1 Historical Review of Cross-Sectional Anatomy of the Brain

It took nearly four centuries to obtain an accurate anatomic representation of the brain. Radiological imaging has undergone a similarly slow but progressive refinement.

The restrictions of the middle ages sharply contrast with the scientific explosion which characterized the Renaissance. Anatomical dissections were prohibited by religious and political authorities which prevented the advancement of medical knowledge. The earliest known anatomical dissections were performed by Mundino dei Luzzi in 1316 and reported by his student Gui de Chauliac in "Anathomia" (1363), one of the earliest dissection manuals.

Avicenna is credited with the first representation of the brain in 1000 A.D. The brain was described as being composed of three compartments or ventricles: the sites of common sense, judgment and memory. This was described by Magnus Hundt (1501) in an anthology on knowledge.

Almost ten years earlier, Leonardo da Vinci had performed numerous brain dissections. He was credited with the first sagittal sections showing the lateral ventricles and the optic chiasm (Fig. 1.1). Unfortunately, the illustrations were kept secret until their discovery towards the end of the fourteenth century. Da Vinci disputed the concept of the three cerebral compartments.

In 1523, Giacomo Berengario di Carpi, professor of surgery in Bologna, published the first anatomy textbook "Isagoge Breves". The brain was primitively represented as similar to intestinal loops ("venter superius"). However the lateral ventricles as well as the choroid plexus were clearly identified (Fig. 1.2).

The earliest axial brain representation was performed by Johannes Eichmann (Dryander), a German anatomist, in 1536. However his representation suffered from lack of perspective as the cut shown included the left lateral view of the head. The ventricles were well demonstrated and the convolutions again resembled intestinal loops (Figs. 1.3, 1.4). The critical role of anatomic dissection is demonstrated by the attempt to distinguish the brain covering from deeper structures, which are presented as anatomical sections. A detailed representation of the skull was also presented (Fig. 1.5).

Fig. 1.1. The cerebral ventricles (Leonardo da Vinci 1490; Staatliche Kunstsammlung, Museum Weimar)

Seven years later, Andre Vesalius, professor of anatomy and surgery at Padua University described for the first time (1543) a realistic horizontal brain section in his work "De Humani Corporis Fabrica", which represented the first textbook of anatomy

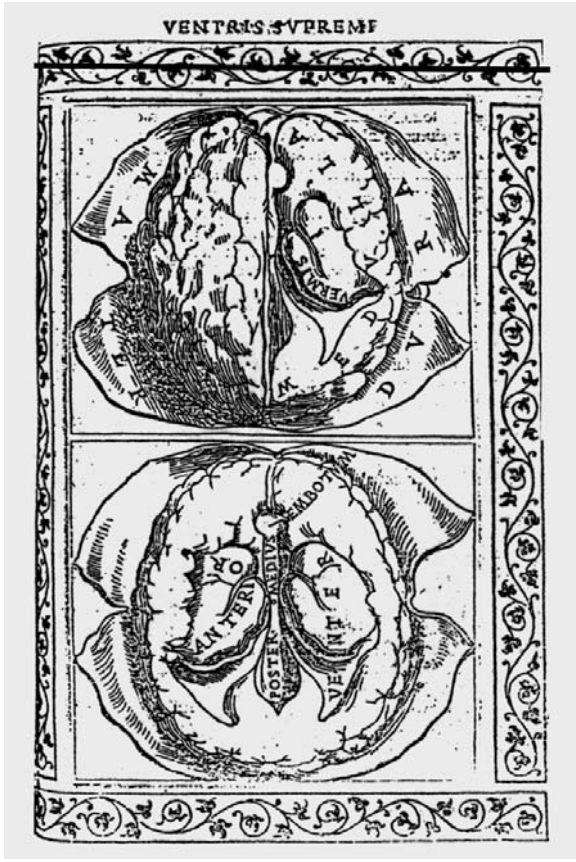

Fig. 1.2. The "ventris supremis" (Berengario di Carpi 1523; Bibl. Interuniversitaire de médecine, Paris)

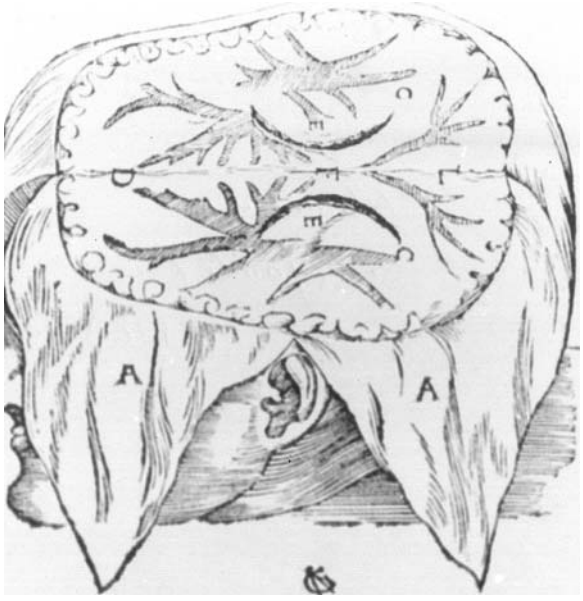

Fig. 1.3. Trial to obtain a horizontal cut of the head and brain through the lateral ventricles shown in perspective (Johannes Dryander 1536; Bibl. Museum National d'Histoire Naturelle, Paris)

