pityingly at you. If he has enough nerve he may tell you that every one knows that the air is heavy on a muggy day because you can feel it so. To him it is a question of psychology and not of physics. One is tempted to wonder what the writer of the news item feels about it.

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SCIENTIFIC BOOKS

THE CEREBRUM

Emanuel Swedenborg. Three Transactions on the Cerebrum. Now first translated by ALFRED ACTON. Philadelphia: Swedenborg Scientific Association. Vol. 1, 1938. xxxiii + 731 pp. "Anatomical Plates" (bound as a separate volume, 175 pp., 148 figs.) Vol. 2, 1940. viii + 179 pp. $12.00.

EMANUEL SWEDENBORG entered the field of neurology with an essay "On Tremulation." He had studied Willis and Vieussens, but was under the spell of Baglivi's "De Fibra Motrice." Baglivi, working with Pacchioni, had seen the dura mater pulsate with powerful systole and diastole, and had called it the heart of the brain. The cerebral cortex, they agreed with Malpighi, consisted of minute glands which extracted a nervous fluid from the blood and discharged it through excretory vessels that made up the white or medullary substance. Thence the nervous fluid was sent through the peripheral nerves to all parts of the body, impelled in the twinkling of an eye, with the velocity of light, by the contractions of the dura mater. Every one knows, says Baglivi, how swiftly a sensory impression made by external objects is conveyed to the mind's chief domicile, the cerebrum; and he discusses the transmission of *oscillations* through solids and through liquids.

For Swedenborg the oscillations are *tremulations,* and life (audition, vision, every sensation and motion) consists of these little vibrations—stillness and rest is death. Impacts from without are received by the cuticle, "which is nothing but a ramification of nerves," and are conveyed centrally along the nerve sheaths which are extensions of the dura mater. "The meninges produce a continuous system of membranes over the whole body." "The dura mater," for example, "applies itself closely to the bones," sending little tendons or threads far into their substance. Bone and periosteum are good transmitters, as are other membranes save when slack, so that reception, spreading like lightning through connective tissue misinterpreted as nerve, is diffuse; yet in the meninges "reside the most subtle sensations."

Outgoing tremulations in the nervous fluid follow the nerves into "finer and finer branches until they are finally expanded into membranes," and the circuit is complete. The fluid distilled into the medullas flows "through the nerves into the membranes and then back again to the medulla, making a circulation similar to that of the blood." Fear, with low blood pressure and therefore slack membranes, prevents transmission of the nervous fluid and paralyzes. In telepathy one's membrane "trembles from the tremulation of the other person's cerebral membranes, just as one string is affected by another, if they are tuned in the same key."

With visions of a new neuropathology, Swedenborg published in briefest note nine "rules" of tremulation (1718), and prepared a manuscript on that subject which he handed to the Royal Medical College a year later. The Board of Health (Sundhets Collegium) to whom it was referred for an opinion, passed it around and lost it; Swedenborg did not preserve the original draft, and all that remains of it is indeed the essential part, which he had sent with interesting letters, to his brother-in-law, librarian of the University of Upsala.[1]

For the next 15 years Swedenborg was occupied "exclusively with mineralogical and metallurgical studies," which led to his *Opera philosophica et mineralia* (Leipzig, 1734, 3 vols., fol.). Then he returned to neurology, reading and copying excerpts from nearly all the standard texts. In 1734 he published also "De Infinito," or, in its English translation, "The Philosophy of the Infinite,"[2] in which he considers the relation of soul and body, and concludes: "The soul resides particularly in the cortical substance of the cerebrum, and partly also in the medullary, where exquisitely subtle membranes can run connectedly from particle to particle, likewise above, around and within every particle of the above substance." This idea of the prime importance of the cerebral cortex was not new. Willis (1664) had said that the reason for the duplex substance of the cerebrum appears to be that the cortical part exists to *produce* the "animal spirit," and the medullary portion to distribute and utilize it. Varolio (1573) in colorful lines had declared the white substance of the cerebrum to be the mirror of the intellect and servant of the mind, since he considered the gray layer merely as white discolored through its great vascularity.

Captivated by neurology, Swedenborg in 1736, at

[1] "On Tremulation," by Emanuel Swedenborg. Translated by C. Th. Odhner. Boston [1899]. xiii + 79 pp. (This includes parts of the letters, the entire publication of 1718, and all that remains of the 1719 MS.)

