

# THE COLLATERAL SCIENCES IN THE WORK OF GOLDING BIRD (1814–1854)

by

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THE IMPORTANCE of physics and chemistry—the collateral sciences—as an adjunct to the study of medicine, was well understood by many nineteenth-century physicians. It seemed that the most promising means of achieving a more scientific approach to the diagnosis and treatment of disease lay in the application of physical and chemical principles to the study of animal tissues and functions. The collateral sciences clearly had a fundamental part to play in the professional training of the medical student. The principal medical schools, such as that at Guy's Hospital for example, offered regular instruction in physics and chemistry, although the lectures were not always accompanied by experimental work. Alexander Marcet (1770–1822), was a physician at Guy's where he also lectured on chemistry and was perhaps best known for his chemical studies of urinary calculi. He placed special emphasis on analysis and attempted to correlate the chemical compositions of the calculi with diagnosis of the pathological conditions leading to their formation.<sup>1</sup> At the same time he set out to provide the medical practitioner with a convenient method of analysing minute quantities of calculi at the bedside of the patient.

William Prout (1785–1850), was also well known at Guy's, though he held no official appointment there. His wider studies of the animal functions of digestion, assimilation and excretion, as well as the inter-relations between them, became classics of chemical physiology in their own times.<sup>2</sup> These physicians, together with others such as Saunders, Babington and William Allen, established a strong tradition for the study of physiological chemistry at the hospital. They received practical suggestions, advice and encouragement from surgeons like Astley Cooper<sup>3</sup> who also practised at Guy's and who was later to recognize the youthful talent of Golding Bird. The latter held Prout in very high regard as one of the true founders of physiological chemistry, from whose work the later advances made by Liebig took their origins.<sup>4</sup>

<sup>1</sup> A. Marcet, *An Essay on the Chemical History and Medical Treatment of Calculous Disorders*, London, 1817 (2nd ed. 1819). Marcet was a physician at Guy's from 1804 to 1819 and lectured there on chemistry from 1807 to 1820. See my article, 'Alexander Marcet (1770–1822), physician and animal chemist', *Med. Hist.*, 1968, 12, 394–402.

<sup>2</sup> First published in 1821, Prout's book passed through five editions, with increasing breadth of treatment. Thus: *An Inquiry into the Nature and Treatment of Gravel, Calculus and other Diseases connected with a deranged operation of the Urinary Organs*, London, 1821 (2nd ed. 1825); 3rd ed., *On the Nature and Treatment of Stomach and Urinary Diseases; Being an Inquiry into the connection of Diabetes, Calculus and other Affections of the Kidney and Bladder with Indigestion*, London, 1840; 4th ed., *On the Nature and Treatment of Stomach and Renal Diseases*, London, 1843; (5th ed. 1848). See W. H. Brock, 'The life and work of William Prout', *Med. Hist.*, 1965, 9, 101–26.

<sup>3</sup> Examples of work done by Marcet and Prout at the suggestion of Astley Cooper include the analysis of chyme and chyle, A. Marcet, *Ann. Phil.*, 1816, 7, 234–35; W. Prout, *ibid.*, 1819, 13, 15, and Marcet's investigation of the alkali present in animal fluids, *Med.-chir. Trans.*, 1811, 2, 340–81.

<sup>4</sup> *Assoc. med. J.*, 1855, 105, 2.

Bird's own work may be considered as a sequel to that of Prout for it was said of him: ' . . . that next to Dr. Prout, no one in this country has done so much to render chemical pathology a general study among medical men as Golding Bird.'<sup>5</sup>

#### BIRD'S EARLY LIFE AND STUDENTSHIP

Born at Downham in Norfolk on 9 December 1814, Bird showed great ability and love of learning even as a child. His father, from whom he derived his unusual Christian name, held office in the Department of Inland Revenue and had lived in Ireland. His mother was Irish and he had two sisters and two brothers, of whom the younger brother Frederick also became a successful physician. As a child Golding was sent to live with the family of a Berkshire cleric, until at the age of twelve he was placed, with his brother Frederick, in a private school of doubtful merit in London. Here, his knowledge of chemistry and botany being far greater than that of his fellow pupils, he is said to have volunteered to give lectures on these subjects to his schoolfellows in the early morning, before official lessons began.<sup>6</sup>

On 23 December 1829, Bird was apprenticed for four years to William Pretty, an apothecary of Burton Crescent, London, a respectable medical practitioner. In this situation, as was customary, he was required to perform the most menial tasks which in no way taxed his mental powers. Here he acquired the life-long habit of working at his books late into the night. Bird's health was always delicate and it is likely that his tireless mental energies, spurred on in his early years by an overriding ambition, led him to drive himself too hard in his ardent desire to achieve recognition in the highest circles of his chosen profession.

In 1832, before he had completed his apprenticeship, Bird became a student at Guy's. He continued to work at the dispensary as well as attending the lectures at the hospital during his first year as a medical student, yet he was outstanding amongst his fellows, especially for his knowledge of the collateral sciences of chemistry, physics and botany. Addison<sup>7</sup> was perhaps the first to recognize Bird's abilities, and the latter, with a sense of gratitude, set out to model his own character on that of his teacher. Bird later gave a glimpse of his feeling for Addison in the dedication of his book on *Urinary Deposits*: 'I cannot look back on my past career, so far as it has extended, without gratefully acknowledging how much I owe to your example, and to the exertion of your friendly influence, from the time I took my seat upon the pupils' benches, until I had the high honour of being appointed your colleague.'<sup>8</sup>

At the meetings of the Pupils' Physical Society at Guy's, Bird soon became known

<sup>5</sup> *Med. Times*, 1854, 30, 500.

