APPLICATION OF SOME PHYSICAL TECHNIQUES IN STUDYING ELECTROPHYSIOLOGICAL CHANGES IN THE EYE RETINA

THESIS

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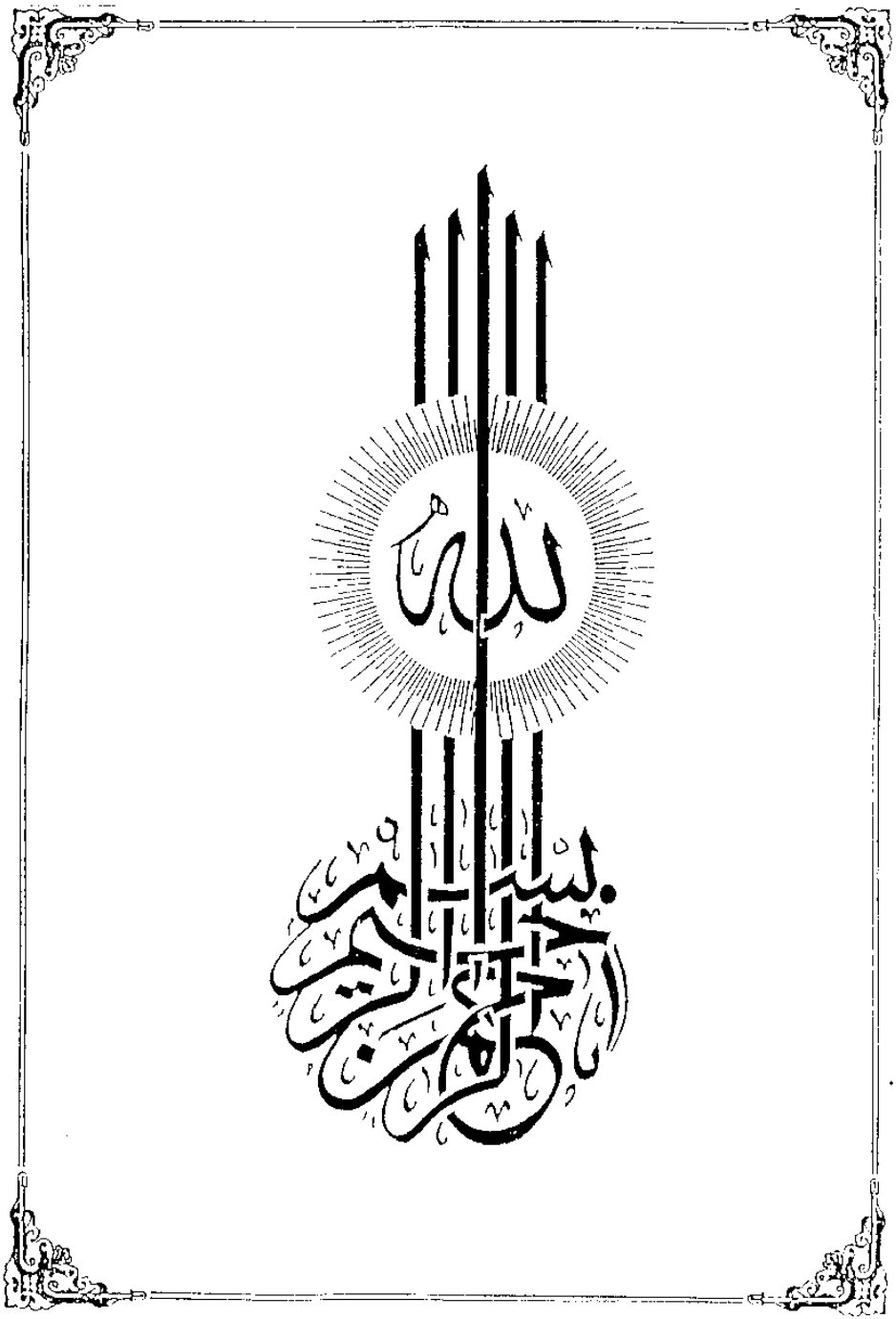
I would like to seize this opportunity to express my sincere gratitude and thanks to my beloved husband and children who accompanied me in every step throughout the journey of completing this thesis.



