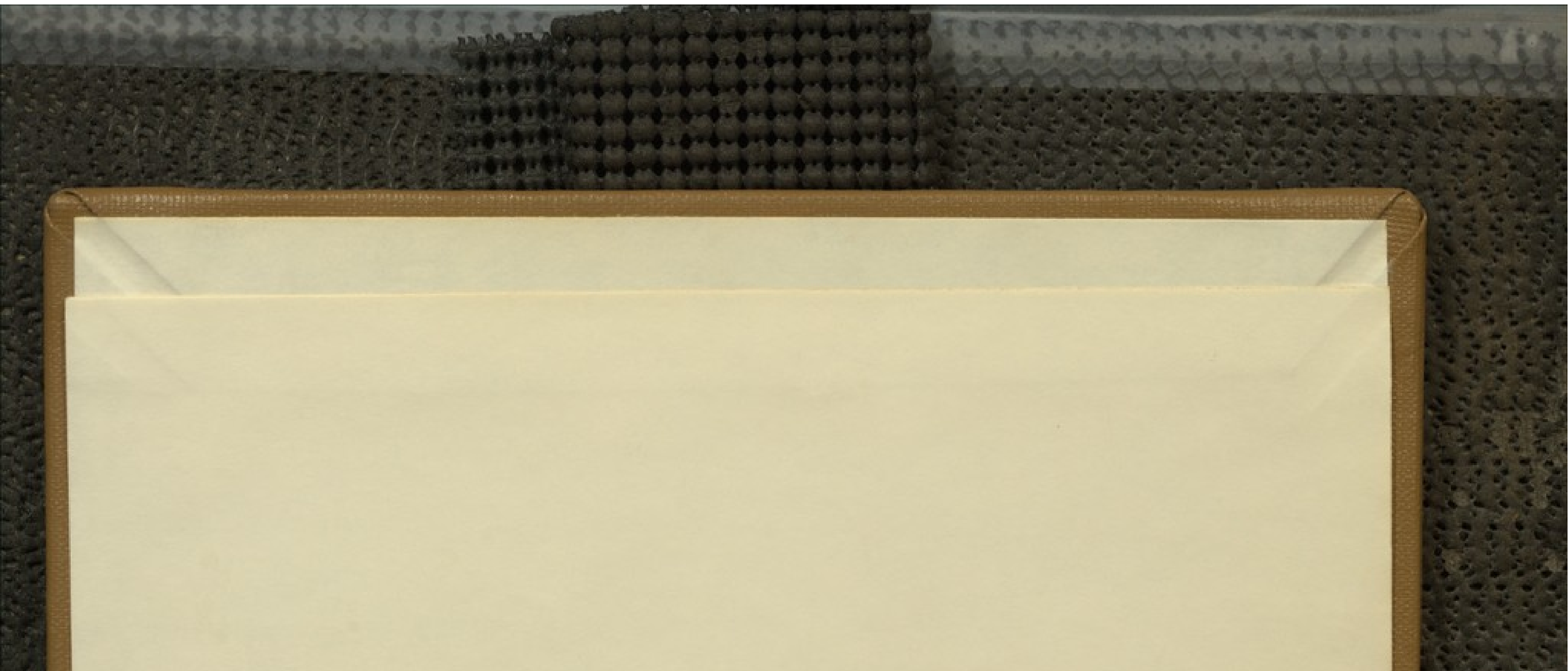

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THE

PRINCIPLES OF PHYSIOLOGY,

BY

JOHN AUGUSTUS UNZER;

AND

A DISSERTATION

ON THE

FUNCTIONS OF THE NERVOUS SYSTEM,

BY

GEORGE PROCHASKA.

TRANSLATED AND EDITED BY

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PREFACE.

The Introduction which I have written, at the request of the Council of the Sydenham Society, might suffice for a Preface also, if it were not that there are one or two matters to be mentioned which a Preface only can include.

In the first place, I earnestly request the reader's close attention to the works contained in this Volume; partly, for my own sake, that I may not lose the sweetest reward of literary labour; but principally for his and for the interests of medical science and art. They belong to a field of research not yet fully entered upon by the medical profession. Emigrants from its ranks have been the "Pilgrim Fathers" of many, if not most, of the natural history sciences; but there is one that has yet to be perfected by its labours—the science of *mind*.

The study of Life and Organisation is confessedly essential to the progress of medical science and art; and it appears to me, that that true intellectual system of the universe, which will and must comprehend, in orderly arrangement, all the phenomena of Life and Mind, ought, therefore, to emanate from the medical profession. If so glorious a result of philosophical inquiry be within its scope and aim, then are the works contained in this Volume of double value and interest to it, since they not only powerfully elucidate the Physiology and Pathology of the Nervous System, but constitute an important contribution to Mental Philosophy.

Having said so much for the works entrusted to my care, I must now say something, by way of thanks, to those who have assisted me in bringing them out. My kind friend, Professor MARX of Göttingen, has not only readily afforded me his advice as to the translation of Unzer's work, but has also contributed much valuable and interesting information respecting the life and writings of his countrymen, which I have embodied in the Introduction. I have also to acknowledge my obligations to Professor SHARPEY, and Dr. ADAMS of Banchory, (so well known to the Sydenham Society for his translations of Hippocrates and Paulus Ægineta,) for the valuable criticisms with which they favoured me when the 'Dissertation on the Nervous System' was going through the press. To these three gentlemen both reader and translator owe their thanks.

But there is one other valued name I cannot omit here without injustice. To Dr. FORBES we owe the first substantial introduction of Unzer's work to the English reader; to him, therefore, our thanks are also due;—and not for this service only, but for many others rendered to the medical profession and to medical science and literature, the value of which have yet to be acknowledged.

Of my own share in this work I have only to say, that I feel I had an important trust committed to me, and laboured accordingly;—laboured, it is true, with the usual drawbacks of an active professional life;—and if this be admitted by the critic as an excuse for errors and failures, I shall be grateful to him.

T. L.

YORK; *February* 1851.

INTRODUCTION

BY THE TRANSLATOR.

It having been thought expedient to facilitate the comprehension of the Physiological Systems laid down in this volume, by a short notice of the labours and literary course of the writers, I subjoin the following remarks.

John Augustus Unzer (or Untzer) was born at Halle, April 29, 1727, and commenced the study of medicine at the university of his native town, when only 12 years old. He showed an early inclination to neuro-metaphysical studies, for, at the age of 18 (while yet a student), he attempted to elucidate mental philosophy by the physiology of the nervous system, in an essay, published anonymously, entitled 'New Views regarding the Emotions,'[1] in which he attributed the emotions to varying tension of the nerves; in the same year (1746,) he wrote a defence of the doctrines of Stahl, entitled 'Thoughts on the Influence of the Soul on its Body;'[2] also 'Thoughts on Sleep and Dreams, together with a Letter showing that there may be Sensation without the Head,' under the somewhat curious signature of 'S. C. I. S.'[3] From this date to the year 1771, when the work now translated was published, a quarter of a century elapsed, during the whole of which period his attention was continuously directed to his favorite subject, as is shown by the essays and treatises he gave to the world during that period. In 1747 he published a 'Treatise on Sighing.'[4] On taking his Doctor's degree, in the following year, he defended his dissertation 'De Sternutatione;' and,

[1] Neue Lehre von den Gemüths Bewegungen.—Halle, 1746.

[2] Gedancken vom Einflusse der Seele in ihren Körper.—1746.

[3] Gedancken vom Schlafe und den Traümen nebst einem Send-schreiben dass man ohne Kopf empfinden könne. Halle, 1746.

[4] Abhandlung vom Seufzen. Halle, 1747.

in 1749, his dissertation 'De Nexu Metaphysices cum Medicina generatim.' In 1750 he published a 'Philosophical View of the Human Body generally,'[1] in which the germ of his future views may be distinctly traced. Towards the close of this year he left Halle to reside at Hamburgh,[2] where he immediately became connected with the 'Hamburgh Magazine' (vide vol. vi), and communicated to it various essays of a neuro-metaphysical character: amongst them was one, entitled 'Reflections on the fundamental Principle of Stahl's Theory.'[3] In 1759 he established a weekly medical journal, 'The Physician,'[4] on the model of Addison's 'Spectator,' with the view of securing a proper estimate of physicians and of the art of healing, and of extending sound medical knowledge, removing prejudices, and checking the misdoings of ignorant practitioners; it is an amusing medley. The first part contains his portrait by Tischbein. This journal was translated into Danish, Swedish, and Dutch, and was published during the years 1759-64; the neuro-psychological essays he inserted in it are frequently referred to in the present work. From 1766 to 1769 he published 'Collections of Minor Physical Essays:'[5] and in the latter year, a new edition of 'Der Arzt,' in six volumes. His portrait, taken in the 42d year of his age, painted and engraved by H. G. Fritzsch, fronts the title-page of the first volume. In 1768 he made an attempt at a better and more systematic arrangement of his views, in a work entitled 'Outlines of a System treating of the Sentiency of Animal Organisms;'[6] and, finally, three years after, he published the work now translated, which he dedicated to his brother, Dr. J. C. Unzer, and which may be looked upon as a new and much improved edition of the last-mentioned publication. Thus his 'Principles of a Physiology of the Animal Nature proper to Animal Organisms,' was given to the world at the mature age of 44, after it had been virtually a quarter of a century

[1] Philosophische Betrachtung des Menschlichen Körpers überhaupt. 1750.

[2] Haller makes a statement in his 'Bibliotheca Anatom.,' (vol. 2, p. 400), which, on careful inquiry, I find to be erroneous, namely, that Unzer was Professor of Medicine at the University of Rinteln.

[3] Betrachtungen über Stahl's theoretischen Grundsatz.—Hamburg. Magaz. Bd. 10.

[4] Der Arzt;—eine Medicinische Wochenschrift.

[5] Sammlung Kleiner physicalischer Schriften;—the third in 1769.

[6] Grundriss eines Lehrgebäudes von der Sinnlichkeit der thierischen Körper.

in preparation, and may therefore be considered as the work of a powerful metaphysical intellect, in the prime of its strength, and thoroughly informed on the subject to which it had been so long, so perseveringly, and so assiduously directed. With the exception of a reply to various reviews of the work,[1] Unzer wrote no more on his favorite subject, but turned his attention to the pathology of contagion, and contagious diseases, which he elucidated with his usual acuteness. He died, rich, April 22, 1799, being a week less than 72 years old.

Having thus given a brief sketch of Unzer's literary career, I will notice, as shortly as possible, the origin and progress of his peculiar views, as finally perfected in this, his greatest work. Although he must have been eminently qualified by natural endowments, and by a natural bias to metaphysical research for grappling successfully with the profound and very difficult questions of physiological metaphysics, it is probable, that to his early associations at the University of Halle we owe the special direction of his mind to the subject. Both Hoffmann and Stahl were professors at Halle for a lengthened period; but when Unzer commenced his medical studies, the former was still professor, at the venerable age of 79, and died at Halle, in his 83d year, so that Unzer must have known him personally. It was, however, as the pupil of Juncker, an avowed Stahlian, that he specially directed his attention to the metaphysics of vital actions, and to him Unzer dedicated his defence of the doctrines of Stahl, in a long and highly complimentary dedication. At this time physiology, and especially the physiology of the nervous system, was fast losing its purely hypothetical character, and assuming the rank of a science. Mental philosophy had long taken cognisance of the different kinds of motion in animals of which every man is led to discriminate at least three:—namely; 1st, those dependent solely on the will; 2d, those of which he is conscious, but which are independent of the will as the exciting cause; 3d, those of which he is wholly unconscious, and which can neither be excited nor restrained by volition. The first class of actions could be readily ascribed to the soul; but the second and third classes,

[1] Physiologische Untersuchungen auf Veranlassung der Göttingischen, Frankfurter, &c. Recensionen seiner Physiologie der thierischen Natur.—Leipzig, 1773.

although independent of reason, volition, and even consciousness, were equally characterised by their intelligent and exact adaptation to the wants of the animal. To explain the origin of these adapted acts, and to determine their relations to those of the reason and will, was a problem which had occupied and baffled the greatest intellects, from Plato downwards, and a satisfactory solution had never been given to the world. In the theory of Aristotle, these various actions were considered to result from the operation of a sentient, or intelligent principle, endowed with certain faculties or powers. All the faculties that, according to this theory, can exist in a living creature, are five:—namely; 1, the faculty of receiving nutriment; 2, of sensation; 3, of motion in place; 4, of impulse or desire; 5, of intelligence: so that soul, considered as endowed with only the nutritive faculty (which is present in all beings), may be attributed to vegetables. The soul of man differs from the soul of lower beings, in being endowed with the faculty of intelligence, in addition to all the others; consequently it may be considered as containing three portions,—logically, not materially, separated,—one, absolutely without reason; a second, rational; a third, participant of reason.

The Aristotelian philosophy was long exclusively current in the universities and schools; but, with the revival of anatomy and physiology, the outlines of various systems of *physiological* metaphysics appeared, and anatomy, physiology, and natural philosophy, were brought into direct relation with psychology. Our own Willis took the lead in this new department of medical science. He illustrated the human and comparative anatomy of the brain and nervous systems, by drawings and copper-plates; he distinguished two kinds of souls, namely, the corporeal or sensitive (the *anima*—the soul of brutes), and the rational or intellectual (the *animus*): and he assigned the cerebrum to the latter, and the cerebellum to the former, the diseases, faculties, and operations of which he treated of specially in his two discourses, 'De Anima Brutorum.'[1] The first discourse is physiological, and, in many respects, is the analogue and prototype of Unzer's work; the second is pathological, and

[1] De Anima Brutorum *quæ Hominis vitalis ac sensitiva est*, Exercitationes duæ quarum prior Physiologica ejus naturam Partes, Potentias, et Affectiones tradit; altera Pathologica, &c.

treats of the diseases of the brain and nervous system. In these, as well as in his other neurological works, Willis follows the line of research which his peculiar position, as Sidley Professor of Natural Philosophy at Oxford, would almost necessarily incline him to take. According to Willis, the vital, sensitive, or corporeal soul, performs two principal offices; namely, first, to form the body of the animal and its organs, and then to render it and them apt and fit for all the purposes of the life of the individual. The better to illustrate his views, he devotes a chapter to a description of the various kinds of lower animals, including therein zoology, and comparative anatomy and physiology. To this corporeal soul he ascribes all the emotional, instinctive, and involuntary acts. Touching this class of movements, he observes, (I quote the quaint, vigorous language of Pordage's translation,)—"First, as to what regards natural Instincts, it is a great and most ancient Notion, That there is, in all Living Creatures, an innate Conservation of themselves; to wit, that every Individual might preserve itself as long as it can. This is a Law of Divine Providence, inbred in all creatures, which gathers together the Principles of Life like a Bond, otherways apt to be dissipated and to depart one from another, and on which, as the Basis, the Duration or Continuance of the whole World stands." "This being supposed, it necessarily follows, that all Animals ordained for this end, are furnished also with certain fit means for following the same, wherefore they ought to know, by Natural Instinct, whatsoever things are Congruous and benign, and what are incongruous or hurtful to them; and that they should follow these with hatred and aversion, and those with Love and delight. Hence it is, that every one of them are able to choose Food proper for themselves, and to seek it, being absent, and remote from their eyes; And, from an implanted disposition of their Nature, are skilful to know and oppose Enemies, to love their Friends, to get a female fit for themselves, and to make ready whatever may conduce to the Procreating and Cherishing their young; besides many other Kinds of powers and habits, granted to us not without Learning and Study, are originally fixed on the *præcordia* of the Beast."[1]

[1] "Quod autem spectat ad *instinctus naturales*, antiquissima, et maxime generalis notio, cunctis animalibus innata est *sui ipsius conservatio*, nempe ut unumquodque

Willis was not, however, solitary in his doctrine as to the existence of two souls in man;[1] Gassendus, and Dr. Hammond, a learned English divine (both his contemporaries), are specially quoted by him; nor was he alone in his direct application of natural science to mental philosophy, for Sylvius was diligently pursuing at Leyden the same course of research which he was following at Oxford. Sylvius, however, followed Descartes, while Willis was influenced in the formation of his theories by the doctrines of Paracelsus. There was, however, yet another neuro-psychologist, whose name is less known in England, but who was the contemporary of Sylvius and Willis, and taught identical or analogous doctrines, with brilliant success, at Jena, —this was G. W. Wedel, the teacher of Hoffmann and Stahl, —and it is through him that we have to trace the views of Unzer in a direct line from Willis.

Hoffmann and Stahl ran a singularly parallel course through life. They were born in the same year (1660), and studied at the same time and place, under Wedel, at Jena, then the most renowned university in Germany. They were appointed professors of medicine at Halle, in the same year (1694), and at the same age; and both became physicians to the king of Prussia; Hoffmann was the first to leave Halle, and fill that office, but, in three years, he abandoned court, and resumed his professor's chair, where he died, in the 83d year of his age. Stahl died at Berlin, the physician to royalty; but, previously to his removal from Halle, he was a professor for twenty-two years. In the neuro-metaphysical doctrines of both these great men, the influence of Willis's views may be traced, but the purely metaphysical bias of Stahl's mind soon showed itself; for he repudiated all histological, anatomical, and bio-chemical researches, as worse than useless in medicine. The foundation of his theory was wholly metaphysical; the organism, considered as matter, had no power to originate movement; it could only be put into motion by an immaterial principle,—the soul; and the laws of action

individuum, quamdiu possit, sese tueatur: hæc divinæ providentiæ lex est, creaturis omnibus indita, quæ vinculi instar vitæ principia alioqui dissipari, et ab invicem discedere apta, una colligat, et cui tanquam basi totius mundi duratio innititur," &c. De Anima Brutorum, *Pars Physiolog.* cap. vi.

[1] Prochaska gives an account of Willis's views on this and other points, in his 'Dissertation on the Functions of the Nervous System,' chap. i, § vi.

of that principle were alone to be investigated. According to his views, the involuntary, instinctive, and habitual acts of the organism, are produced unconsciously by the soul; being adapted, they result *ratione*, or λόγῳ, but not *ratiocinio*, or λογισμῷ. Hoffmann, on the contrary, seems to have been eclectic, and to have constructed his system by modifying those of Sylvius, Willis, Wedel, and Stahl. He recognises a sensational soul, or *anima sensitiva*, as distinct from the rational soul; and an etherial fluid, diffused throughout nature, is the means by which this soul acts on the body. The blood receives this ether from the atmosphere; it is secreted from the blood by the brain; and, being transmitted thence along the nerves, the *anima sensitiva* is enabled thereby to produce all the instinctive and involuntary acts displayed by animal organisms. The conservative and remedial powers manifested by the latter, which Stahl attributed to the soul, Hoffmann considered to be a law of life, seated in the general organisation, as Willis did before him. He distinguished the nervous tissue from the muscular, and attributed the motive power of the former to a *vis nervea*, of the latter to a *vis insita*.

Professor Juncker, the disciple and successor, at Halle, of Stahl, and to whom Unzer attached himself, was the contemporary of Hoffmann, and therefore, in some respects, the antagonist. Unzer seems to have attached himself to his master with youthful enthusiasm, and to have defended the Stahlian doctrines, at the outset of his literary career, rather from feeling than conviction. Perhaps he was influenced by the doctrines of Hoffmann unconsciously to himself;—it is certain that, imbued with the same spirit of eclecticism, he quickly abandoned the Stahlian system and method of philosophising, to investigate the phenomena of life and mind by anatomical and physiological researches. During the time that he was a student, and subsequently, general and histological anatomy and experimental physiology were assiduously cultivated, and every year some interesting experiment or discovery was made. It was then, or a few years previously, that Lancisi, Valsalva, Pacchioni, Baglivi, Santorini, Morgagni, and Spallanzani flourished in Italy,—Winslow and Vicq d'Azyr in France,—Albinus in Holland,—and Lieberkühn, Haller, (his distinguished pupils,) and Sömmerring in Germany; while

Cowper, Cheselden, and the Monros, laboured in Great Britain. There were others, who made the structure and functions of the nervous system their special study,—as Krüger, Wrisberg, Meckel, Lobstein, Walther, de Asche, &c.; and thus, every year, new facts and opinions were brought before the eclectic intellect of Unzer, and, every year, he extended and perfected his views. John Gottlieb Krüger was a popular professor at Halle, the native place and alma mater of Unzer, and he, Haller, and Alexander Monro, appear to have had the greatest influence on his mind;—Krüger, by his doctrines as to the involuntary nature of purely sensational movements; Haller, by his inquiries into the nature of muscular action; and Monro, by his researches into the anatomy and physiology of the nervous system. The doctrines of Haller as to the powers and properties of the *vis insita*, he extended to the whole class of purely automatic movements excited by mere impressions on the nerves or nervous centres; the doctrines of Krüger he adapted to the preceding, and to that great class of excited movements accompanied by, but not necessarily dependent on, sensation: the ordinary metaphysical doctrines of the day, as propounded by Baumgarten,[1] were adapted to the current physiology of the cerebrum; and, finally, with all were incorporated the doctrine of Willis and Hoffmann, as to the nature and seat of the conservative and curative powers of the organism.

Thus, after twenty-five years had been devoted to his subject, Unzer gave to the world his system of physiological metaphysics. He lived and wrote far in anticipation of his age and his contemporaries. That which he established hypothetically, but logically, has since been demonstrated by dissection and experiment; what he thought to be only perceptible to the eye of reason, has been revealed to the eye of the histologist; what he discovered, intuitively but speculatively, has been duly enrolled on the records of science as a proved thing. Yet, after the lapse of eighty years, much that he advanced remains to be duly appreciated; and the present age has still to acknowledge, that his work is a model of psychological inquiry, and a mine of suggestive ideas.

[1] The translation from the Latin into German by Professor Meier, of Halle (1766), is the edition of Baumgarten's 'Metaphysics, to which Unzer refers in his work.

George Prochaska was born at Lospitz, in Moravia, April 10, 1749. In 1776 he graduated at Vienna; in 1778 he became Professor of Anatomy and Diseases of the Eye, at Prague; and, in 1791, Professor of Anatomy, Physiology, and Diseases of the Eye, at Vienna. In 1805 he was appointed a Regierungsrath, and died on July 17, 1820, of hydrothorax and pulmonary disease, aged 71. His portrait was published, in 1812, with his 'Disquisitio Anatomico-physiologica Organismi Corporis humani.'

At the commencement of his career, Prochaska specially investigated the anatomy and physiology of the muscular and nervous systems; and, throughout his whole life, endeavoured to elucidate the vital processes. His first essay was published at Vienna, in 1778, and entitled, 'Quæstiones Physiologicæ de Viribus Cordis,' and was followed, in the same year, by 'De carne musculari; Tractatus Anatomico-physiologicus.' In 1779 he published a histological essay, entitled 'De Structura Nervorum; Tractatus Anatomicus:' and this was followed by his 'Adnotationes Academicæ.' The first fasciculus, published in 1780, contained anatomical observations (with plates) on the wear of the teeth, and an elucidation of the causes of the second dentition; together with a description, dissection, and plates, of a human bicephalous monster; the second, published in 1781, contained various contributions to pathological anatomy, a description of four monsters, and a commentary on their mode of generation; the third, published in 1784, contained contributions to pathology and pathological anatomy, together with a dissertation, 'De Functionibus Systematis Nervosi,' the translation of which has been intrusted to me by the Sydenham Society.[1] In 1797, he repeated the views advanced in this essay, with certain modifications, in a class-book he published, for the use of his pupils, at Vienna.[2] The text of the essay sufficiently shows, that the works of Unzer were well known to him, for not only is direct reference made to the 'Erste Gründe,' but the doctrines as to the functions of the

[1] This was republished, with few alterations, amongst the 'Opera Minora' (Vienna, 1800,) of the author; but the translation is from the first edition.

[2] Lehrsätze aus der Physiologie des Menschen, 2 vols. 1797. A second edition appeared in 1802, and a third in 1810. This work was also published in Latin, in two volumes, under the title of 'Institutiones Physiologiæ Humanæ,' 1805.

sensorium commune contained therein are but a synopsis of the views in Unzer's great work. He obviously was also familiar with the views of Willis, of which he gives a synopsis. In his 'Lehrsätze,' (first edition,) Prochaska adopts the principle of a general sensorium commune, but subdivides it so as to correspond with the views of Willis as to the existence of a rational and a corporeal soul in man; he therefore constitutes it of two separate elements, namely, the sensorium commune of the soul, which is seated in the brain only, and reflects those impressions of which we are conscious; and the sensorium commune of the body, which is seated in the brain, spinal cord, and ganglia and plexuses of the sympathetic system. A literal translation of one or two paragraphs from this work will more distinctly show his relations to Willis and Unzer.

"xxxv. *The relations of the vis nervosa to stimuli.*

"§ 178. The operation of the nervous system and of its *vis* is specially related in this respect,—that it feels external impressions by means of the brain, and thereupon causes adapted movements by means of the muscles. The transition of sensation into motion takes place according to the law of self-conservation, written, as it were, on the organisation of the nervous system;[1] for sensations that are agreeable, and conducive to our preservation, cause such movements as are adapted to retain the impression; while movements result from unpleasant impressions, such, that by them the disagreeable impression must be averted from us.

"§ 179. This transition of sensation into adapted movements, occurs partly with the consciousness of the soul, whereby it is taken, as it were, into counsel, and its will obeyed; now these are termed the sentient operations. In other instances, sensations pass into adapted movements without the consciousness of the soul, and often in opposition to its will; and this transition is termed simply the nerve-operations. Following out this fact, Unzer has divided sensation into soul-sensation, or sensation with consciousness; and corporeal feeling, or sensation without consciousness.[2] By this, and the preceding proposition, the relations of the vis nervosa to stimuli can be easily determined."[3]

[1] On the Functions of the Nervous System, chap. iv, § i, in Adnotat. academ. Fasc. iii, p. 117.

[2] Grundriss eines Lehrgebäudes von der Sinnlichkeit der thierischen Körper.—1768.

[3] Op. cit. p. 113.

"XXXVII. *Function of the common Sensorium.*

"§ 215. That point of the nervous system is termed the common sensorium (*Sensorium commune*), in which external impressions meet, and from which internal impressions are diffused to all parts of our body; in which, consequently, the consensus of the nerves takes place that is necessary to Life, and in which external impressions are reflected into internal impressions, according to the law of self-conservation (178), with, or without, consciousness.

"§ 216. That sensorium in which impressions are reflected with the consciousness of the soul, may be termed the soul-sensorium; and the other, the corporeal sensorium; just as Willis has already divided it, into the rational and the corporeal soul.

"§ 217. The brain, only, is the seat of the soul-sensorium; the seat of the body-sensorium is the brain, spinal cord, and (as all observation shows) the ganglia and plexuses of the nerves. That external impressions can also be reflected in the brain, without consciousness, is shown by the involuntary convulsions of voluntary muscles. Monsters, born without brain and spinal cord, and which live up to the moment of birth, show that the consensus of the nerves necessary to this form of life, imperfect though it be, may take place, and that there may be a corporeal sensorium independently of the brain and spinal cord, and which, consequently, must be constituted by the plexuses and ganglia of the nerves. The movements observed to take place on irritating the nerves of a headless frog, and seen also in decapitated men, prove the same thing. The sympathetic nerve appears likewise to reflect its impressions in its ganglia and plexuses, without the consciousness of the soul.

"§ 218. In accordance with this consensus of the nerves, as well in the brain as in the spinal cord, ganglia, and plexuses, the operation of a stimulus is not limited to the nerves immediately irritated, but is extended to distant nerves, in known or unknown connection with the irritated nerves; and this is demonstrated by innumerable examples of consensus of nerves [consensus nervorum], as, for instance, the irritation in the pregnant uterus often causes nausea, vomiting, headache, toothache, &c.

"§ 219. Both the soul-sensorium and body-sensorium operate according to the law of self-conservation (178), a truth which may be illustrated by numerous examples. For instance, the irritation or impression of too strong a light goes to the optic nerve, from whence it can only get at the ciliary nerves through the brain, and induce contraction of the pupil, so as to exclude the too vivid light from the eye, and obviate its unpleasant impression."

Prochaska then adds other illustrations, which he explains in a similar manner; namely, the closure of the eyelids when a finger is brought near to the eye; the act of sneezing, from irritation of the nostrils; of coughing, from irritation of the bronchi; the increased action of the heart and arteries, from the presence of a poison or other irritating *materies* in the blood, "whereby the blood is circulated more rapidly, and all the powers of those structures are called forth, as it were, to diminish the irritation, to render it harmless, or to expel it from the organism." He then proceeds:

"§ 220. These adduced examples sufficiently show that the sensorium commune acts, in all its operations, strictly according to the law of self-conservation, and that it is ever studious to do the best for our preservation, so long as it is not prevented by disease, or the cessation of vital action; in which cases it is seen that it is thrown into confusion, and no longer always takes the best steps for the cure of disease; often, indeed, proving itself altogether incompetent thereto; just as a delirious or idiotic person, from the disordered state of his soul-sensorium, neither knows what is necessary to his preservation, nor does it."[1]

In his details, we find Prochaska repeating several of the views of Unzer, although they are mixed up with opinions derived from the writings of others, or his own researches. He thus notices an important distinction between the two great classes of involuntary and voluntary acts:

"§ 175. Nevertheless, this need for rest seems only to be a characteristic of the nerves which are subordinate to the will, and not to the involuntary, which have to provide for the motion of the heart, respiration, and digestion; and whose vis nervosa is active, without intermission, during the whole of life, although it may be weaker or stronger. Though it cannot be doubted that both kinds of *vis* have a similar origin (§§ 171, 173), and are of the same nature, still observation shows, that the one belongs to the will, the other is involuntary; that the former is exhausted by sensation and motion, and requires rest and repose; with the latter, the contrary takes place; and, finally, that the two kinds of *vis* are independent of each other. This dis-

[1] Op. cit.

tinctness and independence of the voluntary and involuntary vis nervosa is shown, not only in sleep, but also in apoplexy, when the voluntary vis nervosa is quite arrested, but the involuntary performs its duty. So, also, in cases of fever, the voluntary vis nervosa is quite weakened, but the involuntary so much the more active." [1]

Subsequently to the publication of this work, Prochaska, being attracted by the singularity and novelty of the results of the experiments of Galvani and others, laboured diligently to elucidate the nature of the vital processes by electro-galvanic theories; he also published numerous works, essays, and observations, on physiology, pathology, pathological anatomy, diseases of the eye, &c. A list is before me, supplied to me by my friend Professor Marx, of Göttingen, containing the titles of twenty-seven works, or papers.

A few explanatory sentences are necessary, with regard to the translations. The Council of the Society having required that the two works should be comprised in one volume, a question arose as to the mode in which this condition should be accomplished. It was obvious that one of the two must be abridged; and the work of Unzer being an octavo of 800 pages, while the tract of Prochaska is very short, it was equally obvious that the condition could only be fulfilled by abridging the larger. But an abridgment implies a free translation, and a free translation great responsibility on the part of the translator. This feeling of responsibility was not diminished, when, on consultation with Professor Marx, that accomplished scholar, while recommending a free translation, stated that the antiquated style, and singular phrases of the work, rendered it somewhat difficult for even the modern German physician to comprehend.

The plan I finally resolved upon was this:—To give a full and literal translation of the 'Dissertation' of Prochaska; omitting only the Appendix, which, being on a controversial topic, (that the brain and nerves are made up of globules,) and

[1] Op. cit. p. 110.

having reference to another work published by him, 'De Structura Nervorum,' had no *immediate* connection with the dissertation to which it is appended. To give as condensed an abridgment of Unzer's work as was consistent with a due regard to a full and complete exposition of the writer's views, on the following principles :—1. To omit all quotations from Haller and others, except such as were absolutely necessary to understand the text. 2. To omit all controversial matter, on points of secondary importance. 3. To leave out all anatomical and physiological descriptions and disquisitions, not of an original character, and to be found in the standard works of the day. 4. To condense, wherever that could be done without injury to the meaning of the author, and to avoid numerous repetitions, which he thought to be necessary to the perfect comprehension of his views. 5. Where the sense was doubtful, to give a literal translation. 6. To remodel and freely translate various words and phrases used by the author in a special sense. That the critical reader may be in a position, however, to judge for himself on this point, I have subjoined a glossary of these words and phrases, and a reference to the paragraphs, to which I have appended my reasons for the adoption of the English terms. These have only been decided upon after the most mature deliberation, and with careful reference to other writings of Unzer; I therefore venture to express a hope, that the reader will not criticise hastily, nor without a reference to the entire scope and intent of the work.

T. L.

List of German words and phrases used by UNZER, *and their English synonymes. (The figures refer to paragraphs, to which explanatory notes are added by the Translator.)*

PARAGRAPH

6. *Ein Thierischer Körper*—an animal organism, or, organism, simply.

6, 10. *Vorstellungskraft*, and *Vorstellungskraft der Seele*—the conceptive force; the sentient force; mind.

6, 25. *Vorstellung*—act of mind; conception.

6, 25. *Thierische Seelenkräfte*—animal sentient forces; cerebral forces.

6, 31. *Thierische Kräfte*—animal forces; vis nervosa.

6. *Seelenwirkungen*—(*actiones animæ*) mental, sentient, or sensational actions; actions, simply.

9. *Thierischen Maschinen*—the nervous system.

27. *Natürlich*—Physical, corporeal, organic, natural.

27. *Eigenmächtig, Selbstthätig*—arbitrary, spontaneous.

31. *Thierische Kräfte der Nerven, Nervenkräfte*—vis nervosa.

31. *Sinnlicher Eindruck*—sensational or sense-like impression; impression, simply.

31, 66, 262, 403. *Sinnlich*—sensational, sense-like, impressional.

32. *Sinnlichkeit*—property of respondence to impressions; sense-likeness; impressibility.

88. *Triebfedern des Gemüths*—excitants of the feelings.

121. *Innere sinnliche Eindrücke*—internal impressions, cerebral impressions.

122, 359. *Innere sinnliche Eindrücke der Vorstellungen*—conceptional impressions.

191. *Der naturlichen Verrichtung gemäss*—connatural.

191. *Der naturlichen Verrichtung nicht gemäss*—contranatural.

283. *Willkührlich*—volitional, sensational-voluntary, voluntary.

335. *Freiwillig*—free-will (adjectively).

6, 349. *Beseelte*, and *Unbeseelte*—sentient, insentient.

PRINCIPLES OF A PHYSIOLOGY

OF THE PROPER

ANIMAL NATURE OF ANIMAL ORGANISMS.

BY

JOHN AUGUSTUS UNZER.

40

PRINCIPLES OF PHYSIOLOGY.

PREFACE.

We observe, that in a corpse, purely physical and mechanical forces imitate the processes of our bodies, and can originate that motion in its machines, of which in virtue of their structure and composition they are capable. The fluid portions are combined and separated according to the laws of gravity, of the power of attraction and repulsion, and remain in equilibrium according to the laws of hydrostatics. When an anatomist injects the vascular system, it is made, by merely mechanical forces, to repeat in some degree its former natural function, according to the laws of hydraulics. The muscle, the fibres which are contracted by cold, keeps the limb in the same position in which it had placed it, and, by a mere mechanical action, the arteries of a corpse contract and compress the finger when pushed into them, &c.

These purely physical and mechanical forces are not the peculiar forces which usually move the living animal organism in its natural condition, but there are other forces operating in it, according to a fixed arrangement, and according to laws altogether different from the physical and mechanical laws already known; and it is through these, that the organism performs those natural processes which its structure renders it capable of. That stimulus, which excites no movement in the lifeless heart, or in the perfectly dead muscle, or in the arteries of a corpse, in the natural or living condition keeps up the circulation, changes the pulse in the arteries, and moves the muscles and limbs. Those peculiar motive powers, which give the living organism the advantage over the corpse, although they may co-operate with the purely physical and mechanical forces common to both, I term the PROPER ANIMAL FORCES, and they communicate to the living animal that nature which I call the PROPER ANIMAL NATURE OF ANIMAL ORGANISMS.

The ordinary science of physiology considers the forces of animal organisms in their natural condition, and as they act together in connection with each other, but without distinguishing the simply physical and mechanical from the proper animal forces. This presupposes that we know the laws according to which each of these peculiar forces acts separately; and, indeed, as to the physical and mechanical, whose laws are known, there is in general no difficulty. The physiological works of Haller teach us, in a manner almost impossible to be surpassed, the mechanism of all parts of the animal body, of which the structure developes the functions according to the laws of mechanics, hydrostatics, hydraulics, optics, acoustics, &c. But do we know those laws by which the proper animal forces govern the body when acting separately from the physical and mechanical, and independently of them? Truly, no! or at least very imperfectly. The thoughts and desires are animal moving forces of the animal organism. But do we at this moment know anything of the laws by which these forces regulate their appropriate organs? or have we hitherto troubled ourselves to observe the operation of these laws in each particular class of ideas and desires? We have disputed stoutly enough, whether the soul be matter or brain; whether thought be an electric fire or a movement of the vital spirits; whether souls and bodies exercise a real or an ideal influence on each other; whether souls form their bodies, or whether they are diffused through them, or dwell only in the head; whether an instinctive impulse or a passion belongs to the body or the soul; or whether the vital spirits be elastic or inflexible, electrical or ethereal, &c. All these inquiries will remain for ever inscrutable mysteries, and do not belong to our subject; they can remain altogether uninvestigated without any disadvantage to the real usefulness of theoretical medicine, but we have pursued them with profitless diligence, and have done our best to confuse them more and more. How much have we effected in resolving questions useful to our art, as, for example, in determining by what laws the mind moves the machinery of the animal organism? Under what circumstances the nerves excite sensation? Under what the sensation becomes an animal moving force, so as to move this or that limb, in such a manner and not otherwise? After what laws the imaginations, the conceptions of the understanding, pleasure, pain, the instincts, the passions, and the will, impel various portions of the animal to perform the actions intended by the Creator in uniting the machines with a thinking force? If the doctrines of the first part of this work (which are, however, an imperfect sketch of the elements of the science of the laws which regulate the influence of the mind on the body) be compared with what our physiologists have hitherto produced, it will be seen that, as yet, this whole science has been in some degree a waste field.

As regards the other animal motive forces, with the exception of the conceptions, there scarcely was a notion until the time of Haller, who at least pointed out their existence; and yet the doctrine of irritability, which that great man has taught, comprises only a portion of those animal motive forces which are independent of the mind, as the whole of the Second Part of this work will sufficiently prove. The laws of action of these forces have not as yet been illustrated by any one, and the first elements thereof which this Second Part contains, exhibit to us a large and fertile branch of science with which medical art can and must ultimately be enriched, if Physiology—that science which has to elucidate the mechanism of animal bodies compounded of such multifarious motive forces—is ever to be freed from at least existing defects. It was always premature to attempt to explain the natural actions of the animal body (which are brought about by the common operation of physical, mechanical, and animal forces), by the laws of physics and machines, so long as there were no principles by which to judge of the co-operation of the proper animal forces; but especially premature to attempt their elucidation by the aid of untenable, imperfect opinions, and inadmissible suppositions, when the principles of physics and mechanics were found to be insufficient. Thus Stahl erred, who knew well the necessity there was for the co-operation of the animal forces with the mechanism of the animal body, because it did not occur to him, that it possessed other animal motive forces besides the influence of the mind on the body. So also the mechanical physicians erred, who would deduce all natural phenomena from the physical and mechanical forces of the elements of the animal organism, and absolutely deny the manifest influence of the mind and of the other purely animal forces on animal acts. So at this moment physiologists err, when they exclude the co-operation of the animal forces, in actions which they attempt to explain mechanically; or, when they think that that which cannot be explained mechanically, must necessarily be attributed to mind; or when they would elucidate the animal motive forces by the laws of natural philosophy and mechanics, and never know how to determine the forces, laws, and connection, by and through which the moving springs of animal life, so totally different, regulate the wonderful machines of the living organism.

This defect in Physiology becomes continually the more apparent, now that inquiry has commenced into the diseases of the proper animal forces and their cure; and the present appears to be the proper time to supply it by carefully considering proper animal nature in its uncomplicated state, and distinctly deducing the laws by which the animal forces, as such, act in animal organisms. The pathology of the mind, or of the nervous system, and of other diseases of the animal forces, ought to demonstrate to us the deviations of the animal forces from their proper laws; but what can be really expected from pathology so long as we have no distinct idea of those laws, and are even ignorant of the animal forces themselves? This knowledge will never be rendered in any degree perfect, if the operations of the proper animal forces are not considered quite separately and by themselves, and the laws studied by which they ensue in animal organisms *independently of the physical and mechanical forces in operation at the same time.*

From these considerations originated my idea of a physiology of the proper animal nature of animal organisms, of which the present work supplies the first principles, and by which the physiology of the whole animal economy, which hitherto has been extremely deficient in these principles, may for the future be corrected, completed, and extended. Although I do not overlook the imperfection of my own plan, and have never considered it to be so well carried out, as to be satisfied with my performance, still I thought it deserved to be made public even in its imperfect state; since it would, for the first time, make known the utility and necessity of separating the proper animal physiology from the general physiology of the entire animal economy; of which hitherto no one seems to have ever thought. If I am not deceived in my expectations, some better student of animal nature (and there are at present many with whom I am not to be placed in comparison), being stimulated by this first essay, will project and carry out a much more perfect system; to me it will be a matter of satisfaction that I had the honour of affording the first ideas; and if I might flatter myself that such an one would also publish a *special pathology of the proper animal nature*, according to these principles of a *special physiology*, I should certainly think myself fortunate in having laid the foundation for so great an improvement of our art. Any one who is acquainted with the present condition of medical science, and has at all attempted to remedy the striking defects in the theory of proper animal nature, must be aware it was necessary to any degree of progress that these first steps should be taken.

I will now briefly describe the plan of my work.

The primary seat of the animal forces is in the so-called *proper animal machines*, namely, the brain with its animal spirits, together with the nerves, through which the latter are communicated to the mechanical machines. I originally intended to have given a general division, containing a general account of the animal machines, and their structure and moving forces, in which I should have included an anatomical description of the brain and nerves; but I determined to omit this part, so as not with useless prolixity to extend a simple sketch, inasmuch as this description of the animal machines is already to be found as complete as possible in the fourth volume of Haller's larger work on Physiology, and I have nothing to add to it. I have, however, made extracts from, and given reference to, the most indisputable statements with reference to the animal machines and properties (most of which will be noticed in the following pages), and thus originated the following plan of a *physiology of the proper animal nature of animal bodies*.

Animal nature is the aggregate of the proper animal forces, and the science of these, uncomplicated, is the *physiology of animal nature*. All animal forces act, when untrammelled, either necessarily in connection with the mind of the animal, or not; and thus the science is divided into two great divisions. The first treats of the animal nature in its connection with mind, that is, in other words, with reference to the *animal-sentient* *forces;* but the second, in reference to the *nerve-forces,* independently of the mind; out of these a third division arises, which describes the *animal nature as an independent whole,* compounded of these two animal forces.

The First Part is devoted exclusively to the *animal-sentient forces* of the animal machines above-mentioned; and an epitome of the general doctrines applicable to the brain and nerves, and to the animal spirits and their general properties, is concisely given in the First Chapter and the beginning of the Second. The animal-sentient forces are considered with reference to their action, in two ways; namely, partly *per se,* as they themselves act in the animal machines,—the brain and nerves,—and partly in reference to their *influence on the mechanical machines,* with which the nerves are incorporated. These constitute the contents of the Second and Third Chapters; to these may be added the Fourth, in which the connection of the *conceptive force* and the animal moving forces, or in other words, of mind and body, is generally set forth.

The whole philosophy of the reciprocal influence of body and mind, as laid down in our works on Physiology, is as yet imperfect, being without true principles, and partly confusedly, partly erroneously, propounded. Probably this has arisen from the little acquaintance of physicians with theoretical philosophy except physics, and still less with psychology; as if mental philosophy were not necessary to the science of the nature of man's organism. Nevertheless, our physiologists have only worked at the useless subtilties mentioned before, and the only useful knowledge which they teach as to the union of body and soul, refers to the external sensations, and also to the imaginations and passions. There are others who aspire, with Bonnet, rather to analyse the different mental faculties by means of movements in the brain, of which we are totally ignorant, than to study what is peculiarly within the sphere of the physician, and investigate the laws according to which the faculties act in the body; which, nevertheless, can be easily learnt by observation, if people would only cease from the attempt to deduce them from inscrutable principles.

These doctrines present a somewhat different appearance in the present work. I have endeavoured to define the laws by which the various faculties of the mind operate either through the animal motive forces, or by and through themselves in the entire mechanism of the body. This is peculiarly important with reference to the sensations, and the instincts and passions, and of consequence in every department of medical science.

In the Second Part, the *nerve-forces* are treated of so far as they act independently of the mind. It is shown that, besides the animal-sentient forces of the brain, there are only two kinds of forces of the nerves which act in the body as animal-motive forces, namely, the sense-like [sinnlich] impressions, which are divided into internal and external (Part II, Chap. I). These two kinds of impressions are considered in the Second and Third Chapters respectively; and in the Fourth, their relations to the mental forces are elucidated. Modern physiologists, whose names Europe knows and honours,—Haller, Zimmermann, Whytt, and Oeder,—have rendered much service to this department of physiology by contributing materials thereto. Haller has, indeed, begun to trace out the plan of this new department, which certainly did not exist before him; but there he has stopped. I have ventured to extend this outline, with the hope of inducing able men to complete it. The most important progress that has been accomplished in this matter, consists in the following: I have defined the two kinds of impressions, and the entirely different laws by which they move the body, without having recourse to the hypothesis of vital spirits as a motive power; for these sense-like [sinnlich] impressions can be considered simply as phenomena, and their laws of action discovered without a knowledge of their nature. I have derived primarily from the nerves, that motive force of the external impression, which Haller assigned to the muscular fibres under the designation of *irritability*, but denied it to be a property of the nerves; I have demonstrated the deflection [*declination*] and reflection of the impressions in the nerves, whereby many phenomena of the animal economy, hitherto inexplicable, can be understood; and I have shown how the *vis nervosa* is sufficient of itself to develope those movements in bodies, which were formerly attributed to the influence of the mind or soul, and *vice versâ*.

I have added the Third Part to describe the economy of the animal forces in general, and trace, as it were, the course of life in animal nature. The First Chapter contains a sketch of animal nature; but since every animal is not provided with those animal forces, which the most perfect possess, in the Second Chapter the different genera of animals are classified from the irrational to the rational. I have taken this opportunity to state reasons for the possibility and existence of animals without souls. The other Chapter of this Part treats of the *origin, life, maturity, decline,* and *death of animal nature.* Hitherto we have only had scattered notices of these various matters in our physiological works, or, at most, of the peculiar mechanism of generation; and the growth, decline, and death of animal organisms have only been considered, without separating that which has reference to the *proper animal nature* from the other portions of the subject. In this Part, the most interesting chapters are the last three on the periods of animal life, the system of animal forces, and on animal death; these have a wide and useful application to the pathology of proper animal nature. I have adopted a short, simple, dry, and methodical plan of writing, that the reader may continually be enabled to examine and thoroughly understand the truth of the views and principles, both in the abstract and in their application,—the connection and consequences of the doctrines,—and the whole system of animal physiology. I have avoided, as much as possible, all medical researches of a confusing, imperfect, or merely subtle character, and all hypotheses; or, at least, have made no use of the latter in establishing my own principles; for a system of presupposed ideas, which in a short time must itself be set aside, would not be well received as a commencement in this new division of medical science, instead of true natural laws, the result of accurate observations.

As to the doctrines themselves, and the various controversies that have already arisen concerning them, I can only most sincerely beg the reader to examine them with the greatest rigour; and if the author of a work so extensive, and attempted for the first time from the present point of view, have described anything untruly, indistinctly, or incorrectly, or have omitted anything, not to blame him too harshly. The justice of such an exculpation can only be understood by those who have undertaken to write on such a subject, and experienced the difficulty of avoiding errors and omissions. I desire no indulgence for the doctrines themselves. Truth has been sought, and where I have not found it, I will endeavour to find it. Consequently, I can only ask a mature consideration for those passages of my principles which are open to controversy, or suspected of error. I am confident that there are many errors, and still more defects, in this work; but I have thought much and written little, and I can therefore ask that the critics shall think before they controvert. If any one would reply to any of the doctrines, whether for the purpose of proving them, or limiting them, or correcting misunderstandings, or refuting an error, I will absolutely act only as the interests of truth require, and as an indifferent reader, who has no feeling for personalities, whether they be civilities or insults, and to whom no objecter exists, but only an objection. It is my general rule to answer no attack on my writings, still less on my character and conduct; and I willingly permit many a one to use this advantage, who may think me a very troublesome person to attack, and who I would not for the world should know what I thought on the matter. Why should not every one be at liberty to criticise another as much as he likes, if he thinks him of sufficient importance? And why should the other be bound to answer him, if he do not think it of sufficient importance to entertain the public with his justification? It is seldom that controversial writings are of any great service to science; but it is difficult to avoid explanations with a newly-invented science, only a sketch of the first principles of which has appeared, not supplied with ample illustrations, without any of the advantages of an introductory discourse, and with the disadvantages of unusual terms and expressions, which at first always excite subordinate ideas that lead the reader away from the meaning of the author: thus explanations may not only be required, but cannot be withheld without disadvantage to the reception of the science itself.

I must especially ask the reader's forgiveness with regard to these unusual terms and phrases. It will be seen that they were indispensable to an accurate exposition of the ideas, without which it would be altogether impossible to give the physiology of animal nature that first degree of completeness which it now possesses. At one time I was not inclined to seek unusual phrases; but when, two years since, I used the word "feeling" [Gefühl] with an unusual meaning, from a similar necessity, in a little work I published on 'The Sense-likeness [Sinnlichkeit] of Animal Bodies,' I found that this use of the word with a new meaning was of little advantage, because the majority of the critics dwelt too much on the expression itself, and hardly noticed the weightier matters to which it owed its origin. In the present work I have avoided this objectionable word, and in its stead selected the expression "*external and internal sense-like* [sinnlich] *impressions,*" although I have shown in § 402, &c., the usefulness and propriety of the former. At any rate, the reader must get accustomed to the use of one of the two expressions.

The reader will be reminded in many places that I have not considered any of my principles practically, nor shown their application to the practice of medicine, although I well knew that this step would not only have been useful generally, but would have also disposed many to grant me their approval. But my principal object was to show convincingly, that the *physiology of the proper animal nature* is a branch of science altogether distinct from the *physiology of the entire mechanism of the body*; and to determine satisfactorily the boundaries of the two, which, indeed, are generally laid down in this work. A mere sketch would have been sufficient for this purpose, and it would have been much shorter if it had not contained so many new views, which it was necessary to treat somewhat in full, to render them intelligible; nevertheless I have quoted briefly only all those doctrines belonging to peculiar Animal Physiology, which are contained in the physiology of the whole mechanism of animals, so as to indicate their places in the present work. Now that the principles of a proper animal physiology can be surveyed connectedly, it will be found much easier to separate what is defective, obscure, confused, unintelligible, and false, from what is really useful, and to bring the whole system to perfection. For this reason I earnestly wish that this sketch may not be read and judged of superficially and unconnectedly; but that the reader will endeavour to follow me in the chain of ideas from the beginning throughout the work.

INTRODUCTION.

1. The *nature* of a *body* is the aggregate of its peculiar powers, capabilities, and forces. These depend upon the condition of its parts and the manner of their connection.

2. The aggregate of the forces of a purely physical body is termed its *physical nature.*

3. The general forces of physical bodies belong to the animal and the human organism, so far as it is considered in its constituent parts, and the union of these as a physical body only, and not as a machine; and to that extent we can *philosophically apply the general laws of natural philosophy* to the fluids and the matter of the solids. To these general forces particularly belong general and specific gravity, the force of attraction, which, in the matter composing the solids of animals, is the so-called contractility [Reiz], or the dead force of Haller, and which is simply the effect of cohesion;—also heat, electricity, &c.

4. The aggregate of the forces which a physical body possesses, in so far as it is a machine, is termed its *mechanical nature,* and depends upon the physical nature and the kind of union of its parts, whereby it becomes a machine. (*Its structure.*)

5. In addition to its mechanical nature, the animal or human organism (so far as it is not a living body, but only a mechanical machine), is endowed with the mechanical forces of the machines, and to that extent we can *philosophically apply the laws of mechanics* to the machines of such a body. The forces of the lever, of hydraulic machines, of the force-pump, &c., belong to this class of mechanical forces.

Mechanical machines may be divided into the *artistic* and *natural* (*organic*). The latter differ principally from the former in having a highly compound structure, so that the whole machine, even to its minutest details, is composed of other machines, which by their union communicate equally compound forces to the general machine. On the other hand, in the artistic machines, the coarser elements are either not mechanical machines at all, but only mere physical bodies, or else impart to the whole machinery no other mechanical forces than those which they would still have, if their constituent elements were not machines. The *nature* of the organic machines, considered as such only, is termed their *organic* nature, and the continuance of organic nature is organic *life*, which is common to animals and vegetables.

6. Organic (or natural) machines are termed *animal machines* when, in addition to their physical composition, organical structure, and the general forces of physical and mechanical bodies, they are endowed with other forces, which do not regulate such bodies and machines, according to the general laws of motion, but are only adapted to them by means of an arrangement, the nature of which is unknown. These forces are termed (*primary*) *animal forces*; and the movements directly produced by them are (primary) *animal movements*. When animal machines are combined with those that are purely mechanical, and the latter are moved by the animal forces of the former, they possess *communicated animal forces*, and by means of these they also perform animal movements. The aggregate of the animal forces in the body of an animal is termed its *animal nature*. The animal nature of a body depends on the peculiar condition of the materials of which the animal machines, as such, consist; on the structure of the animal machines; on the animal forces themselves; and on the connection of the animal with the other organic machines of the organism, whereby the forces and movements of the latter are stamped with the animal character. The continuance of animal nature is *animal life*, and its termination *animal death*. In all living animals the animal forces act either in perfect accord with the sentient force of the mind, or not: if the former, then a distinct class of animal movements in the body is connected with each class of ideas, and consequently both reciprocally contain the basis of their twofold existence. These united animal and sentient forces are termed *animal-sentient forces*; and the movements they produce are *sentient actions* (actiones animæ). When the animal forces act independently of the sentient force, they are termed *pure animal*

forces or *nerve forces* [vis nervosa], and their movements are *purely animal* or *nerve-actions*.[1]

Note.—It is absolutely necessary, that these various animal forces and their modes of action should each have their distinguishing designations, and I have not been able to invent more convenient terms than the preceding. They might have been termed simply mental forces and nerve forces; but since the former term is already applied to designate the powers of the mind, the affix *animal* must be used to distinguish the mental forces of the sentient *animal* body.

7. By virtue of their animal nature, the bodies of animals acquire forces, which cannot be explained by the physical and mechanical laws applicable to the motion of other bodies and machines, and which can act only through the proper animal machines. Their workings are manifested partly in the latter, partly in the other machines of the bodies, upon the forces and movements of which they stamp the animal characteristics. With these (primary) animal forces the influence of the soul on the body, and also the moving forces peculiar to the animal machines, are to be classed.

[1] The term *Thierischer körper*, as used by Unzer, exactly corresponds to the modern phrase, animal organism. The word *kräfte* might be rendered forces, powers, properties, faculties, or *vis*. In (3), kräft is applied to express the *force* of attraction and repulsion; and I have, therefore, used that word as its synonym, although it is evident that Unzer uses the word rather indefinitely; and the *Thierische kräfte*, mentioned in the text, might more fitly be designated powers or properties than forces. The true synonym is *vis nervosa* (639). Thierische-seelen-kräfte is a compound word, for which it is impossible to find an English synonym; it is used to signify the properties or functions of the brain, so far as that organ is the seat of consciousness, or, more abstractedly, the combination in action of the purely animal force (*vis nervosa*) with the mental. In either case the term implies the action of mind and the existence of consciousness or will. When used in the former sense, I have rendered the phrase by *cerebral forces;* when in the latter, by *animal-sentient forces.* Whenever the word *seele* is used in the original, either adjectively or in compound words, to express circumstances dependent on the existence of soul or mind, as in *beseelte*, &c. (349, 603), I have rendered it by *sentient.* *Vorstellung* is used indefinitely in the sense of sensation, perception, conception, thought, or of an act of mind generally (vide 25, 34-36); and *Vorstellungskraft* to signify the power or force by which we feel, perceive, think, or will. I have translated *Vorstellung* generally by the term conception, and consequently use the word *conceptive force* as the best rendering of Vorstellungskraft; but where the context required or allowed, I have also rendered it by *sentient force*, or, more simply, by *mind*.—Vide note to § 25.—Ed.

8. The doctrines of animal nature presuppose the doctrine of physical and organic nature (3, 5, 6), and must contan:

i. A description of the animal machines in the bodies of animals, comprising the composition and structure of their parts, and of their system of relation to each other.

ii. The determination of the animal forces proper to them alone, and without reference to their influence on the other parts and functions of the organism.

iii. The determination of their influence on these other organs and functions.

All primary animal forces are either animal-sentient forces, or nerve-forces (purely animal) (6); and hence arises the great divisions of the *entire philosophy of animal nature.*

The First Part considers animal nature in its connection with the thinking power of the soul of the animal, and includes:

i. The animal machines in general, in so far as they are capable of the action of the animal-sentient forces (6).—Part I, Chap. I.

ii. The animal forces, *per se,* without reference to their influence on the rest of the mechanism, and considered specially as animal sentient forces (6, 7).—Part I, Chap. II.

iii. The influence of the animal-sentient forces on the rest of the mechanism of the animal body (6, 7).—Part I, Chap. III.

iv. The connection of the body and soul generally.—Part I, Chap. IV.

The Second Part treats of animal nature with reference to its simply animal forces, according to which the animal machines do not act in connection with the sentient faculty of the animal (355).

Lastly, in the Third Part, animal nature is treated of as a whole (599): in this Part we consider its essential characteristics in the different kinds of animals, its origin, continuance, and state of perfection; its entire system of animal forces, its decline, and finally its cessation.

Man is by no means the only object of this work, although, as the most perfect of animals, he is its principal object; it contains rather the principles of a Zoology, or natural history of every species of animal, but only according to their peculiar animal forces; and as to these, only in outline (15).

PART I.

ANIMAL NATURE IN ITS CONNECTION WITH THE SENTIENT FACULTY OF THE SOUL OF AN ANIMAL.

CHAPTER I.

THE ANIMAL MACHINES IN GENERAL, AND ESPECIALLY AS THEY ARE ADAPTED TO THE ANIMAL-SENTIENT FORCES.

9. THE proper animal machines in animal organisms are the brain and nerves,[1] in which the vital spirits (the nervous fluid) are produced and distributed, with the object of constituting the medium of the functions of these organs.

10. The *brain is the seat of the soul.* We feel that we think in the head; nowhere else are we conscious of our existence; in no other organ is there a thought, or an idea, or consciousness. Now, since the sentient faculty [Vorstellungskraft[2]] of animals is their soul, the soul can have its seat nowhere else than in the brain, and it would be absurd to maintain that it is diffused throughout the body (597). It is sufficient to a physician to know, that the thinking faculty can have no other seat than the medullary matter of the brain.

11. The *brain is the laboratory of the vital spirits* (15, i). "It appears certain that there is such a fluid essence secreted

[1] As the phrase *thierischen maschinen* is used for the most part by Unzer to indicate the *nervous system*, it is so translated throughout the work wherever the context permits.—ED.

[2] The term *Vorstellungskraft* is of very frequent occurrence, and has been translated by the terms sentient faculty or force, conceptive faculty or force, and simply mind.—See note to § 6, 25.—ED.

from the vessels of the gray matter of the brain into the hollow tubes of the medullary matter, which is carried in the tubes of the nerves to their termination, and supplies the principle whereby the nerves are rendered capable of being the organs of the senses and of movements." (Haller's 'Physiology,' sect. 383.) As the gray or cortical substance of the brain is the secreting organ of the vital spirits, the medullary substance must be the seat of the animal-sentient forces. The secretion and action of the vital spirits will be considered afterwards (374).

12. The brain also gives origin to all the nerves, which are continuations of the cortical substance, given off partly from it directly in small bundles, termed the cranial nerves, and partly from a thick cord of it, termed the spinal marrow, which passes downwards through the spine, whence the nerves are distributed to all parts of the body.

13. The nerves generally are enclosed in an investing membrane, and, like the blood-vessels, divide and subdivide in the greater part of the body, which they either penetrate or form loops in; or, having lost their investing membrane, are so incorporated with the soft parts, that they can be no longer traced. Their essential element is the medullary matter of the brain, or the soft substance enclosed within the cortical substance; whereas their investing membrane seems to have no share in the proper animal functions allotted to them. Every nerve is a bundle of much smaller fibrils, each of which runs an independent course to and from the brain. Every nerve has its special point of origin in the brain, and every fibril must have its special origin from that point, from whence it takes an entirely independent and separate course through the medulla oblongata and the spinal cord, to its minutest termination. According to all probability, the fibrils of the nerves are hollow canals.

Since these propositions are of very great importance in the present work, and much will be deduced from them, it is proper to state that they are taken from the Physiology of Haller, the greatest anatomist and physiologist of the day.

14. The nerves so terminate externally, that either they are incorporated with other machines of the organism appropriated to certain movements; or they are distributed over the skin or other parts of the body, as the eyes, ears, &c., without exciting

such machines to motion, if they be appropriated to certain movements, or at least without co-operating therein. The first are termed, in relation to their function, *motor nerves;* the other are *sensitive nerves.* They are, however, identical in structure, and only differ in this local relation. Each nerve may be either the one or the other, according to its distribution; and each motor nerve is at the same time endowed with the properties of the sensitive. The motor nerves have ganglia, composed partly of their own fibres, and partly of other nervous twigs and nerves which accompany them, whereby the direct course of the fibrils and nerves is interrupted. The nerves of the senses, which have no motive influence on the mechanical machines of the organism, have no ganglia.

15. i. All the phenomena of motion and sensation manifested through the nerves, render probable the existence of a remarkably subtle fluid essence, which is present invisibly in the medulla of the brain and nerves, and is the means whereby all the functions of both are performed. It is termed the *vital spirits* or *nervous fluid,* but it is not known how and when it contributes to the animal actions. It is not that fluid matter which is seen in the medulla of the brain and nerves, but a much more subtle spirit, imperceptible to the senses. It is inferred from the phenomena which betray its existence, that this nervous fluid is a remarkably mobile fluid, a spirituous vapour, which can be neither aqueous, nor glutinous, nor elastic, nor etherial, nor electrical.

ii. Although animal machines are indeed proper to all animals (6), still every species does not possess those which have been just described, but only the most perfect, namely, man and the animals immediately below him. But since our object is not to lay down the principles of a physiology of the proper animal nature of man only, but rather of animals in general, these principles will be found applicable to an explanation of the functions of animal machines in the various classes of animals, a detailed description of which may be found in Haller's greater Physiology, and in his 'Opera Minora.'[1]

From these statements we may draw the conclusion, with

[1] The author here gives a sketch of the comparative anatomy of the nervous system, as known in his day; this has been omitted for the sake of brevity.—ED.

reference to the whole animal kingdom, that the *general* animal machines in which no species (so far as is known) is defective, and which, consequently, are the most essential elements of animal life, are the nerves, the ganglia, and the spinal cord, with their (probably) accompanying cortical substance—or the analogues of those structures—in which the vital spirits reside and circulate; and in which, in those cases, there is no cerebral cortical matter, the latter must be secreted directly from the blood (11); and that the cerebrum and cerebellum, together with their cortical substance and the nerves of the external senses, are not so general, and only essentially necessary to certain species of animals, especially those endowed with mind. Those only of the cerebrate animals, however, which, without question, think and desire, are supplied with a large and considerable brain; whilst those which manifest ambiguous traces of ideas have a small, simple, and irregular brain, differing little from the spinal cord, to which it appears to be an appendage; and, consequently, has probably only the same functions.

In this, the *First Part* of the *Physiology*, we investigate the animal nature of the most perfect animals, in which all these animal machines, or, at least, the most important, are combined; and which render them capable of acting in connection with the thinking force. All other animals only differ, in descending the scale, in a continually increasing defect in the animal organs and forces; and there are some whose whole life is so simple and mechanical, that they scarcely manifest any traces of the animal forces. In the *Second Part* of this *Physiology* it will be shown how animal life can equally subsist in these with only the most general and most essential animal machines, and without the co-operation of those peculiar to more perfect animals; and it will be shown, also, how far they are similar or inferior to the latter. Finally, the *Third Part* will exhibit a general view of animal nature, and will explain how the forces in each species of animal connect the machines together, and complete animal life in each (8).

CHAPTER II.

THE ANIMAL FORCES CONSIDERED ABSTRACTEDLY, AND PARTICULARLY AS ANIMAL-SENTIENT FORCES.

16. To what end are the animal forces peculiar to the animal machines only, without reference to their influence on the other portions of the organism, so that the latter would still possess them, even if not united with the mechanical machines which move the body? The answer to this question is the object of the present chapter.

SECTION I.— THE FUNCTIONS OF THE VITAL SPIRITS.

17. The vital spirits originate in the brain (11). If, consequently, they contribute, in some degree, to the functions of the nerves, and are present in them, or carry the impressions made on the brain from time to time along the trunks, twigs, and terminating fibrils of the nerves, they must flow from the brain to the most remote termination of the nerves, or, at least, propagate the impression on the brain in this direction, namely, downwards to the termination of the nerves; and have also a natural motion from the brain downwards along the trunks, branches, and terminating fibrils of the nerves, whereby they become the medium of the direct action of the brain on the nerves (122).

18. If the vital spirits already secreted in the nerves contribute somewhat to the functions of the brain, and carry to it the impressions received from time to time by the terminations of the nerves (11), they must also flow from the latter to the former, or at least propagate the external impression in that direction upwards to the brain, and possess a natural motion from the terminating fibrils of the nerves upwards to the brain, whereby they become the medium of the direct action of the nerves in the brain (36—Haller).

19. This interposition of the nervous fluid between the re-

ciprocal actions of the brain and nerves on each other, derives great probability from all observation of the operations of the animal forces, and takes place so quickly and immediately, that the fluid acts with inconceivable rapidity, either as to its own movements, or in propagating impressions (Haller, § 381).

20. It is a natural inference, and one established by facts, that the vital spirits are diminished, or rendered unfit for their functions, by frequent or prolonged use; and, consequently, the animal forces, of which they are the medium, become weakened or disappear (17, 18), or increase, when they are supplied to the brain and nerves.

21. If the vital spirits are duly secreted from the blood in the brain, and their influence goes uninterruptedly thence to the nerves, or *vice versâ*, the functions of the sentient forces or the nerve-forces, of which they are the medium, are performed naturally; and, consequently, those forces can act freely, so far as they are influenced by the vital spirits.

22. The free action of the animal-sentient or nerve-forces, in so far as it is dependent on the vital spirits, is prevented by whatever prevents the production of the vital spirits in the brain; by whatever destroys their normal, but to us unknown, condition; by whatever interrupts their influence directed from the brain to the nerves, or *vice versâ*; or, finally, by whatever destroys them or wears them out. Obstruction of the cerebral circulation, the compression or destruction of the brain, or its entire removal from the body, prevent the production of vital spirits. A general corruption of the fluids must also necessarily destroy their natural condition; ligature, or compression, or section of the spinal cord, prevents their influence being communicated from the brain to the nerves, or from the nerves to the brain; and an undue straining of the powers of body and mind consumes the vital spirits (20).

23. Experience teaches us, that sleep, wine and other spirituous drinks, light nourishing food, the odour of spirituous vapours, ablution of the limbs with spirituous fluids, friction, gentle bodily exercise, mental enjoyment, cheerful society, moderate and agreeable use of the senses, all strengthen and enliven the sentient and nerve-forces; and it is probable that this occurs either from an increased secretion, or a renewed natural good state of the nervous fluid, or from a greater

facility of flux and reflux which it acquires. In like manner it is probable that prolonged watching, starvation, debilitating food and drugs, the emotions, and the active elements of certain matters which, from their destructive qualities, are injurious to the nervous fluid, as opium, for example; also cold, indolence, want of exercise, fatigue, vexation, intense application of the mind or of the senses, all interrupt or diminish the animal forces, because they either diminish the vital spirits, or impede their secretion, or render them morbid, or hinder their flux and reflux.

Note.—Although little is known of the nature and properties of the forces of the vital spirits, the physician can content himself therewith, even although the little that we think we know is doubtful, and at the best only probable: for they may remain undetermined for ever without any loss to science, because we are under no necessity to show the origin and nature of the animal forces, inasmuch as we learn their true actions and laws from observation only.

SECTION II.—THE FORCES OF THE BRAIN CONSIDERED ABSTRACTEDLY AS ANIMAL-SENTIENT FORCES.

24. The brain has a regular double movement, which is mechanical only, and not peculiar to its animal nature. One movement is simply the motion communicated to it by the arteries; the other consists in an alternate effort to expand and contract, which Haller attributes to the connection between the respiration and the cerebral veins, so that the latter, like the brain itself, become turgid at each expiration, and flaccid at every inspiration (Haller's 'Physiology'). Although this mechanical motor power of the brain, as well as the consequent secretions, together with the cerebral circulation and its purely physical forces, do not properly come under our notice here, but belong to the physiology of the mechanical nature of animal organisms, still it is necessary to remember them in an inquiry into its animal forces, so far as the existence of the latter presupposes their existence. Since respiration is the cause of the continual movements of the brain just mentioned, and without it, indeed, the animal-sentient forces cannot act, because their action presupposes the existence of the mechanical forces (6),

its absence appears to be the reason why the embryos of animals endowed with a sentient brain, display no trace of those animal functions for which the animal-sentient forces of the brain are absolutely requisite.

25. The seat of the soul is the brain (10). Whenever the brain is destroyed, or its natural functions interrupted, the sentient force ceases to act. So soon as it is restored to its natural functions, conceptions return. The whole brain is not immediately necessary to thought, since large portions of it may be lost or be defective, or be compressed, or ossified, or its functions otherwise interrupted, without any perceptible influence on the mental powers, which, as to the cortical substance at least, is not remarkable, because it is not the seat of mind (11); but it cannot be deduced from any observation whatever, that the whole brain may be wanting (as, for example, when the head is removed, or the brain entirely destroyed, or the functions of all its parts generally interrupted), and the slightest trace of mental operations ever be perceived. Further, when a thought arises in the mind, a change must necessarily occur concurrently therewith in the brain, and particularly in the medullary substance, without which the sentient force cannot act; and when this change occurs in the brain, the sentient force is necessarily excited into action. Whatever may be reasoned on the matter, a change in the brain must consist in a movement, and the medullary matter must also be endowed with a motive force, which acts in harmony with the sentient force. So that each distinct class of perceptions is always connected with certain animal movements (6), and with these movements a certain class of perceptions; for it is ascertained from numerous observations, that after certain injuries of the medullary portion of the brain, especially of that part from which nerves of sensation arise (14), certain kinds of perceptions [Vorstellung], as for example, certain sensations, are prevented or disappear, and together with them all the ideas, desires, and instincts, dependent thereon, as well as other faculties of the mind. (Haller.) This motive power of the brain, which is connected with the sentient force [mind], is an animal-sentient force, and hence arises *the fundamental general principle in the doctrines of the connection between body and mind, that the medullary matter of the brain possesses an animal-sentient force, by means of which,*

at every act of mind,[1] *whether it be a sensation, imagination, desire, reflection, or conclusion, there is produced in it a certain animal movement, necessary thereto, without which the act of thought* [Vorstellung] *can neither arise nor continue, and with which it infallibly arises and continues.* This animal-sentient force is peculiar to the brain, and is the property of no other portion of the nervous system, because in none other except in the brain does an animal movement develope perceptions (10). The medullary matter of the brain can also, with propriety, be designated as the only instrument of the sentient force, for it is through its animal movements that the mind puts its force into action, and maintains it, and without which, it would absolutely remain inactive. Philosophers have already introduced the phrase, *material ideas,* to express those movements in the brain that are necessarily connected with each act of thought. (Baumgarten's Metaphysics, § 416.) A psychological materialist considers these material ideas as the ideas of the mind itself. But since it must be firmly maintained, that the thinking faculty is an immaterial substance [Substanz), it cannot certainly be granted that these material changes in the brain are really the ideas themselves; but since the two are inseparately connected with each other, and the mind never acts, nor can act, in animals, without these movements, it is fully established that every act of thought presupposes and causes a movement in the brain (material idea), and every such movement in the brain presupposes and causes a conception in the mind; that the same or a similar conception excites the same or a similar material idea, and that the same or a similar material idea excites the same or a similar conception in the mind; that when there are no conceptions excited in the mind, there are no material ideas, although probably similar movements may take place in the brain; that when no material ideas take place in the brain, no conceptions come into real existence in the mind (112); and that the perfection or imperfection of the mental

[1] The phrase *Vorstellung der Seele* is here translated *act of mind.* Vorstellung is of very frequent occurrence throughout the work, and is ordinarily translated *conception.* The reader must, however, bear in mind, that the term "conception" does not so exactly express the author's meaning as "act of mind," inasmuch as Vorstellung is applied to signify sensation, perception, and thought generally,—in short, *every* mental operation; whereas conception has a more limited application. No other word could be found, however, more nearly expressing the author's meaning.—ED.

powers depends very much on the natural perfection or imperfection of the brain, or on the full or faulty development of the brain at birth, or during growth, &c., of which we have illustrations in the deformed and compressed heads of many stupid races.

Note.—The reader must not object to the expression "material idea," because it has been very variously misapplied. By it we understand no hieroglyphical figures of the objects of the conceptions, no impressions stamped on the medullary substance of which one has no conception, and which can only be considered as the fancies of too contemplative philosophers. It is least in our intention, with Bonnet, to analyse the faculties of the soul by means of their altogether unknown qualities. It need only be granted, that the change which takes place in the medullary substance at each conception, is a *movement* which, since it is unknown, every one may conceive for himself as he pleases; and that we term these movements *material ideas,* so as to have a short phrase already used by writers, instead of a long circumlocution. It will be seen, that throughout the work, we use this expression in no other than this general signification.

26. Since every continuous conception in the mind is to be considered at each moment as a prolonged action of the sentient force, and no act of the latter takes place without material ideas in the brain (25), it follows that each continuous conception excites continuous movements in the brain which are usually considered under the term *impressions,* or *representations* of the *conceptions.* The more a conception is developed, or, in other words, the clearer it becomes (Baumgarten's 'Metaphysics,' § 415), by so much the more fully must the material idea be developed; if, on the other hand, the conceptions be obscure, there are only imperfect and undeveloped movements in the brain. A more forcible conception requires more vigorous movements (material ideas) in the brain, and more vigorous material ideas develope more forcible conceptions. Since every conception is the origin of a material idea in the brain, and *vice versâ* (25), the more vigorous conceptions are larger conceptions so far as they are the origins of material ideas. (Baumgarten's 'Metaphysics' § 379). A large conception contains small conceptions as its constituent parts, and consequently it is made up of several, each of which causes a

material idea in the brain (25). Consequently, the material ideas of more vigorous conceptions are more compound and more vigorous movements than those of the weaker; and for similar reasons, the conceptions of more vigorous material ideas are more compound and larger conceptions than those of the weaker.

