Brain, Mind and Medicine:

Essays in Eighteenth-Century Neuroscience

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'There are three principal means of acquiring knowledge....observation of nature, reflection, and experimentation. Observation collects facts; reflection combines them; experimentation verifies the result of that combination'

–Denis Diderot (1753)

'For is it not reasonable to think that the electrical machine would add greatly to the efficacy of the materia medica?'

–Morris (1753)

'People will not look forward to posterity, who never look backward to their ancestors'

–Edmund Burke (1790)

Contents

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Section A
Introduction

Introduction

Harry Whitaker, C.U.M. Smith, and Stanley Finger

The idea for a volume on eighteenth-century studies of brain and behavior originated during a joint International Society for the History of the Neurosciences (ISHN) and Theoretical and Experimental Neuropsychology/Neuropsychologie Expérimentale et Théorique (TENNET) symposium held in Montreal in June 2004. We believe that these essays provide unique contemporary insights into the science and medicine of the nervous system, hence "neuroscience," during the "long" eighteenth century – a century too often given short shrift in textbooks as well as in historical reviews of the nervous system.

The long eighteenth century, which in thematic ways is often perceived as stretching from the 1660s into the opening decades of the 1800s, was an age of transition in the neurosciences. It saw the classic and time-honored ideas of neurophysiology – animal spirits moving in hollow nerve conduits to and from the ventricles of the brain – being gradually replaced by ideas more in accord with anatomical reality. It also saw an enormous increase in interest in the nervous system as the source of many of the ills of both body and mind, along with new therapies. It even saw, at least in the upper strata of polite society, a new and at times even "neurotic" concern for the health and proper functioning of the nervous system. The chapters in this book tell these fascinating stories, and more.

The volume is divided into six sections. After this brief introductory section and chronological table, the second section deals with the background against which work on the nervous system took place. After an overview of the development of ideas about brain and mind during the "long century," Brian Ford discusses the most revealing of eighteenth-century instruments – so far as anatomy is concerned – the microscope. Next, Jonathan Reinarz reviews the way in which medical education developed in association with the voluntary hospitals movement. Finally, Christopher Gardner-Thorpe uses the life and work of James Parkinson as a lens through which to examine medicine and its milieu during the last quarter of the eighteenth century.

The next section comprises six chapters that discuss eighteenth-century investigations of the anatomy and physiology of the nervous system. The section starts with an account of the neuroscience of one of the most important eighteenth-century anatomists, and anatomical teachers, John Hunter. James Stone, James Goodrich, and George Cybulski review Hunter's many contributions to neurology and neuroscience and by including many quotations from his own work allow him, for the most part, to speak for himself. Next, Larry Kruger and Larry Swanson discuss the important but rather little known work of Pourfour du Petit on the functional anatomy of the brain and nervous system. After this, Julius Rocca describes the work of William Cullen and Robert Whytt who helped establish the preeminence of Edinburgh's medical school and were among that epoch's most influential investigators of the nervous system. The important controversy between Haller and Robert Whytt on the nature of muscular contraction forms the subject of the next chapter, contributed by Eugenio Frixione. The final two chapters examine the origin and growth of what we now call electrophysiology. Marco Piccolino provides a detailed review of eighteenth-century research into electric fish, whilst Rafaella Simili and Miriam Focaccia provide a similarly scholarly account of Luigi Galvani's career and discoveries.

The fourth section of the book is devoted to long-standing complex issues of brain and behavior. Nick Wade opens with a fascinating chapter on the somewhat obscure late eighteenth-century Scottish physician and anatomist, William Porterfield, whose investigations ranged from the anatomy and physiology of the visual system to the nature of the sensations generated by phantom limbs. Robert Glassman and Hugh Buckingham review the influential mid-century physiological psychology of David Hartley, and Harry Whitaker and Yves Turgeon examine the work of Charles Bonnet on memory and hallucinations. In the next chapter of this section, Ulf Norsell shows that Swedenborg was not merely a religious thinker and mystic, but also a very perceptive student of the nervous system who collected evidence for, and correctly envisioned, cortical localization of function well before this "nineteenth-century" doctrine came into vogue.

The fifth and longest section deals with medical theory and practice arising from eighteenth-century neuroscience. First, Peter Koehler provides a scholarly account of the neuroscience and attendant medicine of Herman Boerhaave and his most famous pupil, Albrecht von Haller. Catherine Storey shows how the concept of apoplexy (stroke) altered during the eighteenth century. The next three chapters review the origin and application of one of the eighteenth century's greatest enthusiasms – electricity – for treating medical conditions. Stanley Finger discusses the work of perhaps the greatest "electrician" of them all – Benjamin Franklin – who personally assessed the use of electric shocks in treating various common disorders, including stroke-induced paralysis and the seizures associated with hysteria. In the next chapter, Hannah Locke and Stanley Finger discuss what people learned about medical electricity from *Gentleman's Magazine*, the first widely disseminated periodical in Great Britain. Paola Bertucci takes up this theme in the next chapter where she examines in detail the many attempts to use electricity in medicine in the latter part of the eighteenth century. John Wesley, in addition to his better known religious convictions and desire to save souls, was also involved in medical electricity as an inexpensive way to heal sick bodies, and James Donat examines this and his long-standing interest in nervous disorders in the next chapter. Next, Douglas and Joseph Lanska discuss Mesmer's related, but ultimately fraudulent, pseudoscience of animal magnetism and show how it was ultimately refuted by the careful use of scientific methodology. Finally, Diana Faber takes up the topic of hysteria and shows how it was transformed from an organic to more of a psychological disease during the eighteenth century.

The final section considers the cultural consequences of this developing interest in the nervous system. Timo Kaitaro examines the consequences for the mind–brain argument in French thought of the period, and Marjorie Lorch brings out the way that Jonathan Swift used eighteenth-century understandings of the brain and nervous system in some of his satirical writings. Finally, George Rousseau examines the work of a well-known twentieth-century psychologist, Jerome Kagan, and shows how one of his central concepts, that of temperament, was first defined in the eighteenth century.

The essays in this book provide a wide perspective on the development of neuroscience and its application in medicine during the "long" eighteenth century. They also show the impact of this interest on the general culture of the time not only on philosophical ideas but also on literature and social life. The developments in neuroscience during the "long" eighteenth century form the basis upon which the great advances of the nineteenth and then the twentieth centuries were made. We hope these essays will be of interest not only to practicing neuroscientists and neurologists, but also to others in the many disciplines which study eighteenth-century life and thought.

Chronology

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In this chronological table of the ‘long’ eighteenth century I have sought to place scientific publications in the context of their cultural milieu. I have purposefully omitted birth and death dates of the great figures of the eighteenth century in preference for the dates when their most significant publications and/or other contributions appeared. I have also, rightly or wrongly, sought to keep things as simple as possible by omitting the coronation dates of Kings and Queens in favour of the publication dates of novels and plays, the first performances of music or display of painting and sculpture. My hope is to have caught most of the important events mentioned in the chapters of this book. Finally, in the science column I have attempted to differentiate between primarily neuroscientific works and those pertaining to the other sciences. This is sometimes a matter of opinion and I hope that I shall not have to endure too much censure if in some cases my opinion does not coincide with that of the reader.

