

“More Subtle than the Electric Aura”: Georgian Medical Electricity, the Spirit of Animation and the Development of Erasmus Darwin’s Psychophysiology

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I

This paper examines the importance of medical electricity in Georgian England, the contexts and rationale for the use of electrical treatments, and the relationship between medical electricity and natural philosophy. It focuses upon the application of medical electricity by the physician and natural philosopher Erasmus Darwin, and the role of electricity in his philosophy and psychophysiology. The electrician Tiberius Cavallo complained that electrical therapy was not as effective as it might have been because medical practitioners who employed it had insufficient knowledge of natural philosophy, whilst natural philosophers who used it had insufficient experience of medicine. Darwin’s employment of electrical treatments is recorded in his commonplace book, correspondence and other documents, whilst in the *Zoonomia* he tried to discern the philosophical principles of medicine modelled upon the Linnaean and Newtonian systems. Furthermore, as Paola Bertucci has shown in a stimulating thesis on medical electricity, Cavallo obtained much of his medical knowledge from close medical friends such as the physician James Lind and the surgeon Miles Partington. Darwin, however, was a leading medical practitioner, natural philosopher and electrical experimenter, who was elected fellow of the Royal Society partly for his meteorological electrical work during the 1750s. Furthermore, he was a close friend of three of the most important electricians in Georgian England, Benjamin Franklin, Joseph Priestley and Abraham Bennet, and played a considerable role in encouraging the philosophical researches of the two latter philosophers. Darwin promoted natural philosophy through his publications and membership of scientific associations such as the Lunar Society and the Derby Philosophical Society and was celebrated by Coleridge as “the first literary character in Europe” with a “greater range of knowledge than any other”.¹

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¹E Darwin, ‘Remarks on the opinion of Henry Eeles, Esq., concerning the ascent of vapour’, *Philos. Trans.*, 1757, **50**: 240–54; R Porter, ‘Erasmus Darwin: doctor of evolution?’, in J R Moore (ed.), *History, humanity and evolution: essays for John C. Greene*, Cambridge University Press, 1989, pp. 39–69; P Elliott, ‘Abraham

Although medical electricity was not universally welcomed in Georgian society and encountered some suspicion, the paper argues that Darwin and other medical practitioners were prepared to recommend and employ it experimentally for a variety of conditions, especially where more conventional treatments had failed. The apparent efficacy of medical electricity helped to sustain the vision of Darwin, and friends such as Priestley and Thomas Beddoes, that natural philosophy had the potential to improve society by increasing the comfort and happiness of humanity. As the commonplace book, correspondence and *Zoonomia* reveal, Darwin favoured electrical therapy for certain conditions, encouraged by his experience and enthusiasm for electricity, and friendship with prominent electricians. Extensive experience of medical practice, together with his own researches in natural philosophy, persuaded Darwin to try using the concept of the spirit of animation to bridge the divide between mentalism and physicality. However, although Darwin moved away from regarding the vital spirit as synonymous with or closely analogous to electricity, his psychophysiology excited philosophical and political attacks from politically hostile opponents, contributing towards a greater division between medical electricity and natural philosophy. Instead of transforming medicine and physiology, electricity and galvanism were not universally welcomed in the political climate of the early nineteenth century.²

After examining Darwin's medical career and role in British provincial philosophical culture, the paper contends that one of the most important aspects of this was the enlightenment progressivism espoused by Darwin and his associates, which saw the advance of natural philosophy as the engine of social and political advancement. The next section explores the origins and uses of medical electricity from the middle of the eighteenth century in different contexts, including hospitals and private practice, and how it was inspired by developments in natural philosophy such as meteorological electricity. The fourth section examines Darwin's use of electricity in medical practice arguing that it developed from a combination of empirical practice, philosophical experimentation and theorizing. It shows that he applied it in specific circumstances, whilst this practice informed his natural philosophy, psychophysiology and medical theory. This was because Darwin regarded the kinship of the vital force or spirit of animation, with other ethereal fluids, as providing a basis for electrical and occasionally magnetic intervention in conditions such as nervous disorders. The fifth section broadens the analysis to focus upon the political consequences of the association between enlightenment progressivism and science in provincial philosophical culture, manifest in the hostility aroused by Darwin's electrical, galvanic and physiological ideas. His attempts to retreat and disguise vitalist consequences failed to prevent conservative and loyalist attacks, and medical, galvanic,

Bennet, F.R.S. (1749–1799): a provincial electrician in eighteenth-century England', *Notes Rec. R. Soc. Lond.*, 1999, 53: 59–78; C U M Smith and R Amott (eds), *The genius of Erasmus Darwin*, Aldershot, Ashgate, 2004; P Bertucci, 'Sparks of life: medical electricity and natural philosophy in England, c.1746–1792', DPhil thesis, University of Oxford, 2001, pp. 172–211; D King-Hele, *Erasmus Darwin: a life of unequalled achievement*, London, Giles de la Mare, 1999, quotation p. 302.

²E Darwin, *The botanic garden*, 2nd ed., 2 vols., London, J Johnson, 1789–1791; *idem*, *Zoonomia; or, The laws of organic life*, 2nd ed., 2 vols, London, J Johnson, 1794–1796; *idem*, *Phytologia: or The philosophy of agriculture and gardening*, London, J Johnson, 1800; *idem*, *The temple of nature: or The origin of society*, London, T Bensley for J Johnson, 1803.

electrical and physiological research attracted considerable suspicion and hostility as natural philosophers withdrew from these fields, which were largely left to medical men.

II

Darwin received his medical education at Cambridge and Edinburgh universities during the 1750s and began practice at Nottingham in 1756. Although this proved unsuccessful, he moved to Lichfield and later Derby, quickly building up a reputation and income as a physician with clients across the Midlands.³ Darwin was, however, much more than a prominent physician, although his status as an intellectual was encouraged by professional medical experience and a taste for natural philosophy acquired at home and at Edinburgh. Lunar Society membership provided the opportunity for intensive intellectual discussion and banter with Matthew Boulton, James Watt, Priestley, William Withering, William Small, Richard Edgeworth and other philosophers. The Lunar Society and other intellectual associations such as those in Manchester and Derby were important centres for British enlightenment culture where freemasons, natural philosophers, antiquarians, manufacturers and others banded together in usually convivial sociability. Darwin was largely responsible for founding the Derby Philosophical Society in 1783, usually regarded as a relatively poor substitute for the Lunar Society, although it included Robert Bage, Brooke Boothby, Thomas Gisborne and William Strutt. The society accumulated a philosophical library, books being circulated among members, and provided a forum for medical men in the region including John Storer, Snowden White, Thomas Arnold and Robert Darwin.⁴

Although he had been sending papers to the *Philosophical Transactions* since the 1750s, stimulated by his philosophical networks and secure in his unrivalled professional position at Derby during the 1780s and 1790s, Darwin felt able to develop and publish long-nascent ideas. His translations of Linnaeus' *Systema vegetabilium* and *Genera plantarum* were published under the auspices of the Lichfield Botanical Society but the work that established his reputation was *The botanic garden*, an epic poem in two volumes. The first of these was *The loves of the plants* (1789), a popular and mildly erotic exposition of his work on the Linnaean system, and the second, *The economy of vegetation* (1791), a general philosophical survey with notes on many subjects from steam engines to geology and astronomy. The *Zoonomia* (1794 and 1796) utilized practical medical experience to formulate a nosology modelled on the Linnaean system and informed by associational psychophysiology. *Phytologia* (1800) presented a philosophy of agriculture and gardening, whilst *The temple of nature* (1803) was another epic poem on the origins of life and society with extensive philosophical notes.

³King-Hele, op. cit., note 1 above; D King-Hele (ed.), *The collected letters of Erasmus Darwin*, Cambridge University Press, 2007.

⁴King-Hele, op. cit., note 1 above, pp. 196–9; R Schofield, *Lunar Society of Birmingham*, Oxford, Clarendon Press, 1963; A E Musson and E Robinson, *Science and technology in the industrial revolution*, Manchester University Press, 1969; P Sturges, 'The membership of the Derby Philosophical Society, 1783–1802', *Midland Hist.*, 1978, 48: 212–29;

P Elliott, 'Science, medicine and industrial technology in the English provinces in the early nineteenth century: the Derby philosophers and the Derbyshire General Infirmary', *Med. Hist.*, 2002, 46: 65–92; P Elliott, 'The Derbyshire "Darwinians": the persistence of Erasmus Darwin's influence on a British provincial literary and scientific community, c.1780–1850', in Smith and Arnott (eds), op. cit., note 1 above, pp. 179–92; J Uglow, *The Lunar men*, London, Faber and Faber, 2003.

In the *Zoonomia*, *Phytologia* and *Temple of nature*, Darwin advanced a broad biological, geological and cosmological developmental theory drawing upon his medical practice and natural philosophy, and emphasizing the degree to which life entered into dialectical interplay with its environment. Darwin asserted that life was governed by the spirit of animation, an ethereal force of energy acting through the nerves on the muscles—which had some characteristics similar to electricity—and his system was attacked for mechanical reductionism, infidelity, and the interpolation of unnecessary principles. Ironically, however, the concept served a crucial psychophysiological heuristic purpose underpinning his developmentalism and emphasis upon life as responsive, tenacious and much more than mere laws of motion, animal chemistry or hydraulics.