[2] Outlines of a philosophical argument on the infinite, and the final cause of creation and on the intercourse between the soul and the body. Transl. from the Latin by J. J. G. Wilkinson, London, 1847. xxx + 160 pp. Reprinted as "The Philosophy of the Infinite," Boston, 1848. 64 pp.

the age of 48, obtained leave of absence for travel and intensive study in that field. He spent a year and a half in Paris, presumably frequenting Dr. Petit's School of Chirurgery, and went on to Venice, where, in 1738, he completed the manuscript which forms Volume 1 of Dean Acton's translation. Volume 2 consists of the "Amsterdam additions" thereto (1740). His plan was to copy whatever had been published on a given topic that seemed to him significant, here presented under the caption, "Anatomical Experience," and then to write his "Inductions" therefrom. Anatomy and Induction thus alternate through the volume, on 31 major topics, with an interruption of 10 pages to state that it is inadvisable to consider the brain piecemeal, and to define "animal spirit." We are told (p. 422) that "the cerebrum as affirmed by Hippocrates, Malpighi and others is the most perfect of all glands: that nowhere else can the marvellous nature of glands be explored to better purpose."

The importance of Swedenborg's neurological studies is not so much from observations of his own, as from an uncanny appreciation of what was sound in the literature, especially the recent literature. He has perhaps overstated this in a remarkable passage in his "Oeconomia regni animalis,"[3] abbreviated as follows (Clissold's translation, Vol. 1: p. 7–8):

> In the experimental knowledge of anatomy our way has been pointed out by men of the greatest and most cultivated talents, such as Eustachius, Malpighi [and 18 more whom Swedenborg names]; whose discoveries, far from consisting of fallacious, vague, and empty speculations, will forever be of practical use to posterity. . . . There are others again who enjoy a natural faculty for contemplating facts already discovered and eliciting their causes. Both are peculiar gifts and seldom united in the same person. Besides, I found that as soon as I discovered anything that had not been observed before, I began (seduced probably by self-love) to grow blind to the research of others . . . [warping and twisting other phenomena into conformity with my supposed invention]. I therefore laid aside my instruments, and restraining my desire for making observations, determined rather to rely on the researches of others than to trust to my own.

With the scalpel and probe, Swedenborg also laid aside his pencil, for we have apparently only one neurological drawing that he made—a simple figure of his dissection of a duck's brain in dorsal view, to show the "innumerable" twigs between the cerebral artery and the sagittal sinus.[4]

With neither pictures nor descriptions of his own work, it is often difficult to distinguish Swedenborg's original observations from speculations and quotations. For example, as to the finer vessels of the cortex, he writes (p. 22–23):

> From the experiences adduced it seems inferable to some extent that the cortex, so called, is the noblest substance of the brain, the individual parts whereof are woven of arteries which have terminated in the most delicate threads. . . . What specifically that tunic is, which by means of arteries is transmitted to the spherules of this cortical substance is a matter that can not be explored by help of the senses. From various signs, however, it would seem possible to conclude that it is the *inmost tunic of the arteries.* These arteries when they enter the cerebrum always relinquish their outer coat and also their muscular, while the inner coat is continued even beyond the meninges; and this conducts the purest blood into the cortical substance itself, and thence into the fibrils. This will be further confirmed in the Transactions on the Arteries of the Brain.

Worthy of a Nobel prize! Since all vessels at first are endothelial *intima* and nothing more, and all perfected vessels are but this intima covered by accessory coats which are gradually lost on approaching the capillary ramifications, Swedenborg here seems to have experienced a revelation. Yet what in fact is visible with a good microscope, he declares can not be seen. Willis, who had attempted to picture and describe this intima, had no such comprehensive idea of it. But Swedenborg in that later reference (p. 236–7) rather spoils it all by saying that the vessels of the whole cerebrum are in no way ruled by the heart and vagus nerve—"the internal carotid artery puts off its muscular and other tunics and *puts on tunics wholly different,* to wit, a membranous tunic borrowed from the dura mater, and a filamentary or reticular tunic borrowed from the sympathetic nerve: it retains, however, its own inmost tunic." Histologists know nothing of this change of coats. Elsewhere (p. 283) Swedenborg describes the intercostal nerve and par vagum, not as alternatives or antagonists, but in close companionship in the vessel wall, "so that the artery or vein knows not by what motory it is caressed." The nerve enters the vessel wall "in a friendly fashion and nowhere is dissension to be seen."

[3] Swedenborg, E. Oeconomia regni animalis in transactiones divisa. 4to Pt. I, Londini et Amstelodami, 1740. Pt. II, Amstelodami, 1741. [Swedenborg's "regnum animale" is not Cuvier's, since "animalis" here means "pertaining to the soul."] The Economy of the Animal Kingdom, considered anatomically, physically and philosophically. Parts I and II. Translated by A. Clissold. London and Boston, vol. 1, 1845: vol. 2, 1846. Also, 2 vols. Boston, 1868; also (the ed. here cited) New York [1903] vol. 1, 564 pp.; vol. 2, 432 pp. (See "A Bibliography of the Works of Swedenborg" by James Hyde. London, 1906. xvii + 742 pp. 3,500 items.) Part III, transl. by A. Acton, Philadelphia, 1918. lxii + 385 pp.