Science (Neuroscience in bold)	***Cultural context***
1660 Foundation of Royal Society	1660 Restoration of British Monarchy
1660 Mariotte discovers eye’s blind spot	
1660 Boyle: *New experiments physico-mechanical touching the spring of the air*	
1661 Malpighi: *De pulmonibus observationes anatomicae*	
1661 Boyle: *Skeptical Chymist*	
1662/4 Descartes: *L’Homme*	1662 Spinoza: *De Ethica*
	1663 Ottomans defeated at Vienna
1664 Willis: *Cerebri Anatome*	
1664 Swammerdam: frog nerve-muscle preparation	
1665 Hooke: *Micrographia*	1665 Great plague in London
1665 Malpighi: *De cerebro*	
1666 Foundation of Académie Royale des Sciences	1666 Molière: *Le Misanthrope*
	1666 Great fire of London
1667 Steno: *Elementorum myologiae specimen*	1667 Milton: *Paradise Lost*
	1668 Dryden named Poet Laureate
	1670 Pascal: *Pensées*
	1670 Louis XIV founds Les Invalides
1671/76 Perrault: *Histoire Naturelle*	

Science (Neuroscience in bold)	*Cultural context*
1672 Glisson: ***Tractatus de Natura Substantiae energetica***	
1672 Willis: ***De Anima Brutorum***	
1674 Van Leeuwenhoek's microscopical sections of optic nerve	
1676 Sydenham: *Observationes Medicae*	
1677 Glisson: ***Tractatus de ventriculo et intestinis***	
1678 Lorenzini: ***Observationi intorno alle topedini***	
1679 Bonet: ***Sepulchretum sive Anatomia Practica***	
1680/81 Borelli: ***De Motu Animalium***	
1682 Newton describes partial decussation of optic nerves	
1683 Van Leeuwenhoek sees bacteria	
1686 Ray: *Historia plantarum*	1685 Edict of Nantes revoked
1687 Newton: *Principia Mathematica*	
	1688 'Glorious Revolution' in England
	1690 Locke: *An Essay concerning human understanding*
1691 Ray: *The Wisdom of God manifested in the Works of Creation*	
	1692 Salem witch trials
1699 Tyson: *Orang-Outang, sive Homo sylvestris*	
1701 Grew: *Cosmologia Sacra: or, A discourse of the Universe as it is the Creature and Kingdom of God*	
1702 Baglivi: ***Specimen quatuor librorum de fibra motrice et morbosa***	
1704 Newton: *Opticks*	1704 Swift: *Tale of a Tub*
1707 Stahl: ***Theoria medica vera***	1707 Act of Union between England and Scotland
1708 Boerhaave: ***Institutiones medicae***	
1709 Berkeley: *New Theory of Vision*	
1710 Petit: ***Lettres d'un Medecin***	1710 Berkeley: *Principles of Human Knowledge*
1714 Boerhaave commences clinical teaching	1714 Leibniz: *Monadology*
	1718 Watteau: *Gilles*
	1719 Defoe: *Robinson Crusoe*
	1722 Defoe: *Moll Flanders*
	1725 Vico: *The New Science*
1726 Establishment of Faculty of Medicine at Edinburgh	1726 Swift: *Gulliver's Travels*
1727 Petit discovers functions of cervical sympathetics	
	1729 Bach: *St. Matthew Passion*
1731/5 Gray: *Electrical experiments*	
1732 Boerhaave**:** *Elementa Chemiae*	1732/4 Pope: *Essay on Man*
1733 Cheyne: *The English Malady*	
	1734 Voltaire: *Lettres Pilosophiques*

Science (Neuroscience in bold)	***Cultural context***
1735 Linnaeus: *Systema Naturae* (1st edn)	1735 Hogarth: *The Rake's Progress*
1737 Porterfield: *An essay concerning the motions of our eyes*	
1737 Kinneir: *A new essay on the nerves . . .*	
1737/8 Swammerdam (published by Boerhaave): *Bybel der Natuure* (*Biblia Naturae)*	
	1738/9 D. Scarlatti: *Keyboard sonatas ("exercises")*
1739 Bayne: *A new essay on the nerves*	1739/40 Hume: *Treatise of Human Nature*
1740/41 Swedenborg: *Oeconomia Regni Animalis*	
	1742 Handel: *Messiah*
1744 Trembley: *Mémoires*	
1745 Whytt: *An Enquiry . . .*	
1745/6 Invention of Leyden jar	
1745 Kratzenstein's medical applications of electricity	
1746 Nollet: *Essai sur l'Electricité des Corps*	
1746 Monro (primus): *The Anatomy of Human Bones and Nerves*	
1747 Haller: *Primae Lineae Physiologiae*	
1747 La Mettrie: *L'Homme Machine*	1747 Richardson: *Clarissa*
1748 Needham: *Observations* (spontaneous generation of life)	1748 Gainsborough: *Mr and Mrs Andrews*
1749 Buffon: *Histoire Naturelle* (vol.1)	
1749 Hartley: *Observations on Man*	
	1750 Rousseau: *Discours sur les sciences et les arts*
1751 Maupertuis: *Système de la Nature*	1751 d'Alembert: *Discours préliminaire*
1751 Whytt: *An Essay on the Vital and other Involuntary Motions of Animals*	1751 Diderot: *Encyclopédie*, vol.1
1751 Franklin: *Experiments and Observations on Electricity*	
1753 Beccario: *Dell'elettricismo artificiale et naturale*	
1754 Condillac: *Traité de la Lumière*	
1754/5 Bonnet: *Essai de psychologie*	
1755 Haller: *Dissertation on the Sensible and Irritable Parts of Animals*	1755 Lisbon earthquake
	1755 Johnson: *Dictionary of the English Language*
1755 Whytt: *Observations on Sensibility and Irritability*	1755 Rousseau: *Discourse on Inequality*
1755 Whytt: *Physiological Essays*	
	1756-1763 Seven Years' War
1756 Lovett publishes on medical electricity	
1757 Adanson: *Histoire Naturelle du Senegal*	
1757/66 Haller: *Elementa Physiologiae Corporis Humani*	
1758 Linnaeus: *Systema Naturae* (10th edn)	
1759 Porterfield: *A Treatise on the Eye*	1759 Voltaire: *Candide*