<sup>6</sup> The numerous obituaries and biographical notices of Golding Bird include; unsigned obituaries in the *Lancet*, 1854, ii, 407; *Med. Times*, 1854, 30, 499; *Lond. Prov. Med. Dir.*, 1855, p. 641. His brother Frederick wrote the obituary notice which appeared in *Assoc. med. J.*, 1855, 105, 1–6, and which was later reprinted separately with a portrait, F. Bird, *Biographical Notice of the late Dr. Golding Bird*, London, 1855; See also J. H. Balfour, *Biographical Sketch of the late Dr. Golding Bird*, Edinburgh, 1855, for an account of Bird's Christian activities. W. Munk, *Roll of the Royal College of Physicians*, 5 vols., London, 1861–1968, vol. 4, p. 39; S. Wilks and G. T. Bettany, *Biographical History of Guy's Hospital*, London, 1892, p. 245; W. Hale-White, *Guy's Hosp. Rep.*, 1926, 76, 1–20; *Brit. J. phys. Med.*, 1931, 6, 174.

<sup>7</sup> It was Addison who encouraged Bird to aspire to become a physician. *Med. Times*, 1854, 30, 499. For a biographical account of Addison, see W. Hale-White, *Guy's Hosp. Rep.*, 1926, 76, 253–79.

<sup>8</sup> G. Bird, *Urinary Deposits, their Diagnosis, Pathology, and Therapeutical Indications*, London, 1844 (2nd ed. 1846, 3rd ed. rev. and enl., 1851, 4th ed. 1853, 5th ed., edited by E. L. Birkett, 1857.)

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for his interest in all chemical topics and for his knowledge of chemistry. His first recorded remarks to the Society were made in connection with a paper given by R. H. Brett, who was later to become his brother-in-law. The subject of the paper was arsenic poisoning, and Bird criticized the usual test for arsenic, based on the use of copper sulphate, on the grounds that there were other precipitates which might be formed and which could easily be confused with copper arsenite.<sup>9</sup>

Bird and Brett jointly published chemical papers on the analysis of blood serum and urine in health and disease, in which criticisms were made of Prout's view that the pink sediment of the urine was due to the presence of ammonium purpurate. They understood Prout's statements to mean that the pink sediment was a mixture of ammonium purpurate and purpuric acid, formed by the action of nitric acid on uric acid in the urine.<sup>10</sup> The young chemists thought this to be most unlikely, since it would be difficult to imagine the conditions under which a sufficient concentration of nitric acid might be present in the urine to bring about the necessary oxidation. Bird and Brett extracted the colouring matter from pink sediment with alcohol and compared its chemical properties with those of ammonium purpurate. They found that these two substances behaved quite differently towards the common chemical reagents and concluded that they were really two quite different compounds, though they were unable to suggest the precise nature of the pink sediment.

This work, though carried out whilst Bird was still a student, was so cogently presented that Prout felt it necessary to reply.<sup>11</sup> He pointed out that he had not said that the pink sediment consisted solely of the purpurates, but that its main constituent was lithic acid (i.e. uric acid), tinged with the yellow colour of the urine and with the pink of the alkaline purpurates. The latter might well be formed in the urine by means other than the action of nitric acid on uric acid. Bird and Brett, however, maintained their original view that the pink colour could not in any way be due to ammonium purpurate, in spite of the high authority which attached to the name of Prout and of his somewhat patronising advice as an 'old chemist' to make sure of the facts before pronouncing upon them.<sup>12</sup>

Bird's growing reputation as a chemist led to his being asked by Sir Astley Cooper to contribute an account of the chemistry of milk to his last book on *The Anatomy of the Breast*.<sup>13</sup> In this case Bird confined his remarks mainly to the analysis of milk as it had been described by earlier chemists, notably Berzelius. He also made some

<sup>9</sup> Comments found in the Minute Book of the Pupils' Physical Society, vol. 2 (1831–5), 27 October 1832, now kept in the Will's Library, Guy's Hospital. Marcet had earlier investigated the use of silver nitrate in testing for arsenic, *Phil. Mag.*, 1813, 41, 121–4; *Med.-chir. Trans.*, 1812, 3, 342–47.

<sup>10</sup> G. Bird and R. H. Brett, *Lond. med. Gaz.*, 1834, 14, 600. Prout first referred to the pink deposits in 1819, *Ann. Phil.*, 1819, 14, 363; *ibid.*, 1820, 15, 155. Vauquelin had earlier studied these substances, as had L. J. Proust, *Ann. Chim.*, 1799, 36, 258. Bird returned to his criticism of Prout's purpuric acid theory in 1843. He now called the pink compound 'purpurine', but could not determine its chemical composition, *Lond. med. Gaz.*, 1843, 31, 733. The difficult chemistry of uric acid and its derivatives formed the subject of a classic paper by Liebig and Wöhler, *Ann. Chem. Pharm.*, 1838, 26, 241.

<sup>11</sup> W. Prout, *Lond. med. Gaz.*, 1834, 14, 641.

<sup>12</sup> G. Bird and R. H. Brett, *Lond. med. Gaz.*, 1834, 14, 751–52.

<sup>13</sup> Astley P. Cooper, *On the Anatomy of the Breast*, London, 1840. Bird's contribution, pp. 118–26, included proximate and elementary analyses of the milk of various animals (cow, goat, ass, ewe, mare, etc.) made by Henry, Gay Lussac, Chevalier, and others. He also quoted Berzelius' analysis figures for skimmed milk, *Med.-chir. Trans.*, 1812, 3, 196–276.

proximate analyses of the milk of the bitch and of the porpoise which he communicated to Cooper in December 1839. The main text of the book was complete by that time and these analyses were included in an Appendix.