III

Electricity was the fashionable wonder of mid-Georgian England and perceived as a major discovery in European philosophy. With the development of static electrical generating machines, Leyden jars and other instruments, electrical explanations were proffered for multifarious natural phenomena—meteorological, geological, biological, physiological and astronomical. The demonstration that lightning and artificial electricity were synonymous, together with the invention of the lightning conductor were taken to symbolize the achievements of European enlightenment science. Some electrical experiments were relatively cheap and simple to execute and, as promoters such as Darwin's friend Joseph Priestley emphasized, could be done with basic household apparatus, although the cost of electrical machines varied. The Leyden jar, for instance, consisted of a glass jar coated inside and out with metal foil with a connection between the inner coating and a conducting rod passed through a stopper in the top, and was not therefore difficult to construct. The subtle and powerful qualities commonly observed of electricity, regarded as either fire or ethereal fluid, encouraged philosophers to advance a range of theological arguments, and stimulated enquiries into meteorological and atmospheric electricity. As Priestley explained, electrical experiments were “of all others the cleanest, and the most elegant, that the compass of philosophy exhibits”. They could be “performed with the least trouble”, there was “an amazing variety in them”, and they furnished “the most pleasing and surprising apparatus for the entertainment of one's friends”.⁵

Electrical experiments and demonstrations often involved the electrification of individuals and it is likely that this or accidental shocks received by electrical experimenters

⁵J Priestley, *History and present state of electricity*, 1st ed., London, printed for J Dodsley, J Johnson, B Davenport, and T Cadell, 1767, p. x (2nd ed., 2 vols, London, 1777); P F Mottelay, *Bibliographical history of electricity and magnetism*, London, Griffith, 1922; S Schaffer, ‘Natural philosophy and public spectacle in the eighteenth century’, *Hist. Sci.*, 1983, 21: 1–43; *idem*, ‘The consuming flame: electrical showmen and Tory mystics in the world of goods’, in J Brewer and R Porter (eds), *Consumption and the world of goods in the eighteenth century*, London, Routledge, 1993, pp. 489–526; P Fara, *Sympathetic attractions:*

magnetic practices, beliefs and symbolism in eighteenth-century England, Princeton University Press, 1996; *idem*, *An entertainment for angels: electricity in the Enlightenment*, Cambridge, Icon Books, 2002; J Heilbron, *Electricity in the 17th and 18th centuries*, 2nd ed., New York, Dover Publications, 1999; Bertucci, op. cit., note 1 above, pp. 12–94; M B Schiffer, *Draw the lightning down: Benjamin Franklin and electrical technology in the age of Enlightenment*, Berkeley, University of California Press, 2003; G Pancaldi, *Volta: science and culture in the age of Enlightenment*, Princeton University Press, 2003.

provided the first evidence that electricity might be useful in medicine. The apparent pervasive power of electrical matter in nature suggested to electricians such as George Adams and William Henly that it was one of the primary powers in the divine economy responsible for phenomena as diverse as earthquakes, fireballs, precipitation and vegetation. Furthermore, the fact that electricity might, as Henly put it, be regarded as “a pure, ethereal, elementary fire, inherent in all bodies, intimately connected or blended with an earthy or other base” suggested that it could be synonymous with the vital spirit mediating between matter and God.⁶ Practitioners of electrical medicine were therefore utilizing an elemental natural force. Priestley and other electricians electrocuted cats, mice, birds, sheep and even larger animals such as cows to observe the effects of electricity which were obviously powerful, whether or not they were beneficial.

Medical electricity became popular in France and was advocated in Britain by instrument makers, electricians, natural philosophers and scientific lecturers such as Richard Lovett, Adams, Franklin, James Ferguson, John Wesley and Cavallo.⁷ Electrical treatments were also promoted in magazines, journals, and textbooks, enabling practitioners to marshal an apparently authoritative and overwhelming body of evidence to support their activities. Priestley, Adams, Cavallo and other electricians emphasized that electrical technological improvements facilitated advances in instrument design increasing portability and precise regulation of charges. Timothy Lane's modified electrical machine and jar, for instance, used a dial intended to regulate the quantity of force (see Figure 1). However, it was recognized that this and other methods, such as specifying jar size, were still inexact, and acted as much to reassure patients as to improve treatment. As a natural philosopher rather than a medical practitioner, Cavallo presented medical electricity as advancing closely with natural philosophy through improved instrumentation and other means. Assisted by medical friends such as the physician James Lind and the surgeon Miles Partington, he promoted a series of improved techniques and instruments, especially those intended for delicate operations on sensitive parts of the body. Cavallo detailed a series of experiments intended to demonstrate how electricity induced perspiration, promoted evaporation and passed through bodily fluids, whilst accepting the fear of shocks in this. He concluded that electricity increased the pulsation, whether negative or positive, especially in the sick, was “beneficial in various diseases” producing little ill effects, most effective in diseases “arising from obstructions and nervous affections”, and more effective and less harmful in moderate applications.⁸

⁶G Adams, *An essay on electricity*, London, 1784, pp. 259–65; W Henly, ‘Experiments and observations in electricity’, *Philos. Trans.*, 1777, **67**: 85–143, pp. 130–1, 134–5, quotation p. 130.

⁷B Franklin, ‘An account of the effects of electricity in paralytic cases’, *Philos. Trans.*, 1758, **50**: 481–3; J Wesley, *The desideratum: or, Electricity made plain and useful*, 4th ed., London, printed by R Hawes, 1778; J Ferguson, *An introduction to electricity in six sections*, London, W Strahan and T Cadell, 1770, pp. 115–31; Adams, op. cit., note 6 above, pp. 258–81; T Cavallo, *Essay on the theory and practice of medical electricity*, 2nd ed., London,

1781; S Licht, ‘History of electrotherapy’, in S Licht (ed.), *Therapeutic electricity and ultraviolet radiation*, New Haven, E Licht, 1967, pp. 1–70; M Rowbottom and C Susskind, *Electricity and medicine: history of their interaction*, San Francisco, San Francisco Press, 1984; Heilbron, op. cit., note 5 above, p. 495; Bertucci, op. cit., note 1; Schiffer, op. cit., note 5 above, pp. 107–60; S Finger, *Doctor Franklin's Medicine*, Philadelphia, University of Pennsylvania Press, 2006, pp. 92–114.

⁸Cavallo, op. cit., note 7 above, pp. 15–16, 105–24.

Electrical Machines See System of Electricity.

Plate 1

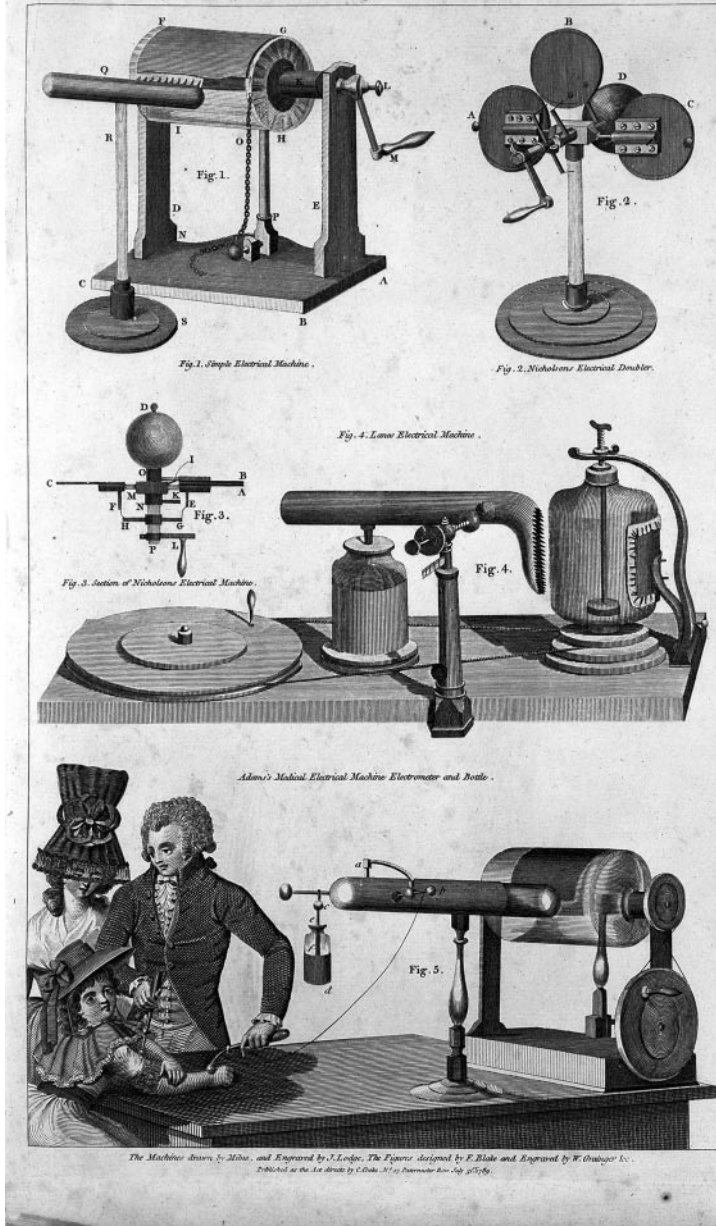


Figure 1: From the top, left to right: Simple electrical machine; William Nicholson's electrical doubler, 1789; Timothy Lane's electrical machine; and George Adam's medical electrical machine, From *The new royal encyclopaedia*, 2nd ed., London, C Cooke, c.1795. (Wellcome Library, London.)

Electricity was used by all kinds of medical practitioners, including physicians, surgeons and apothecaries, who adopted strategies to differentiate themselves from other healers.⁹ Many were educated and, if physicians, usually relatively wealthy individuals who had influence because of their status as members of the gentry. Many were also dissenters educated in Scottish or Dutch universities and well informed in contemporary natural philosophy, including the popularity of electrical treatments on the continent. Medical men such as Darwin, Lind, William Hey and John Birch provided an important impetus for the adoption of medical electricity as supporters of scientific culture in general and by advocating electrical treatments. Medical institutions also often played a role in the development of British scientific culture and the adoption of medical electricity. As well as offering employment and providing status for medical men through involvement in public charities, they were also centres for practical experimentation with novel therapies. Electrical treatments were offered in some hospitals such as St Thomas's in London, thereby providing a demand for the development of easily storable, transferable and quantifiable sources of electricity.¹⁰

Some medicine practitioners remained suspicious of medical electricity, and John Wesley argued that one of the reasons why he had to promote electrical cures was suspicion and hostility from the faculty. For Wesley, medical electricity had the potential to offer relatively inexpensive cures to poor individuals who could not afford the services of physicians. Like other aspects of natural philosophy and history, it also offered the prospect of inspiring reverence for divine power. There were parallels with his attempted reforms of the Anglican Church, also dominated by a hierarchy of professionals and criticized for clerical pluralism and remoteness. These works and the advocacy of established physicians conferred a degree of respectability upon electrical medicine, with many individuals following Wesley's advice and seeking aid from apothecaries, surgeons or physicians, or administering electricity themselves.¹¹

Some healers, such as James Graham and the Prussian lecturer and showman Gustavus Katterfelto, gained considerable fame and notoriety through their exploitation and promotion of electrical medicine. Enterprises such as Graham's temple of health with its elaborate theatrical furnishings, display of electrical apparatus and famous "celestial bed" promising sexual virility, encouraged scepticism despite the fact that Graham had obtained a medical education at Edinburgh University. Adams remarked that although medical electricity as the "offspring of philosophy" deserved a "distinguished rank in medicine", it had "met with much opposition from the interested views of some, and the ignorance of others", been "treated with contempt", and "injured by misplaced caution". After having been prescribed electrotherapy for a sprained ankle in 1790, Major Hayman Rooke, the Nottinghamshire antiquary, was informed by his friend the Rev. Samuel Pegge that "both Mrs Pegge and I think electricity a strange application, and yet not more strange than a dish

⁹ Bertucci, op. cit., note 1 above, pp. 212–49; Geoffrey Sutton, 'Electric medicine and mesmerism', *Isis*, 1981, 72: 375–92; Schiffer, op. cit., note 5 above.

