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XV. *History of a Fœtus born with a very imperfect Brain; to which is subjoined a Supplement of the Essay on the Use of Ganglions, published in Philos. Trans. for 1764: By James Johnston, M. D.*

Read March 5, 1767. **I**N October 27, 1765, a monstrous birth was brought me by a midwife of this place. It was a female child come to its full time, in which the whole scull excepting its basis was wanting: this was covered with something which had the appearance of red flesh. I found it to consist of different membranes; and in a small depression, in a back part of the basis of the skull, lay the brain, such as it was, not exceeding the size of the kernel of a filberd nut, flaccid and membranous. I could not have positively pronounced it brain, had I not traced its continuation into spinal marrow, down the channel of the vertebræ. The eyes were perfect and sound. The optic nerve of one eye I examined, though not large enough, yet in thickness was almost equal to one third of the spinal marrow, which was too small likewise.

Upon opening the breast and abdomen, all the organs contained therein seemed in structure perfect, properly situated and full grown. The heart in particular was plump and strong. This infant had not  
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breathed; its lungs, which were perfect, sunk in water: yet the mother and midwife felt it active and strong just before delivery.

This child had tongue, nostrils, eyes, and ears, and every other part, excepting the brain, perfect and plump; as in the healthiest infants come to their full time.

Many births similar to this, in most circumstances, are recorded in the Transactions of the Royal Society, N<sup>o</sup>. 99. 226. 228. 242.

1. Such of them as were born alive, died soon after birth, though lively and strong in the womb, and perfect in all parts, the brain and scull excepted.

2. In that of which an account is given by Dr. Preston (Philos. Trans. N<sup>o</sup>. 226.), the celebrated anatomist Monf. du Verney traced the eighth and ninth pairs, the medulla spinalis, and the intercostals. The child was well proportioned, the cranium, brain, and cerebellum were wanting; in lieu thereof, remained only a substance, like congealed blood, covered with a membrane.

3. In a case related, and largely commented upon, by the celebrated Wepfer \*, which differs in many respects from other children said to be without brains; the child was well proportioned, its head of the usual size, but its brain had degenerated into vesicles, or hydatides, each of which had its blood vessel (might one from thence infer the natural state of the cortical substance of the brain to be cellular?) and the optic and auditory nerves took their rise from three portions of medullary substance lying upon the sphenoid bone near the sella equina.

\* Manget Biblioth. Auc<sup>t</sup>. Vol. II. p. 339.

4. These singular existences afford useful inferences, and shew that the irritability of the heart, is capable of being sustained, by very low degrees of the nervous power, while that irritability is kept up by the fostering heat of the mother. This feeble life is soon extinguished, when the influences of the mother's warmth and circulation cease (N°. 1). Such infants die as soon as born, or soon after.

5. Such examples more consequentially than experiments demonstrate that the spinal marrow is the principal origin of the intercostal nerves (N°. 2.); and better than ligatures illustrate their vast importance for,

6. From the plump state of the body, and vigorous appearance of the heart, it is evident the circulation, and the development of the several organs, had been carried on properly in the fœtus; and that the irritability of the heart derived a sufficiency of nervous influence from the intercostal nerves, and its ganglions, and these again from the spinal marrow, for growth, and that state of existence.

In the essay which was published in the Philos. Transf. for 1764, I endeavoured to prove, that as ganglions are seated constantly on the intercostal nerves, and on others sent to muscles whose motions are involuntary, and are very rarely seen on nerves sent to voluntary muscles, and not at all on the sensory nerves; it seems that, by means of ganglions, the motions of the heart and intestines and uvea are rendered uniformly involuntary. I was then, and am still sensible that various strong objections may be made to this doctrine, in common with every other system whatever; but especially every system which pretends

to explain any thing relating to so obscure a part of the animal œconomy, as the nerves, and their faculties. But as this doctrine, weighed against what has been said against it, seems to me to have a considerable preponderance of evidence and probability in its favor, I shall now state the strongest objections which have been opposed to it, and endeavour to answer them.

1. The chief objection which has been made to this doctrine arises from observing, that the spinal nerves, have each one *ganglion*: and that one or two have been observed *sometimes* upon the subdivisions of the fifth pair of nerves.

With respect to the first, it is in the highest degree probable that the *ganglion* observed upon each of the spinal nerves respects solely the intercostals (see Winslow's description of that nerve, Exp. Anat. p. 462.) and is there seated to set apart for the uses of the great sympathetic nerves the *furculi*, which are from each of these ganglions detached to that great pair of nerves. 1. Because the spinal nerves have no other *ganglion* in any part of their course. 2. When nervous twigs are sent off from the spinal nerves, to join others besides the *intercostals*, they have no *ganglions*; as the *nervi accessorii* sent from the upper spinal nerves to join the eighth pair: and the first of the spinal nerves, and the last of the *nervi sacri* are represented by Vieussens\* as being without *ganglions*, and sending no contribution to the intercostals.

