STRUCTURE AND FUNCTION OF THE EPIPHYSIS CEREBRI

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STRUCTURE AND FUNCTION OF THE EPIPHYSIS CEREBRI

EDITED BY

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AND

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Engraving after Franciscus van Schooten being, as is now generally accepted, the only authentic portrait of René Descartes (1596–1650), the philosopher whose theories on the structure and function of the epiphysis were once famous.

Preface

The history of research of the epiphysis cerebri is a very long and venerable one. It is also of considerable interest because, during a span of more than 20 centuries, it reflects the leading ideas in medical science which often have been under the influence of philosophical conceptions.

Leaving the ancient Indian literature aside following which the epiphysis would function as an organ of clairvoyance and meditation enabling man to remember his past lives, it can be stated that, probably, Herophilos of Alexandria (325–280 B.C.) first mentioned the pineal body during the long development of occidental civilization. After this author, the epiphysis would function as a sphincter controlling the 'stream of thoughts'. Evidently, this theory is related to his opinion that the organ is situated in such a position that it may regulate the amount of 'substance' passing from the third to the fourth ventricle. To understand the meaning underlying this conception it should be realized that in ancient medical philosophy the ventricles of the brain, not its parenchyma, were considered of paramount functional importance. Following Erasistratos (310–250 B.C.), like Herophilos a teacher at the university of Alexandria, 'pneuma zoticon' (in Latin: spiritus vitalis), present in the blood and transported to the brain by the heart and the large vessels, would, within the lateral ventricles, be transformed into 'pneuma psychicon' (spiritus animalis). Influenced by the senses, this 'pneuma psychicon' was considered the substrate for the development of knowledge. This opinion was elaborated on during the following centuries.

Galenos of Pergamon (± 130–200 A.D.) explained all sensory and motor activity as follows. Agreeing with the very ancient theory that the nerves would be tubules, he held that part of the ventricular spiritus animalis would flow via the nerves to the sensory organs there reacting in some way on stimuli emitted by the objects perceived. Another part of this spiritus would flow to the posterior ventricle the wall of which was claimed to be the site of origin of the motor nerves, including the spinal cord. These nerves, likewise hollow, would lead the spiritus animalis to the motor periphery causing muscular action. Galenos termed the epiphysis *konarion* because, at least in some mammals, it is shaped like a pine cone. The latinized term conarium has been used for a long time and is still recognizable in the 'conary' nerves (nervi conarii) of the present day. Galenos, however, denied the function Herophilos ascribed to the organ stating that it would merely be a lymph gland.

According to Aristoteles the human soul or mind had three faculties, *i.e.* 'phantasia', 'anamnesis' and 'mneme'. In early medieval times it was widely accepted that these mental faculties would reside within the ventricular system consisting of three parts. In the pair of lateral ventricles formerly considered as an entity con-

stituting the anterior part of this system, 'imaginatio' or 'phantasma', (Aristotle's 'phantasia'), was believed to be located. Here our ideas or impressions would be formed by way of the sensory nerves all ending in the wall of these ventricles and transmitting sensory images. In the middle part of the ventricular system, the third ventricle of present days, 'discursus mentis' or 'cogitatio', ('anamnesis' of Aristotelian doctrine), was held to be located. Here we were supposed to be thinking about and selecting the impressions and images collected within the anterior part of the ventricular system. In its caudal part, our present-day fourth ventricle, 'memoria', the 'mneme' of Aristotle, was localized. In the walls of this ventricle, forming a somewhat 'harder' part of the brain, the selected thoughts, worth of recollection, were claimed to be laid down after having passed through the narrow pathway connecting the third with the fourth ventricle.

This conception was evidently based on and developed from much more ancient theories about the function of the brain. Knowing this, we can more easily understand Herophilos' opinion that, due to its position just dorsal to the duct connecting the middle and posterior part of the ventricular system, the function of the epiphysis would consist in regulating the 'stream of thoughts'.

Most remarkably, the ideas of the ancients about the localization of mental abilities within the ventricular system have had, in one way or another, a very long life. In his treatise on *The Organ of the Soul* (1796), dedicated to Kant, Soemmering still claimed the fluid of the cerebral ventricles to be the organ of the mind. As far as the sphincter function of the pineal body is concerned it was probably De Cyon (1907) who was the last author to believe that the epiphysis would regulate the flow of the cerebrospinal fluid in the aqueduct of Sylvius.