Science (Neuroscience in bold)	*Cultural context*
1760 Wesley: ***Desideratum, or electricity made plain and useful***	1760 Sterne: *Tristram Shandy*
1760 Bonnet: ***Essai analytique sur les facultés de l'âme***	
1760 Bonnet describes his eponymous syndrome	
1761 Morgagni: *De sedibus*	
	1762 Gluck: *Orfeo et Euridice*
	1762 Rousseau: *Du Contract Social*
	1764 Reid: *Inquiry into the Human Mind*
	1764 Voltaire: *Dictionnaire Philosophique*
1765 Whytt: ***Observations . . . on Nervous, Hypochondriac, or Hysteric Disorders***	1765 Lunar Society founded
1766 Mesmer: *De Planetarum Influxu*	
1767 Priestley: *History and Present State of Electricity*	1767 Fragonard: *The Swing*
1768 Sauvage*: Nosologia Methodica*	
1768 William Hunter founds the Great Windmill Street anatomy school	1768 Cook's first voyage
1769 Bancroft: *Natural History of Guiana*	1769 Arkwright's Spinning Jenny
1769 Bonnet *La Palingénésie Philosophique*	1769 James Watt invents steam engine
1770 Holbach: *Système de la Nature*	1770 Cook at Botany Bay
1770 Cullen: ***Lectures on the Institutions of Medicine***	
1772 Walsh: ***Experiments on the Torpedo or Electric Ray***	
1772 Priestley: ***The History and Present State of Discoveries relating to Vision, Light and Colours***	
1773 Walsh: ***On the electric property of the torpedo***	
1773 John Hunter: ***Anatomical observations on the Torpedo***	1773 First cast–iron bridge at Ironbridge, Shropshire
	1774 Goethe: *Die Leiden des jungen Werther*
1775 Lavater: ***Physiognomische Fragmente***	
1775 Mesmer demonstrates 'animal magnetism'	
1775 Hunter: ***An account of Gymnotus Electricus***	
1776 Cavendish: ***An account of some attempts to imitate the effects of the Torpedo by electricity***	1776 American Declaration of Independence
1776 Musgrave: ***Speculations and Conjectures on the Qualities of the Nerves***	1776 Herder: *Sturm und Drang*
	1776 Smith: *Wealth of Nations*
	1776 Gibbon: *Decline and Fall of the Roman Empire*
1777 Cullen: ***First lines in the practice of Physic***	1777 Goya: *El quitasol*
1778 Mesmer develops group treatment by animal magnetism	1778 Banks elected President of Royal Society
1779 Mesmer: ***Mémoire sur la découverte du magnetisme animal***	1779 Lessing: *Nathan der Weise*
1779 Prochaska: ***De structura nervorum***	
1780 d'Eslon: ***Observations sur le magnétisme animal***	1780 Gordon riots in London

Science (Neuroscience in bold)

1780 Spallanzani: *Disssertazione di fisica animale e vegetabile*

1781 Fontana's first microscopical observation of a nerve fibre

1781 Fontana: *Traité sur le Venin de la Vipère*

1783 Monro Secundus: *Observations on the Structure and Functions of the Nervous System*

1784 Franklin commission on mesmerism

1784 Vicq d'Azyr: *Recherches sur la structure du cerveau*

1785 Hutton: *Theory of the Earth*

1786 John Hunter: *Observations on certain parts of the animal economy*

1787 Abernethy establishes a surgical curriculum at St Bartholomew's Hospital

1789 Lavoisier: *Traité Elémentaire de Chimie*

1789 Pinel: *Nosographie Philosophique*

1790 Goethe: *Versuch die Metamophose der Pflanzen zu erklären*

1791 Galvani: *De riribas electricitatis in motu musculari*

1792 Volta: *Memoria sull'elettricità animale*

1792 Wells: *An Essay upon Single Vision*

1792 Kirkland: *A Commentary on Apoplectic and Paralytic Affections*

1793 Young: *Observations on Vision*

1794-6 Darwin: *Zoonomia*

1793 Richard Fowler: Experiments and Observations relative to the influence lately discovered by M. Galvani and commonly called animal electricity

1794-1801 Soemmerring: *De corporis humani fabrica*

1794 John Hunter: *A Treatise on the blood, inflammation, and gun-shot wounds*

1798 Jenner: *Inquiry into variolae vaccinae*

1800 Volta: *On the electricity excited by the mere contact . . .*

1801 Bichat: *Anatomie Générale Appliquée à la Physiologie et à la Médecine*

Cultural context

1781 Kant: *Kritik der reinen Vernunft*

1781 Schiller: *Die Rauber*

1781 Houdon: *Bust of Voltaire*

1783 Blake: *Poetical Sketches*

1783 First human ascent in hot-air balloon

1786 Kant: *Metaphysische Anfangsgründe der Naturwissenschaft*

1786 Mozart: *Le Nozze di Figaro*

1789 Revolution in France

1790 Burke: *Reflections on the Revolution in France*

1791 Paine: *The Rights of Man*

1791 Mozart: *Die Zauberflöte*

1792 Stewart: *Elements of the Philosophy of the Human Mind*

1793 David: *Marat Assassinated*

1794 Lavoisier guillotined

1797 Schelling: *Ideen zur Philosophie der Natur*

1798 Malthus: *Essay on Population*

1798 Wordsworth/Coleridge: *Lyrical Ballads*

1798 Haydn: *Die Schöpfung*

1799 Rosetta stone

1799 Napoleon overthrows the Directory

1800 Mozart: *Requiem*

1800 Schelling: *Transcendental Philosophy*

Science (Neuroscience in bold)

1802 Paley: *Natural Theology*
1802 Young: *On the theory of lights and colours*

1802-22 Treviranus: *Biologie*
1803 Darwin: *Temple of Nature*
1804 Aldini: *Essai théorique et expérimentale sur le galvanisme*
1804 Wilkinson: *Elements of Galvanism*

1807 Trotter: *A view of the nervous temperament . . .*

1808 Dalton: *New System of Chemical Philosophy*

1809 Rolando: *Saggio sopra la vera struttura del cervello dell'uomo e degl'animali*
1809 Lamarck: *Philosophie Zoologique*
1809-11 Oken: *Lehrbuch der Naturphilosophie*
1810 Goethe: *Zur Farbenlehre*

1810-19 Gall and Spurzheim: *Anatomie et physiologie du système nerveux. . . . par la configuration de leur têtes* (first two volumes only with Spurzheim)
1811 Bell: *Idea for a New Anatomy of the Brain*

1817 Parkinson: *Essay on the Shaking Palsy*

1820 Cooke: *A Treatise of Nervous Diseases*

Cultural context

1802 Coleridge: *Dejection: An Ode*
1802 Constable: *Dedham Vale*

1804-8 Beethoven: *5th Symphony*
1804 Jacquard invents eponymous loom
1804 Trevithick invents first steam locomotive
1805 Battle of Trafalgar
1807 Hegel: *Phänomenologie des Geistes*
1807 Abolition of Slave Trade Act passed in British Parliament
1808 Goethe: *Faust part 1*
1808 Goya: *El Tris Mayo*
1809 Davy invents first electric light

1811 Luddite revolts in England

1814 Austen: *Mansfield Park*
1814 Stevenson's steam locomotive
1815 Battle of Waterloo; Congress of Vienna
1817 Coleridge: *Biographia Literaria*
1818 Shelley: *Frankenstein*
1819 Schubert: *Trout quintet*

Section B
Background

Introduction

This section consists of four chapters which sketch in some of the background against which the development of Neuroscience in the 'long eighteenth century' took place. The chronological table in the preceding section shows some of the major events in the wider world during the 'long century'. It has often been called 'the Age of Enlightenment' and the table shows how societies in the Western World emerged from the fundamentalisms of the seventeenth and earlier centuries – the Civil War in England during the 1640s, the Revocation of the Edict of Nantes in 1685, the Salem witch trials in the American colonies in the 1690s – to a more secular, not to say rational, settlement. Sterne's *Tristram Shandy*, Diderot's *Encyclopédie*, Gainsborough's *Mr and Mrs Andrews*, Fragonard's *The Swing*, Scarlatti's *Keyboard Sonatas*, all breathe a different air from that breathed by the fanaticisms of the earlier century. It did not last. In 1793 Charlotte Corday came from Normandy to assassinate Marat in his bath, in 1794 both Robespierre and Lavoisier were guillotined, in 1799 Napoleon came to power. The clear rational air of the eighteenth century thickened. In England, taste for the gothic climaxed in Mary Shelley's *Frankenstei*n, in Spain Goya painted *El Tris Mayo*, in Germany, Goethe initiated the *Sturm und Drang* movement and Hegel published *Phänomenologie des Geistes*.