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SUMMARY

SUMMARY

This work used some physical techniques to study the electrophysiological changes in the chicken eye retina.

Chapter I contains the introduction and review of literature, for essential and recent work in the field of retinal activity and magnetic field effects.

Chapter II deals with some physical and electrophysiological methods which are used in the present work. It also contains full description for the techniques of microelectrodes, photo-stimulation and magnetic field exposure.

Chapter III concerns the obtained results accompanied by comments and discussions. It is divided into two main parts :

(1) Electroretinography (ERG) and resistivity measurements and;

(2) activity of retinal cell types (intracellular recording). Effects of alternating magnetic field (AMF), of different intensities, on ERG characteristics and retinal activity were investigated.

The following results were obtained :

1. Chicken retinas exposed to AMF of different flux densities (5 - 60 G) have shown differences in the common ERG components.

During light adaptation the amplitude and duration of the ERG components, recorded from the surface of the whole isolated eye, were increased during application of field strengths 25 - 35 G. In addition the frequency of ERG appearance was increased during this range. Flux densities of applied fields lower and higher than this range showed a decrease in the amplitude and the frequency of the ERG. At all field strengths, the frequency increased immediately after field off.

During dark adaptation, the ERG components, showed a gradual increase in amplitude and durations with the increase in AMF up to a value around 30 G and then declined with further increase in AMF up to 60 G.

In case of simultaneous application of AMF (with graded intensity from 5 - 60 G) and light flash to dark adapted chicken retinas, there were no noticeable changes in both amplitudes and durations of the ERG components from that of control experiment. The frequency of the ERG, recorded from chicken dark adapted eyes by the simultaneous application of AMF and light, and AMF alone, increased in each type of stimulation, reaching a maximum value at 15 - 20 G and then decreased as AMF was increased.

2. The resistivity of the isolated chicken retina was found to be 2200 ± 250 Ω cm. It rose to 3700 ± 150 Ω cm when the pigment epithelium was attached to it. The resistivity of the choroid with the sclera was 1700 ± 70 Ω cm.

The resistance of the chicken eye cup showed a measurable change immediately after the application of AMF of different strengths (5 - 60 G) and fixed duration (0.5 min). For AMF strengths of 5 - 40 G, the resistance decreases for a period of 3 - 7 min after which the resistance returns back to its original value. After application of AMF above 40 G, the resistance also decreases but it takes a longer time (8 min) to restore its original value, then exceeds it to a new level of 2 - 4% higher than the normal value.

The percentage of immediate relative decrease in resistance $(\Delta R/R)_{i}$ increases as AMF increases. It reaches maximum value of 18%, at AMF of 45 G, and then it becomes constant at higher values of AMF. This relation was described by an imperical formula in the form $(\Delta R/R)_{i} = c H^{n}$ where H is the AMF strength and n & c are constants for each specimen.

3. The change in the DC potential level detected from a broadly illuminated chicken retina was measured by the use of penetrating microelectrode. It was found that as the microelectrode advance through the retina, in regions near the fovea, the level of the negative DC potential increases gradually with maximal value at 75 - 90 % of

retinal depth. On the other hand, in regions at the periphery of the retina, the DC potential level showed a quick increase within 10% retinal depth having a maximal value at 10 - 20 % of retinal depth. Thereafter, the potential declined to a minimum value at 45 - 50% of retinal depth and then increased attaining another maximum at a retinal depth of about 80 - 90%.

4. The electrical resistance of different retinal layers was determined, with an AC bridge, during microelectrode penetration. The resistance showed little fluctuations during the first 30% of retinal depth. It started to increase abruptly to reach a maximum value of 120 % of its original value at about 60 - 70 % of retinal depth. Thereafter, the resistance declined, during the electrode advance in the rest of the retinal depth.

