

## Thomas Willis and the background to *Cerebri Anatome*

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*J R Soc Med* 2003;96:139–143

In 1664 Thomas Willis (1621–1675) published a text on the brain and nerves that was to be deeply influential for the next two centuries. Initially, *Cerebri Anatome* had little impact on English medical practice, though it enhanced Willis's reputation to the extent that he was able to become a prosperous London physician<sup>1</sup>.

Primitive descriptions of the arterial anastomosis at the base of the brain already existed in 1664. Willis improved on these accounts, and made the first attempt to attribute a function to the anatomy that he described. In the eighteenth century his description of the brain became accepted as definitive, appearing in the *Bibliotheca Anatomica* of 1774–1777 for the first time as the famous 'circle of Willis'. Modern historical scholarship has highlighted the contribution that Willis made to neuroanatomy, which had been previously eclipsed by contemporaries such as Thomas Browne<sup>2</sup>.

Although his description of the anatomy of the brain remains important for contemporary neurological science, Willis's understanding of the brain was very different from that of modern scientific thought. Willis wrote *Cerebri Anatome* while Professor of Natural Philosophy in Oxford, where he used the anatomy of the brain as a tool to investigate the nature of the soul. He wrote at a time when England was in great political and religious turmoil, following the Civil War and the execution of Charles I, and his work reflects his allegiances during this turbulent period. In this paper, I discuss the dependence of Willis's description of anatomy upon his concept of the human soul. By considering *Cerebri Anatome* as a product of the life that Willis led, it is possible to understand his anatomical descriptions as a reflection of beliefs and practices in the mid-seventeenth century.

### WHY DID WILLIS WRITE ABOUT THE BRAIN?

The early seventeenth century saw an unprecedented increase in learning and scientific advancement. Certain Puritan sects held a radical apocalyptic view that the end of the world was imminent and would be followed by a one thousand year reign by Christ. This doctrine spread to all religious groups and became the dominant concern among English academics. The study of God in the natural world was

encouraged, to gain deeper knowledge of the Creator and thus prepare the reformers for the coming of Christ. This accelerated the growth of 'natural philosophy' as a discipline, so that by the Restoration of the monarchy in 1660 scientific publishing had reached new heights<sup>3</sup>. The mechanistic philosophies typified by Cartesian dualism had begun to permeate continental philosophy and were rapidly absorbed in England. They carried atheistic elements, and theologians such as Henry More responded with anti-atheist writings. More and his fellow Platonist Ralph Cudworth were strongly critical of medicophilosophical work with any atheistic implications<sup>4</sup>.

Thomas Willis (Figure 1) received his medical degree in 1646 but initially had difficulty establishing a practice. Consequently, he spent much of the next decade among the scientific dilettanti of the 'experimental philosophical club' in Oxford, working on fermentation and chemical theories concerning the constituents of matter. In 1659 he published a series of small tracts, *Distribae duae medico-philosophiae*, based on his research on matter and the basic constituents of life, otherwise known as the 'vital soul'<sup>5</sup>.



Figure 1 Engraving of Thomas Willis by D Loggan, published in 1667 [Reproduced by permission from Hughes JT, *Thomas Willis 1621–1675: His Life and Works*, RSM Press, 1991]

Oxford remained a staunchly Royalist city during the Civil War. During the Protectorate Willis remained true to the Crown and adhered tightly to his Anglican beliefs. Services were said in his rooms during the Roundhead seizure of Oxford, with worshippers including his friend and patient Gilbert Sheldon<sup>6</sup>. During the Commonwealth, men such as Willis were excluded from office. The Restoration saw fortunes reverse, with Charles II rewarding loyalty. Sheldon was released from prison and made Bishop of London in 1660 and Archbishop of Canterbury three years later. Sheldon supported Willis and other Royalists, seeking to replace scientific radicals and non-conformists with men loyal to the Crown and Church. Restoration Oxford (Figure 2) was filled with loyal supporters of the King. Sheldon patronized Willis and helped secure his appointment to the University in 1663<sup>7</sup>.

As Sedlian Professor of Natural Philosophy, Willis would have been expected to deliver a traditional lecture course, based on Aristotle. However, the University was still unstable from the Civil War, and relaxed statutory constraints enabled Willis to teach his own programme combining traditional views with the new philosophies. Although required to teach on the nature of the soul, he was able to build upon his chemistry from Oxford and develop other disciplines.