Fig. 1.4. Representation of brain convolutions (Johannes Dryander 1541; Bibl. Museum National d'Histoire Naturelle, Paris)

Fig. 1.5. Representation of the cranium in "Anatomia Capitis" (Johannes Dryander 1536; Bibl. Museum National d'Histoire Naturelle, Paris)

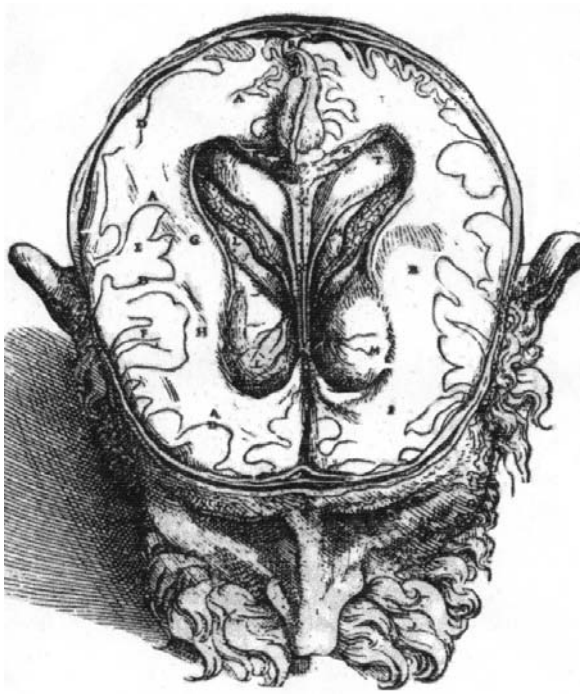

Fig. 1.6. First accurate representation of the brain and the ventricles cut in the horizontal plane in "De Humani Corporis Fabrica" (Andre Vesalius 1543; Bibl. Museum National d'Histoire Naturelle, Paris)

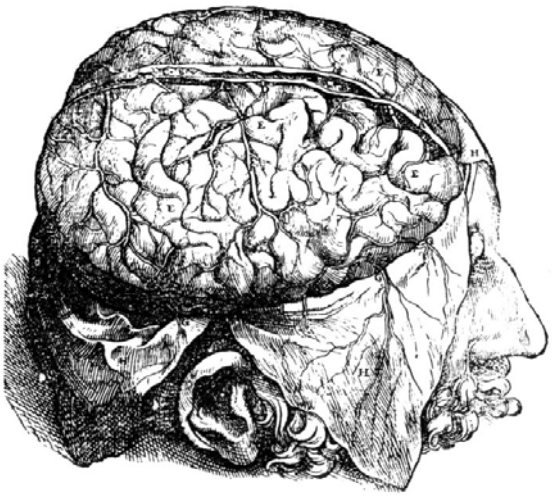

Fig. 1.7. The brain convolutions, in "De Humani Corporis Fabrica" (Andre Vesalius 1543; Bibl. Museum National d'Histoire Naturelle, Paris)

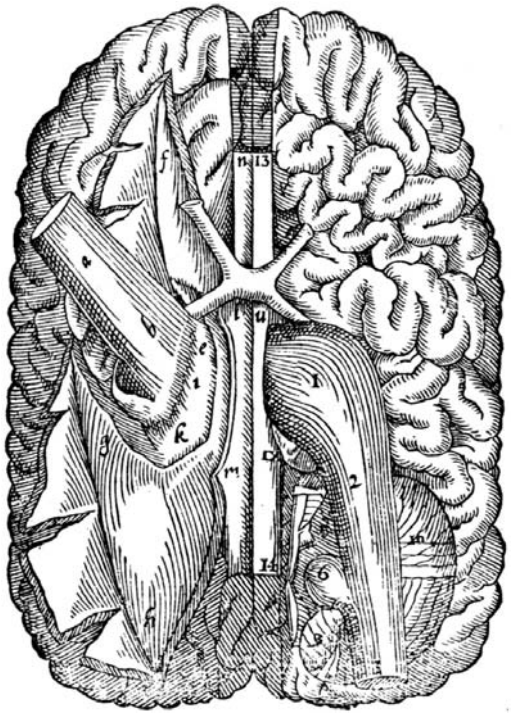

Fig. 1.8. View of the inferior aspect of the brain and the optic pathways (Constantini Varoli 1591; Bibl. Museum National d'Histoire Naturelle, Paris)

combining text and 323 illustrations. These sections were executed by Jean Stéphane Caillé under Vesalius' supervision and considerably enhanced the text. Indeed it was the first such combination of iconography and text. Vesalius distinguished between white and gray matter. His horizontal sections were universally adopted with some alterations for more than two centuries (Fig. 1.6). Vesalius pointed out the repeated errors of Galen, which emphasized the importance of autopsy material (Fig. 1.7), and refuted the existence of the rete mirabile, a key concept in Galenic theory.

