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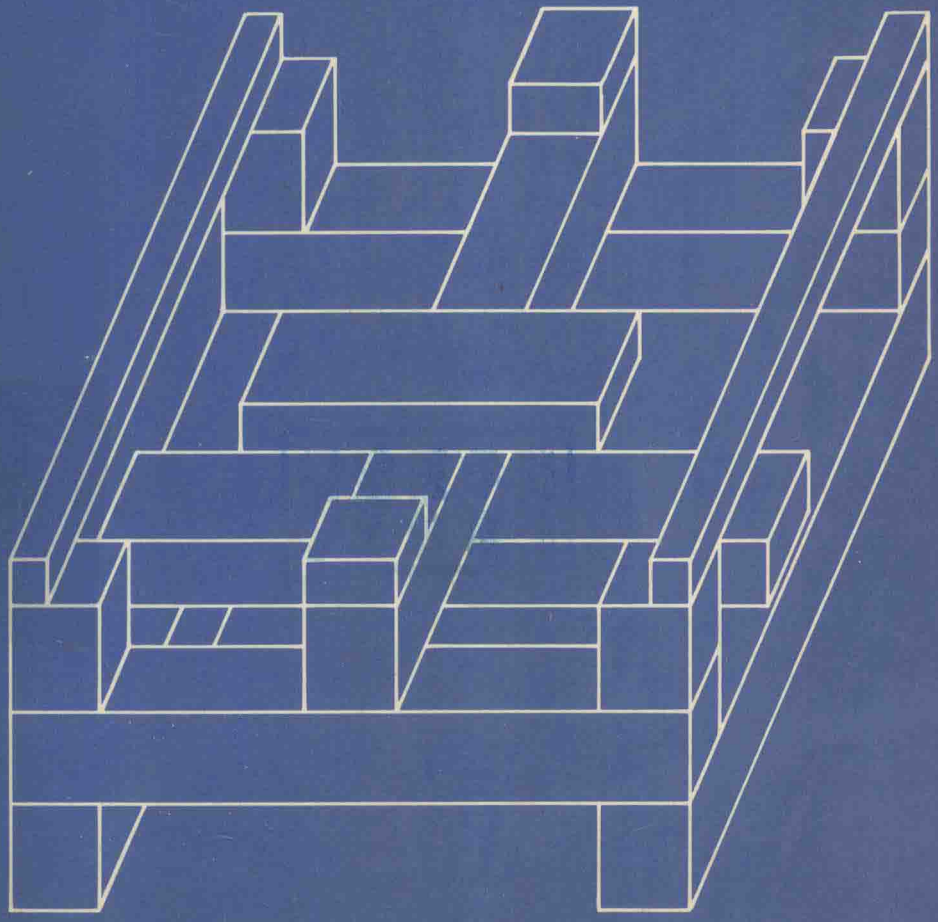
NEUROPSYCHOLOGY

A CLINICAL APPROACH

KEVIN W. WALSH



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A clinical approach

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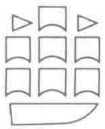

CHURCHILL LIVINGSTONE
EDINBURGH LONDON

CHURCHILL LIVINGSTONE
Medical Division of Longman Group Limited

Distributed in the United States of America by Churchill Livingstone Inc.,
1560 Broadway, New York, N.Y. 10036 and by
associated companies, branches and representatives throughout the world.

First Edition 1978
Reprinted 1978
Reprinted 1980
Reprinted 1981
Reprinted 1982
Reprinted 1984

ISBN 0 443 01569 4 (Cased)
ISBN 0 443 01570 8 (Limp)

Library of Congress Cataloging in Publication Data

Walsh, Kevin W
Neuropsychology.

Bibliography: p. 332
Includes index.
1. Neuropsychology. I. Title DNLM: 1. Neuro-
physiology. 2. Psychophysiology. WL102 W225n
QP360.W34 616.8'04'7 77–1451

Printed in Singapore by
Kyodo-Shing Loong Printing Industries Pte Ltd

Preface

The principal aim of this book is to provide an introduction to neuropsychology which brings together a good deal of the findings, particularly of the past decade, from diverse sources in psychology and the neurological sciences. The accent is on clinical and experimental findings in studies of human subjects with little or no reference to findings from animal experimentation. The material is presented in such a way as to be understandable to those who come to the subject with little or no formal background in biology.