¹⁰ W Hey, 'An account of the effects of electricity in the amaurosis, by Mr. Hey, surgeon at Leeds, communicated by Dr. Hunter, FRS', *Medical Observations and Inquiries*, London, 1776, 5: 1–31; J Birch, 'A letter to Mr. George Adams', in G

Adams, *Essay on electricity*, 4th ed., London, 1792, pp. 519–73.

¹¹ Wesley, op. cit., note 7 above; Bertucci, op. cit., note 1 above, pp. 154–68; P Bertucci, 'Revealing sparks: John Wesley and the religious utility of electrical healing', *Br. J. Hist. Sci.*, 2006, 39: 341–62.

of strong coffee for the asthma prescribed by Dr Percival of Manchester". Despite Hey's success in alleviating blindness with electricity at Leeds, a collier from a village two miles distant who received such treatment was told by local "folk" that "electrifying would do him no good", so he went to an old wise woman "famous for curing eyes". Contemporaries were aware that it was not easy to distinguish between so-called quacks and "legitimate" or qualified medical practitioners, especially when electrical cures were provided by both. Even Graham complained that there had been many "ignorant and improper" applications of medical electricity in the "hands of ignorant and rash people" such as barbers, surgeons, tooth-drawers, apothecaries, or common mechanics" with electrical operators sprouting "in almost every street in this great metropolis".¹²

IV

Darwin used electricity for the treatment of a variety of problems, some of which are recorded in his commonplace book, and recommended it for various conditions in the *Zoonomia*, which was dedicated to the members of the Royal College of Physicians. The classification of diseases and treatments enunciated in the *Zoonomia* was supposed to follow the principles of Darwin's psychophysiological system. According to this, the "efficient causes of motion" or new configuration were divided into the categories of general gravitation, particular gravitation, chemical affinity and "the principle of organic life" represented by the contraction of animal fibres. Electricity was considered a principle of particular gravitation rather than part of the life principle. The sensorium was defined as "not only the medullary part of the brain, spinal marrow, nerves, organs of sense, and of the muscles" but also simultaneously as the "living principle, or spirit of animation, which resides throughout the body, without being cognizable to our senses, except by its effects".¹³ External bodies could stimulate the animal fibres and this stimulus produced irritation, which was the exertion of the spirit of animation. Darwin defined the four faculties or motions of the sensorium driven by the spirit of animation as "four different modes of action", which were "occasionally exerted" and caused all "contractions of the fibrous parts". These were the faculty of causing fibrous contractions through "irritations excited by external bodies", from "sensations of pleasure or pain", by the action of volition and "in consequence of the associations of fibrous contractions with other fibrous contractions, which precede or accompany them".¹⁴

Drawing upon his medical experience and understanding, Darwin defined electricity with heat and magnetism as an ethereal fluid and principle of particular gravitation, which was useful for the treatment of a variety of illnesses.¹⁵ He regarded it as a form of

¹²Hey, *op. cit.*, note 10 above, pp. 19–23; Adams, *op. cit.*, note 6 above, pp. 258–9; J Graham, *A sketch or short description of Dr. Graham's medical apparatus*, London, 1780, cited by Bertucci, *op. cit.*, note 1 above, p. 188; J Graham, *The guardian goddess of health*, London, [1780?]; R Porter, 'The sexual politics of James Graham', *Br. J. 18th-Cent. Stud.*, 1982, 5: 199–206; *idem*, 'Sex and the singular man: the seminal ideas of James Graham', *Stud. Voltaire 18th Cent.*, 1984, 228: 1–24; B B Schnorrenberg, 'A true

relation of the life and career of James Graham, 1745–1794', *Eighteenth-Century Life*, 1991, 15: 58–75; Bertucci, *op. cit.*, note 1 above, pp. 184–91, quotation, p. 188. I am indebted to Emily Tarlton of the School of Geography, Nottingham, for drawing my attention to the Pegge quotation.

¹³Darwin, *Zoonomia*, *op. cit.*, note 2 above, vol. 1, pp. 534, p. 10.

¹⁴*Ibid.*, vol. 1, p. 32.

¹⁵*Ibid.*, vol. 1, p. 534.

“incitantia”, which increased “the exertions of all the irritative motions” and included alcohol, opium and many drugs, but also the “exhilarating passions” of joy and love, and the external applications of heat, ether, essential oils, fraction and exercise. These promoted both “secretions and absorptions” thus increasing natural heat, and removed nervous pains derived from “the defect of irritative motions” whilst preventing “the convulsions consequent to them”. It was also a form of “sorbentia”, which increased the irritative motions that constituted absorption and the amount of “venous absorption” promoted by other external stimulants such as vinegar and perhaps oxygen.¹⁶

As such, Darwin recommended that electricity could be used to treat a variety of diseases defined according to his scheme of irritation, sensation and volition. In the case of the former, this included “*hydrocephalus internus*” or “dropsy of the ventricles of the brain”, which was normally treated with blisters on the head, mercurial ointment and calomel, all of which, however, “generally fail of success”. He therefore recommended “frequent, almost hourly” electric shocks from “very small charges” to be “passed through the head in all directions”.¹⁷ Another disease of irritation susceptible to electrical treatment was the tapeworm, which Darwin regarded as a “chain of animals” that could be several feet long “extending from the stomach to the anus”, and which frequently existed in other animals. Tapeworms possessed a “wonderful power of retaining life” and continued to survive unimpaired when immersed in boiling water, gin and whiskey—“of the strongest kind”. Around 1786, Darwin treated Bateman, a maltster of Lichfield, for the tapeworm with an amalgam of tin and quicksilver, large doses of powdered tin and iron filings, and a “brisk cathartic of Glauber’s salts two ounces” with “common salts one ounce” dissolved in large amounts of water. The amalgam was supposed to purge the worm by tearing it “from the intestine by mechanical pressure”, but, it did not work very well and Bateman claimed still to feel it in great motion crawling and biting. Darwin then administered twenty smart electric shocks from a quart Leyden bottle through the left side of the stomach region, where Bateman felt the worm, to his back. Then the “worm was felt to move no longer”, although a sensation continued, and Bateman took more of the water until it purged him frequently in the night and the worm eventually came away. Darwin was not completely sure whether it was the electricity alone that killed the worm or the combination of treatments, but maintained in the *Zoonomia* that “electric shocks through the duodenum greatly assists the operation”.¹⁸

Darwin considered that jaundice resulted from various kinds of obstruction of the bile duct which prevented the passage of bile into the duodenum. This could be caused by gall stone, “spissitude of the bile” and various kinds of inflammation or compression from enlargement of the liver. He treated one patient, Mr Saville, a middle-aged man who had “laboured six weeks with the jaundice” but had “no pain nor sickness nor fever”, with emetics, cathartics, mercurials, chalybeates, essential oil, and ether in vain before trying electricity. On the supposition that the obstruction of the bile might be the result of the paralysis or torpid action of the common bile-duct and given that the stimulants taken into the stomach apparently had no effect, Darwin administered half a dozen “pretty violent”

¹⁶ *Ibid.*, vol. 2, pp. 678, 710.

¹⁷ *Ibid.*, vol. 2, pp. 104–5.

¹⁸ E Darwin, Commonplace book, original at Down House Museum, Kent, microfilm copy, Derby

Local Studies Library, Derby, pp. 97, 147; Darwin, *Zoonomia*, op. cit., note 2 above, vol. 2, pp. 54–5; A Duncan (ed.), *Medical commentaries*, Edinburgh, 1791, vol. 6, pp. 369–71.

electric shocks rapidly through the body. These were “from a coated bottle, which held about a quart” and “passed through the liver, and along the common course of the gall-duct” whence they were taken out of the body. The electric shocks were continued, Mr Saville’s stools became yellow and “he began to mend the next day”, with his skin becoming clear a few days later, and Darwin recommended electricity in the *Zoonomia* as one form of treatment for both gall stones and jaundice.¹⁹

Darwin sometimes used electricity to relieve pain and swelling caused by other conditions. In 1778 he treated Mrs Stubbs from near Stone in Staffordshire for a sore throat and difficulty swallowing, which had become so severe that she could “now only swallow a teaspoonful at a time and crumbs of bread”. She felt raw from pains “about the middle of her throat” and some swelling, whilst she also had “the greatest number of rotten teeth in the highest degree of decay that I ever saw on one mouth”. Darwin complained that all the “common ways of treatment” for these conditions, such as taking mercury, had the unfortunate effect of killing the patients. He suspected that “the putrid matter from these teeth” mixed with saliva had “long kept the throat inflamed like venereal matter in the urethra” and it had become “contracted as the urethra frequently is”, or skin that had been “burnt half through as not to be quite destroy’d”. He drew all the teeth and applied ten or twenty electric shocks “from a pint or quart phial . . . pass’d through the same part twice a day for a month”. The treatment appears to have been partially successful, as three weeks later he heard by letter that her throat was much better, although after the fourth week it was more sore but “the little swelling of it a little above the sternum was less”.²⁰

Diseases of sensation for which electricity was appropriate included the “debility of the inferior limbs” from muscular torpor experienced in the later stages of sciatica.²¹ Where “excessive fibrous action” and pain was caused by “excess of volition”, then the muscles were liable to become fixed or suffer painful contractions in the calf of the leg or in the jaw. For this, in addition to opium, electricity was “worth trial” by passing “strong shocks through the painful part” which, whether the pain was due to inaction in that or associated membranes, “might stimulate them into exertion”.²² Similarly, “repeated and strong shocks” of electricity were useful for serious cramp, general paralysis or paralysis induced by common hemiplegia, where it had a similar effect as exposing the limb to snow or iced water and then repeatedly to warm flannels, which restored “voluntary excitability” by “accumulation of sensorial power”.²³ In 1779 and 1780, Darwin treated Mary Anne, one of Josiah and Sarah Wedgwood’s daughters, for paralysis and convulsions using electricity, providing instructions as to how his large electric jars could be adapted to deliver smaller charges by being filled with brass shavings. His friend John Whitehurst reported the treatment of a man who had suffered paralysis in an arm through repeatedly stirring the slush of calcined lead in water with his bare hand. According to Whitehurst, more than twenty or thirty shocks were sent through the man’s hand and these helped him to recover movement.²⁴

¹⁹ Darwin, op. cit., note 18 above, p. 27; Darwin, *Zoonomia*, op. cit. note 2 above, vol. 1, pp. 348–52, vol. 2, pp. 40, 138–9.