Since he was determined to make a name for himself as quickly as possible, Bird was soon to be found amongst the members of the Senior Physical Society at Guy's. In order to become a Fellow of this Society it was necessary to have submitted an approved thesis, illustrated by cases, on a medical, surgical, chemical or obstetric subject. Characteristically, Bird put forward a paper on pathological chemistry, applied to the diagnosis of disease, though he confined his address to the Society to that part of the paper relating to the chemistry of the blood.<sup>14</sup> He was granted the Fellowship in recognition of this essay, and thereafter, although he attended the meetings of the Society and voiced his opinions on chemical subjects at frequent intervals, he did not present another paper to the Society for three years.<sup>15</sup>

Bird was an outstanding student and received prizes and honours far above the average. At Guy's he obtained prizes for medicine, obstetrics and ophthalmic surgery, whilst at Apothecaries' Hall he took the silver prize for botany. His studentship was completed in 1836, a year filled with opportunities for him. On 21 January 1836 he was awarded the licence of Apothecaries' Hall without examination—his reputation as a student had preceded him. The Court of Examiners granted him his certificate with honours, at the same time recommending him to the authorities at Guy's where he was seeking a lecturing appointment in the Medical School, as 'one whose merits ought not to be overlooked . . .'. Bird took up general practice as soon as he was qualified, but initially he was not very successful, for his youthful appearance was against him in the eyes of the public. Soon afterwards, however, he was appointed physician to the Finsbury Dispensary and he held this post with success for the next five years. During this period he entered his name at the University of St. Andrews, where on payment of the fees, but without residence, he was awarded an M.D. in 1838 and an M.A. two years later. His work at Finsbury gave him invaluable clinical experience and also brought him considerable financial success, so that by 1842 his private practice was worth at least a thousand pounds per annum—a considerable sum at that time.

#### ELECTROCHEMISTRY AND ELECTROTHERAPY

In 1836 Bird had been appointed to lecture in Natural Philosophy, Electricity, Galvanism and other branches of Experimental Philosophy at the Medical School of Guy's.<sup>16</sup> In the same year he had been given charge of a newly-formed department for the treatment of patients by electricity and galvanism. Electrotherapy had become very popular as a means of treatment which seemed to offer good prospects of success

<sup>14</sup> This paper was read on Saturday, 19 March 1836. Its contents are summarized in the *Minute Book of the Physical Society of Guy's Hospital* (vol. for 1835–6). Bird stated that he had presented his paper to the Library, *Guy's Hosp. Rep.*, 1838, 3, 35, but it has since disappeared.

<sup>15</sup> On 23 February 1839 he read a paper on the pathology of death by carbon monoxide poisoning, illustrated by experiments with sparrows. This important paper aroused considerable interest. *Guy's Hosp. Rep.*, 1839, 4, 75–105. Bird gave his views on this subject to the medical section of the British Association Meeting at Birmingham in 1839. *B. A. Reports*, 1839 (ii), pp. 101–2. (He also acted as a Secretary for the chemistry and mineralogy section of the B.A. Meetings in the same year.)

<sup>16</sup> His lectures were soon extended to include Medical Botany and Chemistry.

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in many cases of nervous disorders. The department for electrical treatment at Guy's had been set up by the Treasurer of the Hospital, Benjamin Harrison, who had appropriated a room and equipped it with all the available devices for producing electric currents and shocks for use in the treatment of patients. This 'electrifying room' was placed under the general direction of Golding Bird, who was assisted largely by medical students. The work complemented his lecturing on physics and led him to make a study of electrical phenomena as he attempted to apply them in medical treatment.

Bird was impressed by the great variety of effects, chemical, magnetic and physiological, which could be produced by electricity. The electrolytic effects produced by long-continued currents at low tension seemed particularly important, since they appeared to be analogous to the nervous currents in the body. Bird was able to demonstrate the electro-chemical relationships between the metals and was successful in depositing crystals of some of them in the pores of a Plaster of Paris plug.<sup>17</sup> Such long-continued weak currents were also found to be capable of extracting metals such as beryllium, aluminium and even silicon from their salts or oxides, whilst potassium, sodium and ammonium amalgams could be formed by the slow electrolysis of solutions of their chlorides with mercury cathodes.<sup>18</sup> Bird carefully repeated experiments made earlier by A. C. Becquerel, who had reduced the oxides of copper, lead and tin as well as some of the more electropositive metals. Edmund Davy, too, had experimented with electrolytic methods of detecting minute quantities of metallic poisons by means of feeble currents.<sup>19</sup> Bird concluded that the success of such methods depended upon the use of steady, uninterrupted currents. He used a battery made with a single pair of plates (his own modification of the Daniell cell), and pointed out that the currents passing were comparable in strength with the nervous currents in the body.

From his experience of lecturing to the medical students, Bird came to realize that there was a need for a non-mathematical textbook of physical science. This led him to produce his *Elements of Natural Philosophy* in 1839, specifically for medical students.<sup>20</sup> This work was acclaimed by reviewers for its clarity and simplicity of style, though a lack of rigorous mathematical treatment was its main weakness.<sup>21</sup> The book was popular with medical students and passed through six editions, remaining in use for over thirty years. In the fourth and later editions the mathematical omissions were rectified by Bird's friend Charles Brooke.<sup>22</sup>

It was naturally the physiological effects of electric currents which most interested

<sup>17</sup> G. Bird, *B. A. Reports*, 1837 (ii), p. 45; 1838 (ii), p. 57.

<sup>18</sup> G. Bird, *Phil. Trans.*, 1837, 127, 37–46.

<sup>19</sup> A. C. Becquerel, *Ann. Chim.*, 34, 152–63, 1827; *ibid.*, 1827, 35, 113–40. Edmund Davy, *Phil. Trans.*, 1831, 121, 147–64.