27. All conceptions are operations of the sentient force, and consequently acts of the soul. All material ideas are operations of the animal-sentient force of the brain (25, 26), consequently they are operations of the animal motor forces of an animal machine. But since neither can exist without the other, the conceptions, as well as the material ideas in general, are effected by means of the two co-operating forces of the soul and brain. When the animal machines produce material ideas in virtue of antecedent impressions derived from without, and thus induce the co-operation of the conceptive force,—such as takes place, for example, in external sensations,—conceptions thus originated are termed purely *natural*[1] (impressional) *conceptions*, which arise in the mind, necessarily and physically (Baumgarten's 'Metaphysics,' § 522), and succeed each other according to the laws of external impressions, so far as they put the animal-sentient force of the brain into activity. When, on the other hand, conceptions, and their material ideas, are developed by the sentient force, independently of any previous external impressions in the animal machines, and thus induce the co-operation of the animal-sentient force of the brain, as, for example, in volitional acts,—these conceptions are termed *arbitrary, spontaneous, physiologically free*[2] (Baumgärtner, § 520; Hallers's 'Physiology,' § 570); and they succeed each other according to the laws of the sentient force. Neither the purely impressional, nor the spontaneous conceptions, can have a real existence, independently of material ideas (25), and when they continue, must embody their impressions in the brain (26). But

[1] The term *natürlich*, here translated *natural*, has a peculiar meaning, being used generally in the sense of organic, somatic, or *corporeal*, or to express something *antagonistic* to spiritual. I have ordinarily translated it by natural, organic, or physical.

[2] The reader is particularly requested to observe, that the words "arbitrary" and "spontaneous" are used here and elsewhere throughout the work in their *strict etymological* and *metaphysical sense*, and indicate conceptions or actions caused or excited by the *will*, as a faculty of mind. This remark is necessary, because, popularly, the word "arbitrary," indicates acts that are despotic, absolute, or capricious; while "spontaneous" is applied to acts done without compulsion. The words in the original are *eigenmächtig* and *selbstthätig*.—ED.

as to the former, the mind cannot, by its own power alone, produce the material ideas in the brain, but must wait for the external impressions which form them in the brain; while, on the other hand, no immediately antecedent impression on the nervous system is necessary to the latter—the ideas of the intellect—but the soul forms them by its own proper power, and lets them follow each other according to their natural psychological laws, free from the restraint of external impressions.

Note.—It is necessary to comprehend clearly this difference between the conceptions, otherwise nothing can be accurately distinguished and taught in the physiology of the connection between body and soul; for this reason, the new expressions must be excused, and their subjoined definitions closely adhered to in the subsequent portions of the work; and there is nothing in them which does not fully harmonise with established psychological ideas.

28. Probably these material ideas and representations of the conceptions in the brain, consist simply in a play of the vital spirits in it; for when the brain of an animal is examined, there is nothing visible, of all the animal movements, or at all events of the material ideas; and its purely mechanical movements in no wise harmonise with the conceptions, but are much more simple, and are in accordance with the mechanism of the circulation and respiration.

29. This fundamental principle of the animal nature of all sentient animals, namely, *that every operation of the soul originates, continues, ceases, is defective, and increases or diminishes, in connection with an operation of the animal-sentient force of the brain* (25, 26),—connects the souls of animals most intimately with their bodies, and the conceptions with the movements, and lays the basis for the whole doctrines of the animal nature of the sentient forces, or in other words, of the union of soul and body, (compare 345). This union is known to, and conceded by, philosophers and physicians, although they explain it in totally different ways; which explanations, however, are unnecessary and foreign to medical art, because it is of no real importance whether the union be explained "materially," "harmonically," "influxionistically," or "occasionalistically." And although the peculiar relations of the movements in the brain (its material ideas), which accompany the conceptions be unknown (28), nevertheless their existence

is rendered evident from the continual operations of each conception on the body, and which must necessarily have their origin in the brain, where the mind has its seat, and is in intimate relation with the nervous system.

30. The doctrines of the animal-sentient forces which follow from these principles, divide naturally into two principal divisions; namely: 1st. How are the material ideas produced in the brain? (31-112.) 2d. What functions do they perform in the animal economy? (113-344.) These two take place mainly through the connection of the brain with the nerves, whereby the animal forces of the nerves keep up a physical relation with the animal-sentient forces of the brain.

SECTION III.—THE ANIMAL FORCES OF THE NERVES, CONSIDERED SOLELY IN THEIR RELATION WITH THE ANIMAL-SENTIENT FORCES OF THE BRAIN.[1]

Of the External Impressions [Äussern sinnlichen Eindrücke]—(*Nerve feelings*).

31. Every nerve has its beginning or origin in the brain (12); and if an impression be made there, and propagated along the nerve, it must necessarily take a direction from the brain outwards towards the branches and their terminations, as the vital spirits would also propagate it (17). If, on the contrary, a similar impression be made on the terminations and propagated along the trunk of the nerve, its direction must be *toward the brain* in the same course as the vital spirits (18). If a nerve be divided, an impression made on that point separated from the terminating fibrils, but still in connection with the brain, takes the same direction if it be propagated, just as if it had been made on the terminating fibrils themselves, namely, upwards to the brain. On the contrary, if an impression be made on that end of the cut nerve which is separated from its connection with the brain, but in connection with the terminating fibrils, if propagated, it will go towards the terminating fibrils. If an impression be made on the cerebral origin, or on the terminating fibrils of the nerve, and it is propagated, it will in both cases traverse the nerve only as far as the point of section; consequently, when an impression takes

[1] The *thierische kräfte* of the nerves, here translated *animal forces* of the nerves, are termed elsewhere *nervenkräfte*, or *nerve-forces*; both phrases are used in exactly the same sense as the Latin term *vis nervosa*, which has therefore been preferred, wherever possible, to the literal rendering.—Vide note to § 353.

place sideways on an undivided nerve, that is to say, neither at its origin nor termination, but on the trunk between these two points, if it be propagated, it can pass onwards from the point of impression (not from its termination!) upwards to the brain, and in like manner from the same point, (and not from the cerebral origin of the nerve!) downwards to the terminating fibrils. When by a touch or some movement communicated to it, or by any other agency whatever, an animal machine (and consequently a nerve) is so changed that it produces actions, which cannot be satisfactorily explained by the physical and mechanical laws of motion, or in other words, so that it manifests animal actions (6); the change thus excited in it is termed a sense-like [sinnlich] *impression* (*nerve-feeling*). A sense-like impression made on the cerebral origin of a nerve in a direction downwards, or on its trunk, if propagated, passes outwards towards the terminating fibrils of the nerve; on the contrary, a sense-like impression made on the terminating fibrils of a nerve, or on its trunk, in a direction upwards from the termination to the brain, if propagated, is transmitted in that direction.[1]

[1] The indefinite use of the words "sinnlich," "*sensible*," "sentient," and "sensational," by German, French, and English writers, on the physiology of the nervous system, has led to innumerable misconceptions by both authors and readers. Agents frequently change the condition of the nervous system, and excite it to action without being *felt*: that is to say, without exciting pleasure or pain, or the feeling of self-consciousness, or any perception whatever of the agent or agents, or of the results of their action; yet movements result therefrom as much adapted to attain a definite and designed end, as if the agents *were* felt, and the mind itself acted. In the text, Unzer analyses these phenomena, and terms the change which takes place in a nerve, when agents so act upon it, a *sinnlich* impression or *Nervengefühl*—nerve-feeling. It is obvious from the context, that to render *sinnlich* by *sensational* or *sentient* would give an erroneous idea of the author's meaning, if by those words we mean "of or belonging to sensation or perception;" for he emphatically discriminates, in a subsequent paragraph (34), and elsewhere, between the property of mere respondence to impressions seated in the nerves ("nerve-feeling"), and the property of sensation or perception requiring a special organ,—a cerebrum.

There is no English word which corresponds to *sinnlich* as thus used by Unzer, which I have hitherto rendered by *sense-like*. The term *sinnlicher Eindruck* may be very correctly rendered, however, by the word "impression," as used by modern neurologists; for when we say that light makes *no* impression on the nerves of the skin, we mean to say that it excites no change in their medulla, so that appropriate vital movements shall follow. I therefore propose to use the word "impression" simply, as conveying the meaning of *sinnlicher Eindruck*, deducing therefrom the adjective *impressional*.

It is to be observed, however, that *sinnlich* is used by Unzer in other senses, when it may be rendered by *sentient* or *sensational*. When *sinnlich* impressions

32. When an impression is received on the terminating fibrils or branches of a nerve, it is termed an *external impression* (a nerve-feeling from without inwards) (31, 403), to distinguish it from an impression passing from within outwards (31, 121), and which must not be confounded with the sense of touch. Whether the impression be made on nerves distributed in the interior of the body or on the exterior, it is the same, provided that when it is propagated, it passes upwards to the brain (31). As to this external impression, experience teaches us, that it is developed in living animals by every touch of the nerve, or by some communicated movement, provided it excites a certain definite, although unknown, change in the medulla of the nerve, and is transmitted upwards to the brain. Every impression on the terminating fibres of a nerve is not an external impression, nor causes one, but only those which so act on the medulla of the nerve, that animal actions directly result (31). For example, light excites no external impression on the most exposed and most delicate nerves of the skin, &c. The most undoubted observations teach us, that animal actions are excited by the agency of contact or movement, not in the investing membrane, but in and through the medullary matter of the nerve. (Haller's 'Physiology,' §§ 365, 372, 373.) The mode in which the medulla is acted upon by a touch, or any other agent, is purely animal, and differs altogether from the physical and mechanical laws of communicated motion. In every case where a touch of the medulla excites most vivid animal actions, whether they be acts of mind, or motions caused by the animal-sentient forces, or simply by the animal forces (6), there is no perceptible movement in the medulla, nor any change visible therein. Nor are the animal actions resulting from such a touch in proportion to its nature and strength, as when bodies act physically on each other by a blow, pressure, &c.; but often the slightest influences will, in the same nerve, excite the most energetic actions, and a more forcible agent the weakest. Certain agencies cannot

reach the brain and are felt, they excite an act of mind, or *a Vorstellung*, as sensation, perception, desire, &c. All acts of mind necessarily and directly dependent upon such impressions are termed by him *sinnlich*; and in this case the word may be rendered by *sensational*. It must be remembered, however, that the word so used implies *causation* as well as condition,—vide § 66, and would, I think, be as correctly rendered *impressional* as *sensational*.

stimulate a nerve to the performance of its function, although in reality they act strongly physically; as, for example, a sound which shakes every bone in the head, excites no animal actions in the optic nerves. There is also the mode in which a nerve receives an external impression; for the working of an animal force in the medulla of the nerve is one thing, the propagation to the brain of the impression received by the nerve, another. Then there is nothing in the medulla whereby this transmission can be explained according to mechanical or physical laws. The medulla is neither hard nor elastic, but a soft body, which according to the laws of physics must prevent or arrest the communication of motion. Besides, this transmission takes place so rapidly, and so soon after the external impression is received, that the mind can perceive no space of time to occur between the stimulation of the nerve, and the animal action excited in a part of the body far distant from the point where the impression was made. Nor can this transmission be effected like a motion in fluids, for the medulla is not fluid matter, nor so filled with fluid as to have the mobility of fluids, but is a soft material which retards motion. Lastly, the properties of ethereal fluids are not observable in the medulla, nor even in the vital spirits, as, for example, such as ether, the electric fluid, &c., which transmit motion in an unknown physical way. (Haller's 'Physiology,' § 379.) Since both the external impression and its transmission along the nerves are operations of the vis nervosa (6), and the aggregate of the animal forces in animal bodies is termed their Senselikeness [*Sinnlichkeit*], it follows that the mode in which the medulla of the nerve receives impressions generally, and external impressions particularly (31), as well as the mode in which it transmits them, together indeed with the impression itself, (it being an animal force,) belong to the Senselikeness [Sinnlichkeit] of animal bodies, and cannot be deduced from or explained by the mechanical and physical laws of motion.

33. There is no difference between the nerves of motion and sensation in respect to the method of receiving and transmitting external impressions (14, 31).—See Haller's 'Physiol.,' § 384. But as in the present section we have to consider the animal forces abstractedly, and without reference to their motive force on the mechanical machines (16), that which has been stated must be understood to apply to the motor nerves only,

in so far as they are at the same time sensitive nerves. In the Third Chapter we shall state how far the animal forces of both kinds of impressions on the nerves act on the mechanical machines appropriated to the motion of animal bodies, and in particular how far they regulate these, as animal-sentient forces of the nerves (8). But how do the impressions, *per se*, act on the nervous system? And what animal forces, and especially what animal-sentient forces, become thereby participants in that action?

On External Sensations.

34. When a nerve of a sentient animal receives an external impression, it is transmitted along it, and unanimous observations show, that at each impression, certain animal actions result therefrom, either in the brain, from which the nerve arises (12), or in those parts of the body with which it is in connection; but these actions no longer result, even when the external impression is made, if its transmission to the structure in which they previously took place be prevented by section or ligature of the nerve (43). This transmission takes place from the point of impression upwards (31, 32), and either arrives at the brain or not. Both cases occur in nature (see illustrations of the latter in 47-51). In the former case, the external impression entering the brain, instantaneously develops that material idea in it which is required for the development of the conception it originates. Since the conceptions [Vorstellungen] thus excited in the mind by external impressions are termed *external sensations*, this animal force of the nerves, in virtue of which they excite sensations by means of external impressions, is termed their *sensational force*, or sensibility [Empfindlichkeit],—(see § 62).

Note.—The word sensation [Empfindung] is commonly used in a threefold sense. 1. As in the preceding sentence, where it expresses the involuntary sensations [Vorstellungen], which we obtain through the nerves of the external senses. 2. When it expresses the inner feeling of the soul,—its consciousness of itself (80). 3. When it denotes generally the perception [Vorstellung] of the existing condition indefinitely, or equally, whether this perception be excited by an external impression or not. It is of the highest importance, that these three meanings be distinguished, for otherwise the doctrines as to the recriprocal influence of body and soul can only be indistinctly and indefinitely comprehended. We have, therefore, for want of more elegant expressions, determined to designate sensations of the first class *external*, and of the second *internal*, and never to vary from these terms, except when we use the verb to *feel*, in the third, general, or indefinite meaning, when it is not necessary to say whether external or internal sensations are meant. The reader will sometimes find it necessary in the sequel, to remember these remarks.

35. A true external sensation is never excited without there being an external impression on the nerves, and consequently the latter is rightly considered the only primary animal force (6), whereby the soul feels. But since external sensations are conceptions which cannot possibly arise without material ideas in the brain (25), it follows that in each case an external impression must excite a material external sensation in the brain, and itself develop true external sensations, independently of the co-operation of the conceptive force.[1]

[1] The Göttingen reviewer of Unzer's work, referring to this doctrine as to the development of external impressions into material ideas (the "species" of Haller), objects "that nerves pass from and to the spinal cord and enter it, and, consequently, that the external impressions made on them ought to be developed therein into material ideas; yet it is certain that the soul neither feels nor has its seat in the spine." This and other objections raised against Unzer's views in this review are the more interesting, because it seems probable that Haller was the writer, and because it gives Unzer an opportunity of explaining some points more fully. He then replies to the objection:—"Although this is hardly advanced as an objection, and although I have not only not neglected to notice the matter referred to, but have entered into details in illustration; still it is sufficiently important to merit further consideration. It is not merely a change caused at the origin of a nerve by impressions, that induces sensation and thought, but it is always necessary thereto, that there be a cerebral tissue into which the nerve must penetrate. Since new fibrils frequently pass out from the ganglia, it might be inferred that all might feel; but as there is that peculiar structure wanting in them, which is present in the brain, and is subservient to the formation of material ideas, the change which the nerves undergo in the ganglia from external influences, is only a motor force—a reflexion of the impression upon other nerve-fibrils,—and which has been fully explained already in my work (399, 421). It is the same with the nerves which arise from the spinal cord, and which probably have the twofold function of transmitting to the spinal cord the impressions they receive, that they may be sent directly forwards to the brain and subserve to sensation; or that they may be reflected in the spinal cord on other nerves, and thus induce certain movements which otherwise would not have resulted from these impressions."—Physiologische Untersuchungen, p. 24. Compare also § 624.—Ed.

36. True external sensations are conceptions excited by external impressions on the nerves. Thereby the mind distinguishes at each act of attention the point where the external impression takes place. Consequently, the sphere of action of the external impression, which causes the external sensation, is only between the point of impression and the material external sensation in the brain; and since there is first the external impression, and then its transmission, the vital changes which cause the external sensations must be propagated from the point of impression upwards to the brain, and not downwards, from the brain, in so far as they are felt (31). If, consequently, a branch of a nerve is irritated at a point nearest to the brain, the external impression which ascends thence to excite a material external sensation, can excite it in the most distant branches, and by their means develope impossible animal actions. And if these actions should arise in the distant branches, or through them, they are the actions resulting from an impression occurring contiguous to the brain which is sent downwards, and contributes nothing to sensation. The probable motion of the vital spirits accords with this view.

37. It may, however, be quite possible, with regard to many external impressions, that the impression on the nerve may so take place, that it concusses it, or its lower or more distant branches, only mechanically. The impressions excited by this mechanical concussion of the nerves are sometimes duly received, and, like other external impressions, propagated to the brain, and there produce external sensations. Thus, an external impression may appear to be transmitted downwards without that being actually the case. An example of this kind is afforded by the tingling which a blow of the elbow causes to be felt as far as the tips of the fingers, the nerve being mechanically concussed; it cannot be said that the external impression felt at the elbow had been propagated backwards, and felt through the fingers.

38. The mind determines the point of external impression in external sensations by an act of the judgment. At first it learns to distinguish the point of contact by a due observation of its external sensations, and a comparison of them with the place where the external impression takes place; but after frequent repetition it determines it in a shorter way, by analogy.

It is accustomed, for example, to decide as to the external sensations which it feels through the terminating nerve-fibrils of the left hand, which transmit the impressions they receive to the brain, along the trunk of the nerve, that they take place in virtue of external impression on the left hand. But if this hand be amputated, and these terminating fibrils be altogether removed, still every external impression made on the cut end of the trunk of the nerve of the left arm, being likewise transmitted to the brain, seems to come from the left hand, when, from a want of attention, the accustomed method of estimating the point of contact is adopted; and the mind is only aware from due observation, that its estimate is erroneous. This case (in which there is no true external sensation from the left hand) cannot prove that a true external sensation of an external impression can reach the mind from a more distant spot than the true point of impression of the nerve; but simply that the judgment may sometimes err respecting the external sensations, which error is a defect of the judgment, and not of sensation. In this way a thousand phenomena must be estimated, as when a person thinks he has sensations in a lost limb, or when he seeks the point of sensation in a broken limb, in a natural direct line, and finds it in quite another place.

39. External impressions may be made on many nerves at the same time, and the mind can distinguish all and each of the external sensations thence arising, although the impressions come from the most distinct nerves into a common trunk (as for example, the spinal cord), before they reach the brain, and there form the material ideas of an external sensation. In the same nerve, and, at the same time, different impressions may be made, yet the mind accurately distinguishes them; so that every external impression on each point of a nerve takes also an uninterrupted course to the brain, and can there form the material sensation peculiar to itself, and distinct from all others, without being confounded or mingled, either on its way with other impressions ascending at the same time, along the nerve, or with the material sensations which arise at the same time in the brain. The reason of this is, that the terminating fibrils which receive the impressions run a distinct course to their origin, and remain quite separate, however they may be united with other fibrils to form an entire nerve, or, however the

latter may be united to form larger trunks, as the spinal cord.[1] Further, at the place of origin of the nerve in the brain, there is a distinct point where the material ideas must be developed from the external impressions which it brings to the brain.

40. It is useless to attempt an arrangement of the various kinds of external impressions according to the variation in their external sensations. Everything is ordered according to laws altogether unknown, and which we can never fathom. Pain, for example, is a sensation which usually arises from very vehement external impressions on the nerves; nevertheless, the most violent disturbance of a nerve is not always the most painful. A corrosive fluid can excite a far more intolerable pain in a nerve, than a blow which shatters the bone of the limb. Neither is it the separation of the components of a nerve by the corrosion, which causes the pain to be so acute, for a sharp knife divides it without any remarkable pain. It

[1] This important doctrine of the distinct course of each nerve-fibril was taught at Leyden during the first half of the last century. The following quotation will interest the reader:—"The doctrine of Albinus,—indeed, of the whole school of Boerhaave,—in regard to the nervous system, and, in particular, touching the distinction and the isolation of the ultimate nervous filaments, seems, during a century of interval, not only to have been neglected, but absolutely forgotten; and a counter-opinion of the most erroneous character, with here and there a feeble echo of the true, to have become generally prevalent in its stead. For, strange to say, this very doctrine is that recently promulgated as the last consummation of nervous physiology by the most illustrious physiologist in Europe. 'That the primitive fibres of all the cerebro-spinal nerves are to be regarded as isolated and distinct from their origin to their termination, and as radii issuing from the axis of the nervous system,' is the grand result, as stated by himself, of the elaborate researches of *Johann Mueller*; and to the earliest discovery of this general fact he carefully vindicates his right against other contemporary observers, by stating that it had been privately communicated by him to Van der Kolk, of Utrecht, so long ago as the year 1830." (Phys., pp. 596-603; Supplementary Dissertations to Reid's Works, by Sir W. Hamilton, Bart., &c., note D; 'On the Distinction of the Primary and Secondary Qualities of Body,' p. 874.)

This whole essay is a mine of suggestive thought to the neurologist, but is specially interesting from containing a general abstract of the doctrines taught by the younger Albinus, in his lectures delivered at Leyden, and which Sir W. Hamilton has obtained from a manuscript copy in his library of the 'Dictata,' of Albinus, taken very fully after the middle of the last century by Dr. William Grant, and collated with another copy by an anonymous hand of 1741. Having, by the kindness of Sir William Hamilton, had an opportunity of perusing a portion of these 'Dictata,' I cannot but concur with that profound metaphysician in an expression of regret that they have never been printed.—Ed.

is the same with the tickling which a fine feather, or particle of dust, can excite, for it is a state of the nerve allied to that of pain, and sensations much pleasanter than it require much stronger external impressions. Indeed, the more indifferent external sensations of heat and cold, hardness and softness, moist and dry, of light, of dissolved salts, &c., are so totally different in the mind, that it is certain the external impressions on the nerves must be different also; but we know of nothing generally, as to this difference, which may serve as a general rule.

41, 42. It is equally impossible to compare the material ideas with the external impressions, or both these with the external sensations (*vide* Haller's 'Phys.,' § 556). Every external impression does not necessarily excite external sensations (34), although external sensations are the only conceptions it can excite (35). Since an external impression differs from every other in this, that it excites animal operations, and these can be either in the mind as external sensations, or only in the body, and consist simply in animal movements (7); and since we have only to consider here the operations on the mind of an external impression (33), we must inquire *under what conditions an external impression develops external sensations, and under what conditions it does not.*

43. If a nerve of special sense be compressed or divided, the sense is lost. If the brain be compressed, sensation ceases in the whole body; and when the spinal cord is compressed, sensation ceases in the part below the point compressed. The reason in all these cases is, that either external impressions are not transmitted to the brain, or, if transmitted, do not excite in it the material ideas requisite to sensation.

44. That a part be sensitive, it is requisite that it be endowed with nerves capable of receiving those external impressions, which can be transmitted uninterruptedly to the brain, and there excite the material idea of a conception. The more a part is endowed with such nerves, the more readily it receives an external impression; and the more uninterruptedly it can be transmitted to their origin in the brain (43), the more sensitive it is. The less a part is supplied with such nerves, although it may have many others of a different kind, and the more difficult it is to convey external impressions to them, that is to say, the more they are covered and protected from contact, and the

more hindrances there are to an uninterrupted transmission to the brain, of an external impression, in the same proportion the part is insensible (34).

45. We are now able to say what is requisite to the development of an external sensation.

i. A nerve must be so acted on, that its medulla thereby receives an external impression (31, 32).

ii. This impression must be propagated into the brain, so far as the origin of the nerve (43, 44).

iii. It must there excite the animal movement (a material idea), which naturally arises from this external impression; and so soon as this takes place, the conceptive force of the soul develops the external sensation (34, 25).

46. An external sensation derived from a given nerve may be interrupted, or cannot arise.

i. When the nerve is not acted on, or not sufficiently so, that its medulla receives an external impression (45, i). All conceptions, consequently, which are considered to be such external sensations, but which arise only from the conceptive force without an external impression, are not true external sensations: of this kind are imaginations, recollections, anticipations, &c.

ii. When the external impression does not reach the brain at all, but particularly that point where the material sensation is to be developed. It does not follow because a nerve has been acted on, and an external impression excited, that the latter must necessarily be felt (42), for to this end the impression must find its way uninterruptedly to the brain (45, ii).

iii. When the material idea, which ought naturally to result from the external impression, cannot arise in the brain (45, iii). The brain may be defective at those points whence the nerve arises, and thus the limb, to which the nerve is distributed, may be rendered insensible to all external impressions, although their existence along their whole course to the brain, be rendered manifest by other animal movements.

47. Since, in the normal condition of animal organisms, all external impressions do not excite material external sensations, so also there are portions amply supplied with nerves which have little sensation; so that the amount of sensibility of a part cannot be deduced, from the number of nerves without certain limitations. Nevertheless, these numerous nerves may be of great

use in the animal economy, by means of other animal operations (42); and as, in fact, experience teaches us, that many parts well supplied with nerves have little sensation, feeling but rarely, and only a few external impressions, and those of a special kind, as the heart, stomach, &c., it is very probable, that in animals in a state of health many external sensations are prevented by similar natural obstacles, and that this is no abnormal condition of many nerves. That this important matter may be placed in its proper light, we will endeavour in every possible way to demonstrate from observations, how external sensations are prevented naturally.

i. Nature protects many nerves from contact by coverings, by envelopes of cutis, or mucus, or so distributes them, that they are only exposed to slight or gentle contact, or to certain impressions expressly adapted to them, and little, if at all, to any other. By this means, also, external sensations are so moderated as not to be painful (46, i).

ii. There are many nerves, so situated and distributed, that they are only exposed to certain agencies, the optic for example; which, in general, are only susceptible of external impressions from the rays of light; while the nerves of the skin receive no impressions from the rays of light (40). In the same way, the undulations of the atmosphere, which duly act as impressions on the auditory nerves, cause no external impression on the delicate and sensitive nerves of vision. The odorous particles which are so perceptible by the olfactory nerves, have no effect on the tactile, gustatory, auditory, or visual nerves. Sometimes certain nerves are endowed for a period only, with the capability of receiving external impressions from certain irritations and influences, which they afterwards lose, as, for example, in the sensational instincts (265).

iii. Further, certain external impressions act so feebly on nerves otherwise sensitive, that they do not go onwards to the brain, but are weakened or lost in their course thereto. That this feeble influence on the nerve has certainly excited an external impression, is made clear by other animal actions, as, for example, by certain animal movements which the impression excites; and the cause of its not being felt must be in its not having reached the brain. Flatus in the stomach often excites a tension of the nerves, which is so feeble, that we do not feel it; although the external impression that takes place at the same time, betrays itself by animal actions, namely, contraction of the stomach, as is proved by the rumbling of the flatus. But the transmission of the external impression to the brain is prevented in the natural state, or state of health, in a way which requires a copious elucidation.

48. iv. It is incontrovertible, that many nerves, although sensitive, are mainly appropriated to certain special movements; and that the external impressions necessary thereto, are seldom or never transmitted to the brain, or only those of a certain kind; but that, for the most part, it is their normal condition to remain in the nerve. The nerves of the stomach, intestines, and heart, illustrate this point. Food which gives rise to a strong sensation in the mouth, causes no sensation whatever when passed into the stomach. Whether it be bitter, sweet, or salt, it is the same in the stomach. Yet the stomach is more amply supplied with nerves than most other viscera, and these are highly sensitive to other impressions, as those of acrid poisons, for example, and consequently quite susceptible of external impressions. As food comes into contact with them as certainly as poisons, and excites an external impression, which undeniably develops the animal movements of digestion that result from the contact, it necessarily follows, that the external impressions on these nerves are not generally transmitted to the brain, but are lost in the mechanical machines, to the movement of which they are specially appropriate. An acridity in the stomach will be felt little, if at all; but if it be in the mouth, it almost suffocates us, and bites the tongue; on the other hand, it will excite a gastric spasm in the gastric nerves by its external impression. The heart is abundantly supplied with nerves, and remarkably sensitive. The impression of the blood flowing through it excites its movement, which, even when it has ceased, can be renewed by the injection of warm fluids, and yet the mind feels nothing of this external impression. The special destiny of these nerves is to excite the motion of the heart, which, according to the views of all physicians, is vital and not mechanical in its nature. It is so little necessary that the external impression made on the nerves which move it be felt, that motion can be re-excited in a heart detached from the body by an external impression on the terminating fibrils

of the nerves, as when salt is sprinkled on them; and by this experiment all probability of a mere mechanical excitement by the impression, (as in filling the heart with warm fluids, or with air,) is taken away. Since, also, external sensation is not necessary to the ordinary motion of the heart, there must be natural hindrances to transmission, in virtue of which certain external impressions are retained in these and analogous nerves, so that they cannot pass upwards to the brain (see § 55—61). It is difficult to say, in what these hindrances consist. The external impression on the heart is really there, since every motion of the heart is excited by it. It is also in the stomach after taking food, since the peristaltic motion of the latter is renewed by it. What prevents the propagation of all these impressions to the brain? There is nothing to be found in the nerves adapted to this end, except certain formations found scattered on the motor nerves, termed ganglia (14), and the point of insertion of the smaller fibrils in the larger trunks, where also a sort of ganglion is formed. At these points, the direct course of the fibrils is interrupted, and here the external impression traversing them can be deflected from its course, and its transmission to the brain prevented (13, 14); the more especially, as the outer thick coat of the ganglion acts in some degree as a muscle, and, by a slight compression, can hinder the transmission (Monro). But is it not probable, that an external impression on motor nerves of this kind, is expressly intended, when it reaches the ganglia, to be deflected to the trunk or branch of another nerve, or to another fibril of the same nerve interwoven in the ganglion? For thereby it would cause a reflected or retrogressive action in the fibril, as if an impression were excited in it, and sent from above downwards, or, as if sent from the brain; when thus deflected, it puts certain parts into movement, just as an impression really transmitted along the nerves from above downwards, and so imitates the latter by this reflected course (31, 121, 122, 137). If, however, this conjecture be groundless, still the fact remains, that external impressions on certain nerves, not received directly, excite movements without reaching the brain, and without being felt.

49. v. Amongst the natural impediments to external sensations, those also may be classed (according to 46, iii) which prevent the external impression from developing in its proper

place the material idea belonging to it, although it has arrived at the brain; that there are such impediments is certain, and *sleep* is an example. This is a periodic state of insensibility natural to all animals endowed with sensation, and enables them to collect new strength after the weariness resulting from activity, and which arises, as some think, from the want or weakness of the vital spirits; light may shine into the eyes, sound fall on the ears, and the nerves may be stimulated in a thousand ways, and yet no external sensation be excited. Consequently, either the external impression never reaches the brain (and for this conclusion, there is not the slightest foundation), or else no material ideas are formed therein, or at least only imperfectly; and this is probably the true doctrine, since a compression of the brain, either by hæmorrhage, or effusion, or depression of a portion of the cranium, or even excessive distension of the blood-vessels, develops the same insensible state, and induces true sleep. It appears as if the brain were in a state of torpor in profound sleep, so that the material ideas are prevented being developed by the external impression on the nerves; whilst the purely animal movements excited by the impression on the latter only appear to experience no change,—(see § 182, 183.)

50. vi. There is still another special cause which prevents external sensations arising in the mind, in one or other of the five methods described (47-49); and this is the frequent repetition of an external sensation. By this, as observation teaches, many external sensations become gradually weaker and weaker, and at last cease altogether, although the impression on the nerve still takes place. This diminution and destruction of external sensations by frequent repetition, is termed *the habit of external sensations*, and since it cannot be explained on mechanical principles, it must be classed with the properties peculiar to animal bodies (6).

51. Habit weakens or destroys external sensations in the five following ways:

i. By their frequent repetition the susceptibility of the nerve may be weakened or prevented (47, i). For example, a thick cuticle is developed, and protects the terminating fibrils, in consequence of certain oft-repeated impressions on the organs of touch.

ii. An impression, often repeated on a nerve, may render it unfit to receive that particular impression, although it may receive every other; as when one who, accustomed to cold, neither feels the cold, nor has goose-skin produced, and yet would feel a tickling from the slightest touch of a feather.

iii. The frequent repetition of the same external sensation may render a nerve insensible (47, iii.)

iv. When the frequent repetition of the same external impression (48), renders the nerve so insensible, that thereby the ganglia and points of anastomosis are so changed that they retain an impression which they previously allowed to pass. This may only be observed in the cases in which an external impression, in an unweakened nerve, excites both sensation and movements at the same moment; but in the abnormal condition excites the latter only. In such a case the occurrence of the animal movement (a proof wanting in other instances), shows that the external impression is really received by the nerve and transmitted to the point, where, on its way to the brain, it is reflected and sent downwards along the trunk of the nerve, being the direction taken by an impression transmitted from the brain itself (31, 122). This is the only explanation admissible, since as the nerve is not enfeebled, the principle just laid down (iii) cannot apply. Instances will be remembered of persons who experienced spasms in their limbs from various external impressions made on nerves in a distant part, and in whom the same spasms continue to occur, although the mind has become at last habituated to the pain, and it is no longer felt. So, also, many epileptic and gouty patients—the paroxysms they suffer being excited by worms or gouty humors, causing external impressions on the nerves of the stomach—can foretell an attack from the sensations thus excited. After a time, however, when the disease is rendered chronic, these sensations are no longer felt, and the paroxysms come on quite unexpectedly.

v. Lastly, the frequent repetition of the same external impression can weaken or destroy the external sensations. The point in the brain, where the impression ought to excite the material external sensation, undergoes such a change, that the development of the material idea is prevented (49). This is the case when a miller becomes so accustomed to the noise of his mill, that he does not hear it at all, or only with an indistinct consciousness. Again, we know that when the mind is abstracted from other conceptions, and devotes itself to one only (an act termed *attention*), it can only do this by a cessation of the movements in the brain; or, in other words, of the material ideas of the conceptions from which it is abstracted (21). Such a repose of the brain probably takes place in cases of the kind under consideration.

52. When the nerves of an organism receive external impressions with greater comparative facility, and when the latter meet with fewer or less important natural obstructions to their transmission to the brain, and to the formation of material external sensations therein (47, 51), the organism is termed *sensitive*, in a special sense (*excitable, susceptible*); or, if the contrary, *insensible* (harsh, unfeeling); and the qualities themselves are termed *individual sensibility* (94), *individual insensibility*. The property of animal nature, in relation to sensibility and insensibility, is the *temperament* of an animal body: the *bodily constitution,—the nature*. By habit, sensitive organisms become insensible; consequently the temperament is changed, and this may take place in all the modes indicated (51). An individual sensibility towards certain external impressions, not shown by the majority of persons of a similar temperament, is termed *idiosyncrasy*.

53. Mental philosophers maintain, that external sensations have greater strength than other conceptions, because they consist of a greater number of elements [merkmalen], (Baumgarten's 'Metaphysics,' § 402). Now, since each element of a conception is also a conception itself, and every conception requires a material idea in the brain (25), it follows, that the material ideas of external sensations are compounded of more movements in the brain, than the material ideas of all other conceptions. Consequently, they exceed the latter in intensity, that is to say, the movements in the brain which external sensations produce, are greater, and consequently have greater results, than those which accompany other conceptions.

54. Every thing that enfeebles external sensations, diminishes also the force of their material ideas in the brain, and of their action in the organism; and this diminution of force can take place by the same means, that enfeeble the external sensations

themselves (46, 50). The material ideas of external sensations, and their operation on the body, are the strongest when they are recent and not habitual, provided other circumstances are the same.

The External Senses.

55. The nerves are the organs of external sensations, but only by means of the brain (43). Those parts of organisms wherein the nerves are distributed that are susceptible only of special external impressions, and consequently only of special external sensations, are termed *organs of the (external) senses.* In man, these are five; other animals have fewer, a few have probably more.

56—64. The senses are—1st, touch; which has its seat in the tips of the fingers, but it is mixed up with general sensation; 2d, taste, subservient to nutrition; 3d, smell, in many animals much more acute than in man; 4th, hearing; 5th, sight. The anatomical relations are to be found in works of anatomy; the metaphysical questions, as for example, why we do not hear two tones, or see two images, or perceive the rays of light and the undulations of the air, or feel the forms of salts, are discussed at length in works of metaphysics, and therefore need not detain us.

The Sensational Conceptions.

It has so far been shown how material ideas are produced in the brain by means of external impressions. In this way the mind receives conceptions corporeally, necessarily, and involuntarily (27), in consequence of the animal force of the nerves developing external sensations. But the mind can also produce voluntarily, in itself, many kinds of conceptions, and through these, material ideas are formed in the brain, as an effect of the conceptive force, and by conceptions only, without the intervention of any external impressions (27). This other kind of material ideas so produced must be defined, before their influence on the animal economy can be explained. Since, however, some of these voluntary conceptions induce only material ideas of a kind that do not manifest externally to the brain any perceptible effects in the animal economy, and nothing therefore can be stated scientifically regarding them, we will only consider those, of whose effects we know something.

65. No animal thinks without feeling. Those which have the smallest external senses, manifest the feeblest mental power. Sensations precede all their other conceptions. However possible it may appear, that animals which have felt for a time, can still continue to think after all sensation is lost, there is no well-established example of this; much less of an animal possessing conceptions which it has never felt. Thus sensibility [Empfindlichkeit] is the first stimulus of the conceptive force in animals, and to this extent all their other conceptions originate in their external sensations. Now, since external sensations presuppose material ideas, produced by external impressions on the nerves (34), it follows that the latter must regulate all the mental phenomena, either directly through external sensations, or indirectly. But since all conceptions are connected with material ideas in the brain, the material ideas of all conceptions must depend either directly or indirectly, on external sensations in the brain, and on the external impressions on the nerves.

66. When, therefore, the matter is very closely considered, we find that even the most spontaneous conceptions are occasioned by external impressions on the nerves; but this causation occurs in many so very indirectly, that the connection becomes imperceptible; in others, on the contrary, it is more direct, often immediate, and this constitutes an important distinction in that class of conceptions which, in our arrangement of external sensations, we have termed *spontaneous* (27). It is necessary, therefore, to bear this difference well in mind, and not to adhere too closely, in a physiological inquiry, to the ordinary psychological division of the conceptions and desires, into the obscure, the indefinite, and the definite; a division neither precise in itself, nor tending to the advancement of physiology. When the mind is compelled to set in operation and exercise its conceptive force by various external sensations, each of which presents to it many sub-impressions of a single object (53), it soon acquires a facility of conceiving some of these sub-impressions spontaneously, although it can never attain to the power to renew completely an external sensation, without the aid of an external impression (35). Or this may be presented

in another aspect, as follows: when the animal-sentient force of the brain is frequently excited into action by various material external sensations derived from external impressions (which must be very compound movements in the brain, since they consist of so many sub-impressions), it partly renews these material external sensations by means of the inner animal mechanism of the cerebral medulla, in conjunction with the free-will operation of its own conceptive force, although it cannot develope them fully without the aid of the external impressions. These spontaneous conceptions, which are nothing more than incomplete external sensations, are *imaginations*, so far as they appertain to *antecedent* external sensations, and *anticipations*, so far as they may belong to *future* external sensations. Consequently, so soon as the conceptive force has attained to that degree of perfection by means of external sensations, that it can of itself form imaginations and anticipations, it is led to re-perceive an antecedent external sensation by every new external sensation that has something in common with the latter; the material ideas of the antecedent sensation being again, in some degree, excited into activity. It can, however, conceive the antecedent sensation again only so far as is possible without the aid of the antecedent external impression; and the animal-sentient force of the brain also co-operates therewith in renewing each material external sensation, but only so far as is possible without the entire antecedent external impression; there being only some of its sub-impressions in the existing similar impression. Now the spontaneous conceptions which are developed by external sensations in the way just described, whether directly or secondarily, are termed *sensational conceptions in the true sense of the word* (32) [sinnliche im eigentlichen Verstande].[1] There are also sensational *imaginations* and *foreseeings*. When sensational conceptions, acting in the same way as external sensations, excite other spontaneous conceptions, the conceptions thus produced are termed *less sensational*,

[1] The word *sinnlich* may clearly be used here in the sense of *sensational*,—see ante § 31 note, and § 34; but it strictly implies that the class of conceptions or act of thought referred to are *sinnlich*, because necessarily dependent upon a sinnlich impression. Hence the term "sensational," as used in this work, must be considered to have a double meaning, expressive both of the origin of certain acts of mind (or conceptions), and of their nature.

physiologically more free (27); these, again, may induce other conceptions, *still more free;* and when at length conceptions arise, so far removed from sensations induced by external impressions, that the connection between them is no longer traceable, and containing only few elements in common with all the sensational conceptions which have induced them, they are termed *conceptions of the understanding or reason; higher, abstract, general ideas.* In proportion as a conception is less sensational, it is the less to be deduced from, and explained by the sensations induced by external impressions; and the less it is under their control, the more it is to be referred to psychological principles (27). On the other hand, when the mind collects and combines from external sensations, associated sub-impressions, which it perceives, *suâ sponte,* without the assistance of their external impressions, and only by the inducement of *similar* external impressions, it causes material ideas in the brain, such that they have something in common with the material ideas of the external sensations from which they are compounded or drawn. They imitate imperfectly those movements in the brain, which can only be fully developed by the co-operation of the external impressions of those external sensations from which the sensational conception is compounded; and when sensational conceptions of this kind excite any actions in the animal economy, the actions must in part correspond with those that result from the external sensations themselves.

Imaginations [Einbildungen].

67. Sensational imaginations are conceptions of past external sensations (66),—(Baumgarten's 'Metaphysics,' § 414), which the mind renews spontaneously, so far as it is able, without the assistance of external impressions (Baumgarten, § 415). Consequently, they are wholly sensational conceptions. The *material ideas of imaginations* are also those of past external sensations, but in that imperfect condition, which necessarily results from the want of an external impression (35, 53); in other words, when the mind excites spontaneous imaginations, movements are also excited in the brain, which are partly the material ideas of former external sensations (66). Generally considered, the material ideas of imaginations are feebler than those

of external sensations. Some may, however, surpass the latter, if compounded of many external sensations (53). The stronger the imaginations, the more effective are their material ideas (26).

68. That which is wanting in the material ideas of the imaginations, so that they do not form the perfect material ideas of external sensations, is, the external impression transmitted along the nerves to the brain; which also renders the material ideas more perfect, and consequently, the conceptions richer in sub-impressions [merkmale] than those which the mind can produce without it (53).

69. If material ideas act as animal-sentient forces of the brain (6) in the animal economy, and excite animal actions, the actions excited by material ideas of imaginations must partly accord with those of antecedent external sensations (67, 66).

70. Since dreams are often imaginations of the sleeping state (sensational conceptions), which in somnambulism, and during the waking state in insanity, become so distinct that they cannot be distinguished from external sensations, the rules stated previously (67—69), with reference to imaginations, are applicable to all these. When the mind spontaneously combines many imaginations, it *invents* poetically [dichtet sie]. (Baumgarten's 'Metaphysics,' § 438.) All that has been stated as to imaginations and their material ideas, is applicable also to fictions (Erdichtungen).

71. All conceptions are connected with their proper material ideas (25). But for the mind to know regarding the same conception returning at different times, that the last is the same as the first, a renewed conception is requisite, and *it remembers*, or an *act of memory* takes place; but it is not necessary to this end, that the first should be continuous with the last. So little, indeed, is this continuity necessary, that a long period may elapse before the renewal, without there being a trace of the conception in the mind, and still when re-developed, the mind knows that it is the same as the previously existing conception. It is equally unnecessary for the material idea of a conception thus remembered to have a continuous impression on the brain, or to leave traces behind it, of which the mind makes use, so as to recognise the renewed conception as having previously been present to it. Each recognition of a conception is much rather an operation of the mind [con-

ceptive force], and is accompanied by its own proper material ideas, of which we know nothing, and of which we can trace no action in the rest of the economy. Granted, however, that a certain continuance of the conceptions is necessary to the recollections of the memory, it follows that the material ideas of these continuous conceptions must continue also in the brain (26), and this is the view usually taken of the conceptions of the memory. But a conception may continue in the mind for a century, and be never remembered, until a new conception is formed to the effect that it is the same as that which formerly existed.

72. Sensational memory induces by its recollections those material ideas in the brain, which have something in common with the antecedent material sensations (71, 66), and, in so far as they can excite animal actions, their actions will accord in some degree with those of the antecedent sensations or imaginations.

Foreseeings.—Expectations.

73. The sensational foreseeings and expectations arise from true present external sensations and the renewal of former sensations (*Imaginations*, 67), which have an element in common with each other; if the mind considers that, wherein they differ as something to come, it *foresees;* or the same as that which is actually coming, it *expects*. (Baumgarten, §§ 444, 454.) They are more remotely dependent on external sensations than are imaginations, because they depend on the latter, which themselves are directly derived from external sensations (66). Purely sensational expectations are termed *forebodings* [Ahndungen] (Baumgarten, § 454). Foreseeings, expectations, and forebodings are consequently conceptions of future external sensations, which have also their proper sub-impressions [merkmale] on the brain. Consequently the material ideas, also of all these foreseeings, must be those of future external sensations, but still very imperfect ones, since the mind can develope them spontaneously, only so far as is possible, without the direct aid of external impressions on the nerves (35, 36); that is to say, when the mind developes foreseeings, movements arise in the brain, which are the imperfect material ideas of future external sensations. Since foreseeings are weaker than external sensa-

tions, or the imaginations themselves (Baumgarten, §§ 445, 446), their material ideas are less energetic than those of either (53). Still, the stronger the foreseeings are, the greater the strength of their material ideas (26).

74. When the material ideas of sensational foreseeings and forebodings excite animal actions, the actions must in part accord with those of the future external sensations, and be regulated according to the strength of the ideas.

75. Sensational foreseeings and forebodings are often produced in dreaming and in insanity (Baumgarten, § 458). What has been already stated generally with reference to sensational foreseeings (73, 74) is equally applicable to this class, and especially to those of *soothsayers*,—persons who have skill in foreseeing the future (Baumgarten, § 456).

Understanding.

76. The aggregate of the sensational powers of the mind (66) is termed the *sensational perceptive power;* and the true external sensations, as well as the other sensational conceptions, are *sensational perceptions* [Erkenntnisse]. All conceptions which are only remotely determined by external sensations (65, 66), are termed *conceptions of the understanding* (*the higher perceptive faculty*); the faculty of judgment, of intellectual memory, of prevision, &c., belong to this class. The material ideas of all these conceptions are not developed directly, either by external impressions, or by the material ideas which they produce; but are impressed on the brain by the most spontaneous action of the mind, and are developed by the very obscure mechanism of the animal-sentient forces (6, 27).

77. *Attention* (the directing of the mind to anything) is such an application of the mind, that it retains a certain conception, while it neglects the rest. During attention, the material ideas of a certain conception are retained when those of the other conceptions become weak, or disappear; and the greater the attention, the more vigorous are the material ideas and their operations. This turning of the conceptive force from other inferior conceptions, in behalf of that to which the mind attends, is termed *abstraction*, and a continuous act of attention to the components of an entire conception or perception, is

meditation, reflection. In abstraction, many material ideas cease in the brain, or become weaker; the weaker, indeed, in proportion as the abstraction is deep. In reflection, they follow each other continuously, and each is immediately determined by its predecessor.

78, 79. Since material ideas of the understanding develope actions in the organism, it follows that the acts of meditation, abstraction, and attention, by causing those material ideas to cease, will diminish, or abrogate those actions (77).

Sensational Pleasure and Suffering.

80. The mind has its own feeling of its present condition, or a feeling of its own conceptions, which has been termed the *inner sense* ("*consciousness*," "*inner feeling*," "*conscience*," "*self-feeling*," Baumgarten, § 396). Under circumstances which metaphysical writers explain (ibid., § 478), many a conception is agreeable or disagreeable, or in other words, pleases, satisfies, gives pleasure or displeasure, dissatisfies, excites uneasiness. This feeling is a property of the conceptions, and may belong to all. Conceptions either please or displease; that which makes them agreeable or disagreeable is a sub-impression in them [merkmal], which the mind perceives at the same time. But since no conception is at once both pleasing and displeasing, except when considered from another point of view, or in other words, when it becomes a new conception, an agreeable conception differs in its nature from a disagreeable conception; and each consequently makes its characteristic impression at the point in the brain where the material ideas of the conception are (25), and which can have also its peculiar and distinct action in the animal economy (26). This is termed the *impression of pleasure* (lust), or *suffering* (unlust).

This difference in the impressions on the origin of the nerves made by an agreeable or unpleasant conception, implies that there is also a distinct external impression, when pleasure or suffering accompanies external sensations, which it forms in the brain as its material idea. A very strong pleasure of the external senses is termed sensual gratification, or titillation [Kitzel], a very strong disagreeable impression is pain [Schmertz]. Both are, therefore, external sensations, differing in their nature, and exciting different material sensations at the origin of the nerve which feels. The pleasure or suffering which the proper sensational conceptions (66) excite, is termed sensational pleasure, or sensational suffering; and under this term pleasure or pain of the senses is often included. The more sensational the spontaneous conceptions are in their character, the more their agreeableness or disagreeableness is in accordance with the sensual pleasure or pain of the external sensations from which they are derived, or to which they are related; and when they excite actions in the economy, the latter are similar to those of the external sensations. We can know and understand from the external impressions of the sensations, which either directly or proximately excite these sensational conceptions, why the conceptions ensue; they ensue, also, according to the same laws (66). On the contrary, pleasure or suffering of the intellectual conceptions is developed according to purely psychological laws, and has no manifest relation to the external impressions of external sensations, which excite them quite remotely. From an unpardonable confusion of ideas, even modern physicians have taught, that the sensational kinds of pleasure and pain have their seat in the body, those of the intellect in the mind. They have also fallen into the same error as to the passions, of which more afterwards (579, iii).

Desires, Aversions.

81. When the mind foresees anything pleasing to it, or (what amounts to the same thing) the conception of anything pleasing, it *exerts its conceptive force,* it endeavours to bring this foreseen agreeable conception forward, to make it present, or to accomplish its fulfilment, that is to say, to feel it (in the third sense of the word, § 34, note); and to develope the contrary conception to a foreseen unpleasant conception (to feel it, to accomplish its fulfilment), in so far as in either case it expects to be able to effect these objects by the exertion of its forces. This effort, this straining of its conceptive force, which it makes with the intention of realizing a foreseen external or internal sensation (34, 80), is termed, in the first case, *desire,* in the second, *aversion.* When the foreseen agreeable conception (or thing), or the opposite to a disagree-

able conception, becomes present (is felt), the effort terminates; that is to say, the *desires and aversions are satisfied or contented*, or the foreseeings are fulfilled (Baumgarten, § 450). When the objects of these are true external sensations, the mind cannot produce them independently of the proper antecedent external impression (34, 27); consequently, desires and aversions of this kind cannot be fulfilled or satisfied without the external impression itself.

Note.—It will be necessary to bear in mind the definitions of the word *feeling*, as given in the Note to § 34.

82. The efforts of the conceptive force are special applications of its power with the object of producing a certain special conception (81); and they manifest their actions on the brain through similar efforts of the cerebral forces[1] to develope a certain material idea suitable to the conception (26). It is, consequently, the same also in the desires and aversions (81).

83. Since pleasure and pain are the motives of the efforts, and consequently the bases of the desires and aversions (80, 81), in which relation they are *incitements of the feelings*, it follows that the impressions of pleasure or pain of a foreseen conception excite to that extent an effort of the cerebral forces to produce the material idea of this future conception (81, 82), and this is the material expression of the desire or aversion in the brain.

84, 85, 86, 87. In every desire and aversion, consequently, we must distinguish:

i. The foreseeing and expectation of a future sensation, or of one the opposite to it, which therefore consists of the sub-impressions of the future sensation [merkmale], and excites material ideas in the brain, that are partly the material ideas of the coming sensation or its opposite, and consequently constitute an imperfect material sensation.

ii. The incitements of the feelings—pleasure or pain—which communicate the impression of pleasure or pain to the imperfect material sensation in the brain (80).

iii. The spontaneous effort of the mind to develope the entire foreseen conception, or its opposite, which is connected

[1] As the animal-sentient forces [Thierische seelenkräfte] are peculiar to the brain, the term "cerebral force," here used by Unzer himself in that sense, will be used to designate them whenever it may be most in accordance with previous definitions, 25. —ED.

with the effort of the cerebral forces to complete the imperfect material sensation which the soul foresees, or in other words to render it perfect, and realize the anticipation (82, 83).

If, consequently, a desire or aversion, by its influence on the brain, manifests actions in the economy, they are compounded: 1. Of the actions excited by the material ideas of a foreseeing and expectation. 2. Of the actions excited by the impression of pleasure or pain in the brain. 3. Of the actions resulting from the effort of the cerebral forces of the brain, to produce the entire material sensation, which is anticipated, or the contrary to it (84); and the stronger all these are, the more energetic the actions of the desire or aversion (26).

88. The conceptions which are necessary to the excitement of desires and aversions, namely, the incitements of the feelings [Triebfedern des Gemüths] (83), pleasure and pain, are in so far as they excite the effort of the conceptive force, either sensational (66) or intellectual (76, 80). When they are sensational, that is to say, when they are true external sensations, or other sensational conceptions (67), or foreseeings (73), they are termed *sensational stimuli* (*sensual stimuli, incitements of the flesh*); if, on the contrary, they belong to the understanding, they are *motives, reasons*. Sensual gratification or titillation [Kitzel], and smarting are, consequently, sensational stimuli (80).

89. The sensational stimuli (which must by no means be confounded with mere impressions or nerve-feelings) (31, 32, 121), excite *desires* and *aversions*, which are termed *sensational* (88); on the contrary, *motives* are termed *intellectual* (*desires or aversions of the will*). The development of a sensational desire or aversion from sensational stimuli may be considered in various ways. Various kinds of conceptions, anticipations, expectations, and efforts of the conceptive force (84, 86), are requisite, all which impress their material ideas and impressions in the brain (25). On one hand, the sensational desires and conceptions may result from sensational stimuli, organically and necessarily (as external sensations result from their external impressions), according to the laws of action of external impressions, and be equally sensational. Or the sensational desires and aversions do not result from these stimuli organically and necessarily; and we can only explain their excitation by at the

same time taking into consideration the intervention of the spontaneous conceptions which they produce in the mind, and which commingle with the former, according to their laws. Now, when the sensational desires and aversions manifest their workings in the economy as in the former case, they can be explained and deduced by the laws of action of the external impressions of the sensational stimuli on the cerebral forces; but in the latter case, we must bear in mind the concurrence of the spontaneous intervention of the conceptive force. The first class, therefore, being almost as fully developed as external sensations, may be termed *wholly sensational,* but the latter being more like conceptions of the understanding in their origin, are more *spontaneous* or more *physiologically free* (27). In the latter, the mind is necessarily conscious of the intervening conceptions; in the former, it need not be conscious of either the conception or of the external impressions of the sensational stimuli, out of which the conceptions are formed.

Note.—It is not possible, in this stage of the work, to render this matter clearer; subsequently (564, 579) it will be made more intelligible.

Instincts, Passions.

90. A strong and wholly sensational desire, which arises from obscure sensational stimuli, and the material ideas of which are consequently little developed in the brain (26), is termed *a blind impulse* (*instinct, sympathy, sensual propensity, sensual inclination, natural instinct* generally), (295); an analogous *aversion* is a *blind abhorrence* (*antipathy, sensual dislike, enmity*); both are *sensational instincts* ("the flesh"). They are divided into the instincts of *self-preservation, self-maintenance,* the *propagation of the species,* and *love of offspring.*

91. Strong desires and aversions arising from confused sensational stimuli, of which there is a consciousness, although it is indefinite, and the material ideas of which are more developed in the brain than those of the sensational instincts (26), are termed *passions, emotions, affections.* Those arising from the sensational stimuli of pleasure are termed pleasing; those from the sensational stimuli of pain, painful.

92. In every sensational instinct, and in each passion, we must distinguish:

i. An obscure or confused anticipation or expectation of an internal or external future sensation, produced by a nearly direct external sensation (34, 80), which anticipation or expectation consequently contains sub-impressions of the future sensation within itself (73), and developes similar material ideas in the brain, consisting of the constituents of the material ideas of the future sensation, that is to say, they are imperfect future material sensations (84, 66).

ii. The sensational stimuli (84—88), pleasure or pain, which communicate to the imperfect material sensation in the brain, the impression of pleasure or pain.

iii. The spontaneous strong effort of the mind to develope the entire foreseen sensation (81), which is connected with a strong endeavour of the cerebral forces to complete the imperfect material sensation that the mind foresees: or, in other words, to develope the foreseeing of the instinct or passion (82, 90, 91).

93. When a sensational instinct or a passion excites actions in the economy, in virtue of its influence on the brain, they will be compounded: 1. Of those arising from the material ideas of a sensational foreseeing or anticipation. 2. From those of the stronger sensational stimuli in the brain. 3. From those of the more active endeavour of the cerebral forces to develope the entire material sensation which is foreseen (92). The stronger each of these are, the more vigorous its actions in the economy (85, 87, 90, 91).

94. The proper development or excitement of a sensational instinct or of a passion is as follows: Firstly, there is an external sensation or other sensational conception in the mind. This causes the obscure and confused anticipation and expectation of a complete future sensation, that is highly pleasing or annoying, which indeed is no other than a portion,—a collection of many sub-impressions (merkmale) of the future sensation, or, in other words, an imperfect sensation with its sensational stimuli. Hereby the mind is moved to apply its spontaneous conceptive force with stronger energy to produce this foreseen sensation (whether it be the opposite of another or not),—that is, to produce all the sub-impressions wanting to complete the true sensation, and thereby to satisfy the instinct or passion (to fulfil its anticipation) (81); this cannot

be accomplished, however, when it refers to true external sensations, unless the appropriate external impression be attained. When we apply this doctrine to animal functions in accordance with the principles laid down in § 25, we find that the material element of a sensational instinct or passion is thus developed: Firstly, there are material external sensations, imaginations, or other sensational conceptions in the brain. Through their action arise in the brain the material ideas of the anticipation or expectation of a future sensation, which contains within itself the impressions of pleasure or suffering. With this is a new impulse of the cerebral forces now associated, to render this incomplete material sensation perfect, either because it results from the impression organically and necessarily, or because the mind has previously spontaneously resolved to complete its foreseen incomplete sensation, and direct its efforts to this end (89). Next, through this effort of the animal-sentient force of the brain, an endeavour is made for the development of the whole material sensation, a portion of which is actually there,—partly to produce more of its elements, to which the mind can add spontaneously the sub-impressions of the anticipations,—partly to impress the elements of the material sensations already present more forcibly, and render them more active, until the remaining elements wanting to complete the entire material sensation, are actually produced through this effort of the cerebral forces. The effort then ceases, the instinct or passion being satisfied; or the effort ceases from enfeebling of the instinct or passion, without the completion being achieved. The satisfaction cannot, however, take place, if to perfect the incomplete sensation it must become a true external sensation, unless an external impression be also added (35). All actions, consequently, which the instincts and passions excite directly in the brain, are material ideas of an anticipation or expectation, which constitute portions of the perfect material idea of the future sensation, together with the strong sensational impressions of pleasure or suffering which belong to this material anticipation; and when these material ideas produce actions in the economy, they are no other than those of the imperfect material sensation combined with the actions of the superadded impressions of pleasure or pain expressed with unusual force (93).

95. A sensational instinct and a passion cease, or are prevented being satisfied, either by the enfeebling of the sensational stimuli which incite the mind to the strong effort, and this may occur partly psychologically, partly physiologically, or—by the contentment of the anticipation, or by the prevention of the requisites thereto (81, 94).

The Free Will.

96. The *motives* [Bewegungsgründe] add the impression of pleasure or suffering to the material ideas of every conception not in equilibrio or passive, and consequently to those of a similar future sensation, which must be stronger in proportion as the feeling of pleasure or suffering is greater, and, according to these views, be able to exercise a corresponding influence in the animal economy (80, 88). But as incitements of the mind, they also excite *desires and aversions* (83), which are termed *intellectual* (*to will*, and *not to will*, *intentions of the will*) *free conclusions* (89), and which arise from an anticipation and expectation of the understanding, and the motives it contains (84, 86, 88). The laws of action in this case are the same as laid down in § 94; the effort of the cerebral forces is strong in proportion with the strength of the *will.*

The Actions excited by the Mind, or Sentient Actions. [Seelenwirkungen].

97—110. All material ideas (25, 26) with their impressions of pleasure and pain (80) and all efforts of the cerebral forces, so far as they are based on the conceptive force (27), together with all real animal actions in the body dependent thereon (Baumgarten, § 224), are termed *actions* of the *animal-sentient forces*, *operationes animæ*, *sentient actions.* Sentient actions in the body may be divided into two classes: 1. Those of the perceptive faculty, or, in other words, those of the external sensations, of sensational imaginations, foreseeings, and of the understanding (67, 73, 76). 2. Those of the incitements of the feelings (80, 83), including sensational stimuli and motives (88), the desires and aversions (81), the instincts and passions (90, 91), and the will (96). The sentient actions which are excited by an entire conception ("*totale,*" Baumgarten, § 378), without the intervention of another, are termed *direct* sentient actions; all others are *indirect* (incidental) actions of this entire conception. The nature and origin of these various sentient actions may be learnt from the paragraphs to which reference is made.

111. Although the sentient actions of the various conceptions are developed, and follow each other, partly according to the laws of action of external impressions on the cerebral forces, partly according to psychological laws, still the conceptive force co-operates in each as well as the cerebral forces (25); and consequently each may be developed, facilitated, hindered, and interrupted in two different ways; namely, physiologically, because the actions of the animal machines requisite to each are partly so developed, facilitated, hindered, or interrupted; and psychologically, because the mind has a similar influence on those actions. It has already been shown (45, 46), how the sentient actions of the external sensations, and consequently through these, those of the sensational conceptions, desires, aversions, instincts, and highly sensational passions are *physiologically* developed and prevented, in so far as the external sensations themselves are physiologically developed or prevented. But it has not been possible hitherto to explain how the sentient actions of the conceptions, desires, &c., are physiologically developed in the brain out of each other as material ideas, and transmitted to the nerves, for we know nothing of the nature of the cerebral forces, or of the mode in which the conceptions excite the cerebral functions. Nevertheless, we know generally under what conditions these sentient actions are physiologically developed or prevented in the animal machines external to the brain, as we shall subsequently show, (121, &c.) But how all this happens *psychologically*, is taught by metaphysics; and therefore in both ways, and on principles entirely dissimilar, sentient actions may be produced, facilitated, and increased; and, on the contrary, in both ways, and on principles as widely different, they may be prevented, weakened, and destroyed. This is the ground of difference in the nature of diseases of the cerebral forces and sentient actions, which arise both from corporeal and mental causes; and in their therapeutical and psychological treatment.

112. The varying degree of senselikeness [Sinnlichkeit] in the

conceptions raises the questions, whether the external sensations and their sentient actions depend solely on the body; whether the *sensational* perceptions, stimuli, desires, aversions, instincts, and passions, with their sentient actions, depend partly on the body, and partly on the mind; and whether the *intellectual* conceptions, motives, the will, and the unwill, together with their actions, depend solely on the mind. Indeed, properly, all sentient actions are produced by the cerebral forces excited into action by the conceptions, but while the mind produces all its conceptions in virtue of its conceptive force, they again are dependent on the material ideas in the brain (25), and consequently on sentient actions (97), as is fully shown in metaphysics. (Vide § 119, and Baumgarten's 'Metaphysics,' §§ 563, 567.)

Action of the Material Ideas in the Nervous System.

113. We have hitherto followed the arrangement laid down in § 30, and shown *how material ideas are produced in the brain,* namely, partly by external impressions on the nerves (through external sensations), which are propagated to the brain (31—64) partly by the influence of the conceptions which the mind, by its own power, produces in the brain (65—112). There is now another question to answer, namely, what functions do the material ideas perform in the economy? In this chapter, according to § 16, we can only consider them in their relations to the animal machines—the brain and nerves—leaving out any reference to the mechanical machines.

114. The material ideas are animal forces, in so far as they manifest their operations in the economy. Now since they act in accord with the mind (97), they are also animal-sentient forces (6).

115. All material ideas are solely and exclusively in the brain (25). Consequently, they produce their effects either *directly* through the brain, or indirectly through the nerves, by means of which the brain is extended through the entire animal body (12, 13); because the nerves are the only animal machines in those animals which possess true conceptions (9); but the vital spirits are only the means by which they perform their functions (17, 18).

116. All actions of the material ideas, whether arising directly through the brain, or indirectly through the nerves (115), are extended solely into the sensitive or animal machines (34, 14), which are *the brain and nerves* only, or *they at the same time put mechanical machines into motion.*

117. All actions of the material ideas are therefore:—1, directly cerebral, and not extended either to the mechanical machines or to the nerves; 2, directly cerebral, but extended to the mechanical machines without the intervention of the nerves; or 3, cerebral indirectly through the nerves, and in this case, either remain simply in the nerves, so far, at least, as not to affect mechanical machines, or are in fact, extended to the latter at the same time, and move them (115, 116). Now since we have only to consider the actions of the material ideas restricted to the nervous system exclusively (113), they may be arranged under two heads:

i. The direct cerebral actions of material ideas not extended either to the nerves or to the mechanical machines; and—

ii. The indirect cerebral actions of material ideas excited through the nerves, so far as they do not put mechanical machines into motion.

Actions of Material Ideas in the Brain.

118. All material ideas are movements in the brain (25); consequently, their actions in animal bodies can be none other than movements; but animal (114) and sentient actions (97), which, when they are not extended beyond the brain, are actions of its own animal-sentient force (114). Now, the latter is no other than the power to produce the material ideas of the conceptions (25, 26). Further, the direct actions of the material ideas which remain in the brain, and are not extended either to the nerves or to the mechanical machines, are simply other material ideas, which produce other conceptions, and, consequently, can be developed in other points of the brain than the first, as is certainly the case with various external sensations (43).

119. The primary material ideas in the brain, which are produced by either external impressions (31, 32), or by spontaneous conceptions of the mind (27, 114), excite, consequently, of themselves *material ideas of a second kind* which are necessary to

those conceptions which arise directly either from external sensations, or from primary spontaneous conceptions (118). Or, in other words, as the conceptions arise from and follow the primary material ideas; so, also, all the material ideas belonging to the secondary conceptions arise from and succeed each other in virtue of the cerebral force put into action by the primary material ideas (112). We are ignorant, however, of these processes.

120. So soon, however, as the actions of the material ideas are extended beyond the brain to the nerves, whether they put mechanical machines into motion at the same time or not, many traces of them can be discovered, and it is these which we have now to consider (117, ii). We will first, however, notice the actions of material ideas through the nerves generally; or, in other words, of the proper cerebral force (121—141), and afterwards their actions as manifested solely in the nerves, and not in mechanical machines.—(Vide §§ 142—152.)

Actions of Material Ideas through the Nerves generally: the Internal Impression in the Brain.

121. Material ideas are to be considered as impressions made by conceptions (acts of mind) on the brain, for even those produced by external impressions only arise when the latter excite external sensations; and we can discover no other source for those which accompany the intellectual conceptions, than the conceptions themselves (25, 112). To distinguish these impressions from *external* impressions, we will term them, for want of a better phrase, *internal senselike impressions, senselike impressions on the brain—internal nerve-feeling*; and include, under these terms, all impressions made on the cerebral origin of a nerve, or on its trunk, and transmitted downwards from the brain, in a direction contrary to that taken by the external impression (31, 32, 406).[1] Although a nerve may receive an internal impression which is not derived from the brain, just as it may receive an external impression which does not reach the brain (47, 199), still internal impressions on the nerves,

[1] The reader is particularly requested to refer to § 31, and the foot-note appended thereto, for an explanation of the word *sinnlich*, here translated *senselike*. In accordance with the views there stated, the word *sinnliche Eindrück*, here used, will be translated simply *impression*.

caused by animal-sentient forces,—material ideas (114),—take place solely through the brain, and may very properly be termed *cerebral impressions* (sinnliche Eindrücke durchs Gehirn).[1]

122. The actions of material ideas in the nerves are therefore impressions of conceptions propagated along the nerves from the brain downwards to the terminating fibrils (31, 121); and since, in this respect, the material ideas act as animal-sentient forces (114), their actions in the nerves are true sentient actions (97), which probably are extended through the system of nerves by means of the vital spirits. (See § 17 and § 28; also Haller's 'Physiology,' § 377.)

123. Since no other animal movements in animal organisms are sentient actions except material ideas and the actions actually resulting from them (97); it follows that, to every true sentient action, a conceptional impression is necessary, which is either confined to the brain, or propagated downwards along the nerves (122).

124. Since there is a particular point in the brain from which each nerve arises (13), and at which alone the material ideas of its external sensations are developed,—no other portion of the brain having a part therein—(43); it follows, that the impressions of the conceptions act upon the origin of a nerve when they excite sentient actions in it (31, 118). Consequently, the whole brain will not be put into action by each conception, but only a certain locality, or that point in which the material ideas are formed; and this action is directly propagated only along the nerve and its branches to the terminating fibrils arising from this point of the brain, although it may also be communicated indirectly to other nerves when in connection with the former in ganglia, and when, in both cases, there is no hinderance to this transmission. The impressions of pleasure and pain are only different conditions of the material ideas of the conceptions which please or displease (80). They consequently take place at the same point as the material ideas of the conceptions themselves, and are only impressions of a different kind at the same origins of nerves.

125. Just as an external impression,—whether made on trunks of nerves, in which many fibrils are collected, or on the

[1] These impressions, caused by, or accompanying, acts of thought or feeling, are also termed *conceptional* impressions. (Vide § 359.)—Ed.

common trunk of nerves altogether different, or even in the spinal cord itself, which is the general stem of a great number of nerves—equally reaches the brain at the point of origin of the nerve which receives it, unmingled with any of the other external impressions taking place at the same time, and in the same direction, and there forms its own proper material ideas; so, also, the conceptional internal impressions travel from the points in the brain in which they take place, along the nerves arising from those points, and are propagated downwards through the branches and terminating fibrils without being commingled with other conceptional impressions taking place in the brain at the same time, although they all pass together along one and the same trunk, or rather first along the spinal cord to the larger branches, and thence to the smaller branches and fibrils (124). The cause of the two phenomena is identical (39). The fibrils of a nerve are already separated at its origin, and run each a separate course as portions of the same larger nerve to their allotted termination in the body (13). Each complete nerve has, again, its special point of origin in the brain, and although it passes downwards combined with many others into a large trunk, such as, for example, the spinal cord, it is afterwards given off again and remains distinct, and continues its own special course to its final termination at the allotted spot. Thus, consequently, an impression in the brain, made on the origin of a nerve, or on one of its fibrils, takes its course along the fibril, although ten other impressions may have been made in the same nerve, or on other fibrils of the same nerve, and produces its results without being intermingled with the others.

126. Although at the same time that conceptional impressions are transmitted along a certain nerve-fibril, and by its means perform their sentient actions, an external impression is made on the same fibril, and takes its course upwards to the brain along the same track, as far as the origin of the nerve from whence the internal impression had set forth, still these two impressions are in no wise interrupted in their course to and from the brain, although opposed to each other, but each are followed by their proper actions, as if the contrary impression had never been received (§§ 17, 18, Haller's 'Physiology,' § 377). Is it not highly probable from this statement of facts, that some of the numerous fibrils of which each nerve consists (17), are

destined solely to the transmission upwards of external impressions made on the terminating fibrils (perhaps the vital spirits being present in them), while on the other hand, other fibrils are destined solely to the transmission downwards to the terminating fibrils of internal impressions on the brain (perhaps the vital spirits being present at the cerebral origin), just as there are two classes of blood-vessels having similarly opposed functions? According to this analogy (which comes nearest to the idea of Borellus ('De Motu Anim.,' § 159, and which A. Monro does not entirely disprove), the brain that produces the vital spirits sends them downwards through certain fibrilli in a nerve to the terminal points (the sensitive papillæ), where they are received by the terminating points of other nerves, and transmitted back to the brain, as if to a heart. Although this theory cannot be fully demonstrated, it has a great degree of probability, since by it we can comprehend many phenomena which otherwise would remain incomprehensible. It will be worth while to render this matter more explicit.

127. When an external expression has been made on a nerve on the surface of the body, it passes upwards if there be no impediment (13), and reaches the brain at the point of origin of the nerve. The other nerve-fibrils, which cannot transmit the impression upwards, are not affected by the influence from without. At the point of origin of the nerve in the brain, the transmitted external impression produces a material idea which excites an external sensation. By this material idea (a movement) at the origin of the nerve, those fibrils are impressed that propagate the internal impression downwards; whilst on the other hand, those fibrils that transmitted the external impression to the brain, receive no impression from the external sensation. The former, however, propagate the conceptional impression to those structures, in which the sentient actions of the external sensation can arise, and these result accordingly. It is now more intelligible, how these opposite movements, arising from opposite impressions in the same nerve, are not impeded by each other, and why the same nerve can, at the same time that it transmits an external impression to the brain, produce a sentient action in some organ of the body, as for example, a voluntary movement. Since a nerve in its course from the brain is divided into many branches, which

are distributed to various organs of the body, it follows that some of its fibrils that transmit the impression from the brain downwards may go to one tissue, and some of those which transmit the external impression upwards again into other tissues widely distant, and thus a sensation in a limb transmitted along the same principal nerve, may, by means of the cerebral impression, develope a sentient action (movement) in limbs far distant from the point of irritation. This connection between the sentient actions of various parts is termed the *sympathy* of sentient actions. When the fibrilli of a nerve which transmits external impressions to the brain, to produce corresponding material ideas at the point of its origin in the brain, have experienced some injury at its origin, being compressed or stretched, for example, in such a way, that those fibrilli only have their function interrupted which transmit the cerebral impression downwards,—the consequence is, that the sentient action (as, for example, a voluntary motion), which formerly resulted from this external sensation (excited by the material idea in the brain), ceases to be excited, until the impediment is removed. Thus, it is intelligible, how a nerve may retain its sensibility and yet have lost its motor power; being sensitive and yet paralysed, as is often observed. If, on the other hand, the obstruction involves those fibrils only at the cerebral origin of the nerve which transmit the external impression to the brain, the latter will develope no material idea in the brain and no sensation in the mind; but a spontaneous conception can excite a material idea (an internal impression) at the origin of the nerve, and this may be transmitted along the fibrils, and produce actions in the body, such as a voluntary movement, for example. In other words, the same nerve may be insensible, and still the channel of the will. How could it be possible to explain these two classes of phenomena, if the existence of this difference in the fibrils of the same nerve be not admitted? It is manifest to every one, that the nervous fibrils are distinct and separated from each other at their origin. From these and other considerations, which will be stated subsequently, this doctrine of two distinct classes of nerve-fibrils existing in the same nerve, and which are appropriated to the two kinds of internal and external impressions respectively, acquires an air of truthfulness which renders it worthy of acceptance; still, in the course of this work, I shall only consider it as a mere opinion, so that what is *true*, and what is only *probable*, may be kept perfectly distinct.

