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SOMATOSENSORY AND VISCERAL RECEPTOR MECHANISMS

Proceedings of an International Symposium held in Leningrad, U.S.S.R. on October 11–15, 1974

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Preface

This volume records the proceedings of an International Symposium organised under the auspices of the I. P. Pavlov Institute of Physiology, Academy of Sciences of the U.S.S.R., and held in Leningrad in October 1974. The symposium provided a welcome opportunity for scientists in the U.S.S.R. and the West to present their work on sensory receptor mechanisms at a meeting of specialists drawn from many active research centres of the world. The programme reflects this situation in making available concise reviews of "tissue receptor" research by the active groups of investigators in the U.S.S.R., in which their hypotheses and results can be seen in conjunction with parallel studies in western laboratories.

The formal programme was supplemented by often vigorous discussion, which is reported briefly in this volume. As in all such meetings there was a development of ideas arising from informal discussion and some of this is reflected in the published articles.

The topics selected for presentation inevitably reflect the interests of the organisers and, as Academician Chernigovsky points out in his introductory article, it was a feature of the symposium that the original intention to give prominence to "tissue receptors" gradually broadened out to become a wide-ranging treatment of the morphology and physiology of cutaneous, joint and visceral receptor mechanisms, the transducer processes, possible central regulation of the receptors in the periphery and the central nervous system, and a consideration of the central actions of the receptors.

The rapid publication of the Proceedings was made possible by the discipline shown by the contributors whose articles are included, and in particular by the very great efforts made to transcribe and edit the recorded discussions on the part of Dr. Ilyinsky and his colleagues. It is hoped that these efforts will be appreciated by those who now have the opportunity to inform themselves of the contemporary state of knowledge of "tissue receptors" in many parts of the world.

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Introduction

During recent years studies on the sensory systems and, in particular, on primary processes occurring in individual sensory elements, have been carried out very actively. This might be explained by several reasons, and perhaps the most significant of all is that studies on sensory systems bear a direct relationship on the activity of the central nervous system — a subject receiving the attention of many physiologists. There is no need, I believe, to go into details and adduce too many arguments to affirm this assumption. It should be readily apparent that the nervous system without its sensory "inputs" would be a mass of neurones completely or almost inactive. Other reasons lie, if I may say so, outside physiological science and result from the rapid development of technology. The progress in this direction began from the time of the appearance of oscillographs in physiological laboratories and the application of electronic amplifiers. These technical devices provided an opportunity to study the processes originating in the individual sensory elements and single nerve fibres. Later, processes occurring within these nerve cells and individual receptors were made accessible by the advent of microelectrodes. Finally, the electron microscope was developed and very rapidly became not only a tool for morphological studies, but also an essential device for physiologists.

Owing to different combinations of all these technical procedures real progress in the physiology of sensory systems was achieved, and the abundant new data permitted several important conclusions to be reached and also the formulation of useful hypotheses.

The wide use of precise methods and new techniques led to the generalisation of discussions at several symposia from some narrow subjects of the physiology of sensory systems into the broader discussion and evaluation of general physiological problems. Of course this is inevitable, because the main problems of physiology of sensory systems are common not only for this field, but for many others. To a certain degree this was also true of our Symposium, held in Leningrad, 11–15, October, 1974, which was originally planned as a meeting to discuss only the physiology of tissue receptors.

Perhaps the widening of the fields of discussion could be explained by the fact that the definition of "tissue receptors" should be more precise and exact, but to find such a definition is a complicated task. Indeed, all receptors belong to some tissue, even the most specialised ones, such as, for instance, Pacinian corpuscles, but they could be found in various tissues, in the mesentery near the blood vessels, in the pancreas and even situated near the tendons of the extremities (in cats).

Finally, we know other receptors of different structures which were found by

morphologists in practically all tissues and organs of the body. The definition of "tissue receptor" is so wide that almost all receptors belong to this category. Therefore, to define these receptors we should mainly use the characteristics of their physiological parameters rather than the tissue localisation. Additional difficulties in classification of the receptors create the fact of the existence of polysensory receptors.

However, it seems to me that we should not regret the widening of the discussion during the Symposium. The participants had a chance to consider different concepts of reception, including the evaluation of properties and peculiarities of numerous kinds of receptors located in visceral organs and firstly described by Sir Charles Sherrington as "interoceptors".

Thus, detailed discussion was held not only on interoceptor systems but also on the properties of somatosensory systems. The proprioceptors of muscles and such specialised receptors as visual, auditory, vestibular, olfactory and taste receptors were not included in the programme. It was the right decision because it would have been impossible for the participants to cover all varieties of sensory systems, and would have transformed the Symposium into a Congress.

An important advantage of this meeting was in the possibility for the physiologists and morphologists from various countries of the world — Great Britain, U.S.S.R., Sweden, Poland, Czechoslovakia, Italy, Bulgaria, U.S.A., Japan and others — to meet each other informally and to exchange their opinions and experiences.

Extensive discussions were followed by the establishment of very important scientific contacts and informal agreements for future cooperation.

In spite of the fact that all the participants knew each other from the literature, I believe that all will agree that direct and informal communication and personal contact are most important for the progress of science and the stimulation and creation of new scientific ideas.

I hope, that such meetings will be continued. Of course, we could not solve all of the scientific problems, but the common and pleasant law of science is that scientific achievements and solutions lead to new problems and new aims.

