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RECEPTION BIOPHYSICS

Abstract: *This paper presents theoretical ideas about receptors, their types, mechanism of excitation, and visual sensory studies on the biophysical and biochemical changes that take place in the cell during sensation.*

Key words: *Receptor, organism, nerve, eye, pigment, light, sensitivity, enzyme, rhodopsin, color.*

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Introduction

Information about receptors

One of the important features of a living organism is its regular contact with the external environment. This process is provided by the activity of analyzers or sensory systems in the body, which include receptors that are part of the nervous system and special cognitive structures. In analyzers, the effect received from the external environment through the receptor is transmitted to the central nervous system along the conductive nerve fiber and processed, and the body's response to the effect takes place.

Receptors receive mechanical, thermal, chemical, acoustic energy and convert it into nerve impulses during the reception process.

Receptors are studied in two major groups, such as external or extrareceptors and internal or interoreceptors. Extreceptors include auditory, visual, olfactory, and sensory receptors. Interoreceptors include viceroreceptors, vestibular, locomotor system receptors, ie propioreceptors, which provide signals about the state of the internal organs. Receptors are divided into groups based on their interaction with the external environment, that is, those that act on the basis of distant sensations, such as sight, hearing, as well as touch, that is, direct stimuli.

Depending on the nature of the adequate receptors, the receptor is classified as follows

1. Mechanoreceptors are adapted to receive the mechanical energy of the stimulus. Examples of such receptors are the receptors of the skin, the locomotor system, the auditory and balance systems, and the baroreceptors of the cardiovascular system.

2. Chemoreceptors have the property of exciting the effects of chemical factors, and such receptors are examples of parts of the sensory system that sense taste and smell. It has also been reported that chemoreceptors are found in different parts of the vascular system and in some types of organs.

3. Photoreceptors have the ability to convert light energy into nerve impulses. These receptors include color vision receptors, which differentiate the intensity of light located in the retina.

4. Most of the thermoreceptors are located in the skin, as well as in the internal organs, enter the receptors sensitive to the central temperature, which have the property of reacting very sensitive to temperature changes.

6. Pain receptors are non-receptive receptors that receive the effects of pain, and this sensation is formed as a result of a strong effect on all receptors.

Receptors are divided into primary sensitive and secondary sensitive groups according to their structural properties. For example, odor perception of primary sensory receptors is an example of sensory receptors, and the energy that affects these receptors is converted into a nerve signal in sensory neurons located in the receptor itself. Secondary sensory receptors include the visual, cognitive, and auditory receptors, where the energy of the effect is transmitted

Impact Factor:	ISRA (India) = 6.317	SIS (USA) = 0.912	ICV (Poland) = 6.630
	ISI (Dubai, UAE) = 1.582	РИНЦ (Russia) = 3.939	PIF (India) = 1.940
	GIF (Australia) = 0.564	ESJI (KZ) = 9.035	IBI (India) = 4.260
	JIF = 1.500	SJIF (Morocco) = 7.184	OAJI (USA) = 0.350

not directly to the neuron, but through a receptor cell with high sensitivity.

The mechanism of excitation of the receptor is as follows, that is, during the reaction, the configuration of the membrane structures of the receptor cell, consisting of protein-lipid molecules, changes. This leads to a change in the ion absorption property of the membrane, leading to the formation of ion currents and receptor potentials. In this process, mainly Na + ions play an important role and a receptor potential is formed. The receptor potential generated in some areas of the primary sensory receptor cells is directly converted into a nerve impulse.

Secondary sensory receptors, on the other hand, induce the release of mediator-like mediators such as acetylcholine in the presynaptic membrane of the receptor cell. Under the influence of mediators, the sensitive neuron leads to depolarization of the postsynaptic membrane. That is, a postsynaptic potential is formed, and this leads to the formation of a nerve impulse in the primary sensory neuron, also called the formation potential. Receptors have evolved to show sensitivity to the effects of certain adequate stimuli throughout evolution.

Biophysical basis of vision.

A person receives most of the information he receives by seeing. Sight is a type of photoreception that is specific to both vertebrates and arthropods.

The mechanisms of photobiological processes underlie the visual activity of the eye, and the field of photobiology also studies the mechanisms of these processes.

The visual receptor of higher organisms is the self-regulating living system of the eye. The focus of the image on the retina is achieved by using the ciliary muscles, by changing the radius of curvature of the crystal. The amount of light falling on the retina is controlled by a change in the size of the pupil as a result of the activity of the arch curtain muscles.