Clinical neuropsychology appears to have at least two roles at the present time (1) in developing further psychology's help in early diagonosis of the nature and location of lesions disrupting brain function; (2) extending our understanding of the psychological processes themselves and thus provide understanding of how the patient's functions are disrupted by his lesion. Though the text has a 'localizationist' structure, this is used solely to further the appreciation of the complex results of lesions in different locations.

The selection of topics is wide though no attempt has been made to make the coverage exhaustive. As usual the selection of topics reflects the writer's bias but it is hoped that a range of major areas has been adequately represented. Equal emphasis is placed on clinical and experimental research approaches and much of the material has been presented in the author's courses and seminars and covers the most commonly encountered problems of the clinic and the most frequently raised questions in the classroom. The introduction of practical courses in neuroanatomy has been of great value in developing a neuropsychological approach in our clinical trainees. For this reason a traditional treatment of neuroanatomy is presented as a background to the study of neuropsychology. Numerous illustrations have been used to try to engender a conception of the nervous system as a three-dimensional set of structures connected through fibre pathways and thus prevent the student from becoming fixated on the cerebral cortex when thinking about psychological function. This should make it easier to understand that a small, strategically placed lesion, for example, may lead to a greater disconnection of brain structures than a very much larger lesion in another area.

The anatomy necessary for understanding *specific* topics in later chapters is laid down in this outline, e.g.

1. the section on the blood supply shows the areas irrigated by the main arteries. This knowledge helps to explain why narrowing of the middle cerebral artery gives rise to a pattern of deficits which partakes of features of lesions of several lobar divisions since the area supplied by the artery cuts across the artificial lobar boundaries;

2. distinctive differences between the effects of lesions of the superolateral as against the basomedial cortex of the frontal lobes is understandable in terms of the different sets of structure with which each is connected;

3. an understanding of the distribution of fibres which cross the midline to join homologous areas of the cortex on the other side of the brain is basic to the understanding of the important work on the 'split-brain' subjects.

Chapter 3 is an endeavour to provide an account in simple terms of neurological conditions which are most likely to be encountered by the neuropsychologist, together with some relevant terminology of the neurosciences, and sufficient details of the commonly used special diagnostic procedures for the student to understand the literature, and for the beginning clinical psychologist to communicate more effectively with his medical colleagues. One has only to place oneself in the position of the naive reader confronted with one of the journals in the neurological sciences to appreciate the need for an acquaintance with this material. The need for a section on elements of neurology has been shown by questions posed by students and psychologists in discussion of case material and journal articles.

Chapters 4 to 8 deal with recent findings in human neuropsychology and are mainly concerned with the questions of localization and lateral specialization of function. In these chapters, examples of a variety of clinical and experimental procedures for tackling neuropsychological problems are cited in detail.

Chapter 9 is concerned with the methodological issues surrounding the assessment of neuropsychological impairment. Many of these are far from resolved and need careful consideration both in training and research. The chapter concludes with further treatment of major clinical topics and some illustrative case histories. No attempt is made to deal exhaustively with the practical methods of assessment as this will be dealt with elsewhere.

It is hoped that the diverse groups who are interested in brain-behaviour relationships in their professions (psychologists, medical students and practitioners, occupational therapists, speech therapists, and others) may gain something from a basic text which brings together recent knowledge of man's higher cortical functions and their assessment by psychological procedures, presented in a manner which can be understood without requiring too much training in academic psychology. It could also form the basis of courses to be integrated with traditional courses in psychology at the intermediate and later years of such programmes.

The author is very much aware of his indebtedness to the numerous texts and articles on the subject and gratefully acknowledges this.

Melbourne, 1977 KWW

Acknowledgements

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American Academy of Neurology and the authors for Table 8.3 from SMITH, A. and SUGAR, O. *Neurology,* 1975, **25**, 813.

Annual Reviews Incorporated for quotation from H.L. TEUBER, *Annual Review of Psychology,* 1955.

Dr David Bowsher and Blackwell Scientific Publications for a quotation from BOWSHER, D. *Introduction to Neuroanatomy,* 1970.

Ciba Foundation and Churchill Livingstone for quotations from MAGOUN in the Ciba Foundation Symposium: *The Neurological Basis of Behaviour,* 1958.