5. The response of the different neurons throughout the chicken retina had been studied by intracellular recording. The recorded responses indicated that the ganglion cells generate transient bursts of spikes through the electrode penetration up to 25 % of retinal depth. At 35 % of retinal depth, transient pulses of longer duration and smaller frequency were recorded which characterizes the amacrine cells response. At retinal depth of about 50 %; the region of bipolar cells, the produced signals were slow, with a graded potential of two phases which antagonized each other. In the region of 70 - 90 %, horizontal and photoreceptor regions, the potential is a graded and more slowly hyperpolarizing one.

6. The effect of AMF on retinal cells responses was studied. The frequency of discharge of electrical activity, during retinal responses, showed three maxima in regions of 5 - 15 %, 25 - 40 % and 55 - 70 % of retinal depth during AMF application of 25 - 35 G.

The amplitudes of retinal activities varied with the percentage retinal depth in a shape which seems to be sinusoidal with two maxima at 30 % and 60 % and the two minima at 12 % and 48 %.

In Chapter IV, theoretical treatments were made to analyze and discuss the mechanism of some retinal cells. A physical quantity σ, which may play some roles in the photoreceptor mechanism was estimated for different AMF intensities. This physical quantity has the dimensions of $Gauss^{-1}$ and it increases as AMF increases reaching its maximum at AMF of 30 G and then declined for higher values of AMF. The effect of AMF on the bipolar cell mechanism was also discussed in this chapter.

Chapter V studied the morphological and dynamical changes in the different chicken retinal layers, by a histological technique, after the application of light and AMF of intensity 30 G. Semi-thin sections and photographs of control and treated retinas were persured. The changes accompanied each type of stimuli were studied and compared with each other.

CHAPTER I

INTRODUCTION AND REVIEW OF LITERATURE

INTRODUCTION AND REVIEW OF LITERATURE

I.1 General Introduction

The study of biological function, organization and structure by physical and physio-chemical ideas and methods is called biophysics. The ideas and techniques of physics are being applied today to physical medicine, radiology, neurology, to the study of circulation, of respiration and of the adjustment of the body to abnormal conditions of life and work. Biophysics deals also with normal activities and characteristics of living matter in all forms. It applies physics to the description of biological phenomena and it studies the effects of physical environmental factors on living matter.

Electrophysiology is a branch of biophysics which deals with the electrical phenomena occurring in living matter. Most of these electrical phenomena specially those related to the activity of some systems, imply extensive electrophysiological studies to analyze the system itself or to solve specific problems concerning the function of these systems. The most important analytical and synthetic processes, forming the basis of the higher nervous activity occurs in the central nervous system (CNS). The electrical characteristics of these activities play an important part in electrophysiological research. The retina is an extension of the CNS which may be regarded as a part from the brain. In this work, the electrophysical changes in chicken retinawerestudied by the application of different physical techniques.

I.1.1 Chicken retina

The chicken retina Fig (1.1) contains three layers of nerve cells, the receptors, the bipolars and the ganglion cells joined to one another in a variety of combinations by cross connections through the horizontal and amacrine cells. Not only is the anatomical structure of the retina very complicated, but also are its physiological reactions. Stimulation of the eye by light, for instance, evokes different types of responses in the optic nerve as well as the complex retinal potential. The receptors; rods and cones, absorb photons and produce the first signals of vision, now known to be slow potentials which are unlike ordinary nerve action potentials. But the retina comprises only a tiny part of the mobile eye, which normally samples the visual environment in a complicated series of smooth movements. Light passes through the various ocular structures to fall upon the retina where it triggers a photochemical process which evokes the neural impulses that lead to vision. In this journey the light first passes through the structures in the anterior compartment of the eye - the cornea, the aqueous humour in the anterior chamber, the pupil, the lens and into the posterior compartment and the vitreous humour to the layers of the retina. The cornea of the eye is a living tissue which is exposed directly to the environment elements. It is protected from drying out only by the tear film. Most light regraction occurs at the optical interface between the air and the cornea. The aqueous as well as the cornea serves as a heat-absorbing water filter for the lens, protecting it from thermal radiation. The iris controls the entry of light into the eye helping to maintain an image quality that the retinal nervous system can