²⁰ Darwin, op. cit., note 18 above, p. 85; Cavallo, op. cit., note 7 above, pp. 41, 125.

²¹ Darwin, *Zoonomia*, op. cit., note 2 above, vol. 2, pp. 207–8.

²² *Ibid.*, pp. 334–5.

²³ Darwin, *Zoonomia*, op. cit., note 2 above, vol. 1, pp. 38–9; vol. 2, pp. 345–6, 390–1; see also, Cavallo, op. cit., note 7 above, pp. 46–7, 51–2, 125.

²⁴ King-Hele (ed.), op. cit. note 3 above, pp. 170–1, 174–5; J Whitehurst, ‘An account of a cure by electricity’, letter to Sir John Pringle

Darwin's interest in medical and atmospheric electricity provided an important stimulus for the development of electrical apparatus, and for the use of novel instruments in treatment. He devised a type of electrical doubler for augmenting charge, which was illustrated and described in the commonplace book, quickly adopted the Voltaic pile for electrochemical and medical experiments, and provided considerable encouragement and support to Bennet in his designs for new electrical apparatus. Darwin's original device consisted of a chargeable central disc of glass with a metal sheet embedded in it surrounded by two outer moveable brass discs which could be made to approach or recede from the central plate (see Figure 2). As the outer plates approached the central one, charges were induced on them which passed to a Leyden jar via the conductor. On withdrawal they were earthed for re-usage.²⁵ With the experience gained by inventing this instrument and with medical and atmospheric electricity, Darwin was able to assist Bennet in his work designing instruments that could detect and measure meteorological electricity.²⁶

Although by 1800 Darwin was retiring from medical practice, he rapidly took advantage of the opportunities that the pile offered for supplying a convenient, portable, continuous and regulated flow of electricity by recommending and utilizing it as a form of treatment. He used it to relieve toothache, claiming it could give 100 powerful shocks a minute, and that one patient, "a lady from near Scarborough . . . used it daily for giddiness with good success".²⁷ Likewise, Darwin recommended the pile for the treatment of Georgiana, Duchess of Devonshire, the famous and beautiful queen of fashionable Whig society. By 1800, however, she was in terrible agony from an infection that had swollen one of her eyes to grotesque proportions and destroyed her sight on one side whilst reducing the vision in her other eye to a blurred state. The problem had probably been exacerbated by the treatments she had been prescribed, and she was desperately hoping that a new treatment could be found to restore some dignity and comfort to her life.²⁸ In 1788, Darwin recommended to Josiah Wedgwood that he have sparks drawn from his closed eyelids for five or ten minutes every morning for a fortnight or more. Similarly, he claimed that Millicent Pole's eye inflammation had been cured by sparks drawn from her closed eyes every morning for a week.²⁹ William Hey and some other practitioners claimed to have had considerable success treating blindness with electricity and it offered some hope for Georgiana, who had supposedly received relief from treatment by James Graham in the past. Hey described how, using an electrical machine, he performed the treatment twice a day on a woman suffering from complete *amaurosis* or *gutta serena* in each eye. The patient was seated upon a stool with glass feet and had "sparks drawn from the eyes and parts surrounding the orbits", particularly where the "superciliary and infraorbital branches of the fifth part of nerves spread themselves". The operation continued for half an hour and was repeated over the next few days until her sight began to return, with shocks sometimes directed across the head from one temple to the other and across the nerves as before.³⁰

(read 23 Dec. 1779), ms. *Journal book of the Royal Society*, vol. 29 (1777–1780), pp. 552–3, archives of the Royal Society, London.

²⁵ Darwin, op. cit., note 18 above, p. 79; King-Hele, op. cit., note 1 above, pp. 147–8.

²⁶ Sutton, op. cit., note 9 above; Elliott, op. cit., note 1 above.

²⁷ King-Hele (ed.), op. cit., note 3 above, p. 557.

²⁸ A Foreman, *Georgiana: Duchess of Devonshire*, London, HarperCollins, 1999, pp. 299–302.

²⁹ King-Hele, op. cit., note 3 above, pp. 299, 307.

³⁰ *Ibid.*, p. 71; Hey, op. cit., note 10 above, pp. 1–2, 3–4.

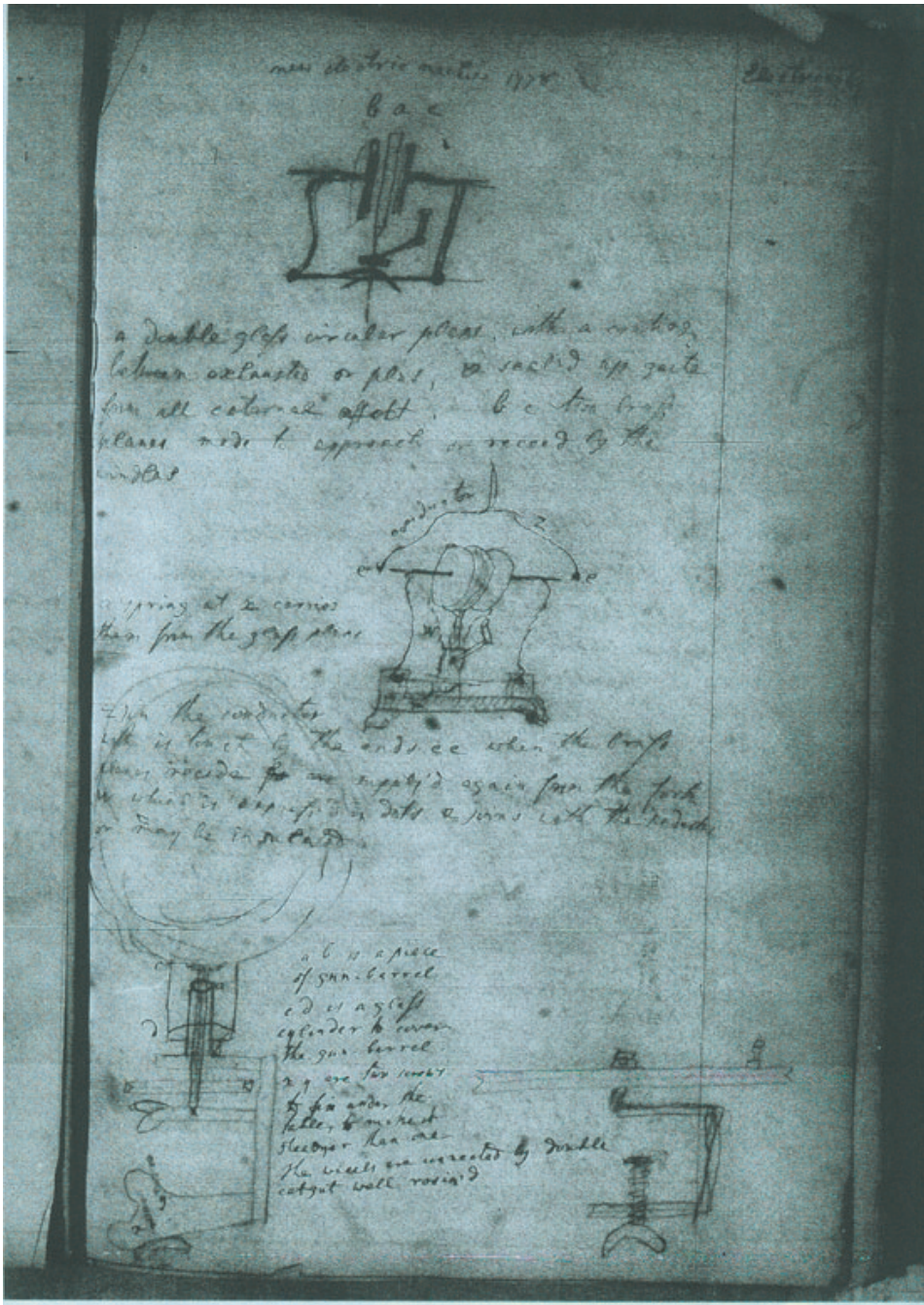


Figure 2: Drawing of an electrical machine dated 1778 from Darwin's Commonplace book. (Down House Museum, Kent.)