Before 1660 Willis had little experience in anatomy<sup>8</sup>. However, his belief was that anatomy held the key to understanding the rational soul, which he considered to act

upon the brain. In his dedication to *Cerebri Anatome* he states that the study of anatomy can ‘unlock the secret places of Man’s Mind and [to] look into the living and breathing Chapel of the Deity’<sup>9</sup>. Willis conceived the brain and the nerves as part of an ordered system, constructed by God, the Omnipotent Creator. Anatomy, he believed, would demonstrate structural similarity between man and animals while showing a difference in higher function, thus proving that man had an immortal soul in addition to the soul held in common with animals<sup>10</sup>.

Willis had a comprehensive collection of anatomical studies and atlases at his disposal. However, as he states in chapter nine of *Cerebri Anatome*, they were inadequate for his lectures on the brain, since ‘among the various parts of an animated body which are subject to Anatomical disquisition, none is presumed to be easier or better known than the Brain; yet in the mean time, there is none less . . . perfectly understood’<sup>9</sup>. The problem was not simply that Galen and the ancients were lacking in anatomical detail; they also erred in their theology. So, Willis sought new material for his Oxford lectures to provide a sound basis for his understanding of the brain and soul. The same material formed the basis for the text of *Cerebri Anatome* and his subsequent publications, *Pathologiae cerebri et nervosi generis specimen* in 1667 and *De anima brutorum* in 1672<sup>6</sup>.

By publishing *Cerebri Anatome*, Willis spread his ideas beyond Oxford to a wider readership, including members of the clergy and the Royal College of Physicians. Printing

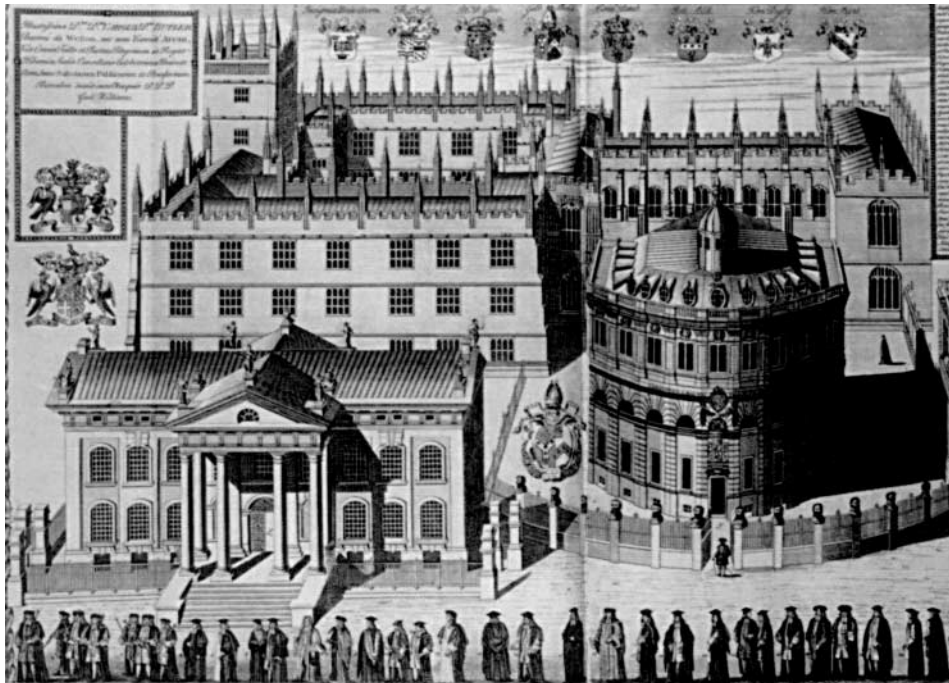


Figure 2 Restoration Oxford, the site of Willis's research and lectureship [Reproduced by permission from Fraser A, *Charles II: his Life and Times*, Weidenfeld and Nicolson, 1979]

restrictions had been imposed by Charles II in 1662, under the supervision of Sheldon, but Willis was exempt from the strict censorship of the time. Willis staunchly upheld the position of the Crown and the Church in his work, supporting the return of the monarchy<sup>11</sup> and accepting the Church as head of the nation<sup>12</sup>. Regarded as conformist and traditional, *Cerebri Anatome* received an imprimatur in 1663 and was published the following year.

### HOW DID WILLIS INVESTIGATE THE BRAIN?

Willis recognized the importance of method in studying the brain. The first (and longest) chapter of *Cerebri Anatome* was devoted to an account on how best to analyse the brain and nerves, since previous anatomists were let down by 'flawed techniques', producing artifactual results. Several approaches were used in conjunction to prepare material for the lectures and for *Cerebri Anatome*. Work on the material was a collaborative effort between Willis, Richard Lower, Thomas Millington and Christopher Wren, who had all worked together in Oxford during the Commonwealth.