Contemporaneously, Sylvius Jacques Dubois (1478–1555), a rival of Vesalius, was contributing to anatomical knowledge as evidenced by the nomenclature of major brain structures: e.g., sylvian fissure, sylvian artery, and the aqueduct of Sylvius.

The modern approach to brain dissection was described by Varole from Bologna in an innovative work on the optic nerve published in Padua in 1572. The method consisted in removing the brain from the skull and turning it upside down to emphasize the ventral aspect. Nevertheless, the brain convolutions remained poorly depicted in the work of Varole (Fig. 1.8), as well as in the contribution of Jules Casserius (1627) (Fig. 1.9).

Building on previous work, Vesling, in a popular anatomy textbook published in 1647, demonstrated the periventricular structures including the choroid plexus, corpus callosum and hippocampus.

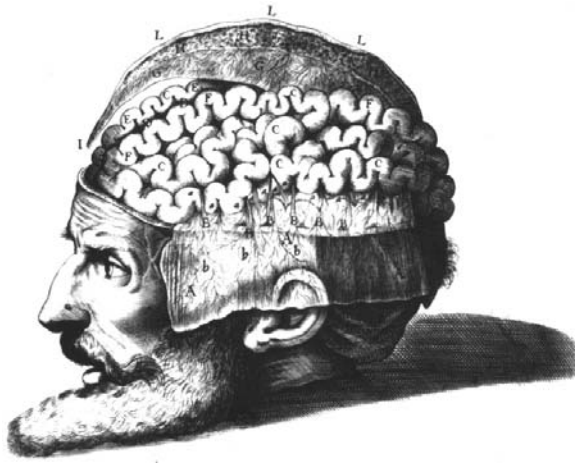

Fig. 1.9. Representation of the brain convolutions of "intestinal" type (Julius Casserius 1627; Bibl. Museum National d'Histoire Naturelle, Paris)

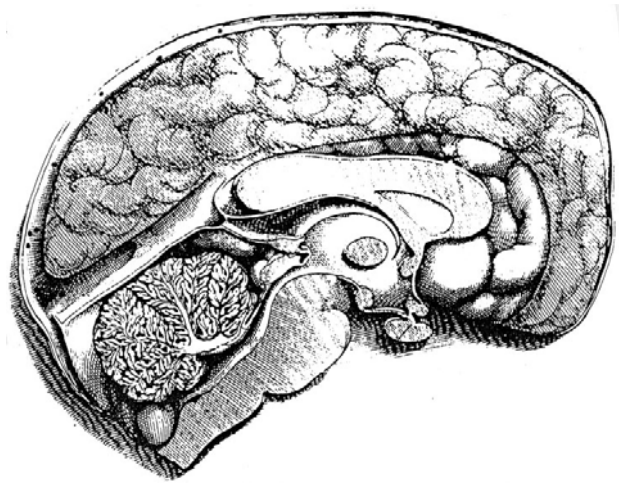

Fig. 1.11. First real sagittal cut of the isolated brain (Nicolas Stenon 1669; Bibl. Museum National d'Histoire Naturelle, Paris)

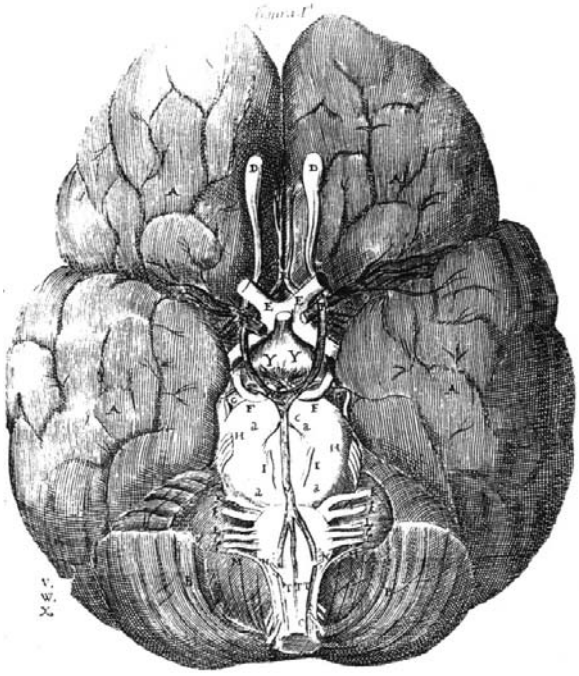

Fig. 1.10. Representation of the arterial circle of Willis at the inferior aspect of the brain (Thomas Willis 1680)

Neuroanatomy took a gigantic leap forward in 1664 when Thomas Willis published the first textbook exclusively dedicated to brain anatomy. He effectively used comparative anatomy to demonstrate the differences between the sheep and the human brain. However, his major contribution was his careful depiction of the vascular supply of the brain (Fig. 1.10), assisted by Edmund King. He was also credited for the demonstration of motor centers in the brain.