Were the *ganglions* only little knots indiscriminately suitable for nerves, which carry the commands of

\* Neurograph.

the will, and those which do not, one might expect them equally frequent on the nerves of the limbs, as at the rise and on the course of the *intercostals*, where they are numerous, large and constant: on the nerves sent to the *sensory organs*, and on the *phrenetic* as well as the *lenticular ganglion* from which the Iris is provided with nerves. In a word the solicitude, so to express myself, and the constancy with which all parts whose motions are involuntary are provided with nerves furnished and beset with *ganglions*; and the great scarcity and rarity of them on nerves detached to muscles subject to our volitions, and the total want of them on the sensory nerves, sufficiently bespeaks their general distinction and use, notwithstanding a few seeming exceptions. I say seeming, because some that are alledged as exceptions are not permanently and constantly found. To ascertain the use and importance of any part of animal structure, we ought to be certain that it is constantly found in that situation; if, on the contrary, it be only accidentally seen, and not perpetually, we can neither assign any important use to it, or draw any important doctrine from it, and have great reason to suspect it to be rather some morbid phenomenon than otherwise. Now this is the case with respect to the *ganglia* described by Mekelius as seated on twigs of the second and third branches of the fifth pair of nerves; betwixt which and other *ganglions* Baron Haller makes a very essential distinction, particularly the *ganglion ophtbalmicum*, which he says is constant and perpetual, whereas these beforementio-

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ed are not so, for he \* mentions his having examined bodies in which they were wanting.

But, supposing the utmost in favour of these *ganglia* of the fifth pair: the nervous twigs on which they have been observed are chiefly distributed to the salivary and mucous glands, about the tongue, jaw, palate, throat, and nostrils, and therefore may be supposed to have some use in glandular secretion; for we see the glandular parts in the *abdomen* are supplied by the *intercostals* as well as the muscular fibres of the heart and intestines.

2. It has likewise been objected that the *intercostals* send some branches to parts under the controul of the will as the *pharynx* and *diaphragm*; as well as to the heart and intestines, not subject to that controul.

It is well known that the *pharynx* has its most considerable supply of nerves, from the eighth pair: and the *diaphragm* is rendered paralytic by tying or cutting the *phrenic* nerves distributed to it, which shews that its motions have very little if any dependence on the minute filaments, which it receives from the *intercostals*. The motions however of both these parts are properly speaking of the mixed kind, sometimes being *voluntary*, at other times *involuntary*: thus the *diaphragm* moves when we are asleep, as well as when we wake, and continues for some time, even during a profound apoplectic fit: and though we can raise the *pharynx* by an effort of the will, yet in the action of deglutition its motions are chiefly *involuntary* from the *stimulus* of the food, passing down the gullet, as has been shown in the most ingenious

\* Haller, El. Phys. T. IV.

work of a great and worthy man lately deceased, an *essay on the vital and involuntary motions of animals*, by Dr. Whytt\*.

And it deserves to be remarked, that parts, whose motions are of this mixed kind, will be found to have generally a double distribution of nerves, namely such as *are without ganglions*, to subject them to the *will*; and such as *have ganglions* occasionally to support those motions of the same parts which go on without the will; but, these supplies from the *intercostals* being very minute, their action is generally called forth and assisted by some degree of uneasy sensation or stimulus.

If these anatomical objections have not force enough to overthrow our doctrine, the following of a physiological nature, it is presumed, will not be more formidable.

3. It has been objected, that if the *ganglia* intercept the communication between the *sensorium commune* and those parts whose nerves are derived from them, they ought not only to intercept the commands of the will, and render the motion of these parts not voluntary, but they ought also to prevent the impressions made on the nerves of these parts from being conveyed to the *sensorium commune*, *i. e.* these parts ought to be insensible. The contrary of which is true; for example, the intestines, whose nerves come from *ganglia*, are among the most sensible parts of the body. And if the uneasy sensation in the lungs, in asthmatic cases, was not conveyed to the *sensorium commune*, how could the will redouble the action of the *diaphragm* and the *intercostal muscles*?

\* P.

To this I answer, that the interruption of the parallel direction of the nervous filaments, which probably takes place in *ganglions*, may intercept the efforts of the will, and also render the sensations of parts wholly supplied with nerves from *ganglions*, more indeterminate and confused than in other parts; which in fact is the kind of sensation proper to these parts, yet without rendering such parts totally insensible, which is well illustrated by morbid cases. Paralytic diseases shew that the nerves may be so affected as to become incapable of conveying the commands of the will, and yet remain sufficiently capable of re-conveying sensible perceptions. In the palsies which are most frequent, the parts rendered immovable by the disease have as quick a feeling as those that remain moveable by the will, and, what by the way deserves attention, are often moved involuntarily, especially upon the application of any painful *stimulus*: and it is observable that the paralytic limbs, which are not to be moved by our volitions, are often called into action, when the paralytic person is suddenly thrown into some vehement passion: just as we observe the same cause to produce extraordinary commotions in the heart and intestines, &c. notwithstanding the will, coolly exerted, has no power over these parts.

