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Historical Vignette

Developing the Brain—Early Illustrations of Cerebral Cortex and Its Gyri

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ABSTRACT

BACKGROUND: Throughout the Middle Ages, most representations of the brain amounted to highly schematized ventricles housed within abstract squiggles of neural tissue. The works by the pre-eminent Flemish anatomist Andreas Vesalius in his *De Humani Corporis Fabrica* (1543) added considerably more accuracy and detail; still, his drawings of cerebral hemispheres do not exhibit the gyral-sulcal pattern recognized today. Identifiable cortical landmarks would not be featured in print until *Cerebri Anatome* (1664) by the English physician Thomas Willis. **METHODS:** A review of primary and secondary sources on the subject. **RESULTS:** Medieval doctors understood neurophysiology according to the cell doctrine, whereby the first cell (modern-day lateral ventricles) was responsible for sensation, the second cell (third ventricle) for cognition, and the third cell (fourth ventricle) for memory. Vesalius challenged this ventricle-centric model and resolved to portray physical form only, without the influence of conceptual function. A century later, Willis and his illustrator, Christopher Wren, citing limited clinical evidence, proposed that the corpus striatum, the white matter, and the gray matter replace the three cells, finally allowing the cortex a physiological rather than a structurally supportive role. This relocation of executive function demanded the more meticulous rendering of the brain provided in the *Cerebri Anatome*. **CONCLUSIONS:** Thomas Willis produced anatomic drawings of the brain depicting previously ill-defined surface features, as in *Fabrica* by Vesalius, because of a paradigm shift in neurophysiology, emphasizing the cortex over the ventricles, not because of advances in techniques of dissection or illustration. Perhaps, as the study of the brain continues, another future revelation in neurophysiology will drive another unexpected, enduring change in the study of the structures of the nervous system.

Keywords: Andreas Vesalius, Thomas Willis, history, neuroanatomy, illustration, cortex, gyri

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Neurologists of the twenty-first century have ready access to images of the human brain—whether in the form of photographs published in print and online, hospital imaging results, or first-hand observations in anatomy or pathology laboratories. If asked to imagine the gross surface of the brain, the reader of this article would have little trouble doing so, likely visualizing a cortex complete with major landmarks such as the lateral and central sulci, among other features. Asked to do the same, however, a member of sixteenth century Europe's educated elite would imagine something quite different.

Andreas Vesalius (Fig 1A) is widely regarded as the most highly skilled and influential anatomist of his time. His illustrations of the body, including the brain, were of the highest accuracy and detail yet produced. A sample neuroanatomy illustration, taken from book seven of his magnum opus, *De Humani Corporis Fabrica* (1543), is shown in Figure 2. Although a vast improvement upon previous works, even Vesalius's prints lack key distinguishing cortical features like the prominent lateral sulcus. The works in his *Fabrica* more resemble heaps of intestines than cerebral hemispheres with their familiar configuration of gyri and sulci. Not until over a century later, with Thomas Willis (Figure 1B) and his *Cerebri Anatome* (1664), would

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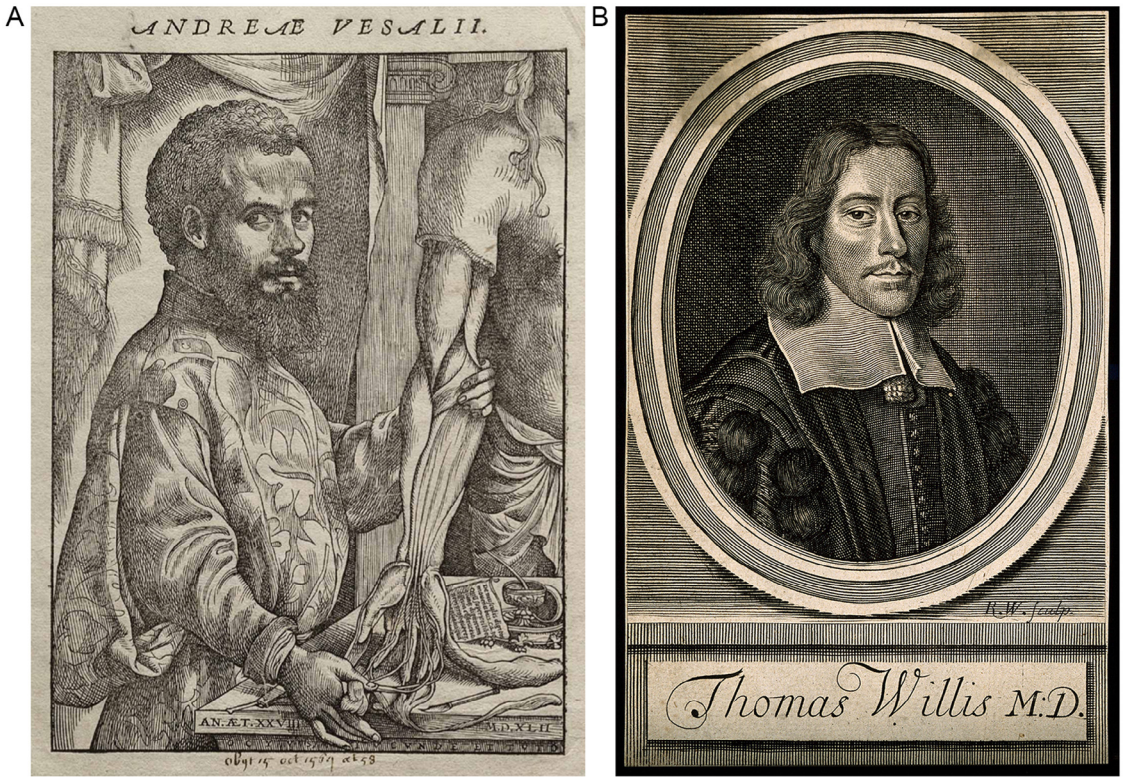

