

SWEDENBORG AND HIS SCIENTIFIC REVIEWERS*

XXXVI[†]

Economy of the Animal Kingdom I

Nova Acta Eruditorum

The Economy of the Animal Kingdom, examined Anatomically, Physically, and Philosophically; divided into Transactions, of which this the first treats of the Blood, its Arteries and Veins, and the Heart. To which is added an Introduction to Rational Psychology. London and Amsterdam, Francis Chauguion, 1740. Large 4to; 2 alphabets and 4 sheets; 1 copperplate.

We are in the possession of a great accumulation of physical observations, as is evident to all; but those who use them rightly for the confirmation and amplification of natural philosophy and a true theory of medicine, have been few in number. The highly learned author of the present work sets his name among this number, deeming it to be to the interest of all, that, from the accumulated heaps, we construct an edifice; that with the sickle we reap the harvest; and that we enjoy the dainty foods which have been prepared; that is to say, that we endeavor at last to gather wisdom from the experience with which we abound [§ 26]. He enters upon this path, and proceeds to search the animal economy, anatomically, physically, and philosophically.

In like manner as the illustrious Swedenborg, who according to common report must be accounted as the author of this book,⁴ has already acquired a great name for himself, by other works,—works which are remarkable monuments of his genius,—so the present specimen of the new work, which we now have before us, abundantly declares the breadth of his doctrine, the great keenness of his genius, the admirable force of his

* Reprinted from *The New Philosophy*, Vol. XXXIII (Oct. 1930), pp. 269–294. Periodic reprinting of these reviews began in this journal, vol. CVI (June–Oct. 2003).

[†] This number and subsequent ones are those assigned by Alfred Acton who, as editor, published these reviews, beginning in 1929, journal volume XXXII.

⁴ It may be noted that this review was published in November, 1742, whereas the second edition of the *Oeconomia* with the author's name on the title-page, was issued from the press in the Spring of that year.

judgment, and his exquisite ability in perceiving the connection of things abstracted from the senses, besides other gifts.

He clearly admonishes us, however, that experiments and observations should rightly and rigidly be set above all else, for we can never come to the conditions and causes of things, that is to say, to truths, save by experience alone [§ n]. But the question is asked, Is there at this day a sufficient store of experiments to enable us to investigate nature on the basis of these alone, without the use of conjecture in addition to experience; and our author sensibly acknowledges, that particular experience, the experience, namely, which strictly comprises and immediately concerns one and the same subject, can never fully exhaust and reveal the occult qualities of that subject, nor be sufficient for the exploration of the subject and its causes, even though that experience were complete in all details and were the result of the accumulations of centuries. On the other hand, if, when exploring particular subjects, we call to our aid general experience or all the experience that is available in anatomy, medicine, chemistry, physics, and other natural sciences, we seem, at the present day, to be richly endowed [§12]. And therefore, that we may not play with the appearances of things, no credit should be given to any particular experience unless general experience adds its vote, as it were; that is to say, unless ultimates and means stand forth, connected and confirmed, in the whole series of progression. In no other way can an edifice be framed which posterity in later and succeeding ages, and on the basis of myriads of additional experiences, will acknowledge as resting on true foundations; nor will each succeeding age find it necessary, with the destruction of the old building, ever to erect a new [§16].

In respect to anatomical experience, we are enlightened by men of the keenest sight and the most cultured genius, such as Eustachius, Malpighi, Ruysch, Leeuwenhoek, Harvey, Morgagni, Vieussens, Lancisi, Winslow, Ridley, Boerhaave, Wepfer, Heister, Steno, Valsalva, Duverney, Nuck, Bartholin, Bidloo, Verheyen, and many others [§ 17].

Armed as with a shield by the watchful observations of these men and by their carefully elaborated writings, our author has undertaken to attack the object of his design and to complete it; that is to say, to lay bare some part of the things that are supposed to lie concealed in the obscurity of nature. To the experiences of others, he had in mind here and there to add

and intersperse his own experience; but this he has done sparingly, because, pondering on the matter more deeply, he considered it more advisable to use the experiences borrowed from others. For there are some men, such as Eustachius, Leeuwenhoek, Ruysch, Lancisi, who, as though born for the understanding of experimental facts, have a keener observation than others; and some who possess a natural faculty of explaining the causes of the things learned by experience. The two gifts are rarely united in one and the same person [§ 18].

Our author judges that the ancients were superior to us in wisdom, and in their soundness in the perceiving of things and their acumen in the suspecting of such as were hidden; but that, as regards the aids of which there is need for the further cultivation of talents, that is to say, as regards the accumulation of experiments which will give support to a future wisdom, and, it is hoped, will be of service to posterity, the ancients must yield to our own age and to the age that has preceded it [§§ 23, 24].

Because commencement must be made from general beginnings, if all is to flow on in its due order, therefore, we have considered that the doctrine of the blood and its vessels must be given first of all; for in the blood, as in a type, can be seen the several parts of which we are to treat; and on its nature, constitution, determination, continuity and abundance depend the lot and condition of animal life [§§ 1, 2]. Yet this doctrine of the blood cannot be completed except in the last place; for it demands a knowledge of all that enters into and constitutes the blood, and, in no less degree, of all the viscera, members, organs, and tunics, which the blood in its circuit imbues with life. If we are ignorant of the universal rationale of these, we are ignorant of the nature of the blood. Thus the science of the blood alone, postulates the whole science of anatomy, medicine, chemistry and physics, nay, and of psychology also; for the animus is affected according to the state of the blood, and the blood is actuated according to the affections of the animus [§§ 6, 7].

In the present treatise, therefore, the illustrious author does not venture to expatiate much further than the particular experience concerning the blood, its vessels, and the heart. Nor has he allowed himself to frame other than certain general positions, or to give any but obscure notions of things. Time and progression are needed, before that which here appears somewhat obscure can be disentangled and distinctly unfolded. For his

own part, he has held it to be sufficient to press closely on the heels of experience, and to follow the order of nature, which is, that an obscure notion precedes a distinct, and a general notion a particular [§ 8].