Note.—Haller seems to object to this doctrine, but his objections appear to be of little importance. He observes, for example, that tubuli of two kinds in the same nerve are not to be distinguished by our senses, and all ganglia seem to be identical with each other. But on similar grounds we may deny the existence of the vital spirits themselves, as they also are invisible. Other arguments of no greater validity are also brought forward as well by Haller as by Monro.[1]

128. When a nerve is compressed by a ligature, or divided, sentient actions are no longer produced by internal impressions in the parts separated from the brain, but are observed only in those still in connection with the brain (31); but if the ligature be removed from the nerve, they are again manifested as before, provided the ligature have not destroyed the structure of the nerve. (Haller's 'Physiology,' § 367.) But if the nerve be injured by the ligature, its sensibility is destroyed (43); hence neither class of impressions can be propagated along either kind of fibril, their progress being impeded by the divided or ligatured portion of the nerve (126, 127). If the brain itself be compressed, as it often is, that portion of the body supplied with nerves from the compressed part of the brain, becomes incapable of sentient actions. The capability returns, however, so soon as the compression of the brain is taken off. When the whole brain is compressed, all animal operations caused by impressions acting on the brain, cease throughout the whole

[1] In this paragraph and elsewhere (§§ 487, 488), Unzer advances the hypothesis, as he terms it, of afferent (aufleitenden) and efferent (ableitenden), fibrils in the same nerve. His Göttingen reviewer (probably Haller) thus objects to it: "Herr Unzer considers that it is probable there are afferent and efferent nerves going to and returning from the brain; and that the objections raised against the doctrine are not of much weight. He forgets that the proof rests with himself, for neither experimental nor anatomical researches support his conjecture." Unzer replies: "Neither anatomy nor experiment *can* determine the question; for it is so microscopically minute, as to escape the cognisance of our senses. It was no part of my plan to prove the existence of the two kinds of fibrils. I meditated on certain phenomena, and found that it was absolutely impossible to explain them, except by assuming that afferent and efferent fibrils do exist. The doctrine cannot be absolutely demonstrated; it is but a hypothesis, and I treated it as such." (Physiologische Untersuchungen, p. 26.)—Ed.

body. (Haller's 'Physiology,' § 368.) The cause of this may be, that either no impression can be made in the brain, on account of the compression, consequently no conceptions can arise in the mind (121, 25) because the pressure entirely destroys the animal force and consequently the sentient force of the brain (6), and then no operations can take place in the body; or, it may be, that by pressure on individual portions of the brain, as when blood or water overflows it, or projecting points of the cranium are forced into it, only those fibrils at the origin of certain nerves, which formerly developed sentient actions in the body, have their functions arrested, so that internal impressions cannot be transmitted; in this case, the external sensations and spontaneous conceptions are unaffected, but the sentient actions resulting from them can no longer be produced. This opinion is based on the doctrines laid down in §§ 126, 127, and without this it is impossible to explain those cases in which certain limbs are paralysed by a pressure on the brain, and yet external sensations and spontaneous conceptions continue. It is impossible that this can depend upon the want of material ideas of the external sensations and other conceptions, for without these the sensations and conceptions could not exist at all (25).

129. When sentient actions are produced directly through the nerves by external sensations, it is necessary thereto:

i. That there be all that is requisite for the production of external sensations (45).

ii. That the external material sensation duly impress the origin of that individual nerve which has to propagate the impression outwards from the brain (122, 124, 126, 127).

iii. That this cerebral impression be actually transmitted along the nerve to the point where the sentient actions are to be developed (128).

iv. In those instances in which the sentient action consists in a movement of a mechanical machine to which the nerves are distributed, it is also requisite, that the mechanical machines themselves be in a condition to perform the movements which constitute the sentient action.

130. When sentient actions are produced through the nerves by conceptions of the mind, it is necessary thereto:

i. That the material idea of the conception make such an impression on the origin of the nerve, and on those fibrilli which are appropriate to the sentient action, as to be transmitted (121); in this case, the impression must be made on those fibrilli of the nerve which propagate it from the brain outwards (126, 127).

ii. That the further transmission take place, as stated in iii and iv of last paragraph.

131. When the material idea of an external sensation makes an impression on the origin of another nerve than its own, it becomes the material idea (121) of another (118), and indeed of a sensational conception; or of instincts and passions by means of the sensational stimuli of the conception (88, 90, 91); and, consequently, of analogous purer conceptions, which although induced by means of external sensations, are also spontaneously (27) developed, as stated in § 130.

132. The medulla of the nerves is naturally adapted to the external impressions of the external sensations (31); but since it is no other than cerebral medulla, the latter is also naturally adapted to external impressions. When, consequently, certain fibrilli of the cerebral medulla are touched or stimulated, they receive an external impression (just as the terminating fibrilli of the nerves), which is propagated along the fibrilli to their cerebral origin (45, ii), and there excites a material external sensation. This latter causes an impression on the brain, which either produces sentient actions directly by means of a nerve at that point, or in the way stated in last paragraph. Consequently when the cerebral medulla of living animals endowed with conceptions is irritated, an external material sensation is produced (as for example that belonging to pain), which produces sentient actions through the nerves (*e. g.*, convulsive movements from pain), in the same way as other external sensations (129, 130, 'Haller's Physiol.' § 368).

133. In proportion as the cerebral impressions, and the forces which excite them, namely, the external sensations (129), and the spontaneous mental conceptions (130) are powerful, in the same proportion the sentient actions which they excite through the nerves are vigorous (121, 26).

134. A sentient action produced directly through the nerves by an external sensation may be prevented:

i. By everything which prevents the external sensation (46, 129, i.)

ii. By this, that the material external sensation in the brain cannot so duly stimulate the origin of the sensitive nerve as to induce the propagation outwards of the impression (129, ii.). Supposing that the material external sensation makes its appropriate impression in the brain at the point of origin of another nerve, and not of that which brought it to the brain; this would be the material idea of another conception of the mind, and the sentient action which it excites through the nerve would not be similar to those produced directly by the external sensation (131). Again, supposing the external sensation only makes such an impression on the origin of the nerve, that it cannot be propagated downwards from the brain along the same nerve, no corresponding direct sentient action can be produced thereby (129, ii, iii). Further,—since external impressions do really occur which develope an external sensation in the mind (a material external sensation in the brain), and yet do not thereby excite the ordinary direct sentient actions (Haller's 'Physiology,' § 384), although the origin of the nerve actually possesses the material external sensation, which is proper to it, and which constitutes the internal impression on the origin of the nerve (121),—we could not explain why the direct sentient action of the external sensation does not take place through the same nerve, unless we assume that there are two classes of fibrils in the nerve, according to the doctrines previously stated (126, 127). The case is explained by assuming that the fibrils of the nerve which receive the cerebral impression, and transmit it downwards, are rendered incapable, in consequence of there being some of the impediments to the reception of the impression described above (127, 128). (As when a limb, for example, which the mind governs through the nerve that receives the impression, remains motionless and paralysed in spite of its external sensations, although the same sensation can excite other sentient actions in other portions of the body, *e. g.*, certain voluntary movements by means of other spontaneous conceptions, and the material ideas produced by them at the origins of other nerves—§ 128).

iii. The direct sentient action of an external sensation caused through the nerves is also prevented, when the appropriate impression received at the cerebral origin of the sensitive nerve cannot be transmitted to the point where the sentient action ought to be developed; as, for example, when the spinal cord, or the trunk or branch of a nerve, is tied, compressed, or divided below the point, or mechanical machine, to which the sensation ought to be transmitted (128, 129, iii).

iv. When the sentient action produced by a nerve consists in a movement of a mechanical machine, to which the nerve is distributed, its production is prevented when the machine is not in a condition to effect the movement organically appropriate to it (129, iv).

135. When sentient actions produced by means of the nerves, are caused by spontaneous conceptions, they may be prevented as follows:—

i. When the material idea of the conception at the origin of the nerve appropriate to the sentient action cannot so make its impression, that it may be transmitted (130, i).

ii. When the further transmission cannot take place (134, iii, iv).

136. There are various kinds of conceptions which do not usually develope sentient actions in the body through the nerves, as inferences, witty thoughts, &c.—(vide 238, 249, 330); nay, many external sensations and other conceptions which ordinarily develope sentient actions through the nerves do not do it, although the animal is in its natural condition. Consequently, just as there are material hinderances which prevent the continuous transmission of many external impressions to the brain (47—51), so similar hinderances may prevent the sentient actions of conceptions, and it is a matter of importance to know every possible hinderance of this kind.

i. Nature has so distributed the origins of the nerves in the brain, that every material idea of a conception has not necessarily relations with any of them, or if it excite one origin, it does not necessarily excite all the others at the same time, or even any one origin. Consequently, when material ideas are formed at points of the brain from whence no nerves arise, they excite no sentient action through the nerves (124). Nay, when the material ideas of external sensations, or other conceptions duly (sinnlich) impress the origin of a nerve, and excite sentient actions through it, all other origins of nerves may remain unaffected thereby, and no sentient actions result, unless under special circumstances (124).

ii. It may be, also, that many nerves are not adapted naturally, or become unadapted to the internal impressions of many conceptions (material ideas), although the change caused by the material ideas really involves their origin; and that only certain kinds of conceptions (material ideas) can affect them, just as certain external impressions only are received by the nerves (47, ii). An agreeable taste, for example, or the imagination or anticipation of it, cannot excite the sentient actions of vomiting, while an unpleasant taste, or the imagination or anticipation of it, produces that effect. Although both sensations pass along the same nerve to the same origin in the brain, and there excite a material idea, and both ideas or anticipations must develope their material ideas or impressions at the same point in the brain (124), yet, from the one kind the sentient action of vomiting results, but nothing from the other.

iii. Internal sensations and other conceptions may sometimes be so feeble, that they do not make so powerful an impression in the brain as is necessary to the production of a sentient action; and this is also the case with sensations from without (47, iii). A slight irritation of the nose, for example, by snuff, does not produce, as a stronger would, the sentient action of sneezing (80); thus it is, that the phantasies being weak in dreams, we omit many voluntary movements which we should otherwise perform, if the latter were as strong as in the waking state, or as in somnambulism. In these cases there is doubtless an impression in the brain from very feeble conceptions (25, 121), only it is not propagated along the nerves to its destined point, but is lost, as it would appear, in the way.

137. iv. The bifurcations and the ganglia of the nerves may act as impediments to the transmission of internal impressions and to the consequent production of sentient actions, just as they prevent the transmission of external impressions, and the consequent production of material external sensations (48). That this must be the case, is demonstrable from numerous facts. The acquisition of skill in the manual arts depends on a removal of these impediments. It is falsely termed *habit*, but it is really *expertness*. The frequent repetition of the same impression in the brain, acts each time on the natural hinderance at the divisions of the nerves, just as occurs in the action of two opposing forces, when that which continually repeats its

shocks must overcome the other which is totally unsupported; in like manner, the natural hinderance is destroyed, and the impression takes its uninterrupted course to the production of its sentient action.

138, v. Lastly, mechanical machines may act as impediments to the production of sentient actions, when a change in them is necessary before the impression in the brain can produce its sentient action. This is the case with the mountebank, whose gestures and postures cannot be imitated by another until his joints are stretched, his muscles practised, and even his viscera partly displaced, so that the machines can instantaneously follow the act of willing.

139. The sentient actions which are produced directly by external sensations, can also be partly enfeebled, partly prevented, in various ways, by the habit of reception of sensations (50, 51, 134, i, 54); and since the actions of sensational conceptions depend proximately upon external sensations (66), the habitual reception of external sensations may have a considerable influence on their development. But it is unnecessary to quote instances of this kind, as they are of daily occurrence.

140. The sentient actions which ideas excite through the nerves in dreaming and in insanity, partly accord with those of former external sensations (69); so also those of sensational memory (72). Those of the sensational foreseeings, expectations, and forebodings, as well as those of dreams and of mania (75) partly produce the actions of coming future external sensations (74). These actions are forcible in proportion to the strength of the conceptions exciting them (69, 74); *abstraction* of the mind can cause many actions of the understanding to cease; *attention* on the other hand can excite and maintain many. The sentient actions of pleasure or suffering are powerful in proportion to the strength of these internal sensations (80, 96). The sentient actions of a desire or aversion are composed of those of a foreseeing, of an expectation, of a pleasure or pain, and of an effort of the conceptive force; and are powerful in proportion as these are vigorous (85, 87). So, also, those of the sensational instincts and emotions (93), and of willing and not willing (96), all these sentient actions result according to general laws, partly physiological, partly psychological (111).

141. Although all operations through the nerves of impressions in the brain are *movements* (122), it is not a necessary consequence, that these movements arise in proper mechanical machines, as muscles, glands, viscera, &c., for they may occur in nerves of sensation which are not distributed to these machines (14); or may, even in motor nerves, be only movements of the vital spirits, which are not manifested by visible movements; yet they are as certainly operations of the cerebral impression acting through the nerves (sentient actions, § 123), and as certainly cause important phenomena in the animal economy (as we shall shortly see), as those which are manifested by visible movements in the animal machines. (This shows incidentally the correctness of the division, § 117).

Actions of the Material Ideas in the Nerves exclusively, and when not extended to Mechanical Machines.

142. After the general consideration of the actions of the material ideas on the nerves, we have now to investigate their special action in the nerves exclusively, without reference to their extension to the mechanical machines. Indeed all kinds of nerves are subject to this influence of the material ideas in the same way. But while internal impressions are distinctly manifested by the movements of mechanical machines, there are only slight traces of movements in the brain, in the nerves themselves, (no action in a mechanical machine following,) or in purely sensitive nerves, with which no mechanical machines are connected. They are best observed in the nerves of the external senses which simply feel.

143. Every nerve in animals endowed with sensation receives external impressions, some of which at least are transmitted onwards to the brain, where they produce, at the origin of the nerve in the brain, a material external sensation (45, 124); or, in other words, an internal or cerebral impression, which must directly excite sentient actions in the nerve itself, even if it only feels, provided it be a nerve capable of so receiving an internal impression; and it must be so capable, if the impression is to be propagated outwards from the brain (129, ii, iii.) That every nerve, whether purely sensitive, or both sensitive and motor, must possess this capability, although it may not be able to

receive and transmit both kinds of impressions (136, ii), is as certain as that the vital spirits of the external impressions pass on to the brain (18, 36), and that their laboratory is in the latter (11). Since there must be an opening at the point of origin of the nerve in the brain, at which the vital spirits must enter to pass along the sensitive nerves to their terminating fibrils, for the purpose of receiving external impressions, we conclude that this is the course which the internal or cerebral impression takes. In other words, the sensitive nerves have fibrils like the motor nerves, which transmit internal impressions from the brain to their terminating fibrils (126, 127).

144. The external sensations develope their direct actions in the sensitive nerves themselves (129, ii, 143). But all sensational perceptions (76) with their sensational stimuli (88), all sensational instincts (90), and all the passions (91), effect their sentient actions through those nerves by which external sensation is received. Now, since all these require such material ideas or impressions in the brain, as the material external sensations partly develope, and by which they are proximately determined (66, 88); it follows, that their material ideas must excite at the same time a corresponding impression at the origin of the nerve, which is propagated downwards along the nerve, and developes actions in it (123). On the other hand, the intellectual conceptions, motives, volition, and involition (which only depend remotely upon external sensations), have less influence on the sensitive than on the motor nerves.

145. By what means can the sentient actions, produced in the nerves by the cerebral impressions of all these sensational conceptions be ascertained, when their influence on the mechanical machines cannot be observed? The nerves have in themselves no visible movements; yet the impressions of the sensational conceptions can only act upon them as movements. But these escape observation quite as much as those of external impressions (31). They are probably only movements of the vital spirits in the hollow fibrilli of the nerves (13). How can the existence of these hidden movements be demonstrated? We infer their existence in the external impressions from their action on the brain, inasmuch as they produce external sensations, and because compression of the nerve, in its course to the brain, arrests or interrupts the propagation upwards of the im-

pression. We infer it to be in the motor nerves from the actions which the cerebral impressions of conceptions produce in those structures to which these nerves are distributed, and because compression of the nerve prevents the transmission of internal impressions to the mechanical machines. As to the sensitive nerves which simply feel, and manifest no visible movements from either kind of impression, we know that the cerebral impression is in them by its operations, which, although certainly taking place, are not visible.

146. The cerebral conceptional impression causes, at the origin of each nerve on which it duly acts, a movement (of the vital spirits) from above downwards towards the terminating fibrils which feel (122). It is at this, the extremest point of the nerves, that this movement is either wholly reflected, or ceases (126); for from that point the external impression causes an opposite movement towards the brain. Further observation may enable us to determine something as to this change, as for example, when a strong sensational conception acts on the nerve with unusual vigour.

147. When the terminations of the nerves are carefully observed in powerful sensational foreseeings, particularly in the instincts or passions, it is obvious that they are erected, and become more prominent. Thus the papillæ of the tongue, in which the gustatory nerves terminate, are visibly elevated when the expectation or desire to taste a piece of sugar or salt is excited by bringing it near to the tongue. So also the nerve-points in the fingers are evidently elevated, when one attempts to feel something more distinctly, which is the foreseeing in a desire. "The sensitive points of the fingers," Haller remarks, "are slightly elevated during an act of attention (an expectation), just as we see in rigors, in the nipple of the mamma, and in a portion of bowel hanging out of the abdomen." ('Phys.,' § 431.) Probably shivering ought to be classed with the sentient actions produced through the nerves in the mechanical machines. That the sensitive points in the nipple are elevated by the expectation of an act of suckling, or simply by titillation, is quite certain. With regard to the senses of feeling and taste many similar observations have been made, but not with regard to the other senses. This erection of the nerve-points is therefore a true sentient action.

148. Erection of the nerve-points is a movement, or change, which, when strong enough, may become an external impression (31), and on arriving at the brain, may excite a conception similar to external sensations; but having no true material impression as its basis, has consequently no real external circumstance. In this way, remarkably powerful impressions in the brain (from very vigorous conceptions) may produce an external impression on the nerves to which they have reference, as if it came from a real thing without; this reaching the brain will excite the analogue to a real external sensation, and sometimes contains so much of the real, that the mind can only distinguish, by great attention, this class of sensations and their concomitant conceptions, from those which have a true external origin. To distinguish these sensations from the latter class, we shall term them *imperfect external sensations*. Hitherto they have been confounded with very vivid imaginations; but their extraordinary distinctness shows that they differ from these, inasmuch as often they are in no respect dissimilar from true external sensations. They are necessarily, however, the results only of very powerful impressions in the brain of other conceptions, as shown above; consequently, they can be the actions of a too-active imaginative faculty, and may, therefore, accompany insanity, drunkenness, impressive dreams, strong forebodings, and very strong and violent passions. These imperfect external sensations are known as *appearances, apparitions, delusions, spectres, ghosts*, &c., and it is of not less importance to pathology and practical medicine than to the present subject, that these be traced to their origin, and distinguished from the feeble images of imaginations and foreseeings. If a vigorous effort be made to see with the eyelids closed, a red colour is seen: if the fear of a sudden fall from a height excites the nerves of vision to give a false impression of surrounding objects, they seem to move, or vertigo occurs: a loud stunning noise is heard long after it has ceased, but with decreasing indistinctness: if food be desired with great longing, its taste is perceived beforehand: if a delightful sensation be anticipated earnestly, the nerves become so sensitive, that every slight impression causes it, although previously they would have had no effect. All these are instances of imperfect sensations of this kind, which happen to the most

healthy persons. Consequently, they are not peculiar to an unnatural condition of animal bodies, but occur in the natural.

149. It will be worth the while to consider more closely the origin of imperfect external sensations. A strongly sensational conception makes a forcible impression in the brain, at the point of origin of a certain nerve (144, 26). This is propagated along the nerve to its terminating fibrils, which are thereby stimulated and erected (147). This action imparts an external impression to the fibrils, just as if they had been acted upon from without, which is returned to the brain, and becomes an imperfect external sensation (148). But inasmuch as the real external circumstance is wanting, the question arises, what is really felt imperfectly? The answer is as follows: The sensational conception from which the whole delusion arises, possesses the sub-impressions (merkmale) of a past or future external sensation (66), and their material ideas also partly excite, at the origin of the nerve which they impress, the corresponding material external sensation. This, which is a *movement* at the cerebral origin of the nerve (43), and is now, in fact, its impression (121), is transmitted downwards to the terminal fibrils, and there makes the baseless external impression, which is returned to the brain, to the same point of the nerve whence it came. The imperfect material external sensation thus excited is a movement at the origin of the nerve, which is partly the same as would have originated if the actual external thing, of which the sensational conception contains sub-impressions, had made an external impression on the terminal fibrils, and which is only defective in that which the external impression alone can supply, to render it a true external sensation. Now, since a true external impression takes place, although without the impression of a real external object, the imperfect external sensation is thereby rendered more similar and equal to a true external sensation, than it previously was by the sensational conception alone. Further, the apparent object of the imperfect external sensation is always the object of that external past or future sensation, which was already the basis of the conception that constitutes the first element of the delusion. Consequently, the maniac, the drunkard, the dreamer, the soothsayer, the enamoured, the scorner, &c., each according to their delusion, feel what their imaginations, foreseeings,

expectations, forebodings, instincts, and emotions bring into the mind.

150. When the nerves which feel these imperfect sensations are distributed to mechanical machines, they excite the same movements, as if the sensation had been real. But these imperfect sensations must not be confounded with others arising from circumstances external to the *nerves*, although not external to the *organs* of the senses; as for example, when sparks are seen in inflammation of the eye, or singing and humming in inflammation or diseases of the cavity of the ear. These are true external sensations, connected with an erroneous judgment. The nerves of the eye and ear are really impressed by something external to them, but it is within the organ of hearing or of vision itself, and the mind judges falsely, that the sensations arise from objects which have customarily excited them; as, for example, that sparks of fire are seen, that bells are heard ringing, water rushing, &c. (*Vide* § 378.)

151. Since cerebral impressions excite movements at the terminations of the nerves, where their course is obstructed or reflected (147), it is highly probable, that very vivid sensational impressions are also deflected in their course from the brain downwards to the periphery, either at the bifurcations of the nerves, or in the ganglia, especially where nerves are given off to other parts, or to surround the arteries, and excite such gentle movements, as may have an influence on the contiguous mechanical machines.

CHAPTER III.

ON THE INFLUENCE OF THE ANIMAL-SENTIENT FORCES IN THE MECHANISM OF ANIMAL ORGANISMS.

152. In the foregoing chapter, we have treated of the animal-sentient forces abstractedly, without reference to their influence in the mechanical machines of the body. We must now bring this influence under notice (8), as being the second class of actions, which the material ideas excite in the animal economy (16, 113). According to § 117, we have to inquire into:

i. The direct actions of the material ideas, which they alone perform in the mechanical machines of the brain, without the aid of the nerves (153—159).

ii. The indirect actions of the material ideas through the nerves in the mechanical machines generally (344), and specially the material ideas of all the various kinds of conceptions.

Actions of Material Ideas in the Mechanical Machines of the Brain.

153. The mechanical machines of animal organisms are capable of many kinds of movement, in virtue of their structure; but they are put in motion much more by animal than physical and mechanical forces. Since the animal forces are not regulated in their operation according to physical or mechanical laws (7), we cannot bring them into the same category; and as their laws are unknown, we can only infer their actions in the animal machines from observation.

154. The influence of the soul on the body is exercised by means of the material ideas, or the impressions of their conceptions in the brain (25, 121), and all the movements of mechanical machines which are actually effected through these, are sentient actions (97). All sentient actions in the mechanical machines are excited either directly, by the material ideas developed in the brain itself, or indirectly, by means of

the nerves along which conceptional or internal impressions are transmitted from the brain.

155. To understand this matter rightly, the meaning of the term *mechanical machines* used in this whole treatise, must be properly comprehended; it must be understood to include all the organs of the body, except the brain and nerves, which are *proper animal machines*. Consequently muscles, tendons, membranes, vessels, glands, bones, cartilages, viscera, &c., are all mechanical machines. Although many of these are endowed with animal moving forces, they are so endowed, only through, and in virtue of, the nerves with which they are supplied. So also the organs of the external senses, although endowed with sensitive nerves, are only mechanical machines, and even the brain and nerves contain the latter.

156. There are no other mechanical machines in direct connection with the brain, than certain glands, the meninges, and the circulating and lymphatic vessels. Consequently, these are the only machines, in which material ideas can develope sentient actions directly in the brain itself, without the aid of the nerves.

157. The uses of the glands situate on the membranes of the brain, and in close proximity to it, are altogether unknown; but they probably constitute a part of its mechanical structure.

158. The membranes enclosing the brain, and partly the nerves, belong to the same class (the mechanical) as tendons, ligaments, &c. They are not only insensible, but the brain itself seems to have no influence on them, except in communicating the mechanical movement (24) which it possesses itself.

159. The tubes, and especially the vascular system, remain only to be noticed among the mechanical machines which are in connection with the brain, and in these, material ideas can develope true sentient actions. The cortical substance is almost wholly a tissue of tubes; it is not the organ of the conceptive faculty, nor the seat of the animal-sentient forces, but the organ for secreting the vital spirits, which it supplies to the medulla of the brain, and thence to the entire system of animal machines (the nervous system) (11); in this respect it can be considered as a viscus of the head, whose proper function is the secretion of certain fluids from the blood; which fluids constitute, however, an essential part of the animal machines (9); it is, therefore, really a mechanical machine (155), but in virtue

of its function to give existence to the animal forces, it differs as little from the proper animal machines, and as necessarily belongs to them, as the roots of a tree to the tree itself (9, 11). This mechanical machine is unique, for while it belongs to the animal machines, it secretes the vital spirits from the blood in its infinitely numerous minute canals, just as other secreting organs secrete other fluids in their minute tubuli. Secretion generally, as physiology teaches us, takes place according to physical laws, rather than animal. But, nevertheless, since the fluids entering the tubuli act as stimuli, and excite them to the performance of their natural functions, as will be shown subsequently (168, 172, 460), the natural function of the cortical substance of the brain must be considered as animal; only its functions do not belong to the proper sentient actions, however necessary and indispensable to them; for, although requisite to the production of material ideas in the cerebral medulla, it is not a direct result of these, nor is it in itself a material idea, since the secretion of the vital spirits is not directly caused by conceptions (25, 97). Nevertheless, the cortical substance can be influenced *indirectly* by sentient actions, as when conceptions, desires, &c., influence the heart and the circulation; and thus, either by increasing or diminishing the amount of blood sent to the brain, increases or diminishes the secretion of vital spirits; which phenomena are rather the *results*, however, of sentient actions, than sentient actions themselves. It is probable, although not established, that the material ideas in the medullary substance exercise, as sentient actions, a direct influence on the vessels of the brain. The brain receives at each stroke of the left ventricle at least a sixth part of the whole mass of blood, and this is distributed through every part of the brain, by means of the almost infinitely numerous capillaries which enter into its substance (Haller), so that the smallest movement in the brain would act almost necessarily on these minute vessels. The vessels which return the blood to the heart, the source of vital movements (Lebensbewegungen), are equally numerous. It is, therefore, probable, that the material ideas in the brain, however hidden they may be from observation (28), have some influence on the vital movements, independently of the nerves, and that this may be one of the causes, why so many conceptions, but especially painful sensations in the brain (headache), change the circulation of the blood, and sometimes distend, sometimes empty, the vessels of the head, and render the colour of the face so variable. All this it is true is conjecture, but it is probable; we cannot decide the question, for proper observations as to the mode are impossible. We see, indeed, that some species of conceptions regularly and powerfully modify the vital movements, and especially the circulation within the head; but still since this may probably take place through the nerves distributed to the heart (for the impressions of such conceptions influence its movements by means of its nerves), it remains undetermined whether the direct action on the cerebral capillaries of the cerebral impression has a share in these sentient actions, and to what extent.

Actions of the Material Ideas in the Mechanical Machines through the Nerves.

160. The most common and most general mode of connection between the nerves and mechanical machines is the ramification and subdivision of the former in the latter, until they become imperceptible (13). Another is, however, possible: the nerves come in their course into contact with various mechanical machines, without being specially distributed to or lost in them. As the cerebral impression on the nerve produces no visible or observable movement at the point of impression, so neither in traversing the nerve does it excite any action in the parts with which in its direct course it comes into contact. But as it is probable, that its deflection at the points where it is turned from its direct course, is caused by a vivid cerebral impression (151); it is probable, also, in such a case it may communicate some movement to the mechanical machines it comes into contact with at such points, and this may be termed a sentient action (97). This conjecture is very probable as to the loops of nerves, which wind round numerous blood-vessels, and enclose them, certainly not without an object. Probably, many vivid cerebral impressions slightly compress the vessels by this means, and so retard the circulation, as Haller has supposed, who by this hypothesis has explained the redness of the face in blushing. ('Opera Minora,' tom. i, p. 513.) Subsequently, however, this distinguished man discarded the

hypothesis, and other learned persons have rejected it entirely, on the ground that although impressions, whether external or internal, may excite convulsions in muscles, they excite no perceptible movement in the nerves. Nevertheless, as the cerebral impression undoubtedly excites movement in the terminal points of the nerves (147), this may be possible and probable, wherever else it is deflected from its direct course (151). Further proofs on this point will be given subsequently (178).

161. Amongst the mechanical machines, in which the nerves are so distributed as to be completely incorporated with them, the muscles hold the first place. Nerves penetrate all muscles, being distributed together with the blood-vessels through the cellular tissue, losing, however, their firm coat, and becoming soft, before they become so minute as to be no longer traceable ('Haller's Physiol.,' § 398). It may be also asserted, that the soft medulla of the nerve is lost in the muscular fibrils, and incorporated with their substance ('Monro de Nervis,' § 22). When a muscle is thrown into contraction by an impulse sent along the nerve, its fibrils are contracted, and the two ends are drawn together, so that the whole muscle is shortened; consequently, it also draws the parts together to which, by means of its tendons, it is attached. The latter are passive, and are neither contractile, nor capable of receiving an impression. The muscle may be moved either wholly or partly. The arteries which are distributed to muscles are necessary to their completeness, so that without them they soon become unfit for their functions, or diseased (129, iv); but the animal actions themselves do not immediately cease when the influence of the blood ceases ('Monro de Nervis,' § 44), and are in no wise produced by it (Haller's 'Physiol.,' § 406).

162. This action of the nerves on the muscles cannot be explained by any of the laws of mechanical motion (Haller's 'Physiol.,' §§ 394, 412.) It is also manifest from all phenomena, that the vibrations transmitted along the nerves, and communicated to the muscles, do not produce the movements of the latter in any mechanical way (Ibid., §§ 376, 377); and as all other methods of explaining mechanically these movements are insufficient, we must turn to other moving forces. The movement in the muscle which it receives from the nerves, only takes place after an impression made on the nerve,—it may be

an external impression transmitted to the brain, or one which does not reach the brain (34, 47), or a cerebral impression from conceptions, or not, or an internal impression in the medulla of the nerve itself in its course (121). An irritation of the nerve of a muscle (an external impression) produces movement in the muscle it supplies; it does this also when the animal is decapitated, or with its nerves tied and rendered insensible, nay, even in the separated muscle itself (Haller's 'Physiol.,' §§ 404, 409, 575.) If the medulla of a nerve be irritated, the muscle or muscles to which it is distributed, are convulsively contracted; and this so long as the animal lives, or even after death, so long as it is moist. It is not at all necessary that the nerve be entire, since if it be divided and then irritated, contractions are equally excited. If a nerve be compressed, or tied, the muscles to which it is distributed are paralysed, and although the will endeavours to act on them, they remain motionless. But if the ligature, or compression, be relaxed, the muscles regain the power of movement, provided the nerve be uninjured. If the crura cerebri be irritated deeply in their substance, the most violent convulsive movements are excited in the whole body; the same occurs when the spinal cord is irritated. If the brain be compressed, that portion of the body is deprived of motion, the nerves of which arise from the compressed portion: in injuries of the spinal cord it is more distinctly manifest, that convulsions or paralyses are induced in that part of the body supplied with nerves from the injured portion. When the spinal cord is injured in the neck, death follows immediately, because the nerves of the heart arise from this portion (Haller's 'Physiol.,' §§ 367, 368). An impression on a motor nerve, of whatever kind it may be, developes the movements proper to the muscle with which it is incorporated in a way quite incomprehensible. It is a movement caused by an animal force (7), and in so far as it is produced by the impressions of conceptions in the brain, it is a sentient action (97). No other movement of a muscle is such, whether it be from mechanical or physical forces, or even from impressions (except those of conceptions), although in the latter case they are animal (6, 7). On the other hand, the volitional movements must not be considered as the only sentient actions, —as is carelessly taught in many elementary treatises, causing numerous errors, — since there are also those which arise from spontaneous conceptions and from external sensations (97, 98, 351). It is, consequently, equally incorrect to say, that the functions of certain muscles, as the heart, intestinal canal, &c., do not depend on the mind, because the mind has no control over them, for the external sensations, imaginations, instincts, and passions equally change, increase, or diminish them, although the mind exercises at the same time no *volitional* influence.

Note.—Haller seems to be of the opinion, that no movements except the voluntary are produced by the soul, "Æternâ lege separatur voluntatis imperium ab irritabilitatis provinciâ" ('Elem. Phys.,' tom. iv, p. 528). He recognises, nevertheless, the action of the imaginations, sensations, instincts, and emotions, and proves somewhat unnecessarily that they are not volitional movements (ibid., p. 525). It necessarily follows that the sensational conceptions, desires, instincts, &c., are not mental, but corporeal, as Haller, in his 'Physiology,' § 564, and other places in his writings, seems to maintain. But no sound metaphysician can grant such a confusion of ideas, as we shall subsequently show it to be (579, iii).

163. All muscular actions are *animal* actions, in so far as they are excited by the nerves; they are only *sentient* when excited by conceptional impressions in the brain. We may enumerate walking, standing, sitting, flexion and extension of the limbs, respiration and its modifications, as speaking, laughing, singing, wailing, sighing, coughing, sneezing, deglutition, digestion in the stomach and intestines, the action of the heart, and the circulation in connection with cardiac action, as *animal* functions, which may be sentient (167). On the other hand every action of a muscle, which takes place in virtue of its physical contraction, or of physical or mechanical moving forces, or by the influence of the vessels, or through its membranes or tendons, or other impressions than the appropriate ones, is neither animal nor sentient (162).

164, i. When a muscular movement, or an action resulting therefrom, is a sentient action, a special impression on the cerebral origin of the nerve that controls the muscle is necessary thereto (123, 124), and which is propagated downwards through special fibrils of the nerve to the muscle into which it arrives, together with the nerve, and excites it to that action, of which, in virtue of its structure, it is capable.

ii. The same nerve, can at the same time in which it excites the muscle into action, receive an external impression, and transmit it to the brain, there to excite external sensations, without the two impressions as they pass in opposite directions, interrupting each other in their course (126).

iii. When a nerve is compressed, or divided, in its course between the brain and the muscle to which it is distributed, the latter cannot be excited into action by cerebral impressions until the compression is taken off (128. Haller's 'Physiology,' §§ 403, 367).

iv. If the brain be compressed, all sentient actions in the muscles cease, and all actions dependent on them (128). If only a portion of the brain be compressed, then the actions cease in those muscles which receive their nerves from the compressed portion, inasmuch as they can no longer receive conceptional impressions.

v. A general irritation of the brain, or such an irritation that the origin of all the motor nerves is implicated, must excite disorder of the whole, or of the greater part of the muscular system (128. Haller's 'Physiology,' §§ 367-8, 568).

165, i. If a muscle be directly excited into action by external sensations, the nerve which perceived the latter must move it (129, 131), although the movement may take place through other and far distant branches (127). This is the *sympathy* of sentient actions in the muscles. Direct sentient actions of this kind frequently take place, as for example, if by a powerful injury the muscles are excited to spasmodic action, or cramps, other sympathising muscles are frequently excited into similar movements.

ii. When the medulla of the brain is irritated, violent movements may be excited in the muscles by the pain (132, Haller's 'Physiology,' § 308), which are sentient actions, and are produced in the same way as those resulting from external sensations (132).

iii. When the mind, by means of spontaneous conceptions, moves the muscles and other parts through them, the conceptions must act on the cerebral origin of the nerves which regulate the muscles (130). All kinds of imaginations and foreseeings, also imperfect external sensations (148), internal sensations, pleasure or pain, desires, aversions, instincts, emotions, and ideas of the understanding, in so far as they are mixed up with sensational conceptions, or are pleasing or painful (330, &c.), and the desires and aversions of the will, have a manifold influence on some muscles, as experience teaches, and the domain of the animal-sentient forces is consequently very general in the muscular system.

iv. The more energetic the impressions of all these conceptions are, the more energetic are the movements which they can produce in the muscles (133).

v. When these movements are caused by conceptions wholly spontaneous, as for example, by volitions, the principle of their sequence must be sought for in the laws of the conceptive faculty (110). On the other hand, the muscular actions produced by sensational conceptions are known to us, partly through the sequence of external sensations and their external impressions.

vi. The sentient actions of the muscular system may be prevented in the same modes as all other sentient actions excited through the nerves (136—139).

166. The muscular action excited by animal-sentient forces, represents the thoughts as it were by external delineations, especially in the face, by which their existence may be discovered; and by a frequent repetition of these movements, in consequence of vivid and oft-repeated conceptions, certain marks are necessarily traced in the skin covering and surrounding the muscles. Hence arises the art of discovering the modes of thought, and the predominant mental characteristics of men, from the lineaments of the face, termed *Physiognomy*.

167. The nerves may have an influence on the blood-vessels, on the secretions, and on the whole circulation, in various ways. In the first place, through *the heart*, a compound hollow muscle, throughout which nerves from various sources are distributed as in other muscles (161). These nerves, like all others, can receive external impressions, since an animal feels when the heart is pricked or irritated (32). They consequently transmit external impressions in such cases to the brain, and produce therein at their origin external sensations (34, 25), or cerebral impressions (129). When there is no impediment, these

are propagated downwards along the same nerve (129, 131), and, consequently, may not only have an influence on the movements of the heart (7), but may excite sentient actions (97). In the same way, the sensational conceptions, desires, and aversions, sometimes excite cardiac movements, which are sentient actions produced through the nerves by various material external sensations (66, 93): examples of this kind are numerous, as when ideas, foreseeings, and emotions change the movements. It is acknowledged by the most eminent physiologists, that the action of the heart generally is not mechanical, but animal; yet that it is absolutely a sentient action is undoubtedly erroneous, since it will continue and be re-excited even after the heart has been removed from the body (164, iii). Neither is it any proof thereof, that an external impression on the terminal fibrils renews the movements of the heart, since the action of that impression becomes sentient only after reaching the brain, and not before (98, 162). If it be asked, whether the motion of the heart is not sometimes changed by numerous impressions made on the origin of its nerves in the brain, and consequently that many a change in its motion may be a sentient action (97)?—I answer, —this by no means proves the contrary, for no change in the heart's movement is subject to the will (162, 163). It is much more indisputable, that such a change is a sentient action, when an external sensation or another spontaneous conception excites the change. Now the mind actually feels many external impressions on the nerves of the heart. It feels its palpitation, or wounds and other irritants; and violent actions result from these, which are necessarily direct sentient actions of its external sensations (129). That its nerves do not respond to all stimuli, is a peculiarity they have in common with all other nerves. Further, it is indisputable, that although the will has no power over the heart, still many sensational conceptions have, and particularly the instincts and emotions; and it is clear from this, that many changes in the heart's action are true sentient actions, in so far as they are produced by conceptions by means of their cerebral impressions (97, 163). Lastly, although the movement of the heart is neither weakened nor ceases, when the brain is compressed, or the nerves tied, nothing more can be inferred therefrom, than that the entire movement is not generally a sentient action, which is indeed the fact; but rather that the undoubted animal force, which continually produces it, is not derived from the brain, and has its seat in other animal machines (the nerves) and forces (the purely animal, §7), which will be treated of subsequently in the Second Part (448, 514). But in so far as the heart is capable of certain sentient actions excited through the brain, no one would deny that they must cease, when the brain, or the origins of the nerves, are compressed, or the nerves tied, or divided in some part of their course. In such a case, the external sensation from the strongest irritant applied to the heart, or any emotion, would fail to excite its action (164, i, iii, iv).

168. The nerves have another influence; namely, on the vascular system generally, since they are incorporated with the coats of the arteries, and thereby probably supply animal force to the muscular fibres which they surround. This influence of the nerves on the blood-vessels is very obscure, and they scarcely appear to effect a sentient action, for, in the experiments which have been instituted, the arteries have never once shown any sensibility (Haller's 'Physiology,' § 32). Nevertheless, Haller asks whether it is not probable, that the arteries derive from these nerves the power of contracting?—Compare what has been already stated (160) and subsequent statements (178.)

169. A third kind of influence possessed by the nerves, is on the vessels distributed to the muscles. It almost necessarily follows, that the numerous blood-vessels distributed in them are affected by the contractions excited by the nerves. Consequently, the latter indirectly favour the circulation of the blood in the veins, and agitate and mix that in the arteries, thereby favouring its course towards the lungs. They regulate the secretions of the liver, mesentery, &c., and diminish or retard them; they urge on the blood, and the large muscles of the abdomen impel the blood contained in that cavity towards the heart (Haller's 'Physiology,' § 416). Many of these acts are sentient, nay, are even volitional (165); and if to all these actions of the nerves on the blood-vessels and the circulation, the direct action of the brain on its multitudinous capillaries be added (159), it is clear that this apparently simple mechanical motion of the heart is much under the important

influence of the mind, and the still more important influence of the nerves.—(Compare § 207.)

170. The nerves act principally in the other canals which have a muscular structure, and numerous nerves, as the *œsophagus, intestinal canal*, &c., by the stimulus of muscular motion, so that these tubes are put in motion by the nerves for the performance of those acts, of which their structure renders them capable. When no natural obstacle is present in the nerves (47, &c.) to prevent the transit of the external impressions to the brain, and they are really sensitive (34), they may be stimulated to action by the cerebral impression of external sensations, and then the action is sentient (97, 129, 131), although their actions are not usually sentient, but nervine (162, 163). The œsophagus and intestines are often really sensitive, and are then affected with spasms, as is proved by colic, which has its seat in the intestines. Now, since in these cases, the spasms are true sentient actions from external sensations (from pain), these tubes do actually manifest some sentient actions; although, in other cases, they are excited wholly by other animal forces, and, although the will has no power over them (162, 163). Nay, since the other sensational conceptions, imaginations, foreseeings, &c., and the sensational desires and aversions, can partly re-excite the material external sensations, of which the sensitive nerves are susceptible at their origin (66, &c., 93), so in like manner, they can excite movements in these muscular tubes which are sentient actions; as, for example, when retching is excited by the anticipation of a nauseous taste, and when the bowels are acted on by the imagination of a purgative being taken.

171. The *membranes* of the human body differ very much in structure,—glandular, cellular, vascular, &c.; the latter will be treated of subsequently (208). The muscular membranes, as the diaphragm and others which enclose different parts of the body, particularly certain glands, are also sensitive, as we learn from observation; the diaphragm, in particular, has large nerves which influence its movements by means of external impressions, and the ligature of which causes the movements to cease (Haller's 'Physiology,' § 403). Further, the motion of the diaphragm is subject to the will, inasmuch as we can change the respiration at pleasure. The remarks previously

made (161—168) as to the action of the nerves on the muscles and blood-vessels, are equally applicable to these flat muscles and muscular membranes.

172. The *glands* are a tissue of vessels and nerves, and their function is to separate the secretions from the blood. The nerves exercise the same influence on these as on other vessels, and, consequently, secretion, which ordinarily appears to be simply physical, is not only animal, but is also sometimes a sentient action. The nerves have the most manifest influence on those glands which are surrounded by muscular tissue, or so placed between muscles that the latter, by their action, express the fluid from the glands when secreted; so that it is poured out. Examples of this kind are the penis [Geilen], the urinary bladder, the bowels, the stomach; also the parotid glands, which are emptied by the action of the muscles of mastication (Haller's 'Physiology,' § 233.) Many glands pour out their secretions from external sensations (titillation—pain, 80); many from imaginations, sensational anticipations, desires, &c., as, for example, the salivary glands from the recollection or expectation of an agreeable taste, or in hunger; many from passions, as the lachrymal and sexual glands; many even from acts of will, as when the saliva is stimulated to flow by voluntary mastication, or weeping is feigned.

173. The action of the nerves in the viscera is very complex, varying with the number of the nerves distributed, or with the various impressions of which the latter are susceptible (34, 47, 121); or, as they are influenced by the muscles, muscular tissues, glands, &c., which surround, or are in relation to them; or, as the nerves act directly or by sympathy (127, 165). We can only notice some of the most important.

174. The *stomach* has many and considerable nerves, and remarkable sensibility. When the trunk of these nerves (the eighth pair) is tied, the powers of digestion fail. Its nerves are susceptible of special external impressions, so that acrid substances which are not distinguishable by the tongue excite the stomach. On the contrary, other things which the tongue perceives most sensibly, cause not only no distinct sensation, but no sensation at all, although it is manifest from the movements which they sometimes excite, that they must cause another external impression, which is not felt, because, probably,

there are natural obstacles that prevent the transmission of the impression to the brain (47); of these we shall treat in the second part (428, 429). In virtue of its sensibility, the stomach is susceptible of impressions from conceptions in the brain (98), which are sentient actions, as, for example, a violent pain causes spasms of the stomach. The observations made with reference to the action of the sensational conceptions and desires on the œsophagus and intestinal canal, are equally applicable to the stomach (170); they induce sentient actions, as, for example, when by an imagination or anticipation of a loathing, its action is inverted, and vomiting is excited; or, when it is excited to motion by hunger; or is thrown into spasmodic action by violent emotions. The will has little influence over it; but the connection between disorders of the mind and the nervous system, and disorder of the digestive powers of the stomach and bowels, is well known.

175. Although the sensibility of the *liver* is not great, and, consequently, only few external impressions made on its nerves reach the brain, still it is capable of sentient actions. They are observable only in the most vivid external sensations and sensational conceptions, as, for example, in the pain of inflammation, or in rage, fury, &c., inasmuch as it can be inferred from the bilious disorders which follow, as icterus, &c., that the secretion of bile must be prevented or increased. The nerves can also exercise an indirect influence on the liver through the diaphragm, and the abdominal muscles, and the other organs in relation with it, and the results are also sentient actions.

176. The *kidneys* have but few nerves, and are only affected by powerful external impressions and sensations, as when there is a stone or inflammation present; in which cases only, certain sentient actions occur, as spasms. The external impressions made by the urine, and which excite vivid external sensations in the nerves of the tongue, the nose, and even the skin itself, are either not made at all on the renal nerves, or a natural obstacle (47, &c.) prevents their transmission to the brain. The urinary bladder, on the other hand, is much more sensitive. Vivid external sensations (pain) cause spasms and spasmodic discharge of urine, which are sentient actions. The sensational conceptions and foreseeings act upon it, whence persons are often induced to pass urine in dreams. The will has also some influence upon it through the sphincters.

177. The organs of the *external senses*, considered as mechanical machines only (155) are subject to the same laws as others. Through external sensations, sensational conceptions, instincts, emotions, and even through the will, the nerves cause movement in the tongue, the nose, the ears, the eyes—even the skin in which are placed the nerves of touch, is contracted by many external sensations (as cold); all which movements are true sentient actions.

178. The *sexual organs of man*, and especially the testes and penis, are supplied with numerous and large nerves, which are extremely sensitive. The sensibility of the testes is so great, that syncope and convulsions are induced by injuries to them, and locked jaw, in particular, from the sympathy of their sentient actions. The sensitive nerves of the penis, which every impression excites, afford a remarkable example of the action of conceptional impressions on the vessels through the nervous loops around them, and independently of muscular action, of which mention has been already made (160), for the tumefaction of the corpora spongiosa must be caused by a retention of the blood in the vessels; which can only be explained by the theory that the nerves induce the vessels to contract. in fact, this tumefaction is excited by every kind of external impression on these nerves, especially by external sensations, as when urine irritates the bladder; semen the seminal ducts; the venereal poison, and spanish flies the urethra,—which is very sensitive; and other causes, as flogging, and friction of the glans penis. In like manner, it is caused by imaginations, foreseeings, sensational desires, instincts, and emotions, as is well known, and altogether independently of the will. Haller maintains the doctrine, that this swelling takes place without the assistance of the muscles, and solely by the blood-vessels, finding analogous instances in the erection of the nipples in sucking, the distension of the wattle of the turkey, and of the organs of generation in lower animals ('Physiology,' § 840), all which are sentient actions. (Compare § 274.)

179. The numerous nerves distributed to the *female organs of generation*, render them extremely sensitive, and the remarks in the preceding section are equally applicable to them (274).

180. It is the most important mechanical machines of animal

bodies, that are susceptible of the sentient actions just described, in virtue of their nerves. We will now consider, in what mechanical machines, and by what laws, the different conceptive forces of the soul manifest their actions externally to the brain, in animal bodies, and in what these consist. We will begin with the sensational perception and desires (76, 89), and afterwards consider those of the intellect.

The Actions of External Sensations through the Nerves in the Mechanical Machines.

181. It is not so easy a task as it appears, to discover the direct sentient actions of external sensations in the mechanical machines. All those produced by an irritation of a nerve, or by the external impression transmitted along the nerve, or even by its propagation to the brain, or deflection thence, are its *animal* actions; but none is a *sentient* action of an external sensation (98), unless it belong to the class caused in the mechanical machines by an external sensation, or by the material cerebral sensation acting as an impression in the brain (121, 97). All movements, consequently, in the mechanical machines, which the external impression excites by its own proper animal forces, before it has formed external sensations in the brain, and all that it produces in other nerves and mechanical machines in its course to the brain, in virtue of the motive force peculiar to itself, cannot be considered as the sentient actions of external sensations, even although they be also developed by the external sensations of the external impressions. All the sentient actions produced in the mechanical machines through the nerves only, of imaginations, foreseeings, sensational instincts, emotions, intellectual conceptions, or desires and aversions of the will, excited in the mind by external sensations, are not true direct sentient actions of the external sensations, although all the material ideas of the conceptions produced by the latter are their indirect sentient actions (97, 98).

182. Hitherto, these actions (altogether distinct) have been indiscriminately considered as direct sentient actions of external sensations, and so the physiological doctrines of external sensations have been sadly confused. It is, consequently, of im-

portance, that we make this distinction as clear as possible; and to this end, we must assume,—what will be demonstrated in another part of this book for the first time, namely,—that the external impressions on the nerves (nerve-feeling, § 32), becomes itself an animal motive force, before it reaches the brain, and develops external sensations therein. The most certain answer to the question, whether a movement, excited in a mechanical machine by the external irritation of a nerve, be simply an action of the external impression (feeling), or whether it result from an external sensation, is found in the experiment of repeating the irritation, of which the movement is the result, *after* the nerve is cut off from connection with the brain; or, for greater security against sympathetic action, after the head of the animal has been separated entirely from the body. So long as traces of animal life remain after this separation, the same movement results from irritation of the nerve, although the external impression is no longer propagated to the brain, and no longer able to excite a material sensation therein; consequently, the movement cannot be a sentient action caused by the external sensation, but is an animal action produced by the motive force peculiar to the external impression. When after this demonstration, the apparently sentient actions of external sensations in the animal machines are investigated, it is found, that the animal motive force of unfelt external impressions can produce, although somewhat less perfectly, the greater number of these movements, which we consider as being solely sentient actions resulting from external sensations, and which are in fact sentient actions also, as will be shown in the second division of the work.

183. The movements developed in organisms by the peculiar animal moving force of the nervous system, not being at the same time an animal-sentient force (6), are termed *nerve-actions*, to distinguish them from sentient actions; consequently, the movements excited in organisms by the motive force of an unfelt external impression, are nerve-actions. The majority of the sentient actions in mechanical machines of external sensations are, therefore, at the same time, nerve-actions (182); and the following propositions must be rejected as erroneous. 1, That an animal movement in the mechanical machines, which is a sentient action of external sensations, is

never a nerve-action; 2, that the movement, which is a nerve-action, is never a sentient action of external sensations; for there is nothing more certain than that a sentient action resulting from external sensations may be at the same time a nerve-action, and *vice versâ*. On the other hand, there may be nerve-actions in the mechanical machines, which are not, at the same time sentient actions, nor resulting from external sensations, because the external impression is prevented developing a material sensation by a natural or other obstacle (47, 48, 199). Thus, the movement of the heart is usually a nerve-action only, and seldom a sentient action (167), for we but rarely feel the external impression which excites the movement, although we often feel the stroke itself, which is the nerve-action.—(Compare § 225.) It is not necessary to inquire here, whether there be sentient actions in the mechanical machines from external sensations which are not also nerve-actions.

184, i. When an external impression on the nerves is not felt, then the movement which it causes in the machines is not a sentient action from an external sensation. If, however, the movement itself be felt, and this acts as an external sensation in exciting new movements, the latter are sentient actions from the external sensation produced by a nerve-action (183, 443).

ii. It is not manifest what influence is exercised by feeling, or the consciousness of an impression in the production of sentient actions which can also be simply nerve-actions, more than by the external impression itself; unless it be that the actions are rendered more complete and regular when the two co-operate. Generally, however, the feeling or consciousness of the external impression seems to have no other object than to excite other conceptions in the mind, and other sentient actions, so that its operation is extended evidently through the organism generally, and becomes of compound utility. For example, if the movement of the stomach when empty from fasting, remain such as it really is,—a nerve-action,—and be not a sentient action at the same time, the desire cannot be excited which we term hunger, and the organism is neglected. If a violent spasm of a muscle were a nerve-action only, and not also a sentient action from pain, the functions of the muscle might be destroyed without our taking any steps to prevent it.

According to this view, external sensations must be considered as watching over our preservation.

185. Again, we often confound the sentient actions in the mechanical machines, resulting from other conceptions, with those resulting directly from external sensations. When we smell or see some nauseous article of food, which, on some previous occasion has made us vomit, the external sensation excites in us the imagination of the previous vomiting, and it again comes on, because this imagination conjoins with it in its action the partially re-excited external sensation (67). In this case, vomiting is not the immediate result of the smell, or perception (the external sensation) of the article of food, but of the imagination thereby excited. When we see a stone coming upon us and try to avoid it, the movement is not a direct sentient action excited by the seeing the stone (the external sensation), but is the result of the abhorrence of the impending danger, which the sight of the stone occasions. Such examples are infinitely numerous, and if we compare them with those mentioned in § 182, it is found that we have mistaken the greater number for the movements connected directly with external sensations, these being either nerve-actions also, or purely nerve-actions (182, 183), or sentient actions of other mental forces which are excited to action solely by external sensations (219, 199).

186. It is to be understood, however, that those inner sensations of the soul of pleasure and suffering excited by external sensations (80) must, on no account, be classed with the conceptions produced by external sensations, the sentient actions of which are so often confounded with those belonging to external sensations; for pleasure and suffering are only qualities in the external sensations of the soul, and not other conceptions excited by them; their sentient actions are consequently to be classed with those arising directly from external sensations, and they extend their influence to no other nerves than those which feel the agreeable or disagreeable (124). But since the two distinct conditions of agreeable and disagreeable external sensations constitute external sensations for two distinct kinds of conceptions, and these presuppose distinct material sensations in the brain (80), and, consequently, distinct external impressions in the nerves (35), they certainly constitute two perfectly distinct

kinds of external sensations which develope totally distinct sentient actions in the body.

187. All external sensations are either agreeable or disagreeable; and if they be intense, the one is gratification [Kitzel], the other suffering [Schmerz] (80). There is no external sensation without these qualities of pleasure or suffering. (See Baumgarten's 'Metaphysics,' § 481, 405.) Consequently all direct actions of external sensations comprise at the same time those of pleasure and pain, and cannot be separated from them, because one or other is present on every external sensation.

188. All direct sentient actions in the mechanical machines, are effected through the same nerve which produces the external material sensation in the brain (129, 131), whether it be the same fibril which received the external impression, or another, in virtue of the sympathy of sentient actions (165, i), or from reflexion (48, iv). But, should the action of an external sensation occur in the same machine that received the external impression, the material sensation must necessarily excite in the brain the efferent fibrils of the same nerve which is distributed to the affected mechanical machines as their motor nerve (129, iii).

189. The difference in the nature of the external impressions on the terminating fibrils of the same nerve, causes the difference between agreeable or disagreeable external sensations. Now, since the external impression is itself an animal moving force of the mechanical machines (182), it follows, that the impression exciting agreeable external sensations, and the impression exciting disagreeable external sensations, can each develope appropriate movements in the mechanical machines.

190. Since we know nothing of the peculiar nature of an external impression, we cannot say wherein it differs when, through the same nerve, it excites in the mind at one time an agreeable, at another a disagreeable external sensation, or when it excites gratification or suffering (40). But since we are no better acquainted with the nature of material external sensations in the brain, the only sources of actions in the mechanical machines, dependent on external sensations (55, 129), the resulting movements can only be known by observation; but by this, we are able sufficiently to discriminate between nerve-actions merely

(183), and sentient actions of conceptions dependent on external sensations (181, 185).

191. It appears that the external impression for agreeable, or for neutral external sensations, if such there be, is conformable to the natural function (destination) of the nerves, or *connatural;* on the other hand, that of disagreeable external sensations is not conformable to the animal structure and properties of the nerve, but does them violence in some degree, or is *contra-natural.*[1] This difference arises probably, because it is in the nature of the soul to be adjusted, as it were, to all which relates to the preservation of the body, and finds nothing to be agreeable which is injurious to the latter (196).

192. So far as is known, all the nerves of sentient animals are sensitive to at least some external impressions. Consequently, all have the power to receive at least some of these sensationally, and transmit them to the brain, where they are changed into material external sensations (34). Material external sensations are animal-sentient forces (114), that cause an internal impression on the nerve that has felt the external influence (121), which internal impression is propagated downwards from the brain along the nerve (143), and if the latter be incorporated with any mechanical machines, may excite actions which are direct sentient actions of external sensations (160). In this way, all those mechanical machines of sentient animals which are supplied with nerves, are in fact capable of at least some direct sentient actions of external sensations, although they may be incapable of a greater number from

[1] *Der natürlichen Verrichtung gemäss* and *nicht gemäss* are terms used here in the same sense as *natürlich* and *widernatürlich* used elsewhere. The terms *natural* and *unnatural* would not, however, exactly express the author's meaning. The doctrine laid down in the text is as profound and truthful as any of the remarkable views advanced by him; the terms referred to imply, that there are agents to which the animal organism is expressly and beneficially adapted, and the impressions of which excite its mechanism *beneficially, in accordance with that scheme of adaptation;* while other agents act upon it in a contrary sense, and impair or derange the normal and beneficial working of the organism. In the former case the term *connatural* best expresses the character of the agents; in the latter, the term *contra-natural.* In the Second and Third Parts of the work, these doctrines have an important application in explaining the conservative and other actions resulting from the operation of the *vis nervosa,* when excited into action by impressions, where the same words are used with the same meaning. (Vide § 546, *et alia.*)

natural or other hinderances (47). Now, since it is not observed of other conceptions, and of the desires and aversions (which come next to external sensations, §§ 68, 89), that they can extend their influence to all the mechanical machines supplied with nerves; nay, that the greater number seem to act only in some, and, indeed, many to act on none (79), it results, that the sphere of the sentient actions from external sensations is the most extensive of all, and that those mechanical machines supplied with nerves, which are excited at all by animal-sentient forces, are capable of certain sentient actions from external sensations.

193. The circumstance which is common to all movements of mechanical machines, whether they be nerve-actions only, or excited by cerebral impressions, or sentient actions resulting from external sensations, or from other conceptions, and in which they differ from simply mechanical movements, is this,—that the stimulus to those movements to which the mechanical machines in virtue of their structure are adapted, is received through the nerves as an internal or external impression (31). The movements themselves, would, consequently, be the same as those produced by simply mechanical forces, since all movements excited in a machine by whatever force, must necessarily be such as are in accordance with its structure. It follows, therefore, that the circumstance which renders the movement of a mechanical machine in organisms *simply animal* is,—that it proceeds solely from an unfelt impression on the nerve, and not from cerebral impressions caused by conceptions; that the circumstance which renders the movement a *sentient* action is,—that it is excited by an internal impression arising from conceptions (154); and lastly, that that which constitutes it a sentient action of external sensations is,—that it originates from the internal impression in the brain of external sensations (34, 121).

194. The more vivid the external sensations are, the more energetic is their action on the mechanical machines, and, therefore, the actions they excite in the latter are vigorous in the same proportion (133).

195. All movements, of which a mechanical machine is capable in virtue of its structure, are either normal, or in accordance with its natural structure in a state of health, or are abnormal, and opposed to that natural function. Consequently,

all sentient actions of external sensations stimulate the mechanical machines to which they are extended, either to those movements that are their natural function, in which case they are sentient actions of agreeable, or at least of neutral sensations, or to those which deviate from their natural function, and these are sentient actions of disagreeable external sensations (191). This applies also to the sentient actions of titillation [Kitzel] and pain [Schmerz], which only differ in degree from the preceding (80).

196. To understand these views properly, it must be remembered, that every pain and every unpleasant external sensation is of itself something contra-natural, and is considered as disease (191), whereas the healthy, that is, the natural condition, is maintained so long as either pleasant or no unpleasant sensations are felt. But since effects are as their causes, it follows, that the actions of unpleasant external sensations are contra-natural, while those of pleasant sensations are connatural. All experience supports this view, and since suffering is to be considered as the sentinel of our preservation (184), so also its actions are to be considered as a natural medicine which develops contra-natural changes for the purpose of thereby expelling contra-natural disorders of the organism.

197. Titillation [Kitzel] is a vivid agreeable external sensation (80); consequently, its sentient actions render the natural functions of the mechanical machines violent and exaggerated (195, 193).

198. Pain is a vivid disagreeable external sensation (80); consequently, the mechanical machines are excited by its sentient actions to very violent contra-natural movements (195).

199. Since a violent and exaggerated natural function of a mechanical machine borders on the contra-natural, the actions from very vivid titillations are nearly allied to pain (197, 198). Consequently, a violent titillation, like pain, often produces convulsive movements.

200. The mechanical machines to which the nerve that has felt, is distributed, are excited to those movements of which they are capable, in virtue of their structure (193). If the external sensations be agreeable, the movements excited are conformable to the functions of the mechanical machine; if disagreeable, are not conformable (195).

201. If external sensations develope actions directly in mechanical machines, they re-act by means of their material ideas along the same nerve that received the impression (188). Hence it would follow (contrary to observation), that all mechanical machines, in which a branch of the same nerve is distributed, must be all put into action at once by every external sensation of the nerve, unless it be granted, either that the impression which excites an external sensation in the brain at the point of origin of the nerve, can only act upon certain fibrils of the brain in connection with one or a few branches going to certain mechanical machines, which fibrils do not accompany other twigs of the same nerve (188); or, that (136 et seq.) there are certain natural hinderances to the transmission of the cerebral impressions (136, iii), or, that it is turned aside, or conducted away, in its course along the nerve from various mechanical machines, and permitted to reach only those appropriate to it, as is detailed *ante* (136—139, also 165, vi).

What influence sleep (49, 136, iii), and habit (51, 139), and the ganglia (48, 137), may exercise in this respect, ought also to be considered. It is probable, that all these hinderances actually occur in nature.

202. The mechanical machines can develope nerve-actions (183), but no sentient actions, if the brain, or the cerebral origin of its nerves, or of those special fibres of the nerve which receives and transmits the external impression appropriate to the sensation (126), be compressed, or their function destroyed; or if the course of the nerve or of the fibrils be interrupted between the brain and their terminating fibrils (128, 164, iii, iv): also when the function of the mechanical machines themselves are interrupted (129, iv).

203. The direct sentient actions developed in the various mechanical machines by external sensations, are as varied as the adaptations of the machines themselves to impressions (193). We will consider their functions more in detail with reference to this point.

204. The sentient actions of external sensations excite *contractions* in muscular tissue which, when violent, are termed *spasms*. Spasms, frequently repeated, are *convulsions*; if continuous, they are *tetanic* [Erstarrungen]. The limbs moved by the muscles thus affected, and the other functions which the

muscles perform, participate naturally in all these movements, partly from sympathy, partly in consequence of a mechanical connection (165, i, 161, 169, 179). Hence, the sensibility of muscles is a very general principle in animal mechanism, since all these movements are developed at each external impression and also when it is felt, and the more vividly it is felt, the stronger the movements (194, 165, iv); consequently, they must all be considered to be direct sentient actions of external sensations (163, 98), although they may be at the same time nerve-actions (183, 162). The muscles are excited to action by various external impressions, as, for example, the urinary bladder by the injection of water, the heart from the entrance of the blood, the bowels by inflation with air, &c. The agreeable, or connatural external sensations, maintain, so far as they act on muscles, the order and degree of movements and functions appointed by nature to the muscles, and to the parts of the animal body regulated in their function by them (195, 196). On the other hand, the disagreeable excite contra-natural movements of the kind mentioned. Tickling [Kitzel] excites vivid contractions; pain excites sometimes violent cramps of a spasmodic character, sometimes tetanic convulsions [Erstarrungen], which are also occasionally caused by tickling. How direct sentient actions from external sensations are induced in the muscular system and in other parts of the body, and how they may be prevented, has been already shown (129, 134, 136); and the doctrines have an extensive application to pathology and therapeutics.

205. The sentient actions which external sensations excite in the other mechanical machines, may be deduced for the most part from the preceding. External sensations act upon *the blood-vessels*, either through the heart, which is a muscle (167), or through their muscular fibres (168), or directly through the muscles which contain blood-vessels (169). In this respect, therefore, they can change the circulation. The action on the blood-vessels, through their muscular fibres and muscles, consists in a contraction of the blood-vessels (204), (as is manifest in spasmodic attacks, which sometimes excite congestion, sometimes accumulation of blood in parts not implicated in the spasms). Probably, the nerves themselves have the power of directly causing contraction of the vessels, especially at their capillary terminations, as has been already

observed (160). Although the distinguished Haller wishes to withdraw this proposition once stated by him, he cannot withstand the force of facts, and observes: "Aliquid autem in minimis vasis esse, quod laqueorum nerveorum similitudinem certe in effectu habeat, adparet ex suppresso sanguinis venosi motu in pene, analogo effectui vinculorum, et ex tuberculis cutaneis, quæ perinde a terrore ut ex frigore nascuntur." (Element. Physiol., tom. v, p. 590.)

206. External sensations also cause contraction of *the muscular tubes*, as the œsophagus and intestines, whereby their natural function—the transmission of the food (170)—is furthered. Pain causes a spasm in these organs which hinders their natural functions (204).

207. All observation shows, that every external impression at the mouths of the *capillary vessels*, whether they contain blood or other fluids, which is felt (and also an impression which is not felt, as will be proved in the Second Part), attracts their fluid contents to their mouths, where the fluid either accumulates, or is effused. "Dolori multa fere cum voluptate communia sunt; fortior nempe sensus, fortior etiam sanguinis confluxus ad eam partem, quæ vel voluptate emovetur vel dolore; exempla sunt in venereis organis, in ipsis oculis acrius tuentibus, in fricta cute." (Haller, 'Elem. Physiol.,' tom. v, p. 597.) This action is animal, for it is not a property of other mechanical machines, although they also possess similar canals; nor is it observed in dead animals; and, consequently, does not result from mere mechanism (7); and so far as it usually follows in the same parts on external sensation, it is a direct sentient action from external sensation (98, 186). The direct action of external sensations on the blood-vessels, is a contraction (205). When the terminations of the arterial capillaries, which are either continuous with the venous radicles, or open into cavities, become contracted, the continually flowing stream accumulates in them, and they are stretched and dilated, and thus, according to the mechanical principles of pathology, congestion, swelling, and inflammation arise. It is in this way that those arteries are excited to pulsation by the pain of inflammation, in which it usually does not occur. (Haller's 'Physiology,' § 33.) If the capillaries open into shut sacs, the great distension of their mouths dilates the opening, and then copious effusion of the congested fluids

takes place into the cavities. This action is the greater in proportion as the sensation is more vivid. Hence contra-natural inflammations and swellings in the muscles and other mechanical machines arise from painful external sensations. From pleasant sensations, as warmth, friction, itching, titillation, arise a gentle glow and excitement; and in cavities, such as the nares, or intestines, in which the capillaries can pour out their contents, an accumulation of fluid, as, for example, a discharge from tickling of the nose (199), a purging from colicky pain, purgatives, poison, &c. (198.) This *afflux of fluids* to the mouths of these capillary vessels, when an external sensation stimulates their own nerves, or by sympathy, those adjoining (165), constitutes the basis of many important phenomena in the animal economy, and has the most important bearing on the instincts, emotions, and diseases of animal organisms, (Haller's 'Physiol.,' § 564.) The greater number of mechanical machines of the body are as thoroughly interpenetrated by capillary vessels as by nerves; it follows, therefore, that this particular action of external sensations is observed to be almost always coincident with all external impressions which are felt; and thus it is a general physiological law, that concurrently with each external sensation there is an afflux of fluid to the point where the external impression is made. This is not, however, the sole law, nor is it quite general, since this afflux cannot take place as a consequence of external sensation in those parts not supplied with capillaries and tubuli; nor does it even take place in other parts, if the external sensation be not of a certain degree of intensity or strength.

208. External sensations excite direct sentient actions in the *flat muscles*, particularly the *diaphragm* (171), which consist of such contractions, or other movements, as they are capable of, in virtue of their structure (193). Thus a painful sensation from inflammation of the diaphragm, causes unnatural respiration, in consequence of the convulsive movement excited in it. Those membranes of the organism, which do not consist of a true muscular tissue, but rather of minute glands, papillæ, cellular tissue, and capillaries and tubuli, must be considered quite differently with reference to their sensibility, and the sentient actions resulting therefrom. Some of these membranes have numerous nerves, and are very sensitive, as the skin, and the

mucous membrane of the nostrils, throat, and other parts. It appears also, that nerves are intimately incorporated with these tissues (160), for every portion of the surface which the point of a needle touches, is sensitive, and the final distribution of the nerves in them cannot be traced. But since their structure differs from that of the muscles, we cannot expect them to manifest similar sentient actions. Nevertheless external impressions on their nerves can proceed to the brain without exciting a visible movement in the point touched, — can be felt, — and can be reflected by means of the internal impressions of the sensation along the principal nerve and its branches, and if there be no hinderances, can excite movements in the mechanical machines to which the nerves are distributed, and, consequently, develope sentient actions in other parts by means of the external sensation thus excited on such surface (129). Thus, titillation of the mucous membrane of the nostrils excites sneezing, and a convulsive movement of the diaphragm and respiratory muscles, the nerves of which are in natural connection with those of the nasal mucous membrane: thus also many an external sensation of the cutaneous surface excites, by means of the nerves, a tremor of the muscles in relation to it, which is termed a *shudder*. Thus also a titillation of the nasal mucous membrane excites effusion of mucus, which is a sentient action of titillation in the capillaries or terminating tubuli of the minute glands (207, 172): thus also the cutaneous surface becomes inflamed, and swells from the stimulus of an acrid irritant: thus also cold contracts the respiratory pores by a sentient action on the minute terminations of the arteries, and interrupts perspiration (168).

Other non-muscular tissues have either no nerves at all, or very few distributed here and there in their structure. Hence their sensibility is doubtful. Of this kind, according to Haller's researches, are the *serous membranes* covering the thorax and diaphragm, the pericardium, peritoneum, &c. Nevertheless, experience proves that they are susceptible of certain actions of external sensations; and that actions may also be excited in other parts by sensations originating in their nerves. Thus it is seen, that if a nerve be injured or divided which traverses a tendon, or the periosteum, paralysis or convulsive movement is induced in the adjoining limbs, or in those in relation with the injured nerve, which may be considered as the sentient action of pain in those tissues, although their proper substance be insensible. Besides, in such tissues, an injured blood-vessel or gland, or other structure supplied with nerves, or with muscular fibrils, may excite a painful inflammation, and therewith the appropriate sentient actions, as an afflux or effusion of fluids, congestions, inflammations, &c. (168, 172), from which as experience teaches, neither the pleura nor peritoneum, nor other insensible tissues, are exempt (Vide §§460—465, 470, 522—530.)

209. External sensations excite the functions of the *glands;* namely, the *excretion of fluids;* and when they are enclosed in muscular tissues, the evacuation takes place according to their mode of action on muscular tissues (172); but when there is no muscular tissue, they excite an afflux of fluid, in virtue of their action on the terminating mouths of the tubuli (207). Thus, a strong flavour excites the secretion and discharge of the saliva; irritation, or pain in the eye, excites a flow of tears; thus, also, titillation causes parts to be lubricated, by irritating the nerves of the glands, and favouring a secretion and discharge of their fluids; thus also irritation and pain of the bronchi cause a mucous discharge from the irritated glands,—all being manifestly sentient actions in the glands from external sensations.

210. The direct sentient actions, from external sensations in the *viscera,* properly so called, are very complicated and varied, inasmuch as these machines are compounded of many others in which external sensations act very variously. We can only mention some of the more important in this sketch, referring the reader to §§ 204—209 for general principles.

211. The *heart,* as a compound hollow muscle, is stimulated by external sensations (167) to the performance of its function, namely contraction, whereby the circulation of the blood through the body is kept up. Consequently a painful sensation in the heart causes a convulsive contraction and an accelerated circulation.

212. The external sensations which are excited in and about the *stomach,* stimulate it and the intestines to gentle writhings, whereby digestion and the transmission of the food onwards is attained. There is a movement excited in the stomach when an external impression is made on it, but this

takes place, for the most part, through nerve-actions (183), for the external sensation of each impression is seldom perceived, only the vivid external impressions being felt, when the painful actions of external sensations caused in it are contra-natural. Thus arises the violent peristaltic action of the stomach and bowels from griping purgatives, poisons, inflammations; hence also the spasm of the stomach from similar causes, or from flatulency, or indigestible food painfully pressing the stomach. The muscles of the limbs participate largely in such contra-natural movements of the stomach and bowels, as is shown by the paralysis which supervenes on violent colic. This takes place in virtue of the sympathy between the sentient actions of muscles, but the question belongs properly to the pathology of organisms.

213. The *liver* and *gall-bladder* are little susceptible of external sensations: an external impression is only perceived when it is remarkably vivid, and also contra-natural, or painful (198). Violent pain in the region of the liver exercises an injurious influence on the secretion and excretion of bile (175). Other conceptions, like external sensations, have a manifest influence on most of the proper viscera of the body by sentient actions on their nerves.

214. Ordinary external impressions on the *lungs* are rarely felt; when, however, they experience tickling or pain, the respiration is partly accelerated, partly rendered contra-natural and spasmodic, as in cough; in cases of this kind the sentient actions are from sympathy (98, 165). Respiration is not excited solely by irritation of the nerves of the lungs, but also by irritation of the diaphragm, and of the respiratory muscles of the thorax.

215. The *kidneys* also are susceptible only of extraordinary and unnatural external impressions; spasm is almost the only example of sentient action from external sensations that can be deduced. It is otherwise with the *bladder*.

216. The *organs of the senses*, considered as mechanical machines, are moved by external sensations in various ways, having reference to their particular functions. When a sound enters the ear, and is heard, the muscles which stretch the tympanum are so put into action, as to render the latter tense in accordance with the tone: so when light enters the eye, and

is perceived, the muscular pupil of the eye undergoes a change. The light has no more such effect upon the pupil of the blind than in a corpse, consequently it is a true direct sentient action from an external sensation. When a savoury drop or two is tasted posteriorly, by means of the tongue, the throat is stimulated to the act of swallowing; and when the skin is affected by an acute external sensation, as from cold or itching, it is contracted, and its exhalation altered (177). These are obviously sentient actions in the organs of the senses from external sensations, rendering them more fit for their functions, and testifying to a fore-seeing wisdom.

217. All that need be said as to the direct sentient actions of external sensations in the *sexual organs* has been already stated; it is their great characteristic that they render the organs fit for the function of reproduction.

218. We may now estimate from previous considerations (204—207) the law laid down by Krüger, in his 'Physiology,' that every external sensation is followed by a movement in the body proportionate to the sensation. In the ordinary state of the body, whenever an external sensation is excited in the mind through a nerve which is distributed to mechanical machines, such movements are developed in the machines by means of the nerve, its branches and fibrils, provided there are no natural hinderances there (136, 199), as in virtue of their structure they are capable of, and the movements are the stronger in proportion as the external sensation is more vivid (194). But it may so occur (as will be demonstrated in another part of this work,) that the same movements may result from an external impression which is not felt, and thus be nerve-actions (83, 462). This law is, however, not to be understood, to the effect that the movements will be stronger in proportion as the external *contact* on the nerve is stronger, or according to the measure of physical forces, but the stronger the external *impression* is, which may sometimes be very strong from a *slight* contact, and *vice versâ* (40).

219. Besides the *direct* sentient actions of external sensations that we have hitherto considered (204—218), we have also to consider the *incidental*, [zufällig] which are so often confounded with the former. It may be stated generally, that the sentient actions of both kinds, and all the mental forces possessed

by animals in addition to the sensational force, are indirect sentient actions of external sensations, although in very different degrees of connection (65). We will glance at the most prominent of the series.