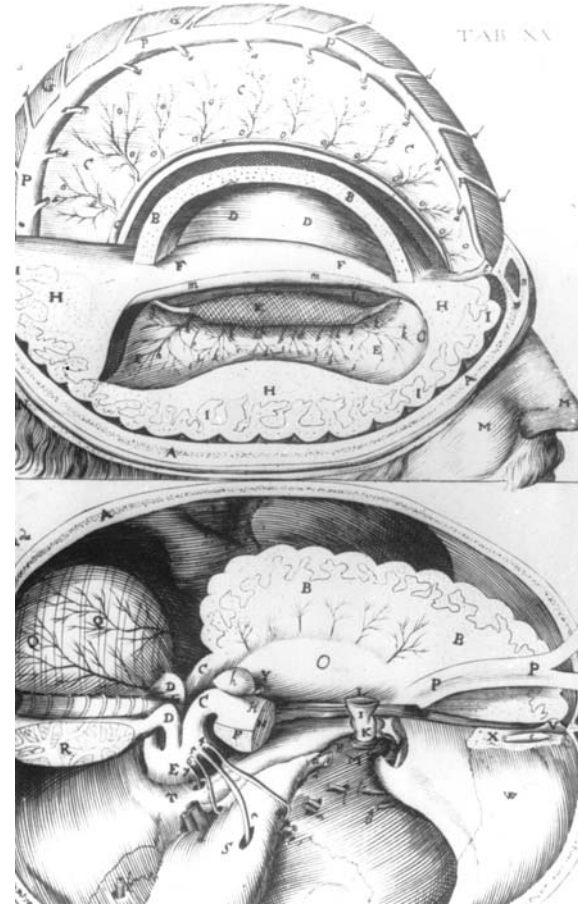

Fig. 1.12. First representations of the head and brain cut in profile (N. Highmorous 1651)

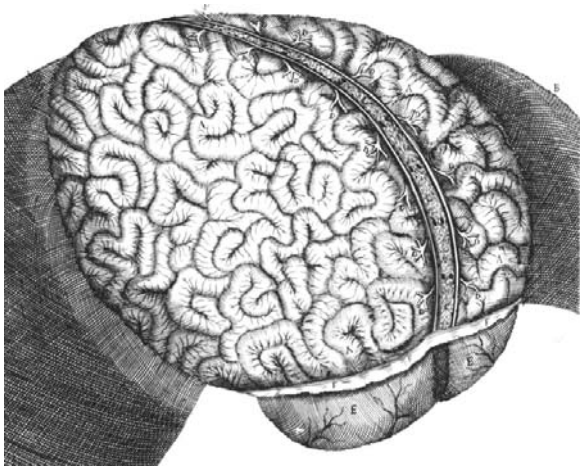

Fig. 1.13. Representation of brain convolutions still showing an "intestinal" type (Raymond Vieussens 1684; Bibl. Museum National d'Histoire Naturelle, Paris)

Fig. 1.14. The meninges and the cerebral hemispheres showing a fairly good representation of the convolutions (Godefroid Bidloo 1685; Bibl. Museum National d'Histoire Naturelle, Paris)