What he has very truly observed as to some obscurity, is, indeed, understood by us from a perusal of his work, we having found therein much that has an extremely difficult and intricate meaning.

And since our author is, as yet, unable to give out anything but what is general and universal, he readily foresees, that some will hold many of the positions which he brings forward, as conjectures or paradoxes, though no others will easily do this except such as have not as yet fully traversed the whole course of anatomy, physics, and chemistry, and the other sciences and arts, or such as are carried away by preconceived opinions, or are unfitted for the distinct comprehension of the connection of things. But he cautions us that, for the disentanglement of these matters, there is need of time and progress; and that this doctrine, although set forth in the beginning, can yet be completed only at the end; and that the outcome will declare whether those things which at first appear perhaps as obscure oracular utterances, will later, at the persuasion of an abundant supply of effects, be genuine responses and truths [§ 9].

Such being the case, none will charge us with fault if, abstaining from any judgment concerning this new philosophy, we simply present a brief and exact summary of it, until perhaps, at some time the clearer light, in the hope of which our author builds, shall follow this dawn. We have prefaced these remarks, though perhaps we have written more fully than was necessary for our purpose, in order that the reader of the entire work which our author undertakes, might see first of all the end of the work and the rationale of the treatment.

The method used by the author in each chapter is, that in the first place he gives the experience of the most learned men, quoting their own words at length, lest, by silence, those may seem to be suppressed, from which the reader might think that entirely different inductions and judgments can be made [§ 28]. Here, however, it would without doubt have been more pleasing to many, had the author also indicated the books of these

* The references in brackets have been inserted to indicate that the reviewer has quoted literally, or nearly so, from Swedenborg's Preface to the *Economy*.

learned men, and the places in the books, from which the observations and experiences are cited. He then lays down certain general positions, or, as he calls them, general inductions, formulated on the basis of these experiences; and, so far as is now possible, confirms each of these inductions by experience laid down as a foundation, and illustrates them by fuller explanations.

And so at last, we can now approach this book more nearly, and can behold, as though they were before our eyes, the author's new arguments and opinions which, for the most part, will be recited in his own words.⁵

The FIRST PARAGRAPH as he calls it, discourses on the composition and genuine essence of the blood, and for this purpose the author quotes the observations of Leeuwenhoek, Lancisi, Boerhaave, Gulielmini, Malphighi, and Verheyen (§ 29 *seq.**). The conclusions drawn therefrom come to the following:

Into the red blood, as its principal substance and as constituting its vital essence, enters that purest fluid which some call Animal Spirits (§ 37). Moreover, there are also many members of the salt family which enter into the composition of its parts (§ 43). Hence the blood comes forth as a compound and ultimate liquor which, in the animal kingdom, acts as the vicegerent of the soul (§ 46).

The red blood is surrounded with serum, and to this serum must be conveyed all that of which the blood is constituted and framed (§ 47). For which purpose, there are conveyed to it by means of the chyle, water serving as the vehicle, spirits of every kind, oils, salts; and by means of the air, the lungs acting as an aid, nitrous and volatile parts which float in the air; while, by means of the ether or purer air, are conveyed parts still more volatile (§§ 49–53). Unless the blood were enriched with each of these, it could not be prepared and renewed for any of the uses demanded by the animal economy (§ 57).

The blood, therefore, is the storehouse and seminary and parent and nurse of all the parts, both the solid and the soft and fluid, in its kingdom;

⁵ What now follows consists, for the most part, of the headings of Swedenborg's "Inductions" which were copied by the reviewer almost word for word.

* The reviewer's references are to the pages of the Latin original. These we have changed to references to the paragraphs.

for nothing exists in the body which has not preexisted in the blood (§ 59). Therefore, on its nature, constitution, determination, continuity, and abundant supply, depend the fortunes and condition of animal life; and in it is contained the reason as to why and how life can be lived and can continue in the body and in the ultimate world (§§ 62–63).

But because the blood exists and subsists from so many substances and elements of the kingdoms of the world, which are as yet unknown as to their qualities, the science of the blood cannot be completed until we have explored, in the general, the species, and the part, the nature of the auras of the world, of waters, oils, spirits, salts, fixed and volatile, essential sulphurs⁶ (§§ 64–69); and, moreover, the causes of heat, fire, flame, cold, colors, and all else that is studied in experimental chemistry and physics (§ 80); nay, and also of the phenomena which are usually the subjects of psychology and pneumatology (§ 90).

When these things have been surveyed,—and in no slighting way,—then it can be evident, to some extent, that it is the spirituous fluid that constitutes the essence of the proprial life and activity in the blood; from which fluid, by the mediation of a copious supply of volatile salts borrowed from the ether, exists a pellucid or middle blood; and finally, by the mediation of tempering, copulating, determining, and perfecting salts, both fixed and urinous, emerges the red and heavy blood; which latter, when forced to flow through vessels, capillaries, and fibres of a like order, gradually suffers itself to be divided into these same principles (§ 90–91).

Hence, in the blood, three degrees of composition must be considered; and these must be perceived distinctly; for it is wont to be distinctly compounded and distinctly divided into each degree (§ 92). The last of these degrees must consist for the most part of six piano-oval spherules, which fit themselves into the concave sides, equal in number, of a single fixed salt; hence comes the spherical shape of the parts of the blood (§ 95).

But although, in the kingdom of every species of animal, the spirituous substance enters into all genuine blood, as its proprial, principal, and sole vital substance, yet in all the species of animals, the blood is different;

⁶ Swedenborg's words are: "of salts, fixed, volatile, essential." He here speaks of "sulphurous salts" only as being produced from the salts on the surfaces of oil particles (§ 75–76).

and in every member of the species it is varied according to their temperament, state, and age; in all of them, however, it comes forth legitimate or spurious, according to the health of the body (§§ 95–99).