The practice of autopsy was commonplace by the mid-seventeenth century in England. Willis dissected bodies of deceased patients, adding information to the animal dissections that he performed<sup>13</sup>. He seems to have directed most of the dissection, performed by Lower in the back rooms of houses and inns. Wren and Millington were frequently present 'to confer and reason about the uses of the parts'. The brain was approached from below and removed from the skull before being sliced from the base upwards, in contrast to traditional methods of *in situ* dissection. The specimens were then examined through a magnifying glass and drawn by Wren<sup>14</sup>.

Willis followed the Galenic tradition of describing parts of the body and then suggesting a use to account for their appearance. In *Cerebri Anatome*, Willis repeatedly cites the similarity in structure between man and animals and the differences in 'uses' as evidence of an immaterial God-given soul.

*Cerebri Anatome* refers to some rudimentary experimentation, although in 1660 the nature of an 'experiment' was not rigorously defined. Willis had formerly collaborated with Robert Boyle, whose discourses on the nature of experimental philosophy had been adopted by the Royal Society as *the way of obtaining knowledge*. Wren used microscopy to analyse brain specimens. Wren and Lower performed dye injections, and these were the basis for Willis's discovery of the flow of blood in the cerebral arteries. Most famously, injection studies on animals immediately after death demonstrated that blockage of just one of the four main cerebral arteries would not lead to apoplexy.

Willis backed up his morbid anatomy and experimental philosophy by recalling case histories from living patients. It was in this way that 'the circle of Willis', referring to the arterial supply at the base of the brain, was described (Figure 3). On other occasions, Willis embellished his empirical data with unsubstantiated speculation, incorporating theories on the compensation of matter and the action of the 'spirits'. Medical practice in the latter half of the seventeenth century was still largely a mix of empiricism and theory, with no clear division between the two.

### BRAIN AND SOUL

The nature of the soul was intensely debated during the Restoration. The relation of man's immortal soul to the body and universe was questioned since new philosophies had thrown doubt on the number of components of the soul and their sites of operation. The answers had a profound bearing on the doctrine of the Resurrection, an issue that dominated theology in the second half of the seventeenth century. In England, natural philosophy grappled with William Harvey's claim that the soul was a property of the blood—a notion derived from Aristotle, who saw the heart as the prime mover. Continental philosophers held different views: van Helmont located the soul in the pylorus and Descartes favoured the pineal gland. Henry More doubted

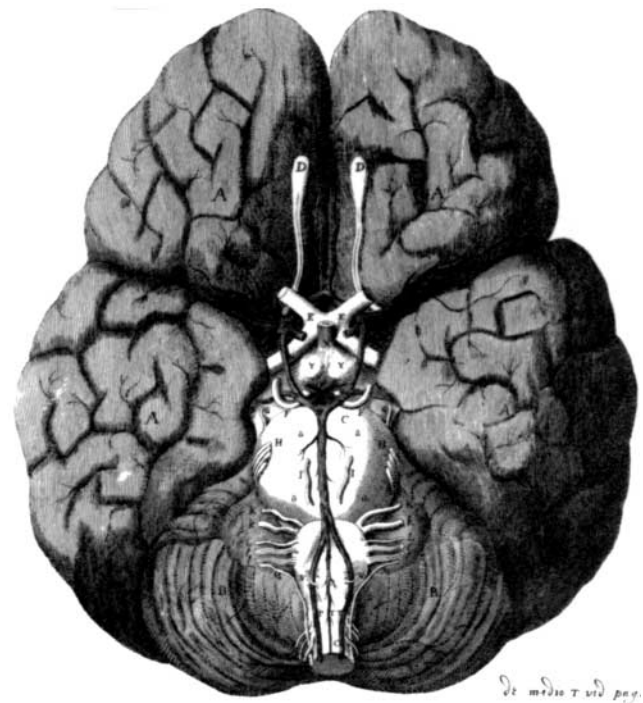


Figure 3 Christopher Wren's famous depiction of the base of the human brain as published in *Cerebri Anatome* [Reproduced by permission from Hughes JT, *Thomas Willis 1621–1675: His Life and Works*, RSM Press, 1991]

whether a soft, curd-like substance such as the brain could allow for higher faculties<sup>4</sup>.