It is against this background that investigations of the brain and nervous system were carried out. This section does not, however, attempt to place eighteenth-century physicians, anatomists and physiologists in their wider cultural context but to focus more closely on their professional interests and technical abilities. The first chapter, contributed by C.U.M. Smith, sets the scene by reviewing the development of ideas concerning mind and brain during the 'long' century. He argues that the century, so far as physiological psychology is concerned, was a century of transition. The old ideas of spirit-filled cerebral ventricles and hollow nerves inherited from the medievals were discredited by anatomical and especially microscopical research. Yet until the very end of the century, when investigations of 'animal electricity' began to take hold, it was difficult to see with what the old ideas could be replaced. This dissonance between what was shown by the anatomist's scalpel and the microscopist's lens and what the general public believed persisted for a century and more. Nevertheless, both physicians and polite society became increasingly interested in the nervous system and nervous disease. The affect of this interest on the sophisticated classes can be seen in the best-selling novels of the time and in the development of fashionable spa society. Right at the end of the period evolutionary ideas began to challenge the established order and Smith's chapter ends with an account of Erasmus Darwin's evolutionary psychophysiology.

In the next chapter Brian Ford reviews the development of microscopy during the eighteenth century. He starts with the first great pioneers – Robert Hooke (1635–1703) and Anthony van Leeuwenhoek (1632–1723). Ford notes that some of Leeuwenhoek's first specimens were preparations of bovine optic nerve (1674) and that he could find no evidence that they were tubular. Other microscopists examined nerve fibres during the late seventeenth century but preparative techniques were not sufficiently well developed to allow a definitive answer to the question whether the fibres were hollow (as had long been believed) or solid, and the controversy lingered on into the eighteenth century. Ford next provides a valuable account of the design of eighteenth-century microscopes and their use by many of the luminaries of that century – Della Torre, Fontana, Monro (Primus and Secundus), Prochaska, etc. – and points out that although the resolution of the these microscopes was often surprisingly good, severe limitations were imposed by undeveloped preparative techniques. The chapter ends with a look forward into the nineteenth century when microtomes and the first achromatic compound microscopes became available, finely tooled from brass, and often collectors' items.

The topic of medical education and its association with the voluntary hospital movement in England is the subject of the next chapter by Jonathan Reinarz. Reinarz starts his account in the sixteenth century when British physicians received a university education but surgeons were taught through an apprenticeship scheme as befitted what seemed more like a craft. After a discussion of the famous Italian centres of medical education, especially Padua, the focus shifts to Leiden. Here graduates from Padua sought to replicate their own educational experience and initiated clinical teaching at the city's hospital. From Leiden many medical graduates migrated across Europe, especially to Scotland where William Cullen, at Edinburgh, lecturing in English rather than Latin, established a systematic medical curriculum. The scene then passes to London where the practice of clinical teaching at a number of the capital's hospitals, especially St Bartholomew's and Guy's, had already been established. Unlike the rather bureaucratic hospitals across the channel, London hospitals customarily allowed students much more freedom to develop their own programmes of study. With the exception of smallpox, they were allowed to see the full range of medical and surgical cases. The most famous London medical courses were given by physician William Hunter and his brother, surgeon John Hunter, at Great Windmill Street. The success of this school soon led to the founding of several other teaching establishments so that, by 1780, no less than 16 anatomical courses were advertised in the London newspapers. By the end of the century London had become a major world centre for medical education. Jonathan Reinarz traces these developments into the beginning of the nineteenth century when clinical teaching in a hospital environment had begun to spread to the English provinces.

In the final chapter in this section, Christopher Gardner-Thorpe examines the medical milieu in the last quarter of the eighteenth century through the lens provided by the life and work of James Parkinson (1755–1824). Although Parkinson is nowadays best known for his 1817 *Essay on the Shaking Palsy*, he had led a varied and eventful life before the *Essay* was published. Like others in the eighteenth century (one immediately thinks of Erasmus Darwin and Benjamin Franklin), his mind voyaged widely over the world being revealed by enlightenment thought and discovery. In addition to his medical interests he involved himself in politics, where he became a notable (though anonymous) pamphleteer, the church, where he was for many years a churchwarden, and geology and palaeontology where he was not only a founder member of the Geological Society but also published a highly regarded three volume work, *Organic Remains of a Former World*. Gardner-Thorpe shows how country physicians (like many country vicars) could sustain a wide-ranging interest in the world around them and yet make significant contributions to their own chosen profession. Parkinson was not only a founder member of London's Medical and Chirurgical Society but also much involved in domestic medicine (writing popular medical compendia for the general public), the regulation of 'Mad Houses', promoting good nutrition, studying gout and many other medical topics. Gardner-Thorpe's review provides a valuable insight into the medical and scientific world of the late eighteenth century. A world which, to paraphrase Thomas Wright's words in his 1750 discussion of astronomy, seemed to open up on all sides, revealing truths undreamt of in earlier centuries.

The Editors

1
Brain and Mind in the 'Long' Eighteenth Century

C.U.M. Smith

Introduction

How should the 'long' eighteenth century be defined? January 1, 1700 and December 31, 1799 are quite arbitrary dates. Why should they be chosen to segment our history rather than more significant periods of time, periods which have a coherent content, or are marked, perhaps, by the working out of a theme? Students of English literature sometimes take the long eighteenth century to extend from John Milton (*Paradise Lost*, 1667) to the passing of the first generation of Romantics (Keats (d. 1821), Shelley (d. 1822), Byron (d. 1824), Coleridge (d. 1834)). Students of British political history often take it to start with the accession of Charles II (the Restoration) in 1660 or, alternatively, the so-called *Glorious Revolution* of 1688 and to end with the great Reform Act of 1832. Others might choose different book ends. In the history of science and philosophy the *terminus a quo* is sometimes taken as the publication of Descartes' scientific philosophy or, in more Anglophone zones, the 1687 publication of Newton's *Principia* with its vision of a 'clockwork universe'. 'Nature and Nature's laws' as Alexander Pope enthused, 'lay hid in Night: God said, "Let Newton be!" and all was light!'.

But in the biological sciences, as the long eighteenth century wore on, the Newtonian illumination dimmed. After early enthusiasms, mechanistic interpretations of life-processes proved unfruitful. The models proposed by Descartes, Borelli and others began to seem absurdly simplistic. The reaction against 'clockwork' models took the form of Romantic biology and, especially in Germany, drifted far from the clarity of Descartes and Newton. Kant published *Metaphysical Foundations of Natural Science* in 1786 and Goethe's *Metamorphosis of Plants* came out in 1790. In early nineteenth-century England, Samuel Taylor Coleridge, eschewing his fine poetical talent, sought to develop a science of life based on *Naturphilosophie* (Smith, 1999). The *terminus ad quem* of this long decline in mechanistic interpretations of the living process can, perhaps, be seen in the publication of Lawrence Oken's turgid *Lehrbuch der Naturphilosophie* in 1809–1811 (trans. Tulk: *Elements of Physiophilosophy* 1847). Thus, in the life sciences, we might adapt Squire's riposte to Pope's encomium and write: 'Then came the devil, howling "Ho! let Oken be!" and restored the status quo'.