As regards its first substance, the spirituous fluid, and its second, the purer blood, each, in its own degree, is highly elastic and readily susceptible of consociation, of plication, and of reduction into every form; but into whatsoever form it be reduced, yet from its nature, it perpetually aspires to its most perfect form, and strives to return thereto; and thus, is so suited to every nature of fluidity and to every mode of an efficient cause, that in this respect there is nothing superior to it (§§ 100–1).

In the last compound, or in the blood, properly so called, are contained the same qualities, but more imperfectly according to the degree of composition (§ 102).

The SECOND PARAGRAPH treats of the arteries and veins, and of the circulation of the blood. The observations and experiments pertaining thereto, are borrowed from Verheyen, Bidloo, Manget, Morgagni, Heister, Lancisi, Vieussens, Malpighi, Baglivi, Leeuwenhoek, and Boerhaave (§ 116 *seq.*). On the basis of these observations, an angiology or doctrine concerning the arteries and veins is laid down, which is extended and amplified to embrace neurology, adenology, and myology, and which is strongly supported by the confirming voices of these sciences.

In order that it may flow determinately to ends and uses, the blood flows within tunicated vessels by means whereof a circulation goes on, namely, from the left chamber of the heart through the arteries to the veins, and from these into the right chamber of the heart, and from the latter through the lungs back to the left heart (§ 130–32).

The tunic of the vessels, like the blood itself, is also of a three-fold origin, nature, composition, and nomenclature; to the end that the containant and the content may act as a single cause of determination (§§ 133–34). The membranes, which are many in number, answer to the blood; and one membrane in relation to the other is prior, more universal, more perfect, more simple (§ 136). All these membranes, taken together and mutually connected by superposition, enclose and convey the red blood; a smaller number, and these the more simple, enclose and carry the purer blood; and a single simple membrane, the spirituous fluid (§§ 143–45).

Hence, in vessels, as in the blood and membranes, we have three degrees of composition; and these must be perceived distinctly. To the first degree belong the vessels commonly called blood vessels, to the second, the exsanguineous vessels, and to the third, the fibres of the nerves (§ 146). Consequently, conformably with the above, the circulation also is subtriplicate, that is to say, there is a less universal circulation which is that of the blood, a more universal which is that of the purer blood, and a most universal which is that of the spirituous fluid (§ 148).

The red blood, when it passes from the vessels of its own order into vessels of the second order, is separated into purer blood, that is, is divided into blood of the second order, laying down, at the doors of the entrance or division, the saline, urinous, or sulphurous atoms which had been the ingredients of its own degree; so likewise, when it penetrates from these vessels into vessels of the first order, that is, into the fibres (§§ 149–50).

It then continues its path through the fibres, and returns into vessels of the second and third order, and is again compounded by the like degrees whereby it had been divided (§ 151). In this way, it accomplishes its universal circle, whereof neither the beginning nor the end can be determined; and by this means continues, irrigates, feeds, renovates, forms, actuates, and vivifies everything in its limited universe (§ 154).

In each of their degrees, vessels, like all other things in the visible universe, have their determined maximum and minimum; and from their maximum they progress to their minimum, and from their minimum to their maximum; that is to say, from the great arteries to the lesser arteries and the least, and from the least veins to the greatest; all these vessels carrying the volume of the red blood and constituting only a single order of vessels. So also with vessels of the second order, which carry the simpler blood, and with fibres, which contain the spirituous fluid (§§ 156–57). Hence, passage from the blood, membranes, and vessels of one order, is granted not by the way of a continuous extenuation and decrease but by the way of a division of each unit or part, and of separation (§ 158).

The sanguineous volume itself, in whatsoever degree, is mixed heterogeneous, mixed homogeneous, and pure. When running through its circle, it reduces itself from a mixed heterogeneous volume to a homogeneous, and from this to a pure. For as it proceeds, it so purifies itself from serum,

that when it passes into its veins it exists as a pure volume, the mixed heterogeneous and mixed homogeneous having been separated and rejected little by little. Again, in the veins it passes from a pure volume to a mixed heterogeneous, and from this to a heterogeneous. The same is also the case with the volume of the simpler blood and of the spirituous fluid (§ 162).

Just as the blood and vessels are of a threefold order, so also is all that which is woven by the vessels; as, for instance, the glands. These are compound, more simple, and simplest, and, according to their order, are called glands, vesicles, pores; one being compounded from the other, and one being divided into the other (§ 163).

In a like order are carried on the secretions and excretions from the arteries into these glands, and also the comminglings and the reabsorptions by the veins (§ 165).

That all these operations may attain their due effect, there is required a perennial circulation of the volumes; that is to say, a circulation of the red blood from the left heart to the trunk of the aorta, from this trunk into its branches, from the branches into the least vessels of its order, from these into the little veins and also into numerous secretory cavities and receptacles—if it be proper to use this expression. This circulation is carried on by means of a successive promotion, within an imperceptible moment, of an undulation or wave; and from this there arises in several places in the permeated arteries a sensible elevation which is called the pulse (§ 166).

Taking its first impulse from the heart, this wave is then promoted to its exits by the whole arterial system, and this with the current of the stream and with increased rapidity; so that, in consequence, in the more minute vessels of the same order, the flow of its wave, thus multifariously divided, becomes almost spontaneous [§§ 173–74]. It is still more swift and spontaneous in vessels of the second order, and immensely so in vessels of the first order, that is, in the fibres, the action whereof does not depend on the single heart of the body but on an infinitude of little hearts, as it were, or of the spherules of the cortical and cineritious substance which are prefixed to the several fibres in their brains and their two medullas (§ 176–77).

For the direction and promotion of the circulation, there is required a certain common pressure, or an equilibrium of the pressure of all the

arteries, all the way from the heart to the successive branches; without which pressure, bestowed upon the entire system, no circulation, just as without a circulation, no general pressure, could exist and subsist (§§ 178, 180).

For the promotion of this general pressure and circulation, there is required in the vessels a muscular tunic furnished with a manifold series of motor rings, and continued from the muscle of the heart itself even to the capillary vessels (§ 182); and, moreover, an inner membrane which shall colligate these rings and shall determine them to this general effect,—as obtains in arteries (§ 187).

