Figure 3.1  Emanuel Swedenborg at age forty-five. From a copper engraving in volume 1 of his *Opera Philosophica et Mineralia* (1734).
In 1743, the Swedish nobleman, polymath, and mystic Emanuel Swedenborg began to see and converse with God and angels, and continued to do so until he died thirty years later (figure 3.1). Soon after his death, his followers founded the Swedenborgian Church of the New Jerusalem that continues today as an active Protestant sect. Before his visions began, Swedenborg's interest in the soul led him to study its housing in the brain, and he wrote a set of extraordinary treatises on brain function. These works contained a number of ideas that anticipated modern discoveries by over 100 years. For example, he posited a crucial role of the cerebral cortex in sensory, motor, and cognitive functions, and this during a period in which the cortex was denied any significant functions at all. He even had something very akin to a neuron doctrine, although actual neurons had not been described. Yet, his writings on the brain had no impact on the development of neuroscience.

This chapter begins by reviewing the knowledge of the brain in Swedenborg's time. I then consider his life, his insights into brain function, and the sources of these ideas. I conclude with his influence on the arts and sciences.
Neuroscience in the Seventeenth and Eighteenth Centuries

From the revival of anatomical investigation by Andreas Vesalius of Padua in the sixteenth century until the middle of the nineteenth century, the cerebral cortex was usually considered of little interest. This is indicated by its very name, cortex, Latin for “rind.” Vesalius himself thought the function of the cortical convolutions was to allow the blood vessels to bring nutriment to the deeper parts of the brain:

... nature impressed those sinuous foldings throughout the substance of the brain, so that the thin membrane, folded with numerous vessels, could insert itself into the substance of the brain and so to make the cerebral vessels safe by guiding them and so very dexterously administer nourishment.

The first person to examine the cortex microscopically was Marcello Malpighi (1628–1694), professor in Bologna. He saw it as made up of little glands or globules with attached fibers (see figure 1.11):

I have discovered in the brain of higher sanguinous animals that the cortex is formed from a mass of very minute glands. These are found in the cerebral gyri which are like tiny intestines and in which the white roots of the nerves terminate or, if you prefer, from which they originate... [the globules] are of an oval figure... [their] inner portion puts forth a white nervous fibre... the white medullary substance of the brain being in fact produced by the connection and fasciculation of many of these.

Similar globules or glandules were also reported by Leeuwenhoek and other subsequent microscopists. Some historians once thought these pioneers were actually observing cortical pyramidal cells. At least in the case of Malpighi, however, artifacts are now considered a more likely possibility, since Malpighi
reported that the globules were more prominent in boiled than fresh tissue. Furthermore, artifacts that look just like Malpighi's globules have been produced by using the methods and instruments he described in detail.\textsuperscript{5,6}

Malpighi's view of the brain as a glandular organ was a common one in the seventeenth and eighteenth centuries. Perhaps a reason for its popularity was that it was consistent with the still persisting views of Aristotle that the brain was a cooling organ, and of the Hippocratic doctors that it was the source of phlegm.\textsuperscript{7,8} The only major figure to attribute any importance to the cerebral cortex was Thomas Willis (1621–1675), professor of natural philosophy at Oxford and author of the first monograph on brain anatomy and physiology\textsuperscript{9} (see figure 1.12). Although Willis denied both sensory and motor function to the cerebral cortex, he did attribute to it such higher functions as imagination and memory. However, even this interest in the cerebral cortex dissipated by the end of the seventeenth century.

In the middle of the eighteenth century, physiology was dominated by Albrecht von Haller, professor at Tubingen and later Bern, who was also famous as a botanist, poet, novelist, and politician. Using animals, he tested the "sensibility" of various brain structures with mechanical stimuli such as picking with a scalpel, puncturing with a needle, and pinching with forceps, as well as with chemical stimuli such as silver nitrate, sulfuric acid, and alcohol. With these methods he found the cortex completely insensitive. In contrast, he reported the white matter and subcortical structures such as the thalamus and medulla to be highly sensitive; their stimulation, he said, produced expressions of pain, attempts of the animal to escape, or convulsions.\textsuperscript{10}

Haller's ideas on the insensitivity of cortex and the sensitivity of other brain structures were repeatedly confirmed by the experiments of his students, such as J. G. Zinn of "zonule of Zinn" fame, professor of medicine at Göttingen. Describing one such study, Zinn wrote\textsuperscript{11}:

Having cut out a small circular piece of the cranium of a dog with a trephine . . . I pierced the exposed dura mater, touched it with a blade of a scalpel, and poured a solution of mercury sublimate on
it; the animal, however, gave no signs of pain and suffered no
convulsions. Since I thought the dog ought to have become apo-
plectic, I irritated the reflected skin and he showed that he felt pain
by giving out a loud cry. . . . Having incised the dura mater, I cut
the cortex into pieces, pierced it, irritated it, but the animal showed
no sign of pain.

