply for the study of nerve impulse apparatus for measuring electrical current. This relative ease of the research has led to the fact that not sufficient attention paid to the fact that an electric current in this case is not the electrons flow, but movement of charged particles - sodium ions in a liquid, wherein in the aqueous medium.

DISCUSSION

The feature of nerve cells is the ability to respond to stimulation - an stimulus. As a result of the stimulus the permeability of the cell membrane increases and in the cell through inlets torrent avalanche-type flow of sodium penetrates. This violation of homeostasis nature uses to transmit information. Avalanche of sodium ions penetrated into the axon together with water molecules strongly depolarizes axoplasm in postsynaptic cell, up to change of the sign of the membrane potential (overshoot). Action potential occurs, which is approximately +50 mV. Particular importance has the fact that after the membrane potential becomes greater than zero, the movement of sodium ions into the cell should be against the potential gradient, as well as the gradient mainly produce sodium ions, even against a concentration gradient. Consequently, should be a mechanism, causing the sodium ions to move into the cell against these gradients. This mechanism, in our opinion, is the ripples of nerve cells that are based on the change in hydration of protein molecules that form the cytoskeleton of these cells.

The greater stimulation is, the higher number of sodium ions come into the postsynaptic cell passes during its expansion per unit time, and therefore, the same acceleration response neuroplasm begins, leading to contraction of the cell. But the compression in this case leads to the exit of sodium ions in tissue fluid, and to advance them along the axon. The assumption is based on the dependence of the channels work from the membrane potential (Jiang *et al*., 2003). It is evident that the encoding intensity of the stimulus in our opinion is made by the ripple frequency. But every ripple is the mechanism of formation of a single peak, which is part of the action potential. Thus, by means of ripples, and thus via hydration of cytoskeleton proteins, the explanation experimentally established encoded stimulus value by the frequency of action potential was given (Adrian, 1946, pp. 8-36). The value of the stimulus is characterized not only by the frequency of the potential in the "volley", but also by the value: the stronger stimulus, the more sodium ions enter the cell at a time. But both in the cell a greater number of water molecules enter. Coming water molecules lead to stronger hydration of cytoskeleton proteins and accordingly to a greater increase in the postsynaptic cell. A larger volume includes a greater number of sodium ions, which increases the height of the peak.

An important stage in the movement of the action potential along the axon is the transition of sodium ions from one node of Ranvier to the other. In this process along with the potential gradient and the concentrations of sodium ions between the nodes of Ranvier ripples play important role too. Exit of sodium ions from tissue fluid into axon depletes tissual fluid adjacent to the site of entry of ions by them. The concentration of sodium ions is lowered. The arrival of ions from other places of tissue fluid compensates this decrease, but primarily from areas adjacent to the next node of Ranvier. The arrival of the action potential (sodium ions) in the interception displaces into tissual fluid potassium ions, which increases in the tissue fluid potential gradient along the axon from the second to first intercept, which facilitates the diffusion of sodium ions from the second to the first node of Ranvier. Diffusion of sodium ions along the tissue fluid occurs without much difficulty, which is not about moving sodium ions forming the action potential in the axon. Cortex elements, organelles and other obstacles (Alberts *et al*., 1994, pp. 174-178) overcome by ripples. Change of the interception from expansion to compression pushes axoplasm with ions in the next intercept.

When braking under the action of the mediator (e.g., GABA) membrane channels for input into the cell chlorine ions open (Alberts *et al*.299-300), (White *et al*. 917-924). Chloride ions increase the negative charge in the cell (lower resting potential), and stimulus in these terms - at low resting potential - does not cause a nerve impulse. To overcome the incoming ions of chlorine negative charge of neuroplasm also helps ripples of the cells.

CONCLUSION

Cell Biology, especially neuron, can hardly be understood without systematic study of hyaloplasm. Properties of the medium are formed in large part by the unique properties of its main components - water. Just the properties of water, such as high reactivity, defines the role of hydration of proteins in many cellular processes, including in the mechanism of the conversion of heat into work, conversion of heat into work occurs during ripples (Yashkichev, JSW 2014), in the sarcomere work (Yakovlev, 1983 , (31-58)), (Vorotnikov, 2009), in the encoding character of the stimulus and in the mechanism of movement of the action potential. In addition to the evidence from physiology, both animal and plant world, desirable estimate of changes in the length of cytoskeletal proteins, which could possibly be obtained by fluorescence microscopy (Betzig at al. 2006), (Wang at al, 2014). Now there are works in which through a complex technique show that water molecules are introduced into a spiral protein molecule of rhodopsin, located between its turns. If you change the lighting of the protein molecules of water change their location (Angel, 2009).

Crucial for cellular processes and especially for processes in the neuron is the ability of water and hence water solutions to respond to external stimuli - a change in temperature, pressure, the effect of the magnetic field. The greatest change in the nature of a thermal translational motion of particles, in particular in their movement routes change, the ability to hydrate the water molecules (main component of the response) to occur when a new hyaloplasm particles - ions or molecules, including sodium ions. It is based on the response of the control cell processes occurring in it. Most clearly it is seen during cell division. For example, the accumulation of nucleotides in the nucleus leads to the composition of the nucleoplasm, where the enzymes become active, unwinds the double helix of the DNA molecule - activating the process of DNA replication. Since the response of tissue fluid on the appearance particles in it with resorption of the dead neuron part growth can be attributed in the right direction of the injured axon.