Neuroscience could not be immune to these movements of thought. Perhaps the most obvious date to start is 1664 with the publication of Willis' *Cerebri Anatome*. The end point is less clear. Should it be with Gall and Spurzheim's phrenology (1810–1819) or Charles Bell's *Idea for a New Anatomy of the Brain* in 1811, or even later still, in the 1840s, with Emil du Bois Reymond's discovery of the action potential and the action current in nerve and muscle? What happened during this long period? It has been called the *Age of Enlightenment*. In France, Denis Diderot and Jeanle-Rond d'Alembert published the *Encyclopédie*, often taken to be the Enlightenment's master work; Diderot was sufficiently interested in physiology to write a treatise called *Eléments de Physiologie*, although this was never published. Roy Porter, perhaps the foremost of our recent historians of this period, saw it as an era when the old spiritual certainties, the old theologies, evaporated to be replaced by an uneasy materialism. Yet this materialism, as we shall see, was very different from the mechanistic materialism put forward by René Descartes and his followers in the seventeenth century. The thought world of Erasmus Darwin, at the end of the 'long' century, is very different from that of the Cartesians at the beginning! Nevertheless, the old ideas about the brain and its physiology refused to go without a tenacious rearguard action. Long before the eighteenth century, Vesalius, in the 1543 *Fabrica*, had strongly denied that the nerves were hollow: 'I have never seen a channel, even in the optic nerve' (p. 317), and in 1620, the Edinburgh medical student, John Moir, recorded in his lecture notes that 'nerves have no perceptible cavity internally, as the veins and arteries have' (French, 1975). Yet the notion of animal spirit travelling in nerve tubes was still current in popular culture 150 years later. For Tristram Shandy, in Laurence Sterne's novel of the 1760s, it was simply conventional wisdom. The long eighteenth century, for the historian of neuroscience, is an age of transition but not of revolution. The old framework of ideas, animal spirit, subtle fluids, spiritual substances and hollow nerves lived on, in spite of the evidence, because it was difficult to see until the very end of the period with what they could be sensibly replaced.

Setting the Scene

At the beginning of the Western tradition 2,500 years ago, Hippocrates expounded a view of the brain with which we would hardly be uncomfortable today. In his work on epilepsy, *On the Sacred Disease*, he located all the psychical functions (' – joys, delights, laughter, . . . sorrow, griefs, despondency, . . . the acquisition of wisdom and knowledge, . . . ethical understanding, . . . seeing and hearing, . . . bad dreams and delirium, . . .') in the brain.

At about the same time, on the other side of the Aegean, Plato's Pythagorean tract, the *Timaeus*, had a very different story to tell. A rational soul is confined within the skull whilst a mortal soul full of passion is confined in the torso and beneath that, separated by the diaphragm, a lower, concupiscent soul. The *Timaeus* is an explicit continuation of the *Republic* and its tripartite schematic mirrors the tripartite sociology of Plato's ideal state. Plato's famous pupil, Aristotle, far more a biologist than his master, also developed a tripartite psychophysiology. The three divisions of his animating principle – vegetable, animal and rational souls – clearly relate to his classification of the biological world, rather than the social stratification of an ideal state.

It is, however, only with the Alexandrians of the third century BC that we find the first physiological thought based on anatomical dissection. Both Herophilus and Erasistratus were aware of the cerebral ventricles and Erasistratus developed a physiology in which *pneuma zotikon* was transported by blood to the brain where it was transformed into *pneuma psychikon* to be distributed to the muscles by hollow nerves (see Smith, 1976). This idea reappears in Galen in the second century AD and variants (*pneuma psychikon* being translated as 'animal spirit') persisted for two millennia up until the Renaissance and beyond.

The origin of that other long-persisting notion, the 'cell' or 'ventricular' theory, where the 'rational' soul is divided into a number of parts and located in three cerebral ventricles or 'cells', is more obscure (1). There are hints both in Nemesius of Emesa (fl. fourth century AD) whose work, *On the Nature of Man*, synthesises ancient Hellenistic and Judaic thought, and in St. Augustine of Hippo at the beginning of the fifth century. It was only with the rebirth of anatomy in the sixteenth century that it was recognised that the medieval cell diagrams, valuable though they were as representations of psychology, bore little or no resemblance to the anatomy of the brain.

Leonardo's early sixteenth-century wax cast of the ox ventricles (unknown until the nineteenth century) is perhaps the first true representation. Leonardo writes, 'My works are the issue of pure and simple experience, who is the one true mistress'. Renaissance anatomists began to insist that function – in this case mental function – should be related to structure revealed by the scalpel. This brings us, rapidly, to the beginning of the modern era.

Descartes and Willis

Descartes' *L'Homme* was published just 2 years before the start of our period, in 1662, though it had been written long before. Descartes' anatomy was, of course, far inferior to that of Willis (Willis, 1664), although he had much first-hand experience of dissecting specimens from butchers' shops in Amsterdam. His psychophysiology is yet more speculative (see Smith, 1998). Both Descartes and Willis were, however, clear that the 'lower' souls of the ancients and medievals, the animal and vegetable souls, were wholly material.

Descartes, it will be remembered, argued that the rational soul swayed the pineal gland, thus directing animal spirit present in the ventricle into one or other nerve conduit, hence causing appropriate behavioural movements. Willis' theory is in many respects rather similar. Animal spirit, distilled from vital spirit in the blood by the grey matter of the brain, fills 'the medullar trunk' and passes from thence via the nerves to the body 'and so imparts to those bodies, in which the nervous fibres are interwoven, a motive or sensitive feeling of force' (Willis, 1681, p. 126). But in both cases an immaterial soul, unique to man, lurked somewhere beyond the scalpel (see Changeux, 1985, p. 11).

On the other hand neither Descartes nor Willis denied infra-human animals sensation. Descartes writes to the Marquess of Newcastle, 'As for the movements of our passions . . . it is . . . very clear that they do not depend on thought, because they often occur in spite of us. Consequently they can also occur in animals, even more violently than they do in human beings . . .' and in a letter to Henry More in 1649 he writes, 'I do not deny life to animals . . .; and I do not even deny sensation, insofar as it depends on a bodily organ' (Cottingham, Stoothoff, & Murdoch, 1985, p. 366). The fashionable notion that Descartes (though not some of his followers) regarded animals as unfeeling automata is plainly incorrect.

Willis, for his part, maintains that animals possess a 'corporeal soul . . . having extension and local parts' (Willis, 1672) which, although thoroughly material, nevertheless vivifies the body and is sensitive to the aches and pains and pleasures of life. It is fashionable to say, with Coleridge, that Descartes, in exorcising the lower spirits, transformed the body into an unfeeling machine. The truth, as ever, is more ambiguous. This ambiguity lived on to plague the eighteenth century.