Although it is well known that Descartes (1596–1650) claimed the epiphysis to be the seat of the soul it has not always been realized that his theory was deeply rooted in conceptions of the ancient Greek philosophers. Descartes, indeed, accepts the existence of very fine particles in the blood which, according to his view, are separated from the blood by the epiphysis to be transformed into spiritus animalis, his 'esprits animaux'. This spiritus, then, is distributed over the ventricles by this organ. By Cartesius, the animal spirit is compared either with a fluid or with a subtle air or wind. Being itself an unpaired organ located in the geometrical centre of the brain, the epiphysis would be instrumental in coordinating the images obtained by the paired sensory organs and be able to regulate the distribution of the spiritus animalis held by Descartes to be the psychic and somatic activating principle.

After this author, the walls of the ventricles were littered with fine pores. Through these pores, likewise being an ancient concept, the spiritus animalis would flow to the periphery by way of the hollow nerves acting there as well on the muscles as on the sensory organs. On the other hand, after external stimulation the sensory nerves were claimed to be able to open or close the ventricular pores, projecting, in this way, the peripheral image on the ventricular wall and even on the epiphysis itself. Our sensory impressions would originate by way of the different specific patterns in which the pores were either opened or closed causing an increased or a decreased stream of the animal spirit through them. This conception is entirely based on me-

chanistic principles making use of psycho-anatomical ideas which, at that time, were nearly 2000 years old.

Following Descartes, the epiphysis is 'le siège de l'imagination et du sens commun', that is the seat of the imaginative power and 'general sensibility' or consciousness. For memory the organ would likewise be of paramount importance. Thus, it is easy to understand that Descartes has been held to have located the soul in the epiphysis. More truly, however, the organ was considered by this philosopher to be instrumental in distilling the 'spirit' from the blood and in distributing it via the ventricles to the periphery of the organism where the spititus animalis would then stimulate the sensory and the motor apparatus into activity. Descartes' speculative theory freely interpreting half-known anatomical facts is an offshoot from the old Platonic idea of the duality of mind and body. It was based on his rather profound knowledge of geometry and mechanics as well as on very ancient psycho-anatomical conceptions concerning the brain.

Descartes was severely criticized by Steensen or Steno (1638–1686) in his *Discours sur l'Anatomie du Cerveau* of which a Latin translation was published in Leyden in 1671 ('Dissertatio de Cerebri Anatome'), and a facsimile edition in Copenhagen in 1950 ('A Dissertation on the Anatomy of the Brain'). Steno not only was rather sceptical about the theories of Descartes and some of his contemporaries on the diverse sites in which the soul was supposed to be located, but he also refuted the assertion of Cartesius concerning the central position of the epiphysis in the ventricular system. This he did on the base of his own investigations showing that the organ is situated dorsal to and not within this system. Moreover, Steno demonstrated that the tip of the epiphysis is rather rigidly fixed by the meninges so that it is quite unable to move as it was supposed to do by Descartes who postulated that the organ would direct the flow of the spiritus animalis by its very movements.

Although later on the idea that the soul was located either in the epiphysis, in the ventricular system or in some other part of the brain, was revived by a few authors, it was slowly but generally realized that the problem of the relationship between soul and body cannot be solved in such a simple way. After Kant, indeed, it is impossible that the 'soul' would be located in any definable space.

After the times of Descartes, interest in the mammalian epiphysis dwindled. It got the reputation of being a rudimentary organ of no great consequence until the existence of endocrine organs was realized. At the beginning of this century it was Marburg in particular who was first to propagate that the mammalian epiphysis would have an endocrine function related to the development of the sexual organs. Besides, some authors held that the epiphysis would act as a reflex organ regulating the outflow of the venous blood from the choroid plexuses of the lateral and the third ventricles, in this way controlling the production of cerebrospinal fluid. Pineal extracts have also been used in the therapy of mental diseases, especially of schizophrenia.

Currently, the function of the mammalian epiphysis as an endocrine organ is the centre of interest. Moreover, since the second half of the 19th century the comparative anatomy of the pineal and of the accessory pineal organs has made tremendous progress.