Georgiana had heard about the invention of the pile and approached Darwin, asking him to administer the treatment to another individual but also that it be performed on herself. She hoped to obtain a pile for her own continuous usage. Darwin offered to get some zinc plates, if the Duchess required, so that a pile could be constructed, and to send the “very ingenious philosopher” Thomas Swanwick, who would bring William Strutt’s galvanic pillar “consisting of larger pieces, as large as Crown-pieces, and shew your Grace its effects”.³¹ However, Swanwick was too busy at his schools, so Darwin proposed that the physician Henry Hadley should come with Strutt’s pillar, although he was “rather indisposed” that day. In a postscript, Darwin suggested that if Hadley came to Chatsworth another time, he would explain the theory of the pile that he had been elaborating with his friends Strutt and Swanwick to the Duchess. Unfortunately, as Darwin explained to the Duchess, she could not buy Strutt’s “Galvanic pillar” as it was unique, having been made by one of his workmen, and he could not, therefore, easily obtain the silver and zinc plates locally, although he thought that they could be had in London.³²

Georgiana was well known for her knowledge of natural philosophy; she built up a large collection of mineral specimens and Henry Cavendish, her husband’s second cousin, respected her knowledge and called upon her frequently.³³ She was keen to understand the science of the pile and Darwin explained why he considered medical electricity to be so effective and outlined the theory of the pile that later formed the basis of the detailed essay on electricity and galvanism in the *Temple of nature*. He explained that a hundred shocks could be administered from the pile which would make a “flash in the eyes” and be felt through both the temples “every time one of the wires is lift’d from the pillar, and replaced”.³⁴ Darwin contrasted his use of medical electricity with that of “pretended . . . empyrics” or quacks, whilst acknowledging that its efficacy was due as much to the psychological as to the physiological impact of the treatment. Electricity did not burn or destroy nerves but by “sudden smart of the skin and the terror of the patient” which cured minor toothache, or by stimulus from “so small a pain and fear” the “torpid membrane of the tooth” recovered its activity, and pain from “defect of action” ceased.³⁵

V

In addition to the psychological stimulus, Darwin considered that the improvement in nervous or paralytic conditions due to stimulation of the nerves by electric shocks demonstrated the close analogy between the vital force and other ethereal fluids. Paralytic conditions apparently caused by nervous constriction or want or abundance of nervous energy might be relieved through the application of other ethereal fluids which were, in effect, mimicking the vital fluid. As we shall see, this approach had major religious and political implications. If the vital spirit was similar to electrical, magnetic and other ethereal fluids, then it was as susceptible to philosophical study as they were, and could potentially be manipulated. This offered boundless prospects for

³¹ King-Hele (ed.), op. cit., note 3 above, p. 557.

³² Ibid., p. 559.

³³ Ibid., pp. 558.

³⁴ Ibid., pp. 556–7.

³⁵ Ibid., pp. 557.

medical and social progress and demonstrated the fundamental kinship between all living creatures, including plants.³⁶ It explains why, from the 1750s, Darwin was attracted to this approach and, according to his grandson, entertained the “wildest speculations on the resemblance between the action of the human soul and that of electricity” in correspondence with Albert Reimarus, son of the German philosopher Hermann Samuel Reimarus.³⁷ In this, Darwin was inspired by the Swiss physiologist Albrecht von Haller and the Dutch physician Hermann Boerhaave, who drew parallels between the operation of electricity and the conveyance of motion through the nerves; although by the 1750s, Haller had rejected the supposition that electricity was synonymous with the nervous fluid. In 1768, Darwin asked Richard Gifford if “the electric fluid” could make a paralytic arm move, why then could not “such-like fluid be used in the animal system, or by the soul?”³⁸ Support for the idea came from the work of William Hunter and others on the electricity of the *Gymnotus electricus* and Torpedo fish, which demonstrated that electrical strength could be varied at will by the animal, even though the tissues involved seemed to be conductors. The revival by electric shocks of hundreds of individuals after drowning or heart attacks, supported by the activity of humane societies, also seemed to demonstrate the efficacy of electricity upon the vital system and the kinship between the two.³⁹

Additional evidence concerning the relationship between electricity and the nervous fluid came from Galvani’s experiments at the University of Bologna during the 1780s and 1790s, and his claim to have demonstrated the existence of a nervous fluid akin to artificial and natural electricity. In the first experiment, dissected frog’s legs were attached to a stump of the vertical column by the sciatic nerves and then placed on a table near an electric generating machine. On touching the nerve with a scalpel the muscles contracted strongly whilst atmospheric electricity also caused them to make violent contractions.⁴⁰ Galvani then hung the frog’s legs from iron railings by copper

³⁶ H E Hoff, ‘Galvani and the pre-Galvanian electrophysiologists’, *Ann. Sci.*, 1936, **1**: 157–72; R W Home, ‘Electricity and the nervous fluid’, *J. Hist. Biol.*, 1970, **3**: 235–51; G N Cantor, ‘The theological significance of ethers’, in G N Cantor and M J S Hodge (eds), *Conceptions of ether: studies in the history of ether theories, 1740–1900*, Cambridge University Press, 1981, pp. 135–56.

³⁷ King-Hele (ed.), op. cit., note 3, pp. 24–5; D King-Hele, *Charles Darwin’s The life of Erasmus Darwin*, Cambridge University Press, 2003, p. 24. Charles contemplated publishing the letters to Reimarus junior, but eventually decided that it was not worth it.

³⁸ R Smith, ‘The background of physiological psychology in natural philosophy’, *Hist. Sci.*, 1973, **11**: 75–123; K M Figlio, ‘Theories of perception and the physiology of mind in the late eighteenth century’, *Hist. Sci.*, 1975, **13**: 177–212; Hoff, op. cit., note 36 above; Home, op. cit., note 36 above; King-Hele (ed.), op. cit., note 3 above, p. 92. Haller’s concept of irritability and arguments, such as the fact that a

ligature on the nerve could take away sensation and motion yet not an electrical fluid, greatly influenced Darwin’s discussion of the problem in the *Zoonomia*.

³⁹ J Hunter, ‘Anatomical observations on the Torpedo’, *Philos. Trans.*, 1773, **63**: 481–9; *idem*, ‘An account of the *gymnotus electricus*’, *Philos. Trans.*, 1775, **65**: 395–407; T Cavallo, *A complete treatise on electricity in theory and practice*, 4th ed., 3 vols, London, C Dilly, 1795, vol. 3, pp. 3–5; W C Walker, ‘Animal electricity before Galvani’, *Ann. Sci.*, 1937, **2**: 84–113; Bertucci, op. cit., note 1 above, pp. 192–9.

⁴⁰ M Pera, *The ambiguous frog: the Galvani–Volta controversy on animal electricity*, trans. J Mandelbaum, Princeton University Press, 1992, pp. 64–6; Alexander Volta, ‘Account of some discoveries made by Mr. Galvani of Bologna, with experiments and observations of them to Mr. Tiberius Cavallo, FRS’, *Philos. Trans.*, 1793, **83**: 10–44; Cavallo, op. cit., note 39, above, pp. 1–75; Hoff, op. cit., note 36 above, pp. 157–9; Walker, op. cit., note 39 above, pp. 109–11.

hooks which contracted during thunder storms and in fine weather. Suspecting that weather conditions might not be responsible, Galvani found that when the legs were on the railings or iron plate and the copper hooks, or indeed other metals, were pressed against the plate, contractions occurred. He discovered that different metals stimulated different levels of convulsion, and, as a result of these and other experiments, propounded a theory of animal electricity. This held that this electricity was peculiar to animals and secreted from the brain, being distributed through the nerves, the inner substance of which, he reasoned, was specialized to conduct the fluid through an outer oily insulation layer. The muscles received the discharge of electricity, and motion resulted from the passing of the fluid from the inside of the muscle via the nerve to the outside, which stimulated the irritable muscle fibres.⁴¹ A third experiment in which the frog's legs were held by one foot and swung so that the vertebral column and the sciatic nerve touched the muscles of the other leg, was regarded as decisive by his supporters. Vigorous contractions resulted if the vertebral column was made to touch the thigh and this was argued to be decisive proof of animal electricity because no metals had been required.⁴²

There was a mixed response to the galvanists amongst British natural philosophers and medical practitioners. Some considered that they had demonstrated that electricity was either synonymous or closely analogous to the nervous fluid, but there was also considerable support for Volta who had strong British connections and contended that no new form of animal electricity had been discovered.⁴³ With his considerable experience of electrical experimentation and medical electricity dating back decades prior to the publication of the *Commentarius*, Darwin did not fully identify with either Volta or Galvani. Although he was a close friend and experimental colleague of Bennet, whose work had assisted Volta, Darwin also had many things in common with Galvani, a fellow medical practitioner. He regarded Volta and Galvani as pursuing similar research programmes, and followed Aldini and others in designating the Voltaic pile as the "Galvanic pillar". Darwin's spirit of animation interfaced mentalism with physicality and was a physiological interposition into the realm of philosophy inspired by his work on natural and artificial electricity, use of medical electricity, knowledge of Hartleyan psychology and the Hallerian physiology of irritability and sensibility.⁴⁴

As we have seen, with respect to the "laws of animal causation" Darwin argued that the spirit of animation was "the immediate cause of the contraction of animal fibres"; this spirit resided in the brain and nerves and was "liable to general or partial diminution or accumulation".⁴⁵ Porter has argued that this combination of powers had "a deep significance" in Darwin's analysis of life and the wider development of physiology and was "an

⁴¹ Pera, *op. cit.*, note 40 above, pp. 80–6.

⁴² *Ibid.*, pp. 123–31.

⁴³ Elliott, *op. cit.*, note 1 above; S L Jacyna, 'Galvanic influences: themes in the early history of British animal electricity', *Bologna Studies in History of Science*, 1999, 7: 167–85; Pancaldi, *op. cit.*, note 5 above, pp. 160–4.

⁴⁴ E Halévy, *The growth of philosophic radicalism*, trans. M Morris, Boston, Beacon Press,

1955, pp. 439–43; Porter, *op. cit.*, note 1 above; CUM Smith, 'All from fibres: Erasmus Darwin's evolutionary psychobiology', and R Simili, 'Two special doctors: Erasmus Darwin and Luigi Galvani', both in Smith and Arnott (eds), *op. cit.*, note 1 above, pp. 133–44, 145–60.

