XXVII. On professor Müller's account of the reflex function of the spinal marrow

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To cite this article: Marshall Hall M.D. F.R.S. (1837) XXVII. On professor Müller's account of the reflex function of the spinal marrow , Philosophical Magazine Series 3, 10:59, 124-129, DOI: [10.1080/14786443708649093](https://doi.org/10.1080/14786443708649093)

To link to this article: <http://dx.doi.org/10.1080/14786443708649093>

Published online: 01 Jun 2009.

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$$S' = \frac{1}{1^2} + \frac{1}{2^2} + \frac{1}{3^2} + \&c. = \frac{\pi^2}{6}$$

$$S' = \frac{1}{1^2} + \frac{1}{3^2} + \frac{1}{5^2} + \&c. = \frac{\pi^2}{8};$$

hence by the first formula we have, when

$$m = 1, S = \frac{\pi^2}{3} - 3 = \frac{1}{1^2 \cdot 2^2} + \frac{1}{2^2 \cdot 3^2} + \&c.$$

$$m = 2, S = \frac{\pi^2}{4} - \frac{39}{16} = \frac{1}{1^2 \cdot 2^2 \cdot 3^2} + \frac{1}{2^2 \cdot 3^2 \cdot 4^2} + \&c.$$

$$m = 3, S = \frac{5\pi^2}{54} - \frac{197}{216} = \frac{1}{1^2 \cdot 2^2 \cdot 3^2 \cdot 4^2} + \frac{1}{2^2 \cdot 3^2 \cdot 4^2 \cdot 5^2} + \&c.,$$

and so on to any extent.

From the second formula we get, when

$$m = 1, S = \frac{\pi^2}{16} - \frac{1}{2} = \frac{1}{1^2 \cdot 3^2} + \frac{1}{3^2 \cdot 5^2} + \&c.$$

$$m = 2, S = \frac{3\pi^2}{256} - \frac{1}{9} = \frac{1}{1^2 \cdot 3^2 \cdot 5^2} + \frac{1}{3^2 \cdot 5^2 \cdot 7^2} + \&c.$$

$$m = 3, S = \frac{5\pi^2}{4608} - \frac{43}{4050} = \frac{1}{1^2 \cdot 3^2 \cdot 5^2 \cdot 7^2} + \frac{1}{3^2 \cdot 5^2 \cdot 7^2 \cdot 9^2} + \&c.,$$

and so on as far as we please*.

By means of the general relation

$$A = \frac{1}{m p} (B - C),$$

a variety of other series may be summed with great ease, all those, for instance, investigated by Mr. Phillips, with the aid of definite integrals, in the *Philosophical Magazine* for 1832, vol. xi. A single example of the mode of proceeding will be sufficient,

[To be continued.]

XXVII. *On Professor MÜLLER's Account of the Reflex Function of the Spinal Marrow. Communicated by MARSHALL HALL, M.D., F.R.S., &c.*

[Continued from p. 57.]

“THE previous considerations however lead us only to the determination of the fact, that, wherever general twitchings originate from local sensation, this takes place by no other

* A valuable paper upon the summation of this class of infinite series, by Mr. Woolhouse, may be seen in the Appendix to the Ladies' Diary for 1836, and another upon the same subject, by Mr. Rutherford, in the Diary for 1837.

connexion of sensorial and motor fibres than through the spinal chord. In very many cases, however, after local excitation of the nerves, there ensue not general, but local twitchings, which, however, must also be constantly explained by the spinal marrow being considered as the connecting link between the sensorial and motor fibres. The cases which may be arranged here, are the following :

“ 1. The simplest is the case, in which the local sensorial stimulation, propagated to the spinal marrow or brain, excites merely local movements, and these in the parts lying in the neighbourhood, whose motor fibres proceed from the spinal marrow near the sensorial. To these belong the spasms and tremblings of the limbs which are severely burnt, &c. Certain very excitable parts of the organism, as the iris, contract extremely easily, when only slight stimuli excite other sensorial nerves, and the excitement of the latter is propagated to the brain, and from it through the oculo-motor nerve to the short root of the ciliary ganglion, the ciliary nerves, and the iris. It has long been known that the iris is not excitable by light, and that light acts on it only through the medium of the optic nerve and the brain; this results from the experiments of Lambert, Fontana, and Caldani. Rays of light passing through a small cone of paper, or through a small hole in a piece of paper, and thus transmitted through the pupil, and falling on the retina, immediately induce motion in the iris, but have no power when they fall on the iris itself. The iris of an amaurotic eye moreover is immoveable, as long as the sound eye is closed, but contracts when the light excites the optic nerve of the latter. The exceptions in which the optic nerve of the amaurotic eye still retains mobility*, may easily depend on an incomplete amaurosis, or if only one eye was amaurotic, the cause of the motion of the iris in the amaurotic eye was the open state of the sound eye. The mobility or immobility of the iris of an amaurotic eye can and is only to be investigated when the healthy one is closed. Every observation in which this precaution has not been taken is valueless; Van Deen has therefore deceived himself in his otherwise very valuable work†, when having in a rabbit cut away one hemisphere of the brain, and the optic nerve of the same side, he saw the iris contract on the application of a light, and therefore concluded, that the optic nerve had no influence on the iris. For as Van Deen brought the light before both eyes (*ante oculos*), the same result would follow as when the iris of an amaurotic eye is moved by the influence of light on the sound

* See Tiedemann in his *Zeitschrift*, i. p. 252.