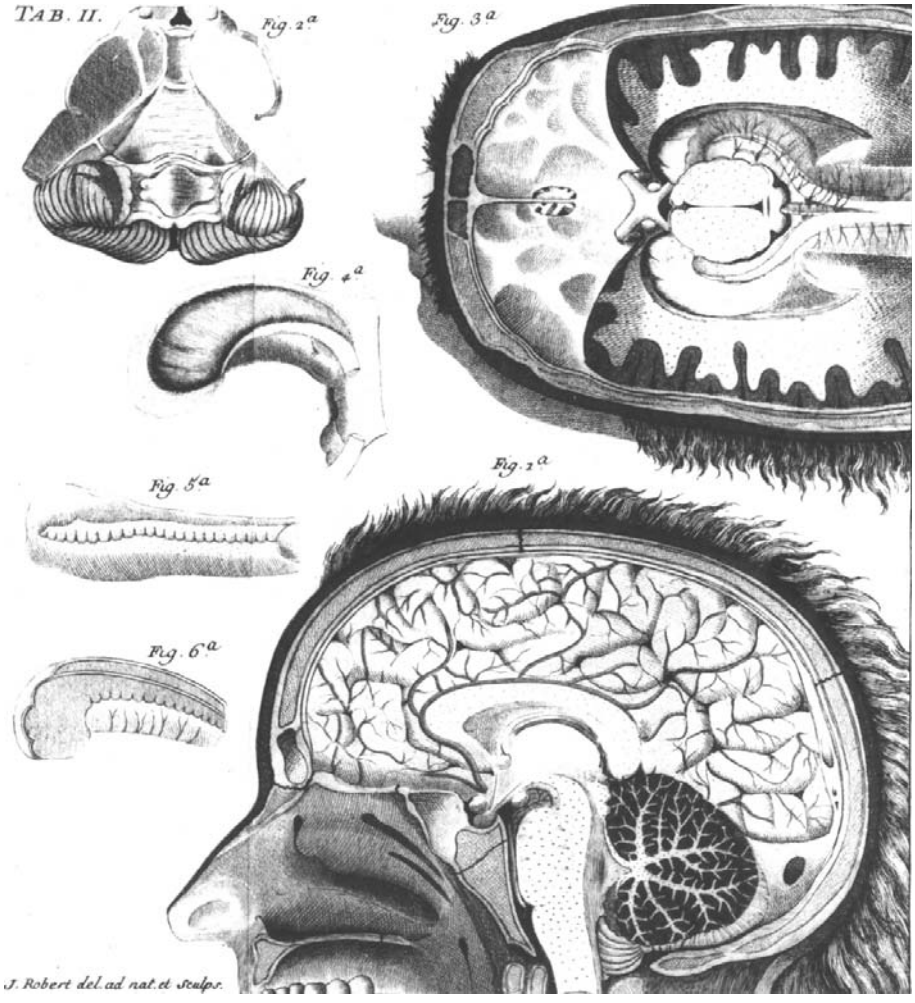

Fig. 1.15. First representation of the head and brain cut in the three planes. Midsagittal and horizontal cuts are shown. The hippocampus and dentate gyrus are represented (Pierre Tarin 1750; Bibl. Museum National d'Histoire Naturelle, Paris)

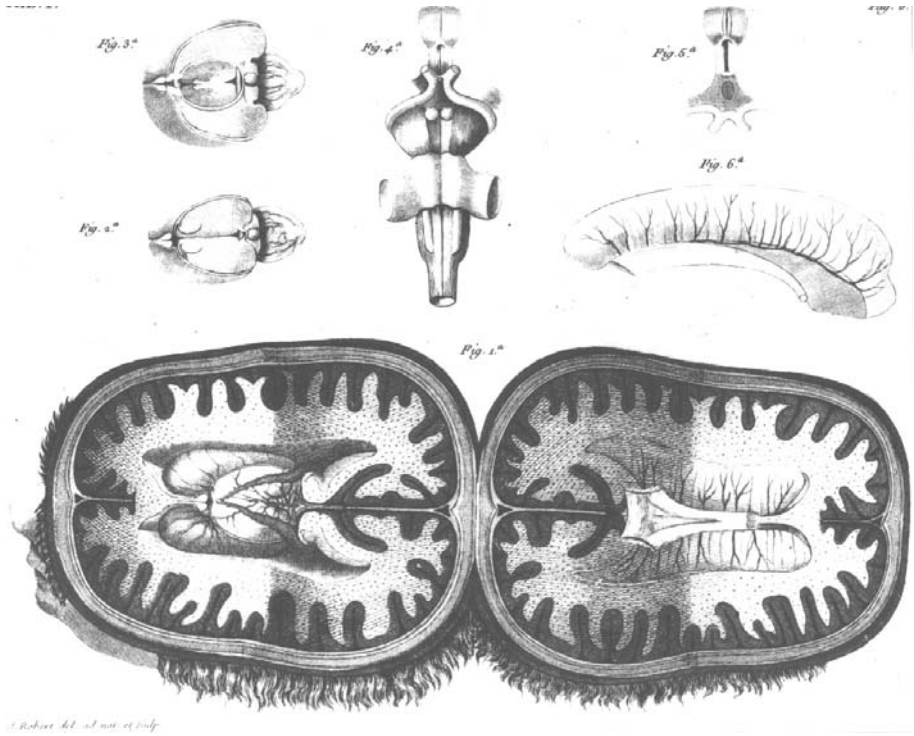

Fig. 1.16. Horizontal cuts of the brain through the ventricular levels (Pierre Tarin 1750; Bibl. Museum National d'Histoire Naturelle, Paris)