V. N. CHERNIGOVSKY
Leningrad (U.S.S.R.)

Contents

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SESSION I

GENERAL PROBLEMS OF SENSORY RECEPTOR MECHANISMS

Tissue Receptors. Historical Scope. Modern View. Perspectives

V. N. CHERNIGOVSKY

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It is rather difficult to give a clear definition of "tissue reception" on the basis of present knowledge. Strictly speaking, almost all receptors, with the possible exceptions of the retina, the organ of Corti and some others, could be placed into the category of tissue receptors since all of them are, to some extent, connected with one or another tissue and themselves constitute a part of neural tissue located at a distant periphery. Among these are the receptors described by Leek (1972) as "abdominal visceral receptors". I think that sufficient evidence is available to refer to the "receptors of lungs and airways", as described by Widdicombe and Fillenz (1972) as tissue receptors.

The morphology of tissue receptors is extremely varied and is represented by free nerve endings of varying structure as well as by complex-built encapsulated bodies such as Pacini, Herbst and Golgi–Mazzoni corpuscles and so on. Sherrington in his famous book "Integrative action of the nervous system" (1911) shrewdly suggested a division into three categories, as follows: *exteroceptive*, *proprioceptive* and *interoceptive*. The first group comprised receptors of the "inner surface", that is, in the digestive tract proper. He believed that the receptors of the third group are mainly adapted to receive chemical stimulations since the chemical processing, splitting and absorption of food substrates takes place precisely in the digestive tract. Sherrington thought that the interoceptive field is much less saturated with receptors in comparison with the other two fields. Further investigations have shown that this assumption was unlikely. In any case, the neuromorphologists have discovered and described a great variety of nerve endings of different structure and form in all tissues and organs. These receptors should be considered, if only conditionally, as *tissue receptors.*

Perhaps Pavlov had these receptors in mind when, in his address at the Fifth Conference of Russian Physicians (1894) he said: "These endings pervade all organs and all tissues. These endings must be visualized as extremely diverse, specific ones, each individually adapted, like the nerve endings of sense organs, to its own specific irritant of mechanical, physical or chemical nature . . . Hence it is clear that many substances introduced into the organism disturb its equilibrium as a result of their interaction in one form or another with the peripheral endings which are predominantly sensitive and in readily responsive parts of the animal body".

Before I describe the data obtained by myself and my colleagues I would like to point out one essential detail: the majority of these results were obtained in the period from 1938 to 1949. At that time, electrophysiological techniques were just being

References p. 13–14

introduced to the laboratories of physiology for the study of receptors, and the cathode ray oscillograph had not yet become such a common device, as for instance the kymograph in the second half of the nineteenth century. We started our electrophysiological investigations much later. Nevertheless, in spite of non-perfected techniques, numerous data obtained in our laboratory were later confirmed and some of them, as I shall demonstrate here, were "newly" discovered.

Our articles were published mainly in Russian, and unfortunately remained almost unknown to our colleagues abroad. Later on, in 1967, my principal monograph "Interoceptors" was fully translated in the United States with the help of Dr. D. B. Lindsley to whom I am very much obliged.

In this report I shall use such a classification where four categories of interoceptors are defined as follows: *chemoreceptors*, *mechanoreceptors*, *thermoreceptors* and *osmoreceptors*. I shall consider only the first two categories since the physiology of thermoreceptors will be discussed separately in this Symposium. Osmoreceptors will not be discussed at our meetings.

There is another remark I would like to make. It seems to me there are no grounds for a definition as a separate group of "baroreceptors" as was done by Paintal (1972). I believe the term mechanoreceptors to be more universal and allow the investigator

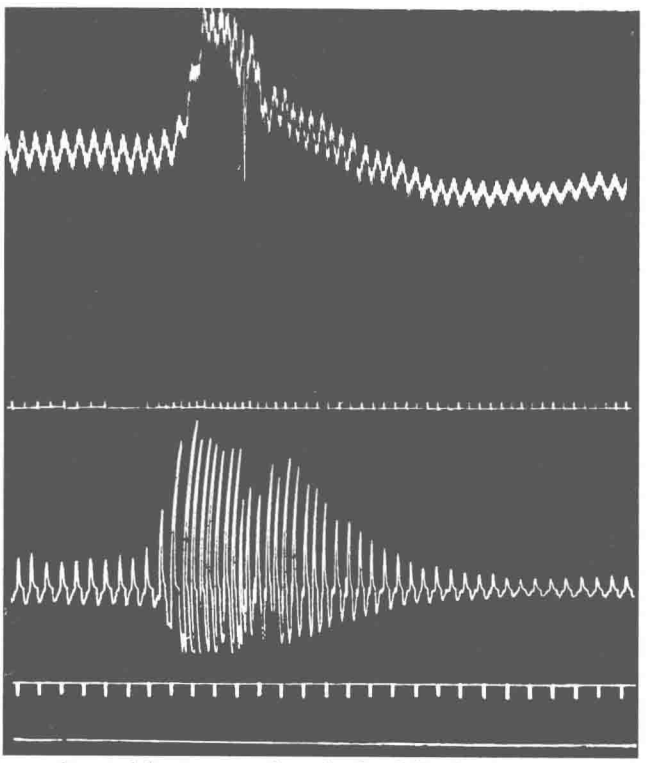

Fig. 1. Reflex changes in arterial pressure and respiration following introduction of 20 μg of nicotine into the vessels of the intestinal segment. Recordings from top: arterial pressure (arteria carotis) (mm Hg); drops of perfusate from vein; respiration; time scale —5 sec; signal marker for nicotine, Cat.

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