<sup>20</sup> G. Bird, *The Elements of Natural Philosophy, being an Experimental Introduction to the study of the Physical Sciences*, London, 1839 (2nd ed., 1844, 3rd ed., 1848, 4th ed., rev. and enl. by Charles Brooke, 1854, 5th ed., 1860, 6th ed., 1867). There was also an American edition, taken from the 3rd London ed., Philadelphia, 1848.

<sup>21</sup> See for example, *Lond. med. Gaz.*, 1839, 1, 363; *ibid.*, 1844, 2, 569; *Brit. For. Med. Rev.*, 1848, 1, 530; *Assoc. med. J.*, 1854, p. 355, etc.

<sup>22</sup> Charles Brooke (1804–1897), surgeon and inventor of the self-recording barometer and thermometer used in astronomical work at Greenwich and Paris. He edited the fourth and fifth editions of Bird's *Elements*, adding some mathematical treatments, and then completely rewrote the book for the sixth edition of 1867. *D.N.B.*, 6, pp. 417–18; *Med. Times*, 1879, 1, 606.

Bird. He gave accounts of the experiments of Galvani, Aldini, and Matteucci, on the currents produced by the interaction of the nerves and muscles in the frog.<sup>23</sup> As a result of such investigations the idea had arisen that electric currents stimulated the muscles in animals and perhaps also controlled the production of the various secretions.<sup>24</sup> Electric shock treatment had already been used with success by Wilson Philip, who found that it could help patients in whom the nervous system was failing to stimulate the secretions or muscular activities, although the organs were otherwise healthy. It was known that division of the nerves of the eighth pair of the *par vagum* produced great difficulty in breathing and stopped the digestive process in the stomach and that galvanism was capable of restoring these functions. Philip had made use of such observations in the treatment of cases of 'habitual asthma'.<sup>25</sup> He applied the galvanic currents to the patients by means of two thin wetted metal plates, one placed on the nape of the neck and the other at the pit of the stomach. His battery consisted of thirty four-inch plates of copper and zinc, immersed in a five per cent solution of hydrochloric acid. The negative wire was found to excite the strongest sensation, but it seemed to be immaterial which way the current was passing. In either case electricity appeared to be capable of supplying the place of the injured nervous powers.<sup>26</sup>

In the 'electrifying room' at Guy's, Bird had voltaic batteries, Leyden jars and an induction coil with an automatic make-and-break key which he had designed himself.<sup>27</sup> With these devices he was able to administer electrical treatment ranging from strong shocks to feeble continuous currents. Following Faraday, Bird realized that electricity and galvanism were identical, though he claimed that there was a difference in the fact that electrical machines would give a small amount of electricity at high tension, whilst galvanic apparatus would produce larger quantities at low tension.

The usual method of treatment was to place the patient on a stool with glass, or other non-conducting legs, and connect him to the positive pole of the electric supply. This caused a rise in temperature, increase of pulse-rate and increased activity of the secreting organs. The patient was said to be in an 'electric bath', and if an earthed conductor were brought near him sparks could be drawn from the skin. Patients were submitted to this treatment in regular courses, sparks usually being drawn from the spine for periods of about five minutes at a time, or until skin eruptions began to appear. It was found to be highly effective in cases of chorea (St. Vitus's Dance) and in some forms of paralysis.<sup>28</sup> In some cases shocks were passed through the pelvis, but it was found that in spasmodic diseases the passage of electricity along the affected part made the disorder worse rather than better. Bird showed that where the nervous system itself had been damaged, or where brain damage was involved, as in epilepsy,

<sup>23</sup> Matteucci's Electro-Physiological Researches were then appearing, *Phil. Trans.*, 1845, 135, 283, 297, 303; *ibid.*, 1846, 136, 483; *ibid.*, 1847, 137, 231, 239, 243; *ibid.*, 1850, 140, 287, 645. Accounts of this work were included in the third and later editions of the *Elements*.

<sup>24</sup> See W. C. Wells, *Phil. Trans.*, 1795, 85, 246-62; E. Home, *Phil. Trans.*, 1801, 91, 1-22; *ibid.*, 99, 1817, 385-91.

<sup>25</sup> A. P. Wilson Philip, *Phil. Trans.*, 1817, 107, 22-31.

<sup>26</sup> A. P. Wilson Philip, *Phil. Trans.*, 1827, 117, 300.

<sup>27</sup> G. Bird, *Phil. Mag.*, 1838, (3), 12, 18-22.

<sup>28</sup> T. Addison, *Guy's Hosp. Rep.*, 1837, 2, 493. Seven cases are described; Addison mentions Golding Bird as the director of the treatment and his brother Frederick as 'our electrician'.

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electricity was incapable of bringing about any improvement. It appeared to act solely by arousing dormant nervous functions.

After employing these techniques for six years with some success, Bird wrote a report of his work in which he described the results of thirty-six cases treated between October 1836 and December 1840.<sup>29</sup> Later, in 1847, when Bird was chosen to deliver the Annual Lectures on *Materia Medica* at the Royal College of Physicians, he took as his subject the therapeutic value of electricity and galvanism.<sup>30</sup> The extension of *Materia Medica* to include electricity was a new departure, which was not by any means generally recognized at that time; but Bird maintained that any valid means of treatment was an important part of the physician's equipment, and electricity, which had proved its effectiveness as a therapeutic tool, deserved to be included. Indeed it was necessary to draw attention to this method of treatment because it was insufficiently understood and employed by the medical profession. Bird deplored the fact that far too few trained medical practitioners appreciated the real value of electrotherapy. It was generally only when all the traditional methods of treatment had failed that electrical treatment would be used as a last resort. The doctor would then frequently order the patient to be 'electrified' with no specific directions as to the kind, duration or intensity of the electrical treatment to be applied. Bird considered that this approach was of no value at all and stressed that electricity should be accepted in a controlled manner, along with the other more traditional modes of treatment.<sup>31</sup>

The reluctance of the qualified medical practitioner to use any form of electrical treatment inevitably led to its exploitation by charlatans, who without any medical training set themselves up as 'medical electricians'.<sup>32</sup> Many of these self-styled medical practitioners were able to attract substantial fees from gullible patients for the application of simple electrical devices. The success which frequently accompanied the use of such electrical treatment led to its being regarded as a general panacea. Bird regretted this state of affairs, especially as electrotherapy required no particular skill and when properly applied could bring relief in many cases where drugs and the traditional medicines were of no avail.