† *De Differentia et Nexu inter Nervos Vitæ animalis et organicæ.*

one. Tiedemann's interesting discovery that the arteria centralis retinæ is accompanied by a fine twig from the ciliary ganglion, cannot in this case explain anything. For all vessels are accompanied by nerves; but this twig is distributed with the arteria centralis, and is in no proved connexion with the retina. This reflex action from the brain to the iris takes place through the oculo-motor nerve, which according to Mayo's experiments at every stimulus excites a contraction of the iris*. We know from the same author that the cerebral end of the divided optic nerve, when stimulated, still induces contraction. Thus, in the contraction of the iris there is presented a kind of "Statik" of the excitement between centripetal-sensorial and centrifugal-motor action through the medium of the brain. Other nerves also may alter this *equilibrium*, as the sensorial branches of the trigeminus, for cold water thrown into the nose produces contraction of the iris. To these more simple instances of reflected excitement belongs also the winking of the eyelids from long impression of light, or from a loud sound (what has the optic nerve to do with the auditory?), or from a threatening impression on the sight.

"Further, to these belong the contraction of all the muscles of the perinæum, the sphincter ani, levator ani, bulbo-cavernosus, and ischio-cavernosus in the emission of semen, in consequence of the irritation of the sensitive nerves of the penis; in these cases the spinal marrow is the connecting link between the sensations and motions. Exposed muscles, whose motor nerves are themselves coincidentally stimulated in the stimulation of the muscles, do not require these centripetal and centrifugal actions to excite contractions. But the muscles which are covered by sensitive membranes, and do not themselves lie exposed to stimuli, must receive the stimulus to motion through the sensorial excitement of their sensitive covering, the centripetal action of these sensorial nerves, and the centrifugal motor excitement from the brain. Thus the contractions of the glottis and air-passages induced by irrespirable acid gases, cannot result immediately from the excitement of these passages, but from the centripetal-sensorial and centrifugal-motor excitement. Brachet has very fully proved this. For if the nervus vagus on both sides of an animal be divided, an exciting chemical substance introduced into the trachea ceases to act as a stimulus to cough. The cough from stimulus in the air-passages is induced only by sensorial centripetal, and centrifugal motor excitement. It is the same with the contraction of the sphincter ani and sphincter vesicæ

* Magendie's *Journal de Physiologie*, iii. 348.

urinariæ. These muscles cannot themselves be excited to contract by the stimulus of the excrement and urine, but these substances act on the sensitive nerves of the mucous membrane, and excite the spinal marrow, which, constantly charged with motor nervous power, acts back on these muscles; therefore after injury of the spinal marrow the contraction of these muscles ceases.

"2. The second case is, where the sensorial excitement being quite local, the reflex acting excitement from the brain is more diffused, as shown already in the phenomena which accompany cough, in which not only the *nervi vagi*, but the spinal nerves supplying the thoracic and abdominal muscles, act in coincidence. It is the same with a number of spasmodic respiratory motions, sneezing, hiccup, vomiting, &c., all of which are produced by stimuli of the sensitive nerves of the system of mucous membranes of the respiratory organs and intestinal canal, which stimuli are reflected to the brain, and thence put in action the source of the respiratory motions in the medulla oblongata. I have already in p. 333* mentioned the remarkable peculiarity, that the system of respiratory nerves may be put in action by local stimuli applied to all mucous membranes. For all the motions, cough, sneezing, vomiting, spasmodic involuntary discharge of fæces, involuntary forcible passage of urine, arise from violent irritation of the mucous membranes of the fauces, œsophagus, stomach, intestines, and respiratory apparatus. Sneezing has been explained as a spasmodic affection of the diaphragm; Tiedemann† and Arnold‡ still speak thus of it: however, it has probably nothing to do with the diaphragm, for it is a violent expiration, and the diaphragm is no expiratory muscle, but the contrary. Under the incorrect supposition that sneezing resulted from the diaphragm, the stimulus of the nasal nerves was considered to be propagated to the sphenopalatine ganglion, the Vidian nerve, the sympathetic, the cervical nerves, the phrenic, the *accessorius Willisii*, and the facial§. The highly talented Tiedemann endeavours also to prove that sneezing does not result from a reflected stimulus from the brain, and supports himself on the fact, that a man has still sneezed from snuff, without any sense of smell. Why should he not, seeing that when the nerves of smell are deficient, the nerves of common sensation in the nose, the nasal nerves, have still as in healthy men the perception of tickling? But by minute anatomy the explanation of a sympathy can still only be

* See note p. 53.