Paul Elek Limited for quotations from J. LEVY in S.J. DIMOND and J.G. BEAUMONT (Eds.), *Hemisphere Function in the Human Brain,* 1974.

Journal of Neurosurgery and the authors for Table 6 from BRAUCH, C. MILNER, B., and RASMUSSEN, T. *Journal of Neurosurgery,* 1964, **21**, 399.

Oxford University Press for a quotation from GESCHWIND in *Brain*, 1965, **88**, further material from the journal *Brain.*

The Regents of the University of California for quotations from E. CLARKE and C.D. O'MALLEY. *The Human Brain and Spinal Cord,* University of California Press, 1968., and a quotation from E.C. CARTERETTE (ED.), *Brain Function: Speech Language and Communication,* University of California Press, 1966.

University of Chicago Press for quotations from J.H. BREASTED. *The Edwin Smith Surgical Papyrus,* 1930.

Dr Denis Williams and Elsevier/North-Holland Biomedical Press for two case descriptions from P.J. VINKEN and G.W. BRUYN, (Eds.) *Handbook of Clinical Neurology,* Volume 2, 1969.

Personal Acknowledgements

The writer of a textbook is indebted to a large number of people. I would like to thank all those research workérs whose work I have described and whose ideas I have so freely borrowed and I trust that I have done justice to their work.

The text was written with the encouragement of two Chairmen of the University of Melbourne, Department of Psychology, Professor Alastair Heron and Professor Gordon Stanley. Professor Austin Doyle of the Austin Hospital, Melbourne provided the opportunities for clinical practice in neuropsychology which form the background of the book.

In the preparation of the manuscript, I was ably assisted by Sandra Carter, Edna Lenny, and Sandra Licquorice, and the technical assistance with photography was given by Geoffrey De Jonge and Maxwell Rademacher.

In an interdisciplinary area such as neuropsychology, it is impossible to proceed without constant help from colleagues in a variety of professions. In this case may I thank all those psychologists, neurologists, and neurosurgeons who gave so willingly of their time to help the author clarify his material. I am conscious of a deep debt of gratitude to that most penetrating and helpful critic Dr Peter F. Bladin whose intellectual stimulation and encouragement through the long period of gestation and the painful process of parturition, enabled the work to be brought to the light of day.

Finally my graduate assistants Maureen Molloy, Mary Kotzmann and Carole Burton together with other senior students provided the maintenance of motivation when application might otherwise have flagged.

Kevin Walsh

Contents

1. History of Neuropsychology

Ancient civilization

The earliest written information we possess on localization of function in the brain is contained in the Edwin Smith Surgical Papyrus. The copy acquired by Smith in Luxor in 1862 is thought to date from the seventeenth century B.C., while orthographic and other evidence would place its origin some thousand years earlier, somewhere between 2500 and 3000 B.C. It contains the earliest known anatomical, physiological and pathological descriptions and has been described as the earliest known scientific document.

The papyrus contains reports of some 48 cases of observations and description of treatment of actual cases many of them suffering from traumatic lesions of various parts of the body including many injuries to the head and neck. Translation of the papyrus was undertaken in 1920 and the detailed examination of the text and commentary was published by Breasted in 1930. It is in this papyrus that a word for brain appears for the first time. The papyrus 'opens the door on cortical localization of function with its description of injuries to the brain' (Gibson, 1962).

The material of the papyrus may be divided into two parts namely the original text and the explanatory comments which have been added at a later date to expand and clarify the text. That these glosses which appear on the back (verso) of the manuscript are of a much later date, is witnessed by their explanation of terms in the text which had, by the time of our extant copy, apparently become obsolete.

Of the 48 cases the first eight deal directly with injuries to the head and brain. Though some of the injuries may have been sustained in civilian occupations, it is more than likely that many of them, as well as wounds described in other parts of the body, were sustained in war. If so, this would be the earliest recording of the contribution of the study of war wounds to the study of brain-behaviour relationships, a source which has been of paramount importance in more recent times.

The following cases serve to illustrate the careful observations made by the ancient medical practictioner. The direct quotations are from Breasted (1930). Thirteen cases of most interest to the neurological scientist have been reprinted

in Wilkins (1965).

1. The examination of case four reads in part—

> If thou examinest a man having a gaping wound in his head, penetrating to the bone, (and) splitting his skull, thou shouldst palpate his wound. Shouldst thou find something disturbing therein under thy fingers, (and) he shudders exceedingly. . .