Nerves are not Hollow Conduits

The ancient neurophysiology to which both Descartes and Willis subscribed – that the nerves are conduits linking the brain with the periphery along which the animal spirit travelled – was, even as their works were being published, on the point of being discredited. In the last decades of the seventeenth century both Jan Swammerdam and Giovanni Borelli provided experimental evidence against the idea that animal spirit travelled down nerve tubes like a wind to inflate the muscles. Swammerdam had shown by an ingenious and delicate experiment, as early as 1663, that frog muscles did not expand on contraction (2). However, although he demonstrated his experiment widely to academic audiences (Nordstrom, 1954), he tried to explain away its implications and his work was not placed in the public domain until Boerhaave published an edited version in the 1737/1738 *Bibjel der Nature (Biblia Naturae)* (see Cobb, 2002). Borelli also contested the old idea of nerves as hollow conduits. He believed the nerves were 'canals filled with a spongy material, like elder pith . . . moistened with a spirituous juice (succus nerveus) originating in the brain . . . saturated to turgescence'. Instead of a flow of 'spirit', he argued that a 'commotion', 'concussion' or 'undulation' was all that was transmitted (Borelli, 1680/1681; see also Glynn, 1999). Willis, although satisfied that nerves contained no cavity visible to the naked eye or simple microscope, nonetheless believed that they were like 'Indian canes' through which animal spirit could percolate (Willis, 1681).

The work of the physiologists was supplemented by that of microscopists (see Ford, this volume). At the end of the seventeenth century Antony van Leeuwenhoek used his microscope to examine sections of bovine optic nerve and concluded that no cavity could be perceived, although he later appears to have had second thoughts. During the next century improved microscopical techniques suggested ever more strongly that nerves contained no cavity (3). The old neurophysiology thus became highly questionable. Yet the old ideas held on tenaciously. In *The English Malady*, George Cheyne devotes many pages to a discussion of animal spirits, what they might be and how they might act (Cheyne, 1733, pp. 75–89). Ford (this volume) refers to an illustration depicting hollow nerves in a publication dated as late as 1842! The old neurophysiology also lingered in popular culture. Tristram Shandy in 1760 is well versed in them. 'You have all, I dare say, heard of the animal spirit' he writes, 'Nine parts in ten of a man's sense and nonsense . . . depend on its motions and activity . . .' (Sterne, 1760, p. 1), and Jonathan Swift, in the 1704 *Mechanical Operation of the Spirit*, writes that 'it is the Opinion of Choice Virtuosi, that the Brain is only a Crowd of little Animals, but with Teeth and Claws extremely sharp, and therefore, cling together in the Contexture we behold, like the Picture of Hobbes's Leviathan, or like Bees in perpendicular swarm upon a Tree, or like a Carrion corrupted into Vermin, still preserving the Shape and Figure of the Mother Animal'. Swift also famously defines 'punning' as 'the art of harmonious jingling with words, which passing in at the ears, excites a titillary motion in those parts; and this being conveyed by the animal spirit into the muscles of the face, raises the cockles of the heart'.

One important reason for the lingering of the old neurophysiology was the difficulty of knowing with what to replace it. The traditional understanding of the human being was at least a consistent system. Alexandre Koyré says the same of Aristotelian physics. He remarks that it '. . . forms an admirable and perfectly coherent theory which, to tell the truth, has only one flaw (besides that of being false) . . . that it is contradicted by the everyday practice of throwing' (Koyré, 1943). The same could be said of the ancient neurophysiology, substituting 'the fact that nerves are not hollow tubes' for 'the everyday practice of throwing'. But replacing the usefully ambiguous psychophysical substance with straightforwardly physical substance, though seemingly inescapable, merely made the psychophysical problem more intractable.

There were a number of attempts to incorporate neurophysiology into the Aristotelian system's successor: Newtonian mechanism. Boerhaave proposed that nerve fluid consisted of the finest of all particles, far smaller than the large corpuscles making up other body fluids, and that these strung end to end communicated impetus along a nerve fibre much as a line of billiard balls in a tube. Because of Boerhaave's immense reputation, this idea helped prolong hydraulic neurophysiology well into the eighteenth century. David Hartley, taking a hint from Newton's *Optics*, proposed a rather different idea (see Buckingham, this volume). He argued that the nervous system operated by way of vibrations and vibratiuncles (in many ways this reminds us of Borelli's 'undulations') (Hartley, 1749). Like most of his eighteenth-century contemporaries he felt the pull of Newton's genius and wished to develop 'an experimental physics of the mind' (see Smith, 1987). However, although his associationist psychology was very influential, his neurophysiology did not find favour. Anatomists like Alexander Monro primus were quick to point out the anatomical infelicities of his theory: '. . . the nerves are unfit for vibrations because their extremities . . . are quite soft and pappy' (4). The beginnings of our modern understanding awaited the second part of the nineteenth century, first with the work of Emil du Bois Reymond and then with that of Helmholtz, Bernstein and others, and was not fully completed until the work of Hodgkin, Huxley and Katz in the mid-twentieth century. Indeed, it might even be said that complete understanding awaited the Nobel Prize researches of Robert MacKinnon and colleagues at the beginning of the twenty-first century (MacKinnon, 2003; Smith, 2002b).

The Mind Escapes the Cells

The puzzle posed by transmission down 'solid' nerves was not the only puzzle facing eighteenth-century anatomists. Another, and equally acute, puzzle was that posed by the neural correlatives of mind. What and where were they? The new anatomy gave no hint. The ancient 'cell' or 'ventricular' psychology had long been recognised as having no anatomical basis. Descartes and many others insisted instead that the 'mind' had no physical dimension and thus, as Henry More remarked, was strictly speaking, 'nowhere'. This seemed to point directly to atheism, a conclusion which did not escape the Holy Office. In 1663, it put Descartes' physio-philosophy on its Index Librorum Prohibitorum.

Interest in this problem was not confined to philosophers, theologians and anatomists. Laurence Sterne, for instance, has much to say about it in his novels. Tristram Shandy's opinionated father philosophises over this very question in intensely humorous passages, eventually insisting that the neural correlatives of mind were to be found in the fine material of the cerebellum. Accordingly he instructed his man-midwife, Dr Slop, to take great care to ensure that the back of Tristram's head was well protected at birth.

More seriously, Samuel Johnson, that epitome of clarity of thought and expression, writes in many places, not least in his *Dictionary*, that the union of psyche and soma is incomprehensible: 'Man is compounded of two very different ingredients, spirit and matter, but how two such unallied and disproportioned substances should act upon each other, no man's learning could yet tell him' (Johnson, 1755, quoting Collier). He was bitingly dismissive of those who would identify mind with brain: a 'quagmire', he remarked, whose 'clammy consistency' could have nothing to do with the 'motion of thought' (Porter, 2003, p. 169).

Johnson was burdened with many of the 'ills the flesh is heir to', half blind in one eye, half deaf in one ear, corpulent, subject to all sorts of tics and compulsions. Yet he was gifted with an astonishing memory and articulacy. It must have seemed obvious to him that mind and body had little to do with each other. Humans, for him, were, as they were for Plato, essentially embodied souls. He lived his life in ever-present fear of the hereafter, seldom far from thoughts of his end, more than once descending into black melancholia, striving always to act so as to be able, as he says, 'to render up my soul to God unclouded' (quoted in Porter, 2003, p. 188). He is said to have refused opiates at the end, wishing to pass over with a clear mind. His hero, Herman Boerhaave, thought much the same. Johnson points out in the biography he wrote for the *Gentleman's Magazine* (Johnson, 1739, p. 174) that 'he (Boerhaave) had never doubted of the spiritual and immaterial Nature of the Soul, but declared that he had lately had a kind of experimental Certainty of the distinction between Corporeal and Thinking Substances, which mere Reason and Philosophy cannot afford, and Opportunities of contemplating the wonderful and inexplicable Union of Soul and Body, which nothing but long Sickness can give. This he illustrated by a Description of the Effects which the Infirmities of his Body had upon his Faculties, which yet they did not so oppress or vanquish, but his Soul was always Master of itself, and always resigned to the Pleasure of its Maker.'