We connect with our external sensations the conception of another like to it, which we have had before, and thus a direct imagination is attached to our external sensation (67), that commingles its action in the mechanical machines with those of the external sensation. In this way we sigh at the sight of a person who is like another, with respect to whom we have had sorrowful sensations. This sighing is the sentient action of the imagination, and only indirectly of the external sensation (97, 99).

220. We often connect with our external sensations the *expectations* of others formerly connected with them, and thus a *foreseeing* (73) accompanies our external sensation, which mingles its actions in the mechanical machines with those arising from the external sensation. A certain person always faints during the operation of venesection; some time afterwards he meets the surgeon in the street, and becomes faint: this faintness was the sentient action of a foreseeing of the blood-letting, and only incidental to the external sensation (97, 99).

221. Since all our external sensations are made vivid by pleasure or suffering (187), and accompanied by imaginations and expectations (219, 220), so they are also associated with desires and aversions, which unite their actions in the mechanical machines with those arising directly from external sensations, and are most manifest in the instincts and passions (93). Thus, an agreeable or odious countenance instantaneously renders a man enamoured or angry; in animals, an odour, or a sound, excites the sexual instinct; or, in one who has fasted, the sight of food excites hunger. Here the whole process of the instincts and passions is set forth, and it is by no means the external sensations that directly excite their sentient actions. The last will serve as an illustration: a man with an empty stomach sees bread, and he recollects that under similar circumstances he has been relieved by the eating of bread. From this external sensation and imagination, there arises the expectation that the same result would follow again if he ate bread, and now there arises the seeking to eat, whereby the mouth fills with

water,—a sentient action of the desire (of the instinct) incidentally produced by the external sensation (97, 103).

222. The strongest sensational conceptions and desires most readily excite *imperfect external sensations* (148). Now since true external sensations excite all conceptions, and consequently the strongest conceptions and desires (219-221), they can incidentally give rise to the sentient actions of phantoms, visions, ghosts, and illusions (148). We seek with the greatest anxiety to lay hold of the object which threatens us with imminent danger, and this vivid conception works so intensely, and as an *aversion* so contra-naturally (195), in our muscles, that the arm remains stiff, swells, and inflames. This is not an unusual circumstance where real objects are concerned. When we see a form in the dark, which we take for a ghost, and the imperfect external sensation excites the instinct of terror, and we reach towards it, the above-mentioned condition may occur to the arm, not directly through the real external sensation, as, for example, the sight of a shadow, but incidentally, inasmuch as the latter excited the imperfect external sensation which produced the phenomenon of the ghost.

223. We often connect *thoughts of the understanding* with our external sensations, when we reflect upon objects that appear to the senses, and thus a reflection (77) accompanies our external sensation, which combines the action it probably may develope in the mechanical machines (330) with those resulting directly from external sensations (100). Thus a glance may quickly cause deep thoughts in us, together with vertigo, the vertigo being the sentient action of deep thought, and only incidentally that of the external sensation (97, 100; see also 331).

224. We connect desires and aversions of the *will* with our external sensations, and so the actions of the latter accompany those of the former (96). Thus, at the sight of a ravening beast, we exert our muscles, and flee. This flight is the sentient action of the conclusion of our will, and only incidentally that of the external sensation (97, 104).

225. All sentient actions of external sensations consist of movements, in which all those structures must take part that are incorporated with the substance of the organ of movement, and, consequently, the nerves (160). When these nerves receive an external impression through their ultimate ramifications in

the mechanical machines, from a movement produced in the latter, by means of material external sensation sent from the brain, they can thereby excite new external sensations (31), and these can develope sentient actions, either in the same mechanical machines by means of the same nerves, or their branches; or in other machines to which they are distributed, or to which their cerebral impression is transmitted (188). Sentient actions from external sensations of this second class are *subordinate*, or secondary, as to their origin, and if we would avoid many errors in explaining the phenomena of the animal economy, they must be carefully distinguished from those which arise directly from external sensations. Pain in a muscle excites cramp of the muscle, its direct sentient action. But this cramp causes also a violent pain, from which convulsions result, involving many other muscles. These convulsions are subordinate sentient actions of the primary pain. A poison excites a burning sensation in the stomach and bowels, in consequence of which they writhe, and are spasmodically contracted. These are the primary sentient actions of the external sensations of burning from the poison. But the writhing and spasmodic contraction cause new pain (colic, spasms of the stomach), whereby the circulation of the blood in the abdomen, and the digestion and transmission forwards of the food, are hindered, the bowels constipated, dysuria induced, and the legs paralysed (212). These are the subordinate or secondary actions of the sensation of burning excited by the poison, and the direct sentient actions of the gastric spasm or colic. It is obvious, that when these subordinate actions excite new sensations, new sentient actions may result which are again subordinate. Thus, therefore, a single external sensation can, by means of its subordinate and continuous direct sentient actions excite most, if not all, the mechanical machines of the body to movement; spasmodic diseases, from titillation, &c., present the most frequent examples of this kind. It must therefore be remembered, (and it will be subsequently advanced in treating of the actions arising from other sentient forces,) that the subordinate external sensations of the mind constitute, when combined with the primary, a compound external sensation (an entire or complete [conception] external sensation, —Baumgarten's 'Metaphysics,' § 378), which consists of the primary and all its subordinate sensations; and that the primary and subordinate, separately considered, are the elements of an *entire* external sensation. The same principles apply to the actions of compound conceptions.

226. Just as the subordinate sensations are developed at the same time as the entire external sensations, so also their sentient actions are produced in the machines in which they act (225). But since the subordinate, like all other external sensations, do not necessarily set the mechanical machines into movement, to which the nerve is distributed that has received their cerebral impression, on account of natural hinderances (201), it follows, that the sentient actions of a complex external sensation may occupy sometimes a greater, sometimes a less, sphere of action, according to the variety in the impressions in the brain, which make up the constituents of the total external sensation, and according to the nature of those normal hinderances, which impede or divert the course of the impressions from the brain to the machines (165, vi). The stronger, however, the subordinate external sensations, the stronger are the actions which they actually excite (218, 225).

227. All external sensations are entire conceptions, consisting of many elements. (Baumgarten's 'Metaph.,' §§ 378, 405.) It follows, therefore, that all their direct actions may consist of many elements, and this may occur when no natural hinderances exist to the transmission of their cerebral impression (116). But all their actions do not depend upon subordinate sensations, since at the same moment distinct primary external sensations may be in the mind, which manifest, at the same time, their proper sentient actions, according to the laws of primary external sensations; these may be termed *co-ordinate* external sensations, and sentient actions.

Actions of Imaginations on the Mechanical Machines through the Nerves.

228. The sensational conceptions are external sensations, spontaneously imitated or repeated by the soul, the external impression which can give them the reality of external sensations not being present (67); that is to say, in each imagination many sub-impressions [Merkmale] of the external sensation

are wanting, the conception of which is necessarily induced by the external impression, and which are not perceived therefore by the soul (68). The material idea, which the external impression develops in the brain, consists of more numerous sub-impressions, and is much more perfect, than that which the mind when it repeats it can develope without its assistance. Further, as the imaginations are only imperfect external sensations, the material ideas of the imaginative force are only constituents of the material external sensations, which the external impression, by reaching the brain, can alone render perfect and complete. Both are conceptions and material ideas of one and the same kind, but the imaginations are weaker and more imperfect (68).

229. It may be readily inferred from these views, that the sentient actions of imaginations in the mechanical machines, correspond generally with those of external sensations; that their range of influence is equally extensive; that they excite similar kinds of movements in the various machines; and that they are only different in being somewhat less complete. Experience teaches us the same thing. An imagination excites in the same mechanical machines, the same movements that the previous external sensation developed. An object which causes us to shudder, produces a similar effect when we recall it to recollection; the remembrance of some food that has caused us to vomit, excites vomiting again; and the recollection of a gratification excites the same conditions of the organs as that in which it was enjoyed. The difference is, that the actions of imaginations are weaker, simpler, and more imperfect than those of external sensations (69). And all this could not be otherwise, since the imaginations produce their material ideas at the cerebral origins of those nerves affected by those of external sensations (124, 67); consequently, the same machines must be put into movement (129, 130), for the same kind of cerebral impression, but more feebly, is made at the origin of the nerves, as by external sensations (67, 228); and the resulting movements are similar, but feebler (133).

230. An entire imagination consists only of some of the elements of a previous external sensation, and, consequently, of only some of their material ideas or impressions on the origins of the nerves. The law, then, of the sentient actions

of imaginations in the mechanical machines, is this:—whatever portions of the elements of a preceding entire (225) external sensation are contained in an imagination, the sentient actions of those elements are repeated, although feebly, in the same mechanical machines (229, 106.)

231. Since many elements of an entire external sensation may consist of subordinate external sensations, and an imagination therefrom be made up principally or wholly of the latter (228, 225), it follows, that an imagination may produce few or none of the sentient actions of the original sensation, but principally or solely those of the subordinate (230). Certain food formerly taken excited spasm of the stomach; this cramp caused a new pain,—a subordinate external sensation (225), from which general convulsions arose, or subordinate sentient actions. Now when this food is brought to the recollection, convulsions are immediately excited, but without the gastric spasm being excited also. In this case the imagination excites only the subordinate sentient actions of the antecedent primary external sensation, passing over the primary sentient actions.

232. Although the absence of the external impression is the cause why the sentient actions of imaginations are less perfect and more feeble than those of external sensations, yet strong imaginations can cause imperfect external sensations which imitate the action of external impressions on the nerves (148); and so imaginations, accompanied by imperfect external sensations, may develope such perfect and vigorous sentient actions, that they can hardly be distinguished from those of real external sensations (229, 150). Thus, an insane person, or one that dreams, or any individual with a vivid imagination, imagines he has swallowed an active purgative, and is purged in consequence; or vomits from dreaming of taking nauseous food, &c.

233, i. A mere external impression can excite no imagination if it be not felt; consequently its nerve-action, as such, is never at any time a sentient action of an imagination, if it be not the sentient action of its sensation (228, 184, i). But such a nerve-action may be felt and therefore imagined, and this imagination can have sentient actions in the mechanical machines.

ii. The external impressions often excite by its own *vis nervosa* (7) those movements which are sentient actions of the external sensation, in which case they are nerve actions (183).

Now, as the external impression is wanting in the sentient actions of imaginations (228, 229), the co-operation of its vis nervosa is wanting, and, consequently, the movements dependent upon it do not enter into the sentient actions of imaginations, or, at least, are not excited by it, but occur only incidentally. If, therefore, an imagination repeats the sub-impressions *a, b, c,* of a preceding external sensation, with which certain movements in the mechanical machines are connected, but which are not sentient actions of the external sensations *a, b, c,* but simply nerve-actions of the co-operating external impression,—these actions do not occur, if the impression itself be not made. Thus, an external impression of food, although not felt, will excite a movement in the bowels as a nerve-action (183), but the imagination of food not actually eaten cannot possibly excite the movement, nor can a mere imagination excite any subordinate action resulting as a nerve action from the impression, as, for example, the micturition which follows the taking of food.

234, i. The sentient actions of imaginations, like those of external sensations, extend to all the mechanical machines which can be moved by external sensations (192, 229), and stimulate them to the same movements, although more feebly and imperfectly; nay, those connected with imperfect external sensations excite the machines to these movements, with a force almost equal to that of external sensations (232, 229).

ii. The imaginations of agreeable external sensations (186, 228) develope connatural actions (195); those of unpleasant external sensations, contra-natural actions; those of titillation and pain excite more violent movements (197, 198).

iii. Just as external sensations do not actually put in motion all the mechanical machines which have nerves to move them (201), so also it is with imaginations (228).

iv. Just as external sensations, in developing sentient actions, act on the mechanical machines according to the capabilities of each, so is it also with imaginations, and all that has been stated with reference to the former (204-217), applies equally to the latter.

235. The direct sentient actions of imaginations (hitherto considered exclusively) are often accompanied, in addition to those of true external sensations, and of other imaginations not belonging to them, by incidental actions (219), as those of fore-

seeings (73), desires, aversions, passions nay, more remotely, by those of ideas of the understanding, and of intellectual desires and aversions of the will. All these actions, which are either only coincident with those of imaginations, or are only incidently connected with them, must be carefully distinguished from those proceeding directly from imaginations. Yesterday a person ran; at night he dreams that he is running, and begins to breathe quickly. This is the sentient action of his imagination. Then he thinks he is falling and calls out; this is the sentient action of his foreseeing. He seeks to place himself upright, and strains his muscles to that end; this is the sentient action of a desire (223, 224).

236. As sometimes in dreaming, and especially in somnambulism and insanity, the imaginations are so vivid, that they equal true external sensations, so also, in such cases, they develope the same sentient actions in the mechanical machines, as if they really proceeded from the latter (70, 69).

237. When the mind is in reverie [dichtet], it combines the constituents of various imaginations with each other, and then each develops its actions in the mechanical machines, according to the laws of imaginations. In a prolonged reverie [dichten], which consists of the most vivid imaginations and imperfect external sensations, as, for example, in somnambulism, insanity, or delirium, the sentient actions are as distinct as if they resulted from real external sensations (236), only they are not so perfect, complete, and regular, and are not so accordant with the natural functions of the body (184), so that there arises danger to its health and conservation. The principles laid down as to imaginations (231—236) are also applicable to reveries of the imagination [Erdictungen].

238. The remembrance of a conception (71) does not appear to be a species of conception, which develops actions externally to the brain, except so far as the conception which is remembered is an external sensation or imagination that so acts. A person sees a visionary figure, and becomes pale with fear. It is the resemblance of an individual who long ago caused him bitter vexation. The pallor comes on before it is remembered whom the figure resembles, and simply from the repeated external sensation, without the recognition. How often in such cases we hear persons say: "this appearance terrifies, affects,

and calms me, without my knowing why, some subordinate ideas, which I cannot remember, must be the cause." When the person whose figure we have seen, actually appears also, no other action results than as stated above; we become pale as before, but now we know why. Hence it appears, that the memory itself [das eigentliche Erinnern] belongs to that class of conceptions, the sentient actions of which are limited to the brain, and excite only material ideas of another kind; whereas the conceptions which are remembered develope their usual actions externally to the brain in the mechanical machines.

Actions of the Sensational Foreseeings on the Mechanical Machines through the Nerves.

239. The *sensational foreseeings* are future external sensations, to which the external impression must supply what constitutes the element of external sensations (73). In other words, a number of sub-impressions of the external sensation are wanting in every sensational foreseeing, the conception of which must be induced by the external impression, and without which the mind does not conceive them. The material idea excited in the brain by the external impression contains many more sub-impressions, and is far more complete than that which the mind can impress spontaneously on the brain, without the aid of the external impression (53, 73); and as foreseeings are only imperfect external sensations, more imperfect, indeed, than imaginations (73), the material ideas of the foreseeing force are only portions of the material external sensations, which the accession of the external impression alone can render complete and perfect. Both are conceptions and material ideas of the same kind, but the foreseeings are much more feeble and imperfect (73).

240, i. The material ideas of foreseeings arise at the origins of the same nerves, as those of the foreseen sensations themselves (73, 124): consequently, their sentient actions, external to the brain, must be similar (129, 130.)

ii. Foreseeings cause the same kind of impressions (73, 121) in these cerebral origins of the nerves as the foreseen sensations, consequently their sentient actions in the mechanical machines must be similar to those of the future sensations.

iii. As these impressions are more feeble than those of sensations, and even of imaginations, so also must be the resulting actions. And this is confirmed by observation. When, for example, a person sees another eat, and himself thinks of eating, this foreseeing, in conjunction with the accompanying desire, stimulates the salivary glands as food itself would have done. The foreseeing of a fall from a height excites us to hold fast, even against our will and purpose, as we should do, if the fall actually took place. When a person dreams that he will empty the urinary bladder, the act often takes place. The expectation of the action of a remedy often causes us to experience its operation beforehand. Yawning, from imitation, belongs to this class of phenomena.

241. The entirety of a foreseeing is compounded only of certain of the constituents of a future external sensation; consequently, its material ideas, or impressions on the cerebral origin of the nerves, are a portion of those of the future sensation, and therefore its sentient actions are expressed in the same mechanical machines, but more feebly (240, 106).

242. Since many of the elements of a complete external sensation may be subordinate external sensations, and a foreseeing arising from it may consist wholly or principally of these (239, 225); it follows that a foreseeing may develope few or none of the primary actions, but principally or wholly those of the subordinate sensations (241). A cold air coming in contact with the cutaneous nerves, when we are warm, contracts the pores, and drives the perspiration inwards. This is the sentient action of the primary external sensation of cold. The repressed acrid perspiration irritates the nerves of the muscles, and our limbs tremble, and our teeth chatter, and this is the sentient action of the subordinate sensation in the muscles which move the limbs and the lower jaw (225). A person in a warm bed dreams, or vividly foresees, that he falls into a river full of floating ice, and he forthwith shivers: a case of this kind really occurred, and may be found in the 'Dictionnaire Encyclop.,' article "Somnambule." A somnambulist once fancied in winter, that as he was walking by the side of a river, he saw a child fall in and drown. The bitter cold did not restrain him from saving it. He threw himself out of bed in the posture, and with the movements of a person

swimming, and when he had laboured diligently, he seized the bed-clothes with one hand, thinking it was the child, while with the other he attempted to swim to the imaginary shore. Then he laid his burden down, shivered with cold, his teeth chattering, as if he had come out of an ice-cold river. He said that he was stiff with cold, and asked for a glass of brandy. The dreamer had not really felt the ice-cold river, nor had repressed perspiration irritated the nerves of the muscles. The whole mental action of his foreseeing of both, manifested itself only by shivering and chattering of the teeth. In this case, the foreseeing develops the subordinate sentient action of the future external sensation only, omitting the primary, because the mind thought principally, in its foreseeing, of the subordinate external sensation,—the irritation of the muscles,—and did not combine with it the foreseeing the antecedent primary sensation in the cutaneous nerves (241).

243. The cause why the sentient actions of foreseeings are more imperfect and more feeble than those of external sensations, is the want of the external impression (239, 240). Still, very strong sensational foreseeings may cause imperfect external sensations, which resemble the external impression (74, 148); and foreseeings, accompanied by their imperfect external sensations, may develope such perfect sentient actions in the mechanical machines, that they are generally similar to the sentient actions of true external sensations (150, 240). Thus, a person who dreams vividly that he hears it thundering, may start so violently in the bed as to shake it. Thus, also, an infant in the cradle sucks the air with all its might, from the foreseeing that it is sucking the breast.

244, i. An impression can excite no foreseeing if not felt, for it is, of course, not imagined (233, i); consequently its nerve-action, purely as such, is never at the same time the sentient action of a foreseeing, until it is the sentient action of its sensation (239, 184, i.) On the other hand, the mind can feel and imagine (223), and, consequently, foresee such a nerve-action (73), and these foreseeings can excite sentient actions in the mechanical machines.

ii. The external impressions often excite by its own *vis nervosa* (7) those movements which are sentient actions of the external sensation, in which case they are nerve actions (183).

Now, as the external impression is wanting in the sentient actions of foreseeings (228, 229), the co-operation of its vis nervosa is wanting, and, consequently, the movements dependent upon it do not enter into the sentient actions of foreseeings, or, at least, are not excited by it, but occur only incidentally. If, therefore, a foreseeing repeats the sub-impressions *a*, *b*, *c*, of a preceding external sensation, with which certain movements in the mechanical machines are connected, but which are not sentient actions of the external sensations *a*, *b*, *c*, but simply nerve-actions of the co-operating external impression,—these actions do not occur, if the impression itself be not made.

245, i. The sentient actions of foreseeings, as well as those of external sensations (192) and imaginations (234, i), take place in all those mechanical machines which can be moved by external sensations and imaginations, and excite the same movements as the latter, but more feebly and imperfectly (193). Nay, even the foreseeings connected with imperfect external sensations, excite the mechanical machines to the same movements as are excited by true external sensations (240, 243).

ii. The foreseeings of agreeable or disagreeable sensations contain, in some degree, the impressions of pleasure or pain (186), and develope such actions as are in accordance with, or opposed to, their normal function (195, 197, 198).

iii. As external sensations do not excite to movement all those mechanical machines which the nerves can move (201, 239), so is it also with regard to foreseeings.

iv. As external sensations, when they produce actions in the mechanical machines, act upon them according to their respective capabilities, so is it also with regard to foreseeings, so that the principles laid down previously under this head (204—217) are also applicable to the latter.

246. There are often connected with the sentient actions of foreseeings certain others of an incidental kind, as, for instance, those of desires, aversions, and even more remotely, those of understanding and efforts of the will (65), and in addition to the sentient actions of co-existing true external sensations, imaginations, and other foreseeings. All these actions, whether co-existent, or incidentally connected with those of foreseeings, must be distinguished from the latter. The foreseeing of a lascivious action acts directly on the organs which have to per-

form it. Therewith is combined the emotion of shame, and the face reddens. This reddening is incidental. A philosopher studies from a foreseeing of fame, until he is hypochondriacal and loses his digestive powers. This action of deep thought (vide § 332) is only incidental to the anticipation of fame, &c.

247. Since sensational foreseeings and prophetic visions are occasionally so vivid in dreams, and especially in somnambulism, as well as in insanity and prophetic ecstasy, that they equal true sensations, particularly as they become usually in such persons imperfect external sensations, and constitute the greater number of apparitions, spectres, &c. (148, 243),—they develope the same actions as are produced by true external sensations.

248. The poetic faculty [Dichtungskraft] is occupied with foreseeings as well as imaginations, and according to the same laws. Hence it is that somnambulists, visionaries, lunatics, inspired persons, soothsayers, &c., are as much deluded by the foreseeings of their bodings and expectations as by their imaginations, taking both for true sensations, while their sentient actions are equally erroneous (237).

249. The true expectations differ from the foreseeings in this, that their sentient actions are confined to the brain, and do not extend to the mechanical machines.

Actions of Sensational Pleasure and Pain through the Nerves on the Mechanical Machines.

250. So soon as a sensation, or other conception of the mind, pleases or displeases, or contains the excitants of the feelings (88), it is said that *they touch the heart, that the heart sympathizes*, &c. This mode of expression has its rise in the universal experience, that the movements of the heart, and especially those actions termed *vital* by physiologists, are manifestly affected by all conceptions which please or displease. It is said of the pleasant external sensation excited by food, drink, or medicine, that it goes to the heart, enlivens, strengthens the heart. A beautiful sight, or music, soothes the soul and exhilarates the heart. Tickling excites convulsive respiration and laughter, and accelerates the whole circulation. Pain causes fever, and sighing, groaning, and weeping. Pleasant condolence, or a kind visit, refreshes the heart; a reproof that

we feel to be merited, goes to the heart; the recollection of a cruel action shocks the heart; the anticipation of a joyous thing causes it to beat more freely and easily. And in short, every sensational and intellectual conception which awakens happiness or misery in the mind, causes changes in the pulse and in the action of the heart, in which the respiration also participates, and thereby exercises an important influence on the whole economy, which a mere perception or a neutral external sensation, imagination, or foreseeing entirely wants. It is consequently a general law of animal nature, that all excitants of the feelings add a special sentient action to the other sentient actions of the conceptions, so that they modify the functions of the mechanical machines subservient to vital movements. But since the sensational stimuli, or in other words, the pleasure or pain of the external senses (80), and of the sensational conceptions, imaginations, foreseeings (88), are, from their nature, stronger stimuli than mere motives [Bewegungsgrunde] (53,88), it follows, that their action on the vital movements is more obvious and powerful.

251. The direct sentient actions of the excitants of the feelings generally, and considered *per se*, are consequently the impressions in the brain of pleasure and pain, in so far as being special conditions of the material ideas of each neutral sensational conception, they excite the origin of those nerves in the brain by which the vital movements are regulated; and this applies, in particular, to the sentient actions of the pleasure or pain of the senses (80), and to all other sensational stimuli, and to motives [Bewegungsgrunde] (88, 250). In addition, therefore, to the direct sentient actions hitherto described, as resulting from external sensations, imaginations, and foreseeings, the latter excite other direct and special actions in virtue of these excitants of the feelings, whenever they become agreeable or painful, so that they modify the vital movements, and in consequence of the physical, mechanical, and vital inter-connection of the latter, powerfully influence the whole animal economy, and this proportionately to the degree of excitation. This doctrine applies also to the motives of the intellect. As to the cause of this action of the sensational stimuli on the vital movements, we can only say, that these inner sensations of the soul must make an impression peculiar to themselves on the cerebral origin of

the nerves distributed to the vital organs (124), and it is probable that by exciting the mind into action (81), the numerous capillaries of the brain are stimulated, and thus by a change in so large a portion of the mass of the blood, a change is produced in the action of the heart, in the respiration, and in all the vital movements (159).

252. The sentient actions of the pleasure of the senses are movements in accordance with the natural functions of the mechanical machines; those of annoyance of the senses are contrary to the natural functions (80). The same applies to the sentient actions resulting from pleasing or displeasing sensational conceptions, imaginations, and foreseeings (234, ii; 245, ii). But since a very active and inordinate discharge of a function borders on the contra-natural, the sentient actions of very vivid pleasurable stimuli are in some degree contra-natural (199). Consequently, a state of gentle calm pleasure is more favorable to the maintenance of life and to health, than excess in pleasurable sensations, or than distressing painful sensations.

253. All experience establishes this doctrine. A person describes a condition of health, by saying that *he is well*;—of sickness, by the expression *he is ill*. This being *well* and *ill*, are sensations of what is pleasant and unpleasant (80). One perfectly in health says, that not a finger aches, one out of health, that nothing goes right with him; obviously expressions of what is pleasant and unpleasant, whereby we designate a natural or contra-natural condition of the body. In particular, it is also observed, that the change in the vital movements excited by moderate pleasures, are favorable to the organism,—the immoderate on the painful are unfavorable. Moderate laughter is beneficial, immoderate is hurtful. Agreeable exercise of the understanding is favorable to health; and it was for this reason that the ancient philosophers maintained, that the study of nature favoured the attainment of old age; while, on the contrary, excessive study and tiresome subtle meditations led to premature decrepitude, and caused nervous diseases.

254. The general law, whereby the direct sentient actions of the excitants of all the feelings are regulated, is this:—just as a sensational or intellectual conception pleases or displeases, so

are the nerves acted on in the brain, and corresponding vital movements excited thereby in the vital organs; in the former case in accordance with their natural functions; in the latter, in opposition thereto (252), but always in another way than when the conception is neutral.

Actions of the Sensational Desires and Aversions in the Mechanical Machines through the Nerves.

255. The direct sentient actions of the sensational desires and aversions, are produced according to the laws already laid down (80—88). They are made up by the sentient actions:—1, of the sensational foreseeings of a coming sensation, or its opposite, expected by the mind (239—247); 2, by those of this expectation (249); 3, by those of the impressions of sensational pleasure and pain (84—87, 250).

256. The same doctrines apply equally to the sensational instincts and passions, since these are only desires and aversions of a greater intensity, arising out of obscure or simple sensational stimuli (90, 91).

257. In each sensational instinct and emotion, there is a sensational foreseeing of coming sensations, the sentient actions of which are none other than those of the imperfect material sensation which is foreseen; when it is external, the actions are developed in those mechanical machines external to the brain, which the foreseen external sensation sets in motion, &c. (240, i, ii.)

258. There are strong sensational stimuli conjoined in every sensational instinct and emotion, the actions of which are the same as those arising from the impressions of sensational pleasure or pain, which impressions depend on the foreseen material sensation. These stimuli change the vital actions in a remarkable manner, and excite the animal-sentient force of the brain to render perfect the imperfect actions of the coming sensation. In all these cases, if the objects of the instinct or emotion be true external sensations, the efforts of the soul cannot attain them, and consequently the instincts or emotion cannot be satisfied without the appropriate external impressions (81, 256); and in the sensational instincts and emotions, therefore, only those sentient actions of the future sensation can be

excited, which are not dependent on the external impression (81, 94).

259. The effects of the pleasing or distressing instincts and emotions on the organism, are regulated by the same laws as those of simple pleasure or pain (191—199), or of the agreeable or distressing foreseeings, (245, ii, 252, &c.) Consequently, every kind of joy is beneficial to health, all sorrow injurious; but the former may be injurious too, if excessive (252).

260. The direct sentient actions of the sensational propensities and emotions, are produced according to the same laws as those of sensational pleasure and pain. (Compare 254, 199.)

261. It may be useful to illustrate these views by special facts.

i. Observations prove, that in the propensities and emotions, the actions of the coming foreseen external sensation therein imperfectly expressed, are produced (257). In the appetite for food, the gratification of which is the taking of nutriment, saliva is poured out into the mouth, as if nutriment were taken; in the sexual appetite, the gratification of which is copulation, the organs of generation are put into a condition suitable to its gratification; in the desire to give suck, the satisfaction for which is the discharge of milk from the nipples during suckling, the nipples become erect, and there is a flow of milk towards them. In the desire of children to suck, the lips are placed in a proper position, and the child sucks the air. In the desire for revenge, the satisfaction of which is an injury to the individual who has offended, the natural weapons partly manifest the functions whereby they inflict injury; animals put their stings or claws into action; they eject or pour forth their poison; they endeavour to bite, to strike, to tear; man doubles his fist, stamps, and gnashes, as he would do if actually taking revenge. In terror, the satisfaction of which is the averting of a great impending danger, the struggles for preservation are seen in starting back, stooping, leaping, standing still, &c. In shame, the satisfaction of which emotion is the avoidance of the glance of the person whose contempt we fear to perceive, we drop the eyelids, and endeavour to withdraw ourselves as much as possible from that glance, &c.

ii. That the propensities and emotions connected with imperfect external sensations, excite the mechanical machines appropriate to them to almost as perfect functions as when they act normally (257), is manifest from various facts. In lascivious feelings, an emission not unfrequently takes place; when we lament for a deceased friend, he so often appears before our eyes, that we believe we see him, speak with him, embrace him; when afraid of ghosts, an individual is often in the same condition as if a ghost had actually appeared, &c.

iii. It is equally a general and undoubted observation, that in all the instincts and emotions, as well as in all the desires and aversions, the vital movements of the organism (the respiratory and cardiac movements) are modified. And this change is the greater, the more powerfully the instincts and emotions operate.

iv. That this change in the agreeable instincts and emotions, is in accordance with nature and with healthy action, or con-natural, and in the disagreeable is opposed thereto, or contra-natural is established by universal experience (Haller's 'Physiology,' § 565).

v. Lastly, that those sensational instincts and emotions, whose objects are true external sensations (258), cannot be satisfied without the adjunct of the external impression, is proved by all the pleasures of the senses. The satisfaction of the instincts and emotions must not, however, be confounded with their enfeebling. (*Vide* § 95.)

Actions of the Sensational Instincts in the Mechanical Machines through the Nerves.

262. The sensational[1] instincts in particular may be arranged under four heads:

i. Strong desires which arise from obscure sensational stimuli, and whose object is our preservation and well-being. This is the instinct of *self-preservation*.

ii. Powerful aversions, which arise from obscure sensational

[1] The word *sinnlich* is here translated *sensational*, for want of a better term; but the reader will please to remember the special meaning attached to the word (*vide* notes, §§ 31, 66). It is obvious from the context (§§ 263—269) that these instincts are not *sensational*, because sensation is the *cause* of the instinctive acts, but because sensation *accompanies* the cause, namely, the external senselike impressions. With this understanding, that the word sensational does not indicate *the cause* of the instincts, but simply a certain *condition* of the cause,—it may be properly used here.—ED.

stimuli, and whose object is to prevent our destruction or ill-being. The instinct of *self-defence.*

iii. Strong desires, which arise out of obscure sensational stimuli, and whose object is the propagation of the species by means of copulation. The *instinct of propagation.*

iv. Strong desires and aversions, which arise from obscure sensational stimuli, and whose object is the preservation and well-being of the offspring, and the prevention of its destruction, or its ill-being. The *instinct for offspring.*

263. Since the natural instincts of self-preservation, of well-being, and of propagation, are specially implanted in animals by nature, that these objects may be attained certainly and infallibly, they are distinguished from all other desires, aversions, and passions, firstly, because nature has so placed them under the control of external impressions, and so arranged the natural functions of organs, that animals cannot prevent their manifestation; while, on the contrary, the others are more left to the proper power of the animal to develop, or suppress, increase or diminish, or even to prevent altogether (89, 90). Secondly, the animals themselves, and the whole of nature around them, are so reciprocally adapted, that these instincts never become inactive until their object, or, in other words, the satisfaction of the instinct is fully attained, which is also the object and will of the Creator (95). Consequently, there is in the instincts of animals a something that points to the attainment of a great object of the Creator, a sufficient origin of which is not to be found in the conceptive force alone, but in certain predetermined adaptations external to animals, whereby they are necessitated to follow their instincts according to their organism: this is termed the *wonderful*, the *magical* [Bezauberung], the *divine* in instincts. Consequently, to this extent the blind instincts bear the same relation to other desires and aversions, as external sensations bear to spontaneous conceptions (27, 89). Both are excited conceptions, which cannot arise nor be satisfied, independently of an external impression on the nerves, and which nature has preordained, especially for the former. This, however, requires a more minute investigation.

264. In animals which think, or in all animals, if it be maintained that all have conceptions, the acts to which they are excited by their natural instinct, or in other words, the

movements of the mechanical machines, are sentient actions of certain pleasing or unpleasing sensational *conceptions* (262, 81). Now, since the natural instincts have for their objects, the preservation and well-being of animals, and of their offspring, but the means to these ends are not taught to animals, nor even to man himself by experience, it follows that the conceptions are imparted to them without their knowledge and choice, nay, even against their inclination, by means of previously arranged inducements (external impressions on the nerves), dispersed throughout nature by the Creator, wherein the sensational stimuli lie concealed, which by means of their impression on the brain develop those sentient actions in the mechanical machines according to the laws of the actions of desires and aversions, that have as their object, and in accordance with the views of the Creator, the preservation and well-being of animals or their offspring. Why the Creator has not so restricted the mental faculty, that it could only develop those conceptions which are in accordance with these objects, and none other, is hidden from our knowledge. It is enough that it is not so in nature; but it has been determined so to use the obscurest sensational faculty [Sinnlichkeit] of animals, as to force upon them, as it were, as often and when it appears necessary, such conceptions as must develop in them instinctive actions in accordance with the objects of the Creator; for the obscure sensational conceptions, and especially external sensations, which are the principal means used by nature to this end, are the only conceptions that the mind cannot develop independently and at pleasure, but must receive from the external impression on the nerves, which nature transmits to them (35, 66).

265. The double object of nature, namely, the excitement and the satisfaction of the instincts, is attained thereby; for the obscure feelings which excite them and the external circumstances which satisfy them by means of their external impression, are so numerous at the fixed times and for the appointed objects of each instinct, and the natural hindrances whereby desires and aversions are weakened and do not attain to satisfaction, so few, that the great object of nature in general is always fully attained. Experience proves this irrefragably. At the moment, when, according to the order of nature, an instinct should be put into action, the nerves are certain to

receive the external impressions necessary thereto, and which are appointed, as it were, to this end. For example, when nutriment is necessary to the body, the fluids collected in the empty stomach must impress on it an external impression, which excites the sensational instinct of hunger; when animals ought to propagate their kind, the male inhales from the female during heat an odour which causes the instinct of copulation to be active. On such occasions, even certain external sensations become sensational stimuli to the animal that formerly were not so, or had even a contrary effect, as, for example, the sight or smell of the sexual organs, previously unnoticed or even disagreeable and disgusting, become the sensational stimuli of the strongest sensual pleasure. At the same time, when the instincts are regularly excited into activity in accordance with the object of nature, the circumstances whereby they can be satisfied are so carefully provided for previously, that the satisfaction of the instincts can hardly fail. Thus, hunger is rarely excited in animals that lie dormant through the winter, until they can find food in the fields. So also the instinct of self-preservation operates, when they fatten themselves towards winter, or return into a warmer climate, or creep into a retreat from the cold, no sooner than they have occasion. Lastly, when once the natural instincts are excited, it is difficult to cause them to cease, by means of psychological or physiological hindrances, before they are satisfied, which may, however, be done as to desires, aversions, and even emotions. A hungry, or vindictive, or enamoured person is not easily appeased by artful management, but the satisfaction of the instinct must be effected, that is to say, repletion of the stomach, or accomplishment of copulation, or wreaking of vengeance. Nature, indeed, seems to have actually weakened or diminished those hindrances which on previous occasions moderated or prevented sensational stimuli (47), so that the instincts might break forth without restraint and overcome all obstacles, and continue their appointed time until their satisfaction has been sufficiently repeated. In other desires and even in emotions, the animal withdraws the sensational stimulus voluntarily, being conscious of it, and its effects; but in the instinct it is not conscious of the stimulus as it is only obscurely perceived (262); consequently, its effects are unknown, and the animal is carried blindly on by the instinct. In cases of this kind, the nerves themselves appear to change their nature and to favour the instinct, since they receive new impressions and stimuli, from which they were previously secured; and, lastly, experience also sufficiently shows to us, how little all psychological means avail in weakening the desires and aversions, when moralists apply them to human nature, with the object of preventing the outbreak or satisfaction of its feelings, or restraining them within certain limits.

266. The sensational instincts act in the mechanical machines in accordance with this preordained arrangement, established by the wisdom of the Creator in the whole creation, as well as in the animal kingdom, for their development and for the attainment of their main objects. They are in no way dependent upon an innate wisdom present in the mind of the animal, by which it spontaneously and voluntarily excites these instincts, and their operations in the body (89, 90). And indeed, those actions which in true sensational animals are sentient actions of the sensational instincts, are excited in other animals, or in the former under circumstances in which they can no longer be sentient actions, by precisely the same external impressions (183): as, for example, when a decapitated animal being brought to another, copulates and lays eggs; when a decapitated frog withdraws its leg on its foot being pinched, and leaps away, in accordance with the instinct of self-preservation, &c., of which more in the Second Part of the work. It is manifest, also, that although these animals, in which the instinctive actions are sentient actions, feel the sensational stimuli so strongly, although obscurely, as to long for their gratification, they have not the least knowledge of the objects of the instincts, or why these movements are produced; but, on the contrary, their other actions are not in harmony with those objects, and this is the reason why so much surprise is felt at the stupidity of animals, which otherwise display so much apparent sagacity in the actions appropriate to their natural instincts; as, for example, when a hen, which has trod upon her chicken, hearing its cry, calls it to some food, without at the same time lifting its foot; or when a lobster having one of its legs fixed in and pinched by one of its claws, excited by the pain, violently tears away the limb, instead of opening its claw; or, when a lark, while over the sea, blindly following its instinct to ascend into the air, and to fall

again, descends to the sea, and is drowned. Lastly, experience teaches us, that when men attempt to develop the instincts in themselves or other animals voluntarily, or to regulate, limit, or extend them, they usually fail, and miss the object of nature, which would more rarely happen, if the instincts were blindly allowed to act, without the interference of their own notions.

267. Nevertheless, it is also certain, that the operations of the blind instincts do not appear to harmonise in all cases with the objects of nature: this may arise possibly from the fact, that we do not sufficiently comprehend those objects; or else that the instincts are rendered incapable of their attainment, where their actions are influenced volitionally by the intermingling of the actions of other sentient forces. It is observed, for example, that many animals are not sufficiently taught by their instinct, not to eat or do certain things which are injurious to them. Some eat poisonous herbs without suspicion, and are poisoned. Many exceed their strength so much in the accomplishment of their instincts, that they become quite enfeebled and die. In cases of this kind we are ignorant what are the designs of nature in the implantation of instincts, or what is the object in limiting the sphere of their utility to the personal weal of the animal, and not extending it to all possible cases. To what extent we ourselves hinder the designs of nature in the instincts, and limit their operations by the interference of our will, is shown by their great uncertainty in mankind, and their much greater certainty in those animals which follow them blindly; but especially is it shown in disease, when we attribute that to an instinct of nature, which is only the consequence of intellectual desires.

268. It is requisite to the attainment of the objects of the instincts, that the inducements previously appointed by nature, shall excite the pleasure or suffering, which will develop a certain foreseen future agreeable or unpleasant sensation (94, 262). These sensational stimuli excite that effort which is the instinct itself (80, 83), and the satisfaction of which nature afterwards provides by means prepared beforehand (262). In this development, the natural inducements of the instinct are to be most carefully distinguished from its sensational stimuli,—the latter from the instinct itself,—and the instinct from its contentment or satisfaction. It is thus that we find the whole order of the phenomena of instinct to occur in nature. With the object of causing

an animal to think of supplying itself with food, at certain fixed periods the stomach is emptied of all the food taken into it, and from this emptiness an unpleasant external sensation arises, termed hungriness. This is the sensational stimulusofthe instinct of hunger, which is communicated to the mind by means of the emptiness of the stomach naturally and necessarily; nay, even contrarily to the wish of the animal (27). This unpleasant external sensation reminds it of the contrary pleasant sensation experienced when the stomach was full. From this combination arises the foreseeing and expectation (73) of the agreeable sensation of a full stomach, and the effort of the mind to develop it (81), which is the instinct of hunger, and the contentment of which by eating to satiety, is the object nature had in view in exciting the instinct, so as to provide for the nutrition of the animal (262). When an animal has remained motionless for a length of time, the body becomes sickly, because the functions of all organs go on imperfectly. This is the pre-ordained cause of the instinct of muscular activity, because the sickliness excites unpleasant external sensations, which the animal cannot avoid, and which are the sensational stimuli of the instinct. Out of this unpleasant external sensation of the animal, and the recollection of the well-being experienced when the limbs were moved, arise the foreseeing and expectation of the opposite pleasant sensation of a future movement, and thus results an effort—the instinct of movement—the satisfaction of which by bodily exercise is the design of nature, so as to provide for the well-being of the animal. The same mechanism and series of phenomena may be readily traced in the development of other natural instincts.

269. In thinking animals, all the sentient instincts, together with the sentient actions that accompany them, are thus developed, although obscurely enough, from the natural inducements pre-ordained by the Creator, according to the laws of the conceptive force and of the animal sentient forces; but only on the condition that the animals have lived so long, and felt, thought, and compared so much as to be able to associate imaginations with the sensations induced, and which must develop the foreseeing into instinct (66, 89). But it is impossible to suppose that this takes place with newly born animals, that have scarcely begun to feel, and seem to have no other concep-

tions, yet perform with remarkable readiness and completeness, all the movements, that, as sentient actions, are appropriate to the development and satisfaction of the instincts. No one will be persuaded that the mind of an animal which has never eaten, is led by the sensation of an empty stomach to the idea of agreeable repletion, and that from this is formed the desire to eat; that the mind of an animal which moves voluntarily for the first time, is led by the unpleasant sensation of repose, to the idea that movement has removed this sensation, and out of this is formed the desire to move its limbs; or that the mind of an animal which as yet knows nothing of an enemy, of violence, or of danger, is reminded of the use of its natural weapons (not yet in fact grown), by the sight of an enemy, and that out of this is formed the desire to defend itself. But since at the same time, an instinct cannot be developed naturally in the mind, in any other mode than that just described (268), according to premises already advanced (94), it follows that in the inexperienced animals, and in all not endued with mind, no instincts are developed; but that those movements, which by the analogy of our own nature we conclude to be sentient actions, and which in many thinking animals really are such, may continually be at least true nerve-actions excited by external impressions (183, 89), and that the sensation itself of the external impressions contributes nothing essential towards the production of these movements. It is undoubted, that the regular and adapted development of conceptions and of the entire instinct, accompanies in thinking animals these nerve-actions, which are also developed regularly and adaptively, in accordance with the designs of nature (268), and this with special designs which have been already noticed (184, ii). In this way these nerve-actions are to be considered as sentient actions; as nerve-actions solely, they will be again treated of (439, 454, 551, &c.)

270. The stimuli of the instincts are obscure sensational foreseeings (262), either pleasing or unpleasing, being the imperfect elements of a coming agreeable sensation, or of the opposite to a disagreeable sensation, which becomes perfect, when the instinct is fulfilled, or satisfied (94). Foreseeings of this kind are highly sensational conceptions, almost as involuntary and as necessarily produced as external sensations themselves, of which, as obscure conceptions, the mind is never conscious;

which are scarcely regularly developed in the depths of the mind, to the special astonishment of the animal when conscious of their operations; and which consequently give rise to the magical (bezauberung) in instincts (263). Consequently, just as they differ from the corporeal inducements of the instincts (264), so they must be distinguished from the instinct itself, which is the effort of the conceptive force excited by them, to develop the foreseen agreeable sensation, or the contrary to the disagreeable sensation, although they act in and with it at the same time (80). Thus satiety is the agreeable foreseen sensation in hunger; in the instinct of self-defence, the foreseen sensation is the contrary to the sensation of danger; in the instinct of propagation of the species, that of copulation; and in the instinct to give suck, that of emptying of the mammæ (94, 268).

271. The sentient actions of the stimuli of the instincts, as such, are those of sensational pleasure and pain (88), and considered alone, change consequently the respiratory and cardiac movements (250), but as foreseeings, they express imperfectly the sentient action of the coming sensation (241). Consequently, the vital movements are very strikingly altered in each instinct (262, 258), and movements are partly excited in the mechanical machines, similar to those which are fully developed when the instinct is satisfied (257).

272. The instinct itself, (which is only the effort of the conceptive force to develop the foreseen sensation,) manifests its influence in the mechanical machines, so as to develop the sentient actions of the coming sensation as powerfully as it possibly can, short of the actual contentment of the instinct, or without the intervention of the true sensation therein foreseen. Their nature, laws, and characteristics, may be learnt from previous statements. (Compare 257—261; also 274.)

273. To each kind of sensational conceptions are usually superadded others, which the mind connects therewith spontaneously, and at pleasure, and which develop their sentient actions at the same time, and incidentally to the preceding (219—224, 235, 246), nay, the direct sentient actions of the external sensations, which play so important a part in the instincts, are often felt, and induce subordinate sentient actions of sensations (225, 226), and subordinate instincts which are often conjoined with other instincts, as, for example, the instincts of jealousy,

or of solitude, accompany the instinct of love, whilst in man, the understanding and will often co-operate with the instincts. It follows from hence that many movements occur conjointly with the actions of the instincts, particularly in those animals, which are capable of conceptions only remotely connected with external sensations (27); and thus a highly compound and complicated condition of the mind and the body may arise, which can never be explained by the nature of the instincts, as has been often uselessly attempted, so long as the subordinate conceptions, together with their accompanying actions, are not carefully distinguished from the instinct itself and its acts. If the acts, for example, resulting from the satisfaction of the instinct, be confounded with those of the instinct itself, the greatest mistake is made. And one great reason why the nature and operations of the instincts and passions have been hitherto so imperfectly elucidated is, that they have been characterised confusedly. It will, therefore, be worth while to take an instinct as an example for analysis; and for this purpose I select the instinct of propagation, as the most important and the most complicated.

274. In this instinct, nature in the first instance imparts certain inducements to the animal,—external impressions, which surprise it (in Staunen setzen), and by means of a peculiar action in the sexual organs, prepare the latter for the sensational stimulus of the instinct, so that their nerves become more sensitive to touch, so as to receive the gentle titillation which constitutes the incitement of the instinct. This peculiar impression causes in the minds of animals during heat only, and at no other time, certain external sensations, and other sensational conceptions, in accordance with the prearrangement of nature (265). For example, the odour of an animal of the opposite sex, a sound, a song, a whining, a chirp, a look, or a sensational conception, imagination, or foreseeing of them by an animal in a state of heat, &c., develops the sentient actions in the mechanical machines (sexual organs) assigned to them by nature; for example, an increased flow of fluids to those organs, and the increased secretion of the seminal fluid, and its accumulation in the vesiculæ seminales, in consequence of which they become gently distended and excited; and thus the agreeable external sensation in the sexual organs (the gentle titillation),

is produced, that constitutes the sensational stimulus of the instinct of propagation, and excites it in the mode described above (268), together with all its sentient actions.—(*Vide* Haller's 'Physiology,' § 870). It is manifested by the strong effort of the conceptive force to attain the complete development of the highly pleasurable, obscure, foreseen sensation of copulation (94), and by the sentient actions which accompany this effort (255). The vital movements, consequently, are powerfully influenced by the instinct itself (251, 258). The heart beats with greater force, the heated blood circulates violently, the respiration becomes a sighing, or a corporeally-produced languishing and moaning, as occur from any other similar heated state of the blood: at the same time, the actions of the future sensation, in the satisfaction of the instinct (in this case copulation), become vividly, although incompletely manifested (257), so that the sexual organs are in the same condition as in copulation, and only the external impression is wanting to the satisfaction of the instinct, which the animal often procures incidentally, often experiences normally in copulation. These only are the true, direct, sentient actions of the instinct. It hardly, however, excites these only in the mind; for other conceptions are conjoined therewith, as subordinate sensations (225), and in particular, spontaneous conceptions, imaginations, foreseeings, imperfect sensations (148), other instincts and emotions, and in men even reflections, and desires, and aversions of the intellect, of which the object that gives pleasure is the exciting cause. For example, similar circumstances are remembered in the instinct with their subordinate impressions, scenes from favorite romances are recollected, new images for the foreseeing faculty are produced, and pleasurable anticipations excited, which often grow into imperfect external sensations, so that the individual has the beloved object before his eyes, and thinks that he converses with it (148). All movements of the animal in accordance with these conceptions, and even all influences which these conceptions exercise according to their nature, on the mechanical machines of the body,—as singing, chirping, crowing, whining, and all spontaneous enticements to copulation, are not direct actions of the instinct (103), but incidental sentient actions, contingent on secondary sensations, or on ideas excited spontaneously, or on secondary conceptions, and sensational or intellectual desires and aversions, and their satisfaction, which have nothing further in common with the instinct than that they are usually connected with and accompany it. The spontaneous and voluntary song of birds, the chirping of insects, the whine of dogs, &c., whereby they allure to sexual congress, may be no more considered as direct sentient actions of their instinct, than the suicide of a lover; for all these are sentient actions of voluntary resolves, induced and occasioned in the mind by the instinct, but which may certainly take place without it, although not usually. Gratification of the instinct ends it (95). The intense longing then ceases, the vital movements become quiescent, the sexual organs return to their former condition, and they lose their excitability, for the parts formerly distended and irritated have become empty. But so long as the period of heat continues, the natural inducements and the secondary conceptions accompanying them and the instinct, exercise a continually-renewed influence on the mind and body of the animal, and often re-excite the instinct, until at last, either from its repeated gratification, or its enfeeblement (95), it is no longer re-excited, and its natural inducements in accordance with the designs of nature, lose their magical influence (263). Hence animals allure to sexual congress during the whole period of heat, because their minds are continually occupied with secondary conceptions and instincts, having reference to the predominant instinct, derived from the natural inducements continually acting, and from the sensational stimuli and instincts repeatedly renewed. Hence also man even often desires amorously the satisfaction of the instinct, and is inclined to solitude and jealousy, so long as he is held in enchantment by the object of his passion; all which were impossible, if these conceptions, with their actions, belonged to the gratification of the instinct, and were its direct actions (94, 95).

275. The gratification of the instinct is the actual development of the foreseen sensation, and to attain which end the conceptive force and the animal-sentient forces of the instinct are excited (81, 90). The mental effort consequently ceases, and the sensational stimuli (pleasure or pain) are weakened so soon as satisfaction is attained (83). Consequently, also, the sentient actions cease, the vital movements return to

their usual order, and the imperfect expressions of movements, which, during the gratification of the instinct, become perfect, are abolished. But inasmuch as the gratification of the instinct is itself a sensation, it also, like a true sensation, develops special sentient actions in the mechanical machines, and these do not belong to the instinct. To this class belong the convulsions that occur during the satisfaction of the instinct of sexual congress, being excited by the excessive titillation. When, as in this case, and in all the true blind instincts, the satisfying sensation is an external sensation, the external impression can excite special nerve-actions in the mechanical machines (183), which are altogether foreign to the instinct, and never belong, as such, to its gratification (184, i).

276, i. Although strong sensational desires and aversions, may and do frequently occur, which are not induced or satisfied by external sensations, nor require to those ends an external impression, but which are based on imaginations, fictions, visions, appearances, forebodings, &c., and are satisfied by them, yet still they all arise from sensational stimuli, and are indirectly determined, both as to their excitation and satisfaction, by external impressions (66). But as regards the regular and truly natural instincts, imparted by the Creator to animals for the conservation of their existence and well-being (262), all, so far as we observe them, are excited and satisfied by external sensations, which require true external impressions (258); these are provided before-hand by nature, and so brought into connection with the whole phenomena of life, that they must affect the animal at the right time and place, at such a period, with such intensity, and in such a way, too, that the instinct is duly excited, and at last satisfied in the way already illustrated (265—268).

ii. Since pleasurable and painful feelings derived from external impressions constitute the stronger sensational stimuli (80, 88), such constitute also the most suitable stimuli of the peculiarly natural instincts of animals (262, 90), and nature has, therefore, specially made use of them for the development of the absolutely necessary instincts, so that the latter may be kept in action in animals in the most effectual manner.

iii. No disagreeable external sensation, and therefore no pain, is ever an object of satisfaction to an instinct, but only the agreeable sensation that is the contrary thereof (262, 80, 81).

Even excessively pleasurable feelings, which border upon the contra-natural (199), cease to be an object of gratification, and are abhorred (191, 80, 81).

iv. The sentient actions of the agreeable sensational instincts all agree in this, that if not excessive, they are conformable with the welfare of the body, but if excessive, they are like the sentient actions of the unpleasant instincts, and are opposed to it (259). But inasmuch as all have the best interests of the animal in view (262), the latter are only serviceable so far as they act like medicine, and compel the animal by abnormal actions to pass from a condition injurious to it, and therefore opposed to their object (as, for example, a state of indifference, of pleasure, or of misery), into the opposite and more salutary condition (196).

v. The sensational stimuli, whether pleasurable or painful, which have to excite the curative instincts of the animal (270, 271), operate sometimes in this way, by maintaining the health of the animal, of sometimes contrarily thereto, according as they are either pleasurable or painful (252). Thus fasting, which is the sensational stimulus of hunger, makes us *ill*, and compels us to think of feeding ourselves.

vi. Since the gratification of all instincts is an agreeable external sensation (276, iii), their sentient actions in the body are generally in accordance with its nature and welfare (196), provided they are not excessive (199). Thus the gratification of the appetite for food, for sexual congress, &c., conduces to health, provided the appetites are not excessive; in the latter case, however, they cease to be agreeable, and are abhorred (excite disgust).

277. The combination of so many corporeal influences in each instinct (which act partly from without through the nerves, and are partly sentient actions of various kinds), renders the explanation of the resulting corporeal phenomena peculiarly difficult; a knowledge of the peculiar sources of each of these influences is, however, of considerable assistance. These influences are:

i. The actions of the natural inducements of the instinct. These inducements are external impressions on the nerves, which they prepare before-hand, in a peculiar way, to receive the sensational stimuli proper to the instinct (264).

ii. The sentient actions of the sensational stimuli on the vital movements (271).

iii. The effort of the animal-sentient forces to develop the complete sensation wherein the sensational stimulus is (272).

iv. The sentient actions of all subordinate conceptions (273, 274).

v. The development of the complete sensation, or the satisfaction of the instinct, when it is fulfilled, for which, in the true instincts, an external impression is requisite, and which impressions themselves excite actions (275).

Since the mind cannot voluntarily satisfy the greater number of the instincts, but must await to this end an external impression, which cannot possibly occur immediately (276, i), we can understand the reason, why the instincts and all other sensational desires and aversions in general, to which an external impression is necessary for their satisfaction, often require so long and fruitless an effort of the mind, and such a combined effort of the animal sentient forces; while others, as the instinct to voluntary movement (283), and the desires and aversions of the will, are much calmer, and are satisfied, apparently, with much less effort of the mind and motor forces; for a limb may be moved, as soon as the motion is willed. In the latter class, the satisfying sensation is not an external sensation, but a spontaneous conception of the mind, to the perfect development of which no external impression on the nerves need be awaited. (*Vide* 336).

278. We have now to consider the instincts in detail, in accordance with this general view: with the object of inquiring in what mechanical machines each kind manifests sentient actions; to what end these are manifested; according to what laws; and what is the great result they have in the animal economy by means of the connection between the physical, mechanical, and animal forces of the part in which they act. But since each sensational instinct may be numerously subdivided, we will take only the chiefest into consideration, so as to give the elementary principles of a more detailed doctrine respecting the actions of the instincts.

279. The sensational instincts of self-preservation and self-defence, may be classed together in reference to their objects and natural intent, namely, the preservation and well-being of the animal, and the modes in which those objects are attained (262). In this class, indeed, we place the instincts of

animals to seek dwellings, to keep themselves warm, to escape the dangers of winter, to avoid or avert oppressive sensations, &c., just as properly as the instincts for food, for movement, for rest, &c., although, at the same time, they are defensive instincts. But since certain natural organs have been given to each animal, as weapons for its defence against injurious attacks, and inasmuch as for the proper use of these weapons, it possesses special instincts, which, although defensive, are different from those of self-preservation, we will at least class the war-instinct (Wehrtrieb) with the defensive instincts, but consider all others, which have the maintenance and well-being of the animal as their object, amongst the instincts of self-preservation, although their object be at the same time the averting of dangers, and attained by means of aversions.

Self-love [Selbstliebe].

280. All the changes in an animal organism, which tend to its preservation and well-being, must ensue in accordance with its natural functions, or, at least, terminate in their full attainment (263). Corporeal changes which thus ensue and terminate are agreeable, if felt or perceived, or else soon terminate in agreeable conceptions or sensations (276, iv, 252). On the same grounds all contra-natural changes tend to the ill-being and destruction of the body (263), and if felt, are painful. Consequently, all instincts for the preservation and well-being of the animal, are efforts of the conceptive force to attain to agreeable sensations, and to avoid the painful (262, 257). This general effort in the instincts is termed the *instinct for enjoyment* (80); and since its objects cannot be attained without the continuance of the forces, or, in other words, independently of the *existence* of the animal, it follows that the instinct termed *love of life* is the fundamental instinct in all animals; so that the instinct for life and for enjoyment, that is to say, *sensational self-love* (selfishness [Eignliebe]), instigates all the others.

Instinct for Food.

281. By the pre-arrangement of nature (263), whenever food is wanting, there arises in the stomach of the animal an uneasy sensation termed hungriness [Nuchternheit], and one which every animal dislikes (280). This is the sensational stimulus of the *instinct for food* (Hunger), which consists in a strong effort to excite the sensations in the stomach antagonistic to this unpleasant external sensation, or, in other words, to feel the stomach filled with food; this being the design of the Creator in the instinct and its object in the animal, although the latter knows nothing whatever of that object (266). Everything that excites an unpleasant external sensation in the stomach develops the sensational stimulus of the instinct, as long fasting, a too quick digestion, acrid fluids in the stomach, stomachic remedies, &c. The sensational stimulus manifests its sentient actions in the vital movements, which it influences the more powerfully in proportion as it is excessive (271), as is shown by faintness, in which the movements of the heart, of the blood, and of respiration are manifestly changed, and these actions are contra-natural (276, iv). In so far as the sensational stimulus is a foreseeing of a future repletion of the stomach, it manifests its sentient actions therein, so that it produces imperfectly in the stomach, and in the mechanism of the instinct, the same movements which actual repletion or the satisfaction of the instinct excites (271-72). Hunger, therefore, acts on the mechanical machines appointed to receive food, and to co-operate in nutrition, as the stomach, bowels, throat, salivary glands, &c.; for it stimulates them to discharge their natural functions (170—174), and which repletion of the stomach in particular develops in them. Hence, in hunger, the stomach and intestines are more vividly moved, and rumble (212), the salivary glands pour out fluid, so that the mouth waters, and the other digestive fluids, including the bile, are discharged, &c. We purposely avoid noticing in this, as well as all other special instincts, the sentient actions of all the associated secondary conceptions, so as to avoid confusion in stating the sentient actions proper to the instinct itself. We pass over, also, the processes of digestion, although partly belonging to the subject, inasmuch as it is already discussed in physiological works. (*Vide* Haller's 'Physiology.')

282. By the pre-ordination of nature (263), animals that drink, feel a painful external sensation (280) in the gullet, throat, and mouth, whenever their bodies require more fluids. This is the sensational stimulus of *thirst*, which consists in an effort to produce the sensation antagonistic to this painful sensation; or, in other words, to feel moisture of the parts, which is the intent of nature in the instinct, and its object in animals, although it is concealed from them, and they are quite ignorant why the parts should be moistened (266). Everything which induces this unpleasant sensation, as heat, dust, want of fluids and of saliva, salts, wine, spices, &c., in a word, everything which dries and heats, excites the sensational stimulus and the instinct to drink. The sensational stimulus manifests its sentient actions more strongly and contra-naturally (271, 276, iv) in proportion as it is excessive, as is shown by the oppressive thirst of fevers, &c. Inasmuch as the sensational stimulus is a foreseeing of a moistening of the mouth and throat, it manifests its sentient actions in the parts by a frequent swallowing of the saliva, for the purpose of moistening the mouth and throat, and thereby attaining the object which results from the real act of drinking, or the satisfying of the instinct: the effort of the animal-sentient forces to excite these movements is the sentient action of thirst, or the instinct for drink itself. Thirst acts consequently on the organs predetermined to be moistened,—the tongue, the muscles of deglutition, the throat, &c.,—so that it develops certain movements necessary to the act of drinking, according to the laws of the sentient actions of the sensational instincts (277), which movements become perfect during the resulting quenching of the thirst (257); and in such cases have, as a consequence, beneficial actions in the animal economy, in accordance with the connection of the physical, mechanical, and animal forces of the body, constituting the design of nature in the drinking of animals, and which are specially described in works on the physiology of the peculiar mechanism of animal bodies. (*Vide* Haller's 'Physiology,' § 639.)

Loathing is just the opposite to the instinct for food. The unpleasant external sensation, or idea, of an overloaded or corrupted stomach, excites the mind to develop the antagonistic sensation, the emptying of the stomach, which is accomplished by abstaining from food, and by the act of vomiting, &c.

The Instinct to perform Sensational Voluntary Movements [Zur willkührlichen Bewegung].[1]

283. Nature has ordained bodily exercise to be a means of the preservation and well-being of animals, and thereby they are kept in the best health. When therefore to its injury, exercise of the body is too long neglected, a number of unpleasant sensations are excited, termed indisposition or sickliness, and which all animals abhor (280). These constitute the sensational stimulus of the instinct for bodily exercise, in which the vital movements are more or less morbid, according to the strength of the stimulus, the pulse becoming feverish, and the respiration impeded. By this unpleasant sensational stimulus (induced by long repose, too much sleep, too great corpulency, and many other causes), the animal is induced to make an effort for the opposite agreeable sensations, which it foresees will be obtained by the movement of its muscles and limbs, and this is the intent of nature and the object of the instinct, although the animal does not know for what ulterior purpose it makes the movements (266). The sentient actions of this sensational stimulus, in so far as they are a foreseeing of corporeal exercise are, consequently, developed in the muscles of voluntary motion, that is to say, in those which conceptional impressions can excite to movement independently of any other impression, so that it stimulates those muscles to the same movements that are fully performed during bodily exercise (271). In the effort of the animal-sentient forces to perform these movements imperfectly consists the sentient actions of the instinct to bodily exercise itself (272). This instinct acts, therefore, in the mechanical machines which formerly exercised the body, namely, the muscles of voluntary motion, for it excites them to the performance of their natural functions (161—166), and which especially the gratification of

[1] In a note to § 335, Unzer distinguishes two classes of voluntary movements, namely, the *willkührlich*, or *sensational*, which accompany the sensations and all sensational conceptions; and the *freiwillig*, or *intellectual*, which are excited by the will of the understanding. *Wille* and *Willkühr* are also sometimes used to distinguish these two kinds of will, but more frequently *Willkühr* is used to express both, as in the note referred to, where Unzer distinguishes between the sensational and intellectual *Willkühr*. I know of no English word which corresponds to *Willkührlich*; I have, therefore, termed the actions of voluntary muscles to which Unzer uses it in the stricter sense, *sensational voluntary* movements; but where it is used indefinitely, I have translated it by *voluntary* simply, or *volitional*.—Ed.

the instinct, or bodily exercise, will develop fully (204). Consequently, in this instinct the muscles contract, the limbs are moved irregularly, and the animal often attempts to hop, leap, soar, sit upright, &c., just as actually occurs during the gratification of the instinct for corporeal exercise; and if there be no extraneous impediment, it usually takes place instantaneously, because a conception only, is enough to excite movement in the voluntary muscles. In such cases, there results, in virtue of the connection between the physical, mechanical, and vital forces of the muscles appropriated to voluntary motion, the further operations in the animal economy, such as a modification of the fluids, promotion of secretion and excretion, increase of muscular strength, and of the animal force itself (204), as is the design of nature in the instinct. For details on the subject, works on physiology may be consulted. (*Vide* Haller's 'Physiology,' § 11.)

284. The instincts of animals for *particular kinds of sensational voluntary movements*, are easily understood from the principles laid down in the previous paragraph. The instinct for song of birds, which is usually a secondary instinct of the instinct for propagation, arises from the sensational stimulus of an unpleasant sensation in the chest, produced by changes in the respiration and circulation resulting from the primary instinct, as is also the case in man and other animals in the acts of sighing, sobbing, weeping, moaning, talking, &c. Every inducement of such external sensations, excites the instinct of similar movements. Warmth, which accelerates the movements and impedes respiration, stimulates birds to sing even in winter, in heated rooms, and compels other animals to sigh and pant [lechzen]. Wine, not less an excitant of the vital movements, causes talkativeness; a too crass state of the blood causes melancholy, and weeping, sighing, sobbing, &c. All these movements constitute generally the satisfaction of the instinct itself, the proper sentient actions of which are only previous imperfect manifestations of them, as, for example, instead of singing, a frequent chirping; instead of sighing, sobbing, or weeping, a deep inspiration; instead of speech, a mere sound, &c. To this class belongs also the instinct of laughter in man, which is often secondary to other agreeable instincts and sensations, and is also an accom-

paniment of various pleasures of the senses (250). Its sensational stimulus is an agreeable external sensation, resembling titillation, about the diaphragm, which originates from the vital movements being altered by a vivid feeling of pleasure, particularly of the senses (titillation, § 80). Sensational stimuli to laughter result from everything which excites this sensation at the diaphragm, even by flatulency of the stomach. The instinct is manifested by the well-known contractions of the diaphragm and thoracic and facial muscles, and its gratification is actual laughter. Further, to this class belong other movements, as the migration and hybernation of animals, the acts of cleaning, bathing, swimming, pluming, revolving; the seeking the sun's rays and a warmer climate, the manufacture of clothing which many animals undertake (as in forming cocoons), the preparation of habitations, the establishment of republics amongst beavers, bees, and ants, if we presuppose that these animals all think. All these follow the laws of the primary instinct for bodily movement, and have all as a basis, certain obscure pleasant or unpleasant sensations, whereby the animal is induced to attempt certain movements without knowing the ulterior object to be gained, but which, according to the plans of nature, are actually accomplished with the co-operation of external impressions, for the purpose of securing the preservation and well-being of the animal.

285. It has not been to this day decided, whether the respiratory movements are mechanical or volitional. Generally, they are neither the one nor the other (Haller's 'Physiology,' § 274), but manifestly the sentient actions of an instinct. So soon as they are suspended, a distressing external sensation arises in the chest, which is abhorred (280). This is the sensational stimulus of the instinct of respiration, namely, the strong desire to produce the opposite to this anxious state, which we remember to be attained by respiring. The desire to breathe consequently arises, the performance of which function is the design of nature and the object of the animal in the instinct, although of its further ends the animal is quite ignorant (266). The sensational stimulus, namely, the unpleasant external sensation, manifests its action on the vital movements (which are the more widely influenced in proportion as it is excessive, § 271) by a contra-natural and powerful beating of the heart (276, iv,

252), and in as far as it is a foreseeing of a future agreeable sensation of respiration, causes the necessary respiratory movements imperfectly (271). The instinct itself brings forth the effort of the animal-sentient forces to produce these same imperfect respiratory movements (272), and acts consequently on the parts subservient to respiration, the diaphragm, the muscles, &c., since it stimulates these to their natural functions, and which the satisfaction of the instinct, namely, respiration produces perfectly (208, 214). The result is, that in this instinct the mouth is opened, the muscles exert themselves to raise the ribs, and the diaphragm is forced downwards, being evidently the movements necessary to respiration, which continue, according to the laws of the actions of sensational instincts, until respiration is actually restored (257); then there results, according to the connection of the physical, mechanical, and animal forces of the parts subservient to respiration, further actions in the animal economy, namely, the expansion and contraction of the lungs, the determination of the circulation of the blood, the cooling of the blood, perhaps the transformation of the chyle into blood, and many other uses, in accordance with the design of nature, which may be learnt in detail in works on physiology. (*Vide* Haller, § 8.) Since in the natural condition, animals are able to satisfy this instinct volitionally almost instantaneously after birth, it does not continue so long a mere instinct as others, and probably this is the sole reason why respiration has not been hitherto recognised as the sentient action of an instinct. Haller has fully shown, that it is a sentient action, (*vide* §§ 268, 273, of that great man's 'Physiology,' for a lucid explanation of the question;) and it is surprising, that his doctrine has not only been opposed, but he has even been blamed for advancing it.

Other questions arising out of this subject will be referred to again (526), or may be solved by the principles already stated. Of this kind are the questions, whether respiration be not at first and in the newly-born a nerve-action, or whether it be not rather a nerve action in them (269) continued afterwards by the co-operation of a sentient instinct (183), resulting from the habit of sensation in the machines (51); or whether it is not so little mechanical, that at each retardation of the respiration the instinct scarcely induces its recommencement, but it is regulated by sensational and intellectual volitions, according to the requirements of other instincts, emotions, intellectual desires, &c., into laughing, or weeping, or sighing, speaking, &c. It is incontrovertible, that these, together with groaning, sobbing, cooing, moaning, screaming, coughing, whistling, sneezing, and all other changes of the respiratory movements which are caused by external sensations or obscure complex conceptions, are in so far true sentient actions of satisfied instincts, since the respiratory actions generally belong to this class.

286. It is manifest from the considerations already advanced, that there are two classes of instincts; the one comprising those in which the acts are under the control of the animal, so that they can be induced or intermitted at will (283—285); the other, comprising those in which the acts are the purely corporeal functions of the mechanical machines, as in hunger and thirst (281, 282). There are some instincts of both classes, however, which gradually change into one or the other class. Thus, at first, in children and animals the unpleasant external sensations resulting from accumulation in the bladder and rectum, and which bring the appropriate instinct into operation, are relieved in a natural and necessary manner, because the sphincter muscles are compelled by mere physical pressure to permit the exit of accumulated excretions; afterwards, however, this takes place when the unpleasant external sensation is again felt, by a voluntary relaxation of the sphincters. In the same way, the first respiratory movement in a newly-born animal is probably the natural and necessary result of a very obscure external sensation; but, afterwards, it takes place by a voluntary movement of the thorax on the recurrence of the unpleasant sensation (285). And, on the contrary, we seek at first to avoid many pains and other unpleasant external sensations by voluntary movements, which afterwards become purely automatic, as, for example, shouting, writhing, and retracting when in pain; the quickened walk and the drawing up of the legs to the body in severe cold; the contraction of the eyelids in a strong light; and a thousand other movements, the objects of instincts, formerly volitional, but become mechanical from frequent repetition. Neither can we infer that the sentient actions of an instinct which, in us or in another animal, are

volitional movements, must have been such formerly, or will be for the future, or are such in any other creature.

The Instinct for Repose and Exhilaration.

287, i. The animal-sentient forces are exhausted by long activity, and the destruction of the animal would result therefrom if nature had not previously provided against this cause of exhaustion. When the animal-sentient forces (that is to say, the forces of the material ideas, as they may be now considered, in so far as they cause conceptions or sentient actions,) have been uninterruptedly used by the animal for so long a time that any further effort would be injurious, it feels during thought or during the performance of the sentient actions in the body an unpleasant difficulty, which has been termed *lassitude, weariness,* or *fatigue* (280). This unpleasant sensation is the natural stimulus of the instinct for repose or sleep, which instinct consists in an effort to develop the contrary to this unpleasant sensation, that is, the withdrawal of the mind from the wearying thoughts, and letting the animal-sentient forces be inactive, so as to experience the sweetness of repose, and thereby collect new forces, as is the design of the Creator in the instinct and its object with the animal, although the latter knows nothing of the actual intent, namely, the renewal of the strength (266). Everything which causes the unpleasant sensation of lassitude develops the sensational stimulus for repose, and the instinct itself, the longing for repose. Causes of this kind are hardships, every long-continued movement, meditation, and all long-continued thought, attention, reflection, and abstraction (77); also articles of food, or medicines, which interrupt the animal-sentient forces, as wine, opium, heavy meals, pressure in or upon the brain, the plethoric state, various poisons, and numerous others. The sensational stimulus, namely, the disagreeable external sensation of weariness, manifests its sentient action in the cardiac and respiratory movements (271), which are at first languid almost to faintness; but in a higher degree the stimulus becomes feverish, and these actions become contra-natural (276, iv. See also Haller 'Physiology,' § 580). In so far as the sensational stimulus is a foreseeing of the future sweet repose (the contrary to the disagreeable feeling of lassitude), it manifests its sentient actions in the parts appropriated to the animal-sentient forces, so that it develops imperfectly the future state of repose (271); and in fact, in the straining of the animal-sentient forces and the effort of the mind to withdraw as much as possible from all external sensations, and spontaneous conceptions, and thereby to interrupt all their sentient actions in the body, consists the sentient actions of the instinct to repose itself (272), so that the organs which co-operate in the act of thinking, and which produce sentient actions, are compelled involuntarily, by the soul and by a purely corporeal process, to cease their functions (270, 49, 51). Consequently, during the instinct to repose and sleep, the external sensations derived from external impressions, and from the spontaneous conceptions are gradually lost, in consequence of the enfeebling of their material ideas in the brain; the muscles, in so far as they perform sentient actions, move heavily, and let the limbs sink; the eyelids shut, and the whole body totters. In short, the instinct induces imperfectly that condition which comes on when the instinct is satisfied by rest or sleep, and there results from the connection between the physical, mechanical, and animal forces, the repose and renewal of the forces appropriate to sentient actions, in accordance with the object of nature in establishing the instinct (*vide* Haller's 'Physiology,' §§ 578—590).

ii. Yawning and stretching are rather sentient actions of the *instinct for exhilaration*, than for rest. For when we feel the unpleasant condition of languor and weariness, we can attain its opposite by new efforts of the animal-sentient forces, as well as by their periodical relaxation during sleep. If, therefore, the obscure stimulus leads us to the former, we then express the anticipated condition of renewed activity of the animal-sentient forces, by imperfect efforts, to which the agreeable obscure foreseeing of the condition of activity excites us. Consequently, although these movements are doubtless signs of weariness, and of the need for sleep, yet they are not sentient actions of the instinct for sleep, but of the instinct for activity, or the waking state. All circumstances that excite the obscure foreseeing of pleasing exhilaration, and, consequently, the above-mentioned causes of weariness render the instinct active, if we desire the antagonistic condition, namely exhilarated activity. Now, as the sight of another person who yawns or stretches himself, reminds us of this condition antagonistic to disagreeable weariness, it leads us to the instinct for exhilaration, and we stretch and yawn with the person.

iii. It still remains to state specially, with reference to the instinct for repose, that the physical and mechanical forces of the machines of animal bodies, as also the *vis nervosa* on which nerve-actions are dependent, in so far as they are not also at the same time sentient actions, are not subject to this law of nature, namely, that their uninterrupted activity shall cause unpleasant external sensations, and, consequently, induce the stimuli of the instinct for repose and sleep. The formation of the blood, and its continuous internal movement, together with its circulation; the working of the elasticity and other purely physical and mechanical forces of the machines; nay, all those processes of the mechanical machines which during the waking state are sentient actions, but at the same time may be and commonly are, even during the waking state, purely nerve-actions (183), as, for example, the movements of the heart, stomach, intestines, and various muscles, particularly the muscles of respiration (285), all these, as such, are never accompanied by a sensation of fatigue, never excite the instinct for repose, never stand in need of repose, are never changed by this instinct, nor directly by its satisfaction during the deepest sleep, but go on continuously, and take no further part in it unless they are at the same time sentient actions, or indirectly influenced through the general connection of all the forces of the animal (Haller's 'Physiology,' § 579). On these principles, all the phenomena of the animal economy, which depend upon the sensational stimulus to sleep, on the instinct itself, and on the satisfaction of the instinct, or the act of sleeping, may be very readily explained.