In contrast, when he thrust an instrument through the skull, corpus callosum,
and corpus striatum to the base of the brain, as confirmed at autopsy, the dog
"howled pitifully . . . vomited repeatedly . . . and died the next day." From
observations such as these Haller and his followers concluded that all parts
of the cortex were equivalent and were involved in neither sensation nor
movement.

In summary, during Swedenborg's time, the cerebral cortex was consid-
ered an insensitive rind with no sensory, motor, or higher functions.

**Swedenborg's Life**

Emanuel Swedenborg was born in Stockholm in 1688 of a wealthy mining
family that provided him with a lifelong private income. His father was
professor of theology at Uppsala, a famous hymn writer, and later a bishop.
Swedenborg studied philosophy at Uppsala, but became increasingly involved
in science and technology. Among his unrealized schemes were ones for
airplanes, submarines, and machine guns. (Do all visionaries dream of flying
through the sky, swimming beneath the sea, and efficiently wiping out their
enemies, or do Leonardo and Swedenborg have something special in common?)
He served on the Board of Mines and made a number of substantial contribu-
tions to astronomy, geology, metallurgy, paleontology, and physics.12-17

In the 1740s, inspired by studying Newton, Swedenborg began seeking
mathematical and mechanical explanations of the origin and nature of the
physical and biological universes. He developed a theory of the origin of planets
similar to the later and apparently independent ones of Kant and Laplace. He
then turned to the problem of the nature of the soul and its relation to the body. This led him to seek the site of the soul in the body and thus to the study of the brain itself:

I have pursued this [brain] anatomy solely for the purpose of discovering the soul. If I shall have furnished anything of use to the anatomic or medical world it will be gratifying, but still more so if I shall have thrown any light upon the discovery of the soul.

He read widely about the brain in the biological and medical literature of the day, and traveled for extended periods to various countries of western Europe.

His first published writing on the brain was in his *Oeconomic Regni Animalis* of 1740, which was later translated into English as *The Economy of the Animal Kingdom*.19 By “regni animali” he meant kingdom of the anima or soul; he considered this kingdom or realm to be the human body and, particularly, the brain. By “oeconomia” he meant organization. Thus a better translation of his title might be *Organization of the Body* or, less literally, *The Biological Bases of the Soul*. He also dealt with the brain and sense organs in his second major biological work, *Regnum Animale*,20 published a few years later. Again, “animale” here means pertaining to the soul.

In 1743 Swedenborg’s religious visions began and for the rest of his life he concentrated his energies on religion and spiritual matters. The resulting huge corpus of theological and psychic writings later formed the basis of the Swedenborgian Church. He never returned to his interest in the brain, and much of his writing on the topic remained unpublished in his lifetime. Various religious disputes led him to exile in London, where he died at the age of 83.21-24

In the nineteenth century a number of Swedenborg’s manuscripts on the brain and sense organs were found by R. L. Tafel in the library of the Swedish Academy of Sciences25 and published, sometimes first in Latin and then in English. The most important of these, *The Brain*, appeared in 1882 and 1887.26
Further translations of Swedenborg's unpublished writings on the brain appeared in the twentieth century, but they were mostly earlier drafts of material already published.\textsuperscript{27-29}

\textbf{Views on the Cerebral Cortex}

At the very beginning of his biological works Swedenborg announces that his writings will be based primarily on the work of others\textsuperscript{30}:

Here and there I have taken the liberty to throw in the results of my experience, but only sparingly \ldots I deemed it best to make use of the facts supplied by others \ldots I laid aside my instruments, and restraining my desire for making observations, determined to rely rather on the researches of others than to trust my own.

In fact, he very rarely does “throw in” the results of his own work. He provides only a single figure of one of his own brain dissections, that of a drake,\textsuperscript{31} and almost no accounts of any of his own experiments or observations.