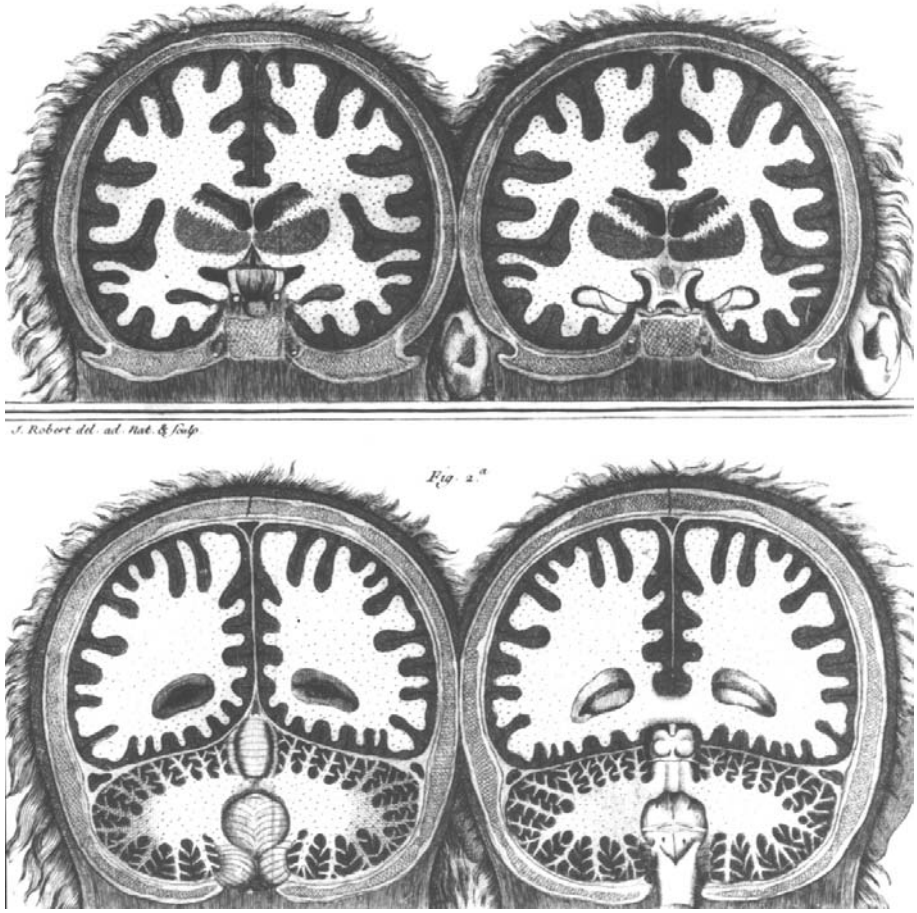

Fig. 1.17. Coronal cuts of the brain through the basal ganglia and the cerebellum (Pierre Tarin 1750; Bibl. Museum National d'Histoire Naturelle, Paris)

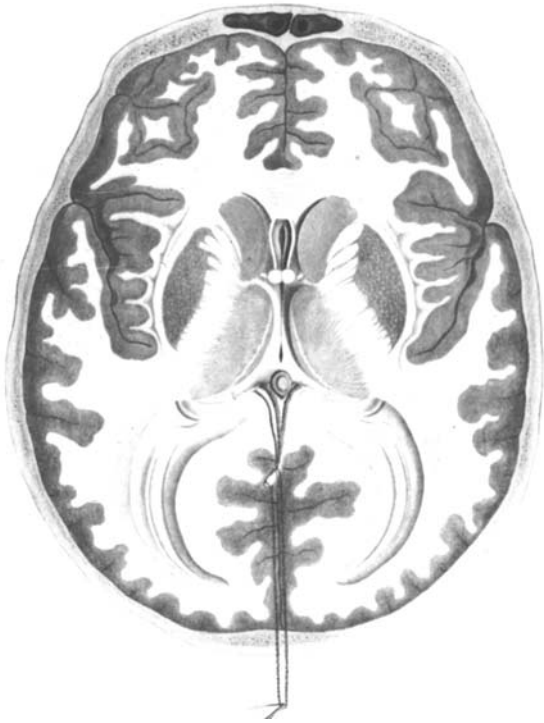

Fig. 1.18. Horizontal cut of the brain passing through the basal ganglia and the internal capsules (Felix Vicq d'Azyr 1786; Bibl. Museum National d'Histoire Naturelle, Paris)

Fig. 1.19. Coronal cut of the brain through the basal ganglia and the brainstem (Felix Vicq d'Azyr 1786; Bibl. Museum National d'Histoire Naturelle, Paris)

The venous system of the brain was described by Stenon (1669), who used a sagittal brain section to demonstrate the importance of this system (Fig. 1.11). Highmorous used "cuts in profile" to show the superior sagittal sinus (Fig. 1.12) in his "Corporis Humani Disquisitio Anatomica"(1651).

Raymond Vieussens (1644–1716) from Montpellier described, in "Neurographia Universalis", the center semiovale in his studies of brain convolutions (Fig. 1.13).

The most true to life representation of the cerebral convolutions (Fig. 1.14) was presented by Godefroid Bidloo (1685) who, in his textbook comprising more than 500 figures, clearly displayed the central sulcus located between the frontal and the parietal lobes. The latter were named by Rolando 150 years later.

In a 50-page publication entitled " Adversaria Anatomica", Pierre Tarin in 1750 showed for the first time several sections of the brain in three planes: sagittal (Fig. 1.15), horizontal (Fig. 1.16) and frontal (Fig. 1.17). Sections through the lateral ventricle showed the hippocampus, the choroid plexus, optic tracts and the corpus callosum.

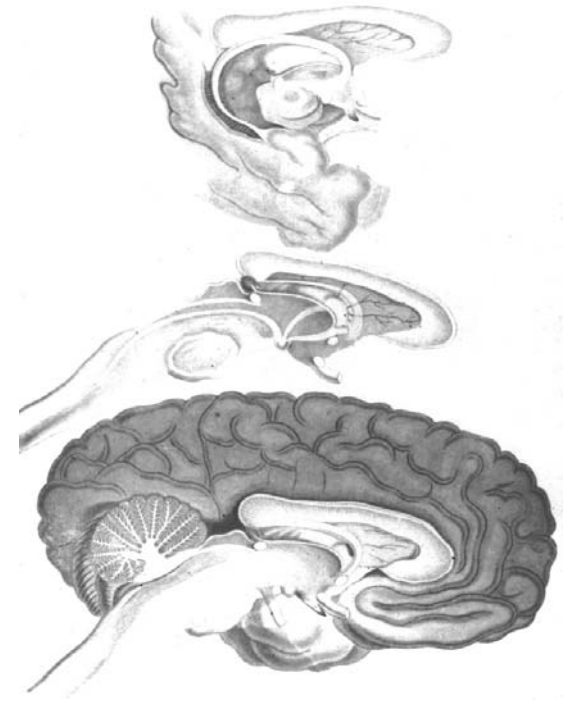

Fig. 1.20. Sagittal view of the brain and description of the uncus and the fornix (Felix Vicq d'Azyr 1786; Bibl. Museum National d'Histoire Naturelle, Paris)