The Instinct of Self-Defence.

288. Just as nature has supplied every animal with mechanical machines (organs), which serve as the instruments of the instincts for self-preservation, for they receive both the external sensational stimuli that excite these instincts and the external sensations that satisfy them (281—285); nay, just as every creature is taught and enjoined by other instincts to

furnish themselves with such instruments for self-preservation as spiders, for example, which weave nets to take their food more readily, or caterpillars, which spin a net around themselves for the purpose of undergoing their transformations undisturbed, &c., so also she has fitted out every animal with special instruments (mechanical machines) for the other instincts of self-defence and propagation of the species, which are partly adapted to receive the sensational stimuli that excite these instincts and partly subservient to the gratification of the instincts, without the animal knowing their objects, or the causes of the movements (266). The instruments appropriated to the instinct of self-defence (262) are termed the *natural weapons* of the animal, and each is provided with particular kinds of weapons, adapted to avert its greatest and most probable dangers, and appropriate to the objects of nature in the satisfying the instinct of self-defence. Thus, the soft animals, which are easily crushed, are surrounded with hard shells; those which are appointed to be pursued and eaten by other animals possess instruments whereby they can inflict as much injury on their pursuers, as may be necessary to check the pursuit; teeth for biting, poisons, stings, talons for wounding, hoofs for striking, claws for lacerating, &c. The animals themselves are ignorant that they possess these weapons, or, at least, of the object of nature in furnishing them (266). They do not make use of them with a deliberate design, but are impelled by their instinct to undertake blindly the otherwise voluntary movements of the organs which are furnished with weapons, whereby these become subservient to self defence without the knowledge of the animal. Consequently, many animals, when they find themselves in danger, make such defensive movements, although their limbs are not yet supplied with the weapons, or have lost them, and although the weapons are useless against such dangers; they bite at a stone, they sting at the air, they spurt out their poison without knowing where, they strike at a thorn-bush or a wall, they even scratch or bite themselves, &c. Now, since the instincts of self-defence are really none other than instincts to voluntary movements manifested in armed organs, they are subject to the same laws as that class. (*Vide* §§ 283, 284.)

The Instinct for the Propagation of the Species.

289. By the pre-ordination of nature (263), with a view to the continuation of the species, there arises in animals an agreeable external sensation, the sensational stimulus of the instinct for propagation, the sentient actions of which are manifested by remarkably active vital movements (253,—Haller's 'Physiology,' § 870), and this arises at a time when the organism is in the most suitable state, at a certain age, during a fixed period of existence, for the most part periodically, in the sexual organs given by nature for this express object, by means of natural inducements prepared beforehand, and already described (268, 874); these depend on a plethoric state, nutritious food, or food stimulating the nerves of the sexual organs, wine, condiments, much rest, idleness, good living, freedom from care, and various external sensations and other conceptions. In man, who, as regards his instincts, is subject to the same laws as brutes, this sensational stimulus is induced by a glance, an imagination, a foreseeing, which surprises him without his desire or even against it; and he terms this operation which amazes him, this wonderful change (263), the *enchantment of love*. He is so little informed as to the design of nature in this wondrous emotion, that at first he considers it to be the feeling of friendship or of great esteem, in short, to be a noble instinct, not arising from sensual stimuli, until at last he learns, from its influence on the sexual organs, that it tends to an object not observed by him, the excitement of the flesh (88), and that it is the instinct for sexual congress, to which all the stimuli converge. In both sexes, the instinct consists in the desire to enjoy this sensual pleasure in the greatest degree which takes place *in coitu*. Consequently, just as sexual congress is the design of nature in this instinct (265), so is it also its object in animals, which know nothing more of the ulterior object, namely, the propagation of the species (266). The sentient actions of the obscure foreseeing of an agreeable external sensation, are manifested imperfectly as they actually occur (271), and in the effort of the animal-sentient forces to attain to these imperfect movements consist the sentient actions of the instinct itself. The instinct acts, consequently, in the mechanical

machines which have to accomplish sexual congress, namely, the organs of generation, since it stimulates them to their appropriate functions (178-179), and in particular is developed fully the satisfaction of the instinct, namely, sexual congress. Hence we understand why in this instinct the organs of generation fall into the same state as in coitus (217), that state being induced according to the laws of the sentient actions of sensational instincts. These incomplete movements becoming complete in the satisfaction of this instinct, in accordance with the designs of nature, other phenomena having reference to the propagation of the species, result, as impregnation, conception, the formation and nutrition of the embryo, and, lastly, its birth, an account of which may be found in works on the Physiology of the Special Mechanism of Animal Bodies. (Haller's 'Physiology,' 28th Division.)

The Instinct to give Suck.

290. The instinct to suckle is one of the most remarkable of the instincts of parent animals for their offspring. It arises by the prevision of nature in the maternal animal, which gives suck even at the period when a young creature is about to be born, and in consequence of an unpleasant external sensation from the distension of the mammæ with milk, which is the sensational stimulus of the instinct. Everything that induces this sensation in the mammæ, excites the instinct to give suck; so that bitches, whose mammæ swell about the time when they ought to whelp, have the instinct fully developed, although not in pup at the time, and willingly allow a strange dog to suckle them. The instinct itself is a strong desire to attain to the sensation contrary to that of painful distension, or in other words, a desire to empty the mammæ, which is the design of nature, as well as the object of the animal, although it is otherwise ignorant to what end the sucking of its mammæ subserves. The painful sensational stimulus changes the vital movements contra-naturally (271, 276, iv), as is proved by the great uneasiness, and by the milk fever; and, as a foreseeing of a future agreeable sensation of suckling, manifests its sentient actions in such a way, that it stimulates the mammæ to similar functions, and partly develops them according to the laws of the

actions of sensational instincts (271-72, 277), as sentient actions actually requisite to suckling, and resulting from the completion of the instinct; so that, for example, the milk fever, whereby the milk is produced, supervenes, and the nipples are erected (105, 247). The sentient actions of the instinct itself consist in the effort of the animal-sentient forces to attain these same imperfect movements (272), and through these, by means of the connection of the physical, mechanical, and animal forces of the organs adapted for suckling, the further operations in the animal economy are attained, as the emptying of the mammæ, a more free circulation in them, the further quiet secretion of good milk from the glands, and the prevention of induration and impaction, all in accordance with the design of nature in the instinct. (*Vide* Haller's 'Physiology,' § 133.) It is obvious from common experience, how this instinct is adapted to another in the offspring, namely, the *instinct to suck*; but inasmuch as this is only a particular form of the instinct for food already treated of at length (281-82) it is unnecessary to enter here into detail.

291. It would be equally unnecessary (and perhaps wearying) to go through the other instincts in detail, inasmuch as the preceding explanations and principles are applicable to all. We need only here state the general laws by which the phenomena must be explained, which the sensational instincts develop in the animal economy. Whether all these phenomena be always true sentient actions from sentient instincts, or always such in all animals, or whether they are in some degree, or altogether, nerve-actions (183), as has been often mentioned (266, 269, 285), all these questions must be left undetermined, until we come to the Second Part of the work. It is sufficient to state at present, that the phenomena of the instincts, in so far as they are true sentient actions, can be explained on no other principles than those hitherto laid down. Nevertheless, it will not be useless to prepare the reader for the doctrines of the Second Part by a few general statements and deductions.

292. It is indubitably clear, from the nature of the instincts, that the true sensational instincts, together with their sentient actions, result naturally and necessarily from external impressions, much in the same way as external sensations and

their sentient actions arise from external impressions, transmitted to the brain (266, 269; 281—290). Although they appear to be actions meditated on, and willed for a special object, they occur without any other aim than those that relate to the external sensation of satisfaction of the instinct, there being no knowledge of the inducements or incitants,—of the ulterior objects of the instinct,—or of the intention of nature. It would be most erroneous to infer, that the skilfully adapted actions of animal instincts are the operations of a sensational understanding or wisdom, and the result of thought. The animal is not only ignorant of the inducements of its instincts, but they act in spite of it. The obscure sensational stimuli of the instinct spring from these inducements, also without the knowledge or preference of the animal, and without its being able to reason regarding them (264, 270). From these stimuli the instinct results, according to the eternal laws of the conceptive force (81, 94), naturally and necessarily, since no animal can prevent itself desiring or avoiding sensationally that which has once become unavoidably pleasant or unpleasant (80, 81). This effort of the mind is forcibly directed to the attainment of the satisfaction of the instinct without a knowledge of the means, or, at least, of their use (266); nature provides them for the animal, and brings them so near to it, that it cannot avoid them; consequently it cannot suppress the instinct, or avoid its gratification, by means of the reason or the will, as man, in many instances, is able to do. Lastly, the animal enjoys the pleasing external sensation accompanying the gratification of the instinct blindly and quietly, without a knowledge of its ulterior objects, and without troubling itself in the least about them (266). Now, since all this applies to the sensational instincts, it is equally applicable to their voluntary movements (283, 284), and consequently it is also a mistake to consider these as the result of reason and reflection.

293. But this is not all; for it can be proved, that these various instinctive actions are, under varying circumstances, only nerve-actions (183, 269), and can take place without any external sensations or conceptions whatever, as will be demonstrated in the Second Part of this work (see § 561), and that it is consequently an error to conclude, that the apparent care of animals for themselves and their young, the wise

use of means to these ends, &c., prove the existence of a soul in them.

294. The instincts of self-preservation and of the propagation of the species are common to all animals, and there are therefore *general instincts*, as the love of life, of pleasure,—the instinct for food, for sexual congress, &c. There are also *special instincts*, which are peculiar to certain animals, as the instinct to breathe, to incubate, to take care of offspring, &c.; these are regulated in their development by the special wants of the animal, and hence a manifestation in instinct *of the Godlike, the adapting*. An animal, for example, which has not to seek its food in water, has no instinct and no adaptation for swimming: the animal, whose eggs are hatched by the sun, has no instinct for incubation: the animal, which has not to seek its food underground, has neither the instinct to dig, nor the claws to dig with, &c.

295. Every instinct excites the development of a special class of conceptions, which constitute the object and satisfaction of the instinct, and are, at the same time, either in accordance with the desires of nature or not (263). If they be the former, they are *natural instincts*; if the latter, *unnatural* (90); as the instinct for self-torture, for suicide, sodomy, &c. The latter never occur in animals left solely to nature, and only in those which have the power to combine them with volitional conceptions. The instinct of an animal for that class of conceptions which are most common to it, because it finds the greatest pleasure in them, and whereby its volitional actions are determined, is termed its *leading instinct*; and this gives rise to the peculiar characteristics of the animal, or its *animal* or *sensational character* [Character seiner sinnlichkeit]. According as the instincts are vigorous or weak, the animal is said to be active, vigorous, &c., or dull, lazy, inactive.

The Instinctive Passions [Affectentriebe].

296. The primary passions are not excited, nor their satisfaction designedly attained, by inducements prepared beforehand by nature, as is the case with the true instincts (263). We are affected by passions for the most part incidentally, certainly not periodically, nor by a corporeal compulsory cause

unknown to us, but volitionally, and with the consciousness of the sensational impulses. We can often avoid or weaken the sensational stimuli at will, so as to prevent the passion; or, on the contrary, seek and strengthen them so as to excite it. During the access of the passions, we have often more power than in the instincts to increase or diminish them at will, and more means of weakening them without satisfying them, because we know their objects. An angry man can more readily mitigate his passion without avenging himself, than a hungry man can quiet his instinct without taking food. A man can often avoid at will every inducement to anger, but hunger arises naturally and necessarily, without our knowledge, as soon as its cause is induced in the stomach. And here it must be observed, that the passions are often not primary, but are excited in us by sensational instincts, and as these are in close relation with the instincts, they may be termed instinctive passions (affectentriebe).

297. The main difference between the passions and instincts consists in this, that in the former we are conscious of the sensational excitants, in the latter we are unconscious (90, 91). The secondary conceptions in the former may be weakened by abstraction, or antagonised, or rendered more vivid at will; whereas in the instincts; their object cannot be brought voluntarily into relation with the secondary conceptions, since the object is unknown (273, 304).

298. When in the course of an instinct in an animal capable of pure conceptions, the obscure sensational stimulus is comprehended, although it is still sensational and confused, a passion is excited in and by the instinct, or an *instinctive passion* (90, 91). The instinctive passions are at first instincts, which become passions during their continuance. Consequently they arise from the natural excitants of the instinct, and manifest like them the *Wonderful* (263); but with this difference, that during their continuance the sensational volition of the animal is combined with the natural impulse to obtain the satisfaction of the instinct: thus a voluntary power over it is attained. We will consider briefly the more prominent instinctive passions from this point of view.

299. Animals are impelled by nature to a love of life, without knowing why; they are blindly led to abhor the

danger of destruction. Nature, without their aid, has prepared beforehand for them the means of defending their life without any knowledge of the object to be attained (285, 266, 280). But when they become conscious of the object of their aversion, namely, the danger of death, the designs of nature hitherto blindly followed become their own, and nature and the sensational volition of the animal co-operate to attain the same object, so that the sentient actions now result as well from the sensational inclination of the animal, as naturally and necessarily from the instinct. Yet, although the animal still follows the impulse of nature, it follows it willingly, since from a consciousness of the object of the blind instinct of life, the latter is changed into an instinctive emotion, the *fear of death*. It is led by this knowledge to a sensational volition, whereby it brings other conceptions, desires, instincts, and emotions, which arise from it, according to the laws of the conceptive force (273), to bear on the object now known, so as to obtain the fulfilment of the instinct. It is thus we understand the differences between passions and instincts. In the primary passions, the natural impulse which characterises the instinct is not present (263): in pure instincts, the volitional element is wanting: in the instinctive passions (or emotional instincts), both are united.

300. In the instincts of hunger and thirst, animals eat and drink before they can know that food and drink induce that pleasant external sensation, which constitutes the satisfaction of the instinct. But if the animal become conscious of the object of the instinct, the volitional element is added, and the blind impulse of nature co-operates with the inclination of the animal to attain it. The blind instinct is become the volitional instinct for food, *the appetite, gluttony, longing for drinks.* The perception of the object leads to a sensational volition, and thus other conceptions, desires, instincts, and passions are brought to bear on its attainment, and the volitional actions of *voracity* and *rapacity* are manifested.

301. The *war-instinct*, a form of the instinct of self-defence, stimulates animals to the blind use of the natural weapons which nature has supplied, together with skill to use them. They know nothing of the object (the injury of another) to be gained by their use, so that they perform the requisite

movements before they actually possess the weapons (288, 266, 269). But if a knowledge of the object of the instinct be added, namely, an infliction of an injury upon another, the volitional element is added, so that the will and the impulse of nature co-operate for the attainment of the same object, and the blind instinct becomes the instinctive passion of *self-defence*. A sensational volition follows this perception of the object of the instinct, and other conceptions, desires and passions are brought to bear on its attainment, whereby the volitional actions of the *desire of revenge* are manifested in the skilful and revengeful use of the natural weapons, as, for example, in selecting the most dangerous point to inflict injury, in the most crafty and violent infliction of it, &c., and in discriminating the objects which should be feared and avoided, or pursued and seized.

Anger [Zorn] is always a passion, and never an emotional instinct, because it consists in an abhorrence of a known injury, of which consequently we are conscious. Animals that possess no pure conceptions, and are incapable of primary passions, never experience it; nor is it even an emotional instinct in them, as the desire of revenge is [Rachgier], but a passion subordinate to the latter, developed by the instinct of self-defence. Anger can excite the *desire* of *revenge* as a subordinate passion, and then the latter is not an emotional instinct, but a passion combined with another passion, namely, anger. The special sentient action of anger on the liver, &c., will be considered subsequently (see § 325).

302. In the sexual instinct, as in the preceding, nature impels animals to the blind use of the organs with which she has supplied them, as well as with the knowledge how to use them; without their being aware that they will thereby propagate the species. It would appear, indeed, that no animal, except man, is aware of this object. But even the immediate object of nature in the instinct, namely, pleasure, is unknown to many animals, so that they are stimulated solely by the blind instinct to the use of the organs of generation (269). But when an animal is conscious of this immediate object of the instinct, namely, pleasure in sexual congress, the blind instinct is combined in its action with the sensational will of the animal, and becomes the instinctive passion of *physical*

love (not the *passion of love*, § 308). Other conceptions, desires, instincts, and passions, are brought to bear upon the object by the sensational volition of the animal, so that the fulfilment of the instinct may be attained. Thus the volitional actions of *lasciviousness, jealousy, amorous enticements*, as well as the discrimination of the beloved object and its sensational selection from all others, are to be explained. As a pure instinct, there is no knowledge of its object and intent; so that, even man, so long as it does not attain to be an instinctive passion, does not know how to investigate the origin of his enchantment and mental disorder (263). He never imagines, that the final object of the strange disquiet which thrills through his whole frame is sexual congress; and amidst the effort, he literally does not know what he wishes, until the blind instinct becomes an emotional instinct, and opens his eyes (289). If amorousness were a primary passion, it would not be accompanied by the natural impulse; it would be a sensational desire for sexual congress more gentle and more volitional, never found in animals, although sometimes in man.

303. The maternal instinct is usually excited blindly and naturally. The parent animal knows neither why she broods, nor what she hatches or gives birth to. She tends, allures, covers, nourishes, and protects her young, blindly: nay, will perform these offices for young animals she has never known before, and which require attentions entirely different from those she affords, consequently, without any knowledge of the objects or aims of the instinct. When, however, an animal becomes conscious of these, the volition co-operates with the impulse of the instinct, and we have the emotional instinct of *love of offspring*. This consciousness induces acts of sensational volition, whereby other conceptions, desires, instincts, and passions are directed towards the attainment of the objects of the instinct, and thus the various actions connected with the care of the young are developed.

304. But although in the instinctive passions or emotional instincts, animals readily perform, by acts of sensational will, that which nature works in them, naturally and necessarily, by means of the instinct, and whether they will co-operate or not; still, as is to be shown subsequently (348), the mind has not only no command over the conceptions and desires which it

directs by sensational volitions towards the objects of the instinct, but it is prevented applying them in any other way than in advancing the sensational pleasure, and in attaining the object of the instinct, by the general instinct for enjoyment (280), by the power of the spell of the instinct (263), and by the close dependence of all complex sensational desires and aversions, particularly of the emotional instincts (298), upon the sensational faculty (Sinnlichkeit) (89). By these views we can explain, why all animals, endowed though they be with sensational volition and with free-will, when in circumstances to encourage, excite, increase, or ennoble certain morally good emotional instincts, or to avoid, repress, diminish, or counteract the morally evil, have a natural infirmity to lean to the side of instinct, and not to deduce from its morality any motives for their voluntary conduct.

Actions of the Passions through the Nerves in the Mechanical Machines.

305. The primary passions arise from pure but still confused sensational stimuli, of which we are conscious, and not from instincts (91). They are free from the powerful impulse of the latter, or, at least, more free than the emotional instincts; and constitute, therefore, an entirely different class of desires, more volitional, and less under the control of the sensational faculty, although always sensational, and only half spontaneous conceptions (27, 66, 89). The direct sentient actions of these desires, and their general laws, have been already laid down (255, 261). The incidental are in all respects analogous to the incidental conceptions in the instincts, and subject to the same laws (273). The desires and subordinate conceptions, which are spontaneous, volitional, and incidental, influence the passions more, either in strengthening or restraining them, according to the pleasure of the animal, although they seldom act in any other way than that most favorable to the instinct of self-love (304). It is, therefore, only necessary here, to distinguish the sentient actions peculiar to each passion; and we will limit our inquiry to the principal of them.

306. Every agreeable passion (*joy*, § 259), is a strong desire arising from confused sensational incitements (91, 94), developed

according to the general laws of the passions. It must be distinguished from the *instinct for enjoyment* (280), in which the object of the pleasure is neither known nor distinguished (262), while in every kind of joy the animal is conscious of the object, although imperfectly. In *joyousness*, there is a future agreeable thing anticipated from the present, in *contentment*, from the past, in *hope*, from the future, (Baumgarten's 'Metaphysics,' § 505 :) and since, consequently, the various species of joy do not arise out of instincts (262), they are never instinctive passions. Their sentient actions are compounded of those of a sensational pleasure and a confused sensational foreseeing (257, 258). Joy for honour is termed *ambition*; for the perfections of another, *love* (the passion); in the various relations of the beloved to the loved, *gratitude, compassion, kindness, benevolence,* &c. (Baumgarten's 'Metaphysics,' § 506.)

307. In as far as every kind of joyous passion is pleasure, their sentient actions act upon the vital movements beneficially for the health (259). They excite the circulation, and further all the natural functions and secretions, especially that of insensible transpiration, and give a sensation of lightness of the body: the last is more particularly felt in joy, contentment, and hope. If violent, however, they act contra-naturally (259), so that great and sudden joy renders the transpiration excessive, or the heart acts too violently, and so brings on an apopletic fit, or causes paralysis of the heart by excessive distension, and sudden death is induced. The gentle calm feelings of satisfaction and contentment, maintained continuously and equally, and the practice of the gentler virtues, conduce, consequently, to health and long life, more than violent emotions of joy and happiness (252). Nevertheless, various diseases of the body, dependent upon contra-natural changes, or upon enfeebled vital movements, maybe cured by joyous emotion.

The sentient actions of joyous emotions, which result from the foreseeing of their object, imperfectly express the condition of their satisfaction (257), and are for the most part volitional movements, such as dancing, leaping, laughing, singing, speaking, and similar actions which accompany the actual enjoyment of a vivid sensational pleasure, and the secondary conceptions and desires thereby excited. These volitional movements are excited in the emotions and instincts in a similar manner (*vide* § 283—5). Everythiug that excites a vivid sensational pleasure can induce the joyous emotions, as wine, music, society, jests, the gratification of other desires, stimulating sensations, imaginations, foreseeings, &c.

308. Every form of the emotion of love, as kindness, friendship, gratitude, pity, and the benevolent virtues, are a species of gentle joy for the perfection of another (306), and manifest the sentient actions of the joyous emotions in a moderate degree. Inasmuch as these are very favorable to health and long life (307), it is a truth established by experience, that a misanthropic or malicious person is his own enemy, and that goodness is its own reward. These nobler passions must not be confounded, however, with the instincts or the instinctive emotions of love, for they arise primarily from pure perceptions (91), and have sensational stimuli and objects of satisfaction, altogether different from those of the latter. Every kind of perfection which we observe in another can excite in us the passion of love, while there is only one sensational stimulus of the *instinctive* passion of love.

309. Every painful emotion (*distress*, § 259), is a strong abhorrence excited by confused sensational impulses (91), developed according to the general laws of the passions (94), and consequently belonging neither to the class of instincts or of instinctive emotions. Their mental actions are made up of those of a sensational annoyance and a sensational confused foreseeing (257—8). Distress for the past, in reference to future consequences, is *regret;* for the present in reference to the future, is *grief;* and for the future itself, is *anxiety, care, dread, despair.* To this class belong also the passion excited by the delay of what is longed for, *longing;* or by the imperfection of another, *sympathy;* or by contempt inflicted or anticipated, *shame;* or by the perfection of another, *hatred;* or by a coveted perfection, *envy;* or by an offence, *anger;* or by the desire to retaliate on the offender, *revenge;* or, lastly, by a sudden, unexpected, and great evil, *terror* (Baumgarten's 'Metaphysics,' §§ 507, 508). Each of these passions have their peculiar sentient actions in the animal economy.

310. The sentient actions of the distressing passions in

general, and of *sorrow* in particular, are vital movements antagonistic to the natural movements, in so far as they depend upon a sensational annoyance (259). The blood is retained and accumulates in the lungs, as is shown by sighing, præcordial anxiety, pallor of the face, small pulse, and coldness of the extremities. Does this congestion take place in consequence of feebleness of the heart? or is it over dilated at each stroke, and contracts again too feebly? or does it beat irregularly, not expelling a mass of blood equal to that which it receives? The latter is the more probable state, since in no true passion are those movements which constitute its direct sentient actions, weaker than in health, but stronger (94), although in the distressing class they are tumultuous and contra-natural (209). This is the more manifest, when the passion of sorrow is distinguished from that condition of the mind, in which there are unpleasant conceptions without a full development of the instincts or emotions,—and termed a *sorrowful, low-spirited, melancholic* state of mind, for in this, the continued annoyance can debilitate the vital movements (254, 261, iii). To this class belongs a continued state of secret anxiety, sorrow, carking care, jealousy, hatred, envy, &c., which consists in a continued state of suffering, seldom or never attaining the force of an instinct or passion, and in which the vital movements are obviously rendered weaker. But in a true passion of the distressing class, the movements do not indicate debility; but, on the contrary, the restlessness, the loud cries, the wringing of the hands, the tearing of the hair, &c., indicate increased activity.

311. The disturbance of the heart's action, in sorrow and in all the painful passions, leads to disturbance of all the functions of the body, and, as experience teaches, to disease and death. If these emotions or passions remove or alleviate many diseases, it is only by their direct sentient actions, or by those of the secondary conceptions (259).

312. Those sentient actions of *regret*, that depend upon the foreseeing of its object, and which imperfectly express its fulfilment (257), are closely accompanied by those of an imagination, since the emotion is felt for some thing passed (309, 67), and this imagination is often so vivid, that it becomes an imperfect sensation (148). Thus it is that the form of a beloved indi-

vidual deceased still hovers around the mourner, and seems to accompany him everywhere, while the latter acts accordingly, addressing and embracing the shadowy form. As foreseeings do not readily become so vivid, this circumstance takes place more frequently in passions having reference to the past rather than to the future. But still it may be observed in the latter class, by a careful analysis. When, for example, we are in sorrow, from the expectation of bad news respecting a dear friend separated from us, and the sentient actions of sorrow are excited, those of an *expectation* (foreseeing) of dreadful news respecting him are distinctly connected with the sentient actions of a *recollection* of the affectionate parting from him, and of his last proceedings, so that we remember his farewell, his tears, his gestures, while, at the same time, the expectation of evil tidings causes us to feel all the workings of a dismaying fear.

313. *Grief, care, fear, anxiety, despair,* are distressing passions, of whose causes we are conscious (309), whereby they are distinguished as well from instincts, as from the instinctive emotions (263—5, 296—8). They follow the laws of other passions in every respect, and, for the most part, differ from each other in degree only.

314. These emotions of grief, and every kind of fear, certainly exhibit the sentient actions of a sensational suffering in common with every kind of afflictive emotion (309, 313), but the close observer will mark differences in each (254). The pulse is altered, is less full than usual, tremulous, and varying in frequency and force; there is a feeling of constriction of the chest from congestion, paleness of the face, cold extremities, corrugated skin, and the sense of constriction of the chest often ends in syncope, and even death, as historical details show. All these are the sentient actions of the vital movements contra-naturally altered by the sensational suffering (259), because, probably, an irregular influence of the vital spirits on the nerves of the heart renders its movements at one time, excessive, at another enfeebles them even to syncope, whence various secondary phenomena result (*vide* §§ 310, 311). It is in consequence of these results, and especially the repression of an injurious humour, in consequence of the suppression of the cutaneous functions, that fear, grief, and all the depressing

passions are so dangerous, when the plague and contagious diseases are prevalent.

315. The sentient actions which accompany a foreseeing in these passions, and whereby they are the most distinctly distinguished from all other kind of distress, exhibit imperfectly that state of the body which would arise during the fulfilment of the foreseeing (257). A timid person abhors most strongly that condition which he foresees; hence a secondary instinct is usually conjoined with the passion, namely, that of self-preservation (288), the sentient actions of which are combined with those of the foreseeing (241, 273). These subordinate instincts of self-preservation or defence, accompany all kinds of fear, and excite the corresponding volitional actions, according to the laws of instinct, as running, shouting, seizing, &c., only they are specially directed to an object by the foreseeing itself. Thus, when a person fears he will perish by the fall of a house, he runs away in virtue of the instinct of self-preservation, but with his head bent down, or his hands lifted over it, induced to act thus by the foreseeing of the evil, exactly as he would do if the house were falling upon him. In the same way he would cover the heart if he feared being run through with a sword.

316. Certain phenomena result from all the sentient actions of these passions combined, which specially characterise them, although only effected by the connection of all other forces of the body with the animal sentient forces, and are to be considered, not as direct actions of the passions, but as purely physical, mechanical, or animal movements caused thereby. Thus all kinds of fear have this peculiarity, that they cause the bowels to be moved; that they contract the skin, causing the phenomenon of shuddering; and that they induce a peculiar contortion (ausschlag) of the mouth; fear, like grief, will also soon turn the hair gray. Alexander Drummond attributes the change of colour in the chameleon to its remarkable timidity.

317. Everything that can excite a strong sensational unpleasant feeling respecting present or future circumstances, favours grief and all kinds of fear. The mind can be thus injured by education, particularly by ghost-stories, which terrify children. All causes of low spirits render the mind disposed to grief or fear. The sensations, and other conceptions,

instincts, and passions, which excite this kind of unpleasant feeling, naturally induce a disposition to sorrow, grief, and fear, while the contrary prevent them. Similar results follow from habits of life, diseases, and other circumstances that injure the health, and cause the same sensations as the depressing emotions.

318. *Terror* is a violent emotion analogous to fear, but much more intense and sudden. For this reason, it is one of the most dangerous to life (259). The action of the heart is so rapidly and contra-naturally affected, that diseases of the vital forces are thereby instantaneously produced, which not unfrequently induce immediate death. The pulse is not continuously full, but remarkably quick, consequently the heart's action is very irregular, and sometimes the contractions become so convulsive and violent, that the arteries burst; there is great dyspnœa; the complexion is deathly; the extremities cold; and there are often dangerous faintings, and even instant death. The other phenomena are analogous to those produced by fear (314).

319. The actions arising from a foreseeing in terror, are similar to those of fear, and are developed in the same way (compare § 315).

320. The special actions produced in the animal economy by the direct actions of terror, are in some respects similar to those of fear (316), although with many there is an opposite condition, namely, spasmodic closure of the sphincters of the rectum, bladder, &c., arising probably from the peculiar influence of terror on the muscular system, its effect being to excite spasms and convulsions (Haller's 'Physiology,' § 565). On the other hand, terror does not turn the hair gray, like grief and fear.

321. Whatever excites fear, predisposes to terror: whatever prevents the one, prevents the other (309, 317). The habituation of youth to endure adversity; that habitual lightness of spirit, which meets great evils courageously; the steady fortitude which anticipates the distressing strokes of fortune; and the happy deception whereby an impending danger is made to appear yet distant;—these are the true means, by which many may be preserved from terror, or at least from a timid temper. Instead of terrific stories, the history of heroic deeds should

occupy the memory; cheerful society, travelling, excitement, wine, &c., are all beneficial.

322. *Anger and revenge,* are depressing passions, we being undoubtedly conscious of their stimuli; they are therefore to be distinguished from the general instinct of self-defence, and from the war-instinct in particular (309, 301). They are developed according to the general laws previously stated (94), and their sentient actions are composed of those of a sensational unpleasant feeling, and of a sensational confused foreseeing (257, 258).

323. The actions of suffering [Unlust] in these, as in all the depressing passions, are contra-natural and violent (259); but they differ generally in this, that they attain a greater degree of intensity, while the action of the heart differs from that of anxiety and terror, in being characterised by a continuous frequency and violence of movement. In anger and revenge, the blood is impelled into the smallest capillaries, so that those which seldom carry red blood are injected, and hence redness of the face, increased temperature of the whole body, hæmorrhages, a full pulse, rapid and violent breathing and panting, livid lips, and analogous phenomena. Both passions are highly injurious to health, and sometimes fatal, as experience shows. In virtue of the general connection of the physical, mechanical, and animal forces of the body, there arise also from this great disturbance of the vital movements, a profuse perspiration, an immoderate agitation of the blood, suffocative catarrh, inflammations of the viscera and of the skin (roseola), apoplectic seizures from rupture of the cerebral vessels, delirium from inflammation, particularly of the brain, violent fevers, &c. On the other hand, diseases, particularly those of the chronic kind, and visceral obstructions have been cured by these emotions (259).

324. The sentient actions of the foreseeings in these passions, and their subordinate conceptions, instincts, and emotions, may have an equally injurious or beneficial influence on health and life, since the greater proportion are of equal intensity (259). In general, revenge is combined with anger as a secondary passion, yet as it is usually an instinctive emotion conjoined with the instinct of self-defence (301), and inasmuch as in this case it is a violent desire excited by anger, to inflict

injury on the offending person (309), and, consequently, to make use of the means most suitable to this end, it follows that these efforts commingle with those of the foreseeing in anger, and the actions of the two commingle with each other, independently of those of many other subordinate conceptions. The angry individual acts, therefore, as he would if inflicting revenge: he strains all the organs subservient to self-defence and combat, particularly the hands, arms, tongue, voice, often as if really in conflict with his enemy; so that convulsions, tetanus, and paralysis, or even epileptic paroxysms, may result. As the foreseeings differ in character, so also do the various motions excited thereby, and offensive words, grimaces, gnashing of the teeth, blows, &c., are excited.

325. The special changes (316) produced in the animal economy, by the sentient actions of anger and revenge, are an increased secretion of bile, often hepatic inflammation, or such a morbid state of the bile, that it sometimes inflames the stomach, induces sometimes a malignant bilious fever; a peculiar poisonous state of the saliva is also induced, so that it is not only injurious to the angry person who swallows it, but if mixed with the blood, or applied to the nerves of another, poisons him, exciting madness, or deranging the whole nervous system. This peculiar and inexplicable influence of anger on the liver and gall-bladder, the bile and the saliva, is observed also in the war-instinct and revenge of many animals; and when biting is the means used for the satisfaction of the instinct, they have either a special poisonous fluid, which is inserted into the wound made by the bite, or their saliva is poisoned at each outbreak of the instinct, as stated above. Hence arise the horrible consequences caused by the bite of enraged animals or men; for hydrophobia is nothing else than a disease, in which the animal is excited to anger by very slight causes, and its body is permanently in such a condition, that it may be excited to the highest degree of rage and revenge. All kinds of anger, —as vexation, hatred, envy, &c.,—have a marked influence on the liver and its secretion, whence jaundice, congestion of the liver, bilious vomitings, and diarrhœa, &c., result. In many animals and in men, the hair, and in birds the feathers, are erected and bristle up in the instincts of war and anger.

326. Since man himself has the war-instinct, exciting in

him the instinctive emotion of revenge (301), and as instincts and instinctive emotions are little under control, we possess few means of guarding against their influence, although the passion of anger is more under control. The excitement of antagonistic ideas, instincts, and emotions, dissipation of the mind, and abstraction of the thoughts, are the best psychological means. Amongst the physiological, are those which prevent the too great secretion and heating of the bile, since it is actually the case, that those animals are least prone to anger, and to quarrelling, which have the least bile.

327. *Longing* is a gentle passion, generally considered as painful; its sentient actions are, therefore, injurious to health, and consist in palpitation, thoracic congestion, sighing, weeping, &c. Its foreseeing manifests imperfectly the fulfilment of the emotion (257), so that he who longs to embrace, often extends his arms as if about to embrace the object of his longing; if he longs for a conversation, he talks loudly to himself, &c. Its special action (316) in the animal economy is the absorption of the fat; hence probably the sunken appearance of the eyes, and their slower movements, termed a *languishing* expression.

328. *Shame* is the slightest of the painful passions. It nevertheless causes palpitation of the heart. The foreseeing excites a casting-down of the eyes, and an averting of the face; a further result of its operations is a redness of the face, as if the vessels below were tied.

329. Just as every thinking animal has its predominant instinct and peculiar sensational character (295), so also each possesses a *predominant passion*, which in so far as it determines principally its volitional actions, co-operates to form its sensational character (295), whereby the latter is made more volitional, and more in the power of the animal, and thus receives a moral relation (296, 297). And since the passions, as well as the instincts, but especially the latter, are dependent proximately on the sensibility of the nerves (90, 91, 66), both the predominant instincts and emotions presuppose a definite sensibility of the nerves of an animal towards sensational stimuli, and thus *temperament* mainly determines the sensational faculty [Sinnlichkeit] of an animal, and its principal inclinations, emotions, and sensational character, and may modify them by habit in various ways (51, 52).

Actions of the Understanding in the Mechanical Machines.

330. The sentient actions of the intellectual conceptions (76, 89, 180) when acting alone, and uncombined with sensational conceptions, nor being at the same time sensational stimuli of pleasure or pain [Triebfedern des Gemuths], are not extended beyond the brain, neither into the nerves, nor through them into the mechanical machines (115, 116); at least we have no traces of such actions. Being excited in the hidden mechanism of the brain by the mind, according to psychological laws (111), and without the co-operation of an external impression, they have no direct action on the origin of the nerves in the brain (124), but their impressions are made on the brain itself, so as to develop material ideas of another kind there, which, according to the laws of cerebral sentient actions, must accompany the chain of intellectual conceptions excited by the mind (119). That this is correct, is proved by the fact, that during the deepest thought, or the most complete abstraction, no action in the nerves is observed similar to a direct action of intellectual conceptions, or like those of sensational conceptions, provided there be nothing sensational commingled therewith, or no sensational incitements of pleasure or pain [Triebfedern des Gemuths]. So little is this the result, that if the deepest meditation be free from what is sensational, the natural movements go on as in deep sleep, while the volitional movements are forgotten, and the body is motionless as a statue.

331. It does not follow, because certain conceptions do not excite direct actions externally to the brain, that they have no influence on the body, since, in the first place, the development of material ideas in the brain is an operation of its animal forces, which, from their connection with all other forces, must have its results. Secondly, although the material ideas do not act upon the cerebral origin of any nerves, they act upon other portions of the brain (124), and also on the mechanical machines (159) which enclose it, and through these may exercise an important influence on the animal economy. Thirdly, material ideas may readily develop unknown actions in the nerves, which have their results in the animal economy,

although we do not see their connection, nor recognise them as the results of sentient actions (141). Fourthly, since the vital spirits are necessary for all animal functions, and consequently to the production of the material ideas of intellectual conceptions (15), and since long and deep thought may waste or destroy them (20), and thus the free action of the other animal forces be restricted (22), it follows that in this way the conceptions of the understanding may act powerfully in the animal economy. Lastly, since they certainly develop some actions in the body through the nerves, partly, as internal sensations, (or as sensational incitements,) in so far as they are pleasing or unpleasing (80), partly, because they are commingled each time with sensational elements, it cannot be matter for surprise, that many and important changes are produced in the body by the exercise of the intellect, although the intellectual conceptions, purely as such, do not act directly on the nerves. (Compare §§ 136—141.)

332. The corporeal phenomena which are manifestly the results of the effort of the intellect must be investigated on these principles. By deep and intense thought, the body wastes, the muscles become weaker, the blood is determined to the head, the extremities become cold; the blood is changed in composition, the sensational property of the nerves is altered, and they become too sensitive, and excite irregular sentient actions, which derange the sentient action of the other sensational conceptive forces: the functions of the viscera are irregularly performed, and in particular the digestion is much impaired. Hence it follows, that deep studies and scientific pursuits are not the natural objects of man, but opposed to his health and well-being. Thus it is, that those learned men who cultivate the abstract sciences are generally feeble, meagre, sensitive, splenetic, hypochondriacal, and fanciful, and have impaired digestion. On the contrary, the strongest and healthiest men, with good digestion, are little given to study the abstract sciences, and little capable of comprehending them. These principles have an important bearing on pathology.

Actions of Intellectual Pleasure and Pain through the Nerves on the Mechanical Machines.

333. The pleasure and pain which are connected with the intellectual conceptions, and render them motives to action, act in virtue of their impressions in the brain (121, 80) on the the vital movements, which are changed in proportion to the strength of the impressions (250, 251). It is a well-known and undoubted fact, that deep thought on abstract subjects causes a manifest change in the circulation of the blood; the extremities become cold, while contrarily the vessels of the head are filled, so that they beat more powerfully, and cause redness and heat of the face, swelling of the head, headache, perspiration on the forehead. Of the changes mentioned, those which are most contra-natural are observed principally when the thoughts are unpleasing, but even the pleasing may excite such, if they be excessive. If a pleasing meditation be not too deep, it excites only a vivid colour in the cheeks, and favours the transpiration from the head; a deep meditation on painful subjects, on the contrary, causes vertigo, strong pulsation of the vessels, and a profuse perspiration, so that it is said the head smokes. But since sensational stimuli accompany all motives, and therefore all intellectual pleasure and pain (251), it is not easy to determine, whether this operation of the motives depends specially on intellectual pleasure and pain, or on the accompanying sensational stimuli (252). Still the difference between the changed vital movements of deep thought and those of sensational stimuli is so great, as to induce us to doubt, whether they both spring from the same source. The determination of the blood to the head, in operations of the understanding, is not like that resulting from sensational stimuli, for the blush of shame, and the violent derivation of the blood to the head in anger, and in other instincts and passions, are changes in the circulation of quite a different kind. Besides these operations of the motives are weaker than those of the sensational stimuli (250), and have this peculiarity, that they are not excited either directly or proximately by external sensational out according to the laws of the intellect (110). The intellectual conceptions please or displease, according as they are considered to be good or bad; the sensational conceptions

please or displease, according as the external impressions from which they directly or indirectly arise, are in accordance with, or contrary to, the natural function of the nerves.

334. From an error of the understanding, the mind may esteem something to be good or to be evil, which is the contrary. But since in either case, nevertheless, the pleasure or pain therefrom is felt, it follows, according to the laws of the sentient actions of both (254), that the agreeable motives will originate changes favorable to health, while the disagreeable originate unfavorable changes. Hence error and truth may alike sometimes advance, sometimes detract from, the well-being of an animal; so that in this respect, as is the case generally, it is not every truth that is propitious,nor every error that is unpropitious.

Actions of the Will through the Nerves in the Mechanical Machines.

335. When the mind wills in reference to the pleasure or pain in a distinct foreseeing of the understanding, it exercises its conceptive force to produce the foreseeing or its opposite (81); and thus it wills, or not wills, from motives (88, 96). The efforts of the cerebral forces connected with this act of willing or not willing, partly express the perfect material idea of the foreseen sensation (96). If the circumstance in the intellectual desire or aversion be only another spontaneous conception, which has no direct influence on the mechanical machines, as, for example, a general proposition (330), then the efforts are limited to the development of the corresponding material ideas, and the desires and aversions of the will have no *perceptible* sentient actions, at least, on the mechanical machines (332). But if the object of the act of willing, or not willing, be a conception, that should act on the mechanical machines, fitting material ideas are developed (96), and thus the desires and aversions of the will have some sentient actions in the mechanical machines (104, 110). For example, the desire to comprehend a truth is manifested by no actions exterior to the brain, but the desire to perform a certain act, as, for instance, to rise and take hold of anything, is followed by the proper movements. The sentient actions, which intellectual desires and aversions develop directly through the

nerves, are termed free-will movements [freywillige Bewegungen].

Note.—The *free will* [freywillige] movements are almost always confounded with the *sensational voluntary* movements [willkührlichen]. Volition [Willkühr] may be either sensational or intellectual. Free-will movements are sentient actions of the intellectual, and not of the sensational will [Willkühr]. Consequently, there is an infinite number of volitional [willkürliche] movements (the sensational), which are not free-will movements.[1]

336. In the sensational desires and aversions, especially in the instincts, neither their sensational stimuli, nor their gratification, is within the powers of the mind (292). It is otherwise with the intellectual desires and aversions. As the mind can choose for itself the favorable side of a thing, or decide in what way it shall consider it, it can cause it either to be pleasing, and therefore desires it; or, contrarily, displeasing, and therefore abhors it. And since the mind chooses such conceptions for the objects of desire and aversion as it has the full power to develop, as, for example, the direction of the muscles to voluntary movements (283), it satisfies its desires as soon as they are excited; and if these conceptions produce sentient actions (free-will movements), the latter result the moment they are desired. This is the reason why the free-will movements, as well as all volitional movements generally (283), follow so implicitly the thoughts, so that the simple pleasure of the mind is sufficient for their production. A comparison of this power of volition (Willkührlichkeit) of the will with the natural impulse of the sensational desires, instincts, and passions, explains why the former, taken alone, has entirely moral relations: the latter, either no moral relations whatever, or only in a subordinate degree (297).

337. When sensational stimuli cause intellectual motives, and both refer to one and the same object, or *vice versâ*, and with both it is either agreeable or unpleasant, the will

[1] In an early work on Human Physiology, and which contains the germ of many ideas more fully developed in this, Unzer distinguishes (as in this place) between sensational and intellectual will, and characterises the movements resulting therefrom respectively as *willkührlich* and *freiwillig*. (Philosoph. Betrachtung des Menschlichen Körpers überhaupt. Halle, 1750.) See also note to § 283.—Ed.

combines with the sensational faculty, and free-will movements are conjoined with the sentient actions of the sensational desires for the attainment of the object. In this way, the will urges a lover to go to his beloved, since, at the same time, the instinct works for its satisfaction, and develops the sentient actions necessary thereto (289). If, on the contrary, in a case of this kind, the object is desired on the one hand and avoided on the other, there arises a conflict between the sensational faculty [Sinnlichkeit] and the will (the *flesh*, § 88, warring against the *spirit*); in this, the victory is usually on the side of the sensational faculty, because its incitements are the stronger (251). Thus the instinct of love will be victorious, in the case where our intellectual motives are in conflict therewith, and teach us to avoid the beloved object. *Video meliora proboque, deteriora sequor.*

338. When the conception of the object of the will is either sensational, or of that character that it cannot be produced solely by the conceptive force, the satisfaction of the will does not take place as in the above cases (336); nor can the will perfectly perform the free-will movements desired (335). Thus the most imperious will completes nothing to which external sensation is necessary, so long as no external impression takes place; nor can the mind force itself into the belief of an absurdity, nor can any effort of the muscles fulfil the desires of the will, when we would leap over a tower, because such fulfilment is an impossibility.

339. All our intellectual motives are intimately associated with sensational stimuli, and all the intellectual desires and aversions are also sensational (65, Baumgarten's 'Metaphysics,' § 512). Consequently, our will is not so free, that it does not either combine its efforts with the sensational, or antagonise them (337); and must, therefore, in some degree receive its contentment from them. We therefore do nothing by a pure will; the flesh has always a part in our efforts, conclusions, and virtues, because it always makes them either more agreeable or more difficult.

340. The muscles are the mechanical machines which are under the influence of the will, and the origins of their nerves must be stimulated by the efforts of the cerebral forces, excited by the intellectual desires and aversions (164, i).

341. The reason why the free-will movements take place in a given series, and in no other, can only be sought in the arbitary and spontaneous production by the mind of the intellectual desires and aversions, and no external inducements are necessary thereto, as in the sentient actions of the sensational desires and aversions, except in so far as the will depends on the sensational faculty (109, 339).

342. The free-will movements are produced by a special impression of an intellectual desire or aversion in the brain, which acts on the origin of the nerves distributed to the muscles, and is propagated outwards from the brain (164, i). Everything hinders the free-will movement, in spite of the will, which prevents this impression being made or transmitted, or which diverts it from its course to the muscles (164, iii, iv), or renders the muscle unfit to perform its proper function (165, vi). On the other hand, an impression may be made on the origin or trunk of a motor nerve independently of the will, and if it be propagated to the muscle, and the latter be in a fit state to perform its functions, may excite movements, usually voluntary, in spite of the will (162). It is, therefore, erroneous to say, that a movement of the extremities, usually voluntary, must always depend on the will, or that all free-will movements must always take place whenever the mind wills. Daily experience contradicts both propositions, for a natural and incidental hindrance in the body, may prevent a movement that we will, from taking place (see § 165, vi); and further, movements that are usually voluntary, may be produced by external sensations, or as nerve actions (183), not only without an act of the will, but in spite of it (162).

343. The free-will movements have a very important and general influence in the whole animal economy, through the mutual connection of all the forces. Works on physiology may be consulted as to the details (*vide* Haller's 'Physiology,' § 416).

344. Just as every animal has its predominent instinct and passion (295, 329), so those that possess an understanding and will have their *predominant inclination*, or, in other words, intellectual desires for that class of conceptions which are most usual with them, because the mind finds the most pleasure therein; and according to which its voluntary actions are for

the most part determined, or its *mental character* constituted. Since all intellectual desires are the most voluntary and free, as compared with the sensational, although always closely connected with the latter (295, 329, 339), they are the most closely related to morals, and the mental character is termed the *moral character*. In reference to their moral relations, the predominant inclinations are termed *cardinal virtues* or *great vices,* both which, however, are connected closely with the sensational faculty (Sinnlichkeit), as is shown by their names, which are derived from leading instincts and passions, as avarice, or inordinate desire for gold; ambition, or inordinate desire for honour, sensuality, selfishness, self-love, &c. Like the instincts and passions, therefore, they may be greatly but psychologically changed by exercise and habit (329, iii, 111). As most of the conceptions, and all the desires and aversions, are characterised by special movements in the mechanical machines (as has been shown throughout this entire chapter), we may by them and by physiognomy know the mental capacities, the leading instincts and passions, the principal virtues and vices, and the sensational and moral character, on which that physiological science which investigates the human mind is based.

CHAPTER IV.

THE RECIPROCAL CONNECTION [*GEMEINSCHAFT*] OF THE BODY WITH THE SOUL.

345. When by the action of one thing, a change can be perceived extending into another, the former is said to exercise an influence on the latter (Baumgarten's 'Metaphysics,' § 140, 141), and the connection in which they stand to each other, by their reciprocal influence, is their reciprocal connection (ibid., § 328).

346. It is sufficiently obvious, why, from an external impression on the nerves, which produces material external sensations in the brain, and consequently from the motive force of the animal organism, an external sensation arises in the mind (35); the animal organism, therefore, acts upon its soul, and has an influence upon it (345) by its sensibility (34). (Baumgarten's 'Metaphysics,' § 540).

347. All conceptions, without exception, have their foundation in their external sensations (65), and are, therefore, partly sensational. Now, since this sensational element of every conception is produced by the influence of the body on the soul (346, 66), it follows that the body, by means of its sensibility [Empfindlichkeit], exercises an influence on the mind in all its conceptions, without exception: and in virtue of the animal-sentient force of sensibility (or the sensational force), the animal organism is constituted a co-operating force of all conceptions of the mind. Consequently, the following depend more immediately on the influence of the body on the mind, namely, the sensational conceptions, imaginations, and foreseeings; sensational memory; the sensational expectations and forebodings; dreams; poetic inventions [Erdictungen], and imperfect external sensations; also pleasure and pain of the senses, and all other sensational stimuli, the sensational desires and aversions, the instincts, the instinctive emotions, and the passions. On the other hand, conceptions of the understanding and of the reason, intellectual motives, and the intellectual desires and

aversions, depend only remotely on the influence of the body on the mind.

348. When sentient actions are excited in an animal organism, it is sufficient to know that they proceed from the conceptive force (97). Since all conceptions are connected with certain actions (25, 97), the mind acts on the body and exercises an influence on it, which extends to all those of its movements without exception that have an origin in conceptions. The free-will movements depend, however, more immediately on free-will (336). This dependence of the movements of the body on the will is termed the *dominion of the soul over the body*, (Baumgarten's 'Metaphysics,' § 538), but the actions of the sensational perceptions, pleasure and pain, desires and aversions, are not directly or immediately under the power of the soul, although they are altogether produced by its influence.

349. The animal organism and the soul have a reciprocal connection with each other (345), and since the influence of the body is extended to all the conceptions by means of external impressions on the nerves transmitted to the brain (347, 113), and since also the influence of the soul is extended to all the sentient actions of the body, by means of the impression of the conceptions on the brain (113, 121), it follows, that this reciprocal connection is more intimate and complete than that of another animal with the soul, or of another soul with the animal body. In virtue of this reciprocal connection, the body is also most closely united to its soul in the brain, and this united whole is a SENTIENT [beseeltes] ANIMAL (*vide* §§ 6, 7),[1] the idea of which consists in the closest reciprocal connection of a body and a soul.

350. Those therefore are in error, who, with Stahl, wholly deny the influence of the animal body on its soul; as also are those who limit that influence to the sensational perceptions, and the feelings of pleasure and pain, and to the desires, aversions, instincts, and passions; inasmuch as the conceptions

[1] The exact meaning of the terms *beseelte* and *unbeseelte* is given in the text (§ 605, et seq.), and the two kinds of sentient or *beseelte* animals defined. A literal translation of the words might have been made in strict accordance with the idiom of the English language; but the term *sentient* seems to me to express as fully the author's meaning as *besouled* would.—ED.

of the understanding, the motives, and the desires and aversions of the will, share in the influence of the body.

351. Those also are in error, who wholly deny the influence of the soul over its body, as some mechanical physicians; nor are those less in error, who limit the power of the soul to the free-will movements, and deny that the involuntary movements are under its influence, for the action of the heart, arteries, stomach, and bowels, are manifestly influenced by it.

352. Lastly, those are also in error, who would explain sentient actions by the physical and mechanical laws of motion (7, 97), as well as those who would explain them by the laws of other animal forces than the conceptive force, although connected with conceptions. Nevertheless, movements identically the same, may take place without being accompanied by conceptions, and since in this case, they are not sentient actions, but take place independently of the influence of the soul, they can be explained on other principles, yet not by the mechanical and physical laws of motion, but rather by the laws of motion of the animal forces (7).

PART II.

ANIMAL NATURE IN RELATION TO ITS PURELY ANIMAL FORCES, OR VIS NERVOSA [NERVENKRÄFTE].

INTRODUCTION.

353. ANIMAL forces acting without the co-operation of the conceptive force, are termed *nerve-forces* (vis nervosa), or *purely animal forces* (183, 186), and their actions are *nerve-actions* [Nervenwirkungen], or *purely animal movements.*

354. In virtue of the *vis nervosa,* the animal body becomes capable of functions, which cannot be explained either by the mechanical and physical laws of motion, or by the laws of the animal-sentient forces, but which are performed by the animal machines, supplied according to special laws with vital spirits (6, 183). To these belong the purely animal movements caused by an external impression on the nerves before it excites a material external sensation in the brain (98, i), with which the muscular irritability [Muskelreiz] of Haller must be classed (*vide* § 388), as well as those excited by internal impressions on the medulla of the nervous system and which excite no conceptions; or by other stimuli than conceptions, including many actions attributed to nervous irritability [Nervenreiz] by Haller. (See § 386.)

The following is the plan of this, the Second Part:

In Chapter I, the vis nervosa and the nerve-actions are considered generally. In Chapter II, the *vis nervosa* of the external impression; and in Chapter III, the *vis nervosa* of the internal impression in the medulla of the brain and nerves, are considered; and lastly, in Chapter IV, the relations of the *vis nervosa* and of the cerebral forces are reviewed.

CHAPTER I.

ON THE VIS NERVOSA AND ON NERVE-ACTIONS IN GENERAL.

356. Only two primary animal forces of the animal machines (the brain and nerves) are known; namely, the two kinds of impressions on the nerves (32, 121). These animal machines being incorporated with the mechanical machines (155), render them capable of animal operations; and it is from the action of the animal forces on the former, and through them on the latter, that all the phenomena of animal organisms are produced. These animal forces constitute the animal-sentient forces when acting in and through the brain of an animal endowed with mind, and are the means whereby the reciprocal connection of the body and mind is effected. It is the external impression which supplies the mind with all its external sensations, but on the condition that it reaches the brain, and produces there material external sensations (46); while the internal impression excites all the sentient actions of the body, with the condition, however, that it be caused by conceptions (123). But if these conditions fail, that is to say, if the external impression be not transmitted to the brain, or at least do not excite material external sensations therein; or if an internal impression at the cerebral origin, or on the medulla of the nervous trunks, is not caused by conceptions, but by other irritants, the two kinds of impressions still excite actions in the organism, and these are the nerve-actions of the vis nervosa (353). Every animal movement is, in reference to the animal force that develops it, either a sentient action or a nerve action; and if it be produced at the same time by both the cerebral forces and the *vis nervosa*, it belongs to both classes of actions (193). Under such circumstances, it would be erroneous to consider the one class as distinct from the other, since they are identical in both cases, just as a musical clock is the same, whether put in motion by a performer or by machinery. "A muscle, when its nerve is irritated, contracts and performs a movement *the same as that*

which nature has appointed, and bends or extends the limb, &c." (Haller.) It now remains to prove, that the animal movements which the cerebral forces excite by means of the impressions caused by conceptions (as has been demonstrated in the First Part) can be excited by impressions not produced by conceptions. In the first place, we will prove by facts that this actually occurs, and we will then investigate the nature and properties and the conditions and laws of these peculiar animal forces, and how they act in co-operation with the cerebral forces.

357. If a nerve, which certain external impressions, when felt, usually stimulate to produce certain movements in the organism, be cut off from its connection with the seat of the conceptive force, namely, the brain, or in other words, if it be cut or tied, or the head of the animal be entirely separated from the body, undoubted observations prove, that the same external impression from the point of impression to the point of division acts as a stimulus to the same movements so long as any traces of life remain in the body, although the external impression never arrive at the brain, but only as far as the point of division (31), and, consequently, is neither felt nor excites material external sensations in the brain (46, ii). This is the first fundamental principle, on which the doctrines to be taught in this Second Part of the Physiology of Animal Nature, are based. The experiment is successful in numerous instances with the most varied external impressions on the most dissimilar nerves; and it would be successful still more frequently, if the decapitation or destruction of the brain were not so rapidly fatal, for it is to be remembered, that the structure of the nerves experimented on must be unaltered, they must also still contain vital spirits, they must be able to transmit the impression, and the parts must also retain some of their natural warmth or moisture, &c. (Haller's 'Physiology,' §§ 367, 960.) The larger mammalia bleed so profusely when experimented on, that the circulation soon ceases, and the natural warmth and moisture of the parts disappear; but so long as these conditions continue, the experiment is successful with them, but still more so with smaller animals, as birds, worms, and insects. In the Second Section of the next Chapter, it will be shown, that this *vis nervosa* of the external impression regulates the animal ma-

chines; in the meanwhile it will be sufficient to prove its existence and reality by detailing a few of the most instructive and most obvious facts. Thus, an external impression made on the nerves of a portion of a muscle, or of the heart, or of the intestines separated from the body (as when, for example, the outer or inner surface is burnt with acid, or pricked, or otherwise irritated), excites the movements proper to the part, or renews them for a time if they have already ceased, just as when, in the natural condition of the animal, it was felt (167, 170). Thus, also, if immediately after decapitation, the body be struck forcibly, the part struck becomes suffused with blood, precisely as it would have been in the natural condition from the external sensation of a blow (207). Thus, also, the glands in an excised portion of intestine secrete on an external stimulus being applied; thus also the external impression of the gastric juice, which in the natural condition excited the instinct of hunger, stimulates the decapitated animal to rise up and seek food, an act which is properly a sentient action of the instinct; thus, also decapitated insects allure with chirping wings to sexual congress from the external irritations of the nerves of their sexual organs; thus, also, in decapitated butterflies, movements necessary to copulation are excited, and the act itself completed by the external stimuli proper to the instinct, while decapitated female butterflies, flies, &c., are in the same way excited to deposit their ova; and thus, also the pinching of the toe of a decapitated frog causes the same muscular contractions and the same movements of the instinct of self-preservation, as pain ordinarily excites in the natural condition. (Compare Haller's 'Physiology,' § 402.)

Note.—These facts (of which a great number may be found scattered through the writings of observers) are stated here without reference to authorities, being generally known and undoubted. If further proofs be required by the reader, especially as to the irritability of muscles, he is referred to the works of Haller, Zimmerman, and Oeder, for it will be shown subsequently, that the experiments which demonstrate the irritability of a muscle, establish also that the animal motive force of an external impression acts independently of the cerebral forces (338). (Compare Haller's 'Opera Minora,' tom. i, pp. 368, *seq.*)

358. *The external impression on the nerves can produce the same movements in the body as if it were felt, although it is not felt, nor transmitted to the brain.*—These movements are animal, inasmuch as they do not result from physical and mechanical forces only (32, 42), (as Haller has shown, particularly with reference to muscular movevent (162), ('Physiology,' § 412). They do not necessarily occur in accordance with conceptions, because the impression is not felt, and, therefore, there are no sentient actions excited by it, that is to say, no actions from external sensations (98, 46); although in the natural condition the two kinds of actions may occur together, and often do (183). Consequently, there are nerve-actions excited by the *vis nervosa* of the external impression (353), and whether the external sensation of the mind co-operates with it, or not.

359. If a nerve, ordinarily stimulated to excite certain movements, by conceptional impressions[1] acting on its origin in the brain, be stimulated at its origin by other internal impressions which are not material ideas (121); or if its medulla be irritated by some other internal impression, at any point of its course downwards, after its connection with its cerebral origin, or with the brain generally, has been severed, either by ligature or division of the nerve, or by the separation of the head from the body,—in either case the same movements are excited (provided animal life continues, and with the other conditions previously stated, § 357), by the internal impression simply, as are usually excited by internal impressions caused by conceptions. This is also an irrefragable principle, and is of the greatest importance in understanding the doctrines to be taught in this second part. In the Second Section of the Third Chapter, abundant examples will be given of the action of the *vis nervosa* of the internal impression: we can here give only some of the most prominent. If the nerve of a limb be irritated with a needle, movements take place

[1] By the term *internal impressions of conceptions*, Unzer means to express the material ideas or changes which take place at each act of mind in the brain, and which are referred to in the First Part (§ 121, foot-note, *et alia*). For brevity's sake, I have termed these impressions *conceptional*, because I have already translated Vorstellung by conception; but it is of importance to remember the wide and indefinite meaning attached to the term. (*Vide* § 25.)—Er.

exactly similar to those produced in the natural condition by the volitional conceptions: thus, the diaphragm renews its motions as in respiration, if the trunk of its nerve be irritated: thus, the body of a dog, or of an ox, (nay, even of a man, as is seen in executions by decapitation,) will be thrown into the most violent volitional movements, when the spinal cord is cut through: if in such an one the cord be irritated inferiorly, the movements involve the feet only; if superiorly, panting respiration, palpitation, deglutition, and vomiting result. When an irritation of the spinal cord produces spasmodic convulsions of the whole body, but a particular nerve has been previously divided, the limb to which that nerve is distributed is unaffected by spasmodic action, because the irritation cannot be transmitted to it: thus also, a decapitated frog rises up and springs forward, and if thrown into water begins to swim, so soon as its spinal cord is irritated by a needle in the cervical region, just as if it knew what it had to do. Bilguer relates a somewhat similar case, in which if a certain part of the neck where suppuration had taken place, was irritated, the patient was obliged to stand upright in spite of himself, &c. A great variety of well-authenticated facts of this kind may be found in Haller's 'Physiology.'

360. *An internal impression on the nerves can produce the same animal movements in the body, as the conceptions produce by means of material ideas, although not caused by conceptions, nor even taking place in the brain.*—These movements are animal, for they do not result from physical and mechanical forces only (§ 121. Haller's 'Physiology,' § 412). They do not necessarily occur in connection with conceptions, because the internal impression which excites them need not be a material idea, and it is in no degree necessary that conceptions cause it. These are not, therefore, sentient actions (123), although the two kinds of actions may occur at the same time, and often do (183). Consequently, there are nerve actions which the *vis nervosa* of the internal impressions produces (353), whether a conception co-operates with it or not.

361. The following irrefragable truth follows from these two leading principles: *while the animal machines are endowed by nature with the property of conducting external impressions*

to the brain, so that they may there excite material ideas, giving rise to sensations, and of receiving internal impressions caused by conceptions, they also possess another and entirely different property, and are intended by nature to effect by means of the external impressions they receive, whether the latter reach the brain and are felt or not, the same movements which are effected when they do reach the brain and are felt; and to effect by means of an internal impression, which they receive from a touch or irritant caused by no conception whatever, the same movements as are effected by means of the cerebral forces, when the same internal impression is produced by a conception. The animal machines are mysteriously and inscrutably endowed by the Creator with these two distinct motor forces derived from impressions, in addition to the equally-inscrutable animal force originating also from them, partly that they may put the animal-sentient forces into action, and partly that through these they may move the organism animally; and the greater proportion of animal movements are so closely dependent upon them, even when these are at the same time sentient actions, that they must be considered as the most fundamental and most general *principium* of the whole animal mechanism. But it is also obvious, that these two kinds of *vis nervosa* have an essentially distinct nature: that they produce their nerve actions in some degree in an antagonistic manner; that the external impression, considered also as simply a *vis nervosa*, is nevertheless a force as entirely different from that of the internal impression as it is from the cerebral forces (32, 121): that the two kinds of *vis nervosa* are excited into action in opposite ways: that they are regulated by different laws in their operations: and that all nerve actions of one and the same kind cannot be all explained by one kind only of the *vis nervosa*, nor that the existence of the one kind implies or excludes the existence of the other. Hitherto, both have been generally confounded too much with each other. Nevertheless, both kinds of *vis nervosa* have certain properties in common, which are now to be considered: those which are peculiar to each, will be investigated in a subsequent chapter.

362. No *vis nervosa* requires necessarily the co-operation of the cerebral forces (358, 360). Further, all nerve-actions may take place in the animal machines [the brain and nerves], and

by their means in the mechanical without the co-operation of the cerebral force, and in fact may take place without any brain whatever. Consequently, we cannot infer,

i. That those actions cannot originate from a sentient brain which are not animal actions or nerve-actions; or if the sentient brain be separated from the body, that no animal actions or nerve-actions can take place in the latter.

ii. That those impressions which are not felt, and do not reach the brain, cannot develop animal or nerve-actions.

iii. That those impressions which are not produced by conceptions, and do not depend upon material ideas, cannot cause animal actions, or nerve-actions.

There is an important distinction to be noted in all. Nerve-actions require the presence and free action of the vital spirits in the animal machines (357, 359). The cortical substance of the brain secretes the vital spirits from the blood, and distributes them to the nervous system. To this extent, the vital spirits and the brain can be considered as being necessary to the two kinds of *vis nervosa*. But again, the brain is not the secreting organ of the vital spirits in all animals, since there are some, in the first place, that have no brain or head distinct from the trunk, yet are nevertheless endowed with *vis nervosa*, and in which in all probability the vital spirits are secreted in every part of the system,—in every nerve, and probably in every ganglion—for their limbs often retain animal life, and have an independent existence, when separated from the body. Secondly, in those that have a distinct brain secreting nervous fluid, it is not the medullary substance, the seat of the cerebral forces (11) that is necessary to the *vis nervosa*, but the connected cortical substance. Lastly, even in these the cortical substance is only necessary, because it prepares and supplies for the *vis nervosa* its animal nourishment, namely, the vital spirits, and is, consequently, unnecessary so long as the nerves retain a sufficient supply of the latter (159); just as animals will live for some time without food, or plants survive after being separated from the stem. The reader will better understand what follows by keeping this view in mind.

363. Although the two kinds of *vis nervosa* be thus independent of the brain and of the cerebral forces, they can nevertheless co-operate with the latter to one and the same

action, through the same nerves. External impressions can produce nerve-actions in their way upwards, before they reach the brain (98, i), and at the same time reach the brain and be felt, although their nerve-actions are independent of the brain and of conceptions (362). The movements which a conceptional internal impression excites as sentient actions, may be equally produced by other internal impressions. Movements may, therefore, have a twofold origin, for an external impression may be felt and excite sentient actions, which are also excited by it as nerve-actions. In the same way an internal impression may, as the result of conceptions, excite sentient actions, and as the result of an irritant applied to the cerebral origin of the same nerve, or in any part of its course, excite the same movements as nerve-actions. When a nerve going to the trunk of a decapitated animal is irritated, movements like those arising volitionally are excited by the irritation (359). It would be, therefore, erroneous to conclude that movements might not be at the same time both sentient actions and nerve-actions, or that actions exactly similar to sentient actions in every respect may not be exclusively nerve-actions, and *vice versâ*.

364. The possibility that nerve-actions may be at the same time sentient actions, is manifest from a simple consideration of circumstances.

i. All animal movements in the mechanical machines (7), consequently all sentient actions and nerve-actions, are produced through the nerves. The impressions of the material ideas also act as stimuli to the nerves (130), and produce the appropriate movements (193): but any other stimulus acting on the same nerves, either at their cerebral origin or on any part of their course downwards, must necessarily have a similar effect (359); the two kinds of stimuli may occur therefore simultaneously, and co-operate in exciting the same movements.

ii. If an external impression produces a sentient action, it must act by producing a material external sensation in the brain, the latter exciting the movement by its internal impression on the cerebral origin of the nerves. But if this external impression on its way to the brain be reflected in the ganglia, or at the points where branches are given off, on the same fibrils, as it would have acted on if it had actually reached the brain (48, 151), movements must result exactly resembling the sentient actions produced by the external impression.

iii. Hence follows the general principle (361), that those movements in bodies which are most usually nerve-actions, may at another time, or in another animal, be sentient actions, or *vice versâ*; or they may be at the same time both sentient and nerve actions; in every case being the same movements, but only excited by different stimuli.

365, i. If a sentient action cannot be also at the same time a nerve-action, no unfelt or non-conceptional impression can cause it as a nerve-action.

ii. If a nerve-action cannot be also a sentient action, no impression, either felt or produced by conceptions, can excite it (362).

iii. If a sentient action can be also a nerve-action, the impression exciting it can act in both ways (364, i, ii).

366. Since sentient actions and nerve-actions are analogous animal movements from impressions on the nerves, and differ only in this, that in the former the impressions are felt or originate from conceptions, but in the latter not, (193, 364, iii,) it follows that all those movements which in one animal are sentient actions only, or both sentient actions and nerve-actions, may be nerve-actions only in another, excited by impressions; so that the external impressions are never felt, and the internal never produced by conceptions, but by other stimuli; in this way an animal may not require for all its animal actions, either material ideas, or a sentient brain, or conceptions, or mind. This appears to be the case with those creatures which have no brain, but only nerve-like fibrils, as polypes, in which there is no brain, but the nerves are interwoven in ganglia only. In animals with a sentient brain, every external impression which is felt passes directly to it, and excites therein a material idea, and in the mind a conception (35). Having reached the brain, it is turned back or reflected, as it were, and goes back as an internal impression of a conception, into those nerve-fibrils that move the limb, which the external impression is enabled to control by means of a sentient action of its sensation (129). At the moment of this reflection, when the external impression is changed into the internal, thought takes place in the mind, and thereby the movement which the external impression excites becomes a sentient action (97). When

a polype receives external impressions, they pass onwards (31) to the nearest ganglion, whence they are reflected as if from a brain, either entirely, or in such a way, that they only partly reach other ganglia, and thus they can be reflected many times. (Compare § 48.) It is sufficient that at these points the external impressions are transformed into internal, and pass again from the ganglia along the nerves to the mechanical machines, which they put in motion, no act of thought taking place during the transformation, because there is no brain (for in that only is the seat of the conceptive force), nor are the internal impressions adapted to excite a sentient action (97). In this way, polypes may be enabled to perform all their animal movements, solely by means of external impressions on their nerves, without having feeling, or thought, and without either brain or soul. But inasmuch as all this is accomplished by means of animal forces (32, 121), these animals do not act as mere machines, as Descartes supposed, but according to purely animal laws, which cannot be deduced from either mechanical or physical principles, or explained by them. As Haller observes on the last page of his introduction to the translation of Buffon's 'History of Nature,' they are animals whose life consists simply in irritability.

367. Other conclusions follow from the preceding propositions.

i. If the agency of material ideas on the cerebral origin of the nerves, whereby they develop sentient actions in the mechanical machines, be sufficiently ascertained—that is to say, if it be known on what nerve-fibrils, with what kind of stimulus or movement, and in what direction and force, each received material idea operates to produce certain sentient actions on the muscles—another stimulus may be applied to the cerebral origin of the nerves, or deeply in their trunks, instead of that of conceptions, and thereby all the movements which the animal performs as sentient acts, may be artificially produced without brain, or mind, or conceptions, just as nature produces them in anencephalous animals, by the transformation of the external impression into the internal without any conceptions being experienced. Thus, if the spinal cord or foot of a decapitated frog be irritated, it moves from one place to another as if acting volitionally, although deprived of both consciousness and will (357, 359).

ii. It is possible, that in animals with a sentient brain, movements are transformed from sentient actions into nerve-actions, as is probably the case with the respiratory and other movements (285-86); and *vice versâ* from nerve-actions into sentient actions, as in the sentient actions of the instincts of newly-born animals (269); or become both when previously they were only one or the other, or *vice versâ*, become only one or the other, when previously they were both. To establish the possibility of these changes, each example must be specially considered.

368, i. A sentient action may be changed into a nerve-action, when the transmission of the external impression to the brain is prevented, which may take place from natural or contra-natural hindrances. (Compare § 51, iii, iv, v.)

ii. A sentient action from a conceptional impression may be changed into a nerve-action when the conception ceases (136—139) and other stimuli, having a similar mode of action, are applied to the conducting nerves (123, 360). Thus, the mere physical irritation of an acrid humour acting upon the motor nerves at their origin in the brain or along their course, will excite contractions of the muscles which ordinarily are volitional. The same may take place automatically, as when an external impression which does not reach the brain, stimulates the nerves in the same way as a volitional conception, in consequence of being reflected downwards in the ganglia, or at the points of division of the fibrils, thus producing movements as nerve-actions, which are exactly identical with those excited by volition (48, 151). The closure of the sphincter of the bladder, whereby the urine is retained, is usually a voluntary act; but when the volition ceases, and even when the contrary state is willed, an irritation in the bladder, which is not felt, causes it to be spasmodically closed, even until death; in this case, the former volitional action is changed by the *vis nervosa* of an external impression into a nerve-action.

iii. A nerve-action may be transformed into a sentient action, if it results from an external impression, when the natural obstacle to the transmission of the latter to the brain is removed (45); if, for example, a limb (as the leg), being deprived of sensation by an injury to the nerve, and being scourged, becomes inflamed, as a nerve-action (207, 357), and then the power of sensation being restored, is inflamed in consequence of the pain excited by the scourging, the inflammation is a sentient action from an external sensation (207).

iv. A nerve-action proceeding from an internal non-conceptional impression may be changed into a sentient action by the addition of conceptional impressions, which act upon the fibrils of the motor nerves conducting the impression itself (130, 360). Thus, in convulsions proceeding from mechanical irritants applied to the motor fibrils at their origin, or in their course, or from worms in the stomach, the external impression is not perceived, and the convulsions are simply nerve-actions (162, 360); but if a fright, or pain, or other powerful external sensation, be superadded, which also excites convulsions, but as sentient actions by means of conceptional impressions, then the convulsive paroxysm is re-excited by the latter as a sentient action. In this way epileptic paroxysms, originally purely nerve-actions, may be reproduced as sentient actions, by fear, or pain, or other violent conceptions capable in themselves of exciting convulsive attacks.

v. An action may be both a nerve-action and sentient action at the same time, if the causes of a change into one or the other are superadded, as in the instances above mentioned, yet neither ceasing to be what it was. If, after both are excited, the causes of the one kind only cease, then the other class remains (364).

369. There naturally arises a question out of the preceding considerations (362—368), as to the advantages which animals endowed with mind and brain derive from their movements being often at the same time both nerve-actions and sentient actions, and produced by a twofold cause; since in fact, mere impressions without the co-operation of the brain or mind may be sufficient to produce the animal functions, as in anencephalous animals. Although this question has been noticed already (184, ii), it requires further consideration here.