⁴⁵ Darwin, *Zoonomia*, *op. cit.*, note 2 above, vol. 1, p. 30.

extremely ambitious attempt to unite the Hallerian physiology of nervous stimulus and response with the utilitarian associationism of Locke, Hartley and his friend Priestley”.⁴⁶ For Darwin, the spirit of animation was the power which allowed life to react to changing environmental situations on the basis of individual ideas in addition to external stimuli. This uniqueness was constantly emphasized by Darwin who claimed that the “sensorial motions” that made up the sensations of pleasure or pain, which “constitute volition” and “cause the fibrous contractions in consequence of irritation or of association”, were not merely “fluctuation or refluctuations of the spirit of animation”, nor just “vibrations or revibrations” or “condensations or equilibrations of it”, but were “changes or motions of it peculiar to life”.⁴⁷ Yet in some places in the *Zoonomia* the spirit of animation appears to be akin to a subtle fluid or essence, close to Galvani’s animal electricity. The suggestion that the spirit of animation was a potentially isolatable substance also appeared in the *Economy of vegetation*, where Darwin argued that “the perpetual necessity of breathing shews, that material thus acquired is perpetually consuming or escaping, and on that account requires perpetual renovation”. The idea was supported by work on spontaneous generation which revealed that some organisms such as polyps could be divided into living segments, whilst other dead or torpid microscopic creatures could be revived.⁴⁸ Darwin suggested that the spirit of animation might therefore be “acquired from the atmosphere” and, if more subtle than electricity, “could not long be retained in our bodies” and must require “perpetual renovation”.⁴⁹

Darwin borrowed from the library of the Derby Philosophical Society the Tuscan philosopher Felice Fontana’s recently translated work on the viper, in which it was argued that, although the nervous fluid might not be “common electricity”, it might well be “something . . . very analogous to it”. According to Fontana, studies of the *Gymnotus* and Torpedo provided support for the argument and, even if they did not “render the thing very probable, make it at least possible, and this principle may be believed to follow the most common laws of electricity”.⁵⁰ In Darwin’s view, various physiological facts suggested the presence of distinct fluid operating in some ways analogously to electricity. When ligatures were placed on any part of the nerves from head to spine then “all motion and perception cease in the parts beneath”, whilst there was an obvious similarity between the texture of the brain, the pancreas and other glands suggesting that a fluid “perhaps much more subtle than the electric aura” was separated from the blood by the oxygen. This was supposed to give motion and sensation to the body. Further support came from analogy with the Torpedo and *Gymnotus* cited by Fontana, which could accumulate electricity and administer shocks, whilst electricity would “frequently stimulate into motion a paralytic limb” without requiring “perceptible tubes to convey it”.⁵¹ Finally, Darwin thought that

⁴⁶Porter, *op. cit.*, note 1 above, p. 46.

⁴⁷Darwin, *Zoonomia*, *op. cit.*, note 2 above, vol. 1, p. 33.

⁴⁸Darwin, *Botanic garden*, *op. cit.*, note 2 above, vol. 2, *Economy of vegetation*, note to canto I, line 401, p. 39; Darwin, *Temple of nature*, *op. cit.*, note 2 above, additional note, p. 7.

⁴⁹Darwin, *Botanic garden*, *op. cit.*, note 2 above, p. 39.

⁵⁰F Fontana, *Treatise on the venom of the viper*, 2 vols, London, printed for J Cuthell, 1795, vol. 2, p. 283; *Catalogue of the library of the Derby Philosophical Society*, Derby, 1793; M P Earles, ‘The experimental investigation of viper venom by Felice Fontana (1730–1805)’, *Ann. Sci.*, 1960, **16**: 255–68.

⁵¹Darwin, *Zoonomia*, *op. cit.*, note 2 above, vol. 1, pp. 7, 10.

the brain and the nervous system did appear to be adapted for the distribution of such a fluid to all parts of the body, ensuring that communications were made with all of the body's major regions.

Darwin used an electrical experiment, which he said was an "illustration" or "simile" that facilitated "the conception of a difficult subject", in order to demonstrate the close similarity between electricity and the spirit of animation. Twenty very small coated Leyden jars were hung in a row by fine silk threads close to each other. The internal charge of one jar was positive and the other negative. Alternatively, "if a communication be made from the internal surface of the first to the external surface of the last in the row" they would "instantly approach each other", so shortening "a line that might connect them like a muscular fibre".⁵² Darwin stressed that the attractions of electricity or magnetism did not apply to the contraction of animal fibres because the force of these attractions increased "in some proportion inversely as the distance". However, in muscular motion, there was "no difference in velocity or strength during the beginning or end of the contraction". This animal contraction was "governed by laws of its own", and was unique to living things, though closest to subtle fluids such as electricity and magnetism.⁵³ For this reason, Darwin did not consider that the galvanists had demonstrated the synonymy of the spirit of animation and common electricity but followed Haller in rejecting such an identification. The electric fluid might "act only as a more potent stimulus exciting the muscular fibres into action, and not by supplying them with a new quantity of the spirit of life". Similarly, he interpreted the effects induced by placing zinc and silver above and below the tongue in a dark room in terms of artificial electricity, and Bennet's experiments with the doubler as evincing "the sensibility of our nerves of sense to very small quantities of the electric fluid" rather than as evidence for animal electricity.⁵⁴ As he knew from medical practice, though paralytic limbs could be moved by shocks, they might remain totally disobedient to the will. Thus when the patient "was electrified by passing shocks from the affected hand to the affected foot, a motion of the paralytic limbs was also produced". Darwin concluded that the electric fluid acted only as a stimulus and "not by supplying any addition of sensorial power".⁵⁵ However, in so far as he continued to discuss the spirit of animation in terms of exhaustion by fibrous contractions and the perpetual action or production of it in the brain and spinal marrow, citing the successful treatment of paralytic limbs in support, the followers of Galvani could be forgiven for thinking that Darwin was arguing for a form of animal electricity using his own terminology.

As the analogies between the spirit of animation and the electricity of the *Torpedo* and *Gymnotus* demonstrate, Darwin did not make sharp distinctions between humans, animals and plants, believing that all animate creatures shared common characteristics, which particularly enraged Tory opponents. There are, therefore, many similarities between his portrayal of vitality in each of these, and he applied ideas from medicine and physiology

⁵² *Ibid.*, vol. 1, pp. 64–5.

⁵³ *Ibid.*, vol. 1, p. 65.

⁵⁴ *Ibid.*, vol. 1, pp. 66–7, 120–2; Home, *op. cit.*, note 36 above.

⁵⁵ Darwin, *Zoonomia*, *op. cit.*, note 2 above, vol. 1, p. 66.

to botany and vice versa. Darwin emphasized that the spirit of animation was the property of “animal life” which mankind possessed “in common with brutes, and in some degree even with vegetables”.⁵⁶ Plants were “an inferior order of animals”, and the motions of the Venus fly-trap and *Mimosa pudica*, or sensitive plant, demonstrated that there were “not only muscles about the moving foot-stalks” of leaf claws and petals but that these “must be endowed with nerves of sense as well as of motion”. Furthermore, the sensitivity of the mimosa showed that “there must be a common sensorium, or brain, where the nerves communicate”, and that vegetable buds possessed irritability, sensation, volition and “association of motion” though in “a much inferior degree even than the cold blooded animals”.⁵⁷

There are significant parallels between Darwin’s belief that electricity could hasten the growth of plants, supported by experiments conducted by himself and his friends, and the role of electricity in his medical and physiological theories. Darwin believed electricity to be as crucial to plant physiology as the spirit of animation to animal bodies. As we have seen, the medical scheme of the *Zoonomia* was supposed to be modelled on the Linnaean system which Linnaeus himself had tried to apply to zoology, and Darwin’s spirit of animation underpinned the vitality of both plants and animals. His friend Bennet applied electricity continuously to plants using a version of his doubler attached to a Dutch wooden clock. Another friend, the future physician Dewhurst Bilborrow, subjected mustard seeds to both positive and negative electricity finding that they germinated “much before” others that received none. Citing recent electrochemical discoveries, Darwin concluded that water was decomposed in vegetable vessels into hydrogen and oxygen, and the former helped to produce oils, gums, resins and sugar, which “accelerates or contributes to the growth of vegetation” and, like heat, entered into combination with many bodies. The artificial production of atmospheric electricity might, therefore, be of benefit to both plants and animals, and Darwin suggested that the erection of numerous metallic points on the ground might promote “quicker vegetation” by supplying plants “more abundantly with the electric ether” and precipitating showers.⁵⁸ It was difficult to determine whether atmospheric electricity in its natural state had a “salutory or injurious” effect upon “animal and vegetable bodies”, but he recognized that some animals and men “seem to possess a greater power of accumulating this fluid in themselves than others”, as the “electric concussion” of the *Gymnotus electricus* and Torpedo appeared to confirm. He suggested that regular journals should be kept recording variations in the state of atmospheric electricity utilizing Bennet’s pendulum doubler. Such a study would probably uncover “discoveries of its influence” upon the human system.⁵⁹

Given that the spirit of animation was a fluid susceptible to accumulation or exhaustion by insufficient or prolonged stimulus, then theoretically it could be possible to increase the human life span. This meant that if the fluid could be isolated and then

⁵⁶ *Ibid.*, vol. 1, pp. 109–10; see also Henly’s comments on vegetable electricity, *op. cit.*, note 6 above, pp. 130–1, 134.

⁵⁷ Darwin, *Phytologia*, *op. cit.*, note 2 above, pp. 39–40, 132–6.

⁵⁸ *Ibid.*, pp. 312–14.

⁵⁹ Darwin, *Zoonomia*, *op. cit.*, note 2 above, vol. 2, pp. 471–2.

administered, a person's health might be improved—or at least optimum degrees of stimuli could be applied to human activities in order to decrease mortality. As heat, electricity and magnetism could be given or taken from iron, so they must exist whether separated from or combined with metal and, by analogy, “the spirit of animation would appear to be capable of existing as well separately from the body as with it”.⁶⁰ Darwin was perhaps deliberately ambiguous here because he recognized the politico-religious implications, however, at this point the spirit of animation was not just a nominalistic or heuristic concept. He tried to offer reassurances begging not to be misunderstood and emphasizing that he did not want to “dispute about words”, but was “ready to allow, that the powers of gravity, specific attraction, electricity, magnetism, and even the spirit of animation, may consist of matter of a finer kind”.⁶¹ There was no question that the “ultimate cause” of all motion was “immaterial” and, perhaps with a touch of sarcasm, Darwin offered to “leave the consideration of the immortal part of us, which is the subject of religion, to those who treat of revelation”.⁶² However, because he held that the spirit of animation occupied the medulla of brain and nerves, which had figure and were spread throughout the body, so it too must have nearly the same figure as experimental work on live animals had demonstrated, though he condemned “cruel experiments on living animals”. This included experiments by Fontana, and presumably the galvanists, where “the heart of a viper or frog will renew its contractions, when pricked with a pin, for many minutes . . . after its exsection from the body”.⁶³ In support of the objection that the spirit of animation could not exist both inside and outside a specific body, he again cited the analogy of the behaviour of electricity and other ethereal fluids including “the uninterrupted passage of light through transparent bodies” and the movement of electricity and magnetism through metallic and aqueous bodies. Darwin concluded that beings could exist “without possessing the property of solidity” just as much as they could exist without existing in space so that “*to be* implies a when and a where; the one is comparing it with the motions of other beings, and the other with their situations”.⁶⁴

Informed by experiments on the electrification of living bodies and analogies between the actions of electricity and the mechanism of the body, Cavallo too wondered whether electricity acted exclusively by mechanical operations or whether there was a close relationship between the vital spirit and the electric fluid. He concluded that mechanical analogies and laboratory electrical experimentation provided much of the explanation of the action of electricity upon the body, and that continental philosophers such as Abbé Bertholon exaggerated the effects of atmospheric electricity upon the body. Electricity, however, had the power to cause involuntary motion making some fibres expand and others to contract, and was able to stimulate torpid muscles and nerves by assisting the “*vis vitae*, or that innate endeavour, by which nature tends to restore the sound state of the injured parts of a living animal”. However, he accepted that “independent of the already known parts of the human body” was another “principle that accompanies the life of an animal”, which was a conductor of electricity and which ceased “as soon as the animal”

⁶⁰ *Ibid.*, vol. 1, p. 109.