The shuddering which occurred upon the surgeon's palpation may refer to convulsive movements produced by pressure upon the exposed brain. It is reminiscent of the extraordinary case described by Gibson(1962).

2. Case six described a skull fracture with rupture of the coverings of the brain.

> If thou examinest a man having a gaping wound in his head, penetrating to the bone, smashing his skull, (and) rendering open the brain of his skull, thou shouldst palpate his wound. Shouldst thou find that smash which is in his skull (like) those corrugations which form in molten copper, (and) something therein throbbing (and) fluttering under thy fingers, like the weak place of an infant's crown before it becomes whole—when it has happened there is no throbbing (and) fluttering under thy fingers until the brain of his (the patient's) skull is rent open—(and) he discharges blood from his nostrils, (and) he suffers with stiffness in his neck, (conclusion in diagnosis).

The commentator has written two glosses in clarification:

Gloss A

> As for: 'Smashing his skull, (and) rendering open the brain of his skull,' (it means) the smash is large, opening to the interior of his skull, (to) the membrane enveloping his brain, so that it breaks open his fluid in the interior of his head.

Gloss B

> As for: 'Those corrugations which form on molten copper,' it means copper which the coppersmith pours off (rejects) before it is forced into the mould, because of something foreign upon it like wrinkle.

Here is a clear description of the meninges and an awareness of the cerebrospinal fluid which bathes the brain, together with a picturesque but apt description of the appearance of the brain's convolutions.

3. In a further example (case eight) we are introduced to statements which obviously relate brain injury to disordered function, that is, the earliest recorded findings in neurophysiology or functional neurology.

> If thou examinest a man having a smash of his skull, under the skin of his head, while there is nothing at all upon it, thou shouldst palpate his wound. Shouldst thou find that there is a swelling protruding on the outside of that smash which is in his skull, while his eye is askew because of it, on the side of him having that injury which is in his skull; (and) he walks shuffling with his sole, on the side of him having the injury which is in his skull. . .

The ancient Egyptian has noted that injury to the brain may affect other parts of the body, here the eye and the lower limb. The shuffling of the foot

presumably refers to the weakness of one side of the body produced by damage to the motor pathways from their origin in the cortex of the brain, what would now be termed hemiparesis. The manuscript had been written so long before that the commentator had to explain the obsolete word for shuffle. The physician who wrote the manuscript also appears to have been aware that the effects of brain injury varied according to the side of the brain receiving the injury. Breasted notes that the physician has reported weakness of the limb on the same side as the head injury and suggests that the physician may have been misled by a *contre-coup* effect. If so, this could be the first of innumerable occasions in the history of neurology where an incorrect inference has been made on the basis of accurate observation through lack of sufficient information. The *contre-coup* effect refers to the fact that trauma to the head may produce injury to the brain either beneath the site of external injury (*coup*) or to an area of brain opposite to the external injury (*contre-coup*). Examples are depicted in Figure 3.14. Since damage to the motor region of the brain produces weakness or paralysis of the opposite side of the body a contre-coup injury may give the appearance of weakness on the same side as the scalp or skull wound.

Apart from these examples of effects resulting from brain injury the papyrus also describes several effects of spinal injury, e.g., seminal emission, urinary incontinence and quadriplegia as a result of injury to the cervical portion of the spine. However, there appears to be no evidence that the author considered the brain and spinal cord to be part of a single system.

Turning from Egypt to the other ancient cradle of civilization in the Tigris and Euphrates valleys we find evidence that medical and surgical practice was well organized and legally regulated in this region in the latter part of the third millennium B.C. However, information from this civilization was recorded on fragile clay tablets which have largely perished and even the few surviving fragments from a much later period provide us with no evidence of knowledge of brain-behaviour relationships possessed by these great peoples. It is unfortunate that no surgical treatise, if such existed, has survived from ancient Assyria and Babylon to compare with the Egyptian papyri.

Craniotomy

No history of the brain and behaviour, no matter how brief, would be complete without reference to the neurosurgical procedure of craniotomy or surgical opening of the skull. This serious and difficult surgical intervention was carried out with extraordinary frequency from late Paleolithic and Neolothic times and has continued without interruption down to the present century. Whether such procedures also included operation upon the brain itself is open to conjecture. Some of the interventions show associated skull fractures but many do not. It is likely that only a relatively small proportion of operations was undertaken for traumatic injury.