370. To the end that an impression be felt, it is changed in the brain into an internal impression (121, 129). But this change of an external into an internal impression may take place also by means of ganglia, or in some other way usual or possible with animals; only in such cases, the external impression will have no other reflex action in the animal machines

than that of which it is capable in virtue of its purely animal force, which it reflects upon the motor nerves (364, ii); and the whole of this action is purely corporeal and automatic, and cannot be changed, or induced, or extended, or limited, or directed volitionally. If, on the other hand, the external impression be also felt, then the mind, according to its psychological laws, connects volitionally with it many other conceptions (219—224), the internal impressions of which can produce through the motor nerves such sentient actions as the unfelt external impression could not have developed at all, or, at least, not in combination with the will of the animal. It is for this reason, that we find animals without brain and without any traces of mind, to be capable of very few kinds of animal movements; that those of which they are capable are excited by the external impressions automatically and necessarily; and that they are so far from being under the control of the animal, as to be excited and continue just the same whether they be injurious or beneficial. In animals endowed with mind, on the contrary, every external sensation develops by means of the series of secondary conceptions caused by it, yet spontaneously or volitionally, a number of new movements, which would not have resulted from the unfelt external impression in this connection, and perhaps not at all. Now, if nature has compensated brainless animals for the want of spontaneous and volitional conceptions adapted to their preservation and well-being, by the automatic and necessary results of mere impressions, as is particularly the case in the instincts (266); it is obvious, that it is with the same object in view that nature has endowed other animals capable of so much more varied animal motor forces, with the faculty of both feeling the external impressions and acting in accordance with the resulting sensations. (Compare § 184, ii.)

371. The same relations exist with regard to internal impressions. When they are not produced by conceptions, they originate automatically and corporeally from mere animal stimuli of the nerve-medulla, either at the cerebral origin, or in the trunk of the nerves; and nerve-actions in the machines result just as automatically and corporeally; either because a purely physical influence suitably irritates the nerves from above downward, or else, because unfelt external impressions reflected in their course to the brain act in the same way. If, however,

the animal itself produces internal impressions, and arranges them by means of spontaneous or volitional or even free-will conceptions, the sentient actions result according to laws entirely different from those of the automatic necessity just described (119, 121), and are subject to the will and reason of the animal. When a lobster gets one of its legs accidentally fixed in one of its claws, and the claw is then made to contract by a mere stimulus solely, the leg is crushed, and the animal is excited to tear away the leg by the external impression of the forcible crushing, and is thereby mutilated for a long time without suffering. But if the closure of the claws and the insertion of the leg between them were sentient actions from conceptions, its mind would readily have deduced a third conception, namely, to open the claws, and withdraw the leg. But as this does not occur, the purely automatic actions are excited, and the animal loses a limb in virtue of the working of a piece of mere animal machinery, which it need not have lost, if the movements resulting from its external impressions had been at the same time sentient actions from its conceptive force. In such cases, in sentient animals, the conceptive force regulates the movements by means of internal impressions, although impressions from mere animal stimuli may have the same effect automatically.

372. Having considered the relation of the *vis nervosa* to the animal-sentient forces, it becomes necessary to show the special seat of the former. The animal-sentient forces, whose seat is the sentient brain, extend their operations as well into the animal machines, as (through these) into the mechanical (117). The proper seat of the *vis nervosa* is the nerves, for all primary animal forces have their seat in animal machines only (6), although they are transmitted through the animal machines into the mechanical, and excite animal actions therein (7). The proper animal machines are the brain and nerves, in which the vital spirits are contained (9). But the operations of the brain as a sentient animal machine, are for the most part only sentient actions (25). Consequently, its peculiar animal forces are animal-sentient forces (6). Now, the two kinds of *vis nervosa* are not animal-sentient forces (356), consequently, are not peculiar to the brain; and since the nerves supplied with vital spirits are the only true animal machines, except the sentient brain and

the cortical substance which surrounds it (159), it follows, that the principal seat of the primary *vis nervosa* must be specially in the nerves.

373. Nevertheless, it cannot be denied, *that the medullary substance of the brain itself has some share in the vis nervosa.* We cannot, however, determine by experiment, whether an external impression which reaches the brain but is not felt, does not develop some animal action through the medullary matter of the brain, although it causes no material external sensation (46, iii). For, although it excites the most energetic movements through the nerves, yet the same phenomena occur when the head is wholly severed from the body (357), consequently the external impression is changed into an internal lower down, probably in the ganglia (48), to produce the nerve-actions, for it would appear as if the condition absolutely requisite to the change of the external impression into an internal in the brain and its reflection is, that it develops therein a material external sensation (25). Nevertheless, there are cases in which it must remain doubtful whether an external impression does not produce purely nerve-actions through the medullary substance of the brain, for when the latter is injured in an animal, the body is convulsively agitated (Haller's 'Physiology,' § 368). It has been already shown (132), that this may constitute sentient actions of an external sensation of pain, because the medullary substance also transmits external impressions to the origins of the fibrils of the irritated nerve, or of the fibrils of the cerebral medulla, and can excite therein material external sensations which may act reflexly by means of their internal impression on the brain, and through it on the nerves in the mechanical machines. But if a similar external impression on the medullary substance should not be felt, and yet excite movements (convulsions), would not these be no other than mere nerve-actions of an external impression on the brain, and must not the brain, consequently, possess a *vis nervosa* of external impressions in addition to its animal-sentient forces? It is difficult to determine, whether external impressions be felt or not, and in the latter case, whether they produce the same movements as in the former. Although indeed many injuries of the brain are not at all painful or manifest, and foreign bodies may lodge therein for a lengthened period without the knowledge of the

patient, still it is probable that sometimes external impressions on the brain itself excite nerve-actions, and it may really be capable in some degree of the *vis nervosa* of external impressions. Many facts appear to corroborate this. "A certain person had a piece of bone driven into his brain. For a long time no results followed, but at last spasms and death took place from a large ulcer of the brain." (Haller.) Still nothing certain can be stated on this point (624, iv). It is more probable, however, that an internal impression on the brain, not proceeding from conceptions, excites, as nerve-actions, the same movements that it would have excited if it had proceeded from a conception, since this continually takes place in the spinal cord, which is analogous to the brain (12[1]). Indeed, in the case just mentioned, when an external impression, though not felt, excites animal movements in the body, they must have been caused by the external impression reflected independently of the animal-sentient force, and without the intervention of a conception, and acting as a mere internal impression. But without laying much stress on this doubtful case, there are many other reasons for recognising the existence of a *vis nervosa* in impressions on the brain not caused by conceptions. When in a plethoric person the brain becomes congested, as in stooping, and the small arteries in the optic nerves are distended, and stimulate the origin or trunk of the nerves, this internal impression in the brain is transmitted downwards to the termination of the nerve in the eye, and there causes an external impression which is transmitted upwards (31), and excites in the mind an imperfect external sensation (148). This imperfect external sensation of various false appearances before the eyes, is a manifest proof, that internal impressions which do not depend on conceptions, are transmitted through the brain, and have the same actions as those which proceed from conceptions; for just as very vivid imaginations, or passions, cause (as sentient actions) imperfect external sensations of various appearances before the eyes (148), so in this case, the pressure of blood in the optic nerves at their cerebral origin acts as a nerve-action, and sparks and motions are seen before the eyes as vividly as if they were real. Now since the optic nerve is

[1] *Vide* foot-note to § 34.—Ed.

in the brain, constitutes a portion of it, and is close to it in its course, this fact can be received as a proof, that there is a *vis nervosa* seated in the brain itself, which develops the same movements as if a conception irritated in a similar manner the same spot in the brain, and, consequently, as if the action were effected by the animal-sentient force of the brain.

374. The medullary matter of the brain having some share in the *vis nervosa*, it is certain that the cortical substance also is endowed with it, since its peculiar function is to secrete the vital spirits from the blood, and supply them to the other animal machines (11). Like all secretions, this process is at least partly animal, and not a sentient action (159); it is therefore a nerve-action of the *vis nervosa* of the cortical substance (353), and subject to the same laws as other secretions, which, as we shall subsequently show, are effected simply by means of the *vis nervosa*. (Vide §§ 471, 530.) As the secretion and distribution of the vital spirits is a process of the highest importance to animal life, this *vis nervosa* of the brain demands great consideration in animal physiology.

375. The nerves, however, must be considered as the principal seat of the *vis nervosa*, and rightly give it its peculiar designation. But the question arises, whether the nerves are endowed with their *vis nervosa* universally and without limitation, or whether only in virtue of their relations to the mechanical machines with which they are incorporated. As, however, the sensory nerves possess a *vis nervosa* as well as the motor, it must be a general property of the nerves, or in other words, the two kinds of *vis nervosa* are primary animal forces proper to the nerves.

376. An external impression on a sensory nerve passes directly upwards to the brain (31), and is not readily reflected on its course, or changes into a non-conceptional internal impression, because this class of nerves has no ganglia, in which the course of the impression could be changed and reflected (14, 48). The only way in which this occurs is the reflection in the brain, where the external impression, when the mind feels it, is transformed into a material idea for the internal impression of a conception (121, 129, ii). But in this way, it produces sentient actions only (97). It is not yet determined whether there be cases in which an impression, when transmitted along sensory

nerves, excites visible animal actions in the brain, without producing a material external sensation at the origin of its nerves. At least such actions are not observed in syncope, or profound sleep (49), when light streams into the open eye, or a loud noise strikes on the ear without being felt. Yet in these cases some animal actions in the nerve must result, because the external impression made on it goes to the brain, which is of itself an animal movement (32), and because the sensational force of the nerves may be impaired at their cerebral origin, when in cases of this kind, the external impressions are too violent, although they are not felt. Thus, for example, deafness gradually comes on in persons who sleep in a mill, and blindness from the gleaming of the moon's rays into the eyes during sleep, &c. Only, these are not perceptible nerve-actions, but are probably only irregularities of the vital spirits, or imperceptible changes in the medulla of the nerves, and consequently no definite conclusion can be drawn as to the *vis nervosa* of external impressions situate in the sensory nerves.

377. A non-conceptional internal impression on purely sensory nerves, displays the traces of its actions distinctly enough, as in the case of the nerves of vision previously mentioned (373). All the visual and auditory phenomena so often noticed on stooping, or whirling round too rapidly, or binding the neck too tightly, are, in fact none other than animal actions (namely, imperfect external sensations) in purely sensory nerves, excited by non-conceptional impressions, which are usually produced by conceptions, and exciting similar actions (148). Analogous phenomena are manifested in the nerves of taste, and smell, and touch, so that persons of great sensibility, and especially in certain morbid states, think they perceive tastes or odours which are not present, and are not caused by any conception.

378. It was previously observed (150), that true external sensations may be regarded as being imperfect, when an external impression is really made on the sensory nerves, but by something *within* the organ of sense; as, for example, when in inflammation of the eyes, or in retention of air in the ears, phenomena are seen or heard which are not in fact so real as it is thought. These may be termed generally *imperfect external sensations from an erroneous judgment*; those mentioned in the preceding section may be termed imperfect external

sensations *from non-conceptional internal impressions*, and those in § 148 imperfect external sensations from *conceptional internal impressions*. It is manifested, that the first of these may be easily but erroneously confounded with the second.

Note.—It may be permitted just to state here, a bearing which these views have on pathology. Since the phenomena mentioned, as arising from the causes aforesaid, may be excited the more readily in proportion as the nerves are more sensitive, and the conceptions vivid (148), it is obvious, why persons of irritable temperaments and nerves, and patients in whom the nerves are unusually susceptible of all kinds of impressions, have those phenomena so frequently, and how erroneously they are attributed to a too-vivid power of the imagination.

379. Now since, therefore, both the brain and sensory nerves are endowed with *vis nervosa*, it must be understood, that its actions are developed independently of the brain (375, 358, 360), although they can be rarely rendered visible, as they can scarcely communicate any visible movement (151) to a mechanical machine. But it is quite otherwise with motor nerves; and as almost all movements of animal machines are either muscular movements, or effected by means of muscles, or at least by muscular fibrils, the *vis nervosa* would appear, although erroneously (375, 377), to be peculiar to muscles and muscular fibrils only. This has probably given rise to the new doctrine in physiology propounded by the otherwise correct observer, Haller, who has laid down the principle, that the muscular fibre possesses in itself a primary animal motor force, which he has termed *vis insita*, muscular irritability [die angeborne kraft], (*Vide* Haller's 'Physiology,' § 400, 402.) It is, therefore, of importance to investigate the subject, and see whether this opinion be well founded or not.

380. To prove that the muscular fibre possesses an animal motor force peculiar to itself, it must be shown to put itself in action without the co-operation or assistance of other animal machines or forces. A probable way of doing this, would be to separate a muscle from all other animal machines, and then demonstrate the existence of an animal motor force. But since every muscle has its nerves (161), and is therefore connected with animal machines, which enter into its substance, and are so intimately incorporated therewith and so constituting a

whole, that no one has been able hitherto to trace them to their terminations, it follows that it is impossible to separate the muscular fibrils from the nerve-fibrils, and so afford the proof required; so that when it is affirmed, that a muscle retains its animal force after being separated from its nerves, it is first of all necessary to show how this separation has been effected.

381. The trunks of the nerves distributed to a muscle have been divided, and the latter have nevertheless been excited to movement by an external irritant. Is this the required proof? Certainly not. The division of the trunks does not destroy the infinitely numerous twigs distributed to the muscle, and so long as it retains these, the *vis nervosa* is incorporated with it. Further:

i. Nerves retain their purely animal motor force derived from external impressions from the point of impression to the point of bisection (357, 358). So long, therefore, that it cannot be shown, that the irritant which moves a muscle after its nerves have been divided, cannot act impressionally on the nerve-twigs in the muscle, and that the animal movement in the latter is not excited thereby, the peculiar animal force of the muscular fibre is not demonstrated by the experiment. Consequently, although the movement of a heart separated from the body be renewed and increased by puncture with a needle, by acrid irritants, by injections of water, &c., still this does not prove that the irritation induced this activity through the muscular fibrils only, without the co-operation of the nerves, for it is incontrovertible that it can produce them in virtue of the impression on the nerves of the heart, because every point of a muscle, and consequently of the heart, both its inner and outer surface, which the needle's point touches, can, in the healthy state, so receive the irritation, that it is felt, which is only possible by means of nerves; while further, the same increased activity of the heart results as an animal action excited by the external impression which this irritation causes, whether it goes to the brain or not (357, 358).

ii. The nerves retain also their *vis nervosa*, excited by non-conceptional internal impressions from the point of impression (whether it be at the origin of the nerves, or on their trunks), to the terminating fibrils (359, 360). When, consequently, the a separated muscle is irritated by a physical irritant applied to the medulla of the trunk, or when an external impression is reflected in the muscle itself and becomes an internal impression, in either case movement of the muscle may result, without it necessarily following that the motor force is situate in the muscular fibres, independently of the nerves. Unless it can be proved that the irritant which moves a muscle, whose nerves are divided, cannot have excited a non-conceptional impression in the medulla of the nerve, whether by causing a mere physical irritation of the latter, constituting an internal impression, or by the reflexion of an external impression in the muscle itself, and that the movement of the muscle is not produced by such impression, it cannot be allowed that the peculiar animal force of the muscular fibre is demonstrated by the experiment (380).

382. But perhaps, it may be urged, a muscle may be so irritated, as to be excited to movement without the irritant causing at the same time an impression on its nerves, for it is not every excitant which causes an impression (32); and possibly the muscular fibres are excited to movement by irritants which do not animally affect the nerves.

This proposition would be of importance, if it had been previously shown that muscular fibres are capable of movement, independently of their nerves; but this condition is wanting. Besides, facts prove that the impressions which move muscles affect also the nerves, because they can be felt. We will, however, notice the leading points which Haller advances in defence of his doctrine.

383. Haller observes that muscle is excited to movement when touched, but nerve is not. Consequently, this irritability, or the property to be moved animally, from a certain contact, is proper to muscular fibres rather than to nerves. May not, however, they possess this property simply through their nerves? If the muscular fibres constitute a mechanical machine, excited to movement by suitable impressions on its nerves, it is the machine that possesses this capability of movement rather than the nerves themselves, for an impression never visibly excites movement in the nerves, but in the mechanical machines with which they are incorporated (153). The same applies to all movements of muscle excited by conceptions, or by the will.

The spring of a watch produces, by an invisible movement, the visible movements of the wheels. But should the primary force which sets them in motion be therefore attributed to them?

384. Haller observes, that it cannot be proved that from so few nerves as are distributed in a muscle, so many fibrils can arise as there are muscular fibrils; consequently the latter cannot be considered as prolongations of the former. But this is not necessary; it is enough that every part of a muscle is supplied with nerves, and that every muscular fibril, wheresoever irritated by the point of a needle, is sensitive. And if, as Haller thinks, the nervous fluid communicates this irritability, the fluid is derived through the nerves.

385. Haller advances (§§ 402, 407), that animals without brain, spinal cord, or nerves, such as polypes, are equally excited to motion by an irritant, and thus show that the structure of the muscle alone is sufficient for animal movement. The vital movements of plants lead to the same conclusion.

The movements of plants, even those of the sensitive plant, are regulated according to the mechanical laws of movement of organised bodies. The fibrils in insects, which a touch excites to animal movements, are not such nerves or muscles as ours, but still animal machines (6), which are capable of receiving external impressions (31, 32), whereby they stimulate the mechanical machines of insects to animal movements (7, 162), and, consequently, a species of motor nerves (14), and thus afford no proof of the existence of the primary motor force of muscular fibre.

386. The heart (it is advanced by Haller) and the intestinal canal are regulated by the *vis insita*, or muscular force, and by stimuli, for their movements are independent of the mind, whilst the movements of the muscles actually dependent upon the nerves are under the control of the will.

The error here is very manifest: the great man has not properly distinguished between sentient actions and nerve-actions. If, according to Haller, when movements are excited in muscles through their nerves, they must be excited in connection with the brain, or the mind, or the will, then it follows that animal movements excited after division or ligature of the nerve going to the muscle, are not produced through the nerves. (Compare 362, iv, and 367, ii, for a further correction.)

387. The movements dependent on nerves (Haller states) cease with life, those on the *vis insita* continue after death; destruction of the brain, or ligature of the nerves, prevents the former, the latter continue without brain. Parts that have no sensation are moved, others that have are not moved; the will excites or arrests the nerve-motions, it has no power over the actions of the *vis insita*.

All this only demonstrates the difference between the cerebral [animal-sentient] forces and the nerve-forces, between sentient actions and nerve-actions. It does not prove, however, that the nerve-actions are not produced through the nerves, but that they are not produced through the brain or the mind.

388. It does not appear then, that this doctrine of Haller can be supported by valid arguments. There are other objections to it. No irritant applied to parts unsupplied with nerves, can excite movements. Then irritability is peculiar to muscular fibre, but all muscular movements are motions of mechanical machines intimately connected with the nerves, and the latter cannot be entirely separated from them without at the same time destroying their structure. Every impression which excites the muscle irritates also the nerves. An internal impression on the medulla of the nerves, excites the same movements as when the muscular fibres are irritated. Opium, which if applied to a nerve deprives it at the point where applied of its *vis nervosa*, also suddenly renders a muscle unirritable at the point of application (Whytt's Works). Every nerve retains the animal motor force, even if cut, or tied, or otherwise so treated that an external impression on it can no longer be felt (381, i); and, in fact, the same muscular action is excited by an irritant, whether it be felt or not (204, 357). Now since, therefore, all muscular movements which are attributed without adequate grounds to the irritability of muscles can also take place in virtue of impressions on their nerves, and in undoubted instances actually do so take place, and as there is no reason why they should not occur in every case, so soon as the muscular fibre is irritated, it is probable that no truth in all physiology is so physically certain as this; *that all animal movements of*

muscles are primarily effected through the nerves only, whether in, or without connection with, the brain and the mind.

389. The two kinds of *vis nervosa* then, like the cerebral forces, are primary properties of the true animal machines, and especially of the nerves (372—388), and cause the same workings in the mechanical machines, whether they be caused at the same time by cerebral forces or not (362—371). That which renders a mechanical machine external to the brain capable of sentient actions, namely, the nerve incorporated with it, also renders it capable of nerve-actions, and there is not a single animal motor force, independently of it, nor even in muscular fibre.

390. The mechanical machines that are not endowed with nerves, as tendons and tendinous tissues, bone and cartilage, &c., are not adapted to the *vis nervosa*, and primarily their movements are neither sentient actions nor nerve-actions, although from their mechanical relations they are either or both. All such parts of the body without exception have neither irritability nor sensibility, being deficient in nerves.

391. On the other hand, those mechanical machines that are supplied with nerves become thereby not only capable of sensation and sentient actions (162—179), but also of nerve-actions, as will be shown subsequently.

392. It has been already shown, that the *muscles* are moved by the *vis nervosa* as well as by cerebral forces (162, 204); the experiments already detailed prove this amply (357, 359). The action of the *heart* (as proved also by experiment—§ 357), is usually a nerve-action, although it is likewise changed by sentient actions (161, 211). The action of the blood-vessels can be renewed and continued in decapitated animals that do not bleed to death too quickly, by purely animal irritants. The phenomena previously detailed (168, 207) may all take place as nerve-actions.

393. The natural functions of the *œsophagus, stomach, intestines*, and other muscular canals, are ordinarily (as has been already stated) rather nerve-actions than sentient actions (170, 174, 212), and experiments on portions separated from the body confirm the statement. These remarks apply to the *diaphragm*, and similar muscular structures (171, 359).

394. The *glandular* and other secreting tissues belong to the same class as the preceding; their functions going on without

sensation and after decapitation. (*Vide* §§ 172—176 and 209—215.) The cortical substance of the brain is to be classed with the secreting organs.

395. The functions of the *sexual organs* both in the male and female are carried on not solely by means of the cerebral forces, but often through the *vis nervosa* only, as experiments on decapitated animals demonstrate (357).

396. The *movements of the limbs* display the influence of the *vis nervosa* strikingly, because its action is greatest on the muscular portion of the organism. These, as a thousand experiments prove, may arise as nerve-actions, although they usually occur as sentient actions from external sensations and sensational conceptions, instincts, and passions, as well as volitionally. Thus, a decapitated animal will stand, move forwards, raise itself up, leap, fly, or flutter its wings, seek food, clean, defend or conceal itself, copulate, &c. A decapitated man immediately after decapitation struggles to free his hands, attempts to stand upright, and to stamp with his feet; if the head of a pigeon be cut off whilst it is running, it continues to run on for some distance, until it knocks against something; a frog leaps forward without its head, so also a headless fly flies, a snake, a fish, a worm, writhes and twists about, if touched, although wholly deprived of sensation; a fly makes the movement of brushing its eyes by a natural instinct, although its head be cut off; a headless snail seeks its food by its usual plan of feeling about; a decapitated tortoise does the same thing, and will live for half a year after decapitation, and raise itself up, or endeavour to do so if placed on its back; an earwig nips with the nippers of its abdomen at its own separated head, when the head bites the abdomen; the abdomen of a wasp will sting; animals that fight with their hind feet use them vigorously when decapitated, at every irritation applied to the nerves; butterflies, caterpillars, and silk-worms copulate after decapitation, and they and flies deposit their ova; in short, all the instinctive actions of animals are sometimes seen to occur as nerve-actions; and it naturally follows that they occur at first in newly-born animals as such, and that it is only after the perception of external sensations that they become sentient actions (269).

397. Thus the dominion of the *vis nervosa* is in reality as

extensive as that of the cerebral forces, and it would be difficult to discover a movement which occurs as a sentient action, which may not be also effected by the *vis nervosa*, although, in many cases it is not practicable to show this by satisfactory experiments. The greater number of movements take place by means of muscles or muscular tissues, whether they be sentient or not (379). That, however, which a muscle can effect when stimulated by the cerebral forces, it can also effect very easily solely by means of an unfelt internal or external impression on its nerves (364, i), for in either case it is stimulated to the same movement (356). It is not surprising, therefore, that suitable impressions on the motor nerves can act as the primary incitants to all nerve-actions independently of sensation or thought, and maintain the whole machinery of an animal body in continued working and reciprocal functional activity, just as is effected by external sensations and their sensational conceptions by means of internal impressions on the brain. For we must remember that an impression not only develops the same movement as it develops when felt, or as when excited by conceptions; but that, just as from external sensations and their sentient actions, other sensational conceptions and their sentient actions are produced and combined together, whence the connected acts of the cerebral forces arise, so also unfelt external impressions cause unfelt internal impressions, from which sometimes other external impressions originate; all which have unitedly their special nerve-actions, constituting connected and combined acts. To show this more distinctly, and to render it by successive proofs more probable and obvious, how an animal body can be regulated and excited, as well to automatic as to what are usually volitional movements, independently of mind, as regularly and connectedly as if directed by thought and sensation, we must now consider the relations of the two kinds of *vis nervosa* to each other; and thus facilitate a comprehension of this important matter, which will, for the first time, be placed in its proper light in the succeeding Chapters.

398. Either of the two kinds of impressions may reciprocally excite the other, without the intervention of the conceptive force; and both can excite the same or other movements, either consentaneously or consecutively; and from their reciprocal connection whole series of acts may take place as the result of

a single impression, and be combined together by the proper animal force of the body; although there be neither sensation nor thought, even although the animal possess neither brain nor mind, or, if it possess mind, without the mind in any way influencing the acts. Consequently, the general principles that we shall lay down as to the connection and reciprocal influence of the two kinds of *vis nervosa* with and on each other are equally valid, whether or no external impressions be felt or internal impressions be excited by conceptions.

399. An external impression is changed into, or develops an internal impression, whenever its course which is naturally towards the brain from the terminating fibrils, is so reflected or turned back, that it returns in the direction from the brain downwards to the branches and terminations of the nerves (32, 121). This usually takes place in the brain in animals endowed with cerebral forces, by means of the external sensation of the external impression (129). But since the external impression without either being felt, or without either the presence of the brain or of mind, causes the same movements as are excited by the internal impression of its external sensation (358), it must become a non-conceptional impression without this transition into a sentient action taking place, because it is turned back and reflected in its course to the brain, before it forms the material external sensation in the latter. There are grounds for supposing that this can take place in the brain itself (373, 376). In the nerves, however, there is no place in which it can occur, except the ganglia of the motor nerves (14), and at their separation into branches and fibrils (48). According to all probability, these ganglia and points of division of the nerves, perform in the motor nerves the office of the brain in relation to the external impressions, since they deflect these from their course upwards, and communicate an internal impression, either to other nerves and their branches, or to different fibrils in the same nerve, conducting in the direction from the brain downwards; whereby these twigs and fibrils are suitably stimulated, and such muscular movements excited, as would have been caused if the external impression had reached the brain and had been turned back or reflected from thence by the intervention of an external sensation (364, ii). If this reflexion of the external impression be made upon the same efferent fibrils,

as transmit internal impressions, then the nerve-actions produced by the two kinds of impressions are the same, and also identical with the direct sentient actions of the external sensations (188). If, however, other nerves, or nerve fibrils, be the channel of the reflexion, other nerve-actions are excited, which accord with the sentient actions of the external sensation produced by the impression so reflected (97, 124; compare also 435, 436).

400. In so far as an external impression can excite a non-conceptional internal impression, it may also induce all such nerve-actions as can be produced by the latter. Now, these are in fact the same as sentient actions (363). Consequently, an external impression although unfelt, can induce the same movements which, when felt, it induced as sentient actions (364, i). In the animals destitute of brain, as sea-anemones, tape-worms, &c., and in microscopic animals, polypes, &c., external impressions, although unfelt, can be the incitants of the machines, whereby they are incited to all those movements which arise as sentient actions from sensation, when the impressions are felt by these or other animals (366). If, therefore, brainless animals like those alluded to, are so formed by nature, that all their external impressions are reflected, and changed into non-conceptional internal impressions, in the plexuses, ganglia, and points of division of the nerves, and which move their limbs just as they would have been moved by sentient actions, it ought not to be matter for surprise, that such animals although without thought or sensation, appear to act as designedly, spontaneously, thoughtfully, and volitionally, as animals really endowed with mind.

401. A non-conceptional impression can develop obvious animal movements in the purely sensitive nerves (377). Still more can it put muscles into action by means of the motor nerves (360). These muscular movements in the healthy condition of the individual (225), are often felt, and consequently cause an external impression on the nerves of the muscles (35), and which, even if not felt, can excite the same movements as if they were. In this way non-conceptional impressions can produce external impressions, which, although not felt, still imitate in the mechanical machines the sentient action of their external sensation. Thus, if the spinal cord of a headless frog be irritated with a needle, the internal impression thus

produced acts in the same way as a volition, and the animal is excited to raise itself up. Whilst the muscles are contracted to this end, their nerves have an external impression communicated to them by the movement, which irritates them and other muscles to new movements, so that the animal either places itself upright, or balances itself, or turns round, retreats, makes a spring, swims, &c., according as the irritation of the spinal cord has excited the first movement.

402. To determine more definitely the relationship which the two kinds of impressions bear to external and internal sensations, we will still further consider their relations. An external impression is necessarily required for all external sensations (35), and, consequently, constitutes a portion of them, but only in so far as it is felt, for the entire external sensation is in the mind—is a conception (34). Taken alone, it is a portion of the material external sensation, but only in so far as it forms therewith a material idea at the origin of the nerves which have received it (34). Popularly, and indeed in books also, external sensation generally, and in its widest signification, is termed feeling [Gefühl], and attributed to the five senses, for it is said that the eye feels the rays of light, the ear feels the undulations of the atmosphere, &c. It is also customary to apply the term *sensation* and *feeling* to animal bodies, for it is said that the hand, the flesh, a nerve, feels and has sensation. According to this established signification of the terms, it may be said that the external impression is an element in feeling (the material external sensation), and since it produces the same phenomena, whether it reaches the brain to form material ideas in it or not, the name is derived from a part, and the external impression thus becomes to be designated the *external feeling* [Gefühl] *of the nerves* (32). In this way, the external impression and the material external sensation in the brain may be distinguished by convenient terms, both of which are figurative, the latter being termed sensation [Empfindung], the *sentiment* of Buffon; the former, the external feeling of the nerves — *sensation* of Buffon. Thus it is said, that the tongue, the hand, the ear, have sensation, whilst a decapitated animal, or an excised heart, or portion of intestine, so long as it is excited to motion by a purely external impression, is said *to have feeling left in it*, or that the acephalous embryos, which

are born destitute alike of head and brain, but are moved, nevertheless, by external impressions, *have feeling*, &c.

403. The *external feeling of the nerves*, or what is identical therewith, the external impression, is that animal force of the nerves, the properties of which have been already stated (32, 34, and 364, iii). According to the laws and principles previously established, it is in no degree mental, although it excites external sensations, being neither conception nor sensation [Empfindung], but seated externally to the mind in the nerves (98, i, &c.) Neither is it a sentient action, but a property independent of the conceptive force, peculiar to and innate in the nerves, of being excited to this wonderful movement by an irritation of their medulla, which is the case with no other bodies, nor with any purely mechanical machines, and is wholly independent of the physical and mechanical laws of motion;—a movement which penetrates the brain, and awakes the soul to sensations, and at the same moment puts the machines of the body into motion, in a way that no other force in nature can attain to.

Note.—So important an animal force merits well to be specially distinguished as well from sensation, which is a property of mind, as from the physical and mechanical forces of inorganic machines. I have termed it for the reasons previously stated (402), *the feeling of the nerves*, but the expression is so new, that although quite correct, it may lead the reader to misapprehend its meaning and application. I have, therefore, in this work used the term external senselike (*sinnlich*) impression in its stead.[1]

404. If this difference between external feeling (the external impression) and external sensation had been better observed, that erroneous proposition of the ancients (renewed by Whytt) would have been long ago forgotten, which propounded that the soul was diffused throughout the entire organism, because in sensation the mind determined and fixed the point where the nerves received an external impression, or in other words, where it felt. Even a materialist cannot defend so fundamental an error. If the mind be that which has self-consciousness, or which forms ideas, the nerves can constitute no part of it;

[1] The reader is particularly referred to the note to § 31 for an explanation of this term.—Ed.

for they at least, can neither conceive nor perceive, if we grant that the brain can; nor can sensation [das Empfinden] be conceived to be a property of the nerves, by those who maintain that the brain is the soul. From the point of impression at the termination of the nerves to their origin in the brain, the external impression (external feeling) is nothing more than a hidden movement in the nerve, which, at the point where it forms a material idea, is only first perceived, conceived, felt, observed by the soul (80). If, therefore, the materialist maintains, that it is the *materies* (Stoff) of external sensation, still it does not become an external sensation until it enters this point of sensation [Fühlpunkt] in the brain; and it cannot be antecedently to this, while in the trunk of the nerve from whence it puts the animal machines which it can regulate into motion, either an external sensation or sentient moving force; but is a pure *vis nervosa* [eine blosse Nervenkraft], and all its operations are purely nerve-actions and not sentient actions from external sensation (98, i).

405. The distinction between internal impressions with consciousness and without, is equally as great as that between an external impression and external sensation. The conceptional internal impression, which operates in the mechanical machines, is a material idea at the point of origin of a nerve in the brain, where the mind felt in virtue of its self-consciousness [Selbstgefühl]; (80) and so soon as this hidden movement at the origin of the nerve (the material idea) passes onward from this point of consciousness [Fühlpunkt der Seele] over to the nerves, to the end that they may put the mechanical machines into motion, the internal impression becomes nothing more than what the external impression is before it enters the point of consciousness in the brain; it is therefore neither a sensation nor conception, but a hidden movement in the nerve, which continues downwards from the brain towards the terminations of the nerves, and puts the mechanical machines into motion to which they are distributed. In so far as a conception was the basis of this animal movement, and in so far as the impressions passed from the brain downwards from the point of consciousness, at which the mind perceived the conception of this material idea, to that extent the movement is a sentient action (97); and the internal impression (the material idea) is an

animal-sentient force. But if an irritation of the medulla of the nerve constituted the internal impression, and if it did not depart from the point of consciousness, that is to say, from the locality of the material idea of a conception, then it is not an animal-sentient force, and the resulting movements, although similar to sentient actions, are not such, but nerve-actions of a *vis nervosa*. This may be termed the *internal feeling of the nerves*, to distinguish it from internal sensations (80, 121).

406. This *internal feeling of the nerves*, or what is identical therewith, the internal impression not produced by conceptions, is that animal force of the nerves, in virtue of which they receive in their medulla a certain impression, not mental in its origin, and communicated to them in the direction from above downwards; transmit the impression thus received in the same direction to their minutest fibrils; and excite in the mechanical machines with which their fibrils are incorporated, the same movements as would have occurred if the impression had originated from conceptions. It is a property peculiar to and innate in the nerves, in virtue of which a stimulus applied to their medulla in the direction from above downwards excites hidden movements in them, which no other bodies and no purely mechanical machines could acquire from such a stimulus, and which are not subject to the physical and mechanical laws of motion. These hidden movements are propagated by the nerves to the mechanical machines to which they are distributed, if no hindrance arise, and move them in the same way as they are usually moved by conceptions.

407. According to these views as to the distinction between the cerebral force and the internal feeling of the nerves, it follows, that it is manifestly erroneous to say (as is said in our elementary works), that the animal movements excited by the internal impression are mental, or at least, cerebral. Hence have arisen the erroneous views, which have had so injurious an influence on pathology and therapeutics; to the effect that the phenomena of fevers, spasmodic diseases, epilepsy, paralysis, and all nervous diseases in general, depend upon some affection of the brain, and that they must be cured by remedies which act upon that viscus. On the contrary, an internal impression excited in nerves far distant from the brain by various irritating

agents in the body, especially by reflected external impressions which are not felt, may induce all these affections quite independently of the brain, and must be cured by the removal of these agents.

It is manifest, too, with what justice we have controverted the doctrine of Haller, that the motor force of the nerves can neither arise nor continue independently of the brain, and how prejudicial such views must be to pathology and the practice of medicine, especially when advocated by so eminent a physiologist. It has simply escaped his notice, however, for it could be shown by a hundred passages in his writings that the truth was known to him.

CHAPTER II.

ON THE VIS NERVOSA OF EXTERNAL IMPRESSIONS.

408. After having considered the two kinds of *vis nervosa* in general (355), we will consider them separately, and, firstly, the *vis nervosa* of the external impressions, generally and specially.

SECTION I.—ON THE VIS NERVOSA OF EXTERNAL IMPRESSIONS IN GENERAL.

409. An impression passes upwards to the brain, along the nerves, from the point of impression. If it reaches the cerebral origin of the nerves, it develops there an external sensation, and the actions which it thus produces in the body are sentient actions from external sensations (32, 34). On the other hand, all actions which it produces before it reaches the brain, or in other words, before it becomes an external sensation, are nerve-actions of its *vis nervosa* (98, i, and 353). It is the latter which we have to consider here.

410. When a nerve is irritated with a needle, it receives both an internal and external impression; if, for example, it be a motor nerve, the latter acts on the muscles above the point irritated, and the former (or the non-conceptional internal impression) on the muscles situated below, or in a direction from the brain. Both kinds of movement are equally nerve-actions.

411. If when, as in many external sensations, the irritation is so applied that the nerve is mechanically concussed below the point of irritation, and this concussion of the lower portion of the nerve acts as another external impression, and thus develops movements in the parts below, they will be the same as those induced by the first irritation (37).

412. Since the external impressions that are made at the same time on several nerves, do not hinder or confuse each other in their course to the brain, but pass along the same nerve, or through the spinal cord, unmingled with each other (39); it follows, that they can produce their corresponding

nerve-actions, without the one kind interfering with the other. Experiments on decapitated animals establish this fact.

413. It is as difficult to discriminate the various kinds of impressions from their nerve-actions as from their external sensations (40, 41). An irritant may often act when we cannot detect it, or when we think it not an irritant; and hence it is that the phenomena of idiosyncrasies are so inscrutable (52). The heart is more stimulated by blood than by acrid irritants, the urinary bladder by water, the intestinal canal by air (Haller's 'Physiology,' § 402). An irritant which *à priori* would be expected to be more active than another apparently less irritating, is in fact less active: many parts that remain unchanged when the most acrid chemical spirits are applied to them, are excited to convulsive movements on being irritated by the point of a needle. It is in fact impossible to infer from mechanical or physical laws, what nerve-actions will follow on certain kinds of irritants; the laws of their action can only be known by experiment and observation.

414. It is not every impression on the nerves that is adapted to their structure, but only that which excites animal actions (31, 32); nor is it adapted if it be not made so as to excite that hidden movement in the nerves, which when propagated to the brain, excites external sensations; or excites movements in the mechanical machines when propagated to them. We have already discussed the former (42, et seq.): we will now treat of the hidden movements in the latter, as disclosed by nerve-actions, and inquire under what circumstances they take place.

415, i. If, at the point where a nerve receives an external impression, it be completely incorporated with a mechanical machine which is capable of performing certain movements at that point, as in muscles for example (161), it excites these directly to perform their animal movements; and the nerve-action thus excited requires nothing more than the external impression, whether it proceeds further or not. Thus a muscular fibre in an excised muscle contracts immediately at the point where a point of a needle irritates it, or a particle of salt is dissolved upon it.

ii. If a nerve causes nerve-actions, by means of an external impression in parts remote from the point of impression, or even at the point itself, but through other fibrils than those which primarily received the impression, or through its own efferent fibrils (127), the impression is transmitted along the nerve upwards to the brain; but ere it reaches there, it is turned from its course, and so reflected downwards, that it excites (as an internal impression) the nerve of the other remote parts, or the nerve-twigs or efferent nerve-fibrils of the part receiving the impression; and this internal impression, which is nothing else than the reflected external impression, thus reaches the mechanical machine which has to perform the nerve-action. This is proved by undoubted experiments. If the toe of a frog at rest be pricked, the external impression thus made goes to the brain. From thence it is reflected upon the limbs, and the animal rises up and springs forward. But if the head be cut off, and the toe be again pricked, the same motions take place (357). In this case, the external impression on the toe, must pass upwards towards the brain, although it cannot reach it, for if the nerve be divided in the thigh, so as to prevent its transmission, the motion does not take place. Further, it is obvious that it is reflected on the nerves of the limbs, as an internal impression, and along their twigs to their muscles, because no other part of the body, except this single toe which was pricked, receives an external impression. Again, supposing while one toe is pinched, that the nerve of the other leg be divided; in this case, the movements will be repeated in all the parts except that whose nerve is cut through. This explains what takes place in similar circumstances, when an impression is made on the spinal cord, and spasms and convulsive movements are excited in all parts below the point of irritation, except those the nerves of which are cut through. The reflected external impression passes as an internal impression to, and only excites movements in those muscles to which it can be transmitted from the point of reflexion.

iii. Examples of this class of nerve-actions are to be met with daily, which sometimes are mistaken for sentient actions (which they often accompany), sometimes for special operations of unfelt external impressions acting through the brain, sometimes for inexplicable sympathies. Numerous instances of this kind may be found in Haller's 'Physiology,' vol. iv, p. 529, and B. 10, Absch. vii, §§ 30-31.

416. As the brain secretes the vital spirits, and as in

animals endowed with brain, it is requisite that the nerves be supplied with these, as the medium for the transmission of impressions, the brain must be considered as being necessary at least to the *continued* production of nerve-actions; unless the animal be so constitnted, that the vital spirits are secreted in the medulla of the nerves themselves, or in their ganglia, as is the case in avertebrate animals (362). Compare also § 673. This is one of the reasons why in animals endowed with brain, the *vis nervosa* is abolished so soon after decapitation; for the vital spirits gradually flow out of the nerve-medulla, and are not re-produced. So long, however, as a sufficiency of vital spirits remain in the nerves, their *vis nervosa* continues to act with vigour, thus establishing its independence of the brain. In many animals, the *vis nervosa* is retained after decapitation for days and weeks, and in turtles for half a year. The destruction or removal of the brain, which destroys consciousness, hinders therefore the continuance of the *vis nervosa*, but only so far as it prevents the influence of the blood in the muscles (161); or, in other words, in proportion as the nerves thereby become gradually more feeble and dead, but not because the co-operation of the brain is a part of the *vis nervosa*.

417. Those portions of animals which are supplied with nerves highly susceptible of impressions (160), are endowed with more acute external feeling, and a stronger *vis nervosa* from external impressions (403) than others; as for example, the heart, stomach, and intestines. Structures with few nerves, or nerves little irritable, are endowed with a feebler *vis nervosa* from external impressions; and those to which no nerves are distributed, have neither external impressions, nor *vis nervosa* (390). Thus bones, tendons, cartilages, and ligaments, however they may be irritated, display no traces of movement. A part, to possess the *vis nervosa* of external impressions must have nerves that can receive an impression, fully incorporated with it; the more numerous such nerves, the more varied the impressions, and the more susceptible they are to these impressions, the more vivid its external feeling, and *vice versâ* (44, 47).

418. When an external impression in a nerve distributed to a mechanical machine, excites a nerve-action in the latter at the point where the impression is received, it is termed, whether the impression be transmitted onwards or not (415, i),

in so far as it is independent of that transmission, its *direct nerve action*. The conditions requisite to the production of this are—

i. That the mechanical machine be endowed with nerves (160, 417).

ii. That its nerves be so touched, that an external impression be communicated to their medulla (414).

iii. That the mechanical machines be capable at the point of impression of such movement as the impression can excite.

419. The *direct nerve-actions* are to be distinguished from the *indirect*, which are induced either remotely from the point of impression, or, if they arise in the machines whose nerves are irritated, are not excited through those nerves, but through some other, or else through the efferent fibrils of the irritated nerve (127). The conditions under which they arise, are more numerous than the preceding, and to understand them the following must be premised.

420. Take a nerve which pursues a direct course from the brain to a limb, and penetrates tissues, without giving off a single branch to any organs or structures in its course, having neither ganglia nor plexuses, and instead of ending in numerous fibrils, gives off one only to a simple muscular fibre. If the latter be irritated with the point of a needle, and the nerve thus receive an external impression, the fibril contracts, and so a *direct* nerve-action is produced, whether the impression be transmitted upwards or not (161, 204). But suppose it to be so transmitted, what then happens? Since there are no ganglia or plexuses, in which the impression can be reflected, and since there are no branches whatever given off, the tissues it penetrates cannot be excited to action; but the impression must go on to the brain, in which, if it reach the brain, it causes sensation, and can then be reflected from the brain as the internal impression of an external sensation, and thus again move the fibrils it moved before (188, 127). This result is, however, a sentient action, and not a nerve-action.

421. When, therefore, an external impression on a nerve excites, in addition to its *direct* nerve-actions, a movement in remote machines, or in the same machine, to which it is distributed by fibrils of nerves distinct from that which received the impression, or by efferent fibrils; or, in other words, when it develops *indirect* nerve-actions, it follows that either the nerve itself is deflected,

from its course, or it must have ganglia, plexuses, or points of division, in which the impression itself may be deflected in its course upwards. In this case, the impression is reflected either in the nerve itself, or on its efferent fibrils, or in the ganglia and plexuses, on altogether different nerves, and thus it passes downwards, as a reflected internal impression, but unfelt, and, as such, can excite nerve-actions in those machines supplied with the nerves, along which it is reflected.

422. The conditions, then, which are requisite to the production of indirect nerve-actions by an external impression, are—

i. The external impression must be transmitted upwards, to that point of the nerve where it is reflected, and changed into a non-conceptional, internal impression; as, for example, to that point where the efferent fibrils of the nerve are excited by the external impression, or where the nerve-fibrils are given off which subserve to the required nerve-action; or to the ganglia, or to the plexuses which contain them (415, ii).

ii. Reflexion of the external impression, or its change into a non-conceptional impression, must actually take place there, or, in other words, must duly affect the efferent or other fibrils above mentioned (121).

iii. This new internal impression must also be transmitted to, and reach, the mechanical machines to which the fibrils are distributed (128, 415).

The indirect nerve-actions of external impressions are, consequently, no other than nerve-actions of non-conceptional internal impressions, originating from external impressions turned back from their course towards the brain, and unfelt.

423. Although this reflexion of external impressions frequently takes place, and always in certain circumstances ordained by nature (48), yet it does not follow that it takes place absolutely in every case. On the contrary, it is often seen that an external impression, which excites in certain machines direct or indirect nerve-actions, excites also, at the same time, the same movements in other machines regulated by other nerves; nay, is even felt, and produces them as sentient actions of the internal impression of the external sensation (363, 364, ii).

424. An indirect nerve-action from an external impression cannot arise, or is prevented,—

i. If the mechanical machines which ought to be its seat, are not endowed with nerves.

ii. If their nerves be not irritated, or only so irritated that the nerve-medulla does not receive thereby an external impression (418, ii). Something more than mere irritation is required to this end, as a strong excitant fails to excite the nerve-actions, if it be not such an one as stimulates the nerve suitably. (Compare 413, 414.)

iii. If the mechanical machines be unfit, at the point of impression, to manifest the nerve-actions to which they are stimulated (418, iii). In such cases, the impression has no direct action; but leaving the machines unchanged, acts upon them indirectly, and causes an indirect nerve-action, or, if it be felt, a sentient action. Thus, a stimulus applied to a muscle, excites no contraction, if it be already affected with spasm, although it may be felt, and excite spasmodic movements in many other muscles. (See §§ 208, 464.)

425. An indirect nerve-action from an external impression cannot arise, or will be prevented,—

i. If the external impression do not reach to the point, where it can be so turned as to be reflected (422, i), as when the nerve is tied, or divided.

ii. If the external impression, although it reach this point, be not changed into a non-conceptional impression, or, in other words, at least partly deflected from and hindered in its course to the brain; as when there is induration, or other disease, of the ganglia, or plexuses, or of points of branching.

iii. If the transmission of the reflected impression downwards to the machines be prevented, as by ligature; it being understood that the machines themselves are capable of the actions (422, iii).

426. Since we can prevent the action of irritants and of external impressions, and hinder their course, reflexion, and transmission downwards, so also nature herself regulates them; and the impressions do not act blindly and necessarily, being prevented in various ways, and guided so as to excite the mechanical machines for specific objects, just as various external sensations are prevented by various means, to the end that the conceptive force be not excited by every irritant applied to the body (47—51). It is of importance to comprehend all the modes

in which, in the natural condition, the nerve-actions of external impressions can possibly be prevented, and we will therefore go through them.

427. All those natural obstacles which hinder external impressions arising, prevent them also from developing direct nerve-actions (47, i, ii, iii).

i. If a part be not supplied with nerves, nerve-actions cannot take place in them: of this kind are bone, cartilage, &c.

ii. If the nerves of a part be so protected by nature, by means of membranes, mucus, &c., that they cannot receive various impressions, they cannot excite the corresponding nerve-actions, although they may be moved by internal impressions, and manifest, through these, either sentient actions or nerve-actions.

iii. If a nerve is naturally susceptible of certain impressions only, these alone can excite the direct or indirect nerve-actions, and none others (424, ii; 47, ii). Various insects, as spiders, endure the application of very acrid irritants, from which other animals would experience violent inflammation and convulsions, and yet feel the slightest irritation of another kind (413, 414). It is often observed, in animals endowed with sensation, that some nerves are only susceptible of certain impressions for a given period, consequently the nerve-actions dependent thereon cease so soon as the period of susceptibility terminates (265). The phenomena of idiosyncrasy belong to this class.

iv. If a mechanical machine be endowed with nerves, and yet is naturally incapacitated for animal movement at the point of impression, no direct nerve-actions can arise therein (424, iii). The liver, spleen, &c., are incapable of motion at the point irritated, namely, the substance of the viscus, and therefore no external impression excites movement in them.

428, v. If the external impression be too feeble to reach a point of reflexion, to be there changed into an internal impression, it may excite a direct, but not an indirect nerve-action, although the body be in the natural state (425, i). Thus, in a decapitated animal, a slight irritation of a muscle excites a gentle contraction of its fibres, without any of those convulsions resulting in other parts, which a more powerful irritation generally produces.

vi. Doubtless there are cases in which, in the natural state of the body, a certain external impression is not reflected in its course to the brain, or changed into a non-conceptional impression, and in which direct actions result, but not those indirect actions as would have occurred had not the reflexion been prevented (425, ii). There are numerous instances of this kind, in which the impression is naturally not felt, and not transmitted to the brain, and which render it probable that there are secondary points in the nerves, whence it must be reflected, and sent in a certain direction, where it is to be changed into a non-conceptional internal impression. A great number of external sensations, and also of unfelt external impressions on the stomach and intestinal canal, are never communicated to the muscles of the limbs, although these two kinds of nerves are in close connection: there are also impressions of this kind, which are not felt (48), yet excite the most violent convulsions. Here we can only say, with reference to the greater number of these impressions on the nerves of the stomach and intestinal canal, that the points where the latter come into contact with the nerves of the muscles, are not duly excited, or do not reflect the external impression. Since many of these impressions are, in fact, felt, it is certain that they reach the brain, and if they had been reflected, they would also have excited the muscles to action; unless it be that the impressions actually reflected do not reach the muscles, being interrupted (as shown in the next section) in their course between the point of reflexion and the mechanical machines. In the examples above quoted, this is neither demonstrable nor probable.

429, vii. When an external impression on its way to the brain is actually reflected and transformed into a non-conceptional internal impression, but is not transmitted back again along the nerve which received it, or on account of a natural deflection by means of intervening ganglia, or plexuses, or is reflected upon a certain other nerve, the nerve-actions which usually result from it, do not take place, but those mechanical machines are put into motion in connection with the nerve along which the impression is deflected (425, iii). This case often occurs naturally (137), but the proof is difficult. When an external impression has caused an external sensation, we know that it has reached the brain, and that the cerebral origin of the nerves has received the internal impression of the conception; and if the ordinary sentient actions do not result, we conclude that the internal impression cannot have reached the mechanical machines (137). But with regard to the non-conceptional internal impressions, we have not the direct proof afforded by sensation, but only secondary evidence, when their indirect nerve-actions remain unperformed, whether they be reflected at the point of reflexion [Reflexionspunkte] of their nerve; and, consequently, whether the cause of the failure is in their course to the mechanical machines or not. We can only incidentally conclude in a case of this kind, that the reflexion has taken place, if another organ situate below the point of reflexion, and receiving its innervation from the same nerves, is excited to action by the same external impression which ordinarily excites the other organ, but now fails to do so. It is difficult to adduce instances, but reasoning from analogy, (compare §§ 138, 360,) it is probable that the reflexion takes place, and it is the transmission downwards of the reflected impression that is arrested.

430. Just as habit enfeebles and prevents many sensations and their sentient actions, in like manner it influences nerve-actions from external impressions, as follows:

i. The terminating fibrils may be so changed by the frequent repetition of an external impression, that they are no longer capable of the irritation requisite to the production of the impression; and, consequently, no nerve-actions result from the application of the stimulus.

ii. The sensibility to certain stimuli only, may be destroyed by frequent repetition of them, whilst with regard to others it is unaltered (51, ii), and thus the former are no longer able to excite nerve-actions (427, ii, iii).

iii. The frequent repetition of the same external impression on the same part of a nerve, may so enfeeble it, that whereas previously it could reach the point where it was reflected, and thereby excite indirect nerve-actions, after long habit it cannot reach that point, and thus its indirect nerve-actions cease, while its direct continue (428, v).

iv. Frequent repetition of the same external impression on the same nerve, can so affect the point of reflexion, that reflexion and transformation of the impression no longer take place (137, iv); and thus, although its direct nerve-actions continue, the indirect no longer occur (428, vi).

v. Lastly, in consequence of this frequent repetition of an external impression, the reflexion and transformation may take place so imperfectly, that it is not transmitted as a non-conceptional internal impression, with sufficient force to reach the accustomed mechanical machines (138); and thus the indirect nerve-actions cease, although the ordinary direct actions, or other direct actions still occur (429)

431. That continued-frequent repetition, or *habit*, has considerable influence on nerve-actions excited by external impressions, as well as on external sensations and their actions, is proved not only by the analogy of all experience as regards the latter (51), but also by experience in all instances in which the external impression is not felt. The habituation to various foods, poisons, &c., are examples of this kind. The movements excited by these, until a person is habituated to them, are usually nerve-actions of their external impressions, and continue to be such, although they may be felt (364, ii); but these movements often cease from constant repetition of the stimulus.

432. The organisms of those animals, whose organs being well supplied with nerves, have, as compared with other animals, a vivid sensibility (417), are termed *irritable organisms* (animals): those which are the contrary, are *inirritable*. Sensibility [empfindlichkeit] may co-exist with irritability, and insensibility with inirritability; but irritability does not always imply sensibility, because a very irritable organ, as the heart or stomach, may be endowed with a less sensibility than a less irritable one, as the tongue. But as sensibility implies irritability, the latter enters also into the *temperament*, or *corporeal constitution* (52), and like the former, is influenced by habit, and thus forms the basis of all the peculiarities of idiosyncrasy (Haller 'Elem. Phys.' tom. iv, p. 576).

Note.—That which Haller terms *vis insita* [angeborne Kraft], is really only a part of the same property of animal organisms, and has the same relations to sensibility and habit; for, according to our views, it is nothing else than the *vis nervosa* of external impressions exciting direct nerve-actions. Let the reader compare Haller's 'Physiology,' § 400, with other parts of his works, and with our own views, and it will be seen that the latter afford a ready explanation of all the phenomena which he refers to the *vis insita*.

433. When an external impression is felt, it is also felt to be either pleasing or displeasing (187). This difference lies in the impression itself (186); consequently, the external impression, which when felt is pleasing, is totally different in its nerve-actions, and is of quite another kind, than the impression which when felt is displeasing (189). Now since the nerve-actions of an external impression are the same, whether it be felt or not (364, iii), it follows that the impression which can cause a pleasing sensation will excite the same animal movements as the pleasing sensation itself will excite; and so in regard to the external impression of a displeasing external sensation. Consequently, external impressions produce, as nerve-actions, the same movements which their external sensations, accompanied with sensual pleasure and pain, would develop as sentient actions (186, 80).

434. By means of the same force, an external impression also produces the sentient actions of smarting, or tickling, although not felt, provided it occur under the circumstances when it would have caused titillation or pain (80). It cannot, consequently, be inferred from the occurrence of those movements which usually accompany an external sensation, particularly tickling or smarting, that the latter are felt, but only that there is that present in the external impression which can cause tickling or smarting. If an acephalous fœtus, or the headless trunk of a worm or insect, be irritated, the same movements result as would have been considered the direct and incidental sentient actions of the irritation, if it had been felt, although this is impossible (25, 34). If it be so irritated, that pain under ordinary circumstances would have been caused, then those movements result which are the ordinary direct and indirect sentient actions of pain. The injured part contracts, is congested with blood, and swells and inflames, and the animal writhes, tries to escape, leaps, flies, defends itself, and exhibits all the signs of suffering, although it is incapable of sensation. Titillation has a similar effect under similar circumstances, so that decapitated animals may be excited to the performance of sexual acts, by the external stimuli appropriate thereto (274, 396).

435. If we would comprehend more distinctly how the nerve-actions of an external impression can resemble all the sentient actions, whether direct or indirect, of its external sensation, we must take into consideration that the direct nerve-actions in the part irritated result immediately from the application of the external impression, and before it can be felt; to this class the internal impression is not required. With regard to the *indirect* nerve-actions of external impressions, the matter is as follows:

436. When an external sensation, either from sympathy or natural deflexions, develops direct sentient actions, or excites incidental sentient actions by means of subordinate conceptions, imaginations, foreseeings, desires, &c., through other branches of the nerve which has received the external impression, or by means of nerves quite different (131), it is requisite to these series of phenomena, that the external impression be changed into a conceptional internal impression before it can suitably excite the cerebral origin of the nerve, or be reflected in its course downwards on the other branches or nerves, as an internal impression (123, 124). If the same nerves be suitably excited in the same manner, by a reflexion or turning back of the external impression, exactly the same phenomena are excited, as if they had resulted from secondary sensational conceptions, foreseeings, desires, &c.

437. It is thus we comprehend, how it is possible for headless animals to exhibit on a stimulus being applied (as proved by experiment), the same adapted movements as are produced by sensation, and by the ideas, foreseeings, desires, &c., resulting therefrom; as when a fly deprived of its head, flies away if irritated, or as when a headless snake quickly withdraws its body from whatever comes in contact with it, or a headless fish strikes the boiling water it is put into with its tail, &c.

438. It appears really wonderful that a blind external impression is so reflected on other nerve-fibrils in its way to the brain, as to produce those movements which the mind produces in virtue of its sensational volitions. The wonder arises, however, from our ignorance of the laws of animal nature, and from our prejudice in concluding that all which results from sensation, can result in no other way. The nerve-actions produced by external *impressions*, are referred by the mind to

their external *sensations*, and to the pleasure or pain they excite, or to the secondary conceptions they produce. There must be then a sub-element [Merkmal] for the mind in the external sensation of an external impression, so that it feels co-ordinately the reflexion of the latter, and also the force required for the resulting indirect nerve-action; and it is thereby led by the sensational secondary desires to effect the movements volitionally, which then take place the more readily, because the mind can of itself satisfy the desires for volitional movements (283). In this way, the indirect nerve-action becomes at the same time the incidental sentient action of the external sensation excited by the same external impression (97, 221). But having observed, that adapted motions excited after decapitation were always previously volitional, we are led to presuppose that they must be volitional in their *nature*, and, therefore, always volitional; and are astonished when we find that they can take place independently of the will. It is so in every instance; but it is those motions only that excite astonishment, which from their nature we have always been accustomed to consider as wholly dependent on the will. We are little surprised at seeing a muscle in a decapitated animal contract when irritated, because we often feel the irritation without at the same time feeling or observing the contraction; but when we see the animal rise up and leap away when strongly irritated, we are surprised, because a similar sensation was always previously connected with the determination to escape, made by a sensational act of will. If the movement to escape were not always connected with the painful sensation in the uninjured animal, we should see it produced in the decapitated animal without thinking it resembled a volitional movement, and without being surprised.

439. It is clear from the preceding statements (366, and 398—401), that brainless animals, although without sensation, because not endowed with mind, nevertheless by means of external impressions which operate incessantly in them, perform all the acts and manifest all the activity of the sentient animal; everything, in short, that is effected sensationally and volitionally they effect by means of the organic forces of the impressions; and since they can act as orderly, judiciously, and rationally as it were, as if they thought, it has been inferred

erroneously, that the apparent voluntariness of these acts depended on sensational conceptions, even although they might be only external sensations. That which is termed voluntary motion, we term so only in *ourselves*; the voluntariness is not in the movements—which remain the same whether sensational conceptions produce them or not—but simply in this, that *we* produce them by spontaneous sensational conceptions. But who has proved that animals thus produce *their* movements? or who can demonstrate, in the face of ocular proof to the contrary, that these movements can be effected by no other animal force than conceptions (400)? That these animals act in this way according to the preordained objects of nature, especially in the instincts, is undeniable (262); but of these objects even the greater number of thinking animals themselves know nothing (265). They are the objects of nature, not theirs (266); and nature has so provided when their adapted acts should take place, or their instincts ought to be in operation, that certain external impressions are imparted in a naturally necessary manner, which pass along their nerves, and are so reflected and changed into internal impressions (399), that the animal must perform those apparently adapted and volitional movements; and which are intended also for the gratification of an instinct, if it exist, but which are nevertheless just as fully effected without it (269). Thus it is from erroneous views that our astonishment arises, inasmuch as we think that these acts cannot be developed by any other animal force than the conceptive force of the mind. For the same reason we erroneously infer, that because the acts of bees, ants, flies, polypes, and other insects and worms, are regulated to ends and in agreement with preordination of nature, they are dependent upon the conceptive force (266). It is quite possible, however, that the external impressions manifestly provided by nature for the instincts in a preordained manner, and which excite the organs according to a pre-established order of sequence, cause in them all those wonderful and apparently voluntary acts, without a conception being at all necessary thereto (286, 292, 293).

440. We know as little how and wherein external impressions on the nerves differ from each other as we know with regard to the various external sensations which they excite (413). An external impression produces as nerve-actions the same movements

which it would excite if it were felt and caused a painful or pleasing sensation; but we know no more in what it differs from an impression which produces the contrary effect, than in what sensations themselves differ (190). Nevertheless, it is very probable, that the external impression which would have excited pleasing sensations, operates upon the nerves connaturally or in a way that is in accordance with their normal and appointed functions; while on the contrary, those which would have caused a painful sensation, act upon the nerves contra-naturally [widernatürlich]; consequently, the resulting nerve-actions themselves are either connatural or contra-natural (191, 195). Experiment supports this view. If a decapitated animal be irritated, so that in its ordinary state the irritation would have caused pain, it fights with its natural weapons, as if the pain were really felt; a headless wasp stings, a headless earwig attacks with its nippers, &c. All these movements are violent, convulsive, and contra-natural, just as they are in the ordinary state of the animal. An acrid irritant causes a convulsive contraction in the excised intestine of an animal, just as usually occurs in the painful colic excited by ths same acrid poison. Gentle stimuli, on the contrary, excite in headless animals gentle movements only; when a decapitated cricket receives the external impressions which ordinarily excite the insect to the act of sexual congress, a disordered and half-convulsive manifestation of the sexual instinct is excited, which borders closely on a contra-natural state, because its sensational stimulus is a titillation of the sexual organs (274). It chirps incessantly with its wings, and allures to sexual congress with unusual energy and activity.

441. Consequently, just as external impressions follow upon each other, so also the same movements result as nerve-actions, which take place as sentient actions, when the external impression excites pleasing or unpleasing external sensations, pain or tickling; and these nerve-actions are in like manner, either in accordance with the natural destination of the mechanical machines, or opposed thereto.

442. It is not necessary that an external impression shall always develop indirect nerve-actions in the mechanical machines supplied with fibrils from the nerve which received the impression, or from others in connection with the latter, for

the same reasons as laid down in § 201 with reference to external sensation.

443. The nerve-actions of an unfelt external impression may be felt, and induce external sensations (184). This constitutes in sensational animals, a new link between the nerve-actions of external impressions and the sentient actions of external sensations. A loaded state of the stomach, worms, or poisons cause therein external impressions, which usually are not felt. These have their direct nerve-actions in the stomach, producing in it a contraction and contra-natural movement, and this nerve-action it is which we feel, when we say that we are ill. Vomiting follows upon this external sensation, as its sentient action, and as the result of a nerve-action of an unfelt impression. So the headaches accompanying disorder of the stomach, are *felt* nerve-actions from *un*felt external impressions (419). Examples of this kind are of daily occurrence.

In specially considering the nature of the nerve-actions in the different mechanical machines, it must not be forgotten that the latter are by nature peculiarly adapted to certain movements, and to none other (193).

SECTION II.—THE VIS NERVOSA OF AN EXTERNAL IMPRESSION IN SPECIAL RELATION TO DIRECT NERVE-ACTIONS.

444. The nerve-actions, produced indirectly by an external impression, are really nerve-actions of a non-conceptional internal impression (422). As these will be considered in the next Chapter, our inquiry as to the *vis nervosa* of an external impression need not extend beyond the direct actions it produces in the mechanical-machines (418).

445. Muscular fibre of all the tissues is most eminently that in which an external impression excites direct nerve-actions. The structure is peculiarly adapted to the latter, since the fibrilli are easily excited to movement at any point of their length, when the two ends either approach or separate from each other (161). An external irritation which duly excites the nerve-medulla distributed through the muscle can therefore very readily impart an obvious movement at the irritated point, and produce a direct nerve-action (418). An external impression cannot so easily excite motion in other mechanical machines,

not constituted of longitudinal fibrils like those of muscles (161), although supplied with nerves; as the substance of the liver, the osseous medulla, the glands, and the membranes not made up of sensitive muscular tissue, as the mucous. When such a tissue is irritated, no immediate movement results; nevertheless, an external impression is transmitted along the nerves, and felt or reflected in its course upwards, and can produce indirect nerve-actions and sentient actions of external sensations in the same or other mechanical machines (424, iii).

Note.—This peculiar capability of muscular fibre for direct nerve-actions, as compared with other machines, has probably been the principal source of the erroneous doctrine, that the animal motor force of an external impression, or, in other words, their irritability, is a property peculiar to the tissue, and independent of the nerves. It is probable, however, that it is not the only seat of direct nerve-actions, as will be shown subsequently (463).

446. When many muscular fibres are united together, so as to form bundles, the motion excited in one readily extends to others, and puts the whole bundle into action; or, if a viscus be made up wholly of such bundles, the whole machine may be thus excited to action, as is the case with the heart, stomach, intestines, &c. This compound and communicated action is as much a direct nerve-action, as if only one fibril had been excited to contract; consequently, when the motions of the heart, or of portions of intestine, are renewed after their removal from the body, by pricking with a needle, direct nerve-actions are produced. (*Vide* Haller's 'Elem. Physiol.,' tom. iv, p. 467.)

447. Nevertheless, it is not advisable thus to consider them. For, firstly, the movements excited in the fibrils connected with those primarily irritated, is only a mechanical result. Secondly, it may be considered as a nerve-action, the direct result of an internal, or the indirect nerve-action of an external impression, and this may take place as follows. The nerve entering a muscle is distributed to every fibril of it, otherwise every portion would not be sensitive (35). Consequently, there must be numerous points of division of the nerve in the substance of the muscle, at which an external impression on its way upwards can be reflected, and changed into a non-conceptional impression

(48). This reflexion of the impression can excite indirect nerve-actions in all other parts of the muscle. It is difficult to decide which of these two modes of action takes place, when an entire muscle, or muscular viscus, is excited to movement by the irritation of a single point; but it is necessary for the sake of establishing the correctness of the doctrine, that the possible distinction be known.

448. The motion of which a muscular fibril is capable, is alternate contraction and relaxation. According to the views stated in the previous paragraph, irritation of a single fibril may excite entire muscles, or bundles of fibrilli, into action, and by means of the latter, entire viscera and limbs be put into motion. When an impression produces this motion it is animal, whether it arise from a conception, or from an irritation applied to the nerves of the fibrilli (161—163, 193). Thus, in a decapitated animal, an external impression produces contractions, spasms, &c., in a muscle, by a direct nerve-action, and thereby puts those limbs into movement to which it is attached, just as a volition would. And thus, many movements which are or may be sentient actions, result from the direct nerve-actions of external impressions on the muscles; as when the irritated muscle moves a limb by its contractions, or closes a cavity, or, as in the intestines, causes peristaltic movements and numerous writhings.

449. Neither the mind, nor internal impressions on the brain or nerves, are necessary to direct nerve-actions in the muscles. They occur, although the brain be compressed, or even the head removed from the body, and although the nerve going to the muscle be divided, or the muscle itself excised. All these are points of distinction between direct nerve-actions and sentient actions generally, but especially those of external sensations (164, 204).

450. Although, therefore, after the functions of the brain are arrested, or the nerve divided or tied, the muscle is excited to motion neither by the cerebral force, nor by any other internal impression above the point of division, but remains paralysed (415, ii) to all impressions, still the nerve itself retains the power of producing direct nerve-actions in it, by means of an external impression.

451. It is not every irritation that excites direct nerve-

actions in a muscle (424); nor is it to be inferred, that because certain irritants fail to excite movement in a muscle, it is defective in the *vis nervosa* of an external impression; or because it is excited to movement by some, it must necessarily be so excited by all. Every muscle, like the nerves, has its own special external impressions, which directly irritate it rather than others, and that whether they be felt or not. And the same irritant of the nerves in a muscle may cause an external impression, be transmitted upwards, be felt, or be reflected downwards, and consequently produce sentient actions, or indirect nerve-actions, and all without having produced a direct nerve-action in the muscle itself (424, iii).

452. Those external impressions on the muscular fibre which can excite an agreeable external sensation, excite the muscles to movements in accordance with their healthy functions, as the sensations themselves would; on the other hand, those which would be painful to the animal under ordinary circumstances, excite the irritated muscle to spasmodic and convulsive actions, and convulse the limbs (204, 440). Thus acrid, irritant poisons, excite violent writhings in an excised portion of intestine, and render an excised muscle hard, and permanently contracted; the excised heart beats irregularly, if strongly irritated, &c.

453. The direct nerve-actions of an external impression on the muscles are the same as the direct sentient actions of its external sensation, and can cause the same series of movements which these latter excite by their pleasure and pain, and the resulting sensational conceptions as incidental sentient actions; so that external impressions may thus excite a whole chain of apparently volitional acts, without one of them being felt, or any conception whatever excited (437-8). Hence an animal may, by external impressions only, perform all the organic and apparently volitional movements necessary to its existence, without having either brain or mind, if its body be so constituted (as is quite possible) that all external impressions on its nerves can produce their direct and indirect nerve-actions, without having to excite material ideas in the brain, or conceptions in the mind, connected therewith.

454. Although muscular movements be, for the most part, excited volitionally, either by external sensations or volitional

conceptions (163), still an infinite number of instances are observed in the natural state, in which they take place solely by means of the *vis nervosa*, and, in particular, that of external impressions. A limb is often moved, not only against our wish, but often without any feeling of the irritation that causes the involuntary movement. It often happens that an impression in the intestinal canal, which is not felt, causes, in virtue of an indirect nerve-action, the most violent movements of the limbs; as is proved by epileptic paroxysms dependent on worms, and the presence of which, in the intestinal canal, is not indicated to either the physician or patient, by any peculiar phenomena (470). Thus, also, an irritant poison causes spasmodic action of the intestines, which is only indicated by the rumbling of flatus, but not felt. So, also, the stimulus of light causes contraction of the iris, as an indirect nerve-action, without any accompanying sensation. Consequently, there are many movements considered to be sentient actions of external sensations only, which are nevertheless, at the same time, direct or indirect nerve-actions of an external impression which is felt; and in this way may be explained many movements made during sleep, particularly by somnambulists, and those habitual voluntary movements which are induced by external impressions that are not felt. But the principal point is, that on this depends the secret of the instincts in those animals which probably do not feel the sensational stimuli of the instincts; as, for example, animals *in utero*, or *in ovo*, which already know how to aid their birth before they seem to have felt anything; or animals which are stimulated to undertake movements the most skilfully adapted to their preservation, without having been taught by experience (269); or animals which, during their whole life, do nothing that shows the least trace of ideas, and, consequently, of external sensations, as polypes and oysters, &c. In all these examples, the external impressions which are ordinarily the sensational elements of the instincts, seem to act as a *vis nervosa* in producing the movements of the so-called instincts; and many of these are undoubtedly true, direct, nerve-actions, although it is equally certain that others are indirect. In animals which gradually learn to feel, and to form volitions, these external impressions become, in time, to be external sensations, and the movements, hitherto nerve-actions, become to be also sentient actions, as has been already shown in detail, in Part I. (Compare §§ 269, 285—293, &c.)

455. The heart is a muscular viscus, which can be excited into direct nerve-actions by an external impression (357), applied either externally or internally; and even when it has been removed from the body, and its action has already ceased for a lengthened period. (Haller's 'Physiology,' § 102.)

456. Since the cardiac movements, thus excited, are necessarily independent of the mind or the brain, and are, therefore, in no respect sentient, they are direct nerve-actions excited by an external impression, and would still be such if they were also felt, and occurred (as they sometimes do) as sentient actions of external sensations (452, 512).

457. The external stimuli which more especially excite direct nerve-actions in the heart, are the blood and other fluids, and the air itself, if in contact with the inner surface. (Haller's 'Physiology,' § 101, and 'Opera Minora,' tom. ii, pp. 389, 390.) Various stimuli, applied externally, have also the same effect; the heart is, indeed, the organ which, of all others, possesses the greatest irritability (Haller's 'Physiology,' § 102); or, in other words, which is the most readily excited to violent, direct nerve-actions, by the greatest number of external impressions.

458. Just as painful or pleasing sensations excite the heart's action contrarily to, or in accordance with, its natural functions (211, 204), so, also, are the nerve-actions, when excited by those external impressions, which, if felt, would excite painful or pleasing sensations (452). An excised heart is irritated to convulsive movements, if the irritant be violent, or such as would have been painful. Now, inasmuch as the circulation of the blood is closely connected with the motions of the heart, it may be either in accordance with the well-being of the organism, or opposed to it, just as the external impressions on the heart differ; and it thus appears that an abnormal composition or temperature of the blood renders the stroke of the heart contranatural, in fevers and other diseases.

459. The ordinary and natural stimuli, or the external impressions of the heart, are not felt by animals (167); consequently, their transmission beyond the heart is not necessary to the excitation of its action, although it seems to be necessary, in many animals, to the more certain maintenance of the

movements. (See § 515.) It follows, therefore, that the heart's action is, for the most part, purely a nerve-action of an external impression, and *direct*, although, at the same time, a sentient action also (167), especially of external sensations, and, therefore, may be also an indirect nerve-action (421—423). Consequently, in animals without either sensation or brain, the movements of the heart may go on just as in sentient animals, and be either connatural or contranatural, according to the nature of the external impressions exciting them; and the change thus induced in the circulation may induce the same movements, which, when the animal felt it, constituted incidental sentient actions of the external sensation exciting the movements (453).