Various observations show that the feelings of parts whose nerves come from *ganglia* are by no means acute, but blunt and confused. We have it on the authority of the great Harvey, confirmed by the experiments of Baron Haller, that the heart, though highly irritable, is yet when touched hardly sensible of it. Dr. Haller asserts that the lungs, liver, spleen  
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and kidneys, all supplied with nerves from the *intercostals*, have been cut in pieces without the animal's seeming to feel pain. And what is less liable to exception, operations and diseases in the kidneys, and ulcers in the lungs, shew their feelings not to be exquisite\*.

The stomach, which has a very large portion of the eight pair of nerves bestowed upon it, by ligatures of this nerve, loses its sensibility and contractive power so perfectly, that the food neither passes down the œsophagus, nor is concocted in the stomach, but, by spontaneous corruption there, puts on the appearance of the fæces themselves in the great intestines †. This proves what was asserted concerning the eighth pair, as being a sensory nerve; and 'tis in consequence of the sensibility which the stomach derives by means of this nerve, as well as its own structure, that the stomach becomes the principal seat of hunger: "And (to use the words of Dr. Whytt ‡), as it is affected with a more disagreeable sensation, when we have wanted food for any considerable time, than the guts, so likewise it is more sensible of an agreeable feeling from grateful food, and in these respects it may be said to be more sensible than the intestines." Baron Haller has observed that parts which have nerves from *ganglions* are not so distinctly painful as others, "ut anima non adeo accurate locum dolentem distinguat, sed obiter utcunque, et cum aliqua latitudine §." And this confused indeter-

\* Haller. Irritab. et Whytt. Path. Essays.

† See Vieussens, Bruni, Morgagni, Haller.

‡ Path. Ess. p. 155.

§ Elem. Phys. T. IV. p. 407.

minate sensation is the sensation proper to the intestines, though in many instances they are the seat of exquisite pain; yet, in consequence of the concurrence and commixture of the nervous filaments in *ganglia*, any painful disease seated in the intestines, or in others of the viscera contained in the *abdomen*, is less determinable to its particular seat, or rather is more apt to affect the parts contained in the *abdomen*, not primarily affected, than diseases of a painful nature, which are seated in the stomach itself, or other parts whose nerves are unsupplied with *ganglions*. And this leads to a natural solution of the cause of that sympathy, that communion of sensation, or imputation of sensation, which so frequently takes place, in the diseases of the contained parts of the abdomen, from which some writers (Linn. \*) have very conclusively argued for the necessity of such a communication of the nervous filaments in *ganglia* as we contend for, from the best anatomical authority, and which appears to have such important uses in the animal œconomy, and to be the occasion of that sympathy or confusion of sensation among the *abdominal viscera* in particular †.

\* In Haller. El. Phys. T. IV. p.

† The solution of the problems concerning the sympathetic affections, or consent of parts, has employed the hands and pens of many ingenious writers; and if all the questions relating to it were discussed, volumes might be filled, and the subject neither exhausted nor understood. The ingenious Dr. Whytt has with great acuteness shewn that sympathy in general is only to be accounted for from a sentient principle, seated in the *sensorium commune*, where all nerves begin, and communicate; his objections to particular sympathies arising from a connexion of nerves in *ganglions* seem inconclusive; for he remarks that such a communication as is supposed in *ganglia* to occasion sympathy,

4. It is objected also that every voluntary muscle in the body becomes involuntary when it is strongly stimulated, for example the *acceleratores urinæ* are quite voluntary in their action of expelling the urine, but act involuntarily in expelling the *semen*.

When we consider the state of the soul and body under any great commotion of mind, we find the usual operations of the mind itself are not only interrupted, but those parts of the body too which the will cannot controul are now agitated by the storm; for every one has experienced that the heart and *viscera* in general are vehemently affected by strong passions. The mind is in its turn re-acted upon, by very strong bodily sensations; it being well known that muscular parts, which are ordinarily subject to our volitions, cease to be so if any part is stimulated by exquisitely pleasing, or excessively painful sensations; under such a *stimulus*, they are necessarily contracted or convulsed. But it is not therefore to be concluded that the gentle *stimulus* of the blood on the surface of the heart, and of the air, food, and intestinal juices on the intestines, of which the mind has no conscious perception at all, much less a disagreeable one, can lay it under any similar necessity, as some have argued; and therefore the independence

would cause a confusion in our sensations as well as in the motions of our muscles.—with respect to sensation I have remarked that confusion or indeterminate sensation, is that, which is proper to parts whose nerves arise from *ganglions*—and that the muscular motions of these parts are by means of *ganglions* not regulated by the will, but subsist by the application of an irritating cause: and, instead of proving that sympathy in the *abdominal viscera* does not arise from *ganglions*, they prove that it does. See Whytt on diseases of the nerves.