Animal Spirit Escapes the Nervous System

Not only did the 'mind' escape its traditional confinement in the cerebral cells, but the 'animal spirit' of the ancients also began to escape, this time from the nervous system itself. Towards the end of the seventeenth century, the first microscopes allowed Leeuwenhoek, Hooke (Willis' pupil), Swammerdam and others to discover the world of microbes and protista. Leibniz at the beginning of the eighteenth century, impressed by the work of Jan Swammerdam and Antony van Leeuwenhoek, saw continuity all the way from monad to man. He believed, furthermore, that there was no discontinuity between the plant and animal kingdoms. In a letter to Louis Bourget in 1715 he writes that 'Mr Swammerdam has supplied observations which show that insects are close to plants with respect to their organs and that there is a definite order of descent from animals to plants. But perhaps there are other beings between these two' (Loemaker, 1956, vol. 2, p. 1079) and in another place he writes that the existence of zoophytes is 'wholly in keeping with the order of nature' and 'the principle of continuity' (5).

Notions of a so-called 'great chain of being' had, of course, been around for centuries but, as Lovejoy remarks, they achieved great prominence in the eighteenth century (Lovejoy, 1930). Alexander Pope's lines are only the best known of a multitude of similar expressions:

Vast chain of being, which from God began,
Natures aethereal, human, angel, man,
Beast, bird, fish, insect! what no eye can see
No glass can reach! from Infinite to thee,
From thee to Nothing! . . .

Essay on Man, 237–241

Leibniz' prediction that zoophytes (links, as he supposed, between the animal and plant worlds) must exist was confirmed in 1739 when Abraham Trembley discovered the fresh water hydrozoa. Trembley went on to show that fresh water polyps could be subdivided indefinitely and that from each fragment a new polyp would regenerate (Trembley, 1744). This had an important implication, for it was taken to show that 'soul', the principle of life, was distributed throughout the body. Rieppel (1988) shows how strong an affect Leibniz' ideas had on the development of Bonnet's holistic thought. Bonnet concluded that it implied that body and soul could not be two distinct and separate substances but that animate beings constituted what he called an 'être mixte' (6). Julien Offray de La Mettrie also seized on this implication in his mid-century works, *l'Homme Machine* (1747) and *Traité de l'âme* (1751) (see Smith, 2002a). He concluded, like Bonnet, that the division of creation into two parts – body and soul – was absurd. Both, he writes, were created together, at the same instant, as if 'by a single brush stroke' (de La Mettrie, 1745, p. 2). To think otherwise was nothing more than a casuistry designed to throw dust into the eyes of the watching theologians (6). But this sort of panpsychism has, of course, tricky implications. Does all matter have this 'dual aspect'? Leibniz, at least, recognised this implication and was content to allow his fundamental units – the monads – to possess both attributes.

Irritability

Towards the middle of the eighteenth century another concept, that of 'irritability', began to make headway. The concept is, of course, of great antiquity. Francis Glisson had developed the notion and coined the term in the seventeenth century, but Albrecht von Haller made the idea very much his own (7). Indeed, in Tissot's 1755 preface to Haller's *Dissertation on the Sensible and Irritable Parts of Animals*, he apostrophises him as having made 'the great discovery of the present age' (von Haller, 1755, p. 3).

Haller writes of making a multitude of experiments designed to discover which parts of an animal are irritable. His stimuli included blowing, heat, spirit of wine, lapis infinalis, oil of vitriol, butter of antinomy, touching, cutting, burning, etc. He concludes that 'it (irritability) does not depend on the nerves, but on the original fabrication of the parts which are susceptible of it' (p. 32). And, a little further on, he homes in on muscle fibres, '. . . there is nothing irritable in the animal', he writes, 'but the muscular fibre and the faculty of endeavouring to shorten itself when we touch it is proper to this fibre' (p. 37). This they do when quite isolated from the nervous system.

What is it about muscle fibres which give them this property? In the first half of the eighteenth century this had to remain a mystery. Haller would have nothing to do with Stahl's mysterious animism and writes that muscle fibres are composed of nothing more than gluten and earth. The power of contraction could hardly be inherent in earth; *ergo* it must be a property of gluten. 'Hence', he concludes, 'the physical cause must depend upon the arrangement of the ultimate particles (of which gluten is composed), though the experiments we can make are too gross to investigate them'. It is interesting to note that Erasmus Darwin, later in the century, could not restrain his powerful speculative energy, and developed an interesting hypothesis to account for this contractile power (see below and Smith, 2005). But, as with the physical basis of the nerve impulse, a further two and half centuries were to elapse before experimental techniques had developed sufficient delicacy to provide an answer to Haller's question.

Sensibility

Sensibility is quite different. Haller writes that '. . . the sensible parts of the body are the nerves themselves, and those to which they are distributed in the greatest abundance; for by intercepting the communication between a part and its nerve, either by compression, by tying, or cutting, it is thereby deprived of sensation . . . Wherefore the nerves alone are sensible of themselves . . .' (von Haller, 1755, p. 31). Far from all, eighteenth-century physiologists agreed with Haller's distinction. William Cullen, in particular, believed that the fine endings of nerve fibres transformed into muscle fibres in the interior of muscles (Cullen, 1827; see Rocca, this volume). This somewhat bitter dispute seems to have been more about words and personalities than about the observations. Both Haller and Cullen agreed that the muscle fibres contained an inherent power of 'contractility', a *vis insita*, and this implied that the animate principle was diffused throughout the neuromuscular system, not confined to the brain. Similarly, both agreed that the webwork of nerves was endowed with 'feeling'. Robert Whytt, a colleague of Cullen's at Edinburgh, writes that 'we know certainly that the nerves are endowed with feeling' and the notable eighteenth-century English physician, George Cheyne, also educated at Edinburgh, agreed, writing that 'Feeling (physical sensibility) is nothing but the Impulse, Motion or Action of Bodies, gently or violently impressing the Extremities or Sides of the Nerves . . .' (Cheyne, 1733, p. 49).

This recognition that the nerves were not merely inanimate conduits for an animating principle originating in the brain influenced medical practice. Thomas Trotter writes in 1807, p. 17, that

> the last century has been remarkable for the increase in a class of diseases little known in former times, and which had but lightly engaged the study of physicians prior to that period . . . Sydenham at the conclusion of the seventeenth century computed fevers to constitute two thirds of the diseases of mankind. But at the beginning of the nineteenth century we do not hesitate to affirm that nervous disorders have now taken the place of fevers and may be justly reckoned two thirds of the whole, with which civilised society is afflicted.