He begins each section of his biological works with an extensive set of quotations from previous writings on the subject. (These are a marvelous boon for those of us who cannot read medical Latin.) In the next section, entitled “Analysis” or “Induction,” he proceeds to weave his own theory of biological structure and function. Such a section from \textit{The Economy of the Animal Kingdom} on “The Cortal Substance of the Brain” characteristically begins, “From the foregoing experience we infer, that the cortex is the principal substance of the brain.” In fact, his inference was actually a radical and total departure from the contemporary literature he had just reviewed. Swedenborg then proposed that the cerebral cortex was the most important substance in the brain for sensation, movement, and cognition\textsuperscript{32}:

From the anatomy of the brain it follows that the brain is a sensorium commune with respect to its cortical substance \ldots since to it are referred the impressions of the external sense organs as if
to their one and only internal centre. ... The cortical substance is also the motorium commune voluntarium for whatever actions are mediated by the nerves and muscles are determined beforehand by the will, that is, by the cortex.

This must be taken as a general principle, that the cortical substance ... imparts life, that is sensation, perception, understanding and will; and it imparts motion, that is the power of acting in agreement with will and with nature ... 

Central to his brain theory were the cortical globules or glandules described by Malpighi and his successors (see chapter 1 and figure 1.11). In an extraordinary anticipation of the neuron doctrine, Swedenborg suggested that these globules or, as he sometimes called them “cerebellula” (little brains), were functionally independent units that were connected to each other by way of threadlike fibers. These fibers also ran through the white matter and medulla down to the spinal cord, and then by way of the peripheral nerves to various parts of the body. The operations of these cerebellula, he maintained, were the basis of sensation, mentation, and movement.33

From each cortical gland proceeds a single ... nerve fiber; this is carried down into the body, in order that it may take hold of some part of a sensation, or produce some action ...

Sensory and Motor Functions of the Cortex

Whereas Descartes projected sensory messages to the walls of the ventricle and Willis brought them to the thalamus, Swedenborg thought they terminated in the cerebral cortex, “the seat wherein sensation finally ceases,” specifically in the cortical cerebellula34:

The external sensations do not travel to any point beyond the cortical cerebellula. This is clear since these are the origin of the nerve fibers.
In addition,

The organ of sight is the eye, while the organ of internal sight is the cortical gland.

He even outlined the pathway from each sense organ to the cortex, a totally unprecedented view and one that was not to reappear until well into the nineteenth century:

... the visual rays flow, by means of the optic nerve, into the thalami nervorum opticorum, and are thence diffused in all directions over the cortex... Also the subtle touches of the olfactory membrane lining the labyrinthine cavities of the nares and the consequent subtle transformation or modifications... do not terminate until they arrive... in the cortical circumstance. Again the modulations of air, striking upon the delicate... internal ear allow themselves to be carried to the medulla and thence toward the supreme cortex... Further, that the tremors excited by the touch of angular bodies in the papillary flesh of the tongue, spread themselves with the sense of taste in a similar manner by their nerves, toward... the cortical substance. And that every ruder touch whatever springs up from the surface of the whole, through the medium of the nerves into the medulla spinalis or medulla oblongata, and so into the highly active cineritious [grey] substance and the circumambient cortex of the brain.

He seemed unclear about whether there were discrete cortical areas for every sense or whether all the senses went to the same cortical region, as shown in the following contradictory passages from the same work:

It is clear from examining the brain that the cortical substances are so wisely arranged as to correspond exactly to every external sen-
sation . . . the general sensorium is designed to receive every species of external sensation—sight, hearing, taste and smell distinctly.

It is the cortical substance collectively that constitutes the internal organism, corresponding to the external organism of the five senses . . . no individual part of the cerebrum corresponds to any sensorial organ of the body; but the cortical substance in general corresponds . . .

The cortex for Swedenborg had motor as well as sensory function, or, in his typically picturesque language:

The cortical glandule is the last boundary where sensations terminate and the last prison house whence the actions break forth; for the fibres, both sensory and motory, begin and end in these glandules.