#### PULVERMACHER'S CHAIN AND THE 'ELECTRIC MOXA'

Before electrotherapy could become more widely used, convenient and reliable apparatus for administering shocks and weak currents was needed and it was for this reason that Bird welcomed the invention of Pulvermacher's hydro-electric chain as a valuable addition to the portable equipment of the general practitioner.<sup>33</sup> Each

<sup>29</sup> G. Bird, *Guy's Hosp. Rep.*, 1841, 6, 84–120. A later report by W. Gull appeared in 1852–3, *Guy's Hosp. Rep.*, 1853 (2), 8, 81–143.

<sup>30</sup> G. Bird, *Lond. med. Gaz.*, 1847, N.S., 4, 705, 799, 886, 975, 1064. Later published as *Lectures on Electricity and Galvanism in their Physiological and Therapeutical Relations*, London, 1847 (2nd ed. rev. and extended, 1849).

<sup>31</sup> See J. Althaus, *A Treatise on Medical Electricity, Theoretical and Practical*, London, 1859; M. I. Guitard, *Histoire de l'Électricité médicale*, Paris, 1854; Hector A. Colwell, *An Essay on the History of Electrotherapy and Diagnosis*, London, 1922.

<sup>32</sup> G. Bird, *Lancet*, 1846, p. 649. Magnetic telegraph operators employed by the Railway Companies were sometimes engaged in this practice.

<sup>33</sup> J. L. Pulvermacher, Viennese physicist and inventor, first described his hydro-electric chain in August 1850. See *Schmidt's Jahrbücher der Gesamten Medizin*, 1851, 70, 142. He visited Golding Bird in the winter of 1850 in order to demonstrate the invention to him, as a well-known physician. *Lancet*, 1851, p. 388.

link of this chain consisted of a small wooden core on which were wound two wires, one of zinc and the other of gilded copper, almost touching. The ends of these wires were shaped into loops so that one link of the chain could readily be attached to or separated from the next.<sup>34</sup> In use, the chain was first dipped in vinegar and then withdrawn; electric shocks could then be obtained from it proportional in intensity to the number of links employed. The current produced by the chain, though small, was at a high tension and would continue so long as any vinegar remained unevaporated on the wooden cores. A chain of fifty links was capable of administering a sharp shock and Bird recommended the use of such a chain in the treatment of paralysis. It was conveniently small, so that it could be carried about by the doctor and it was simple in operation so as to be easily applied by the patient himself. Some of Bird's favourable comments, written in a letter of introduction for Pulvermacher, were used in advertisements for the chain and, although this was common practice at the time, this led to complaints about his professional behaviour.<sup>35</sup> It would seem that Bird was the innocent victim of his own generous spirit, for he was far too high principled to descend to the practice of recommending any device purely for the purpose of having his name brought before the public in advertisements. Indeed, Bird criticized this practice since he felt that it tended to lower the dignity of his profession.

A minor discovery to which Bird can lay claim is that of the 'electric moxa'. It had long been believed that by creating a suppurating sore at some convenient point on the skin, relief could be obtained for certain inflammatory or congested conditions. The usual procedure had been either to produce a burn by means of the cautery or a piece of burning charcoal, or to introduce a seton in the form of a piece of horse-hair or a strip of linen under the skin so as to cause irritation. In any case the process was painful and most patients, not unnaturally, shrank from it. Bird was able to claim that he had removed the terrors for timid patients by the invention of the *electric moxa*.<sup>36</sup> This consisted of two small metal plates, one of silver and the other of zinc, which were applied over two small blisters raised on the skin for the purpose. The plates were connected together by means of a piece of copper wire and were held in place on the skin by ordinary bandages. After four to five days the blister under the silver plate was found to have healed completely, whilst that under the zinc plate had become a healthy suppurating sore. The apparatus had originally been designed as a means of applying electric stimulation locally in cases of hemiplegia, but Bird's modification of it made an ordeal of medical treatment much less alarming for the patient and was in this respect an advance on the older methods of applying the *moxa*.

#### CONTRIBUTIONS TO ANIMAL CHEMISTRY

Amongst his early electrical experiments, Bird had investigated the effects of electrolysis on solutions of albumen.<sup>37</sup> W. T. Brande had come to the conclusion that

<sup>34</sup> Pulvermacher's chain is described by M. I. Guitard, *op. cit.*, pp. 26-9, and Plate VI, fig. 12.

<sup>35</sup> *Assoc. med. J.*, 1853, pp. 316-8

<sup>36</sup> G. Bird, *Lancet*, 1847, 1, p. 677.

<sup>37</sup> G. Bird, *Phil. Mag.*, 1836 (3), 9, 109-15.