The case is different in the veins, wherein is no circulation but a bare filling and emptying, that is, a pressure upon their blood, equal in every direction, upwards, downwards, and to the sides, as in the case of liquids in their recipient cones (§ 190). For the sanguineous volume flows in and is taken up by innumerable venous origins; and it is unloaded into the right chambers of the heart not at set moments but at different moments and by a single venous sinus,—differently than obtains in the arteries (§ 198).

By comparing this general pressure and circulation of the volume with the condition of the vessels, and the nature of the blood, the arcana of the science of angiology may be referred to the following general laws: (1) Congruous liquids and elements must be conveyed to the blood; (2) must be commingled, (3) insinuated and proffered, (4) separated, (5) sequestered, (6) and, when sequestered, either eliminated or reabsorbed. (7) The blood globule itself must be resolved and reunited, and this continually (§§ 199, 200).

The conveyance, commingling, and insinuation of liquors and elements, in a word, the whole compounding of the blood, is carried on in the veins; but the separation, sequestration, and elimination, in the arteries; and the division of the parts of the blood, at the threshold where it passes over from the vessels of one order to those of another (§ 201–2).

Therefore, the more purified from serum is the blood that is transmitted by the arteries immediately into the veins, the more nearly does the state of the circulation approach to a state that is natural and most perfect (§ 203). All else that is to be mingled with the blood thus propagated from the arteries into the veins, is eagerly taken up by innumerable receivers, ducts, and pores of divers orders, and by the little veins (§ 205). Thus

arteries are averse to and reject such things as are not suitable to the blood, while veins seek out and procure such as the blood necessarily and contingently demands for its renewal and conservation (§ 207).

Therefore, lest immoderate aversions on the part of the arteries, and immoderate appetencies on the part of the veins, and also other causes, bring ruin to the animal economy, nature has provided against this by means of a perpetual communication between the vessels, and an omnipresent multiplication of causes producing the same result; and also by the subordination of the vessels of one degree to those of another. Hence, effects are rendered sure; and causes repair all that is lacking and fallen in causates (§§ 211–16). And to the end that the brains, from their causes and principles, may continually effect this, and that they be not constantly affected by the ills of the body, the arteries and veins proper to the body and those proper to the brains, communicate with each other in a singular manner, and are dependent on different origins of motion (§§ 217, 219).

THE THIRD PARAGRAPH follows up the formation of the chick in the egg, and the primordial beginnings of arteries, veins, and heart. It quotes the observations made in this connection by Bellini, Malpighi, Lancisi and Harvey (§§ 241–46), from which the following positions are deduced:

When the embryo is formed in the womb, or the chick in the egg, all things are carried on in the most distinct way. The several members are produced successively, or one after the other; nor is there any actual effigy of the greatest in the least, or any type of the future body in any first form thereof which will simply be unfolded (§§ 248–49). For all that coexists, must come into existence successively.

All that is thus produced successively is formed prior to and in accordance with the use which it will afterwards perform; nor is there anything which does not contribute something to a further use and end; and this in such way that while set in the middle, it contains the reason of the sequences, and harks back to the antecedents on which it depends and because of which it exists as it does and in no other way (§ 251–52).

There is a certain formative substance or force which draws its thread from the first living point, and when drawn, continues it even to the last hour of life; of which thread, from lack of terms, scarcely anything can adequately be predicated save that it is the first, the most perfect, the most

universal, the most simple of the substances and forces of its kingdom; to which, within its own little corporeal world, is assigned a species of omnipresence, power, knowledge, providence; in which, simultaneously and in the present, are seen to be at hand and inwardly contained, those ends, both prime and mediate and ultimate, in accordance with which, causes will follow on in foreseen and sure order, even to the ultimate effect (§§ 253–60). Hence it represents to itself the state yet to be formed as already formed, nay, and the formed state as yet to be formed (§ 261). Moreover, in this substance, is at hand in the present, being, as it were, inwardly contained, the series of all contingencies, as they seem to be, for the perfection of the work of formation; for in the egg and in the womb, all that can ever be present contingently is already present, being provided and prepared (§ 263).

According to the nature and state of this formative substance, causes flow into their effects, agreeably to its intuition or representation; as is apparent from the different forms of animals; from the imaginative force of gravid animals, and from the little body of the embryo marked in agreement therewith; from the formation of the brains, that is, of the organism of the internal senses, which differs in different species of animals, and in the subjects of the species (§§ 265–68). Therefore, the condition of the organism is not primarily the cause of the internal faculties, but that formative force according to the nature of which, and the image of its representations, all things have been formed (§ 269).

It is this formative force and substance that is the soul; after it comes the spirituous fluid; then the purer blood; and lastly the blood; which latter is, therefore, as the corporeal soul of its microcosm. All these, though each according to its own degree, may be called formative substances and forces, wherein presides the one only vital substance which is the soul (§ 270).

Since, therefore, all things are most fitly subordinated and coordinated, it follows that the spirituous fluid acts as the first cause, the purer blood as the second, and the red blood as the third, or as the effect of the prior bloods; also that fibrils of the utmost purity are produced first of all, then the vessels of the purer blood, and lastly the vessels of the red blood; of which productions, the one precedes the other, and afterwards, as they are compounded, the one acts with the other (§ 271–72).

Hence, the animal, successively growing in the egg and womb, runs through four marked changes and different states; the first, when, by the aid of the spirituous fluid, the initiaments of the two brains and the two medullas are drawn out and delineated; the second, when, by the aid of the purer blood, the simple texture of the heart is prepared; the third, when, by means also of the red blood, the lungs are produced; the fourth, when the lungs, thus produced, begin to breathe air, which takes place after exclusion from the natal egg or from the genital womb (§ 273–78).

There are three general sources of motions on which all the particular motions depend, namely, the brains, the heart, and the lungs. The motion of the brains is called animation; on this depends the action of the spirituous fluid. The motion of the heart is a systole and diastole; from this comes the circulation of the blood. The motion of the lungs is respiration; from this mainly comes the circulation of the purer blood; but since this blood is intermediate between the spirituous fluid and the red blood, therefore, its circulation is also due to the motion of both the cerebrum and the lungs (§ 279).