The widespread use of craniotomy is evidenced by the discovery of prehistoric trepanned skulls from Europe (Italy, France, Austria, Germany, the Netherlands, England), Africa (Algeria, Rhodesia), South America (Peru, Bolivia, Colombia), North America and numerous islands of the South Pacific region.

In some places such operations continued in their primitive form into the twentieth century. Apparently no skulls showing prehistoric trepanatiòn have been reported from China, Vietnam or India (Gurdjian, 1973).

Early instruments were made of obsidian or stone while, with the development of later civilizations, metallic instruments of iron and bronze were employed. Hundreds of examples of trepanation have been reported from the Peruvian civilizations beginning with the Paracas Culture around 3000 B.C. and extending up to the end of the Inca civilization in the sixteenth century A.D. In their examination of these pre-Columbian craniotomies Graña, Rocca and Graña (1954) have provided us with illustrations of (1) operations in every part of the human skull; (2) operative openings of different shapes, circular, oval, rectangular, triangular, and irregular; (3) sets of craniotomy instruments from different eras which include chisels, osteotomes, scalpels, and retractors as well as bandages and tourniquets.

That many patients successfully survived such major cranial surgery is amply attested by skull specimens which show more than one surgical opening and having evidence (such as the bony changes around the opening) of different dates of operation in the same individual's lifetime. As many as five separate craniotomies have been discovered in a single specimen.

In 1953 Graña and his colleagues successfully employed a set of these ancient instruments for the relief of a subdural haematoma (a large clot of blood pres-

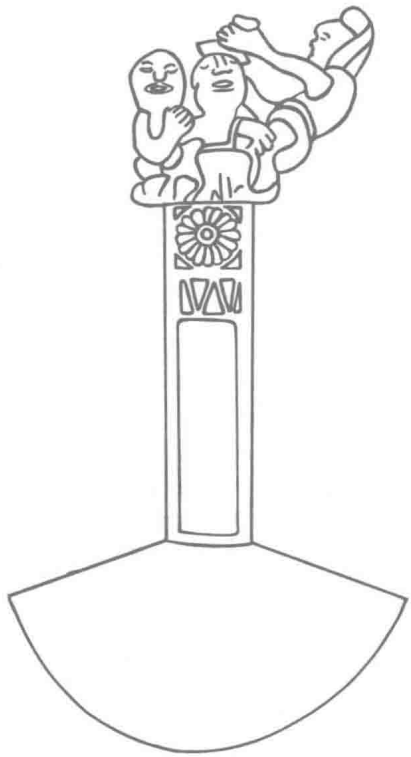

Fig. 1.1 Ancient Peruvian tumi

sing on the brain) in a patient who had suffered a head injury resulting in aphasia and right hemiplegia.

An elegant example from the Peruvian collection of instruments is shown in Figure 1.1. Known as a tumi, it depicts on its handle an operation on a patient where the surgeon is employing a similar instrument.

One can only speculate about the reasons for many of these early operations. Gurdjian lists as possible indications for operation headaches, the releasing of demons from the cranial space and for certain religious and mystical exercises. . .' also 'the fact that some of the openings in the skull have been repaired with silver alloy suggests surgical treatment for the possible skull wound caused in battle.' (Gurdjian, 1973, p.3).

How much evidence regarding brain functions was brought to light by these ancient operations is lost to us because of the absence of a written language among these various early peoples.

Classical Greece

The most frequently referred to writer from this period is Hippocrates. As Clarke and O'Malley (1968) point out, the Hippocratic writings were clearly the product of a group of physicians between the latter part of the fifth century B.C. and the middle of the fourth century B.C. These physicians probably had little familiarity with the human brain because of the aversion for dissection of the human body which existed in Greece at that time; but they did open the skulls of certain animals. Despite this lack of anatomical knowledge they considered that the brain was the seat of the soul or of mental functions and offered comments which showed that they had made very careful observation of their patients. Many would agree with McHenry (1969) that the Hippocratic tract *On the Sacred Disease* contains antiquity's best discussion of the brain and demonstrates the care with which a number of epileptic patients were studied. Another of the Hippocratic writers observed that damage to one hemisphere of the brain produced spasms or convulsions on the other side of the body though little was made of this observation and it appears to have been forgotten in the period which followed. Hippocrates also 'warned against prodding blindly at a wound of the temporal area of the skull lest paralysis of the contralateral side should ensure' (Gibson, 1969, p.5).