Let us state the hypothesis that the images of the external world are fixed by the brain in the form of a specific structure of neuroplasm and associated thermal motion of its particles. The specific distribution of the particles of the solution to the kinetic units and subsystems, and other features of the thermal motion, the special ability to hydrate; nature of the ripples, the need to maintain a predetermined neuron in a stable, healthy state, make certain averaged over a large number of neurons hyaloplasm, unambiguous "replica" of the image with the impact of the external environment. To keep such a "cast" nature had to abandon the division of neurons - adult neurons do not divide. Evolution has gone the way of the stock of neurons - a large excess of their numbers, their protection and development of relations between them. The study of coding the outside world via hyaloplasm would identify new ways to explain complex phenomena such as learning, memory, emotion and thinking.

Neurons ripples play an important role in their vital activity, in exchange with tissue fluid with oxygen, nutrients and metabolic products. Ripples are involved in the genesis and coding of nerve impulse and the mechanism of its movement along the axon. Ripples - the result of changes in the hydration of proteins of the cytoskeleton.

Depolarization and repolarization curves describe neuronal ripples in the membrane coordinates - potential time.

REFERENCES

1. Adrian E.D. The Physical Background of Perception. Clarendon Press, Oxford (1946).
2. Alberts B., Johnson, B., Lewis, J., Raff,M., Roberts, K. & Watson, J.D. Molecular Biology of the Cell. New York: Garland Publishing, Inc (2013).
3. Angel, T.E., Gupta, S., Yastrebska, B., Palczewski, K. & Chance, M.R. Structural waters define a functional channel mediating activation of the GPCR rhodopsin. *J. Proc. Of the National Academy of Sciences,* **34**(106), 1467-1476 (2009).
4. Betzig E., Patterson, G.H., Sougrat, R., Lindwasser, O.W., Olenich, S. Bonifacino, J.S., Davidson, M.W., Lippincott-Schwartz, J. & Hess, H.F. Imaging intracellular fluorescent proteins at nanometer resolution. *Science,* **313**(5793), 1642-1645 (2006).
5. Eisenberg H. & Kauzmann, W. The structure and properties of water. Gidrometeoizdat, Leningrad (1975).
6. Goncharov V., Yashkichev, V.I., Markova, V.G. & L.S. Alekseeva. Self-diffusion Cl^- in aqueous solutions of lithium chloride, sodium, potassium, cesium and ammonium. *radiochemistry,* **12**(6), 905-906 (1968).
7. Huxley, A.F. The Origin of Force in Skeletal Muscle, in Energy Transformation in Biological Systems. *Cuba Found. Symp.,* **34**: 271-299 (1975).
8. Jiang V., Ruta, V., Chen, J., Lee, A. & Mackinnon, R. The principal of gating charge movement in a voltage-dependent K^+ channel. *Nature,* **423** (6935) 42-48 (2003).
9. Kuffler S.W. and J.G.Nicholls. From neuron to brain. Sinauer associates, Inc. publishers Sunderland, Massachusetts (1976).
10. Leontyeva N.N. Electrophysiology excitable formations. Moscow, Publishing House of the Moscow State Pedagogical Institute nam. Lenin (1972).
11. Samoilov O.Ya. Structure and hydration of ions in aqueous solutions. Publishing House of the USSR Academy of Sciences, Moscow (1957).
12. Ukhtomskiy A.A. Collected Works, Leningrad, Leningrad State University (1951).
13. Vdovenko V.M., Gurikov, Yu. V. & Legin, E.K. Diffusion of ions and water structure. *radiochemistry,* **8**(3); 323-330 (1966).
14. Vorotnikov A.V., Shcherbakova, O.V.,

Kudryashova, T.V., Tarasova, O.S., Shirinskiy, V.P., Pfitzer, G. & Tkachuk, V.A. Phosphorylation of myosin as the main way of regulation of smooth muscle contraction. Russian Journal physiological them. IM Sechenov, **10**(95), 1058-1073 (2009).

15. Wang K., Shao, L., Chen, B.C. & Betzig, E. 3D live fluorescence imaging of cellular dynamics using Bessel beam plane illumination microscopy. *Nat. Methods,* **11**(6): 1083-1101 (2014).
16. White A., Handler, Ph., Smith, E.L., Hill, R.L. & Lehman, I.R. Principles of biochemistry. Principles of biochemistry. New York: McGraw-Hill Book Company (1973).
17. Yakovlev, N.N. Chemistry movement. Leningrad, Publishing House of "Science" (1983).
18. Yashkichev V.I. Hydration of structural proteins and model of cellular pulsation. *International scientific journal Science and world,* **2**(6), 140-141 (2014).
19. Yashkichev V.I. Changes in protein hydration means a transition mechanism of heat energy into mechanical one. *Life Science Journal,* **11**(11): 413-417 (2014).
20. Zholkevich V.N. Water transport in a plant and its endogenous regulation, Moscow:Nauka (2001).