In the state of formation prior to exclusion from the egg or womb, the animation of the brains is concurrent with the systole and diastole of the heart; but after the lungs are formed, and the chick or embryo is excluded, the animation of the brains, leaving the company of the heart, conjoins itself with the respiration of the lungs. But it again unites with the heart whenever the lungs, from divers causes, cease to respire, while the heart continues to pulsate (§§ 280, 285).

Moreover, from the primitive fabric of the heart, and from its pulsation in such animals as are provided with one heart, and also from such as are provided with many, it is apparent that the primitive heart, distinguished into three vesicles, bears the nature and mode of action of the veins and, at the same time, of the arteries, between which the vesicles occupy the middle space; that is to say, from the concurrence of vessels of dissimilar nature and mode, results an intermediary distinguished by three oval vesicles (§ 288). Furthermore, from the simple fabric of the primitive heart is designated the state of the adult heart and of the arteries (§ 290).

These things, however, usually take place in different ways in the perfect and in the more or less imperfect animals; in those formed in a

womb, and in those formed in an egg. But all that has thus far been mentioned proclaims in the most evident way an infinite providence and a divine omnipotence (§ 295–96).

The FOURTH PARAGRAPH expounds the circulation of the blood in the unborn foetus; also the foramen ovale and the arterial canal belonging to the heart of the embryo infant. Here, having first given the observations of Verheyen, Lower, Harvey, Needham, Munnicks, Mery, Morgagni, and Fantoni (§§ 316–24), the rationale of the circulation is explained as follows:

The circuit of the red blood, as is apparent from the anatomy of chicks hatched in eggs, undergoes three marked changes and vicissitudes: the *first*, when the primitive heart or salient point, having received blood through certain branches, sends it upwards toward the brains, while the brains press it downwards into the umbilical vessels; at this time, the brains act as the principal causes of the blood's circulation (§§ 326–29).

The *second*, when the aorta is carried into the abdominal region also; then the blood, passing through the cardiac vesicles, is carried to the brains by the inferior vena cava, and from these, by the superior vena cava, again passing through the cardiac vesicles, it is dispersed by the descending aorta into the parts of the abdomen, from which it then returns, as before, by the inferior vena cava (§§ 330–31). The circle described by the blood when thus translated, is, as it were, a double and reflected circle, but yet continuous. Thus, while a circulation of this kind is going on, necessity requires the successive existence of two motions in the auricles and two in the ventricles (§ 333).

Similar also is the mode and determination of the circulation in the united or conical heart prior to the commencement of the respiration of the lungs, this being such that the blood, carried by the superior vena cava from the brains to the right ventricle of the heart, is then propelled through the tubus arteriosus into the descending aorta and so into all parts of the lower region; from there it ascends through the inferior vena cava and is driven through the foramen ovale into the left ventricle of the heart, and from thence toward the brains; and so on continually, the little heart thus determining the stream on both sides in a distinct way. For this end, the foramen ovale and tubus arteriosus were prepared, without which such a circulation could never be carried on (§§ 335, 339).

Prior, therefore, to the blood being granted a passage through the lungs from the right ventricle of the heart to the left, the whole of it passes through the brains before being carried off to the body and its viscera. And, lest the brains be contaminated by foul blood, it is first passed through the liver to undergo purification (§§ 340–41). All this, however, takes place with a difference in ovipara and vivipara (§ 344).

Finally, it experiences its *third* change, after birth and exclusion; for then the blood is impelled from the superior vena cava and at the same time from the inferior, into the auricle and ventricle of the right heart, and after passing through the lungs, into the auricle and ventricle of the left heart, and from thence into the trunk of the aorta; from which, the brains take and withdraw no more than the rationale of their state demands. At this time there are no longer two successive motions in the auricles and two in the ventricles (§§ 345–46).

When, immediately after birth, the hinge of the circulation is thus turned, the foramen ovale and the tubus arteriosus are necessarily closed. Yet, from various causes, this foramen may for a long time be held open from the right auricle toward the left, and also, from certain causes, from the left toward the right (§§ 351–56).

THE FIFTH PARAGRAPH, which treats of the heart of the sea turtle, gives Morgagni's observation on this subject (§ 373), and from a comparison of this heart, as being triventral, with the heart of a land animal, as being biventral, the author points out five points of difference, as follows (§ 374):

1. That the heart with three ventricles sends out two great arteries from its right ventricle; while from the heart with two ventricles proceeds only one great artery, namely, the aorta, and this from its left ventricle.
2. That the former extends the pulmonary artery from the intermediate or third ventricle, so that the ventricle seems to be an extension of the canal of the pulmonary artery; while the latter carries this artery from its right chamber.
3. That the former does not send out any artery from its left ventricle, so that the latter seems to be merely a sinus of the venous pulmonary blood; but the latter extends the aorta from its chamber immediately.
4. That for these reasons, in the former, the two posterior ventricles must communicate with the right common ventricle by two foramina, the

septum being pierced in this way; but not so in the latter or bivalent heart.

5. That in the former, there is a certain venous sinus in front of the right auricle, whereby the stream conveyed to the auricle through the tensed valves, is restrained from flowing back; but in the bivalent heart it flows in, from the inferior vena cava and from the superior distinctly and immediately, the inflow not being hindered by any valve.

Many points are then discussed, as to the use of this mode of fabrication in the sea-turtle (§ 375).