In his earlier work in Oxford, Willis had modified the theories of Aristotelian elements, the Paracelsian concept of active particles, and a version of Gassendi's atomism. He created a system composed of five elements (spirits, sulphur and salt which were active, as well as earth and water which bound the others together), from which all matter was derived<sup>15</sup>. Although Willis rejected the Galenic doctrine of the four humours, he did little more than change the emphasis, still concentrating on imbalances and the non-naturals.

In chapter ten of *Cerebri Anatome* Willis described a three-component soul. Like Harvey and the Paduan school, he argued that a vital soul, the *flamma vitalis*, acted within the blood. A sensitive soul arose from the vital soul, formed by the procreation of spirits in a 'double fountain' of arteries supplying the cerebrum and cerebellum in a parallel neural circulation of *spiritus*. Both vital and sensitive souls were, according to Willis, to be found in man and beast alike. They were responsible for basic biological functions such as sensation and motion, as well as some higher functions including knowledge and simple reasoning. In addition, man alone had an immortal soul for higher thought, will and judgment. Though immaterial it operated on the brain. Willis claimed that the 'rational soul variously moves the sensitive', using it as a vehicle<sup>9</sup>. His view of the functioning body, and the anatomy of the brain and nervous system, was formed by his understanding of the nature of the soul.

## FORMAT OF *CEREBRI ANATOME*

The original publication of *Cerebri Anatome* in 1664 consists of a title page (Figure 4), dedicated to Sheldon, a Preface to the reader, 29 chapters on the uses and parts of the brain and nerves, and a conclusion. In contrast to many of his contemporaries such as Boyle, Willis published his work in Latin. The Reformation had led to an increase in the use of the vernacular, and from the mid-sixteenth century the liturgy, the Bible and theological works had started to appear in English. But Latin remained the language of university, Monarchy and the established Church. By writing in the language of the scholar, Willis not only identified himself as an authority but also acted in defence of a learned medical tradition. He sided with the Royal College of Physicians, who were under attack from the newly formed Royal Society, and in the following year Willis was elected as an honorary fellow of the College. Latin was also the language of religious authority and political power; thus *Cerebri Anatome* would have tacitly supported the Church and the Crown with the language of God and the King<sup>16</sup>.

One of Willis's favoured literary devices was metaphor—a commonplace device in Restoration literature, sermons and philosophical works<sup>17</sup>. With simile it offered a way for Willis to express his opinions on the role of the King and the Church while writing on the brain<sup>18</sup>. The brain was a 'kingdom', a 'den', a 'chest', a 'vault', the capital of the empire and the 'chapel of the deity'. It was the primary organ of the body, divided up into 'provinces' and 'villages'

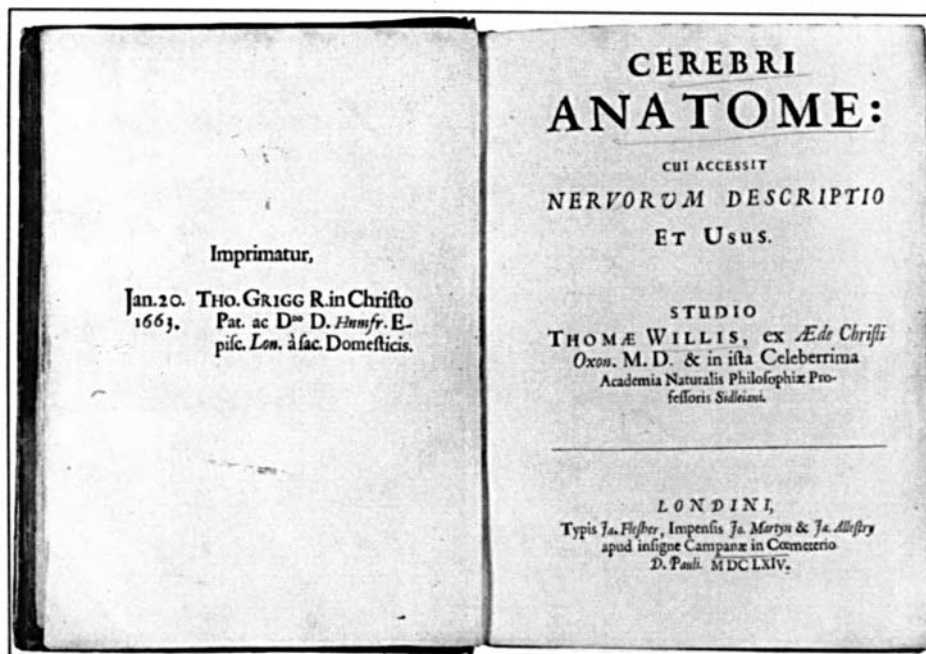


Figure 4 Title page of *Cerebri Anatome*, 1664 [Reproduced by permission from Hughes JT, *Thomas Willis 1621–1675: His Life and Works*, RSM Press, 1991]