The ventricular localization hypothesis

This theory of localization of function postulated that the mental processes or faculties of the mind were located in the ventricular chambers of the brain. The cavities were conceived of as cells, the lateral ventricles forming the first cell, the third ventricle the second cell, while the fourth ventricle made up the third cell. Hence this doctrine is often termed the Cell Doctrine of brain function.

In its almost fully developed form the ventricular doctrine was first put forward by the Church Fathers Nemesius and Saint Augustine around the turn of the fourth century A.D. and it was to remain very much the same for well

over one thousand years, that is, well into the beginning of the Renaissance. Outlines of the doctrine together with excellent pictorial representations are given in Magoun (1958) and Clarke and Dewhurst (1972).

The ventricular theory had its roots in a number of earlier ideas particularly those of Aristotle and Galen. Aristotle had discussed the separate sense modalities and their contribution to perception. To account for the unity of sense experience he proposed a mechanism of integration which he called the common sense or *sensus communis*. Aristotelian psychology divided mental activity into a number of faculties of thought and judgment, e.g., imagination, fantasy, cogitation, estimation, attention and memory. These faculties were to become allotted to the ventricular chambers in the Cell Doctrine. Even as early as 300 B.C. Herophilus of Alexandria had localized the soul in the fourth ventricle.

Galen, in the second century A.D. contributed his theory of the psychic pneuma or gas and, though he himself did not propound the ventricular theory he contributed to it in no small way. The reverence with which the writings of the 'prince of physicians' were held in the centuries which followed helped to set the doctrine in a form which was to remain unchanged for the next millenium. Unfortunately, Galen's followers were to copy his ideas slavishly without developing further his knowledge of the brain's anatomy and his careful and detailed observations of behavioural change. As Gibson (1969) has it, Galen's 'brand of orthodoxy overcame medical science for a thousand years so that it required a Leonardo and a Vesalius to overcome it.'

With the intellectual ascendancy of the Arabic speaking peoples around the eighth century all the important Greek medical works were translated into Arabic and preserved in this way for some five hundred years until retranslated, this time into Latin, where they formed the basis of medical science at the beginning of the Renaissance and, indeed, long after. The anatomy of the great Arabian medical writers, Avicenna, Hali Abbas, and Rhazes around the tenth century depended to a great extent on translations of Galen.

Galen had incorporated into his system the knowledge of the anatomy of the ventricles already present in Alexandrian medicine. He described the ventricles in detail and, though he laid the foundation for the final form which the Cell Doctrine was to take, did not himself do more than hint at the association of the ventricles with intellectual functions preferring to locate the faculties in the brain substance itself.

Magoun (1958) gives the following concise account of Galen's theory of the 'psychic gas'.

> Nutritive material passed from the alimentary canal through the portal vein to the liver, where natural spirits were formed. These ebbed and flowed in the veins, taking origin from the liver, to convey nutriment to all parts of the body. A portion of these natural spirits passed across the septum, from the right to the left side of the heart, and joined with material drawn from the lungs to form the vital spirits. These ebbed and flowed to all parts of the body through the arteries, taking origin from the heart, to provide heat and other vital requirements. A part of these vital spirits passed to the base of the brain, to be distilled there in a marvellous vascular net,

> the rete mirabile, and to mix with air inspired into the cerebral ventricles through the porous cranial base, for, at this time, the pulsing of the brain in the opened cranium was conceived as an active process, much like that of thoracic respiration. As a consequence, animal spirits were formed, and 'animal', in this use, was derived from the Latin 'anima' and Greek 'psyche', meaning soulful, and was not animal in any lowly sense. This psychic pneuma, stored in the brain ventricles, passed by the pores of the nerves to the peripheral organs of sense and to the muscles, to subserve sensory and motor functions. Its equivalently important role in managing central functions of the brain was effected either within the ventricles themselves or in the immediately bordering substance of their walls.