460. The pulse, or the contraction and dilatation of the arteries, and the entire circulation of the blood through the blood-vessels, are, for the most part, nerve-actions only, although they may sometimes be also sentient actions (167, 205), and indirect nerve-actions. They may take place independently of the brain or of sensation. The action of the arteries, independently of the heart, seems to be rather mechanical than animal. They are endowed with the force of contractility, as is shown when they contract on a finger inserted into them, and when they contract again, so soon as they are distended with the blood sent from the heart. This force is, in all probability, purely mechanical, for the arteries are always contracted in the corpse; and if fluids be injected, so as to distend them, they contract again so soon as the pressure is withdrawn. They have also a natural elasticity, for they retract very considerably when divided. (Haller's 'Physiology,' § 33.) But they have no sensibility, if their nerves be not irritated, which, however, are certainly not distributed to their fibrous tissue: even Haller himself denies that they have any visible irritability. ('Physiology,' § 32, and 'Opera Minora,' tom. i, pp. 377, 418.) Nevertheless, they are surrounded with muscular fibres and nerves, that have both properties. It appears, however, that these are supplied by nature, to the end that their ordinary mechanical stroke may be changed by means of direct nerve-actions, when certain external impressions, which are unusual or contranatural, are received. This is observed, when an artery, being so wounded, that its nerves or muscular fibres are injured, becomes inflamed at the spot, and pulsates strongly. Probably

the alteration of the pulse, when the blood is at a higher temperature, or has undergone a morbid change, is connected therewith, the nerves and muscular fibres being irritated by the morbid blood, so that the arteries contract more forcibly and quickly; which action must be a direct nerve-action, excited by an external impression of an unnatural kind. The reader is recommended to take into consideration the proofs of the irritability of arteries, adduced, from his own researches, by Verschuir, in his excellent dissertation, "*De Arteriarum et Venarum vi irritabili,*" &c.—Gröningen, 1766. However, whether the natural movement of the arteries be simply mèchanical, or whether it be a direct nerve-action of external impressions received from the in-streaming blood, in either case it is independent of the brain or the mind. Lastly, since every assistance which is given to the circulation in the blood-vessels of the muscles by muscular action (169), may be as often the result of a direct nerve-action of an external impression on the muscles as of a sentient action; it may be asserted, that the entire circulation of the blood, and the functions, and changes in organs mechanically connected therewith, may be carried on without the co-operation of either the brain or the mind, and, in fact, are so carried on, even in animals endowed with consciousness.

461. This is proved by experiment. In animals which do not bleed to death immediately after decapitation, the beat of the heart and the pulse, and the entire circulation (so far as the great disturbance of the organism admits of) goes on uninterruptedly for a considerable period (Haller 'Opera Minora,' tom. i, p. 425), and are altered by external stimuli, especially by the various qualities of the blood. The arterial pulse, in cases of suffocation, when life is restored by artificial means, returns only after the heart's action is established, and is first felt in the vessels nearest to the heart. In the dying and in syncope, the pulse continues in the latter vessels, when it can be no longer perceived in the more distant.

462. The arterial capillaries, as has been already shown (207), are capable of special movements, which although sometimes sentient, belong properly to the class of direct nerve-actions, excited by external impressions on the nerves which surround these vessels. They consist in this, that an external

impression on these capillaries, attracts the contained fluids to them, which are thence in many cases effused, but in many other cases rendered motionless, and thus redness, swelling, and inflammation are caused. That this is a purely direct nerve-action of external impressions is proved by the fact, that if a portion of the body be struck after decapitation it becomes congested, just as if the animal had felt the blow. And we often perceive similar effusions, redness, congestions, swellings, and inflammations, take place in sleep, syncope, convulsions, delirium, &c., without the external impression having been felt that caused them, so that the principle that at each external sensation a flow of fluids to the irritated part takes place proportionate to the external impression, must have a wider application, and be extended to every external impression, whether it be felt or not (218).

463. The question has been raised, whether this direct nerve-action in the capillaries takes place through muscular fibrilli, or through the irritation of the nerves. Without attempting to solve this difficult problem, it is sufficient to observe, that it may be analogous to the sentient actions described § 147; that is, an external impression on the capillaries causes a slight movement, whereby it immediately induces a closure of their mouths, and so the other phenomena described (207) result.

464. The flat muscles and muscular membranes, are capable of direct nerve-actions independently of the brain and of mind, just as other muscles: this has been fully established by experiments with reference to the diaphragm. "Caro diaphragmatis per integram horam tremuit, et mansit irritabilis, cum intestina jam quievissent," &c. (Haller, 'Opera Minora,' tom. i, p. 368: Exp. 181, 182, 194).

Those tissues which have no muscular element, as the skin and mucous membranes, are not capable of movements from external impressions at the point of irritation, although they be felt (208, 445); but since they contain numerous blood-vessels and glandular structures, which are capable of direct nerve-actions, it follows that these membranes, however little irritable they may be of themselves, will still exhibit certain movements, which will sometimes occur in them at the irritated spot, as sentient actions (208). When a painful irritation of the skin causes redness, it is the sentient action of an external sensation at the irritated part; but when the same takes place after decapitation, it is the direct nerve-action of an external impression on the terminations of the capillaries of the skin (462). When an irritation of the mucous membrane of the nares, causes a flow of mucus, a sentient action of an external sensation takes place; but if the same occurs after removal or destruction of the brain, it is a direct nerve-action in the capillaries, or the glandular tissues of the mucous membrane.

On account of the deficiency of nerves in the insensible fibro-serous tissues of the thorax and abdomen (208), no other nerve-actions occur than those produced in the sensitive nerves. Thus a repelled transpiration from cold excites the capillaries of the pleura to contract, and thereby induces congestion and inflammation, although no sensation is excited by this external impression; for the pain results from the inflammation (208, note).

465. Although the broad muscles and muscular tissues are sensitive (171), and an external impression excites their natural functions as sentient actions (as, for example, when an irritation causes spasmodic action of the diaphragm); yet it often happens that the excited functions are the direct or indirect nerve-actions of the same external impression, or even mechanical results of the direct nerve-action (447, 464). Thus, the external irritation which excites the diaphragm to motion, and that which irritates the muscular tissue of the glands, when they pour out their secretions, are very seldom felt. It is the same with the indirect nerve-actions in the membranes devoid of muscular tissue; although they sometimes arise from external sensations, yet general observation shows, that small suffusions, inflammations, congestions, induration, effusion, &c., take place in the pleura, peritoneum, &c., which necessarily result from external impressions on those tissues that are altogether unfelt; just as occurs in various diseases, namely, erysipelas, catarrh, cough, pleurodynia, cutaneous eruptions, &c.

466. The large muscular viscera, particularly the œsophagus, stomach, and intestines, are not only directly excited by external impressions, but in virtue of their peculiar structure, and by means of their direct nerve-actions, are so excited through-

out their whole extent (446), that, like the heart, they move actively on being irritated, when separated even for a lengthened period from the body (357). See Haller's 'Physiology,' § 402, and 'Opera Minora,' tom. i, pp. 384, 199, 390, &c.

467. The co-operation of neither the cerebral forces nor the mind is necessary to the natural functions of the œsophagus, stomach, and intestines, excited as nerve-actions by external impressions; they can take place in animals deprived of both (418).

468. The œsophagus and gastro-intestinal canal are directly excited by numerous external stimuli. Food of various kinds, air, medicines, poisons, injuries, &c., excite contractions at the point of irritation, which are propagated to their whole extent as a result of the direct nerve-actions of the external impression (446). Those excitants, which can excite an agreeable external sensation, produce only natural movements in these viscera: those which would excite pain, excite convulsive contractions, as in muscles (compare § 452).

469. In accordance with these views, it follows that the entire process of digestion, considered as an animal function, is the result of the nerve-actions of the external impressions derived from the food in contact with the digestive organs, and it may, therefore, take place quite independently either of brain or mind. The movement of the chyle in the chyliferous ducts belongs also to this class of functions. See Haller's 'Opera Minora,' tom. i, pp. 378-9.

470. The ordinary stimuli of the vermicular motions of the alimentary canal, are not felt or propagated beyond its tissues. We feel nothing of the food after it has passed beyond the tongue: the violent irritants, which excite spasmodic action and convulsive movements, are so little felt, that their presence is only inferred from the rumbling of flatus, or from their indirect nerve-actions, or from the external sensations excited thereby in widely distant parts (212); as when worms in the stomach or bowels excite convulsions, paralysis, pleurodynia, frequent nausea and vomiting, &c.

471. The functions of glandular secretion and excretion are, for the most part, regulated by physical laws (159); but since a gland is a tissue compounded of blood-vessels and nerves, these functions must depend upon the influence of the

vis nervosa, and are, consequently, animal (6, 9). It has been already shown, that they are sometimes sentient actions, especially of external sensations (172, 209). Can they occur also as nerve-actions? Experiments, as to this point, are not decisive; but, it has been observed, that the glands of excised portions of the intestines may be excited to pour out fluid, which act is undoubtedly a nerve-action (Haller, 'Opera Minora,' tom. i, pp. 390, &c. "Humorum a purgante medicamento copiosior adfluxus," p. 401.)

472. Granting, however, that the doctrine is not proved by direct experiment, the principles already established as to the action of external impressions on the blood-vessels and their terminations (460—463) and on muscular fibre (which also enters into the composition of several secreting organs, §§ 448, 454), sufficiently prove that secretion and excretion may be simply direct nerve-actions of external impressions.

473. An additional proof, that secretion and excretion in animals endowed with mind, are nerve-actions of external impressions, is found in the fact that they are rarely sentient actions of external sensations, and, consequently, the external stimuli are not usually felt; and as nerve-actions can only occur in so far as the functions of the capillaries and the action of the muscular fibres and muscles are *directly* excited (472), it follows that secretion and excretion from glands are nerve-actions of an external impression acting directly on their nerves (*vide* Haller's 'Physiology,' § 233). Hence we conclude that the whole of these phenomena may take place perfectly in animals unendowed with brain or mind, and differ in being either in accordance with the objects of nature or opposed thereto, just as in animals endowed with consciousness. (Compare Haller's 'Elements of Physiology,' tom. iv, p. 575.)

474. The *viscera* are compound mechanical machines, made up of muscular fibres and coats, muscles, vessels, glands, or secreting vessels, which are, in fact, the mouths of capillaries; consequently, the statements already made (445—473), apply equally to them in every respect. We need only mention a few experiments to establish this truth.

475. As to the *heart* (*vide* §§ 455—459), the *alimentary canal* (§§ 466—470), the *diaphragm* (§§ 464, 465), *glandular structures* (§§ 471—473), *fibrous tissues* (§§ 460, 461), *muscular*

structures (§§ 448—454). The *lungs* have mechanical functions (Haller's 'Phys.' §263*), in which their nerves have little share; neither are they endowed with much sensibility or irritability. (*Ibid.* § 245.) Yet the bronchial tubes, far into the lungs, are supplied with muscular fibrilli, a very sensitive membrane, and numerous glands. Hence, external impressions excite many direct nerve-actions, as spasmodic contraction of the tubes, and a flow of fluids from the irritated glands and the mouths of the capillaries. *Respiration* is carried on by means of the muscles of the thorax, back, abdomen, and diaphragm; but many changes are caused in it, as in singing, speaking, coughing, by means of the upper portion of the air-tubes which are regulated by muscles, and by the mouth, lips, tongue, and nose, all which are muscular structures. Now, since all these organs are usually moved by means of direct nerve-actions of external impressions, it follows that the whole function of respiration may take place independently of either the brain or mind (*Vide* Haller's experiments, 'Opera Minora,' tom. i, pp. 368, &c.), and be either connatural or contranatural (454), although it may be, at the same time, a volitional act, and the result of an instinct; or, in other words, an incidental sentient action of external sensations (221, 285). It is thus that unfelt external impressions re-excite this highly complex process, in cases of suspended animation, by stimulating the nose, air-passages, and respiratory muscles. It is not to be forgotten, that some of these act as internal impressions, producing indirect nerve-actions. (Compare § 525.)

476. The liver is only capable of the nerve-actions, which are produced through the nerves that accompany its blood-vessels. Experiments are not easily instituted on this viscus. The irritability of the *gall-bladder* is somewhat doubtful.

477. Various remedies, and articles of food, act quickly, in increasing the secerning function of the kidneys. The external impressions they cause on the kidneys are not felt; the function, therefore, is a nerve-action, and the doctrines already laid down with regard to secretion and excretion are applicable to the kidneys.

478. The urinary bladder is opened, contracted, and shut, by muscular fibres; consequently these processes may be and are nerve-actions of external impressions, inasmuch as the latter

are often not felt, although usually the natural functions of the bladder are volitional, and therefore sentient actions.

479. The spleen, being composed of vessels, is in the same category with the liver.

480. The organs of the senses (considered as mechanical machines, and not as organs of sensation), being supplied with muscles, are, to that extent, capable of nerve-actions : the spasmodic affections of the tongue and of the muscles of the orbit, horripilation, and, in lower animals, twitchings of the ears, are manifest examples of these. Are not the actions of the iris in contraction and dilatation, and the tension of the muscles of the ossicula aûditus, although usually sentient actions, caused by external sensation, at the same time also nerve-actions caused by the same external impressions? It is difficult to decide the question. (Compare Haller's 'Physiology,' §§ 494, 496, 513.)

481. The functions of the sexual organs in mammalia, and in animals of a similar organisation in this respect, are usually sentient actions; but, nevertheless, there are some reasons for thinking, that the cerebral forces only co-operate, and that they may be induced by the *vis nervosa* alone, as direct nerve-actions of external impressions. Erection of the penis will take place in sleep, or in disease, without any external sensation, and is, therefore, a direct nerve-action. The uterus is endowed with as much irritability as the intestinal canal: and, lastly, Bibiena's experiments, lately instituted, show that butterflies and silkworm-moths copulate, and deposit their eggs, after decapitation; and thus a natural instinct is fulfilled by nerve-actions alone. (Compare § 269.)

CHAPTER III.

ON THE VIS NERVOSA OF INTERNAL IMPRESSIONS (WITHOUT CONCEPTIONS).

SECTION I.

482. Every internal impression is transmitted along the nerves, in a direction from the brain downwards, and is a motor force not subject to physical or mechanical laws (32, 121). If it be caused by conceptions at the cerebral origin of the nerves, the movements it excites are sentient actions (122), but if it be not caused by conceptions, then the movements it excites are nerve-actions of its *vis nervosa*, and it is of these we propose to discourse.

483. Non-conceptional impressions, that is to say, internal impressions not caused by conceptions, consequently not originating from a material idea in the brain (123), can take place at any point of a nerve, even at its cerebral origin, but always excepting the terminal fibrils, for it would then be an *external* impression (32, 121). Consequently, the indirect nerve-actions of external impressions are nerve-actions of non-conceptional internal impressions (422).

484. Since every internal impression on the nerves is propagated downwards only (141)—if made on a nerve between its origin and termination, it cannot be transmitted as an internal impression upwards to the brain, nor can it excite any animal actions in the parts situate above the point of impression; and if such result, they must be considered as being excited by a concurrent external impression, transmitted upwards to the brain, and consequently are either sentient actions of external sensations, or indirect nerve-actions of the external impression; although, in the latter case, nerve-actions of another internal impression (419, 422). Supposing the trunk of a motor nerve is irritated by a needle, its medulla receives an external impression, which is transmitted upwards, and, if it reaches the brain, excites sentient actions by means of an external sensa-

tion; or is reflected downwwards, and develops indirect nerve-actions of the external impression; or else, both results take place: at the same time, however, the irritation made by the needle is transmitted downwards to the terminating fibrils of the nerve, as a non-conceptional internal impression, and excites nerve-actions in the parts to which the terminating fibrils are distributed.

485. An internal impression, unconnected with conceptions, acts downwards from the point where the impression is made along the twigs and branches of the nerves, and if there be no obstacle to its course, operates in those mechanical machines connected with the fibrils. It may also (as when produced by conceptions) be communicated to other nerves and to other mechanical machines, if the fibrils be interwoven in ganglia beneath the point irritated (124).

486. As the action is the same in the mechanical machines, whether the internal impression be produced by conceptions or by other irritants, so also is its transmission; so that, just as internal impressions from conceptions are transmitted along the trunks of the nerves to the terminal fibrils, without being commingled with each other, although passing along the same trunk, as, for example, the spinal cord, or principal branch of a nerve (125), so also the non-conceptional internal impressions have *their* independent course, and are not confused by or commingled with each other; whence it is inferred, that every internal impression takes place in a special fibril, running an independent course to a distinct mechanical machine, as has been previously shown (125). If we knew which particular fibrils were excited by a certain conception, when it produced a certain movement of a mechanical machine, as a sentient action, we might be able to excite the same movement as a nerve-action, by irritating the special fibrils, and thus causing an internal impression, either in the spinal cord or in the branches given off from it. It is not possible, however, to perform this experiment, because we cannot distinguish the various efferent fibrils on which a special conception acts; and because the irritation of a single efferent fibril would probably require much more delicate instruments than we possess.

487. The non-conceptional internal impressions will be as little interrupted in their course to the terminal fibrils, by ex-

ternal impressions taking the opposite direction, as the conceptional internal impressions (126), because it is indifferent whether the stimulus be a material idea, or some other irritant in the brain, or on the course of the nerve; and because the apparent reason of this phenomenon, namely, the natural distinction between the afferent and efferent nerve fibrils remains the same (126, 127). Experiments confirm this doctrine.

488. The doctrine laid down in § 126, as to the existence of two kinds of fibrils in each nerve,[1] the one transmitting external impressions upwards, and the other internal impressions downwards, enables us to explain how it may happen, that in a natural or contranatural condition of the nerve, certain mechanical machines may be excited into action by the one, and not by the other; although it may be excited to action by both kinds of impressions. For example, the terminal nerve-fibrils, in a mechanical machine, may not be duly excited by certain external excitants (424), or a natural or contranatural impediment may take place in the fibrils which have to transmit the external impression upwards (425), and, consequently, neither a direct nor indirect nerve-action results (427—431). But, if there is no such impediment in the efferent fibrils of the same nerve, a nerve-action may take place in the mechanical machine from an internal impression on the medulla of the nerve, and *vice versâ*. Except on the hypothesis of such a difference in the nerve-fibrils, it is very difficult to understand phenomena of this kind. That such phenomena really take place is undoubted; for a limb which has become insensible to all external impressions, and never once manifests nerve-actions, as in the case of a paralysed limb, which neither feels nor even contracts when scourged with nettles, may be stimulated to contractions, independently and even in spite of the will, by irritation of the trunk of its nerve; or when some internal agent causes a morbid change in it; and these contractions are manifestly nerve-actions of a non-conceptional internal impression. Again, there are instances in which the limb is not moved either by conceptional internal impressions, or other internal stimuli of the nerves, although it is sensible of external impressions on the terminal nerve-fibrils, and nerve-actions are produced

[1] See note to § 126, with reference to this point.—Ed.

thereby. This, it would appear, is the normal condition of the heart; for it is not only not sensitive, but is excited to the most violent movements by external impressions on its nerves (455, 456). It is also excited to movements by the internal impressions of some conceptions (167, 211). Nevertheless, the will exerts no influence over it; and the internal irritation of the trunks of its nerves never causes, so far as has been observed, any internal impression in them, and develops no nerve-actions in it; on the contrary, the heart's action remains unchanged, and, if separated from the body, is not re-excited thereby, although this readily results from an external irritation. (*Vide* § 515, and Haller's 'Physiology,' § 101.) If it be conceded that, from natural impediments, the efferent fibrils of the cardiac nerves transmit only few kinds of internal impressions, and are capable only of certain conceptions, being at the same time incapable, for the most part at least, if not wholly, of other kinds, and particularly of non-conceptional internal impressions; whilst, on the other hand, the afferent fibrils are readily susceptible of an infinite number of external impressions, we can thus comprehend the phenomena, without having recourse to the erroneous doctrine that the cardiac movements result from an animal motive force innate in the muscular fibre, and independent of the nerves (380—388).

489. The *ordinary natural stimuli of the nerves causing internal impressions*, are,—1, the conceptions which produce sentient actions (121, 123); and, 2, reflected external impressions (399), which excite indirect nerve-actions of external impressions, and, consequently, nerve-actions of non-conceptional internal impressions (399, 421-2). Both can effect the same movements in the mechanical machines, or one only, as well as both (360, 364). These movements may be nerve-actions, excited by reflected external impressions only, and be as connected and adapted as if they were sentient actions excited by conceptions (438). Nature has endowed sentient animals with both kinds of stimuli, but to those which exhibit no conceptive faculty, she has only given the last mentioned; and she thereby attains, in both, the same end, namely, to impart to them internal impressions, which, together with the direct *vis nervosa* of the external impressions, constitute the proper natural incitants of the animal movements of the me-

chanical machines. For all conceptions are primarily produced by external sensations, that is, by means of external impressions (65); and by means of these identical impressions, when reflected ere they reach the brain, can those movements be excited, as simply nerve-actions of non-conceptional impressions, which are sentient actions of conceptions; or they may act concurrently with conceptions (421-2). This great truth will be amply established, by what will be laid down in this and the following chapter, as to the *vis nervosa* of non-conceptional internal impressions.

490. Nevertheless, there are other irritants that act as non-conceptional impressions. When the medulla of a nerve is irritated, as by pricking, pinching, cutting, &c., the same movements take place in the mechanical machines to which the nerve is distributed, as if a conceptional internal impression had produced them; or as if they were the indirect nerve-action of an external impression. Thus, a decapitated frog retracts its leg when its spinal cord is irritated, just as it did when, during life, it willed to make a spring, and as also, if decapitated, when its toe is pinched (359). So also a muscle contracts, when its nerve is cut through. (Haller's 'Physiology,' §§ 403, &c.) Suppose that instead of this artificial irritation, some *materies* so irritates a nervous trunk in the direction downwards from the brain, that the muscles which the nerve regulates are thereby put into motion; the resulting movements are then nerve-actions of a non-conceptional internal impression, which are not in the first place indirect nerve-actions of an external impression, but are produced by a *primary internal impression.* Such irritants, while exciting movements in a direction downwards from the brain, may be also felt; but in this case sensation contributes nothing to the movements which are excited at the same time by the primary internal impression.

491. Observation teaches, that this class of nerve-actions occurs, but the most distinct are usually contra-natural. Various contractions, spasms, convulsions, and cramps of muscles and of limbs, occur in disease, without being induced by a conception or an external sensation, or even by an external impression on the motor nerves, and are therefore neither sentient actions, nor indirect nerve-actions of external impressions, and have no other origin, than that some acrid irritant matter

is applied to the trunk of the nerves, and develops in them primary internal impressions, which cause these nerve-actions. Movements of this kind are observed, for the most part, in persons in whom the whole mass of humours is acrid, so that when they come into contact with the medulla of the nerves, they stimulate it. Of this class also are the movements which occur if the trunk of a nerve be ulcerated, and the limbs to which it is distributed are moved in various contra-natural ways; or when a tumour, a foreign body, &c., irritates the nervous trunks, and thereby excites the muscles to contra-natural movements. Examples of primary non-conceptional impressions will be given subsequently, (515, 525, 532, &c.)

492. We are as ignorant what peculiar irritation of the medulla in the nervous trunks must be excited, to produce a certain kind of internal impression and thereby certain definite nerve-actions, as we are with reference to external impressions (413). Thus much is known, however, that it is not every irritation or impression on the trunk of a nerve that is effective [sinnlich]; or, in other words, it is not every irritation, although directed from the brain downwards, that causes in the nerve itself that mysterious movement which is propagated downwards in the nerve, and puts the mechanical machines to which it is distributed into motion. Every irritation which is adapted to act on the nerves [or is sinnlich], develops animal actions (121), and all others act simply as physical or mechanical forces (7). We have in the heart an example, in what a minor degree many nerves receive certain internal impressions (488); it is also known that nitric acid applied to a nervous trunk corrodes the medulla, but does not excite the muscle to which the nerve is distributed, although irritation of the same nerve with a needle will throw the muscle into convulsions (Haller, '*Opera Minora*,' tom. i, p. 364). The action of impressions can be learnt only by experiment and observation.

493. Just as a conceptional internal impression on a tied or cut nerve does not pass beyond the injured point (128), so also no other internal impression made above the injured point, nearer the brain, passes beyond the ligature or section, to excite nerve-actions in those parts only which are supplied with twigs from the trunk between the point of irritation and of injury. But if an internal impression be made on the nerve below the

ligature or section, it is transmitted to all the terminal fibrils, and nerve-actions are excited in all the organs supplied with twigs given off from the trunk below the point of injury, provided there be no impediment to the course of the impression (359). These are principles well known to physiologists (Haller's 'Physiology,' §§ 367, 403).

494, i. Non-conceptional internal impressions excite nerve-actions only, when duly transmitted from the point of irritation to the mechanical machines (493). Consequently, the brain may be destroyed, or even the head wholly separated from the body, and yet an internal impression made on the spinal cord, or the trunk of a nerve, will develop nerve-actions in those mechanical machines which receive their nerves from the cord, or from the nervous trunk from below the point of irritation, provided there be no impediment to its transmission downwards (483). Thus, a frog, although headless, will leap forward, when its spinal cord is irritated with a needle, so that the brain and the conceptive force are as little necessary to the nerve-actions of internal impressions as of external, with the condition, however, that the vital spirits be present in the nerves as stated in § 416.

ii. Nevertheless, there are cases in which the existence of the brain and its uninterrupted connection with the limb are necessary to the nerve-actions of internal impressions, although the cerebral forces and the mind do not come into action. In the natural condition of the animal, certain functions are performed by both kinds of *vis nervosa* acting at the same time, so that ordinarily they are both direct nerve-actions of external impressions and nerve-actions of non-conceptional internal impressions. The heart, diaphragm, and muscular system generally, will be subsequently referred to, as exhibiting examples (575, 524, 514). In instances of this kind, a shock may easily injure, enfeeble, or interrupt the functions so compounded, by causing one of the two kinds of *vis nervosa* to cease to operate; although the other is able of itself to restore the disturbed functions, when after this interruption its influence on the mechanical machines be renewed. Consequently, if the trunk of a nerve distributed to a mechanical machine, the natural function of which is at the same time both a direct nerve-action of an internal impression and a nerve-action of an internal impression, be tied or divided, the function may cease or be interrupted, because the co-operation of the internal impression ceases; although the same function can be renewed, if an external impression be made, or a new internal impression be communicated to the nerve below the ligature or section. If, however, the usual non-conceptional impression stimulus be applied to the nerve near its cerebral origin, whether directly, or whether as an external impression reflected and changed there into a non-conceptional impression, then the presence of the brain and its unbroken connection with the nerves of the machines are requisite to the continuance of the natural functions of the latter; although they may be renewed by a renewed impression, or by the renewal of one or of both impressions. Thus, a muscle is enfeebled, or the natural movements of the heart, diaphragm, &c., interrupted, so soon as the connection of their nerves with the brain is broken; yet their functions can be renewed so soon as one of the two kinds of *vis nervosa* communicates a new impulse, and the heart receives an external impression below the ligature, or the diaphragm an internal impression, or the muscle either or both.

iii. Nevertheless, the brain and the conceptive force are necessary to these movements of the non-conceptional internal impression, when, to continue in their natural order, they must be at the same time sentient actions; for the removal of the brain interrupts this natural order, although it does not abolish it irreparably.

iv. That the brain is necessary to the prolonged continuance of the nerve-actions of non-conceptional internal impressions, in so far as its medullary substance supplies vital spirits to the nerves, has been already stated; it is also necessary in those cases, in which the nerve-action depends on an internal impression made near to or at the cerebral origin of the nerve, but not by conceptions. But it is manifest, that in none of these cases, the action of the cerebral forces or of the conceptive force is necessary to nerve-actions, and that even in the instances mentioned in par. iii, neither contributes to the sole production of the movements as nerve-actions.

495. When an internal impression is not a primary, but a reflected external impression, it causes nerve-actions, as if it were primary, and (under like conditions) as independently of

the brain and the conceptive force. When a decapitated frog leaps from pinching of its toe, the action is a nerve-action of an internal impression derived from a reflected external impression (419, 415, ii). The external impression in this case can pass uninterruptedly from the point of irritation in the toe to the point of injury in the spinal cord, where it is reflected, and passes uninterruptedly back again, and thus the same nerve-action is caused by it, as if a primary internal impression had excited the spinal cord (494).

496. A non-conceptional internal impression can excite nerve-actions under the following conditions only:

i. The medulla of the trunk of the nerve must receive an internal impression in one direction downwards from the brain, independently of any conception (121, 483).

ii. This internal impression must be transmitted downwards, along the trunk and its branches through the efferent fibrils, to the mechanical machines which have to perform the nerve-action.

iii. The mechanical machines must be capable of performing that nerve-action, which the received internal impression can effect in virtue of its nature; just as is necessary in sentient actions excited by conceptional internal impressions (130, ii, 129, iv).

The conditions under which those nerve-actions of internal impressions take place, that are caused by a reflected external impression, have been already stated (419, 422).

497. The nerve-actions of non-conceptional internal impressions are quite independent of the brain and the conceptive force; nevertheless, at another time, or in other animals, they may be sentient actions of impressions caused by conceptions (364, i); and this applies especially to indirect nerve-actions of external impressions (423). Thus, the volitional movement of a limb (a sentient action) may occur as the nerve-action of a primary internal impression, when an acrid humour irritates the trunk of the nerve going to the limb; and although this acrid humour, as in gouty diseases, may cause pain, yet this external sensation of pain is not the motor force of the limb, but the concurrent internal impression (484). See a previous paragraph for examples of this class (423).

498. A nerve-action of a primary internal impression cannot take place, or will be prevented:

i. If an irritation, although applied to the medulla of a nerve in the direction downwards from the brain, excites no internal impression therein. Thus, in disease, there are often traces of putrid humours collected about the points where the trunks of nerves occur, without any motions resulting in the muscles; either because the putrid fluids do not penetrate to the medulla of the nerve, but remain externally to it, or else because they are of a kind which excites no internal impression in it (492).

ii. If the transmission of a primary internal impression is prevented by some impediment, so that it cannot reach the mechanical machines which it regulates (496, ii). Thus, an acrid humour in the axilla may irritate the nerves, which regulate the forearm and hand, and so excite convulsive movements therein. But if there be a tumour at the elbow-joint compressing the nerves, or if some external pressure be made on them (as when a limb goes to sleep), then the transmission of the primary internal impression from above downwards is prevented, and no nerve-actions take place.

iii. If the mechanical machines are rendered incapable of the requisite nerve-action. Thus, when an acrid humour irritates the nerves, a bandaging of the muscles of the convulsed limb, will prevent their action, and so the patient may obtain sleep and rest. (Compare also § 425.)

499. There must be natural obstacles to the development of the nerve-actions of non-conceptional internal impressions, as well as of sentient actions (136—138). Those already enumerated as preventing the indirect nerve-actions of external impressions, act also in preventing the nerve-actions of primary internal impressions (428, vi; 429). The following is a short statement of some others.

500. A natural impediment to the production of certain nerve-actions from primary internal impressions, occurs—

i. When a nerve, by nature, is but slightly or not at all susceptible of certain primary natural stimuli (492, 498, i); consequently, if it do receive an impression, the latter is too weak to be propagated to the mechanical machines. It is quite certain that there are stimuli, which, when applied to the medulla of the nerve in its normal condition, do not excite nerve-actions. The nerves are in close relation with many tissues, and their medulla is penetrated by capillaries and fluids, all which must often necessarily act as active stimuli, but they seem to act as such, for the most part, extraordinarily and abnormally only, otherwise they would incessantly stimulate our limbs to movements.

ii. When certain internal impressions on the nerves are not naturally transmitted to certain mechanical machines (498, ii). This hindrance is principally constituted by the ganglia and points of division of the nerves (137, 429), which sometimes so receive internal impressions of a certain kind, that they go forwards; but also, sometimes, so that the nerves are not excited internally by them, and consequently the impressions have no influence on the mechanical machines innervated by the nerves.

iii. When the mechanical machines are as yet naturally incapacitated for the animal movement which a certain internal impression can communicate to it, or becomes so incapacitated. This impediment is observed in young animals, or in the very old, which are excited to certain movements simply by their blind instincts, in virtue of the *vis nervosa* (439).

501. Habit, and the frequent repetition of internal impressions, can act as impediments to this class of nerve-actions, in the way already laid down (430, 431).

502. Since the nerve-actions of non-conceptional impressions are, for the most part, indirect nerve-actions of external impressions (which determine the sensibility of animals), the *vis nervosa* of internal impressions has also its influence in determining the irritability and vital constitution of animal bodies.

SECTION II.—ON THE VIS NERVOSA OF INTERNAL IMPRESSIONS IN PARTICULAR.

503. Nerve-actions of internal impressions, whether the latter be primary internal impressions, or reflected external impressions changed into internal, can be developed in all the organs that are capable of sentient actions; for the whole difference of the two consists in this,—that in the development of the latter, the nerves are excited by conceptions, and solely at their origin in the brain; of the former, by other stimuli applied to the whole nervous system, except the terminal fibrils (121, 483). Both kinds of stimuli consist in the same changes in the nervous

system [the animal machines]; both kinds of impressions are transmitted in the same way through the nerves, and move the mechanical machines with which they are incorporated (360). We have now to show, by facts, in what structures this class of nerve-actions are produced in the normal condition.

504. Conceptions act on the brain and nerves, so as either to put mechanical machines into motion or not (117). In the latter case, they are manifested specially in the brain and sensitive nerves. It is already established by experiment, so far as the difficulty of investigating this profound subject will allow, that there are also other stimuli than conceptions, which excite nerve-actions in and limited to the brain itself, by means of their internal impressions (374). It has also been shown (377, 378), that internal impressions not caused by conceptions, excite in the purely sensitive nerves, as nerve-actions, the same changes which the internal impressions of conceptions produce, as sentient-actions, inasmuch as both induce imperfect external sensations (148, 377). Hence it follows, that the internal impressions not caused by conceptions, are subject to the same law of deflexion, and excite the same changes in the nerves, as the internal impressions derived from conceptions (*vide* § 151). The question is, however, so recondite, that it is difficult to institute experiments in regard to it.

505. Conceptions act on the mechanical machines (155) either directly through the brain, or through the nerves. Now, as non-conceptional internal impressions develop changes in the brain, they can also thereby put mechanical machines into motion. It is properly, however, the vessels, and especially the blood-vessels, that experience this change (156—159), enabling them to alter the cerebral circulation and the vital movements generally. It is not, however, possible to show clearly, that non-conceptional internal impressions cause the same changes in the cerebral capillaries, since it is impossible to determine whether a certain stimulus of the brain acts through the nerve-fibrils in the brain, according to § 132; or directly on the membranes and mouths of the capillaries of the brain, according to § 392; or whether in either of these two cases it acts as an external impression by means of direct or indirect (418, 419) nerve-actions, or through the sentient action of an external sensation (132); or (much more probably) as a primary internal

impression not induced by conceptions (490). The obscurity in which these changes in the brain are involved, is an apology for the want of experiments. (Compare § 159.)

506. Except in the example stated, § 504, non-conceptional internal impressions act on the mechanical machines, only so far as the latter have nerves incorporated with them. Their nerve-actions, as well as the sentient actions of the conceptional impressions, are effected through the nerves (160).

507. The laws of action on the muscular system of the impressions derived from conceptions, are applicable to the internal impressions not derived from conceptions, whether they be primary or reflected in their origin (161, 162, 204). The primary are illustrated § 498; those from a reflected external impression §§ 415, 495.

508. Since non-conceptional impressions act on the muscular system, they must also excite movements of the limbs. Examples of this kind are seen, when a decapitated man, either from the primary internal impression of the sword-stroke in his spinal cord, or from the reflected external impression of the injury, makes those movements, which a conception of danger, or an external sensation of the injury, would have led him to make; or when an animal, decapitated while moving, still goes on, and continues its former sentient actions in the muscles of locomotion, as nerve-actions, &c.

509. A nerve-action in a muscle from an internal impression implies the transmission of the impression along the nerve, in the direction from the brain downwards to the muscle which is excited to movement. If the movement be the indirect nerve-action of an external impression, it implies that an external impression, is reflected in its course upwards to the brain, and transmitted from the point of reflexion downwards, as an internal impression, to the muscle excited to movement (422, 496).

510. The same nerve of a muscle may receive external impressions, at the same time that internal impressions on it excite muscular action, and this external impression may be either felt, or develop nerve-actions, without the two antagonistic impressions impeding each other's action (487).

511. When a nerve is tied, divided, or compressed, an internal impression (whether primary or reflected in its origin) if

applied above the point of injury, cannot excite a nerve-action in the machines to which the nerve is distributed. Nevertheless, the brain and conceptive force are not necessary to nerve-actions, although in many cases nerve-actions cannot take place without the brain; not, however, because the cerebral forces or the conceptive force are requisite, but because it contains the origins of the nerves, and without it non-conceptional impressions cannot be applied to that portion of the nerves. If the brain be excited by some general stimulus, in which the roots of all or the greater number of the motor nerves participate, its influence must be extended to the greater part or the whole of the muscular system, as occurs with internal impressions caused by conceptions (164, v). The same doctrine applies to the spinal cord. Consequently, in experiments made on animals when the brain and spinal cord are irritated mechanically, sometimes partial, sometimes general convulsions are excited (359).

512. The nerve-actions from the two kinds of internal impressions are liable to the impediments that have been already indicated (428—431, &c.), and hence it is not every internal impression which can excite nerve-actions in the muscles (500).

513. Unfelt external impressions in the muscles can be reflected in the muscles themselves, and then cause nerve-actions in them by means of internal impressions (447); so that various movements of the limbs and the viscera, which appear to be nerve-actions of external impressions only, are at the same time nerve-actions of an internal impression induced by external impressions (448, 423). The excited motion of the heart and intestinal canal may be taken as examples (446).

514. A direct nerve-action of an external impression may at the same time, or at another time, or in another animal, be indirect, or the nerve-action of internal impressions, or a sentient action of external sensations, or of other conceptions, nay, may even be volitional; and *vice versâ*. Consequently, those go too far who maintain that the irritability of muscles is their only or principal motor force. It would rather appear, that although the greater number of muscular actions can be directly excited by external impressions, in the natural condition of animals endowed with a brain and conceptive force, yet internal impressions, whether primary or originating in a reflected external impression, may co-operate therewith; so that the

muscular movements may be either sentient or nerve-actions only, or both at once. It is this common action of the two kinds of *vis nervosa* in the muscular movements of animals which renders the presence of the brain and its uninterrupted connection with the muscles, necessary to the development of many nerve-actions; the co-operation of the cerebral *forces* or of the conceptive force being unnecessary (494, ii). Haller referring to the instinctive acts of animals, observes that the causes of muscular action in these instances depend on a law given by God, and not on the mind ('Physiology,' § 408).

515. External sensations and other conceptions in many ways change the action of the heart by means of their internal impressions (167, 211)—that action being for the most part an indirect nerve-action of external impressions on the heart (457, 459). Can internal impressions not caused by conceptions also exercise a motor power over it? It is *à priori* probable, for the heart is a muscle. It is much more probable, however, from another consideration deduced from experiment, namely, that when in animals endowed with brain the cardiac nerves are tied, the movements of the heart cease, even although all the nerves are not tied at the same time (Haller's 'Physiology,' § 100). Consequently, although the natural movements of the heart be a direct nerve-action excited by external impressions, yet it must be maintained by a co-operating internal impression, and this must depend either on conceptions or other stimuli. Now, although the ordinary natural stimuli of the heart's action be unfelt, they are not the less sentient actions of other conceptions (457—459). Perhaps the natural motion of the brain, which synchronises with the respiratory movements, may be enumerated amongst these, although that motion is itself dependent on the heart's action, and acts by communicating non-conceptional internal impressions to the cerebral origins of the cardiac nerves; yet, on the other hand, the heart beats in the fœtus in utero, or in the embryo in ovo, and also in animals which have no respiratory movements. Or the heart's action may be influenced by primary internal impressions, communicated to the cardiac nerves by the arteries of the brain (505). In this way we may understand why the connection of the brain with the heart, is necessary to the movements of the latter, without the cerebral forces being requisite. But reflected external im-

pressions may constitute this co-operating force in the action of the heart; the external impressions being reflected downwards in the ganglia on their way to the brain, or changed into internal impressions in the spinal cord, and so acting reflexly in the heart; for it is quite certain that external impressions made on the cardiac nerves are transmitted upwards to the brain, because they are sometimes felt (35). The object of nature in thus providing that internal impressions shall co-operate in the natural movement of the heart, although external impressions alone may fully effect it (457), seems to be simply this, that the continuance of an action so important to life may be the more certainly maintained, and in the less danger of being interrupted than it would otherwise be, if wholly dependent upon the usual external impression, namely, the stimulus of the inflowing blood on the heart. When this ceases momentarily, or acts only feebly, as in syncope, still the heart is not left without a stimulus to its continued action. Observation seems to corroborate this opinion, for the enfeebled or interrupted stroke may be restored or invigorated in a moment by the external impression of irritating vapours on the nerves of the nose, and which are reflected upon the cerebral origin of the cardiac nerves. It is not probable, that any other end is gained from this co-operation of internal impressions, for they only strengthen the motion of the heart, and if it be interrupted, a slight irritant re-excites it, as has been shown by experiments, when by means of an irritation (a non-conceptional internal impression) applied to the eighth pair, to the brain, or to the spinal cord, the stroke of the heart has been rendered stronger (Haller's 'Physiology,' § 100), although by no means able to maintain it continuously. Farther, although the ligature or section of the cardiac nerves enfeebles the heart's action, it never quite abolishes it (Haller, *loco citato*); whilst a slight external impression (its principal excitant) will re-excite the movement.

516. Without, however, entering further into this obscure part of the subject, we conclude that the heart is susceptible of nerve-actions from non-conceptional internal impressions, although the principal motive force consists in unfelt external impressions (459). Additional proofs will be found in § 519. Further researches are much to be desired, for the properties

of the cardiac nerves are peculiar, and the action of impressions on the heart differs from that on other muscles. The number of the cardiac nerves, their origin from such different points, their intricate combination, and their ganglia and remarkable plexus all merit the closest attention. Probably, the results of external impressions would be very different, according as the nerves were irritated, or tied, or divided, above or below the ganglia and plexuses and points of division into branches; and that the different results observed when the cardiac nerves are irritated —the heart's action being sometimes increased, sometimes unaltered—may be dependent upon some such difference in the mode of experimenting (Haller's 'Physiology,' *loco citato*).

517. Since the heart is compounded of several muscles, and since these can be excited to action independently of each other, as has been shown in excised hearts, it is more probable, that the stroke of the heart, or the combined action of all the muscular structures, is an indirect nerve-action of external impressions, they being reflected in the heart itself (513), than that it is simply a mechanical result of their direct nerve-actions (447); for in the latter case, the whole heart must be excited to action by an external impression which acts only on certain of its fibres—a conclusion opposed to the results of experiments (Haller's 'Physiology,' § 101).

518. Although the preceding propositions are well founded, still many a change in the heart's action is either a sentient action, or at the same time both a sentient and a nerve-action; and consequently, it is erroneous to infer, because the heart's action is usually a direct nerve-action of external impressions, or in other words, a result of irritability, that it is always such, or such only, or such in all animals. Lastly, in so far as the circulation is dependent on the heart, each kind of impression contributes something thereto, so that the whole of the circulation derives some stimulus to its continuance and maintenance from every kind of animal motor force, although the customary and principal stimuli consist in unfelt external impressions (459).

519. The arterial pulse, in so far as it is dependent on the heart's action and the circulation, may be a nerve-action of every kind (518). Many of the stimuli used in cases of suspended animation to restore life by re-exciting the action of the heart, the circulation, and the pulse, act as non-concep-

tional internal impressions; although it may be easily conceived that these re-excited movements are simply direct nerve-actions of external impressions on the heart, arising from inflation of the lungs, and from the various stimuli applied to the throat, stomach, intestinal canal, &c. But as these stimuli are applied to the nerves adjacent to the heart, and which have a much less degree of irritability than the cardiac nerves, they must be applied strongly and for a lengthened period, before the external impressions they receive are transmitted upwards to the points of reflexion, and hence sent downwards; and when the result follows, the heart makes only a few strokes and then stops, so that the stimuli must be renewed continually to keep up its action. But if the heart be excited by stimuli applied directly to its nerves, all this takes place more readily and actively.

520. The changes in the pulse, resulting from the action of the muscular fibres and nerves of the arteries, independently of the heart, are direct nerve-actions from external impressions derived from the blood, as in the case of the heart (460). Why should not these impressions on the muscular fibrils be propagated to the nerves, and, although not felt, nevertheless, at least in some cases, be reflected so as to change the circulation by means of indirect nerve-actions? The possibility of this is hardly doubtful, yet it is as difficult to demonstrate by experiments, since the phenomena of direct nerve-actions from external impressions on the blood-vessels are scarcely perceptible (460). As conceptional internal impressions, and particularly those of external sensations (147, 151), excite changes in the pulse and circulation, the same may result from primary internal impressions, or from external impressions reflected before they are felt (360, 503).

521. Lastly, in so far as muscular action changes the pulse, all those non-conceptional internal impressions which excite muscular action will influence the pulse. Every effort, or bodily movement, whether convulsive or volitional, accelerates the circulation, and often the causes of the movements are neither felt nor perceived.

522. The mouths of the capillaries are as subject to changes from non-conceptional internal impressions, as from external impressions, whether felt (207), or unfelt (462). The action of certain remedies on the capillaries proves this: as when certain

hæmorrhages are cured by external applications. Sleeping with a pillow of oak-chips beneath the loins, or having a decoction of gall-nuts applied to the abdomen, cures a hæmorrhage from the hæmorrhoidal veins; cold water to the forehead or nape of the neck, cures a bleeding from the nose; a blister applied externally, relieves inflammation of the subjacent parts, &c. The external impressions made by such remedies on the nerves they are brought into immediate contact with, are in many cases transmitted upwards, since they are felt; but in other cases in which they excite no external sensation they must be reflected downwards on the nerves distributed to the capillaries, and excite contraction of their bleeding mouths.

523. That the diaphragm may be excited to action by non-conceptional internal impressions made on its nerves, has been proved by experiments. (Haller, 'Opera Minora,' tom. i, pp. 365, 199.) Further, the irritants, which when applied to the nose, excite sneezing—a convulsive action of the diaphragm—as the sentient action of an external sensation (208), contribute much to the restoration of life in cases of suspended animation; and since they are not felt for some time after the action of the heart and lungs is re-excited, it follows that they act in virtue of a reflexion of their external impressions on the trunk of the phrenic nerve, and thus excite the movements of this muscle as their indirect nerve-action. Consequently, we can infer that the same movements will result from non-conceptional internal impressions.

524. The ordinary and natural movement of the diaphragm, does not arise from external stimuli that are felt, although it is very much influenced by such (208); nor is it ordinarily a sentient action from external sensations; and inasmuch as it takes place without our consciousness, and even without any knowledge on our part of its existence, it is not a sentient action from other conceptions, although these can change it volitionally (171). Consequently, the usual stimulus to the continued natural movement of the diaphragm, acts by means of non-conceptional impressions, and it is either a direct nerve-action of the latter, or of external impressions (356): if from the non-conceptional, it may be either from primary internal impressions or reflected external impressions (419, 483). Granted that it arises from external impressions, still as in the instance

of the heart's movement, the co-operation of an internal impression is necessary to its maintenance, and probably with the same object (515), for so soon as the phrenic nerve is tied, the movement of the diaphragm is interrupted (171).

525. Although the motion of the diaphragm is influenced by volitional conceptions and external sensations, still its natural action in respiration is a nerve-action. Nevertheless, while the cerebral forces and the mind are not requisite to that action, the connection of its nerves with the brain is, inasmuch as non-conceptional internal impressions co-operate in exciting it. This doctrine is equally applicable to the respiratory movements, in which the diaphragm plays so important a part. The morbid changes in the respiratory movements arising from contra-natural nerve-actions in distant parts, especially the abdomen, sufficiently prove this influence of the *vis nervosa* of non-conceptional internal impressions on the nerves of the thoracic muscles, and of the structures subservient to respiration.

526. We can hence confirm the proposition already mooted (285) as to the respiratory function; namely, that at first in the newly born, it is a nerve-action of external impressions, or at the most a sentient action excited by obscure external sensations (525); that subsequently it continues both as a sentient action excited by an instinct originating in those obscure external sensations (364, 285), but being also, from the habitual recurrence of those stimuli, a direct or indirect nerve-action of external impressions (51), occurring mechanically (475); and is continually changed into a sentient action by new instincts, or volitional conceptions, constituting the acts of laughing, weeping, sighing, singing, speaking, &c. (285). According to all probability, this is the true nature of the respiratory movements in animals endowed with consciousness. In those not so endowed, their mechanism is altogether different, and they consist solely of nerve-actions.

527. The skin and mucous membranes have not a structure capable of movements from external sensations, and, consequently, cannot manifest nerve-actions from non-conceptional internal impressions. Their vessels, and the glandular structures imbedded in them are, however, capable of their proper nerve-actions. (Compare §§ 520—522.)

528. The functions of glandular structures generally must be comprised in the same proposition, except in those cases in which secretion or excretion is effected by means of muscular tubes, or the action of adjoining muscles (172). Since secretion is effected by the action of stimuli on the mouths of the capillaries, the general views already stated are applicable to it. Thus, by means of the *vis nervosa* of non-conceptional internal impressions, certain external impressions of food and poisons in the stomach which are not felt, excite a flow of saliva and a discharge from the bronchial tubes, as an indirect nerve-action (419).

529. The glands, whose functions are regulated by muscular action, are subject to laws previously stated (172, 473).

530. Although the glandular system is excited to the performance of its functions by cerebral forces (172, 209), as well as by the *vis nervosa*, yet the latter is the most general and most usual excitant. Many glandular functions go on in decapitated animals, so long as they possess *vis nervosa* and the functions are not interrupted by deep sleep, syncope, &c. They are observed, too, in many animals not endowed by nature with cerebral forces.

531. The œsophagus, stomach, and intestinal canal, are capable of nerve-actions from non-conceptional internal impressions. Vomiting, from injury of the brain, is an illustrative example (490); colic or diarrhœa, produced by the application of poisons externally to the umbilical region, is another; vermicular action excited by puncture of a portion of the intestinal canal, another (513).

532. Although the movement of the digestive apparatus is usually a direct nerve-action of external impressions, and consequently requires neither the cerebral forces, nor the conceptive force (466, 467), nevertheless, not only conceptional internal impressions often change it (170, 174, 206, 212), but it also requires the co-operation of non-conceptional internal impressions for its continuance, just as is required in the movements of the heart, diaphragm, and other parts; for the moving power of the stomach is abolished, when the trunk of its nerves is tied. Hence the continued connection of its nerves with the brain is necessary to the movement of the digestive apparatus, although independent of the cerebral forces and

the conceptive force. External impressions on the stomach and intestines are the principal motor forces, and the peristaltic motion may be excited in those viscera when separated from the body. The point whence the co-operating internal impressions proceed, as well as the natural stimuli which cause them, are as yet unknown.

533. The entire process of digestion, although peculiarly a direct nerve-action of external impressions, is changed in various ways by non-conceptional internal impressions. It is by no means correct to conclude, that because a certain alteration in the digestive process is usually a direct nerve-action of external impressions, it cannot originate in other animals from primary non-conceptional impressions, or even that it may not be a sentient action. It is also a great mistake, to refer all such changes to the great irritability of the intestinal canal.

534. The muscular fibres of the lungs are as capable of nerve-actions from non-conceptional internal impressions as muscular fibres generally; and since their capillaries and glandular tissues are in this respect under the same general laws, as the skin and glands at large, no further illustrations are here necessary.

535. The capillaries of the liver, like those of the lungs, and probably the ductus communis choledochus, are influenced by non-conceptional internal impressions. Is it probable that the animal poisons, introduced by the fangs or stings of enraged or poisonous animals, thus excite, by means of reflected external impressions, contraction of the gall-duct and jaundice, just as they excite spasmodic nerve-actions of the œsophagus and the muscles of deglutition? or are they the direct nerve-actions of the external impressions, derived from the poisons introduced with the blood into the viscus?

536. The kidneys are liable to the same changes in function as the liver. Is the change in the urinary secretion which occurs when cantharides are simply held in the hand, but not so as to excite any manifest external sensation, a nerve-action of a reflected impression? or is it not rather a direct nerve-action, excited by the poison itself being carried to the kidneys? The latter is the more probable.

537. The urinary bladder is capable of many sentient actions (176), and, consequently, of many nerve-actions from

non-conceptional internal impressions, although it is excited for the most part by unfelt external impressions. This is shown by the development of various spasmodic phenomena involving the bladder.

538. The nerve-actions of non-conceptional internal impressions in other viscera, as the spleen, pancreas, are either the same as those of the glands, blood-vessels, &c., or else experimental researches have not thrown light on the subject.

539. The organs of the senses are the seat of the same nerve-actions, as the muscular system generally; it is therefore not necessary to give special illustrations.

540. The sexual functions in animals not far removed from quadrupeds, are undoubtedly, for the most part, nerve-actions. The seminal emission, which takes place in epilepsy, and in which all sensation and consciousness is abolished, is of this nature, as also the sexual congress of decapitated animals before alluded to (481).

CHAPTER IV.

RELATIONS OF THE ANIMAL-SENTIENT [CEREBRAL] FORCES, AND OF THE VIS NERVOSA TO EACH OTHER.

SECTION I.—ON THE SUBSTITUTION [ERSETZUNG] OF NERVE-ACTIONS FOR SENTIENT ACTIONS.

541. When an internal impression, caused by conceptions, develops sentient actions in the mechanical machines by means of the nerves, the material ideas must, firstly, be suitably in contact with the cerebral origin of the nerve which regulates the machine; secondly, the internal impression must go uninterruptedly downwards along the same nerve to the machine itself; and, thirdly, there must be no impediment in the latter, when duly excited, to its performing the movements, which are in accordance with its structure (129, 130). When an internal impression, not derived from conceptions, develops nerve-actions in the mechanical machines, it acts under the same conditions (422, 496); only it is not necessary that it be made at the cerebral origin of the nerve, or by means of material ideas there, but it may be made at any point of the nerve, provided it can go uninterruptedly from the point of impression to the mechanical machine, which it moves (493). In either case, the movement excited is the same, whether it be a sentient action or a nerve-action (360).

542. When an internal impression, from external sensations, develops direct sentient actions by means of the nerves, and, even, at the point where the external impression of the sensations has taken place, it must be reflected, and sent downwards along the same nerve which received the external impression (188). When an internal impression, by means of an indirect nerve-action of an external impression, causes movements at the point where the external impression has taken place, it produces the same movements as nerve-actions (422), which, as sentient actions, were produced under the circumstances just mentioned; these are also produced by a reflected external

impression (399, 422, 360), and may likewise result as direct nerve-actions, from the *vis nervosa* of external impressions (435). These principles have already been fully established by the details of experiments on decapitated animals, and by an analysis of the phenomena of muscular contraction. Compare §§ 204, 357, 445, 453, &c.

543. When an internal impression, from external sensations, excites direct sentient actions in mechanical machines, which have not received the external impression, it is reflected at the cerebral origin of the nerve along fibrils which were not impressed (188, 129, iv). If a non-conceptional impression, by means of a direct nerve-action of an external impression, develops movements in another machine than that duly impressed by the external sensation, or excites them in the same machine by means of other fibrils, it operates exactly as in the preceding case. A non-conceptional primary internal impression produces the same effects under conditions already stated (436, 496). If, therefore, such an impression excite a nerve-fibril, in the same way as it is excited by the internal impression of an external sensation, then the same changes take place, as a nerve-action, that usually accompanied the felt external impression, and constituted a sentient action of the external sensation.

544. When external sensations excite incidental sentient actions, the material external sensation impresses the origins of other nerves in the brain, which have not received the external impression (124, 131), since it causes material ideas in the brain for other conceptions (97). Consequently, the incidental sentient actions of external sensations differ only in the mode of causation, from those of other and spontaneous conceptions (219, &c.), and are not really different. But just as in a similar manner felt external impressions, acting through nerves indirectly, induce sentient actions of spontaneous conceptions, so also unfelt external impressions induce nerve-actions of non-conceptional internal impressions, constituting the same movements which the spontaneous sensational conceptions caused by sensation would develop; provided only, that the unfelt external impressions be so deflected from their course before they reach the cerebral origin of their nerve, as to impress the same nerves as the spontaneous con-

ceptions would have impressed, and in the same way; and provided also, that they be transmitted thence as non-conceptional internal impressions to the same mechanical machines, as the spontaneous conceptions would have set in motion (436). It has already been demonstrated, that the bodies of animals may be so constituted, that external impressions, while being transmitted to the brain, are reflected here and there upon other fibrils of the same nerve, or upon other and different nerves, and thereby cause an indirect nerve-action; that a part [Merkmal] of this reflexion may be present in the external sensation caused by the external impression, and induce the conceptive force acting with the sensation to form a certain spontaneous conception, foreseeing, imagination, &c., of which the indirect nerve-action, excited as aforesaid, is the ordinary sentient action; and that thus the same animal movement may be at the same time both an indirect nerve-action of an external impression, and the sentient action of a volitional or incidental spontaneous conception, connected by the mind with the sensation of the external impression (438,439). There are phenomena which accord with the view of the constitution of animal bodies, and render it probable; but this probability is rendered much greater, when it is recollected that in each kind of spontaneous sensational conceptions, (all which are proximately induced by external sensations) (66), phenomena are actually observed, that indicate that their sentient actions are not solely developed by primary non-conceptional internal impressions, but that also in virtue of their connection with the impression from whence the sensations which excite them originate, they are excited as indirect nerve-actions of those external impressions. This will be subsequently shown more distinctly.

545. The material ideas of the sensational conceptions arising out of external sensations, namely, imaginations, foreseeings, imperfect external sensations, &c. (67, 73, 148), are simply imperfect material external sensations, which the cerebral force produces of itself, without the assistance of external impressions derived from external stimuli (228, 239). Their sentient actions are those of the external sensations to which they refer, only they are less complete (229, 240, ii, iii). Now, since unfelt external impressions and non-conceptional

internal impressions imitate the complete sentient actions of external sensations, so also their nerve-actions resemble the sentient actions of all other sensational exceptions: and inasmuch as the dominion of the *vis nervosa* extends over all the mechanical machines capable of any sentient actions, it follows, that all the sentient actions of imaginations and foreseeings are imitated by the *vis nervosa* only. This view is supported by observation. A gouty person dreams that he has an attack of gout, and this foreseeing is accompanied by the sentient action of retraction of the limb: in this case, the obscure external sensation caused by pressure of the toe against the bed-post, induced the foreseeing. But if the toe of a decapitated frog be pinched, it makes the same movement, although the irritation is quite unfelt. The same movement is a sentient action in the one case, and a nerve-action in the other.

546. By the same cause that a sensational conception is rendered agreeable or disagreeable, but especially by means of the impressions of sensational pleasure or suffering, its sentient actions are also so ordered, that at the same time they cause changes in the vital movements (251); and these changes are connatural, if resulting from a moderate sensational pleasure, and contra-natural, if from an immoderate sensational pleasure, or from sensational suffering (252). The *vis nervosa* can induce similar changes. Examples of this kind are afforded by changes in the heart's movements—especially in the circulation through the thorax—and in the mechanism of respiration (519, 520, 525).

547. A change is caused in the vital movements—a sentient action—by external sensations, in so far as they are pleasant or unpleasant, or cause titillation or pain (80, 250). Now, the cause why an external sensation is pleasing or unpleasing, consists in a difference in the external impression itself, and this difference exists whether it be felt or not (189). Consequently, the *vis nervosa* of external impressions alone causes those changes in the vital movements, which were caused when its sensation was titillation or pain. For illustrations, see §§ 433, 434, but the number might be readily increased.

548. Spontaneous sensational conceptions, imaginations, foreseeings, &c., are only portions of external sensations (228, 239),

and, consequently, the pleasing or unpleasing internal feelings they excite in the mind, depend on the difference in the nature of the external sensation to which they are related. Now, since sensational pleasure or pain depends on a difference in the nature of the impressions which are felt (80), so also the pleasure or pain excited by all spontaneous sensational conceptions, differs accordingly as the external impressions differ that excite the external sensations to which they are related (88). The sentient action of sensational pleasure or pain is either a connatural or contra-natural change in the vital movements (251, 252); and an imagination, foreseeing, &c., in so far as it is agreeable or disagreeable, produces also a connatural or contra-natural change by means of its internal impressions of pleasure or pain, just as the external impression whereon it depends produces change by means of its *vis nervosa* alone (546, 547). The imagination or foreseeing of a titillation or pain, changes the vital movements in the same way, but less perfectly, as the titillation or pain itself. From hence we conclude, that the *vis nervosa* of the external impressions, by which the pleasure or pain in the imaginations, conceptions, &c., is indirectly excited, can of itself excite vital changes, which constitute the sentient action of the imaginations, foreseeings, &c., themselves. In the example already given of the dreaming gouty patient, we have an illustration of this view; decapitated animals and acephalous fœtuses seem also to be as much distressed by violent external impressions merely, as they would have been if those impressions had been felt, so that the heart palpitates, and the pulse is manifestly quickened. This doctrine will be also fully illustrated, when we consider the relations of the instinctive and emotional acts to the *vis nervosa.*

549. From the preceding considerations (542—548), it follows, that the actions of external sensations, or of imaginations, or foreseeings, or of their sensational pleasure or pain, may at the same time be both sentient actions and nerve-actions, or may at another time be nerve-actions only; or in other animals, they may be solely nerve-actions resulting from impressions independently of the co-operation of the cerebral forces, so that neither head, nor brain, nor mind, is absolutely necessary to their development; nay, if there be animals altogether

devoid of cerebral forces, and so constituted that the impressions made on their nerves, are communicated to the mechanical machines, as they are when felt, or produced by spontaneous sensational conceptions, these animals can perform all the sentient actions of pleasurable or painful sensations, imaginations, foreseeings, &c. (437—439); and the actions themselves will have all the favorable or unfavorable influence on the economy, which they wonld have had if they had been true sentient actions.

550. The effort of the conceptive force, arising out of the pleasurableness or painfulness of sensational foreseeings, is termed *desire* or *aversion* (81, 89); and by it the cerebral forces are strained to develop fully the material idea of a certain foreseen conception (83). All the sentient actions of the sensational desires and aversions are compounded of those of a sensational foreseeing and of its pleasure or pain (255). Now, since all these sentient actions can be caused also by the *vis nervosa* (549), it follows that the sentient actions of the sensational desires and aversions can be caused in like manner.

551. The *blind instincts* and *emotions* are sensational desires and aversions differing from the latter only in this, that they manifest a higher degree of intensity, that they are wholly sensational, and that the mind has only an obscure and confused knowlege of their objects (90); their sentient actions differ also in attaining a high degree of intensity, often bordering on the contra-natural (256). Now, since the *vis nervosa* can of itself cause the actions of the sensational desires and aversions, it follows, that it can also cause those of the sensational instincts and emotions.

552. Nature leads animals by means of sensational instincts, to perform the acts necessary to self-preservation and self-defence, to the propagation of the species, and to the care of their young, by means of external impressions which she places in their way at the proper time, if necessary (262—265); and which impel even rational animals by very obscure sensations to the fulfilment of these duties (266—269). Hence it is so much the less surprising, that external impressions so wisely prepared beforehand and produced by nature, can excite the sentient actions of the natural instincts, as nerve-actions; and attain to and accomplish their object without their being felt, and without the cerebral forces taking any share therein (89).

But direct sentient actions of the instincts are none other than changes in the vital movements arising from pleasure and pain, combined with those movements which take place more completely during the satisfaction of the instinct, and which are properly the sentient actions of a foreseeing (271, 272). To these may be added a number of incidental sentient actions of the instincts, which the *vis nervosa* can develop as regularly and as providently as those of the instincts themselves (436—439). Lastly, the sentient actions of the satisfaction of the instinct, are simply those of the foreseeing and of the actual sensation, or of other sensational conceptions (275, 276), and these also can be developed by the *vis nervosa*. We will demonstrate these views with reference to some of the principal instincts.

553. The external impressions on the stomach, which excite the instinct of hunger, excite an unpleasant external sensation in the stomach of faintness, which, being a painful sensation, changes the vital movements contra-naturally, and otherwise stimulates to the performance of their functions, all the mechanical machines which co-operate in the mechanism and function of digestion (281). Incidental sentient actions accompany these direct sentient actions of the instinct, as, for example, that the animal shall go out to seek food, seize it, and carry it to the stomach. Satiety, or the satisfaction of the instinct by these means, is an external sensation in the stomach, which has also its peculiar direct and incidental sentient actions, subservient to the whole process of digestion. All these actions may be excited by the *vis nervosa* only, especially in those animals whose organisms are so constituted that the *vis nervosa* can take the place of the cerebral forces (439). A headless tortoise lives several months; it cannot possibly feel the sensation of faintness from emptiness of the stomach, yet the external impressions must change the vital movements contra-naturally like that painful sensation, because it becomes feeble and faint from starvation. The digestive organs must be excited to the movements which are requisite to digestion, by the external impressions of emptiness, just as by the instinct, since the bowels are moved peristaltically, and the digestive fluids are secreted, so long as life continues (468). The most convincing proof, however, of the general principle is, that those movements

are excited as nerve-actions, which usually are volitional; for the animal raises itself, and creeps about to seek food. In animals in whom the existence of a conceptive force is more doubtful, the same thing is observed, for it appears from Schäffer's experiments, that decapitated snails can obtain food, and satisfy the instinct of hunger. (Schäffer, Versuche mit Schnecken.) He placed headless snails under a glass, with some bean-leaves; on the following day he observed traces, showing that they had crept about; on the fourth day, the leaves were eaten into holes; by the end of the month a new head had grown.

554. It must be remembered, however, that direct proofs of the production as nerve-actions of sentient actions, by the *vis nervosa* only, are not always possible. In many cases, decapitation arrests certain functions, which although purely nerve-actions, require some influence from the *vis nervosa* produced in the head and cerebrum. (Compare §§ 515, 524, 532.) Again, when the head is separated, many nerve-actions cannot possibly take place, because the organs in which they ordinarily occur as sentient actions, are removed with the head. Thus, the flow of saliva cannot be excited in a headless animal, by the sensational stimulus of hunger. Further, the proof in many cases can only be indirect, or an inference, as in the example of the headless tortoise just mentioned, which, after long fasting, crept about as if in search of food. Certain actions result from certain stimuli previously to decapitation; the same results follow on the same stimuli after decapitation; hence we conclude, that in both cases the actions result equally from the stimuli.

555. The external impressions that develop the instinct to voluntary movements, excite unpleasant external sensations of weariness, lassitude, indisposition, &c., which, being strong sensational painful feelings cause the vital movements to be feverish, and stimulate the muscles of voluntary motion to perform their proper functions, so that they jerk, move the limbs, and produce complete movements. When the instinct is satisfied by the performance of the movements, the agreeable sensation thence resulting has also its peculiar results in the economy, and induces a general healthy tone of the system (283). The instincts for particular kinds of movements, as walking, sighing, laughing,

yawning, crying, singing, striking, swimming, spinning, building, &c. (284), have, as their inducements, various external sensations, imaginations, foreseeings, and other instincts; and it is an established fact in the whole animal kingdom, that all the actions of these instinct for voluntary movements may be produced by the *vis nervosa* only. Various experiments and observations made on decapitated frogs and other animals already detailed, prove this amply. An acephalous child retracts its limbs when pinched or burnt, exactly as an ordinary child would have done. It is related, that a decapitated man, being thrust through the breast with a sword, threw his arms together,—a movement which under ordinary circumstances would have been the sentient action of the instinct of self-preservation. The movements made by a decapitated man, immediately after decapitation, are for the most part volitional in character. He struggles violently with his arms, that he may free his hands from their bonds, and so be able to use them to save himself. He grasps with his hands, and endeavours to turn, to stand on his feet, &c. Similar movements in great variety may be seen daily in decapitated animals, as turtles, snakes, snails, flies, centipeds, &c. Many of this class of movements, as singing, sighing, &c., cannot, however, be excited as nerve-actions, because decapitation renders the experiment impossible, the organs themselves being removed.

556. From the preceding and other considerations already adduced (435—439), it is extremely probable, that these actions of the instincts, ordinarily voluntary movements in all animals which feel true instincts, often take place as pure nerve-actions (269); that they are sometimes of the one kind, sometimes of the other (286); and, consequently, that animals which are endowed with neither sensation nor true instincts, being stimulated solely by unfelt external impressions, can apparently act volitionally, and as if endowed with sensation. Respiration has already been quoted as an example of this kind (285, 526). When the instinct of an animal excites it to walk or run voluntarily in a certain locality, the muscles of the legs are only sentiently excited at first to the suitable movements, and, subsequently, an external impression is sufficient to excite the same movements. Thus there are examples of persons who continually traverse the same streets, who fall fast

asleep on the way, are conscious of nothing, observe nothing that they meet, and yet reach their destination. If it be advanced, that these movements depend on obscure sensations, (which, however, is not the case,) there are innumerable illustrations in lower animals, that are unanswerable. A frog uses its legs quite differently, when it swims than when it leaps. If, when decapitated, it be pinched, it leaps away, not because an external sensation excites an instinct, but simply in virtue of the nerve-action of an external impression. If, in leaping, it falls into the water, it then uses its legs to swim, not because the external sensation of the water excites the instinct to swim, but because the external impression from the contact of the water excites the movement as a nerve-action. This being undoubted, why should it be presupposed that a living frog leaps or swims only in consequence of the excitement of the instinct by external sensations? It is clear that it may do both without external sensations, and without the development of the instinct. Thus, it is manifest, that the movements are probably often nerve-actions only, which we constantly suppose to be sentient actions, because they are such in ourselves and in other animals.

557. We can manifestly see from these considerations, what truth there is in the inference made from the performance of volitional motions of animals, especially of those which are instinctive, as to the existence of mind, and of sensations, and volitional conceptions. If the most voluntary instinctive actions of animals really sentient and endowed with true instincts can be excited by means of mere external impressions, and can go on after their organism has been subjected to so great an injury as decapitation,—or if volitional movements can be excited and regulated under such circumstances, by various and successive external impressions, just as if they were felt, and so excite new instincts into operation (555, 556), it were altogether unreasonable to infer from the apparently voluntary movements of many animals, whose whole conceptive force is of doubtful existence, that those movements in them are sentient actions of true instincts, and the results of external sensations; or to accept these as the sole decisive proof, that they possess conceptions. When we consider how carefully nature has provided, that in the apparent instincts of animals,

the external impressions shall be applied in such order, and with such energy, that in a like order and with proportionate vigour, those voluntary movements are excited, which we consider as the sentient actions of the instincts (265), remembering at the same time how closely these are related to the ordinary nerve-actions caused by these impressions, it can hardly be a matter of surprise, that the latter take place as regularly and as adaptively, as if they were sentient actions. Our astonishment, as we have already shown, arises from our erroneous conclusions (438). Is not that which appears to be performed adaptively, volitionally, and in a definite order, by a worm without a head or brain, by an insect, or by any other animal whose structure is widely different from that of sentient beings, although in such we can scarcely trace vegetative life—is not the whole life of an oyster, a sea-worm, a polype, a snail, a spider, a flea, an ant, a bee, &c.—is not the whole of their acts, or part of them, solely an operation of the *vis nervosa?* Nay, are they not such even in sentient animals? We know of no reason why it should be doubted, that such is the case with those animals whose organisms are not constructed to be the seat of mind, like the bodies of sentient animals, but are manifestly so formed as to lead to the conclusion, that the nervous ganglia, so numerous in many, perform the office of a brain, and that the external impressions which nature supplies, are so reflected from them to the limbs, that the latter are excited thereby to perform those movements, according to the pre-ordained intent of nature, which, in sentient animals, the material ideas of the instinct develop in like manner by means of the cerebral force.

558. The external impressions, which cause the sensation of weariness, lassitude, and fatigue, whence the instinct for repose and sleep arises, develop the sentient actions of this instinct, as nerve-actions; namely, a relaxation in the activity of the cerebral forces, and the weakening of their action on the mechanical machines (287, i), without the instinct itself being excited, and without being felt. A sudden pressure on the brain arrests in a moment the operation of the cerebral forces, without the instinct for sleep being previously developed, and all conceptions and sentient actions suddenly cease. Opium, when taken, excites this instinct, and not only changes the vital movements

thereby, but the sentient actions gradually cease, in consequence of the brain being rendered unfit for the performance of its functions, and no material sensations being excited in the brain. Opium acts on the nerves, as on the brain, and renders the *vis nervosa* as inefficient as the cerebral forces. When opium is applied to the nerves of a decapitated animal, it changes and arrests the movements of the heart, but somewhat more slowly than if taken. According to Whytt, a muscle suddenly loses its irritability, if opium be applied to its nerve. But the power of the *vis nervosa* to excite indirect nerve-actions, as well as the direct, is abolished by opium, since all the nerves of the body are rendered insensible, as well as those with which it comes in contact; so that external impressions are neither transmitted upwards along the nerves, nor reflected downwards. Very frequently, not a particle of opium or other narcotic poison, reaches the brain in narcotization; for it acts when it has scarcely come in contact with the stomach, and even when applied externally, or when the heart is excised, and, consequently, the circulation of the blood arrested (Whytt). It is often impossible, that narcotics can excite sleep by causing external sensations, since their impressions on the stomach and intestines are rarely felt (470), for they deprive the terminal points of the nerves with which they come in contact, of both their sensibility and *vis nervosa* at the same time, and thus, in a moment abolish the most violent external sensation of a nerve, namely, pain. It would appear, that Whytt (whose experiments we have just quoted) was correct in concluding, that the sleep which opium induced, was much more probably the result of a diminution of the general sensibility of the nerves caused by it, or in other words, of the cerebral forces and the *vis nervosa*, than of the excited instinct for sleep; although when the opium acts at the same time on the brain, this instinct may be developed.

559. The war-instinct, by which animals are motived to use their natural weapons when exposed to danger, is really only another form of the instinct to voluntary movement; and, consequently, its sentient actions may, under suitable circumstances, be nerve-actions, excited by the same external impressions, which, when felt, excite the instinct. Insects, as the earwig and bee, thus use the natural weapons, placed in their abdomen,

after being decapitated. A horse with his head shot off by a cannon-ball kicks when it is struck down, just as it usually does when its war-instinct is otherwise excited. Examples of this kind are numerous.

560. It scarcely requires proof, that the sentient actions of the instinct of propagation may take place as nerve-actions from external impressions only. Crickets allure to sexual congress, after decapitation, by the vibration of their wings; and Redi, Bibiena, and others, have observed that butterflies, after having copulated but once in their lives, repeat the function perfectly when decapitated, and the females after sexual congress, deposit their eggs as carefully as if excited thereto by their instinct.

561. The preceding statements fully establish the general fact, that all this class of sentient actions are only animal movements, which may be produced as perfectly by the *vis nervosa* only, as by the cerebral forces; in many animals they are the preordained and adapted results of external impressions made by nature on the nerves for the express purpose; in many others, are at the same time sentient actions, being produced by the co-operation of the cerebral forces, and in this class are at one time excited as nerve-actions only, at another as both sentient actions and nerve-actions; and in newly-born animals, which are insensible to the external impressions of the instincts, are developed as nerve-actions only. Further, the acts which take place in connection with its principal and secondary instincts, characterise an animal, and determine its sensational character and leading propensities (295), constitute no proof that such animals are controlled by true instincts, or are endowed with the sensational faculty or with mind (437—440).

562. The instinctive passions originate like instincts from obscure sensational stimuli; differing only in this, that the latter are perceived during their continuance (298). Their sentient actions are the same as those of the instincts, but the incidental sentient actions are developed rather according to psychological laws (297). But inasmuch as they arise in the instinct itself, and, consequently, in close connection with the external impressions which excite it, and since the sentient actions of the instinct are excited by the *vis nervosa* only, and can take place in the same order as if excited volitionally (552),

it appears that the incidental sentient actions of the instinctive actions, stand in the same relation, and may be equally excited by the *vis nervosa*. All the actions which a sentient animal performs under the influence of the instinctive passions (299—303, &c.), may be excited in another animal by the *vis nervosa* of external impressions in the order and succession preordained by nature. Decapitated insects supply illustrative examples. In many animals these actions take place naturally as nerve-actions.

563. That the sentient actions of the passions can be excited as nerve-actions, by means of non-conceptional internal impressions, does not admit of doubt (503). All the passions modify the circulation, the action of the heart, the respiration, and the vital movements in general (307, 310). Internal impressions do the same in a thousand instances, simply by means of the *vis nervosa* (515—521, 525). The other sentient actions of the passions are often volitional movements, often changes in the natural functions of the viscera (307—325), and these also can be produced by the *vis nervosa* of internal impressions (508, 532—540). But an important question arises, whether the sentient actions of a passion, considered as incidental actions of the primary external sensation, can be excited by the *vis nervosa* of the external impression proper to the latter, according to the doctrines stated, § 544.