and was separated by 'waters' (blood vessels). Nerves were like 'silver and gold', containing spirits, who acted as 'many distinct troops or companies of soldiers' causing muscular movements 'like the explosion of gunpowder'. The brain rules over the other parts of the body and the nerves (soldiers) carried out the actions. It is difficult to avoid concluding that Willis was commenting on the right of the King to rule over his land, under the watchful eye of the Church of England. In the preface to *Cerebri Anatome*, Willis describes awaking from a sad dream and ends the book talking of a 'long and tiresome' journey, in which he has laid a foundation for future work. It is possible that he was speaking of the journey through the Civil War and Commonwealth, and that he had now woken in the Restoration, watching the return of a former glory.

Willis used the macrocosm–microcosm metaphor of God ruling the world as the soul rules the body. God is portrayed as an 'artist' and 'divine workman', but Willis went further in his dedication, stating that in nature there was 'no page . . . which shews not the Author and his Power, Goodness, Trust and Wisdom . . . [and the] . . . Providence of the Great Creator'<sup>9</sup>. Willis ended his dedication with the claim that even the most 'perverse atheist', having studied the brain, must acknowledge God or reject not only religion but also reason.

## CONCLUSION

It is instructive to read *Cerebri Anatome* as a whole, rather than as a collection of anatomical descriptions. Although certain of the observations were the basis for current understanding of cerebral blood flow, *Cerebri Anatome* is above all else a work of philosophy. Anatomy was for Willis part of philosophy and provided a way of investigating the human soul.

*Acknowledgments* I thank David Harley for his suggestions on the text, and Christina Bastow and Nicola Winter for their help in preparing the typescript. The passages from *Cerebri Anatome* are reproduced by permission of the Syndics

of Cambridge University Library. Quotations in English are from the translation by S Pordage in *Practice of Physick*, London, 1681.

## REFERENCES

- 1 Dewhurst K. Some letters of Dr Thomas Willis. *Med Hist* 1972;**16**: 63–76
- 2 Compston A. *Dr Thomas Willis and the Origins of Clinical Neuroscience*. Cambridge: Plumridge, 1997
- 3 Webster C. *The Great Instauration: Science, Medicine and Reform, 1626–1660*. London: Duckworth, 1975
- 4 Henry J. The matter of souls: medical theory and theology in seventeenth century England. In: French R, Wear A, eds. *The Medical Revolution of the Seventeenth Century*. Cambridge: Cambridge University Press, 1989:87–113
- 5 Porter R. *The Greatest Benefit to Mankind: a Medical History of Humanity from Antiquity to the Present*. London: Harper Collins, 1997
- 6 Hughes JT. *Thomas Willis 1621–1675: His Life and Works*. London: Royal Society of Medicine Services, 1991
- 7 Cook H. *The Decline of the Old Medical Regime in Stuart London*. New York: Cornell University Press, 1986
- 8 Frank RG. Thomas Willis and his circle: brain and mind in seventeenth century medicine. In: Rousseau G, editor. *The Languages of Psyche*. Berkeley: University of California Press, 1990:107–46
- 9 Willis T. *Cerebri Anatome: cui accessit nervorum descriptio et usus*. London, 1664
- 10 Bynum W. The anatomical method, natural theology and the functions of the brain. *Isis* 1973;**64**:445–68
- 11 Shapin S, Shaffer S. *Leviathan and the Air Pump*. Princeton: Princeton University Press, 1985
- 12 Martensen RL. 'Habit of reason': anatomy and Anglicanism in Restoration England. *Bull Hist Med* 1992;**66**:511–35
- 13 Harley DN. Political post-mortems and morbid anatomy in seventeenth-century England. *S Hist Med* 1994;**7**:1–28
- 14 Dewhurst K, ed. *Willis's Oxford Lectures*. London: Sandford, 1980
- 15 Wright JP. Locke, Willis and the seventeenth-century Epicurean soul. In: Osler MJ, ed. *Atoms, Pneuma and Tranquillity*. Cambridge: Cambridge University Press, 1991:239–58
- 16 French RK. The languages of William Harvey's Natural Philosophy. *J Hist Med* 1994;**49**:24–51
- 17 Harley DN. Medical metaphors in English moral theology, 1560–1660. *J Hist Med* 1993;**48**:396–435
- 18 Niebyl P. Science and metaphor in the medicine of Restoration England. *Bull Hist Med* 1973;**47**:356–74