Sherrington pointed out how the movement of the brain which is a passive or transmitted pulsation misled Galen and his followers by apparently supporting their notion of the ventricular system as pumping the fluid to different parts of the body. Sherrington supposed that Galen had not only seen it in the scalp of the young child before the vault closes but that he had observed it often after trauma since Galen had written that 'war and the gladiatorial games were the greatest school of surgery,' (Sherrington, 1951).

It was as cells to contain the animal spirits that the ventricular chambers took on their great significance. A number of writers have pointed out that, of course, the ventricular cavities are the most striking features on gross dissection of the untreated brain. Sherrington comments 'It is interesting to speculate how much this concentration on meninges and ventricular cavities, an obsession that was to dominate thought about the brain for nearly two thousand years, was due to the simple fact that, unless fixed and hardened, the brain resembles an amorphous gruel, of which one of the few distinguishing features is that it possesses cavities.'

After Galen there was no significant development of anatomical knowledge for many centuries and Galen's influence can be most clearly seen in the slavish copying by those who followed of the *rete mirabile* a network of blood vessels at the base of the brain. This network which appears in ungulates such as the pig and the ox is not found in man and those who followed Galen's findings for so long were apparently unaware that, although the master had knowledge of the human brain and that of the Barbary ape, his neuroanatomical descriptions were mainly derived from the ox. This also explains how his descriptions of the ventricles seem erroneous for man while they are highly accurate for the ox.

Two early Sixteenth Century woodcuts serve to illustrate the Cell Doctrine. Because of its clarity, Figure 1.2 has been reproduced very frequently. It is from an encyclopedia produced by the Carthusian monk, Gregor Reisch about 1504. It shows the senses of smell, taste, sight, and hearing connected to the *sensus communis* at the front of the first chamber. This chamber is the seat of fantasy and imagination, the second of cogitation and estimation and the third memory. There is also a possible depiction of part of the cerebral convolutions. The label *vermis* or worm would seem to refer to the choroid plexus which passes through the opening which connects the lateral ventricle (first cell) with

the third ventricle (second cell) (see Fig. 1.3).

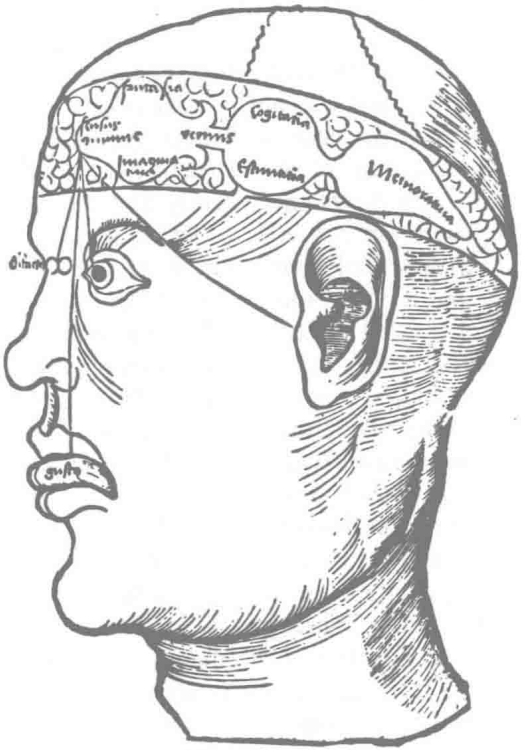

Fig 1.2 Cell doctrine. Gregor Reisch (1504)

The second illustration is noteworthy for its reproduction of the *rete mirabile* at this late date. It is taken from Magnus Hundt, 1501 (Fig. 1.4) and illustrates not only the Cell Doctrine but also the cranial nerves according to Galen's classification together with the skull sutures and the different layers of the scalp. Magoun (1958) gives us a liberal interpretation of the Cell Doctrine.

> 'On passing to the brighter functional aspects of these early views, they first proposed that incoming information from a peripheral receptor was conveyed to a sensory portion of the brain, where it could be interrelated with other afferent data. Activity was thence transmitted to a more central integrative region, equivalently accessible to internal impressions related to sense and to general memory. Last, activity was capable of involving a motor portion of the brain, so as to initiate movement or behaviour. The sequential ordering of these Aristotelian faculties from the front to the back of the brain conveyed an implication that central neural function normally proceeded through such successive stages. Such conceptualization is not excessively different from that reached by Sherrington in his founding studies of modern neurophysiology nor from that which confronts us continually today.'