The SIXTH PARAGRAPH treats of the arteries and veins proper to the heart, and of the coronary vessels. In the beginning, the author adduces what has been put forth by Lancisi, Lower, Boerhaave, Winslow, Ruysch, Morgagni, Verheyen and Vieussens (§§ 387–97), and from this are deduced the following:

The coronary vessels of both classes, the arterial and the venous, spring not from the beginning of the aorta but from the heart itself (§ 399). For in the ventricles and auricles of the heart are columns and lacunae, fleshy ducts and motor fibres (§ 403). The blood flows from the heart into the lacunae, especially under the columns; from the lacunae it is expressed into the fleshy ducts, and from these into the fibres; from the fibres into the coronary vessels, both those called arterial and those called venous; from the coronary vessels, either by two foramina into the aorta, or by one large foramen into the right auricle, or by many smaller foramina into the same (§ 405–15.) But any superfluous quantity in the coronary vessels flows back into the lacunae and ventricles of the heart (§ 417).

All these vessels depend solely on the action of the heart, they—and also the motor fibres, the fleshy ducts, and likewise the lacunae of the ventricles and auricles—being all set in the stream of the heart's motion (§§ 418, 420). From which it follows, that the vessels which occupy the surface are all venous vessels, to which, in the substance of the heart are corresponding arteries (§ 421).

Seeing then, that the coronary blood emerges from such an origin, it follows, that the superficial vessels, commonly called coronary, perform their diastole when the heart performs its systole; and likewise, that the vessels constituting the superficial vessels of the auricles perform their

diastole when the auricle performs its systole (§ 423). But since the auricles, and especially the right auricle, are subject to many anomalies, therefore, in order that the auricular blood may find outlets in any contingency and at any crisis, a number of open orifices are provided whereby it can be expelled in accordance with every diversity of states (§ 428).

If the origins of the coronary vessels are compared with their outlets, it will be clear that the blood of the right heart is transferred immediately into the aorta, or the blood of the left heart into the right auricle, in a ratio not much unlike that which formerly obtained by means of the foramin ovale and the tubus arteriosus; so that, in respect to the determinations of the quantity of blood running through them, these vessels and their mouths, have succeeded in the place of the above-mentioned foramen, and also of the tubus arteriosus, the path and mode of circulation alone being changed; and this, to the end that no superfluous quantity of arterial or venous blood shall ruin or destroy the natural state of the kingdom, which is subject to such frequent changes (§§ 431,446).

Neither the motion of the heart nor the circulation of the blood can long endure, unless the vessels proper to the heart, those namely, which unload the blood into the aorta, and those which unload it into the right auricle, progress distinct from each other and without intercommunication. Were these vessels conjoined, the like effect would result as if the ventricular septum of the heart were pierced (§ 448).

Meanwhile, one who diligently searches into the origins, progressions, and outlets of these vessels, and reflects upon them, will find therein, and consequently in the heart, a certain effigy and representation of the state of the body and animus (§ 449); in which respect, many affections may not improperly be attributed and ascribed to the heart also, in agreement with the familiar mode of speech (§ 452).

THE SEVENTH PARAGRAPH, on the Motion of the Adult Heart, after setting before the reader the observations of Boerhaave, Harvey, Lancisi, and Steno (§ 460-67), warns us, that:

For the investigation of the proximate and remote causes of the motion of the heart, in addition to bearing in mind what has been laid down concerning the blood, arteries, and veins, concerning the primitive fabric of the heart, and its proper and coronary vessels, and concerning the circulation in the foetus (§ 469), it is necessary at the outset that we inquire

into the cause of the action of the nerves in general, and also of the ganglia; and especially of the intercostal nerve and par vagus, of the great cardiac plexuses and, individually, of each of the nerves of the heart dependent thereon (§§ 471–98); and also, into the cause of the action of muscles, seeing that the whole heart is nothing but a muscle (§ 502).

From which it will be evident that the proximate cause of the heart's diastole is the continuous pressure and action of the blood and of the two vena cavae upon the right auricle; and that the proximate cause of its systole is the extension of nerve fibres, this being such that when the blood acts, the nerve fibre yields, and when the fibre acts the blood yields (§ 512).

The cardiac machine is so constructed that its alternate motion depends on the auricles, especially on the right auricle, as on a wheel and its pivot, and is determined thereby; and consequently, on the intumescence of the auricle owing to the incumbency, action, and influx of the blood; and on its detumescence when the nerves are on the stretch (§ 538). All the other parts are so mutually connected, that whatsoever of them comes into motion, contributes to its reciprocation. Hence, the several parts, together with the whole, are held in such equilibrium that the least thing turns the hinge of the motion, and the resistance, which, in the natural state is very slight, is easily overcome (§ 546).

The remote efficient causes of the motion of the heart are: The lungs, in that they admit and transmit the blood of the right heart, and hold the praecordia in the universal motion (§ 548–49); the cerebrum, in that it propels its blood toward the jugular veins, and besprinkles it with spirituous fluid, by its own force; and also in that it acts upon the muscles of the body (§ 533); the cerebellum, in that, also by its own force, and so from a living fount, it rolls the blood down into the superior vena cava, and fills and animates the cardiac nerves, nay, and also the nerves of the arteries and veins, with spirituous fluid (§ 558); the medullas oblongata and spinalis, in that they transmit the blood to the two vena cavae, transmitting it to the superior cava more especially by means of the vena azygos (§ 562). It is not necessary that the moments of the animation of any of these should coincide with the alternate motions of the heart (§ 569).

And since these are the remote causes of the heart's motion, it follows that this motion can be continued for some time, in the absence of any of them; but the time will be longer or shorter, according as the above-

mentioned bodies are in the nexus of causes, the motion enduring so long as the nerve fibres can be preserved in their integrity and force of action, which is an office proper to the cerebellum, and the blood be poured into the vena cava from a living fount (§ 571).

From the above can also be readily gathered, the causes of the variation of the pulse, these causes being divided, in general, into internal and external, natural and extraordinary. But the doctrine of the pulse can be given and completed in a suitable manner only at the end (§ 578).

In his several Paragraphs, the illustrious author does, indeed, discuss in the most learned way many more points than those we have noted above; but were we to extract all that seems to us worthy of note, what would be the length of our review? and where the end? Let us proceed, therefore, to the EIGHTH and last PARAGRAPH, comprising the Introduction to Rational Psychology—a Paragraph to be examined the more diligently, in that it sheds much light on what has preceded, where the doctrine of series and degrees has been so frequently mentioned.