Trotter also notes that nervous disorders 'are to be found in abundance in large towns, or wherever luxurious habits have displaced simplicity' (p. 200). It has been remarked that these luxurious habits led to the growth of the fashionable 'spa society' so well captured in the novels of Jane Austen, Brinsley Sheridan and Tobias Smollet.

This new understanding of the nerves influenced late eighteenth-century English literature in other ways. In Samuel Richardson's best seller of the 1780s, Clarissa, the heroine dies because of her nervous sensibility (Stephanson, 1988). 'The origin of your disorder', the doctor tells Clarissa, is that 'you were born with weak Nerves . . . and then the Nerves have been wasted and relaxed by your sedentary life and thinking attentively'. Robert Whytt writes in 1765 that 'In some, the feelings, perceptions and passions are naturally dull, slow and difficult to be aroused . . . in others the opposite is the case on account of a greater delicacy and sensibility of the brain and nerves' (Whytt, 1765). George Cheyne agreed. 'Persons of slender and weak Nerves are generally of the first Class: the Activity, Mobility and Delicacy of their intellectual Organs make them so', he writes, and he goes on to say that nervous debility only attacks persons of this upper class, 'the brightest and most spiritual, and whose Genius is most keen and penetrating' (Cheyne, 1733, p. 105). The lower, plodding, labouring classes are spared these agonies. It was comforting for those living a cosseted life to be told by their medical advisors that their ailments were not due to character or spiritual weaknesses but to real physical causes (see Porter, 2001).

Yet the old understanding of what it is to be a human being refused to go quietly. It may be that the age-old language of 'animal spirit' was becoming as metaphorical as the late-medieval cell theory, but the concept still pervaded popular culture. People felt differently about themselves in the eighteenth century than we do today in our computer-obsessed time. As John Sutton remarks, the language of spirit spills easily across the divide 'from fibres and pores to passions and feelings and conscious and unconscious motivations' (Sutton, 1998).

Electricity

Animal spirit refused to go quietly largely because there was, at the beginning of the long eighteenth century, no obvious successor and clearly *some* influence passed along the nerves, to and from the brain. However by the mid-eighteenth century, there was at last a contender which began to grow in popularity: electricity. The study of electricity had, of course, been set on its modern course by the publication of William Gilbert's *De Magnete* in 1600, but it only became a popular subject in the mid-eighteenth century. In the 1730s, Stephen Gray in England and Charles du Chisternay Dufay in France initiated what became an electrical 'craze'. A little later, both Gray and the Abbé Jean-Antoine Nollet devised a series of public shows in which they astounded audiences by electrifying boys and girls. Indeed this developed into a piece of theatre in both countries. According to Joseph Priestley the Abbé Nollet remarked that he would 'never forget the surprise when the first electrical spark was drawn from a human body' (Priestley, 1775, p. 47), and electrified young women provided more than the usual excitement to the young men who ventured to embrace them (see Bertucci, this volume).

But what was this mysterious new 'vertu'? In his great work on the *History and Present State of Electricity*, Priestley asks again and again whether it is identical to Sir Isaac Newton's aether (Priestley, 1775, especially pp. 448–450). Notions of 'subtle fluids' or aethers were, of course, common in the eighteenth century. Could the electrical fluid have medical applications? In the 1740s

Kratzenstein and others suggested that this might well be the case and soon many physicians and would-be physicians were trying their hand at 'the electrical cure' (see Bertucci, this volume). The study of electricity in the mid-eighteenth century hovered between science, quackery and entertainment. As Paola Bertucci remarks, it played to that taste for the marvellous and the inexplicable, which is so much a part of human nature and which pervaded the eighteenth-century learned world. No one yet understood this mysterious and powerful influence.

It was in this environment of intellectual uncertainty that Franz Mesmer (1734–1815) popularised the idea of animal magnetism (see Bloch, 1980). Mesmer had qualified in medicine in 1766 with a dissertation on the influence of the heavenly bodies on human health. Just as the planets were held in their courses by the mysterious force known as 'gravity', so he believed that human bodies were affected by another mysterious force-carrying aether, 'animal gravity'. This idea of an all-pervasive 'subtle fluid' recurred in his later work when, after being introduced to a new type of treatment using magnets by a Jesuit priest, Father Maximillian Hell, he replaced 'animal gravity' with 'animal magnetism' (see Lanska & Lanska, this volume).

In essence, he believed that good health depended on the free flow of the processes of life through the body's innumerable channels. He agreed with George Cheyne in regarding the human body as 'a Machine of an infinite Number and Variety of different Channels and Pipes, filled with various and different Liquors and Fluids, perpetually running, glideing (sic) or creeping forward, or returning backward, in a constant circle' (Cheyne, 1733, p. 4). When these channels were blocked, illness ensued. In 1774 Mesmer successfully treated a patient by getting her to swallow a solution containing iron and then attaching magnets to various parts of her body. Later he dispensed with iron and magnets and cures were alleged to be effected by direct control of the mysterious magnetic 'fluid'. The physician's task was to act as a conduit for this all-pervading magnetic aether and channel it out of the patient's body, rather like that other popular practice, 'blood-letting', so that a healthy equilibrium could be achieved. Mesmer believed that he was able to control the flows of the magnetic aether in a patient's body by staring fixedly into his or her eyes and making certain passes with his hands until a 'magnetic crisis' was experienced, analogous to an electric shock, after which recovery would ensue. He also developed a device, the *baquet*, for concentrating the magnetic fluid which he regarded as analogous to the Leyden jar. Anton Mesmer epitomises the confusion which reigned during the latter part of the eighteenth century concerning the phenomena of magnetism and electricity. It was, as Priestley remarked, 'a field just opened . . . (where) there is great room to make new discoveries' (1775, preface x). Mesmer's belief that he had made one of these discoveries and was able to control the new 'fluid' proved as groundless as many of the other 'discoveries' of the time. He was unable to convince his fellow physicians in his native Vienna and, when he transferred to Paris, his practice was investigated by a commission set up by Louis XVI in 1784 which included Lavoisier, Guillotin and the American ambassador, Benjamin Franklin, and was shown to be without foundation (see Finger, this volume; for more detail on Mesmer see Lanska & Lanska, this volume).

Very different from the unfounded speculations of Mesmer were the sober researches of experimentalists interested in the electricity generated by electric fish such as *Gymnotus* and *Torpedo*. These investigations made considerable headway in the eighteenth century and in the next century led both to the science of neurophysiology and via the electric or voltaic 'pile' to the physics of electricity itself. Indeed when Volta, at the end of the century, constructed the first 'electric (voltaic) pile', he modelled it closely, on J. W. Nicholson's *artificial torpedo* which, in turn, had been modelled on Hunter's dissection of the *Torpedo*'s electric organ (Pancaldi, 1990). Indeed, in his letter to the Royal Society announcing his discovery he called it an 'artificial electric organ' and hoped to improve it by adjusting its structure more closely to that of the organ found in *Torpedo* (Volta, 1800). These researches are discussed in detail by Piccolino in this volume so it is unnecessary to expand on them here.

Finally, at the very end of the century, in the 1790s, Galvani and others published the results of their famous frog experiments (see Focaccia & Simili, this volume; Piccolino, 2006;). Richard Fowler, a pupil of Monro Secundus, repeated Galvani's experiments (as had Monro) and concluded that the effect was caused