[4] The Economy of the Animal Kingdom, Vol. 2, p. 94. No figure by Swedenborg accompanies Dean Acton's "Three Transactions" but an unnumbered, unpaged volume of "Anatomical Plates" has been provided, selected from 20 of the authors cited by Swedenborg. The plates, with explanations conveniently opposite, are arranged alphabetically by authors, from Bartholin to Willis. Malpighi, with 26 pages of pictures, chiefly of the chick, is perhaps predominantly represented. There are 21 pages of Vieussens' plates, 14 from Willis, 8 from Ruysch, etc.—an instructive assemblage of curious old drawings.

Swedenborg also had glimpses of a neuron theory, built upon Malpighi's observation of "glands" in the cortex, which were presumably groups of cell bodies. Leeuwenhoek had seen the smaller individual "globules," none too clearly distinguished from droplets of myelin and other debris. Swedenborg stated that there was no "scarcely visible spherule of the cortical substance" that does not "bring forth a fibre as its own proper path of determination";—"the beginnings of the fibres are indeed as many in number as are the spherules of this substance." Thus he anticipated the demonstration of neuraxons. Dendrites he less clearly adumbrated in the capillaments too fine for red blood to enter, which connect the vessels with the spherules. Each spherule which thus receives and discharges is a "brain in least effigy"—a "cerebellulum."

Swedenborg's recognition of motor areas in the cortex is the acme of these divinations, accounted by Gustaf Retzius, in his presidential address before the Anatomical Congress of 1903, not merely as "recht merkwürdig" but as "wunderbar" and "erstaunenswert."[5] For Swedenborg not only knew that such centers existed, but "on the whole he correctly described their location,"—that for the leg above, trunk in the middle and head below, in the anterior portion of the hemisphere, being related to the body "in an inverse ratio." The historian Neuburger was profoundly impressed.[6] Ramström, seeking to account for this "work of genius," believes that pathological cases, combined with pictures and findings of Vieussens, were the source of Swedenborg's conception.[7] But, as the present reviewer has noted, when Swedenborg declares that the determination of what convolution corresponds with this or that muscle of the body can be made only "per experientiam in vivis animalibus, per *punctiones, sectiones* et *compressiones*" he recommends a succession of procedures that he learned from Baglivi. The latter studied the nerve sheaths in living animals *"varie punctis, resectis, affectisque."*

Retzius intimates that Swedenborg discovered the central canal of the cord and the cerebro-spinal fluid. An easy reference to Burdach would have shown that the central canal was found by Estienne (1545) and that Columbus, Piccolomini, Bauhin and Malpighi had considered it normal; moreover, Swedenborg merely surmised its existence. The cerebro-spinal fluid, as the reviewer finds, was known to Coiter in its usual thin and occasionally thickened condition (1573). Whatever is new in Swedenborg is not labeled as such, and often is buried in fiction and romance, not always "lustrous with points and shooting spiculae of thought":—"The pons is the bed or conjugal chamber or couch for both the brains; for there like a pair of consorts, they join their first embraces and enter into a common covenant for the conception and bringing forth of their nerves."

Swedenborg has made a long story of his progressive study of the brain, nearly all of which is now available in English, included in the following works. On Tremulation, 79 pp.; The infinite, 160 pp.; Three Transactions, 2 vols., 910 pp.; Economy of the Animal Kingdom, 3 vols., 1,381 pp.; The Brain, 2 vols., 1,439 pp.; Animal Kingdom, Part 3, 226 pp. Even when Swedenborg tore vertically in halves eight pages of Latin manuscript and threw one half away, the missing portion has been conjectured and added so that not a line be lost. It remains for some neurologist to discard the quotations, repetitions and revisions, and present Swedenborg's contribution in a form that does not require a Swedenborg research on the part of every reader. For it is clear that Swedenborg deserves an honorable place among the "Apostles of Physiology"—a place that too often has been denied him. Essential for this undertaking are the Three Transactions, now made available by Dean Acton, through his scholarly and devoted labor, in the highly commendable volumes here inadequately reviewed.

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REPORTS

STATEMENT OF CONDITIONS OF THE AMERICAN CHEMICAL SOCIETY

THE American Chemical Society is still growing in numbers, in prestige and in influence, far more so than some of us who have been in closest touch with its progress had any reason to hope. It simply means that American chemists are more and more realizing that the American Chemical Society is their friend, is interested in their welfare, is doing all it can to enable them to develop themselves, and that membership in the society is a catalyst to success. Its efficacy is not

[5] "Emanuel Swedenborg als Anatom und Physiolog auf dem Gebiete der Gehirnkunde." *Verh. d. Anat. Ges.*, pp. 2–14, 1903.

[6] Dr. Max Neuburger. "Swedenborg's Beziehungen zur Gehirnphysiologie." *Wiener Med. Wochenschr.*, Jahrg. 51, col. 2077–2081, 1901.

[7] Martin Ramström. Emanuel Swedenborg's investigations in natural science, and the basis for his statements concerning the functions of the brain. Kungl. Vetenskaps-Societet., Uppsala, 1910, 59 pp., fol.