FIGURE 1.
(A) Andreas Vesalius (1514-1564). (B) Thomas Willis (1621-1675). (The color version of this figure is available in the online edition.)

such convoluted depictions of the brain begin to give way to more faithful renderings of its characteristic folds.

This essay aims to explore why it is that, although both Vesalius and Willis based their illustrations on observations of cadaveric brains, the two represented the surface of the brain so differently. The key lies not with the skill of the anatomist or the illustrator, but with a newfound appreciation for the role of the cerebral cortex in cognition. For millennia, the substance of the brain was regarded as little more than a structural support for the ventricles, which were considered the real seat of the intellect, filled with animal spirits and psychic fluids.[2] Only once gray matter was ascribed a functionality of its own was it necessary to transcribe its intricate gyral-sulcal pattern.

The only significant departure from the physiology of Galen (129-216) by the time of Vesalius was the development of the cell doctrine in the fourth to the fifth century by Nemesius, the Bishop of Emesa.[2] Under this theory, the brain was composed of three distinct chamber-like "cells" through which information would be serially processed. Now known as the two lateral ventricles, the first cell was responsible for the conscious perception of external stimuli (*sensus communis*). Sensory information would then pass to the third ventricle for analysis in the second cell (*cogitatio*). Finally, the output of the first two cells would move to the fourth ventricle to be stored as memory (*memoria*).[3] The focus of most subsequent scientific inquiry and neuroanatomic

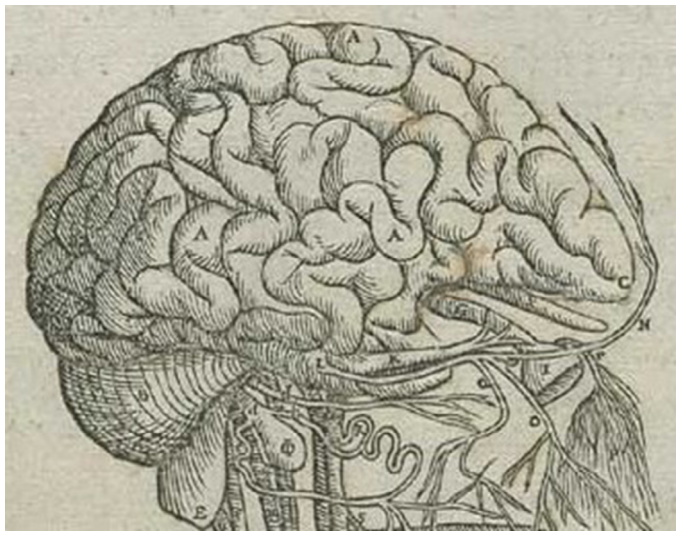

FIGURE 2.
Lateral view of the brain from *De Humani Corporis Fabrica* (1543).[1] Note the absence of major cortical landmarks such as the central and lateral sulci. Indeed, the appearance of the gyri in this illustration is nearly intestinal. Why is it that even the celebrated anatomist Andreas Vesalius should fail to include such prominent surface features of the cerebral hemisphere? The answer has to do not with the skill of the anatomist or illustrator, but with the supposed relative unimportance of the cortex and the apparent chaos of its gyrations. (The color version of this figure is available in the online edition.)