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strong electric currents caused albumen to coagulate at the negative pole, whilst weak currents led to coagulation at the positive pole. Bird was able to show that coagulation always occurred initially at the positive pole and that it was a secondary chemical effect of the electrolysis, caused by the formation of chlorine and hydrochloric acid at the positive pole. The apparent coagulation at the negative pole was the result of mechanical currents set up in the solution by the strong electric currents which Brande used.<sup>38</sup>

Since albumen was to be found in all the secretions, as well as the blood, Bird thought that its chemical properties were of fundamental importance in Animal Chemistry. There seemed to him to be a need for a more detailed study of this substance, as little attention had been paid to it since the work of Brande and Pearson,<sup>39</sup> apart from Babington's experiments on the coagulation of mixtures of soluble and insoluble albumen by the addition of solutions of simple salts.<sup>40</sup> From Babington's results Bird suggested that albumen was capable of taking part in double decomposition reactions. When mixed with sodium carbonate solution albumen was found to expel carbon dioxide, which indicated that it should be regarded as a weak acid. Also, salts of the mineral acids and the acids themselves were found to precipitate albumen from its solution in sodium carbonate, again favouring the view that albumen should be regarded as a weak acid. Bird suggested that these reactions could be used to identify albumen in mucus, saliva and blood serum.<sup>41</sup>

Digestive disturbances, accompanied by the secretion of excessive quantities of saliva and mucus also occupied Bird's attention. He pointed out that little had been added to the knowledge of the digestive system since Tiedmann and Gmelin had written about it<sup>42</sup> and that almost nothing had been done to elucidate the problems of morbid digestion. The difficulty was to distinguish between the different forms of mucus, saliva and gastric juices which escaped from the mouth in such conditions and Bird attempted to produce a set of simple chemical tests by which these substances might be positively identified.<sup>43</sup>

#### THE CHEMISTRY OF URINE AND URINARY CALCULI

Bird, like his predecessors Marcet and Prout, devoted a large part of his chemical work to the study of urine analysis and urinary calculi. His work was characterized by the systematic use of the microscope, by means of which he believed that it would be possible to identify even minute quantities of urinary deposits with a very high degree of certainty.<sup>44</sup> His papers on this subject were illustrated by sketches of the appearance of crystals of the various common deposits as seen under the microscope. Bird regarded the nucleus of any calculus as its most important part, for once a few solid particles were present in the urine crystallization was quickly induced and a

<sup>38</sup> W. T. Brande, *Phil. Trans.*, 1809, 99, 373–84; G. Bird, *Phil. Mag.*, 1837 (3), 10, 84–93.

<sup>39</sup> W. T. Brande, *op. cit.*, G. Pearson, *Phil. Trans.*, 1809, 99, 313–44. Brande was the first to demonstrate the presence of albumen in saliva and mucus.

<sup>40</sup> W. Babington, *Guy's Hosp. Rep.*, 1837, 2, 534–43.

<sup>41</sup> G. Bird, *Phil. Mag.*, 1838 (3), 13, 15–22; *Guy's Hosp. Rep.* 1838, 3, 35.

<sup>42</sup> F. Tiedmann and L. Gmelin, *Recherches expérimentales physiologiques et chimiques sur la Digestion*, 2 vols., Paris, 1827 (trans. from the German by A. L. Jourdan).

<sup>43</sup> G. Bird, *Lond. med. Gaz.*, 1841, 28, 571, 642, 722; 1842, 29, 13, 378; 1842, 30, 391, 426.

<sup>44</sup> G. Bird, *Guy's Hosp. Rep.*, 1842, 7, 211. In this paper the microscopic examination of calcium oxalate is described.

calculus formed. He therefore made a study of the calculi in the collection at Guy's from the point of view of the composition of their nuclei and it was upon this basis that he classified them.<sup>45</sup> There were three hundred and forty-two stones in the collection in Bird's day and most of them had been divided so that the chemical composition of their interior parts could be determined. Bird arranged the types of calculi into seven genera according to the composition of the nuclei, each genus being further subdivided into a small number of species.

It appeared that by far the commonest cause of calculus formation was the presence of an excess of uric acid or its salts. This product of 'vital chemistry' was always present in the urine and it had long been known that the volume of water present was often insufficient to dissolve all the uric acid. Prout had thought that the acid was held in solution as its ammonium salt, since it was always obtained in this form in excreted matter, and Bird agreed with this view.<sup>46</sup> After uric acid and its ammonium salt, calcium oxalate formed the nucleus in the next most numerous group of calculi.

His study of the calculi in the Guy's Hospital collection led him to the conclusion that there were only two great classes instead of several. First there were the organic calculi, formed within the body under the influence of the vital agency operating in the presence of some deranged function or functions of the body. The second group were calculi formed from inorganic sediments, derived from the wear and tear of healthy organs, resulting in the formation of excessive amounts of the inorganic salts.

Compounds such as uric acid and oxalic acid and their salts were clearly formed in the body by chemical processes. They appeared as a result of the rearrangement of the atoms and their formation could be accounted for by simple schemes of addition and subtraction of these atoms in the manner proposed by Liebig.<sup>47</sup> For example, by the addition of the elements of water urea might be converted into ammonium oxalate (C=6),

	C N H O		C N H O
1 atom of urea	2 2 4 2	2 atoms of oxalic acid	2 0 0 3
2 atoms of water	2 2	2 atoms of ammonia	2 6
	2 2 6 4	(less 1 atom of oxygen) ≡	2 2 6 3

In a similar way it could be shown that cystine might be related to uric acid and urea, although the presence of sulphur in cystine caused some difficulty.<sup>48</sup> By this method of regrouping the atoms, Bird was able to indicate how the substances found present in urinary calculi and other urinary deposits could have been formed from the tissues by oxidation. Soluble matters formed at the same time would be removed from the

<sup>45</sup> G. Bird, *Guy's Hosp. Rep.*, 1842, 7, 175-232.

<sup>46</sup> G. Bird, loc. cit., p. 183. The first identification of an ammonium urate calculus was due to Prout, *Med.-chir. Trans.*, 1819, 10, 389; *Ann. Phil.*, 1820, 15, 436-38.