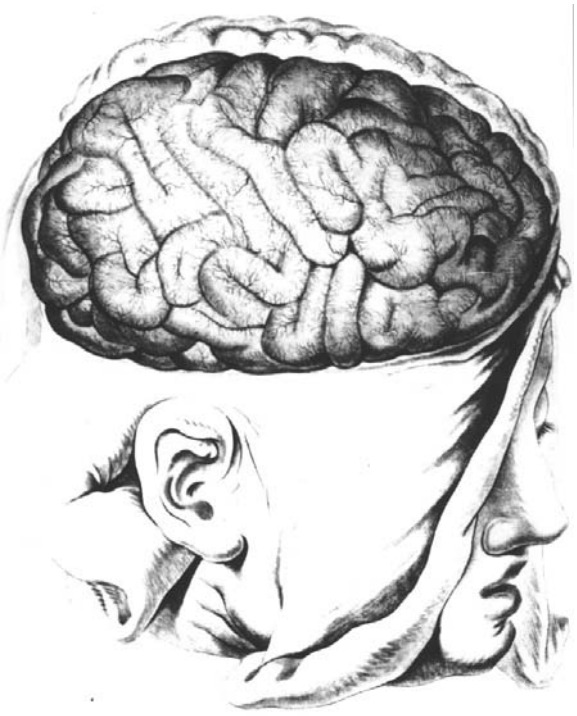

Fig. 1.21. Representation of brain convolutions and first attempt to provide a nomenclature preceding lobulation (Felix Vicq d'Azyr 1786; Bibl. Museum National d'Histoire Naturelle, Paris)

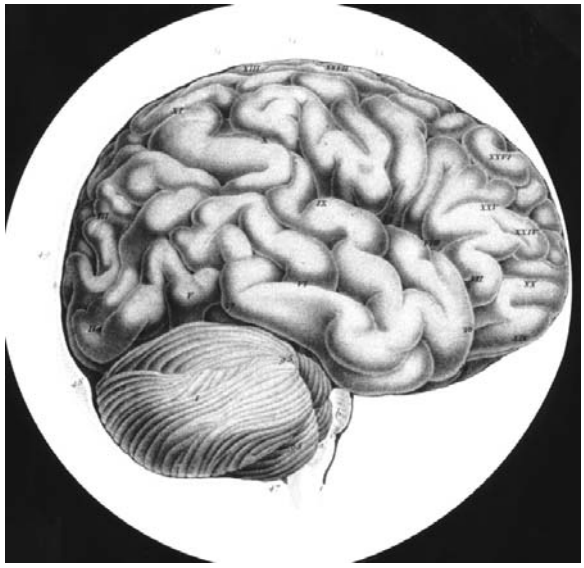

Fig. 1.22. Fairly good representation of brain anatomy and first attempt to ascribe neuropsychological functions to areas of the brain and skull (Francois-Joseph Gall 1810)

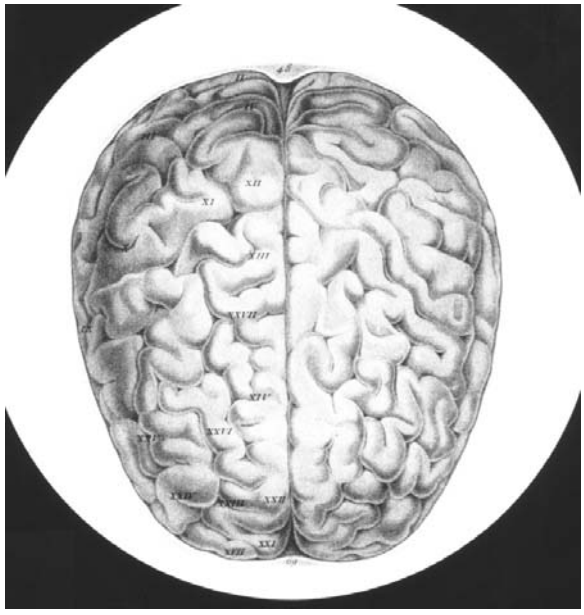

Fig. 1.23. First attempt at localization of brain functional areas based on phrenology (Francois-Joseph Gall 1810)

Towards the end of the eighteenth century, Felix Vicq d'Azyr (1748–1794), famous for the description of the "mamillothalamic" tract, in a treatise of anatomy and physiology published in 1786, showed well displayed anatomical brain cuts in different planes (Figs. 1.18, 1.19, 1.20). His works marked the earliest contribution to gyral anatomy, and described the pre- and postcentral convolutions and coined the term "uncus" (Figs. 1.20, 1.21).

In 1809 Johann Christian Reil (1759–1813) comprehensively described the insula, which was previously noted by Bartholin in 1641. Between 1810–1820, Francois-Joseph Gall published a 5-volume book, "Anatomie et Physiologie du Systeme nerveux en general et du Cerveau en particulier", dedicated to the anatomy and physiology of the brain. Morphology was adequately detailed (Figs. 1.22, 1.23). However, the correlations with mental functions were arbitrarily attributed, marking the prelude to phrenology. Although lacking any scientific foundation, this theory was accepted in Europe and the United States for more than 50 years.

