Occasional paper

The life and work of Marshall Hall

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On the outskirts of Nottingham lies Basford, where Marshall Hall was born on 18 February 1790. He was the son of Robert, the first cotton manufacturer to use chlorine for bleaching; his brother Samuel was an acclaimed inventor. At the age of 14, an apprenticeship to a chemist in Newark marked the start of his interest in science. He became a medical student at Edinburgh in 1809, and distinguished himself academically not only in his medical studies but in extracurricular work on chemical affinities. Qualifying in 1812, he was granted the much-sought post of resident house physician and within the year had delivered a course of lectures on diagnosis.

Hall left Edinburgh in 1814 and studied in Paris, Göttingen and Berlin. He started in General Practice in his native town in 1817 and established a good reputation, enhanced by his critical comments on the common and indiscriminate use of blood-letting, leeches and wet-cupping. His views, published in *The Effects of Loss of Blood* (1824), were to revolutionize contemporary practice, and received international attention and respect. His industry was rewarded with the appointment of Physician to the Nottingham General Hospital in 1825, but within 12 months ambition drove him to London. He was again successful in clinical practice, and continued to write on several topics including *The diagnosis of disease* (1817) and *An essay on the symptoms and history of diseases* (1822), which he dedicated to his mentor, Matthew Baillie. He also made contributions on crush injury and traumatic shock.

His *magnum opus* was undoubtedly his experiments on the reflex arc, although its precise anatomy was not unravelled in his lifetime. In *Tractatus Homine* (1662), Descartes had introduced the concept of mind-body dualism, and contrary to all current thought, asserted that *automatic* actions occurred independently of the soul. We should remember that in the early 19th century the cord, like the brain, was thought to have a psychic function or soul. Reflex action was considered a manifestation of an informing spirit resident in the organism (Sherrington).

The physiological groundwork for neural function evolved slowly. Robert Wytty's experiments showed that the spinal cord was needed for the 'sympathy', i.e. connexions between different parts of the body—illustrated clearly in his description of the stretch reflex in 1763. Prochaska had realized motor and sensory nerves were connected, but related this to some latent, intrinsic force driven by an afferent stimulus: 'the vis nervosa is latent, nor excites action of the nervous system until excited by an applied stimulus ...'

Obsessed by hard work, Marshall Hall spent his evenings experimenting in his own home on frogs, lizards, eels, snakes and turtles. After making new and important observations on the capillary circulation he reported: 'I incidentally observed a remarkable phenomenon; the separated tail of the eft [newt] moved on being irritated by the point of the scalpel ... I conceived it impossible that any such phenomenon should exist in nature without such connection, and I resolved to pursue the subject.'

This was the root of a lifetime's growing preoccupation with the reflex activity of the nervous system. He was an indefatigable worker, experimenting each night, writing, often somewhat repetitiously, in the mornings and in his coach en route to patients' homes. He remarked in 1850, that he had 'devoted 25,000 hours to it, disentangling the maze ...'. This was the result of countless experiments in several species, which culminated in his classic first paper in 1833 on the spinal reflex function and reflex arcs. Marshall Hall recognized and described: (i) the cerebrum as the source of voluntary motion; (ii) the medulla oblongata as the source of respiratory motion; and (iii) the spinal cord as the middle arc of reflex function. He then described reflex activity:

'There is a fourth which subsists, in part, after voluntary and respiratory motions have ceased by
removal of the cerebrum and medulla oblongata, and which is attached to the medulla spinalis, ceasing itself when this is removed and leaving the irritability undiminished. In this kind of muscular motion, the motive influence does not originate in any part of the central nervous system, but at a distance from that centre: it is neither spontaneous in its action, nor direct in its course; it is, on the contrary, excited by the application of appropriate stimuli, which are not, however, applied immediately to the muscular or nervous muscular fibre, but to certain membranous parts, whence the impression is carried to the medulla, reflected, and reconduted to the part impressed, or conducted to a part remote from it, in which muscular contraction is effected.  

His 1837 memoirs were perhaps unjustly critical of the deductions of Prochaska and many other physiologists, but he allowed that Sir Gilbert Blane (1749–1834), physician to St Thomas’s hospital, came nearest the truth in his statement: ‘instinctive or automatic motions, can be exerted without the intervention of the sensorium commune, without sensation or consciousness.’ Blane had shrewdly observed reflex movement in an acephalic monster, and noted that a decapitated bee could still sting. In his Croonian lecture, Hall introduced the term diastaltic, referring to the reflex action through the cord. Diastaltic was ‘congeric with peristaltic’. He added:

'I observed that [for a spinal reflex] the following anatomical relations are essential:
1. A nerve leading from the point or part irritated, and into the spinal marrow;
2. The spinal marrow itself; and
3. A nerve, or nerves, passing out or from the spinal marrow,—all in essential relation or connection with each other.'

