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HISTORICAL NOTES

Marshall Hall and the concepts of reflex action

In *Tractatus Homine* (1662) Descartes introduced the concept of mind-body dualism, and contrary to all current thought, asserted that *automatic* actions occurred independently of the soul. In the early 19th century the cord, like the brain, was thought to have a psychic function of soul. Reflex action was considered a manifestation of an informing spirit resident in the organism (Sherrington¹).

The physiological groundwork for neural function evolved slowly. Jan Swammerdam (1637–80) had discovered that isolated nerves were irritable if still attached to a muscle. Bell² and Magendie distinguished sensory from motor nerves. Albrecht von Haller showed that muscle itself also was irritable. And, Robert Whytt's experiments showed that the spinal cord was needed for the "sympathy" between different parts of the body; and he clearly described the stretch reflex in 1763. Procháska had realised that motor and sensory nerves were connected, but related this to some latent, intrinsic force: "the *vis nervosa* is latent, nor excites action of the nervous system until excited by an applied stimulus . . .".

But it was the controversial work of Marshall Hall in 1833 that plainly showed the reflex function—an "excito-motory system"³—of the spinal cord and nerves in animals after removal of the brain. This ended the misconceptions that the soul and psychic functions resided in the cord as well as in the brain. Since Hall failed to obtain a hospital appointment, his studies were based on experiments in his own home on frogs, lizards, eels, snakes, and turtles. His discoveries began whilst examining the capillary circulation:

"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."⁴

The demonstration by Golgi and Cajal of a network of neurons ("*retia nervosa diffusa*") that mediated complex movements, formed a foundation for observations of spasticity, clonus, and tendon reflexes by Charcot and Vulpian, Erb and Westphal, which were delayed until 1860–1880.

Marshall Hall recognised and described⁵ that the cerebrum was the source of voluntary motion, the medulla oblongata was the source of respiratory motion, and the spinal cord was 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 nervo-muscular fibre, but to certain membranous parts, whence the impression is carried to the medulla, reflected, and reconducted to the part impressed, or conducted to a part remote from it, in which muscular contraction is effected."

His 1837 memoir³ was critical of the deductions of Procháska 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 observed an acephalic monster, and noted that a decapitated bee could still sting.

In his Coonian lecture⁶ he 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, to 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."

Despite many objections to his argumentative and captious presentations and to the novelty of his conclusions, his work was eventually accepted by the neurological hierarchy. It is not without interest that he was made FRS in 1832, but Fellowship of the Royal College of Physicians was not granted until 1841.

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