Remarkably, he had the idea of the somatotopic organization of motor function in the cerebral cortex. He correctly localized control of the foot in the dorsal cortex (he called it the “highest lobe”), the trunk in an intermediate site, and the face and head in the ventral cortex (his third lobe):

. . . the muscle and actions which are in the ultimates of the body or in the soles of the feet depend more immediately upon the highest parts; upon the middle lobe the muscles which belong to the abdomen and thorax, and upon the third lobe those which belong to the face and head; for they seem to correspond to one another in an inverse ratio.

No other suggestion of the somatotopic organization of motor cortex appears until the experiments of Fritsch and Hitzig in 1870.
Chapter 3

Further Insights into the Nervous System

Swedenborg localized functions in addition to sensation and movement in the cortex. For example, he claimed that the anterior cortex is more important for higher functions than the posterior:

If this [anterior] portion of the cerebrum . . . is wounded then the internal senses—imagination, memory, thought—suffer; the very will is blunted. . . . This is not the case if the injury is in the back part of the cerebrum.

Frontal lesions are still considered to “blunt the will.”

Beyond the cortex, there are a number of other unusual insights about nervous function in Swedenborg’s writing. He called the pituitary the “arch gland . . . which receives the whole spirit of the brain and communicates it to the blood.” It was the “complement and crown of the whole chymical laboratory of the brain”; and the brain “stimulates the pituitary gland to pour out new life into the blood.” Similar views of the pituitary do not appear until the twentieth century.

Swedenborg’s view of the circulation of the cerebrospinal fluid was not surpassed until the work of Magendie a 100 years later. He was the first to implicate the colliculi in vision, and in fact the only one until Flourens in the nineteenth century. He suggested that a function of the corpus callosum was for “the hemispheres to intercommunicate with each other.” He proposed that a function of the corpus striatum was to take over motor control from the cortex when a movement became a familiar habit or “second Nature.”

Sources of Swedenborg’s Ideas on the Brain

Where did Swedenborg’s amazingly prescient views come from? Because of his detailed knowledge of contemporary brain anatomy and physiology, some historians thought that he must have visited brain research laboratories and there
carried out dissections or participated in experiments.44-46 For example, he was in Paris when Pourfour du Petit was conducting experiments on the effects of lesions of the cortex on movement in dogs. Thus, it was proposed that he participated in du Petit’s experiments and might have observed the somatotopic organization of motor cortex. Du Petit did realize that the cortex had motor functions, although his claims to this effect were ignored.47 However, there is no sign that du Petit himself had any notion of the topographic arrangement of motor cortex. Furthermore, Swedenborg’s detailed travel diaries provide no evidence that he visited du Petit’s or any other laboratory studying the brain during his travels abroad.48 Visiting churches was more his wont.

The available evidence indicates that Swedenborg’s ideas came primarily, if not entirely, from a careful reading and integration of the anatomical, physiological, and clinicopathological literature that was available and that he so copiously quoted.49, 50 He paid particularly close attention to detailed descriptions and observations rather than simply to the authors’ own interpretations and conclusions. Furthermore, he was unusual in attempting to integrate observations of the effects of human brain injury with the details of comparative neuroanatomy.

Influence and Lack Thereof

Swedenborg’s writings on religion and spiritualism had an enormous impact on European and American writers and artists. Blake, Yeats, Balzac, the Brownings, Beaudelaire, and Strindberg, for example, all claimed to be particularly influenced by him.51, 52 In nineteenth-century America his influence was strong among those interested in spiritualism and in transcendentalism.53 Ralph Waldo Emerson, who was involved in both, declared in 1854, “This age is Swedenborg’s.”

In spite of his fame in literary, artistic, and religious circles, or perhaps partly because of it, Swedenborg’s ideas on the brain remained largely unknown until the twentieth century. The Latin originals of the Animal Economy books of the 1740s were not even mentioned in the major physiology textbooks of
the following decades, such as those by Haller (1754), Unzer (1771), Prochaska (1784), Blumenbach (1815), Magendie (1826), Bell (1829), or Müller (1840)

English translations of Swedenborg that appeared in the 1840s do not seem to
have fared any better. They were ignored in the standard physiology textbooks
of the day such as Carpenter’s (1845) and Todd’s (1845), and in Ferrier’s (1876)
monograph on the brain. Even one of the translators of The Animal Kingdom,
J. J. G. Wilkinson, a London surgeon, hardly mentioned the brain in either his
biography of Swedenborg or his commentary on The Animal Kingdom.54