of these motions on our minds, cannot be explained from this analogy, which does not subsist in fact. This objection therefore can have no force against our doctrine, however it may recoil upon another; as all voluntary muscles whatever may be excited to contractions by irritations excessively painful or pleasing, the contraction in such cases being involuntary, necessary, and uncontroulable. But the *stimuli* that affect the heart and other parts, whose motions are naturally involuntary, are not of this class and strength, and indeed are so little perceived by the mind, as to lay it under no such necessity, as that *stimulus* which renders the action of the *acceleratores urinæ* involuntary in expelling the *semen*.

5. Lastly it has been objected, that, though the motions of the *uvea* are involuntary from light affecting the eye; they are truly voluntary when it contracts in order to the distinct vision of an object placed near the eye, whose minute parts we want to observe accurately.

It seems on the contrary certain, that the contractions of the *uvea*, in order to distinct vision, equally arise from different impressions of light on the *retina*, and are equally involuntary, and solely dependant upon the impressions of different degrees of light in all cases: the distinction indeed is chiefly verbal; as it is granted, that the motions of the *uvea* are involuntary from light affecting the eye, that is, different degrees of light striking upon the *retina* necessarily occasion more or less of contraction in the pupil. But as vision, considered as distinct or indistinct, is occasioned by various impressions of light upon the *retina*, the contraction of the pupil necessarily fol-

lows, according to the degree of that impressiōn : in the case of distant objects, the faint impressiōns of light on the *retina* make the pupil contract little, and it remains wide ; for dilatation is the natural state of the pupil. In observing very near objects, the light is *cæteris paribus* stronger, and stimulates the *retina*, and contracts the pupil more.

In a word, the contractions of the *uvea* arise from the sensations of the *retina* involuntarily and uniformly, according to an invariable law and connexion ; otherwise why does the pupil constantly become immoveable, when by a *gutta serena* the *retina* becomes insensible ? Let any one observe the motions of the pupil, by the help of a mirror, they will always find it impracticable to subject them to the will. Indeed it is clear from experiments, as well as diseases, that the *iris*, like all other parts provided with nerves from *ganglia*, has but a dull degree of feeling, and is moved entirely independent of the will \*. “ What persuades me, says M. de Haller, “ that the *iris* is much less sensible than the *retina*, “ is, that if, after having pierced the *cornea*, you irritate or cut the *iris*, it is not therefore contracted, “ whereas the least increase of light makes it contract ; which evidently proves that this contraction “ does not depend upon the proper sensibility of the “ *iris*, but on that of the *retina*. The *gutta serena* “ serves to prove the same thing, the *iris* being no “ ways changed in that disease, any further than it “ is deprived of motion, from the sensation of the “ *retina*, being destroyed by a palsy of the optic “ nerve.” Essay on Irritability, p. 31.

\* See Whytt, Ess. on the Invol. motions. Le Cat, on the Senses. Haller, Elem. Phys. &c.

To conclude, the *ganglia*, respecting their structure, may justly be considered as little brains, or germs of those nerves detached from them, consisting, according to Winslow, of a mixture of cortical and nervous medullary substance, nourished with several small blood vessels\*, in which various nervous filaments are collected, and in them lose their parallel rectilineal direction, according to Baron Haller †, who likewise observes that *ganglia* send off more and larger nerves than came to them ‡; so that a new nervous organization, analogous to the brain, probably takes place in them.

Respecting their uses, *ganglions* are the origins of the nerves, sent to organs, moved involuntarily, and probably the cause, or check, which hinders our volitions from extending to them. As different sources of nervous power, *ganglions* are analogous to the brain in their office, though they derive their nervous filaments (to be new arranged in them), and consequently their power, ultimately from it.

In a word, *ganglions* appear to limit the arbitrary power of the soul in the animal œconomy.

They put it out of our power, by a single volition, to stop the motions of our heart, and in one capricious instant irrevocably to end our lives: and however in the dark we may be, what subordinate agents are substituted, so uniformly to guide and direct, independent of us, our vital and involuntary motions; we must at least clearly discern, in the contrivance, the goodness, boundless, and unerring wisdom, no less than the power, of our adorable Creator! “ad impellendum satis, ad docendum parum.”

\* Winslow, *Traité de la Teste*, 629.  
 Phys. T. iv. p. 203.

† Haller, *ibid.*

‡ Halleri Elem.