Psychology, by which is meant the science of the essence and nature of the soul and of the manner whereby it flows into the actions of its body, is the first and last of the sciences which lead to a knowledge of the animal economy. But since the soul lies concealed in so deep a retreat that she does not come to view unless the bands are removed and unfolded one after the other, therefore, it behooves us to ascend to her by the same degrees and the same ladder as that by which her nature, in the formation of her things, descended into her body (§ 579).

First, then, must be submitted the doctrine of series and degrees, that doctrine namely, which teaches the mode observed by nature in the subordination and coordination of her things, and which she has prescribed for herself as to be observed in her actions (§ 581).

Series are what comprise successively and simultaneously things subordinate and coordinate. Degrees are the distinct progressions observed when one thing is being subordinated under another, and when one thing is being coordinated by the side of another; so that, in this sense, degrees are divided into degrees of determination and degrees of composition (§§ 582–83).

In the mundane system, there are many series, these being universal and less universal. The most universal series is the universe or the mun-

dane system, and this contains within itself many series. The series comprised in the mundane system are divided into three superior and three inferior, the former pertaining to the circumambient universe or mundane system, and the latter to the earth. The series of the circumambient universe or mundane system is a series of substances derived simply from the first substance by the order of succession. The second series is that which is constituted by these substances when left to themselves and their own nature, or when endowed with the liberty of gyration; whence comes fire, both the solar and the lower elementary. The third series is that of the auras of the mundane system arising from the two former series, and thus from their actives and quasi passives. It is this series which actually constitutes the circumambient mundane system, and without it the three inferior series cannot exist. According to the dictate of general experience, when investigated as to its causes by means of rational analysis, the auras which constitute this series are four in number; and, as they follow each other in order, they decrease in simplicity, purity, universality, and perfection. These are the most perfect forms of active and passive nature, and represent her forces as already formed. The mundane system itself so strongly confirms their existence that he who calls them into doubt closes for himself the road whereby to explore phenomena, and to find the causes in every causate.

The general series of the earth, that is to say, the inferior series, are commonly called the mineral, vegetable, and animal kingdoms. They have under them many species, and they follow each other in time and order. For the first is the mineral kingdom or the earth itself, being the parent of the other series. The vegetable kingdom owes its existence to the minerals of the earth; into the earth, moreover, as into a matrix or womb, it lets down its little seeds whenever it is to be born anew. After this comes the animal kingdom; for every animal, that it may exist and subsist, requires a previously existing nature and world. The last of this series is the most perfect animal, man, who is the complement of all the series and of the whole, and is the microcosm of the macrocosm.

In these six series nature seems to have rested; for there is no seventh (§ 584).

Each of the above series contains under it many series proper and essential to itself, and each of these again contains its series, and this not

only in the general but also in the species and in the individual of each species. Thus, for example, every individual animal is a general series consisting of many essential and proper series. Its essential and proper series are the viscera⁷ which, taken together, effect the form. Each such series contains its own essential and proper series as subjects; and these may be called partial series, if the former be called integral; or singular series if the former be called general. An example of this is the liver, which is a great gland, and comprises a conglomeration of many glands, just as the latter comprise a conglomeration of their own least glands. So also in all other series, these referring themselves to their integral series, and this to its general series, and so forth (§ 585). Nor is there anything extant in the visible world which is not a series, or in a series (§ 586). Consequently, the science of natural things depends on a distinct notion of series and degrees, and on a distinct notion of their subordination and coordination (§ 587).

The man who is desirous of progressing in this matter, from common initiations, must make his commencement from substances which are the subjects of accidents and qualities. And while there are manifold substances in existence, yet, of all the substances of the universe there is but one first substance, from which flow all the rest, and wherein, as in a beginning, are impressed by the supreme Deity, the principles of natural things (§ 589–91). Each series acknowledges its own first and proprial substance, but nevertheless, for its existence, this depends on the first substance of the world. Thus, there is a first substance of the mineral kingdom, a first of the vegetable kingdom, and a first of the animal kingdom, and by some this is called an element, a monad, a simple primitive substance (§ 592).

The first substance of a series is its most simple and only substance which rules in that whole individual series. From this, and in accordance with its nature, flow all the things that are seen to be determined in the entire series. For from it, by order of succession and by the mediation of copulants, are derived more compounded substances which are its vicegerents in the ultimates of the series, and which thus determine the

⁷In the Latin, this word has a wider meaning than is usually given it in English. It includes all the organs of the body from the brains to the lowest viscera of the abdomen.

things contained in that series (§ 594–97). By the determination of these substances are formed other and more compounded substances, these being the mediate and subdeterminant substances from which are compacted and connected together the essential and proper series which constitute the entire series (§§ 598, 600). By determining substances, with the mediation of such as are subdetermining, one thing is so perpetually connected with the other that no part proper to that series is unconnected. Consequently, there is a coestablished harmony (§ 601). The more distinctly the simpler substances discriminate themselves from substances that are more compounded, and the more completely substances of the same degree distinguish themselves from their associates, their essence and attributes remaining ever the same, the more perfectly is the harmony co-established; and from this also exists harmonic variety (§§ 602–4).

In this way a corporeal system is constructed and perfected, wherein one thing is so subordinated and coordinated in relation to another, that all have mutual regard to each other and mutual dependence on each other; and this in such way that the more simple substances of a series are at once rendered conscious of whatever of mutability occurs in the compounded series and substance; and all that is determined into act, is done with the determination or concurrence or consent of the more simple substances. All this, moreover, is carried on in accordance with natural order, from an inferior substance to the next superior, or from a superior to the next inferior; but not from the supreme substance to the ultimate, except by means of substances that are intermediate (§ 608–11).

Simple substances, with the more or less compound substances which are the determinants of things in their own series, are prior and posterior, superior and inferior, interior and exterior, more remote and more proximate, and are inter-related as causes and effects, according to the degrees of their simplicity or composition. Those which are prior are also more universal than the posterior, and more perfect in every quality. Moreover, those which are prior can exist without the posterior but not the reverse (§§ 613–17).