Early nineteenth-century reviews of Swedenborg’s biological works were
few and puzzled. An Athenæum reviewer in 1844 noted that The Animal
Kingdom “will startle the physiologist and [contains] many assumptions he will
be far from conceding.”55 The most positive responses seem to have come from
books on phrenology56 or mesmerism.57

However, by the time the first volume of The Brain was published in
1882, the Zeitgeist had radically changed. Fritsch and Hitzig (1870) had dis-
covered motor cortex, and the race to establish the location of the visual and
other sensory cortices was well under way. Now Swedenborg’s ideas on the
brain made sense, and both volumes received long rave reviews in Brain,58
where the reviewer called it “one of the most remarkable books we have seen”
and noted that:

... it appears to have anticipated some of the most modern
discoveries [on the brain] but that because of its metaphysical,
onontological, theological phraseology ... if it had not been that
attention was arrested and enchanted by finding so many anticipa-
tions of scientific discoveries by as much as 120 or 130 years, we
should have been tempted to throw aside the book as beyond our
province, if not hopelessly unintelligible.

Nevertheless, Swedenborg’s writings on the brain seem to have disappeared
from sight again, not being mentioned in Foster’s (1893) or Schäfer’s (1900)
authoritative textbooks of physiology, in Ferrier’s (1886) or Campbell’s (1905) monographs on the brain, in the history of the field by Foster,69 or even the massive two-volume one by Soury.60

In 1901 Swedenborg’s extraordinary anticipations on the brain were finally publicized by the great historian of neuroscience Max Neuberger, professor of the history of medicine in Vienna.61 As a result, they became the subject of further accounts by neuroanatomists and historians, particularly Swedish ones.62-66 In 1910 a conference of 400 delegates from 14 countries was held in London in honor of his many contributions to science, philosophy and theology.62

**Why Was Swedenborg so Ignored?**

Several examples of biologists were so ahead of their time that their writings were read but not understood by their contemporaries. Appreciation of their ideas had to wait until further advances closed the gap between them and lesser mortals. Arguably, the most famous example was Gregor Mendel.68 Sometimes it is an otherwise well-known and successful scientist who has certain ideas that are only grasped in later generations. Outstanding examples of this are Darwin’s concept of the irregularly branching and nonhierarchical process of natural selection69 and Claude Bernard’s maxim on the necessity of a constant internal milieu for the development of a complex nervous system.70

Swedenborg’s case is more extreme. There is little evidence that contemporary physiologists and anatomists even read his writings on the brain. He never held an academic post or had students, colleagues, or scientific correspondents. He never carried out any systematic empirical work on the brain, and his speculations were in the form of baroque and grandiose pronouncements embedded in lengthy books on the human soul by one whose name was soon to be that of a mystic or madman. Even he seems to have lost interest in his ideas on the brain, as he never finished or published many of his manuscripts on the subject. Furthermore, some of his more advanced theories, such as on
the organization of motor cortex or the functions of the pituitary gland, did not appear in print until after they were no longer new. As a neuroscientist, Swedenborg failed to publish, and as a neuroscientist he certainly perished.

Notes

1. Vesalius, 1666.
9. Willis, 1664.
17. Tafel, 1877.
18. Swedenborg, 1887.
22. Toksvig, 1848.
24. Tafel, 1877.
25. Tafel, 1877.
27. Swedenborg, 1938.
29. Swedenborg, 1914.
30. Swedenborg, 1845–1846.
32. Swedenborg, 1845–1846.
33. Swedenborg, 1922.
34. Swedenborg, 1845–1846.
35. Swedenborg, 1882–1887.
37. Swedenborg, 1882–1887.
38. Swedenborg, 1882–1887.
40. Squires, 1940.
41. Swedenborg, 1882–1887.
42. Swedenborg, 1882–1887.
44. Akert and Hammond, 1962.
45. Retzius, 1908.
46. Acon, 1938.
47. Neuberger, 1981.
48. Tafel, 1877.
49. Ramstrom, 1910.
50. Ramstrom, 1911.
52. Tøkveig, 1848.
54. Wilkinson, 1846.
55. Anonymous, 1844.
56. Cembe, 1852.
57. Bush, 1847.
59. Foster, 1901.
60. Sojry, 1899.
61. Neuberger, 1901.
63. Transactions . . ., 1911.
64. Retzius, 1908.
68. See chapter 1, note 113.