⁶¹ *Ibid.*, vol. 1, p. 109.

⁶² *Ibid.*, vol. 1, pp. 109.

⁶³ *Ibid.*, vol. 1, p. 111.

⁶⁴ *Ibid.*, vol. 1, pp. 113, 114.

dies. It was clear that after death shocks passed over the surface of the body rather than through it as they had when alive.⁶⁵ In response to further experiments, discussions with his medical and philosophical friends and the galvanists, Cavallo returned to the question of animal electricity during the 1790s and turned away from medical electricity as a result. He suggested to his friend Lind in 1794 that he should turn his thoughts to animal electricity, which was “likely to become interesting rather than to the medical administration of various sorts of elastic fluids”, which he had been informed had met with little success.⁶⁶

Cavallo obtained detailed reports concerning Galvani’s work and took a renewed interest in the origins of animal electricity, the relationship between electricity and muscular motion, how transmission was achieved and the possible role of the brain in the generation of animal electricity. He examined afresh the history of animal electricity, but rejected the galvanic notion that the nervous fluid was synonymous with electric matter. Noting that dry and moist nerves had different conducting powers, Cavallo supported the Voltaists in attributing muscular motion in the Galvanic experiments to the contact between two metals rather than as evidence that the galvanic and electrical fluids were synonymous.⁶⁷ Like Cavallo, Darwin rejected some of the arguments of galvanists, such as Eusebius Valli’s idea that the nervous fluid was synonymous with electric matter. He had assisted and praised Bennet in his electrical researches using the doubler, which had demonstrated the importance of the “adhesive affinity” of electricity and the charges induced by contact between metals, and predated Volta and Galvani’s work on the subject.⁶⁸ However, unlike Cavallo, as we have seen, Darwin continued enthusiastically to advocate and conduct medical electrical treatment making use of new technology such as the pile. Furthermore, because of this medical electrical experience, interest in animal electricity and consideration of the vital fluid question, Darwin was less dismissive of the galvanic arguments than Cavallo and his friends, and continued to regard the analogies between the spirit of animation and electricity as useful.

It is also significant, given Darwin’s psychophysiology, that he was prepared to countenance the limited use of magnetic medicine when most other British natural philosophers and medical men, including Cavallo, had little time for it. Magnetic medicine found greater favour on the continent, where universities and medical societies promoted and investigated magnetic treatments. In Britain, medical magnetism never became popular partly because magnetism in general attracted far less interest than electricity, which produced much more dramatic effects. Medical magnetism therefore became an object of ridicule, and when James Graham promoted the therapeutic value of magnetic beds and chairs it was taken to reinforce his reputation for quackery.⁶⁹ Likewise, although animal magnetism—which did not necessarily require the use of artificial magnets—had a short vogue from the 1780s, it quickly came to be regarded with derision.⁷⁰ Cavallo complained of the “greatest

⁶⁵ Cavallo, *op. cit.*, note 7 above, pp. 10–11, 21–3, 115–17; Bertucci, *op. cit.*, note 1 above, pp. 192–5.

⁶⁶ Quoted in Bertucci, *op. cit.*, note 1 above, p. 210.

⁶⁷ Cavallo, *op. cit.*, note 39 above, pp. 48–67; Bertucci, *op. cit.*, note 1 above, pp. 200–2.

⁶⁸ Elliott, *op. cit.*, note 1 above, pp. 64–8.

⁶⁹ J Graham, *A short inquiry into the present state of medical practice*, London, 1776; Fara, *op. cit.*, note 5 above, pp. 17–19, 57, 159–61.

⁷⁰ Sutton, *op. cit.*, note 9 above; Fara, *op. cit.*, note 5 above, pp. 195–207.

absurdities” related to the “pretended medicinal properties” of magnets, such as the use of magnetized plasters, but accepted that it was “not unusual” to find people who believed that “the application of the magnet cures the tooth-ach, eases the pains of parturient women” and offers relief for other conditions.⁷¹

Whilst medical electricity could, therefore, transcend the shifting borders between perceptions of quackery and generally accepted practice, medical magnetism was usually regarded as ineffectual continental quackery. However, it is significant that, as a physician and natural philosopher being drawn towards parallel multi-fluid electrical and magnetic theories, Darwin was less concerned to police the boundaries than Cavallo. He saw analogies between magnetism and the spirit of animation, and was prepared to accept that the “accumulation or passage of the magnetic fluid might affect the animal system”. In the *Zoonomia*, one of the analogies for the spirit of animation was the mutual attraction of magnetized particles of iron, whilst, as we have seen, the fact that the magnetic fluid could apparently be passed between bodies implied that the vital force might also exist independently. As with electricity, this close analogy suggested that magnetism might be effective for some conditions. Darwin considered that it was worth trying to treat toothache by placing the tooth between the south and north poles of a horse-shoe magnet or between two different magnets, so that magnetism might be “accumulated on the torpid part”.⁷²

VI

In keeping with their Enlightenment progressivism, Darwin and his friends believed that their philosophical studies would help to facilitate social improvement and political reform. Perhaps the most visible aspect of this was the support provided to industrial, manufacturing and transport improvements by the members of the Lunar and Derby philosophical societies, which so impressed visiting continental philosophers such as Volta. Wedgwood, Boulton and Watt were, of course, major industrial and manufacturing entrepreneurs whose interests encouraged them to invest in business ventures, support canal development and ignore some of the more oppressive manifestations of industrialization. This liberal progressivism was manifest politically in the support offered by most of the Midlands philosophers to the American colonies in their struggle for independence, in campaigns for constitutional reforms during the 1780s and 1790s, and in the initial celebration of the French Revolution. These political activities proved controversial, especially as France descended into bloody dictatorship, and Priestley’s house and laboratory were destroyed by a mob in Birmingham. Led by Darwin, the Derby society published a letter in support of Priestley and expelled a member who opposed the gesture, whilst the *Morning Chronicle* was prosecuted for seditious libel for publishing an address of the Derby political society widely attributed to Darwin.⁷³

⁷¹ T Cavallo, *A treatise on magnetism in theory and practice*, 2nd ed., London, 1795, pp. 102–4.

⁷² Darwin, *Zoonomia*, op. cit., note 2 above, vol. 1, p. 54, 109, vol. 2, p. 472.

⁷³ *Rules of the Derby Society for Political Information*, Derby, 1791; *Address to the friends of*

free enquiry and the general good, Derby, 1792; *State trials*, compiled by T B Howell, London, 1793, XII, 34 Geo. III, pp. 954–70; *Derby Mercury*, 19 December 1793; E Fearn, ‘The Derbyshire reform societies, 1791–93’, *Derbyshire Archaeol. J.*, 1968, 88: 47–59.

Government supporters focused upon Darwin, Priestley and Beddoes's more extravagant and speculative claims that the progress of natural philosophy would have such a major impact upon medical practice that it might, in the future, be possible to cheat death. Darwin's psychophysiology became a particular target, partly because of the perceived association between natural philosophy, electricity and reform embodied in the careers of Franklin, Priestley, Beddoes and Darwin, and partly because of its apparent metaphysical and theological implications. The attacks, in effect, condemned the interdependency of Darwin's natural philosophy and medical practice, helping to sever the two and discourage medical interventions in natural philosophy and philosophical engagement in clinical physiology. Darwin's vitalism and that of the galvanists' excited considerable hostility during the 1790s due to the apparent mechanistic and deistic implications and the political situation. Despite Darwin's qualifications, the concept of an ethereal nervous fluid was attacked as philosophically and empirically unjustifiable, representing an apparent secularization of the vital powers. It seemed to strike at the heart of Christian theology, the belief in human creation in the image and likeness of God, and the designation of the soul as a spark of divinity. Indeed, it is interesting that Darwin, Priestley and Beddoes were pilloried and not other Whig philosophers such as Cavallo, who had also taken a keen interest in animal electricity during the 1790s, yet who had become more closely identified with the Voltaic position.

In *The golden age*, a satirical poem ostensibly by Darwin and Beddoes, their suggestion that life could be prolonged by scientific intervention in medicine was ridiculed.⁷⁴ In 'The loves of the triangles', a parody of Darwin's *Botanic garden*, the author is made to remark that "the sphere of our disagreeable sensations" might in future be "considerably enlarged", as Galvani's experiments indicating "that the electric fluid is the proximate cause of nervous sensibility" had demonstrated. As "dead frogs" were "awakened by this fluid to such a degree of posthumous sensibility as to jump out of the glass", then why could the same not be done for men who were "sometimes so much more sensible when alive?" The idea that natural philosophers using galvanism could revolutionize medicine was risible, for if this was so, then why not utilize this discovery to "deter mankind from dying (which they so pertinaciously continue to do) of various old-fashioned diseases".⁷⁵

Darwin's interventions in speculative psychophysiology were also condemned by the Scottish philosopher Thomas Brown. Although Brown's Humean conclusions were equally unsatisfactory to ministry theists, like Tory loyalist attacks upon Darwin and Beddoes, they also served to encourage the growing division between medicine and natural philosophy. Brown contended that there was no requirement for a spirit of animation for "in no instance . . . is the introduction of unknown substances allowable". Although it might "correspond exactly, with the preceding and succeeding phenomena", as Hume had contended, there was no explanatory advantage that

⁷⁴*The golden age, a poetical epistle from Erasmus Darwin, MD, to Thomas Beddoes, MD*, London, printed for F and C Rivington, 1794, pp. 7–9.