As it is with substances, so is it with their essences, attributes, accidents and qualities, that is to say, with all their adjuncts. Of these adjuncts also it can be predicated that they are a series and in a series; and likewise that they are simpler, prior, superior, interior, more universal, more per-

fect, entirely according to the substances in which they are and from which they flow; also that the superior adjuncts flow into the inferior, and the reverse, flowing in according to the manner in which the substances had been formed, and communicating by connection (§ 619–22). But those which hold a superior position are incomprehensible, and, to the sensory of things inferior, appear as continuous (§ 623).

Nevertheless, in the same series there is such a co-established harmony of all things that they mutually answer to each other, with a discrimination of perfection solely according to degrees; for which reason, inferiors regard superiors as their analogues and eminent (§ 625–26).

Aggregate entities of the same degree and series,—by which, however, are not meant the monads of Morinus nor the homoeomeriae⁸ of Anaxagoras of Clazomene, nor the atoms of Epicurus, Democritus, the Elean Leucippus, or the Phoenician Mochus, nor the primitive and simple elements of certain other philosophers, in that they do not admit of resolution, but the least in every degree of a given series,—refer themselves to their unities as to the most simple points with which they are homogeneous [§ 629]. From the form, nature, and mode of action of such aggregates, we learn the form, nature, and mode of action of the parts. Consequently, general and particular experience with regard to all such things as can possibly reach any sensory, indicates the essence of the least things of that degree, nay, and also of the corresponding things of the yet more simple and superior degrees. Therefore, by the doctrine of series and degrees, when joined to experience, we are led at last into the inmost knowledge of natural things [§§ 631–32].

The most simple and unique substance of the animal kingdom is the spirituous fluid, which is most perfectly determined by the first aura of the world. This aura, than which nothing can be said to be prior, superior, more universal, or more perfect, is formed immediately from first substances, from which it derives its whole power,—of which latter hardly more can be uttered than of the parent substance itself, and in which as in a beginning are implanted the principles of natural things. This aura is called the verimost form of the forces of the created universe, to which the

⁸ The homogeneity of the elements or first principles.

qualities of inferior auras, such as determinability, modificability, etc., can be applied only by way of eminence; it is also, the most perfect force of nature. Phenomena indicate how the inferior auras, such as air and ether, and also the superior and finally the supreme, flow into the life of an animal [§§ 634–35].

From the above-mentioned determination of the spirituous fluid results its nature, this being such that it is able to be the formative substance of its body, a substance wherein is the life and consequently the soul which constitutes the principle or beginning of all that exists in this whole series [§§ 636–37].

But in order that the efficient, rational, and principal causes of the operations and effects existing in the animal body may be explored, it is necessary that we inquire as to what things in the superior degree answer to things in the inferior degree, and this would be the work of experience and ingenuity. For, as nature ascends by her degrees, so she betakes herself from the sphere of singulars and of ordinary words, to the sphere of universals and eminent; and this in such way, that at last, in the supreme region of the animal kingdom, where is the human soul, no corporeal speech is found which adequately expresses its nature and much less the nature of things still superior [§ 648–50]. Wherefore, a mathematical philosophy of universals must be elaborated which, by characteristic notes and by letters, shall express, in a way not much unlike as to its general form, the algebraic analysis of infinites, things which cannot be expressed by words; a philosophy which, if rightly developed, would be the one science of all, because embracing all (*Nova Act. Erud.*, Nov. 1742, pp. 642–63).

Neue Zeitungen von Gelehrten Sachen

The above review was noted in the *Neue Zeitungen* for November 26, 1743, p. 856.

XXXVII

Carmen in Typographiae Solemne Seculare tertium celebratum Lipsiae (a verse in honor of the third century of printing, solemnly celebrated at Leipzig in 1740).

NOTE. This consists of a Latin verse which was printed in a memorial volume *Gepriesenes Andenken von Erfindung der Buchdruckerey wie Solches in Leipzig beymschluss des dritten jahrhunderts von dem gesammten buckdruckern daselbst gefeyert worden* (Memorial in Praise of the discovery of printing, as this was celebrated in Leipzig at the end of the 300th anniversary by the printers there assembled *Leipzig 1740*. 4to, pp. LVI + 176. This is a handsome quarto volume published at the expense of Emperor Frederick III, in October, 1740. It contains the history of printing; extracts from sermons preached in connection with the celebration; the oration read at the great meeting on June 27, 1740; and laudatory poems from the learned and others. It is evident that Swedenborg, who, after the issue in Leipzig of his magnificent edition of the *Opera Philosophica et Mineralia* was well known in that city, had been requested by those concerned in commemorating the celebration, to contribute to these laudatory poems.⁹ His contribution is signed "Emanuel Swedenborg, Assessor of the College of Mines of the Kingdom of Sweden." The only other Swede who contributed to the volume was Nickolas v. Oelreich, Professor of Philosophy at Lund, who was a personal friend of Swedenborg.

XXXVIII
On Charles XII

NOTE: This is an account of Swedenborg's contact with Charles XII, and dwells mainly on the king's genius in mathematics, and particularly on his invention of a new system of numbers. It was written to Dr. Joran Nordberg, after the latter had received a royal commission to write a life of Charles XII, in 1731. Dr. Nordberg published it in his *Carl den Tolfstes*, volume 2, Stockholm, 1740, pp. 599–602. A German translation was published in Hamburg, 1746, and a French translation in The Hague, 1748.

⁹One of the poems has the words, written after the author's signature, *Scripti rogatur* (written by request).

Bibliothèque Raisonnée

Although Charles XII had lived in the fatigue of a campaign which was almost continuous for twenty years, yet he had a thorough knowledge of mathematics; and MM. Polhem and Swedenborg could not sufficiently admire the force of his views on subjects which it would seem impossible deeply to enter into save in the leisure and silence of a student's closet (*Bib. Rats.*, Jan.–Mar. 1747, p. 134).