<sup>47</sup> Compare Bird's use of this method in his book on *Urinary Deposits* (see note 8 above), and in *Lond. med. Gaz.*, 1843, 31, 677, 727, 761, 841, with Liebig's treatment in his *Animal Chemistry, or Organic Chemistry in its Applications to Physiology and Pathology*, ed. W. Gregory, London, 1842. (Reprinted, with a historical introduction by F. L. Holmes, 1964, New York and London, Johnson Reprint Corporation, pp. 128-51, 170-71.)

<sup>48</sup> G. J. Mulder had shown that albumen contains sulphur, *Pogg. Ann.*, 1838, 44, 443-45, and Bird thought that this might be the source of sulphur in cystine.

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body in the urine, whilst gaseous products such as carbon dioxide were lost during respiration. By the oxidation of muscular tissue for instance, it was possible to obtain some organic constituents of the bile, uric acid, urea and carbon dioxide,

	C N H O		C N H O
2 equivs. of muscle tissue	96 12 78 30	1 equiv. of the org. part of bile	76 2 66 22
4 atoms water	4 4	1 equiv. uric acid	10 4 4 6
8 atoms oxygen	8	3 equivs. urea	6 6 12 6
		4 atoms carbonic acid	4 8
	96 12 82 42		96 12 82 42

This approach to the chemistry of physiological processes had been adopted by Liebig because he thought that the function of the vital force was to disrupt the normal chemical forces of cohesion by setting up molecular motions in the substances of the tissues and of the food. In this way the compounds initially present were broken up and their atoms were then attracted into new combinations under the action of the vital force. The resulting products were either identical in chemical composition with the living tissues and were absorbed into the body, or else they were so different from those tissues that they were rejected by the body and appeared in the excretions.

**RESERVATIONS ABOUT LIEBIG'S THEORIES OF ANIMAL CHEMISTRY**

Although Bird was prepared to use Liebig's method for its convenience, he was not satisfied that it really represented the mechanism of the changes occurring in the body. The addition and subtraction of atoms was a ready way of accounting for the reactions which seemed to occur in the living body and it looked plausible enough on paper in the absence of more detailed knowledge, ' . . . but who shall dare to state that the great and mysterious agent presiding over the chemistry of the animal body proceeds in such a manner?'<sup>49</sup>

Indeed Bird felt that Liebig's theoretical concepts about the metamorphoses of tissues did not give a sufficient account for the mechanisms involved in vital chemistry. It seemed necessary to try to suggest a reason why the atoms should recombine in the observed manner once they had been shaken free from their original compounds by the vital force. Bird attempted to supply the reason from his knowledge of the behaviour of the elements in electrolysis. Each atom of matter was endowed with an electric charge, giving it polarity and it was due to these charges that they combined so readily. The chemical reactivities of the atoms were greatest when they were in the free or 'nascent' state and this was why they recombined so readily to form new and more stable compounds.<sup>50</sup> In this way Bird came close to reconciling the dualistic chemistry of Berzelius with the chemistry of organized bodies.

The successful application of chemistry to pathology and medicine seemed to indicate the fundamental simplicity of the life functions. It was so easy to 'throw the web of mystery over the chemistry of life' and to refer all the changes connected with

<sup>49</sup> G. Bird, *Lond. med. Gaz.*, 1843, 31, 727.

<sup>50</sup> G. Bird, *Lond. med. Gaz.*, 1848, N.S., 6, 929.

secretion and animal metabolism to the action of the vital force. This concept Bird was prepared to accept as a useful convention, but he thought that it was positively harmful if put forward as an expression of 'substantive and abstract truth'.<sup>51</sup> It seemed likely that all the non-organized products of vital chemistry would at length be brought under the influence of the recognized laws of chemistry and when this became possible such substances would be producible at will. It was possible, even then, to bring about in the laboratory some changes analogous to the physiological processes, and Bird believed that there was every likelihood that the extent to which this could be done would go on increasing.<sup>52</sup>

Bird agreed with Liebig's general contention that the vital force opposed itself to chemical changes of decomposition and oxidation which tended to destroy organized tissue. It was due to the relative balance of these two factors at different periods in life that the body grew in youth, maintained a steady state in health and then declined in old age or disease.<sup>53</sup> Liebig argued that since atmospheric oxidation was the external cause of wastage of matter in the tissues and fluids of the animal body, it must follow that whenever the circulation was increased a more rapid destruction of the tissues resulted from the increased volume of oxygen carried in the blood. Bird agreed that this view would seem reasonable and could be supported by many plausible arguments, but he insisted that it required experimental verification. He thought there were too many chemists and physiologists who were prepared to imitate Liebig's ideas without question. They should be regarded as 'signposts' rather than 'idols' and should not be accepted without reservation until they had been shown to agree with experimental observations.<sup>54</sup>

One deduction from Liebig's theory concerned the formation of uric acid and the proportions of this compound and urea, its oxidation product, in the urine. Uric acid was considered by Liebig to be the first product of the oxidation of tissues and the proportion of uric acid which was later converted into urea depended upon the degree of oxidation available in the body. From this it followed that the ratio of uric acid to urea in the urine should be inversely proportional to the rapidity of the circulation, degree of completion of the respiratory processes and heat of the body. Imperfect oxidation of the tissues led to the formation of uric acid whilst a more complete oxidation produced urea.<sup>55</sup> The theory was supported by the observations that the boa constrictor, which ate great quantities of animal food and then lay inert during its digestion, had been found to excrete largely uric acid, whilst the urine of

<sup>51</sup> Bird chose the influence of researches in organic chemistry on therapeutics, with particular reference to the depuration of the blood, as the subject for his second series of lectures on *Materia Medica* at the Royal College of Physicians in 1848. *Lond. med. Gaz.*, 1848, N.S., 6, 841, 929, 1018, 1105; 1848, 7, 141, 227.