In fact, during recent years an increasing number of research workers in many different countries spend much time and energy on the investigation of the structure and function of this intriguing organ. Using the old approved methods next to new tools and techniques which became available during and after the last war, histologists, histochemists, biochemists, pharmacologists and endocrinologists collected much new information on the epiphysis, each in their own, often very specialized, field of research. It was shown that, even in mammals, the pineal body, far from being a rudimentary structure, is actively related to important functions and contains many compounds which are of the utmost biochemical and endocrinological interest.

Keeping this in mind it appeared useful to invite a number of prominent workers in this field to a round table conference. In this way, in my opinion, it would perhaps be possible to coordinate and integrate the many old and recent data on the structure and function of the epiphysis in lower vertebrates as well as in mammals thus achieving a better understanding of its meaning.

The proceedings of the conference testify to the industrious efforts of the participants to unravel, by various methods and techniques, the many structural and functional problems offered by this curious part of the central nervous system. My sincere thanks are due to all participants cooperating by contributing so many important papers and taking such a lively and fruitful part in the discussions. Not a few final articles, published in these proceedings, are more extensive and detailed than the papers originally read at the conference. By this, the scientific value of many contributions has certainly still been enhanced, but also a regrettable, however inevitable, delay of the publication of this volume was caused. Being responsible for the reconstruction of the discussions, my apologies are offered in advance to anyone who would not be entirely satisfied with what has finally been published from his remarks and comments.

I feel also most grateful to the staff members of the Netherlands Central Institute for Brain Research. Without their assiduous help and experience the organization of the conference and the editing of its proceedings would have scarcely been possible.

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J. ARIËNS KAPPERS

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DEVELOPMENT, LIGHT MICROSCOPIC ANATOMY AND CYTOLOGY, INNERVATION AND VASCULARIZATION

Survey of the Development and Comparative Morphology of the Pineal Organ

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From a phylogenetic aspect, few organs have undergone such change in form and cytological differentiation as the pineal organ. Consequently it is very difficult to present a short comparative review that gives a clear, general picture and still does not treat the important facts too briefly. Among the lower vertebrates the pineal organ is a sense organ containing receptor and nerve cells; in some forms it resembles an eye. In reptiles and birds and even in some lower forms a structural change to an endocrine gland is apparent. Comparative analysis is difficult because the roof of the vertebrate brain, from which the pineal organ is derived, gives rise, in the very same region, to still other organ-like differentiations (Fig. 1). One of these is the parapineal organ, which is very closely associated with the pineal organ.

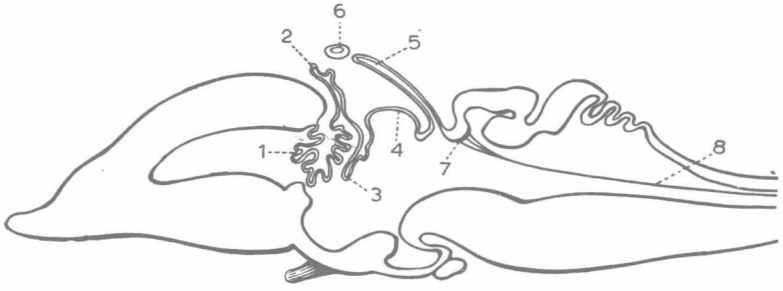

Fig. 1. Diagrammatic sagittal section of the brain of a lower vertebrate. 1. choroid plexus; 2. paraphysis; 3. velum transversum; 4. dorsal sac; 5. epiphysis cerebri; 6. parietal eye (parapineal organ); 7. subcommissural organ; 8. Reissner's fiber. (From W. Bargmann, 1943; Courtesy of Springer-Verlag).

As shown by fossil skulls, both of these organs are phylogenetically very old, having appeared first in certain Devonian (and Silurian) tetrapods, the ancestors of recent amphibians and lizards. 'A well-marked pineal foramen is found in the skulls of both branchiosaurs and lepospondyls' (Noble, 1931). Reference should be made to the recent communications of Edinger (1955, 1956).

It seems certain that such profound phylogenetic changes, which have produced a remarkable number of variations in form, must involve corresponding changes in function. Concerning this there have been so many hypotheses and ideas that an

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