The work was to be controversial, and despite the clarity of his ideas, his papers repeatedly covered the same ground and were somewhat dull and disrespectful of other work. Consequently, he faced obloquy and was accused of plagiarism. Thomas Wakley, the editor of the Lancet, however, repeatedly defended him and was an influential advocate of both his work and integrity. Hall’s second paper on reflex action published in 1837 was rejected by the Royal Society, as was a later paper in 1847. He complained of unjust treatment to the president, the Earl of Rosse. This had some effect, since in 1850 he was elected to the Council of that august body.

Although his tireless, cheerful and painstaking care were highly regarded by his patients, he was rejected in some circles. Criticisms arose because he gave insufficient acknowledgement to past and contemporary workers, and tended to dismiss their work as missing the essential conclusions about reflex function. Personally, he was therefore to some extent isolated, and probably was difficult to deal with. He lectured by invitation at St Thomas’s hospital, but, like Duchenne and Oppenheim, he did not secure a hospital appointment. However, adulation, respect and encouragement he received in full measure on his frequent visits to France and America. Many of his estimated 19 books and over 150 papers were reprinted in European countries. In 1841, he was elected Fellow of the Royal College of Physicians, ironically, long after election to the FRS in 1832. He was granted the Goulstonian lecture in 1842 and was the Croonian lecturer 1850–52.

His contributions were many and diverse. In 1841 he published On the diseases and derangements of the nervous system, dedicated to Louis in Paris, a staunch supporter. The book is perhaps flawed by an undue concern with reflex and spinal function, which he invoked to explain: chorea, the impaired growth of limbs in infantile hemiplegia, and the signs of paralysis above the level of a spinal lesion. He considered epilepsy the result of emotionally-caused spasm of neck muscles impeding venous return of blood from the brain. However, his texts and memoirs also contained much sound and reasoned clinical neurology.

Later in life, he worked on drowning. He recognized the importance not only of lack of oxygen but of the accumulation of carbon dioxide that stimulates normal breathing, but failed to do so in the presence of suffocation. The suspension of exhalation of carbonic acid, even if incomplete, destroys life in a short time. He devised a form of artificial respiration, described in his pamphlet entitled Postural Respiration in Drowning. This method quickly replaced the existing one of warming and transport of the victim in France and Britain. He advocated transport of the semiconscious patient in the prone position rather than the conventional posture of head and shoulders raised. He warned of the danger of the tongue falling back and closing the glottis.

Experiments with opium and strychnine were early pathfinders in experimental pharmacology. He applied and exemplified his notions of spinal reflex function to many clinical observations such as anencephalic babies, idiocy, patients with cord transection, swallowing reflexes, pupillary reflexes, hemiplegia and cerebellar disease. With Barlow, he recorded the grasp reflex of the sleeping infant and of hemiplegia. He recognized spinal shock, which he accurately described as ‘a state of diminished excitability’.

Many of these phenomena were familiar to clinicians of the day, but Marshall Hall’s unique contribution was that he analysed them, and initiated numerous experiments to explore their basic pathophysiology. If his personal claims were at times
inflated, his work was of the highest order, and his honesty stands unsullied by a minority of contemporaries, motivated more by envy than by understanding. Less well known are his tireless campaigns against slavery and flogging.

The respected historian, Dr Walther Riese, considered that ‘he ultimately introduced the conception and the term of the reflex into neurology. He came very close to modern concepts and to Goldstein’s holistic approach …’. 12 Sherrington’s view of the prime importance of reflex function confirms the singular standing of his discovery: ‘The edifice of the whole central nervous system is reared on two neurones—the afferent root-cell and the efferent root-cell. These form the pillars of a fundamental reflex arch.’ 2 In the last year of his life, he was increasingly troubled by dysphagia. He died on August 11th 1857. Autopsy disclosed an extensive oesophageal stricture and ulceration with several perforations into pouches and sinuses. Its probable carcinomatous nature was not stated.

References
5. Hall M. Synopsis of the diastaltic nervous system: or the system of the spinal marrow and its reflex arcs, as the nervous agent in all the functions of ingestion and of egestion in the animal oeconomy. London, J. Mallett, 1850.