It is known that the retina contains rods and cones, which play an important role in the perception of light, and in the activity of visual tissues in general. In this process, the rod-shaped cells are very sensitive to light, which means that they are also sensitive to weak light. The cone-shaped cells, on the other hand, are exposed to strong light, providing color-separating activity to the eye.

To understand the visual activity of the eye, an indicator of the sensitivity of the eye to light is included, which consists of the minimum light value that is capable of generating visual perception under certain conditions.

The sensitivity of the eye to light can vary over a certain range due to its ability to adapt to different light spectra, and the mechanism of this adaptation is as follows:

a) by changing the diameter of the pupil and increasing the value of the luminous flux;

b) by shielding the tube and rod cells with a dark pigment;

c) by reducing the concentration of light-sensitive and non-degradable substances;

g) by changing the number of cells involved in the formation of visual perception depending on the level of illumination of the body.

In the range of illumination range from 10-7 kd / m2 to 105 kd / m2, visual activity of the eye is normal. At low levels of illumination, for example in the dark, the retina of the eye is affected by an average of 100 photons per second, and an average of 10% is absorbed by rod and tube cells, and 90% of the photons return from the cornea.

The human eye apparatus senses the effects of electromagnetic waves in the wavelength range of an average of 40 nm to 760 nm. In this process, the spectral sensitivity of the eye is expressed by the following equation:

$$\mathbf{S = \Delta\Phi / \Delta\Phi_э}$$

Where: $\mathbf{\Delta\Phi}$- light flux; $\mathbf{\Delta\Phi_э}$- is the radiant power that creates this stream of light.

Based on this equation, the values of $\mathbf{\Delta\Phi}$ and $\mathbf{\Delta\Phi_э}$ are appropriate for the range of wavelengths $\boldsymbol{\lambda}$ to $\boldsymbol{\lambda+d\lambda}$ The human eye apparatus is very sensitive to monochromatic yellow, green light with a wavelength of 555 555 nm. In this case, an irradiance of 1 W produces a light sensitivity corresponding to a luminous flux of 683 lm. Based on the above equation, the radiation visibility for the wavelength S = 555 nm = 683 lm / W is obtained.

The concept of relative visibility is also introduced in the visual process, which is represented by the following equation:

$$\mathbf{S_\lambda = S_\lambda / S_{\lambda max}}$$

Where: $\mathbf{S_{\lambda max}}$ - the maximum visibility of a given radiation spectrum is an indicator of S_λ depending on the wavelength of the light.

For daytime visibility, the maximum wavelength corresponding to $\mathbf{S_{\lambda max}}$ is and in low light $\boldsymbol{\lambda}$**=555 нм** ни, and in low light $\boldsymbol{\lambda}$**=510** nm. In low light conditions, the eye's ability to distinguish colors is reduced, and different colors are perceived as bluish-gray.

The rod cells located in the retina of the eye are composed of light-sensitive outer, i.e., the first and inner, i.e., the second segments, and the inner segment contains the nucleus and mitochondria that support the cell’s functioning. Inside the outer segment are thin discs with a diameter of 6 µm, and each of these discs consists of two layers of membranes, similar in shape to liposomes.

These visual discs contain the visual pigment, a complex protein molecule called rhodopsin, which has a molecular mass of 40,000 D. The rhodopsin molecule belongs to the group of chromoproteins and is composed of an opsin protein as well as a group of chromophores called retinal.

In general, rhodopsin is composed of vitamin A aldehyde, retinal, and protein opsin. When a quantum of light is absorbed, photophysical and photochemical changes take place in this compound. In this case, the retinal isomerizes, the side chain of the molecule is corrected, and the binding to the protein is lost. The enzymatic centers of the protein molecule are activated.

This initially produces intermediates such as metorodopsin, which are then separated from the retinal protein opsin. Under the action of the enzyme retinal reductase, vitamin A is finally formed. When the eye pigments pass into the dark phase of the retina, the visual acuity, rhodopsin, is restored. For this process, the retina must contain vitamin A tsis-isomers. If the body is deficient in vitamin A, the rhodopsin molecule regenerates and the pathological condition known as rickets occurs. In the retina, 0.006 rhodopsin expression occurs after 5 hours under the influence of 100 lk of light, and this process takes place in a strictly economical manner.

The retina has several spatial isomers, and only its II-tsis-retinal isomer binds to the opsin molecule. Under the influence of light, retinal rhodopsin is broken down and transformed into a stable trans-isomer. As a result of this process, changes occur in the membrane of the discs associated with the change of rhodopsin, i.e., rhodopsin moves from the interdiscal hydrophilic surface to the internal hydrophobic phase of the membranes.