⁷⁵'The loves of the triangles', *The Anti-Jacobin or Weekly Examiner*, 4th ed., 2 vols, London, 1799, vol. 2, p. 275. The work was partly composed by George Canning.

could be gained from inventing subtle fluids which implied mistaken notions of causation. They encouraged philosophers to resolve perceptions “into vibrations . . . vibraticules, or direct motion”, and mentalists and rational materialists to construct isolated systems when it was possible to bridge the two. In Brown’s view, Darwin’s vital fluid failed to connect the two because it oscillated between being physical substance and psychological phenomena. Both mentalist and materialist agreed that a sentient principle existed but “the mentalist acknowledges” his ignorance of the causation of ideas, whereas materialists such as Darwin try to resolve them into the concerted action of sensations and the spirit of animation. So Brown wondered what Darwin had gained “from the labour, and ingenuity” he had devoted to “constructing his hypothesis”—though the real mystery was the same—“the apparent mystery is less by being divided”. He ignored Darwin’s attempts to distance himself from galvanic crudities by carefully distinguishing animal motion and behaviour from electrically induced convulsions.⁷⁶ Darwin had failed to determine where and how the spirit of animation was produced and distributed in the sensorium, and how it was responsible for motion. If it was a property of animation, this led to the ludicrous notion that infinitely divided bodies should be equally capable of irritation, sensation, volition and association. Each person might therefore contain “a multitude of beings, independent of each other, each being susceptible of motion, on the application of stimulus”.⁷⁷ Although he exaggerated to make his case, by concentrating on the physical manifestations of the spirit of animation and reducing this to absurdity, Brown underlined how important the analogy with electricity and other ethereal fluids had been in Darwin’s construction, whilst ungenerously ignoring its heuristic function.

The growing division between medicine and natural philosophy, signified and encouraged by the attacks upon philosophical medical men such as Darwin and Beddoes, is also apparent in the reception of galvanic medicine during the early 1800s. Encouraged by the activities of humane societies, electricity continued to be employed in medical treatment, and the pile seemed to offer the potential for limitless portable charge in medical practice. However, the practice and study of galvanic medicine was constrained by the political situation, which is reflected in Mary Shelley’s *Frankenstein* (1818). *Frankenstein*, of course, can be interpreted as a union of mechanistic physiology with mental associationism, the monster being animated by the application of electricity, although this is never explicitly stated in the novel. Shelley’s creation became the ultimate symbol of perverted science, yet her monster is a much more ambiguous creation, especially in the first edition, reflecting contemporary perceptions of the potential of galvanic medicine, and it is significant that Darwin’s reflections on the spirit of animation and re-animation were cited by the Shelleys as a principal source.⁷⁸ Giovanni Aldini, Galvani’s nephew, and an important proponent of medical electricity, used galvanism in Bologna in treating nervous and other conditions. In

⁷⁶T Brown, *Observations on the Zoonomia of Erasmus Darwin, MD*, Edinburgh, Mundell, 1798, preface, pp. xvii, xvii–xviii; H C Warren, *A history of the association psychology*, New York, Constable, 1921, pp. 68–80.

⁷⁷Brown, op. cit., note 76 above, pp. 20, 22.

⁷⁸M Shelley, *Frankenstein: or The modern Prometheus*, ed. M Butler, Oxford University Press, 1994, original preface, p. 3, preface to 1831 edition, p. 195.

1803, during a visit to London, he conducted galvanic experimental demonstrations with oxen heads and the corpse of a murderer which induced widely reported fantastic convulsions. Natural philosophers and tutors produced similar effects using animals at public lectures around Britain. At York in 1805, for instance, Charles Sylvester exhibited “all the motions attendant on winking, chewing, breathing, kicking, etc.” using the galvanized separated head and body of a sheep. In 1818, Andrew Ure followed Aldini in conducting galvanic experiments upon the body of an executed murderer at Glasgow, inducing wild contortions and facial expressions, some of which drove members of the audience from the room. As such effects could be obtained from tissues without metal, they were claimed to demonstrate that the galvanic fluid was physiologically essential.⁷⁹ Although they were controversial, for Aldini and Ure these results demonstrated the potential of galvanic medicine and offered the chance of “raising this wonderful agent to its expected rank, among the ministers of health and life to man”.⁸⁰

Although intended to demonstrate the power and potential of galvanism and electric medicine by exploiting the dramatic and macabre quality of galvanic effects, these demonstrations also excited revulsion and fear, helping to increase suspicion and political opposition towards medical galvanism and vitalism. An important example is the dispute between John Abernethy and William Lawrence from 1815, which revisited many of the arguments used by Darwin and Brown, in which Abernethy defended what he claimed was a version of John Hunter’s vitalism. Lawrence attacked Abernethy for supposing that the bodily structure contained “an invisible matter or principle” of vitality, which he regarded as being an unnecessary and uneconomical supposition. In turn, Abernethy saw the party of “modern sceptics” (which was intended to include Lawrence) as advancing a dangerous form of French materialism, forcing Lawrence to defend his position on the grounds that he was propounding a neutral physiological system without ethical or political implications. Like Darwin, Abernethy condemned for their cruelty some of the experiments conducted on living creatures, especially those by continental philosophers, and it is striking that he employed arguments similar to Darwin’s, despite his notoriety, for the purposes of attacking what he claimed was a French materialist physiology. Indeed, as Coleridge contended, the fact that Abernethy followed Darwin in seeing a possible identification between the electrical fluid and the vital principle was hardly a defence of animation and an incorporeal soul but potentially an equally dangerous form of materialism.⁸¹ The

⁷⁹ I Inkster, *Scientific culture and urbanisation in industrialising Britain*, Aldershot, Ashgate, 1997, p. 122; ‘Abstract of the late experiments of Professor Aldini on galvanism’, *Journal of Natural Philosophy*, 1802, 3: 298–300; ‘Galvanism’, *Philosophical Magazine*, 1802, 14: 364–8; G Aldini, *An account of the late improvements in galvanism*, London, printed for Cuthell and Martin, 1803; *idem*, *General views on the application of galvanism to medical purposes*, London, Callow, 1819; A Ure, ‘An account of some experiments made on the body of a criminal immediately after execution with physiological and

practical observations’, *Quarterly Journal of Science*, 1819, 6: 283–94; I Morus, *Frankenstein’s children: electricity, exhibition and experiment in early nineteenth-century London*, Princeton University Press, 1998, pp. 126–30.

⁸⁰ Quoted in Morus, *op. cit.*, note 78 above, p. 129.

⁸¹ O Temkin, ‘Basic science, medicine and the Romantic era’, in *idem*, *The double face of Janus and other essays in the history of medicine*, Baltimore, Johns Hopkins University Press, 1977, pp. 345–72; T H Levere, *Poetry realized in nature: Samuel Coleridge and early nineteenth-century science*, Cambridge

strength of these fears motivated Mary Shelley to remove most of the more specific chemical and electrical references and simplify the moral message of the 1831 edition of *Frankenstein*.⁸² They also overshadowed subsequent work on galvanism and vitality, such as Andrew Crosse's claim to have created insects from coal during the 1840s, and later attempts to apply electricity in medicine.⁸³

VII

When interest in medical electricity was revived in Britain during the 1830s and 1840s, it was argued that, although it had enjoyed Georgian popularity, applications had been random and this interpretation coloured twentieth-century accounts of the subject. This article has, however, used a case study of Darwinian medical practice and ideas to demonstrate that the use of medical electricity was strongly influenced by natural philosophy and, in turn, medical electrical applications played an important role in the development of psychophysiology. British Enlightenment medical practice and natural philosophy were therefore closely intertwined. Whilst electricians such as Cavallo required the assistance of medical friends like Lind and Partington, Darwin employed his own medical experience to assess and improve applications of medical electricity. As a close friend of other major electricians and an enthusiastic electrician himself undertaking detailed work on atmospheric and meteorological electricity, Darwin presented electricity as a major power in the natural economy. Like Cavallo, he did not, however, support what he regarded as some of the more exaggerated claims concerning natural electricity, especially those made by continental natural philosophers, and he was sceptical of the role attributed to electricity in many meteorological phenomena such as precipitation and earthquakes. This philosophical scepticism fed through into his assessment of the efficacy of medical electricity, galvanism and magnetism, resulting in careful, measured applications in specific contexts.

As we have seen, the equilibrium of British natural philosophy was shattered by the revolutionary wars of the 1790s and the Tory loyalist reaction, resulting in aspects of Darwin's philosophy straddling medicine and natural philosophy, especially psychophysiology, being exposed for ridicule and condemnation. More optimistic and speculative pronouncements by Darwin, Priestley and Beddoes concerning the benefits of natural philosophy for medicine and society were now interpreted with their progressive political pronouncements as threats to order, church and state. The exploitation of galvanic effects upon corpses in dramatic public displays by proponents of medical galvanism such as Aldini and Ure backfired, increasing suspicion towards medical

University Press, 1981, pp. 45–52; A Desmond, *The politics of evolution: morphology, medicine and reform in radical London*, Chicago University Press, 1989, pp. 117–20, 255–7; M Butler, introduction to *Frankenstein*, op. cit., note 78 above, pp. xv–xxi; L S Jacyna, 'John Abernethy (1764–1831)' and 'Sir William Lawrence (1783–1867)', Oxford DNB online, accessed 4/1/2007.

⁸² *Frankenstein*, op. cit., note 78 above, appendix B, pp. 198–228.

⁸³ J Secord, 'Extra-ordinary experiment: electricity and the creation of life in Victorian England', in D Gooding, T Pinch and S Schaffer (eds), *The uses of experiment*, Cambridge University Press, 1989; Morus, op. cit., note 79 above, pp. 110–51, 231–55.

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electricity and helping to drive the doctor from the laboratory and the scientist from the sickbed. Far from promoting a vision of universal human progress driven by scientific discovery and medical advance, Darwin's medical electricity and psychophysiology helped to give birth to *Frankenstein*, the most powerful vision of twisted, apocalyptic science ever created.