† *Zeitschrift*, i. 278.

‡ *Der Kopftheil des Vegetat. Nervensystem*, p. 181.

§ Tiedemann, *l. c.*, p. 278.

attained through the sympathetic nerve. Yet how can sneezing be explained by a connexion of nerves, by which everything and yet indeed nothing can be explained? We may explain anything by it, because the sympathetic is connected with almost all nerves; and yet nothing can be explained by it, because there is not the most remote reason why a stimulus of this nerve of the nose should produce sneezing and not many other motions, as, for instance, an increased motion of the intestinal canal. Nothing can be explained by it, because in no connexion of the sympathetic with another nerve is there an actual union of their filaments. In sneezing, for instance, there is a violent contraction of all the muscles of respiration; all the primitive filaments of the intercostal nerves therefore, which produce contraction of the thoracic and abdominal muscles, must therein be irritated. But how could all these filaments be irritated from the sympathetic nerve, which adds to each of these nerves a fasciculus of filaments, that, far from uniting its primitive filaments with all the primitive filaments of a spinal nerve, only receives them with the latter from the spinal marrow? Now since primitive filaments cannot impart anything to others lying near them, especially in a motor root without a ganglion, so in this case the sympathetic affection of all the primitive filaments of an intercostal nerve by the sympathetic nerve is a perfect impossibility. All these sympathies of sneezing, coughing, vomiting, are done away with, as soon as we know of the reflex function of the spinal marrow and brain, which we have before proved; and no further difficulty lies in the way of the explanation, as soon as one proceeds from the fact, that all respiratory nerves, the facial, vagus, accessorius, phrenic, and the other spinal respiratory nerves of the trunk, by their origin from the medulla oblongata, or their dependence on it, may be easily excited to convulsive motions in muscles, by all stimuli, which are conducted from the sensitive nerves of the mucous membranes to the spinal marrow or the medulla oblongata.

“On every violent stimulus in the intestines, the urinary bladder, and the uterus, contraction of the diaphragm and the abdominal muscles easily ensues, lessening the cavity of the abdomen; and its contents are forced upwards when contained in the stomach (vomiting), or downwards through the rectum or urinary apparatus, or through the genitals as in parturition. The forcible expulsion of fæces is the same phenomenon in the lower part of the intestinal canal as vomiting is in the upper. The forcible expulsion of urine presents the same motions in mental passions; parturition calls into action the same muscles as produce expulsion upwards in vo-

miting; the parturition too which takes place even after death, just like the firm application of the pharynx round a finger introduced into it in a beheaded young animal, shows us, of what important influence, and how intimately connected with life, this power of the spinal marrow is, of being excited to motorial discharges by local excitations of its sensitive (or perceptive) nerves. In many of the stimulations belonging to this class, in vomiting, &c., the sympathetic nerve may indeed take some part, but it is nothing more than that of reflecting, like all other sensitive nerves, the stimulation to the sensorium. But that it may have this action may be shown by an experiment on rabbits; for instance, by tearing the splanchnic nerve in the abdomen, I have observed frequent twitchings of the abdominal muscles, and have repeatedly seen the same phenomenon in other rabbits, though the same experiments did not succeed with me in dogs.

“3. In the cases mentioned under 2, the reflected motion is the motion following on perception, and diffused through a large series of nerves, the respiratory nerves, and it arises most easily from stimulation of the mucous membranes; but in greater stimulation the diffusion of the reflected motions may be still greater, and, affect nearly all the nerves of the trunk, when the irritable condition of the spinal marrow is extensive. Among these cases are to be reckoned those of sporadic cholera, (I do not mention Asiatic cholera because of the obscurity of that disease,) in which, when severe, spasms may take place even in the trunk.

“4. In the reflected motions which arise from violent perceptions of the cutaneous nerves, and not those of the mucous membranes, the group of respiratory motions is not brought into associated action, but there more usually occur spasms of the muscles of all the nerves of the trunk without spasmodic respiratory motions. The highest degree of this is the epileptic spasm from local nervous affections and the tetanus traumaticus from injury of a nerve.

“If the first demonstration of the phenomena of reflection in the first part of this manual * which appeared in the spring of 1833, and which I have here enlarged with reference to the observations of Van Deen, be compared with Dr. Marshall Hall's demonstration, a remarkable correspondence is found in the ideas and instances.

[To be continued.]

* See note, p. 53.