With the discovery of lithography in the nineteenth century, Jean Marc Bourgery, a surgeon of Napoleon's army, published an extensive treatise in 14 volumes. This included color illustrations and is considered one of the most comprehensive works of anatomy to date (Fig. 1.24).

The first photograph of a preparation of a human brain was attempted by Emile Huschke (1797–1858) of Jena (Fig. 1.25). Photographs quickly replaced drawn illustrations.

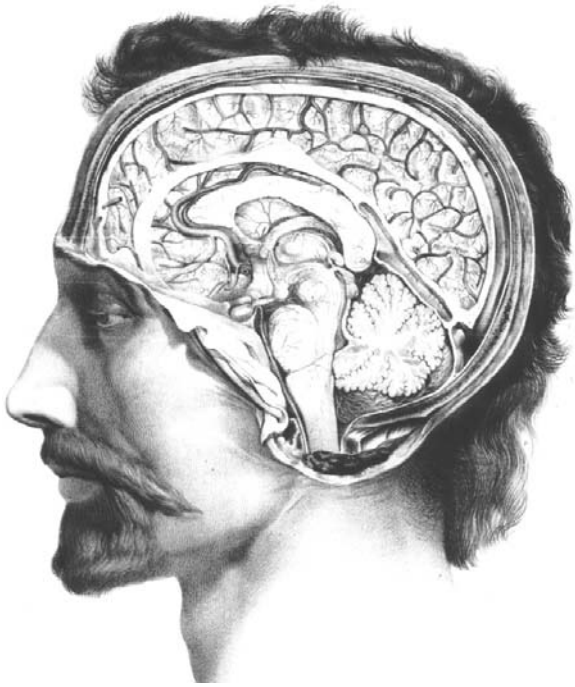

Fig. 1.24. Sagittal cut of the head and brain (Jean-Marc Bourgery 1844; A. Gordon)

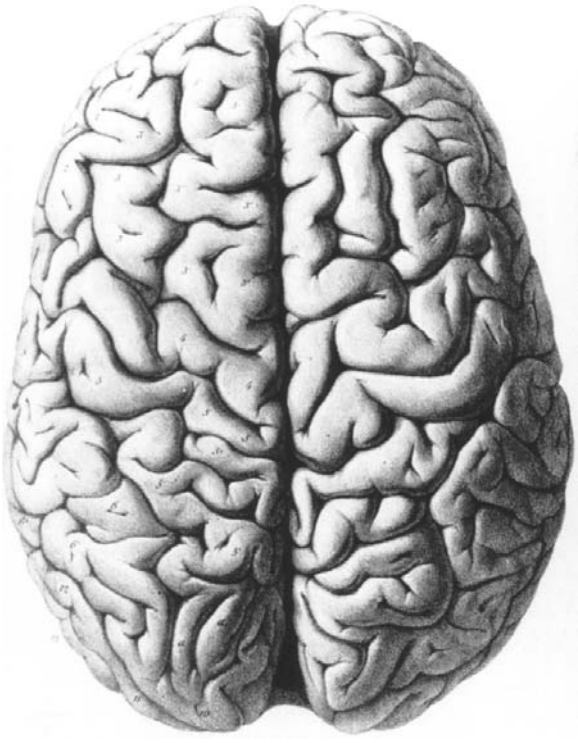

Fig. 1.25. Photograph of the superior aspect of an isolated brain (Emile Huschke 1854; Bibl. Med. Paris)

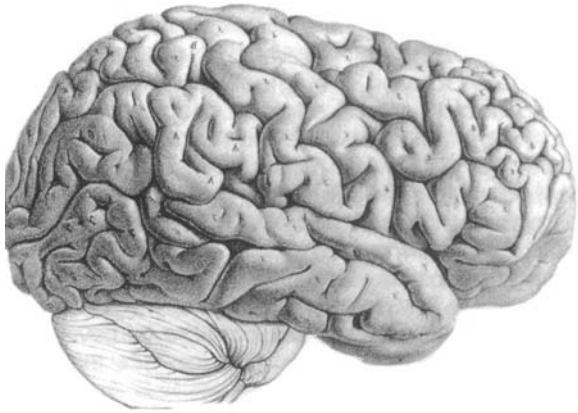

Fig. 1.26. First attempt to classify lobes and fissures of the brain, in "les circonvolutions restituées" (Louis-Pierre Gratiolet 1854; A. Gordon)

In the same year (1854), Louis Pierre Gratiolet, one of the most famous French anatomists, defined the lobes and fissures of the brain (Fig. 1.26). The nomenclature he devised is still in use today. He distinguished primary and secondary gyri based on their respective appearance phylogenetically. His interest was concentrated on the primate brain, and he introduced the study of comparative anatomy. His large collection of isolated brains is conserved in the French National Museum of Natural History, in Paris.

Other notable workers in the field included William Turner (1832–1916) of Edinburgh, who redefined the limits of the brain and its fissures, establishing the Rolandic fissure as the posterior limit of the frontal lobe, and Alexander Ecker from Freiburg who described in 1869 in great detail the sulci and gyri of the brain. This contribution is still valuable today.

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