<sup>52</sup> G. Bird, loc. cit., p. 841. The expectation that it would ultimately become possible to prepare animal and vegetable substances by normal chemical processes ran high amongst nineteenth-century chemists. See J. H. Brooke, *Ambix*, 1968, 15, 84-114.

<sup>53</sup> Bird suggested that the mucus linings of the air passages and the bile in the intestines were preferentially oxidised, protecting the tissues from destruction. His views on the relationship between chemical and vital forces are outlined in *Med. Times*, 1848-9, 19, 487, 565, 617, 635; *ibid.*, 1849, 20, 24.

<sup>54</sup> One exceptional application of Liebig's theories was made by his pupil, H. Bence Jones, *On Gravel, Calculus and Gout, chiefly an Application of Prof. Liebig's Physiology to the . . . Cure of these Diseases*, London, 1842.

<sup>55</sup> J. von Liebig, *Animal Chemistry* (repr. 1964), pp. 52f, 130f.

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the lion and tiger, which were also carnivorous animals, contained a high proportion of urea, due to the fact that they were more active and the increased rate of their circulation and respiration led to a more complete oxidation of their tissues.<sup>56</sup>

Bird challenged this theory because he said it was not borne out by clinical observations. It had been shown, for example, that in anaemia the proportion of uric acid to urea was diminished, whilst in fevers this ratio was increased. This indicated the exact opposite of Liebig's predictions, and since these observations had been made quite independently, Bird thought they could not lightly be dismissed.<sup>57</sup> The most telling objection to the theory came from the composition of the excreta of birds. Here was a whole group of creatures whose body temperatures were high and whose rates of respiration and heart-beat were both rapid, and yet they excreted a high proportion of uric acid. Bird thought this was a fatal objection to Liebig's theory and it led him to suspect that some of Liebig's other views on Animal Chemistry were too hypothetical and should be questioned.

For Liebig, the efficient agents of the vital functions were always chemical,<sup>58</sup> but Bird's clinical experience made him think that the animal organism was more involved than this. The body functioned as a whole under the influence of the nervous system and it seemed essential to include both nervous and mental influences as part of the total organism. Bird was not convinced, for example, that Liebig's chemical explanation of the origin of animal heat was altogether adequate. According to this, the whole of the heat in the animal body could be accounted for by the oxidation of carbon and hydrogen in the food or in animal fat. Liebig held that people who lived in colder climates ate larger quantities of carbohydrates, required for the support of respiration and the maintenance of the body temperature. Bird pointed out that the Italians, though they have a warm climate, nevertheless eat large quantities of oily and starchy foods, and in any case it was not possible to account for the whole of the heat generated in the animal body in terms of the combustion of the elements of the food alone. Bird thought that the nerves also had some part to play in making up the deficit. It was always found that the temperature of a palsied limb was lower than that of a sound one, and consequently it seemed likely that the electric currents circulating in healthy parts of the body played some part in raising the temperature.<sup>59</sup> Thus, for Bird the animal body was more than a mere chemical laboratory.

#### BIRD'S CHRISTIAN CONVICTIONS

Throughout his life Bird was an active Christian. He always thought of himself both as a physical and as a spiritual healer; and he tried to employ both his professional skill and his religious beliefs for the good of his patients. Such an outlook was not common in the medical profession, though in some of the medical schools attempts were made to foster Christian ethics amongst the students. It was Bird's hope that a Christian Medical Association might be formed in London with the object

<sup>56</sup> See L. N. Vauquelin, *Ann. Chim.*, 1812, 82, 197–204; *Phil. Mag.*, 1813, 41, 17–20.

<sup>57</sup> G. Bird, *Lond. med. Gaz.*, 1843, 31, 761, 765.

<sup>58</sup> J. von Liebig, *Animal Chemistry* (repr. 1964), pp. 16–18, 28, 36, 59, 88–90.

<sup>59</sup> G. Bird, *Lond. med. Gaz.*, 1847, N.S., 4, 705. The notion that the nerves played a part in the generation of animal heat had been investigated earlier; B. C. Brodie, *Phil. Trans.*, 1812, 102, 378–93; E. Home, *Phil. Trans.*, 1825, 115, 257–268. Liebig totally rejected it. *Animal Chemistry* (repr. 1964), p. 28.

of promoting a religious outlook among its members and he worked hard during the last year of his life to bring this about.<sup>60</sup> He had many critics who unjustly accused him of cant and hypocrisy, saying that medical students were far better employed in studying medicine and surgery than in reading the Scriptures, but there was also a large body of support for the scheme and ultimately the resolution to form the Christian Medical Association was passed at a meeting on 17 December 1853, held at Bird's London home.<sup>61</sup> The first public meeting of the Association was held in November 1854, at Exeter Hall, when a large number of Metropolitan medical students were present. However, the one who had done so much to promote the Association, Golding Bird, was missing, for he had died on 25 October 1854, at the early age of thirty-nine. He was buried quietly at Tunbridge Wells, where he had lived in retirement during the last few months of his life. He was a man of considerable talent and great personal ambition, who did much to establish the study of physics and chemistry—the collateral sciences—in medicine.

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<sup>60</sup> Correspondence containing both encouragement and criticism is to be found in *Assoc. med. J.*, 1853, pp. 1002–3, 1042–3, 1090, 1138, 1153, etc.

<sup>61</sup> The other founder members of the Christian Medical Association were: F. Le Gros Clarke, surgeon at St. Thomas's, J. H. Gladstone, the chemist; Charles H. Moore, surgeon at Middlesex Hospital; A. P. Stewart, Assistant Physician at Middlesex Hospital; H. Burford Norman, surgeon at the N. London Eye Infirmary; and J. C. Habershon, Demonstrator at Guy's.