At rest, the membranes of the discs do not transmit Na +, K +, Ca2 + and other ions, and under the influence of light, the permeability of the membrane to ions increases. The role of rhodopsin in this process is that its conformational change under the influence of light creates “pores” for some ions in the membrane and closes Na + channels in the outer membrane. As a result, an uneven distribution of ions on the inside and outside of the membrane, i.e. a potential difference, is formed. The action potential in this view generates a nerve impulse during vision.

The outer segment of the rod cells is due to the uneven distribution of potential sodium ions formed as a result of weak light in the membrane. As a result of changes in the conformational structure of rhodopsin under the influence of light, the membrane permeability for the Na + ion decreases sharply, but does not change for other ions. The peculiarity of the outer segments of the retina rods is that at rest the potential in their cytoplasmic membrane, nerve and many other cells differ from the membrane potential and are determined by Na + ions. At rest, the permeability of the outer segment membrane to sodium ions differs sharply from that to other ions. Sodium ions move along their electrochemical gradients from the outside to the cytoplasm, then diffuse toward the inner segment through the leg connecting the outer segment to the inner segment, and are expelled through the inner segment membrane in the presence of Na, K-ATF-aza. In this case, the membrane permeability for K + ions is at its highest and the potential K + nature formed. As a result, the cytoplasmic membrane potential in the outer segment of the rod cell has a negative sign outside the membrane and a positive sign inside the cell.

Color vision refers to the ability of the eye to perceive light differently with different wavelengths. The human eye can perceive light rays around 302-950 mm. Color vision is conditioned by the presence of three types of rhodopsins with rhodopsins, characterized by areas of absorption maxima of 445 nm, 535 nm, and 670 nm, according to the three-component theory. Absorption of light by rhodopsins causes potential formation in the tubules. Colors and the perception of the image through them are the activity of a whole vision analyzer, not just the cones in the retina.

The pigment of the bulb cells also contains II-tsis-retinal, like rhodopsin, and the protein part of this pigment has a different structure and is therefore called iodopsin. Human tubular cells are composed of iodopsins with maximum absorption wavelengths of 445, 535, and 570 nm, and this is based on a three-component color-sensing theory. Defects in the protein structure of iodopsin lead to the emergence of various pathologies in the activity of the visual apparatus in the body. For example, in color blindness, the synthesis of iodopsin proteins is disrupted and the eye loses its ability to distinguish between red and green.

Light light is characterized by spectral properties, and visual pigments, such as rhodopsin, are emitters of light energy. Their ability to switch to an electron-excited state in exchange for light absorption conditions the trigger property that initiates the chain of processes that enable the visual signal to emerge.

The general reaction of photoreception can be described as follows:

Rhodopsin + light ——→ nerve impulse

The absorption spectra of visual pigments correspond to the spectra of action of the visual receptor. Light-sensitive cells are characterized by an amplification factor of 10^5-10^6. The quantum of light, through rhodopsin, initiates a strong flow of ions across the membrane, which underlies the formation of the nerve impulse. From an energy point of view, photoreception is a highly endogenous process.

Retinal photoreceptors are composed of multilayered cells. The image formed in the pigmented epithelium acts as an input signal. The output signal is a neutral image encoded by pulses in the optic nerve. The photoreceptor cell is an elongated device consisting of a series of parallel discs containing rod and cone molecular photoreceptor structures. The thickness of the discs is about 12-15 nm and the distance between them is 14-16 nm. While the bulbs provide color vision, the bulbs are affected by poor lighting.

There are intercellular synaptic contacts in the retina. While horizontal cells bind adjacent receptors to each other and ensure the lateral transmission of information, bipolar cells ensure the transfer of information to the inner synaptic layer. Each ganglion cell receives information from a limited number of photoreceptor cells. Visual pigments are a complex of lipochromoproteins, i.e. proteins, lipids and chromophore retinal.

With the passage of rhodopsin metarodopsin II, the permeability of the cytoplasmic membrane to sodium ions decreases sharply and the permeability to potassium ions increases, the membrane potential is determined by potassium ions, and membrane polarity changes.

Information about light discoloration of rhodopsin in rod discs is transmitted through mediators to sodium channels in the cytoplasmic membrane. Light-activated rhodopsin activates the G-protein transducin. Transducin, in turn, activates phosphodiesterase and enhances the hydrolysis of ts-GMF. The sodium-calcium channels are closed, an electrical signal is generated, and a neurotransmitter is released from the synaptic ends.

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