564. Animals not endowed with reason are peculiarly maintained in the performance of their natural functions by the blind instincts; and it is only the most skilful in which we see the latter attain to the stage of instinctive passions, because their brain is capable of containing a greater number or a greater development of material ideas (26); for it is certain, that a more perfect conceptive force which can form wholly pure conceptions and a higher degree of sensational perceptions, are necessary to the development of the passions in general (305), and these are possessed only by the more perfect animals. A true passion never results so directly from external sensations, however pure [klar] they may be, as the natural instincts and instinctive passions (276, i, 298). The former usually require entire series of other pure [klar] sensational conceptions, often only distantly related to external sensations, which the mind connects together according to psychological laws, and of which

a very imperfect and obscure conceptive force is not capable (89, 108). It is only necessary to compare an instinct and a passion, in one point, to be assured of this. Any painful external sensation immediately excites the war-instinct, and the movements proper to the instinct as instantaneously follow, even in man himself, and before the cause of the sensation is known. Between the external sensation exciting the instinct and its sentient actions, no traces of conceptions can be discovered, consequently there are no material ideas of imaginations, foreseeings, &c., produced by the external sensation; so that there appears to be a direct transition [Uebergang] of the latter into the instinct itself, and the material ideas proper to it to take effect in the sentient actions of the other. So that it may in some degree be asserted, that in the instincts the brain turns back [umwendete] the felt impression, and reflects it on the nerves appropriate to the sentient actions of the instinct, just as an unfelt external impression is reflected in the ganglia, and this without the material ideas of the conceptions necessary to the instinct becoming an object of special thought, they being too little developed; and without its sentient actions being obviously excited and connected with each other, according to psychological laws. If, on the contrary, a man be excited to anger by a pain inflicted by another, between the passion which excites to combat, and the painful sensation, a number of connected sensational conceptions arise, which are psychological and volitional in their character. He perceives clearly that an injury has been done him; he resolves to retaliate on the offender; is undecided as to the means by which he should do this; chooses that which comes first to hand, and by a continually repeated and magnified conception of the injury, is more and more irritated against his enemy. Just as these sensational conceptions, excited by the external sensations, are developed in the mind, and excite the instinct (94), so also are the material ideas which produced the material external sensation developed in the brain; so that in this case there is not that apparently direct transition of the external sensation into the passion itself, and of the material ideas of the former into the sentient actions of the latter. To comprehend the sentient actions of the passion, in their connection with the external impression which first excited it, the course of all the sensational conceptions and their sentient actions must be traced as far as the outbreak of the passion and its sentient actions, so that it may be noted how they are developed from each other, according to psychological laws (108).

565. Amongst those sensational conceptions induced by an external sensation, and which must be generally developed ere they form the passions (94), there are in many passions some which are incidental and as little related to the primary sensation, as conceptions of the understanding; and, consequently, are not really produced by the external impression which excites the sensation, but are excited in successive series, according to psychological laws. But since these conceptions are nevertheless the incitements [Triebfedern] of the passion which they excite into activity, it follows that the sentient actions of the passion so excited are not really produced by the primary material sensation, and, consequently, not by its external impression; and therefore cannot be developed either as its sentient action or nerve-action. An example will illustrate this. An individual sees another who resembles a deceased friend. This constitutes the primary external sensation of all that follows. In accordance with psychological laws the mind perceives the resemblance, and this is the first intermediate conception which is not connected with the sensation according to the laws of the *vis nervosa*. Thence arises the imagination of the deceased friend, which has only, in common with the sensation, those sub-impressions of the two persons in which they are alike. Next arises the recollection of the death of the friend, and all its accompanying circumstances, with which the primary sensation has nothing in common. Lastly, the foreseeing arises, that death has cut off all possibility of future converse with him. This foreseeing is painful, and the mind endeavours, according to psychological laws, to develop the conception antagonistic to this painful one. In the effort of the conceptive force to effect this, consists the passion of sorrow, which was excited by the sight of the individual. All the conceptions thus excited are as far removed from the primary sensation, as many an abstract conception induced by sensations, consequently, the sensation has really contributed nothing to the sentient actions of the sorrow. But the *vis nervosa* of the external impression of the sensation can only develop as nerve-

actions, those movements which its external sensation would have, or had, excited as its sentient actions (542, 543). Consequently, the *vis nervosa* of the external impression which induced the emotion of sorrow, cannot excite as nerve-actions, the sentient actions of the emotion. The same doctrine applies to many other passions.

566. Nevertheless, all passions are not excited so remotely, and with the intervention of so many purely psychological conceptions; for there are some which, from their closer connection with external sensations, are similar in their origin and development to the instincts. With regard to this class, it must often remain doubtful, whether they belong to the passions, or to the instincts, or instinctive passions. Thus fear, alarm, and terror (313, 318), which an external stimulus excites in us, without an intervening series of irrelevant and purely psychological conceptions, is usually rather a form of the instinct of self-preservation (299): the anger and revenge of the dog rather a modification of self-defence (326). The affection of many animals for their offspring, which sometimes (as in monkeys), appears to be a passion, is but a form of the instinct to tend offspring (303); the frolicsomeness and cheerfulness of many animals rather an instinctive passion for enjoyment (299). The sentient actions of emotions of this class do not differ from those of true instincts, except in being accompanied with the sentient actions of some other conceptions, which the conceptive force intermingles according to its own laws (297—304). Now, since all these may be excited by the *vis nervosa* only (549, 552), no repetition of proofs from observation (compare 553—562) is necessary to demonstrate, that the same external impressions, which, when felt, excite the sentient actions of these instinctive passions, will also excite them by means of the *vis nervosa* only, as nerve-actions. We will, however, analyse the emotion of terror. In this, the external impressions cause a painful external sensation; or such a sensation as induces a strong sensational unpleasantness [Unlust], because it excites a sudden secondary sensational conception: as, for example, when an individual hears a noise, he immediately imagines it to be thunder, or, if he receives a blow, he conceives it to be given by a robber. This disagreeable sensation changes the vital movements contra-naturally, and violently (314, 318), and puts

those machines into motion, which must act in flight and defence from the foreseen danger (315, 319), whence all the other phenomena result (316, 320). All these sentient actions may be excited as nerve-actions, in decapitated animals, insects, or frogs, or in a decapitated man, or in an acephalous fœtus.

567. Not even the same kind of passions arise always from external sensations in the same way, but sometimes directly from them, sometimes with the intervention of many psychological conceptions. When a dog is frightened by a sudden blow, so that it excites its muscles for the purpose of running away, it connects with the external sensation of the blow, the foreseeing excited by frequent experience, that many more blows will follow, and thus the emotion of fear arises, without the intervention of other conceptions. This sentient action of fear can be developed by the *vis nervosa* only of the same external impression, and would be manifested if the animal were decapitated (555). If, on the other hand, fear is excited in a man by a sudden blow, it may arise from a sensational conception, which has little in common with the sensation. He judges, for example, that the blow must have been inflicted by a man: he looks about, and sees no one. This excites surprise and thought, and he now concludes from probabilities: firstly, he thinks it may have been from a concealed robber, and thus fear incites him to those sentient actions which can protect him: then he conceives it was a ghost, and fear incites him to run away: lastly, he attributes the blow to some missile, and fear incites him to hide himself, &c. The impression of the blow could not possibly excite all these various kinds of sentient actions, since so many volitional conceptions influence them; the external sensation only excites the will into action.

568. We conclude, therefore, from the preceding statements:

i. That the sentient actions of the passions generally may be excited by means of the *vis nervosa* only (563); but that the same external impressions, which by means of their corresponding external sensation induce the passions, however remotely (66, 90), can only excite by the *vis nervosa* the movements constituting the sentient actions of the latter, in so far as these actions, although always incidental to the external sensation excited, are not produced by intermediate conceptions, induced by other sensations differing altogether from it, and only in so far as the movements are at least in part dependent on it.

ii. That the reason why the sentient actions of the instincts, although only incidental, are much more frequently excited as nerve-actions by the *vis nervosa* of the external impression only, than those of the passions, is this: namely, that the external sensation which excites an instinct, being seldom or hardly an object of consciousness to the animal, is in closer relation with the sensational volition of the conceptive force than in the passions; in which other sensational conceptions, altogether foreign to the primary external sensation, are so widely removed from it, that the sentient actions are quite incidental and excited by them according to psychological laws.

569. Although the *vis nervosa* can excite the sentient actions of the passions generally, it cannot imitate the operations of the cerebral forces, in the order in which they are developed psychologically, from the primary external sensation to the outbreak of the passion, unless the latter, like instincts, depend directly, or for the most part, on the sensation. Now since the other results in the animal economy, which peculiarly characterise each passion, are caused by the sentient actions of the passion, by means of the natural connection of all the forces of the animal body, they can be induced by the *vis nervosa* of the external impressions which excite the passion only under the same conditions. Thus, the sentient actions of joy, namely, the quicker and more vigorous action of the heart, the half-convulsive movement of the diaphragm in laughter, and the volitional movements of dancing, singing, &c., may all be induced by the *vis nervosa* only, as has been already fully shown. But if the attempt be made to trace the greater number of the joyous emotions to their primary sensations, and to deduce their sentient actions and their other animal movements from their impression alone, as for example, from the nerve-actions caused by wine, or by music, or by a look, or conversation, observation will not afford an instance in which these flow directly from the external impression, except in those cases in which the emotion arises directly from external sensation, like the instinct for pleasure. Such is the case when a chrysalis writhes and turns about if placed in the sun, as if from the pleasurable sensation of warmth; or when a torpid

newly-born child, after being washed with wine, moves its limbs, having its circulation accelerated, &c., just as would have followed from the taking of wine; or when a headless butterfly is excited to copulation, by the fluttering of the female, just as if the sexual sensation had been excited in it.

570. Who can doubt, that the sentient actions of sorrow (310, 312) may be induced by the *vis nervosa* only? Yet if we were to trace them back in the majority of cases to the primary sensation, and attempt to deduce them from their external impressions only, namely, from the nerve-actions of black bile in the stomach and bowels, of imperfect digestion, &c., in the order in which they arise, together with their material results in the economy, such as diminished transpiration, weeping, wailings, &c., we should find no examples in which it could be done, except in instances in which they arise directly from the external sensation. In this way, a child cries from the first external impression of the air, as if suffering pain, a decapitated man clasps his hand, when wounded, as if lamenting, &c.

571. The sentient actions of all kinds of fear, anguish, despair, and terror (314—320), may also be excited by the *vis nervosa* solely; still, as in the preceding cases, they cannot be traced directly back in the order in which they arise to the primary sensation, and thence to the external impressions causing them, except in the instances in which they arise (as in instinctive actions) immediately from the external sensation, and of which illustrations have been already given (566).

572. Lastly, the sentient actions of all kinds of anger and revenge (323—325), may be excited by the *vis nervosa* only; still, as in the preceding instances, they cannot be traced back to their primary exciting impression, except when they are instinctive in their nature, and arise directly from an external sensation.

573. In investigating the sentient actions of all the other passions, and other desires and aversions, the material ideas of all the intervening sensational conceptions must be considered (111, 568, i, ii). The sentient actions of the true passions (306, 309), can never occur in decapitated animals, solely by means of the *vis nervosa*, or in those not endowed with mind, or capable at most of only feeble and obscure external sensa-

tions. The apparent instances adduced to the contrary, are really only examples in which the sentient actions are instinctive in their nature, and have arisen from direct external sensations.

574. The material ideas of the *conceptions of the understanding*, are not excited like those of sensational conceptions by external impressions (66); consequently, they cannot be excited by the *vis nervosa* of the latter, in the order in which they are developed psychologically. But as all material ideas, and, consequently, those of the intellectual conceptions are internal impressions on the cerebral origin of the nerves (121), it follows that their actions may be developed by the *vis nervosa* of non-conceptional internal impressions (360). Still, as they manifest no visible direct sentient actions (330), except in so far as they are either at the same time sensational (and then the *vis nervosa* can excite them) or incitements of the mind, and excite the will, it follows that no direct actions of the intellectual conceptions can be induced as nerve-actions by the *vis nervosa* acting through the nerves.

575. The incidental influence of the understanding on the animal economy arises in various ways (331), and can only be replaced by the *vis nervosa* acting alone, in so far as it consists in sentient actions from sensational conceptions, or from pleasure or pain of the desires and aversions, whether sensational or intellectual (574). In so far, however, as the effort of the intellectual power involves and disorders the entire organism (331, 332), and an abuse of the cerebral forces must necessarily have this effect,—to this extent the effects of the abuse of the *vis nervosa* are identical, whether the latter co-operate with the former or not (356—360). For example, just as study enfeebles the body, wastes it, and disorders its natural functions, so also does an excessive indulgence of the sensational instincts (261, iv). Thus, an abuse of the sexual instinct has the same injurious effect as excessive study.

576. The gentle influence which the intellectual conceptions, in so far as they are agreeable, or the contrary, have on the vital movements (333), may be exercised by non-conceptional internal impressions; and in this way the movements of the muscles which the intellectual desires and aversions, and their satisfaction, develop as direct sentient actions (340), are often incidentally mere nerve-actions of impressions

(342, 445, 507). But since the mind produces all these kinds of motives [Bewegungsgründe] and desires of the will, according to purely psychological laws, and independently of external impressions (333, 341), the movements resulting cannot be induced like the sentient actions of sensational conceptions, feelings, and desires, by the *vis nervosa*; and, although those movements which are excited by the will, in intellectual beings, may and do occur in decapitated animals, or in purely sensational animals, still they are induced by impressions, and not psychologically.

577. The incidental influence which the will exercises, by means of its acts on the animal economy (compare 336, 337, 343), can be exercised also by the *vis nervosa*, in so far as that influence consists in sentient actions directly dependent on the internal impressions of sensational conceptions, incitements, and desires.

578. The intellectual conceptions (330), the motives contained in them (333), and all desires and aversions of the will (339), in addition to their remote connection with sensation (65), possess a special connection in virtue of the sensational conceptions, incitements, and desires, intermingled with them. Hence all their sentient actions have a sensational character, and to this extent can sometimes be induced by the *vis nervosa* of external impressions, although always very imperfectly. When the external sensation of a tune excites our instinct to dance, the desire of the will to dance a rhythmical dance is combined with the instinct, and by dancing we satisfy that desire. In so far as this free-will act is a sentient action of the instinct, it can be excited purely as a nerve-action of other impressions: those affected with chorea St. Viti, for example, dance involuntarily and convulsively, even when sleeping, but certainly not rythmically, since this is an action of the will.

579. The following conclusions may be drawn, as to the substitution of nerve-actions for sentient actions. All movements which can be sentient actions may be excited, either as nerve-actions only by the *vis nervosa* alone, or as the latter at the same time that they are sentient actions (503); and so far as it is possible to illustrate the question by observations and experiments, the latter establish this principle without exception. If, however, the sentient actions be considered in reference to

their exciting cause, namely, the conceptions of the mind, and in connection with the order in which they are developed, and succeed each other, we find there are two kinds:

i. Certain conceptions, namely, the sensational, are induced in the mind by external impressions corporeally and necessarily (65, 66), and are developed by the mind, so as to succeed each other only in the same order as the external impressions succeed each other, and determine the conceptions to act, according to the laws of the *vis nervosa*. These sensational conceptions are—the external sensations, imaginations, foreseeings, &c.—the sensational incitements they contain, and the sensational desires and aversions, particularly the instincts and passions. External sensations, together with sensational pleasure and pain (80), and the blind instincts (263), are the most directly induced of all these by external impressions, and are developed and succeed each other just as the impressions succeed each other, according to the laws of the *vis nervosa*, and develop their material ideas in the brain; and the sentient actions of these sensational conceptions are also developed in like manner, (542, 543, 547, 552, &c.) The remaining sensational conceptions, incitements, and desires, namely, the imaginations, foreseeings, &c., with their sensational pleasure and pain (66, 80), and the passions (305), are somewhat more free from the natural and necessary influence of external impressions, and are developed and succeed each other more according to psychological laws; nevertheless they are not to be confounded with recollections, expectations, &c. (238 249), considered as simply imperfect external sensations, and not directly dependent on external impressions. Hence the sentient actions of imaginations, foreseeings, &c., are in fact those of the external sensations to which they are related (237, 247), and as such (as experience teaches) may be induced by the *vis nervosa* only (545, 547). It is only the sentient actions of the higher passions, and of the higher sensational desires and aversions, which are formed and developed rather according to psychological laws than the laws of the *vis nervosa*, and which cannot be induced by it as nerve-actions (573).

ii. The other class of conceptions is the intellectual. This comprises those perceptions which are not sensational, the motives they contain, and the desires, aversions, and satisfactions of the will. Their material ideas are formed, and connected with each other, in the brain, solely according to psychological laws, and their sentient actions are developed and succeed each other independently of external impressions: consequently, they cannot be induced by the *vis nervosa* as nerve-actions, except incidentally, and then not in the same sequence as that in which the mind develops them (574—576).

iii. This difference in the two classes of conceptions, as regards their relations to external impressions, has led eminent men into the singular error of placing the seat of the first class in the body, and that of the second in the mind. The occasion of the error is so obvious, that further explanation is not necessary. All that is conception, consciousness, thought, is in the mind [in der Seele]. External sensations are conceptions of external impressions on the nerves; all sensational conceptions are only repetitions, or anticipations of these; the feeling of that which is pleasing or displeasing in a sensational conception constitutes sensational pleasure or pain [Unlust]; hence are developed sensational desires, instincts, and passions; and although all these take place from the impulse of external impressions, still it is always in the mind that these conceptions, pleasures, and desires, are forcibly developed. They are as certainly sentient as the most voluntary sensational conceptions and desires, or the most abstract ideas, and the noblest motives, passions, and conclusions of the will. But the external impressions which excite sensational conceptions, pleasures, and passions in the mind, can, nevertheless, if they do not develop these, excite, by means of their *vis nervosa*, the same movements in the animal economy, and in the same order and series, as if they were excited as sentient actions. In cases of this kind, the organism performs the sensational acts of desires, of instincts, of passions, without these being really in the mind; but how can it be inferred from hence that they are present in the body? There is a force, it is true, which imitates their workings, whether it co-operates with them or not; but the crude matter cannot feel pleasure and disgust; or desire, or shun anything.

SECTION II.—ON THE SUBSTITUTION OF SENTIENT ACTIONS FOR NERVE-ACTIONS.

580. There are three principal kinds of nerve-actions in the mechanical machines: firstly, those of primary internal impressions, not caused by conceptions (419); secondly, those of unfelt reflected external impressions; and thirdly, those of direct external impressions (418).

581. The nerve-actions of primary non-conceptional internal impressions may be excited by the impressions of conceptions, since the two kinds develop the same animal movements (541). The non-conceptional internal impressions may be divided into the contra-natural, to which class the experimental belong, and the natural. The experimental internal impressions are those made on the brain, spinal cord, or nervous trunks, by various stimuli in experimental researches. There is no nerve-action caused by impressions of this class, which is not induced also as a sentient action; and it is because we know them as the latter, that they surprise us so much when excited artificially (486). Nerve-actions are often excited in the usual condition of an animal, by contra-natural internal impressions, as when the cerebral origin of the nerves, the spinal cord, or the trunk of a nerve is irritated by stimuli, which are not conceptions, and so cause nerve-actions; as, for example, when effused fluid in the brain partly paralyses, partly causes spasmodic action in the extremities; or when an acrid humor is determined to the spinal cord; or it has been injured; or a tumour or growth on nerves causes contra-natural movements in the parts regulated by the affected nerves. These are also similar to movements which occur as sentient actions in the natural condition, or at least, as contra-natural sentient actions. Thus, a fright will paralyse or convulse the limbs, as much as a paralytic stroke from effusion; the convulsions excited by an acrid humor determined to the nerves are excited also by anger or anxiety; and the most violent convulsions may accompany intense passion in sensitive persons, &c.

582. When reflected unfelt external impressions produce nerve-actions, they act in the same way as internal impressions, and the same animal movements are excited. Consequently, the observations made in the last paragraph apply equally to

them. But the question arises, whether the unfelt external impression, which, by its reflection causes an indirect nerve-action, can, when felt, excite the same movement as a direct or indirect sentient action of its sensation? It is not easy to answer this question without going into details.

583. When the toe of a decapitated frog is pinched, it places its limbs in a position for leaping, and actually leaps, in consequence of the indirect nerve-action caused by the external impression on the toe (415, ii); and the question arises whether the same impression, when felt, would cause the same leap as a sentient action of the pain caused, either indirectly or incidentally, in consequence of the excitement of an instinct? Probably it is so, for a healthy frog leaps when it feels the pain caused by pinching its toe; but in this case is the leap necessarily a sentient action caused by the pain? for although it may take place as such at the same time that it occurs as a nerve-action (364), still it does not follow, that in the case of the healthy frog, the leap is so produced. How can it be shown, experimentally, whether it occurs from the sensation of the external impression, or from the impression only? Everything which prevents the action of the external impression, also partly prevents its being felt, and if felt, partly prevents the same movement being excited as a sentient action of the sensation. Other difficulties might be mentioned, and, in fact, there is only one means of solving the problem.

584. The sensational conceptions, namely, imaginations, foreseeings, &c., are imperfect external sensations, which are in relation to an external impression; and their sentient actions are the same as the actions of the external sensations, but are imperfectly so, since the external impression and all its nerve-actions are wanting (68—74). Now, if an imagination or foreseeing of a sensation excites imperfectly as sentient actions, the same movements which the external impression of the sensation usually excites, as its indirect nerve-action, the conclusion is obvious, that the sensation of the impression itself will produce the same animal movement; particularly, as in the normal condition it always accompanies sensation, which would not be the case if it were always a nerve-action only of the external impression. Now, the former proposition is established by observation; and the latter must be true, since it does not appear

that any objection can be raised. If a frog could dream, and dreamed of a pinching of its toe, the imagination would certainly induce it, if not to take a leap, at least to place its limbs in the necessary state of preparation for leaping. Animals endowed with sensational conceptions and instincts afford a thousand proofs of this doctrine, since all their imaginations and fore-seeings express, although imperfectly, the sentient actions of the sensation to which they are related; while many of these actions are at the same time nerve-actions of the external impression which causes the sensation (543, 545). A person dreams that his finger is touching red hot iron, and withdraws his whole arm, as if he really touched it. This retraction is the imperfect sentient action of the imagined sensation, and may occur as a nerve-action, being analogous to the retraction of its foot by a decapitated frog, when its toe is pinched. Illustrations of this kind could, in fact, be multiplied to any extent in support of the proposition, that the indirect nerve-actions of external impressions are, when the latter are felt, at the same time direct or incidental actions of the sensations of those impressions; and that the feeling itself is nothing superfluous in the production of these movements, which the impressions themselves can excite as indirect nerve-actions.

585. The direct nerve-actions of an external impression, or in other words, the movements of irritability (432), can, in general be replaced by sentient actions. Since they take place principally in muscular fibres (445), which are moved by all cerebral forces from external sensations to free-will acts inclusive, the movements of the muscles are the same, whether they be nerve-actions or sentient actions (161-162); and no result of irritability can be mentioned, which cannot be a sentient action. Innumerable illustrations might be advanced (445—448, 204, 229, &c.)

586. But since the direct nerve-actions of external impressions are developed at the point where the impression is made when it is not transmitted to the brain, or, if transmitted along the nerves, before it reaches the brain—the question arises, whether the impression can produce, when felt, the same direct nerve-actions it produced when unfelt? This question offers the same difficulties as that mooted in a previous paragraph, regarding indirect nerve-actions.

587. The answer must, as in the preceding paragraph, be deduced from a consideration of the sensational conceptions, and *mutatis mutandis*, the line of argument is the same. When we imagine that we have swallowed an emetic, and the imagination excites retching and vomiting, as if an emetic had been really taken, the conclusion is obvious, that the felt external impression on the stomach of such an emetic, or its felt nerve-actions (443), must have produced the same movement, namely, vomiting, as a sentient action of the external sensation at the irritated point, which the same external impression had excited there at the same time, as a direct nerve-action. This occurs also when purgation takes place, simply from dreaming that a purgative has been taken; when we shiver from the imagination of intense cold; when suffusion and blue marks take place, at the spot where we dream that we have received a blow, pinch, &c.

588. Although the direct nerve-actions of external impressions, or in other words the results of irritability (432), do not require the co-operation of the cerebral forces for their production, still, in cases where the impression is felt, they may occur also as sentient actions of the sensation. Consequently, it would be erroneous to conclude, that a result of irritability could not be at another time a sentient action of the sensation caused by the irritant, or that it may not depend on sensibility. This conclusion can only be made when the external impression which causes the movement is not felt nor cannot be.

589. We conclude therefore, that all nerve-actions of non-conceptional internal impressions can be altogether replaced by sentient actions, that is to say, induced by internal impressions caused by conceptions (581). With reference particularly to those excited directly by external impressions, it may be stated, that they are developed as sentient actions by the external sensation of the external impressions which excite them (584, 588).

SECTION III.—THE RECIPROCAL CONNECTION OF THE ANIMAL-SENTIENT [CEREBRAL] FORCES WITH THE VIS NERVOSA IN THE NATURAL STATE.

590. When an external impression is not felt, and a primary internal impression is not excited by conceptions, the movements

resulting from either are only nerve-actions, since they cannot be also at the same time sentient actions (97), and there are no other animal forces than the *vis nervosa* (356), inasmuch as in this case it does not signify, whether the unfelt external impression *can* be felt or not; or whether the primary internal impression not caused by conceptions *can* be caused by conceptions or not. It follows, that no combined action of the cerebral forces and *vis nervosa* effects these animal movements, even in sensational and thinking animals, and *à fortiori* in those which have no sensational faculty, and, consequently, no mind. Since the latter class, in common with all animals, without exception, are endowed at least with the *vis nervosa*, it alone must be sufficient for all the objects of their existence. According to this view, the acts of all anencephalous [hirnlosen] animals (to all which, as far as can be observed, they are excited by external impressions), are partly direct nerve-actions, partly dependent on the reflexion of the impressions in the ganglia and plexuses, and thereby are rendered similar to sentient actions and volitional acts (438-439); while, on the other hand, their vital movements and the indispensable functions of their mechanical machines, are maintained by non-conceptional impressions, as occurs in sensational animals (515, 519, 525, 532). These views apply also to the acts of sensational animals, in as far as the impressions which excite them are unfelt, or not induced by conceptions, for as they all possess the two kinds of *vis nervosa*, the acts must necessarily be nerve-actions, inasmuch as the mind cannot act (353, 356).

591. When an external impression is felt, the resulting animal movements are both nerve-actions of its *vis nervosa* and sentient actions of its external sensations. The first—because they equally result, even if the sensation be wanting (542—547): the last—because the sensation of an external impression excites material ideas at the cerebral origin of the sensitive nerves; the internal impression thus caused is transmitted downwards, and excites movements in those machines to which the nerve is distributed, and these are the direct sentient actions of the external sensation, and identical with the direct or indirect nerve-action of the external impression, which gave rise to the sensation (418, 419, 358). But since the transmission of the internal impression, caused by a material external sensation,

may be prevented by natural obstacles, and thus the movements may never take place (136—139), it follows that animals may, in the natural state, exhibit direct or indirect nerve-actions of external impressions, which never occur as sentient actions of their external sensation, and never can. Direct physiological illustrations are almost impossible, for the reasons stated, §§ 583 and 586, and the proofs can only be argumentative. The morbid condition affords an illustration in those cases in which a limb, still possessed of sensation, cannot be excited to those movements by external impressions, of which in a natural condition it is capable (127).

592. When an internal impression depends on sensational conceptions, as imaginations, foreseeings, feelings [Reizungen], desires, aversions, instincts, instinctive emotions, and various passions, the movements it excites are both sentient actions of the conceptions and nerve-actions of the external impression that causes the external sensation upon which they depend. They are nerve-actions, because they can be excited when there is no sensation; they are sentient actions, because all these sensational conceptions develop no other sentient actions than movements that are identical with those excited by the external sensation itself. The probable object of nature, in thus uniting the action of the cerebral forces and of the *vis nervosa*, in the movements of external sensations, and of sensational conceptions, desires, and aversions, has been already referred to (184, ii, 370, 371).

593. When an internal impression arises from the higher passions, from intellectual conceptions and motives, and from desires and aversions of the will and their satisfaction, the movements it excites, in so far as these intellectual conceptions, &c., are unmingled with sensational conceptions, are solely sentient actions, and there is no combined action of the cerebral forces and the *vis nervosa* in their production. They are not dependent on any external impression, and consequently cannot be nerve-actions induced by the *vis nervosa*, and the only other animal forces are the cerebral (353—356). Nature has granted this higher species of conceptions to the most perfect animals only, whose souls are not simply sensational [Sinnlich], but spiritual [Geister], (Baumgarten's 'Metaphysics,' § 590).

594. Those err who conclude, that because an animal per-

forms animal acts, it must necessarily therefore be endowed with cerebral forces, or with a soul, or with will; for it is undeniably possible, that the *vis nervosa* alone can cause the greater number of the animal acts (590). The majority of philosophers have been led by this error to consider all animals without exception as endowed with souls; but it is highly probable, that many have neither consciousness nor feeling.

595. It cannot be correctly inferred, that, because in a sensitive or thinking animal, movement is excited in virtue of irritability, or by the *vis nervosa* of external impressions generally, it cannot be a sentient action of the external sensation caused by the impression; or, *vice versâ*, that because it is a sentient action of the external sensation of an external impression, it cannot be a nerve-action of the impression only. The first is the error of some recent writers, who, since Haller recognised the agency of the *vis nervosa* of external impressions in exciting direct nerve-actions, and taught it under the term *irritability*, wished to maintain, that all animal movements not resulting from volition are dependent on irritability, and erroneously deny those dependent on sensation. The latter error is that of the Stahlians, when they maintain, that in external sensations the body is purely passive, and does not co-operate by means of its own proper forces.

596. It cannot be correctly inferred, that because in a sensitive or thinking animal the movements which accompany the sensational conceptions, incitements, desires, aversions, &c., are sentient actions, for this reason they cannot be nerve-actions; and *vice versâ*, that they cannot be sentient actions of these sensational conceptions (592). From this error, taken in connection with the second mentioned in the preceding paragraph, the old error has probably arisen, and which the author of the article "Sensibilitè," in the 'Dictionnaire Encyclopédique' has lately reproduced, namely, that there are two kinds of souls in reasoning animals, the one being the rational soul, by which sentient actions are developed according to psychological laws; and the other a sensational soul, by which the sentient actions of the external sensations and other sensational conceptions are developed according to the laws of the *vis nervosa*. We have shown, however, that to the action of the latter no soul is necessary.

597. Lastly, those also are in error, who conclude that because an animal performs movements, which are effected by the cerebral forces alone, without the co-operation of the *vis nervosa*, all its animal forces are actions of the cerebral forces (590, 593). This is the error of the Stahlians, who consider all animal movements to be sentient actions, nay, to be meditated acts of a will, of which the soul is necessarily unconscious. The old error, lately renewed by Whytt, is also connected with this erroneous supposition, namely, that the souls of animals are distributed throughout their bodies by means of the nerves, because animal movements, which are usually sentient actions, can be excited in decapitated animals, thus assuming that no other force than the mental can effect this.

PART III.

ANIMAL NATURE CONSIDERED AS A WHOLE.

INTRODUCTION.

598. The cerebral forces and the *vis nervosa* are essential constituents of the proper animal nature of animal organisms (6, 356), and in the more perfect animals are in close connection (591—593). The aggregate of those animal forces, which act naturally in connection in an animal body, constitute its *whole animal nature*, and this whole is now to be considered; its two essential constituents even in the most perfect, having been discussed in the two preceding parts.

599. The arrangement of this part is as follows:—first, the character of the whole animal nature of an animal will be sketched; secondly, the existence of distinct classes of animals will be proved; then the origin of animals according to their nature will be considered; next, animal life and its natural periods up to its full development; then the system of forces necessary to animal life, or how they act with and through each other for its maintenance and perfection; and, finally, old age and death will be treated of in succession.

CHAPTER I.

ON ANIMAL NATURE IN GENERAL.

600. An organism, which, in its entire and *natural condition*, is regulated by the animal moving forces of its own proper animal machines, is termed a *living animal organism*, an *animal endowed with life*, an *animal in the widest sense*. In determining the general characteristic distinction of plants and animals, by which we decide whether an organism belongs to the one or the other division, we have to determine whether it is moved in its natural condition, according to the known physical or mechanical laws of gravity, of the force of attraction, of elasticity, of the mechanism of its structure, &c.; or, according to peculiar laws:—whether a touch, or an external impression upon it, excites it to the movement that we should be led to expect from the known physical and mechanical laws of motion, or whether a movement is excited thereby, which compels us to recognise the phenomena of a peculiar force put into action by this external impression; and which regulates it according to other and widely different laws. It is not denied that this distinction is always somewhat indefinite, still it exists in nature, and we universally form a judgment thereon; but we only become more definite, when we have become acquainted with the laws of the animal moving forces. If some persons distinguish animals from plants by their voluntary movements, others by their instinctive actions, and others by their external sensations, it all comes to the same thing; inasmuch as we recognise a moving force in animals differing altogether in its nature from physical and mechanical forces, and acting according to altogether different laws. But these distinctions are wholly deduced from the phenomena of the cerebral forces, while the nerves themselves possess peculiar animal forces, which are not taken into consideration; so that they who adopt this as an universal distinction, are at a loss when they come to decide, whether a certain organism which cannot

possibly be endowed with cerebral forces, be a plant or an animal. Hence the confusion of ideas, caused by the researches on decapitated animals, moved solely by the *vis nervosa*,—by the phenomena of anencephalous infants born alive—and by animals so constituted by nature, as to live without head or brain, and which manifest no traces of mind; regarding all which no definite opinion can be stated. If, however, the above general distinction be adopted, no difficulty arises in such cases; for, although entirely without conceptions, all these organisms are regulated by external impressions, in a way wholly different from plants, and according to wholly different laws. Now, since we recognise the existence of the *vis nervosa* of external impressions in animal machines [the brain and nerves], and know that it is adapted to sentient animals, and excites in them the same movements, according to the same peculiar laws as external impressions excite in these organisms; and since we find machines in the latter, which are very similar to the animal machines [brain and nerves] of sentient animals, we can positively decide, that all these organisms are moved animally by nature, by means of animal machines, and that they also belong to the class of animal bodies.

601. Still, as has been said, the line of distinction is always indefinite, and the limits of the animal and vegetable kingdoms run so into each other, that they cannot be defined. The fault, however, is not in the want of grounds of distinction, but in the difficulty of discovering them in many cases. The movements excited in the sensitive plant by a touch, leads us to the conclusion that it is a zoophyte; so fixed is the principle in us, that an organism must be an animal which is moved by certain impressions—not according to physical and mechanical laws—but according to the laws of movement in animals. But these movements are neither sentient actions nor nerve-actions, for upon investigating the structure of the leaf, it is found that the closing of the leaves is simply a mechanical action, excited by a touch.

602. The question may arise, however, whether a body may not be animal in its nature, and yet not be *an* animal; as, for example, in the case of a decapitated animal. A man, deprived of his limbs, is not the less a man; and so if the *vis nervosa* continue in a mutilated creature, it is still an animal. Besides,

our definition is based on the condition, that the organism be entire, and in its natural state. A decapitated animal is a living animal body, and not a living animal.

603. A living animal is regulated in its natural state by the animal moving forces of its own animal machines. These are the analogues of our nerves and our brain, at least we know of no other; and their animal forces are the impressions of which they are susceptible, when touched, or when a movement is communicated to them (31, 32, 121). Further, every living animal is regulated, either by the *vis nervosa*, or by the cerebral forces, or by both (356). If by cerebral forces, then it is by means of external sensations and conceptional impressions (65, 121), and, consequently, also by the *vis nervosa* of the external and internal impressions (35, 32, 358, 360). That the *vis nervosa* alone regulates living animals is fully proved in the Second Part. Now, since the cerebral forces imply the action of a conceptive force, or mind, it follows that the animals endowed with the former have also the latter, or are sentient animals; while those which are regulated solely by the *vis nervosa* are *insentient*, or simply *living animals*.

604. Every insentient animal must possess nerves, or their analogues, to which the *vis nervosa* is adapted by nature. But since their external impressions are not felt, and their internal impressions never produced by conceptions, and as they require no animal sentient forces, it follows, that in so far as the brain is the seat of the latter, and of mind, or the conceptive force, it may be entirely wanting, and yet they may perform all the acts necessary to their existence.

605. Every sentient animal must not only be endowed with mind, or the conceptive force, but also with the *vis nervosa* and nerves, and with the cerebral forces and a brain: if the soul be spiritual, that is to say, if the animal be endowed with understanding and will (574), it is termed a *reasoning animal*, but if the soul be simply sensational, then the animal is a *sensational* or *unreasoning animal* (a brute).

606. Insentient animals are moved solely by means of the nerves; and if, also, in sentient animals, the cerebral forces do not act, still the greater number of their vital movements, natural functions, and sentient actions, can be produced by the *vis nervosa*; and when in such the brain does co-operate, it is by

means of its *vis nervosa* (373, 374), and not by the animal-sentient forces. But, on the other hand, when the latter act on the body, they are excited into action by the conceptive force (Baumgarten's 'Metaphysics', § 554).

607. The *vis nervosa* is distributed to every portion of a nerve (31). The seat of the animal-sentient forces is in the brain, or the nerves dependent on it (25). The seat of the animal-moving forces in insentient animals is in their nervous system, and this is the case with sentient animals, in so far as they also possess the nature of the insentient. But the seat of the animal-moving forces of sentient animals, peculiarly as such, is in the brain, the seat of mind (10).

608. All the animal movements of an insentient animal are dependent on the *vis nervosa*, and all the animal acts take place according to its laws of action. This is the case also with sentient animals, in so far as their movements are dependent on the *vis nervosa;* but in so far as they are sentient actions of those conceptions which the conceptive force forms and develops in the mind, according to psychological laws, independently of the *vis nervosa*, they flow from the cerebral forces, which the conceptive force regulates (6). But if the movements be both sentient actions and nerve-actions, they follow the laws of both kinds of forces acting in co-operation (Part II, Chap. IV, Sect. III. Compare also § 579).

609. Insentient animals are moved animally by the *vis nervosa* of external or internal impressions, according to their nature (31, 32, 121). The external impressions act upon them, either by means of direct nerve-actions (418), or indirect; when they are reflected in the ganglia, or points of division of the nerves, along which they pass upwards upon other nerves, and thereby put the organs to which the latter are distributed into motion (419, 421). Nature herself causes in insentient animals such external impressions as are necessary to the maintenance in them of those animal acts on which their preservation and the objects of their existence depend; and to this end their animal acts are as adaptively excited, arranged, and connected with each other, as in sentient animals by means of their natural instincts (435—439), although neither the sentient nor insentient act from consciousness (266). The natural primary internal impressions, in insentient animals, excite those move-

ments which either cannot be caused by external stimuli, or else require the co-operation of others that they may go on uninterruptedly; their continuance being necessary to the maintenance of life in the animal. Consequently, they are to be particularly observed in the vital movements and in the viscera, the functions of which are the most necessary to the preservation of the animal (515, 525, 532). The stimuli to the movements thus induced, being deeply hid in the interior of the medulla of the nerves, and traceable to no external cause, we infer erroneously that the movements themselves are the result, either of obscure sensations, or of other and volitional conceptions.

610. The movements necessary to existence, preservation, and other objects of nature, in insentient animals, are effected wholly in them by means of the *vis nervosa*, and in some degree in the same way as in sentient animals; so that they are capable of movements, which experience and observation prove may be effected without the co-operation of the cerebral forces; that is to say, they are capable of muscular action, and the apparently voluntary movements, the movements of the heart, and the circulation of the fluids; the arterial pulse; the flow of humors to an irritated part; the movements of the diaphragm; the animal mechanism of respiration; digestion and peristaltic action; glandular secretion and excretion; and the animal functions of the lungs,—of the liver in the secretion and excretion of the bile,—of the kidneys and urinary bladder in the secretion and excretion of urine,—and of the sexual organs in the propagation of the species (445—481, 507—540).

611. Insentient animals can also excite, by the *vis nervosa* alone, according to its animal laws, all those animal movements which are excited in sentient animals by means of the animal-sentient forces of the sensational faculty [Sinnlichkeit]; developing them in the same order, connecting them with each other in the same way, and just as consecutively as when the movements constitute sentient actions of sensational conceptions; that is to say, the *vis nervosa* excites the same movements in insentient animals, as constitute the sentient actions of external sensations (433, 439); of imaginations and of foreseeings; of sensational desires, aversions, and instincts; namely, of the alimentative instinct, of the instincts for volitional move-

ments, for repose and playfulness, for combat, for self-defence, for propagation of the species and care of offspring; and of the instinctive emotions, as rapacity, revenge, lasciviousness, and all the passions closely allied to them (542—573). On the other hand, the sentient actions of sentient animals, which arise as free-will movements, from desires, aversions, and passions, developed in the mind according to psychological laws (564—573), or from pleasing or displeasing conceptions of the understanding, or from desires or aversions of the will (564, 576), cannot be developed in insentient animals by means of the *vis nervosa*, unless there be a sensational element in the conceptions themselves (578).

612. Since sentient animals are endowed with the *vis nervosa*, in common with the insentient, and which sometimes acts in them alone, sometimes in connection and in harmony with the cerebral forces, they are capable, under certain conditions, of all those movements of which insentient animals are capable.

613. Sentient animals are moved according to their nature, not only by the *vis nervosa*, but by the forces of material ideas in the brain. These material ideas are those either of external sensations, and other sensational conceptions and desires, or of intellectual conceptions: the former are regulated according to the laws of the *vis nervosa*, the latter according to the psychological laws of the conceptive force. By means of these cerebral forces of conceptions, the movements in sentient animals in the natural condition are developed, arranged, and changed, in accordance with the conceptions in their mind: this, however, is so done, that in purely sensational animals, and in the reasoning animals also, in so far as their sensational conceptive force acts, the conceptions are caused and connected in the mind by means of the *vis nervosa* of external impressions. On the other hand, they arise and are linked together in rational animals, when the conceptive force acts solely according to psychological law (60, i, 579, i, ii).

614. Purely sensational animals are capable of all the vital actions just enumerated in § 600 (compare 161—179, 207, &c), in virtue of the cerebral force of the sensational material ideas, which external impressions excite and connect in the brain, and which develop the vital actions as sentient actions.

615. Purely sensational animals perform as sentient actions,

by means of various external sensational conceptions, and enumerated in § 611, those animal movements which, although they can be, and often are, in unreasoning animals, mere nerve-actions, can, nevertheless, be developed, arranged, and modified by the cerebral forces solely (581—592).

616. Reasoning animals, in addition to the preceding, are capable of performing as sentient actions all movements which the higher emotions, intellectual pleasure or suffering, and the desires, aversions, and satisfyings of the will develop through the free-will movements; and this by means of the cerebral force of the material ideas connected with the understanding and the will. And since these animal monements are neither sensational actions, nor nerve-actions (336, 593), they are the peculiar privilege of reasoning animals, and distinguish them from all others.

617. The animal nature (1) of an insentient animal is the aggregate of its two kinds of *vis nervosa*: that of a sentient animal is the aggregate of its two kinds of *vis nervosa* and its cerebral forces; and implies also the animal nature of the insentient. The animal nature of a purely sensational animal, is the aggregate of its two kinds of *vis nervosa*, and of the cerebral forces of its sensational conceptions, desires, &c. The animal nature of a reasoning animal is the aggregate of the cerebral force of sensational and intellectual conceptions and desires, &c., and presupposes the nature of the sensational animal, which includes that of the insentient animal.

618. The animal natures of all other animals are conjoined in a reasoning animal, as well as the two essential principles [principien] of all animal movements, namely, the *vis nervosa* and the cerebral forces. The physician need not seek to explain the mode in which the *vis nervosa* excites sensational conceptions and desires, and in which these, together with those of the intellect, excite animal movements, for it is inexplicable: consequently he need not investigate psychological explanations of the union of body and soul; or the hypothesis of physicians as to the nature of the vital spirits, of the medulla of the brain and nerves, and of material ideas; his business is with general facts, from whence he must deduce his principles of theory and practice. The whole physiology of animal uature must be based upon the following general principles:

i. The nerves receive external impressions in a manner peculiar to themselves; that is, according to their peculiar laws, which accord with neither the physical nor mechanical laws of any other bodies, than animal bodies; these impressions are transmitted along the nerves to the brain, and laterally by means of branches or ganglia to other nerves, and thereby become animal-motor forces of the mechanical machines with which the nerves are incorporated, as well as animal-sentient forces by means of the brain, for the development of external sensations and sensational conceptions, desires, aversions, instincts, &c., which are developed and connected with each other in the mind, according to the animal laws of the *vis nervosa* of the external impressions.

ii. The conceptions of the mind communicate internal impressions to the brain, which it receives in a peculiar manner, according to the laws of its own peculiar animal-sentient forces, and transmits along the nerves, whose cerebral origins these conceptions excite, to the mechanical machines in which the nerves are distributed, or along their branches, or by means of their ganglia along other nerves going to mechanical machines, and thereby the impressions become motor animal-sentient forces of these machines, and are developed and connected with each other in them, according to the psychological laws of the conceptive force; but which are themselves nevertheless necessarily regulated in the sensational conceptions, by the animal laws of the *vis nervosa* of external impressions.

iii. The *vis nervosa* of external impressions can produce all the sentient actions which sensational conceptions excite, even if the conceptions themselves do not ensue.

iv. The animal-sentient forces can reproduce the nerve-actions of impressions, when the impressions themselves do not actually take place.

v. Lastly, the movements excited by unfelt external impressions are purely nerve-actions: those excited by the higher passions, intellectual conceptions, desires, aversions, and satisfyings of the will, are purely sentient actions, and all others are excited by the combined operation of the animal-sentient forces and the *vis nervosa*.

CHAPTER II.

THE PRINCIPAL GENERA OF EXISTING ANIMALS.

619. MAN is an example of a reasoning being, and all the principal forms of existing animals are combined in him, namely, the insentient, the sensational, and the reasoning; he is also capable of all the animal functions proper to these.

620. The nature of a reasoning being implies the presence of the natures of merely sensational and insentient animals, but the last two do not necessarily require the former. There is a great number of sentient but purely sensational beings, endowed with neither understanding nor will; and even a reasoning being may, by poisons or disease, or in the early periods of life, exist only as a purely sensational animal, without any use of the reason or the will, and usually capable only of those functions, of which purely sensational and insentient animals are capable (612—615).

621. A sentient animal may be entirely deprived of its animal sentient forces (for by separating the head from the body, the brain and soul are removed), and yet may live for some time as an insentient animal, and continue all those functions of which as an insentient animal it is capable. But do *true insentient animals exist?* We will state the arguments for the affirmative and negative, leaving the reader to decide.

622. It is unquestionable that every animal does not require to have a soul: the definition that an animal is a whole compounded of soul and body is a *petitio principii*, for no one has ever proved that a soul is requisite, and we therefore base one false proposition upon another. Many eminent men have doubted, whether unreasoning animals possess a soul; although like others they have been educated in the dogma, that body and soul constitute an animal.

623. It is incontrovertible, that the nature of an insentient animal can only be requisite to the existence and continuance of an animal absolutely; firstly, because all the processes

required for the life and preservation of an animal organism, can be effected by the *vis nervosa* only; nay, even the greater number of the actions of sensational conceptions, desires, instincts, &c., may be induced by it, simply as nerve-actions; secondly, because experiments on decapitated animals prove it.

624. As to a large class of animals, it has never been proved that they are endowed with animal-sentient forces, and it is highly improbable that they are:

i. Because we can detect no traces of mind or a conceptive force with which their animal forces can co-operate (6). If those movements of sensation and volition, which occur in decapitated animals, as results of the *vis nervosa* solely, are all that can be adduced as proofs of the existence of an external sensation, then an oyster, a sea-worm, a snail, a polype, do not manifest, during their whole existence, a single movement which renders the existence of conceptive force in them at all probable.

ii. Because many animals, unlike those undoubtedly sentient, have not a head distinct from the body (15, ii). We may conclude from analogy, with some probability, that since all animals to which we can undoubtedly attribute the possession of a conceptive force and consciousness, have heads distinct from the body, it follows that the former must be governed by forces altogether different from the latter; and since these are regulated by animal-sentient forces, the others must be governed by the *vis nervosa*, for there is no other force (356). The relations of mental endowments to the cerebral development is specially noticed by Haller. ('Physiology,' vol. iv, p. 634.)

iii. Because, although all animals possess the analogues of nerves, the most numerous genera have nothing analogous to a brain, even when they have a head distinct from the body; or, indeed, a part which in movements all others are accustomed to follow. This principle is of very great importance. In those animals undoubtedly endowed with sensation, there is a distinct, complete brain, the seat of mind (10): all observations establish this doctrine—none are opposed to it—none render it even doubtful. Yet this undoubted dwelling-place of the soul is not a necessary portion of many animals; nor necessary to the performance of numerous acts, performed in virtue of the *vis nervosa*, by animals after decapitation, in the same order, with the same connection, and from the same external impressions, as before decapitation. A single series of experiments, having such results, would be sufficient to refute the proposition, that to every animal life a body, soul, and brain are necessary. Yet nature presents millions of such examples: the whole creation, nay, every drop of water is full of them; numerous genera of animals exhibit no trace of a brain, or its analogues; all their acts, as in sentient animals, can be simply nerve-actions; their bodies are so constructed, that these acts can take place without any co-operation of a conceptive force. Their souls must be extended, and be everywhere present in their bodies, since polypes may be cut into pieces, and each piece becomes a new animal. Contrary to all analogy, there must be consciousness in various parts of their organism, or they must consist of many souls. How opposed is all this to sound theory and to common sense!

iv. Because, although some trace of a brain, or its analogue, be found in animals, as in worms, snails, crabs, spiders, mites, caterpillars, lice, ants, fleas, bees, and other insects and worms, no indications of animal-sentient force can be detected in them. In none of the animals undoubtedly sentient is the brain ever the organ of the animal-sentient forces only; but it is endowed also with the *vis nervosa* necessary to all animal life, even of an insentient animal, since to it belongs the function of separating the vital spirits from the blood, and distributing them to all parts of the nervous system, for without these the mere *vis nervosa* cannot act in any animal (21, 22). It is true, that this is only the function of the cortical substance of the brain (159, 374); but who has proved that in the animals in question, the brain consists of any other than this cortical substance? Moreover it is probable, that the medullary substance of the brain, even in sentient animals, possesses the *vis nervosa,* in virtue of which, like the ganglia and spinal cord, it reflects external impressions, receives non-conceptional internal impressions, and by means of both moves the mechanical machines (373). It is extremely probable, that the structure considered to be brain in these animals is either only cortical substance, or only a general ganglion,—an addition to the spinal cord, in which the vital spirits are separated from the blood, and thence transmitted through all the nerves; in which also, as in the spinal and other ganglia,[1] unfelt external impressions are reflected, in accordance with the objects of nature, upon those nerves through which the nerve-actions appropriate to the impressions are induced, and in which certain non-conceptional internal impressions (internal stimuli of the nervous fluid) induce or maintain, by means of the mechanism of the animal, various animal movements necessary to its existence, well-being, &c.; but which cannot be induced, at least solely, by external impressions. Such a brain could be no more the seat of mind, than the spinal cord or the ganglia. Haller, quoting the observations of Swammerdam and Lyonnet, as to the great simplicity of structure of the small ganglion in lobsters and caterpillars, termed a brain, and its great similarity to the other ganglia, adds, that even in fishes and cold-blooded animals, the brain appears to be only an appendage to the spinal cord. ('Physiology,' vol. iv, p. 6.)

v. Because, all the proofs which are adduced to show that certain nerve-actions in sentient animals are not sentient actions (129, 130), are equally valid here. All the conditions necessary to sentient actions are wanting in animals without a brain, or with a brain of the kind just referred to, and in which no material ideas are produced. There is medullary substance in all the nerves; the spinal cord is for the most part made up of it, and yet in neither are the material ideas of conceptions ever formed.

625. All these grounds taken together, render it extremely probable, that such animals are constituted insentient by nature, and endowed with *vis nervosa* only, so as to be fitted for all the objects of their existence. We will deduce no arguments in favour of this doctrine, from the nature of the soul, so totally unknown to us, nor will we answer any objections brought against it from the same source, for what can be adduced where we are so completely in the dark? There is the same difficulty in explaining how a pure soul develops animal movements, whether the body through which it operates be a skilfully constructed mechanism, or mere matter. Nature has prescribed this law to them, on grounds entirely unknown to us, and it remains with her, whether all or only a few animals be endowed

[1] Compare note to § 35.—Ed.

with mind. We can only infer the true condition of animals, in this respect, from their organisms and their acts. We have conclusively shown, that animals unendowed with mind perform, by the *vis nervosa* only, in the highest degree of completeness, those acts (with certain exceptions) which are performed by sentient animals. Consequently, nature was not obliged to render all animals sentient, if she were willing to be satisfied with those which could sufficiently perform the natural functions of alimentation, defence, and propagation of the species, although not capable of the more perfect acts of sentient animals. If, then, there are animals defective in the higher order of passions, in reason, and will; animals, which do not possess the organ of the conceptive force peculiar to sentient beings; whose whole life is so uniform, simple, and unvaried, that they do not possess even the *vis nervosa*, so perfectly as sentient animals possess it after decapitation; animals, which can continue in life, almost as perfectly, when that is removed which is considered the machine (if the phrase may be allowed) of the conceptive force, namely, the entire head wherein their mind must dwell (621—624) as before; we are necessarily led to the conclusion, that it has pleased nature not to place a considerable portion of the animal creation in closer connection with a thinking essence, or to endow it uselessly with mind. Still it would be well to notice the opposing arguments, few of which, however, are of much weight.

i. The objection that the definition of an animal includes the idea of the existence of mind, has been answered already (622).

ii. But it is advanced, "that all animals feel when they receive external impressions, and since external sensations are conceptions, they must therefore have mind." To this we reply, that we have no knowledge that they feel external impressions, but only that the latter induce animal movements. It is allowed, that all direct and incidental sentient actions of external sensations may be excited in animals endowed with mind, by the *vis nervosa* of their external impressions, both during life and after decapitation (542—544); and, in fact, it is more difficult to prove, that these movements are sentient actions of the external sensations of the impressions, than that they are nerve-actions of the impressions solely (582—588).

iii. It is also objected, that "many insects, worms, &c., which must be considered unendowed with mind, have nevertheless organs of sense, particularly organs of vision; and, since these nerves are purely nerves of sensation, these animals must possess a conceptive force." But are the organs of the senses in these animals analogous to ours? Are they—like ours—without ganglia? Or is it not, that their brain can reflect external impressions in the same way as the ganglia? (624, iv). We see in the senses of taste and touch external senses, the nerves of which are also motor nerves, and accomplish, by their *vis nervosa* alone, all those movements which they can excite as sentient actions (Haller's 'Physiology,' vol. iv, pp. 615, sqq.). Now, since the organs of the senses in insects and worms are very different from those of animals endowed with mind (15, ii), it is possible that their nerves are altogether motor, like the nerves of touch in sentient animals, and thus they may regulate an animal without there being any sensation. It cannot be maintained, that the organs of the senses are constituted for the sole purpose of exciting certain special kinds of external sensations—as the eye for seeing, the ear for hearing, &c. Their proper function is to render the nerves capable of receiving certain external impressions, which could not be received without the aid of such machinery (55, 42). If these impressions are felt, the nerves certainly develop a particular kind of external sensation; but if they act as motor nerves, they excite a particular class of movements only, for they are the same that the sensation caused by the impression would excite (358), and this is their function in animals not endowed with mind. In cases of this kind, the animal would not see with its eyes, nor hear with its ears, nor smell with its nose, but only have the same animal movements excited by the special external impressions, as would result if they were actually felt (542—544). The external impression of light in the eye, which sentient animals perceive, and through which they are excited to a thousand volitional movements, can imitate the actions of the instinct to volitional movements in insentient animals, and excite them directly as nerve-actions (555). Impressions on the ear can excite as nerve-actions the actions of the instincts of self-defence, sexual congress, &c. (559, 560, 566). So also the actions of the instinct for food may be excited in insentient animals as nerve-actions, by external impressions on the nerves of taste and smell (552, 553).

iv. But it is further objected :—all these animals appear to be moved and excited by external sensations, and to act volitionally, rationally, and designedly. Ants like sugar, bees like the juice of certain plants, and each species of insects and worms has its peculiar food, which they seek, avoiding others. They are guided by certain sounds, as when they are allured by sexual intercourse (in the case of crickets), or when bees would swarm; they fly away when they see any thing unexpectedly; they smell the odour of their food, and go towards it. In these actions, an effort to satisfy an instinct is shown, which is directed volitionally, and an animal that so acts must be sentient. The argument has much plausibility; it has, however, been demonstrated already, that external impressions will excite volitional acts simply as nerve-actions, whether the animal feels them or not, and independently of any reference to the gratification of any desire or instinct (263—269, 552, 561). The phenomena manifested by newly-born and decapitated animals, some of which have been already stated (555, &c.), amply prove that such apparently volitional acts may take place, under circumstances which altogether exclude the idea of mind. What in them appears to be volitional, only *appears* so, because we draw conclusions as to other animals from the nature and working of our own minds (436—439). What appears to be designed, arises from the preordination of nature, and in no case enters into the minds of even sentient animals (266, 609).

v. But it is further objected,—that these animals act designedly and volitionally, without the incitement of external impressions, and consequently they must be under the influence of conceptions. The answer is, that the movements alluded to result from primary internal impressions not caused by conceptions (609), and it would be indeed difficult to show, that these animals had such, independently of external impressions. (Compare § 553.)

vi. It is further objected, that many of these animals, as bees, ants, &c., act socially and in combination, for the purpose of attaining certain objects. They assist each other in their labours, get out of each other's way, take each other's burdens, appear to apprize each other of danger, combat their common enemies, &c. This is really the most weighty argument that can be advanced in support of the doctrine, that these animals are endowed with mind. Granted that bees, ants, and other social animals, are endowed with mind, and have external sensations, and other conceptions, and true instincts, all their social acts would be sentient actions of their sensational instincts, and these are almost the direct results of external sensations (276, i, 579, i). These social acts are, therefore, either direct or incidental actions of the sensations of their external impressions. Now, it is indubitable, that all such may be also nerve-actions of the impressions only, and consequently, these social acts may be excited solely by the *vis nervosa*, even if the animals be endowed with mind. That this actually is so in other animals is fully established by observation (555—557); how then can we infer the existence of mind from these social acts? If the acts of an animal are required to follow each other, or other acts, in a certain order, the impressions which excite them must be received in the same order, and the former will result, whether the latter be felt or not. Which method nature has adopted in social animals must be determined by the question, whether they are endowed with mind or not; but it would be a perversion of the argument to say, that because the acts may occur in two ways, they therefore are dependent on mind. The probability is, that these animals are not endowed with mind, because they have no brain, or at least not a brain, constituted like those of animals undoubtedly endowed with mind. If it be replied, that bees and ants no longer perform social acts when deprived of their heads, it must not be forgotten that the eyes of the insects are removed at the same time, and that it is by means of the eyes that all these external impressions are received which excite social acts. They yet can and do perform former movements, although headless, but not in a definite order, and in relation to and in connection with the labours of others, because the impressions which excite them are merely accidental, whilst previously the impressions were made through the organs of vision, in a given order predetermined by nature. The wonderful concord in the acts of these social animals, is much more probably a result of that wisdom which is manifested in the sensational instincts of the whole animal kingdom, and in virtue of which animals, even the sensational and thinking, perform acts according to a design and preordination of nature (561, 263—270). When the acts of republican insects are considered from this point of view, it is readily seen how the operation of the mysterious and God-like element of the instincts (263), may lead us to erroneous conclusions in attributing them to mind and external sensations.

626. An argument for the existence of animals endowed with mind may be drawn from analogy. In the scale of creation, nature ascends by successive degrees of perfection. From physical bodies she constructs natural mechanical machines, as elastic matter, capillaries. To these, by means of the intimate connection and combined action of many mechanical machines for a common object, or in other words, by means of organisation, she communicates organic forces, and thus from them she forms organised bodies, such as plants and growths. Organised bodies are undoubtedly capable of three successive degrees of perfection. If by means of animal machines, they be endowed with the *vis nervosa*, they attain the grade of insentient animal (609—611). If to this a brain be superadded, and the *vis nervosa* determine and act in accord with a conceptive force, it becomes then a purely sensational animal (605, 620); and when in this class the conceptive force attains to that perfection, that it regulates itself and its body independently of the *vis nervosa*, then it is a rational animal, such as is man (619). If there were no insentient animals, the scale of nature would be defective in that one point. Now this is very improbable, and, consequently, it is in accordance with a perfect creative scale, to consider microscopic creatures, conchifera, and insects, as insentient animals.

627. There are degrees of perfection in every genus of animal. A mathematician and a hottentot, equally belong to the class of rational beings. Both comprehend the multiplication table, both can think of God, and distinguish between right and wrong; both in short are capable of ideas and acts, to which the most intelligent monkey can never attain. But what a difference between the two, and how much the one is more nearly allied to the brute than the other! A bee, an ant, a cheese-mite, are in the same class of insentient animals as a snail, an oyster, or a microscopic animal, but how intelligently and perfectly the *vis nervosa* acts in the former, how imperfectly and awkwardly in the latter! *Those* are nearly allied to the sensational animals, whose actions they imitate so

closely, *these* are little above the sensitive plant. Yet the line of demarcation is never passed. The monkey never acts from general principles, or ever meditates on an abstract truth. All its actions are such as a man might perform independently of his reason and will, in virtue of the high perfection of his sensational perceptions and sensational will. However cleverly the ant or bee acts, it so acts independently of perception or sensation; and its actions are those which a sensational animal could perform after decapitation, and, therefore, independently of mind, and in virtue of the high perfection of its *vis nervosa*. However animal-like the movements of the sensitive plant may be, they do not take place according to the laws of impressions on the nerves of sentient animals.

Note.—The question as to the existence of insentient animals, must not be considered as quite decided, and it has no very important bearing on the other doctrines of proper animal physiology. Animals placed in this class must be considered to be those which either have no brain at all, or else a brain of very simple construction, widely different from the brain of undoubtedly sentient animals, and which is capable only of those movements that sentient animals can execute after decapitation, and independently of their animal-sentient forces.

CHAPTER III.

ON THE ORIGIN OF ANIMAL NATURE.

628. The *commencement* of animal nature is termed its *generation* or *procreation*. (Baumgarten's 'Metaphysics,' § 311.) Consequently, an animal in the widest sense of the term is produced so soon as an organised body is capable of being moved by means of the animal-motor forces of its proper animal machines. No animal can thence arise, not even the insentient, unless provided at least with nerves and vital spirits, or their analogues, of which the *vis nervosa* of impressions is a peculiar property (15, 604). No insentient animal can become sensational, unless furnished with brain and its vital spirits, or an analogue, and of which the animal-sentient forces (10), are a peculiar property. A sensational animal can only become a rational animal when it attains to the power of regulating its body by intellectual conceptions and volitions (76, 574, 96).

629. Every animal springs from one like itself. The minutest, with few, if any, organs and functions, and a very brief life, are generated after a very simple mode. They are produced without any difference of sex by fissiparous generation. In others, the mode is oviparous, and of these a large class is hermaphrodite, the same individual containing both male and female organs. In a larger class, the two sexes are distinct. The females of cold-blooded animals deposit their ova, and then they are fructified by the male; in warm-blooded animals, the ova are fructified in the uterus, and may be incubated either within or without that viscus; in some genera and species of animals either method is followed, and they are both oviparous and viviparous.

630. The generation of an animal always takes place by one similar to it, and by which the essential constituents of its animal nature are communicated to it. The origin of an animal machine and its vital spirits, whether it be nerve or brain, is one of the hidden secrets of nature, of which we are totally ignorant.

631. The organs of generation are very different in different animals. In the higher classes in which there are two sexes the instinct of propagation of species is requisite, its satisfaction (or copulation) having no other natural object than the fertilization of the ovum. The objects aimed at in the various modes of generation are concealed from us, but in animals endowed with mind, the intent of the difference of the two sexes seems to be this, that the sexes may be led to associate in protecting their offspring, and providing for their various wants.

632. So far as our observations on the development of the ovum extend, we find that the new animal is a portion separated from the parent, duly furnished with both animal and mechanical machines necessary to its existence and development. With regard to those animals which produce their young like themselves, we find that their offspring is furnished with all the essential animal structures, so soon as separated from the parent.

633. The whole process of generation is a masterpiece of nature, and animal bodies are constructed most skilfully to this end, so that even the most intelligent animals do not possess the least knowledge of the varied arrangements and plans of nature in carrying it on (289, 290). This is not the place, however, for details.

634. The period of development comprised between the time of conception and of birth, is a period of imperfection, and, consequently, no animal can be expected to have the full use of its natural animal forces; it is for this reason that insentient animals and even sections of polypes are inactive during this period, until full development be attained. In the more perfect animals it is different after the appearance of the *punctum saliens*, for this movement is a direct nerve-action of the external impression of the blood on the heart (459), and, consequently, sentient animals have at least the use of the *vis nervosa* to some extent, and, therefore, possess the nature of living organisms. The intestines of the chick in ovo are not irritable during the first fourteen days, but subsequently they become more and more irritable every day. (Haller's 'Opera Minora,' p. 401, tom. ii, pp. 364, 398.) As development advances, (in man about the fourth month,) the fœtus is excited

by external impressions to movements, which are usually sensational voluntary [Willkührlich],[1] but are probably only nerve-actions, since, besides that there is no proof of senations being felt by the fœtus *in utero*, the brain seems to be unfit for the operation of the animal-sentient forces, inasmuch as its natural movement is dependent on respiration (24). So that the fœtus is analogous to an insentient animal in its nature, and becomes sensational at the moment of birth.

635. Since an animal is procreated by one like itself, so the structure of the two are in accordance; a resemblance in incidental peculiarities of structure may accompany a similarity in outward form, and as the embryo, whether in *utero* or in the shell, receives all its fluid elements from the female parent, peculiarities in the condition of the fluids, as well as of the solids, may be thus communicated from parent to offspring; hence the hereditary predispositions to various states and conditions of health and disease.

636. Original defects in the structure of the germ, an unnatural condition of the fluids which nourish it, violent movements of the latter in the germinal tissues, injuries to its structure by external force, the unnatural connection in growth of two or more germs, and many other incidental causes, give rise to various monstrosities (Haller, 'Oper. cit.,' tom. iii). In some of these ways, violent emotions or sensations of the mother may influence the fœtus, and to this extent the former can act upon the latter; but the doctrine of a harmony between the sentient actions of the mother and fœtus is fabulous.

637. Merely organised natural bodies can never be developed into living or sentient beings, as Needham erroneously taught. The existence of an animal pre-supposes that it originated from an animal germ, and that this was secreted by an animal similar to itself. (Compare Spallanzani and Haller.)

[1] See note to § 283.—ED.

CHAPTER IV.

ON ANIMAL LIFE.

638. The continuance of animal nature is *animal life.* (The *life of an animal,* as such, Baumgarten's 'Metaph.,' § 311.) So long as an animal force operates in the animal, and there is the smallest animal action left, so long the animal *lives* (5, 6).

639. The continuance of the animal nature of an insentient animal may be termed *simply animal* life, just as the *vis nervosa* is termed a *simply animal* force. This mere animal nature implies the existence of the organic nature, and the existence of the latter implies the existence of the mechanical and physical natures: consequently, the entire nature of an insentient animal (598) is made up of these; but since the last mentioned may continue independently of animal life, it may cease, or in other words, the animal may die, and yet the organic, mechanical, and physical nature remain. Consequently, the continuance of the *vis nervosa* is solely necessary to animal life, and so long as there are the minutest traces of the *vis nervosa,* life remains.

640. The continuance of the animal nature of a sentient animal, and especially of a purely sensational animal, may be termed *sensational life.* Such an animal nature implies the existence of the animal nature of insentient beings, and consequently it is a whole, compounded of the two animal natures. But a sentient, and particularly a sensational animal, may lose its sensational life, and still be a living creature (603); or in other words, it may *die sensationally,* and still live. Consequently, so long as it retains in the slightest degree that animal sentient force which characterises it, so long it remains sentient, and exists sensationally. Again, sensational life only continues so long as the soul is in such connection with the body, that it performs any one of its movements as a sentient action: when this connection is broken, mere animal life may still continue (621).

641. The continuance of the animal nature of a reasoning being may be termed its *spiritual life* [geistiges Leben]: this

animal nature implies the existence of the sensational animal nature, and is consequently compounded of these two—the intellectual and sensational. But inasmuch as sensational life can continue independently of the intellectual (620), it follows that a reasoning animal may lose its intellectual life, and yet continue to be a sensational animal :—it may *die mentally*, and live sensationally, or merely animally. So long as the higher animal-sentient forces continue in action in the slightest degree, mental life continues. As this life depends on the intimate union of the soul and body, when this union is broken, that is to say, when reason and will are abolished, mental life ceases, but sensational life may still go on (620).

642. All these differences in the lire of animals exist in nature (638—641); but their nomenclature does not accord with the terms in ordinary use, so that their specific designation enables us to analyse our ideas more correctly. Ordinarily, sensational life and intellectual life (made up of the sensational and natural) are both designated by the term *proper animal life*, or the *life of an animal* (Baumgarten's 'Metaphysics,' §§ 575, 576), which can only be understood to mean, the actual continuance of the union of soul and body. This idea is too narrow, and is founded on the erroneous notion, that every animal is endowed with a soul, and consequently excludes the idea of mere animal life (639); but since insentient animals may exist, the definition must include these, and thus various errors will be avoided : as for example, that decapitated animals still possess souls, or that the soul is extended throughout the body, or that a sentient animal must have several souls, or that all animal movements are sentient actions, &c.

643. If, therefore, the usual phraseology be adopted, sentient animals alone (640—642) possess *proper animal life*, and there remains a special class of animals, intermediate creatures possessed of *mere animal life* solely (639). We would designate the aggregate in sentient animals of the two kinds, namely, of the proper animal life and the mere animal life—*complete* [ganze] *animal life*, or the continuance of their *complete animal nature* (598). We should not, consequently, infer that an animal had lost its complete animal life, because its proper animal life —the connection of body and soul—had ceased; nor that no sentient actions could take place in it; otherwise we should

fall into the error of those who thus argue (Baumgarten's 'Metaphysics,' § 576), and say—contrary to the ordinary meaning of terms—that a tortoise, which crept about for six months, deprived of its head; or that a headless butterfly, which had sexual intercourse, and deposited its ova; or that a snail, similarly mutilated, which sought about for food, and had its head regenerated; or that a lizard that ran about in the grass for several days after decapitation, &c., was a dead animal, or a corpse.

644. The life of every animal is divided into four periods. The first is the *period of development*, and extends from the moment at which the germ is separated from the parent, to the time when it is so far developed as to be capable of an independent existence. In the majority of animals this occurs at birth.

645. The second period is the *period of growth*, and extends from the moment of birth to the time when the animal is fully developed, and fit for the performance of the entire range of its functions, and of those duties which nature has assigned it. During this period the animal is unfit for many functions which it performs afterwards, when fully developed.

646. Neither nutrition nor growth are purely animal functions, nor do they involve animal machines only, but are effected by the common action of the forces of all parts of the entire nature of an animal,—the physical, mechanical, organic, and animal—and in sentient animals—the animal-sentient forces—all acting in wonderful union to that end.

Note.—The laws of nutrition and growth are laid down in physiological works, and we refer to them here only in so far as they bear on proper animal nature, and influence the proper animal machines, and the proper animal forces.

647. Neither the nerves, nor, in sentient animals, the brain, are fully developed at first, or are fully capable of the *vis nervosa*, or of all the animal-sentient forces. Innumerable facts show, not only that the nerves continue to grow after birth, but are developed in new growths. This is most clearly seen in insentient animals, as in insects; in the metamorphoses they undergo during the various stages of their development; and in animals in which entire limbs, or entire segments of the body, have been reproduced after mutilation.

648. In fact, we see that all animals perform more numerous and perfect acts as they approach the period of perfect development. Many animals, especially the insentient, act from the beginning with great skill and adaptiveness, but they cannot perform those movements which belong to a more perfect stage. A caterpillar acts principally from the instinct for nutrition; it must undergo several changes, before it is capable of the animal act of spinning: it is only when fully developed into a butterfly, that it can perform the acts necessary to propagation of the species. No signs of a desire to perform motions of this kind are manifested before the organs requisite to their performance are developed. (Compare Spallanzani, 'Phys. Abhand.,' p. 167, for examples in the infusoria.)

649. The brain is always imperfect at first in sentient animals. During the period of growth, it becomes larger and firmer, and receives a movement from the respiratory act, which it had not before, and which seems to have an influence on the actual use of the cerebral forces. The nerves also increase in sentient animals after birth, not less than in the insentient, and parts become sensitive and irritable which were not so formerly.

650. In sentient animals, as well as in insentient, we observe a progressive development of the animal forces; although from the moment of birth many of these display a readiness in the use of the *vis nervosa*, and a perfection in the instincts necessary to their maintenance, so as greatly to surpass man in these respects. Still many of their sensational and motor faculties are so imperfect, that the earliest portion of their existence is only the vague dream of an almost continuous sleep.

651. Since it is during the period of growth that the nervous system and its forces are developed, it is at that time that they determine the *temperament* of the animal (52, 502), together with its animal and even moral character, if capable of such (65, 295, 344). Now, as every genus and species of animal has originally the capabilities of its parents, and these only become more perfect and fixed during the period of growth, it follows that every genus and species have each their special characteristics. These capabilities and endowments may be changed in numerous ways, by habit, education, and accidental modifications of development (52, 431, 501).

652. The third period, or that of propagation of the species,

is the perfect or adult stage of life. In some animals it is extremely short, in others prolonged; but without it no animal is complete, and so soon as it terminates, the animal begins to decline. This period is also the great object of nature in the animal creation, and to this there is no exception from man to the simplest animalcule.

653. In sentient animals the propagation of the species takes place by means of the satisfaction of the instinct for sexual congress (289) : in insentient animals which propagate by copulation, this instinct is replaced by nerve-actions. It has been already illustrated fully (274, 289, 290, 481, 540, 560); and we have only to consider here the changes which take place at this period in animal nature.

654. All animals are not born with sexual organs: some only acquire them after undergoing a succession of transformations, as insects. But these organs in those animals which possess them at birth, as well as the body generally, undergo such great changes, as the period of propagation of the species approaches, that the period itself becomes of the greatest and most general importance. The whole body is invigorated, the seminal fluid is secreted, and often communicates its odour to the whole animal; smooth parts become hairy, horns grow, the voice alters, &c. In the female equally important changes take place.

655. It is a necessary result, that great modifications of the nervous system accompany these important changes in the animal. The nerves of the whole body, and particularly of the sexual organs, become susceptible of new impressions, and in sentient animals this occurs so extensively, that it appears as if a wholly new sense of feeling had been developed. A look, a tone, an odour, a touch, which the sentient animal had experienced a thousand times before, without any other than ordinary results, cause an emotion during this period, which excites the instinct to sexual congress, while the sexual organs themselves undergo analogous changes (274, 289). The external impressions of these sensations in sentient animals excite the same unusual operations in the insentient (481). Without exciting a sensation, they are so reflected as to act upon the sexual organs, as if they had excited a sensation (540). That external impressions are so reflected on the nerves of the sexual

organs, even when these are not directly irritated, and act as though they were felt, is shown by the fact that the fluttering of the wings, whereby the female butterfly allures the male to sexual congress, irritates the nerves of the decapitated male butterfly generally, and not those of the sexual organs in particular, as any other fluttering would; yet it has the same effect on the sexual organs of the male as if they felt it, and it was reflected as a conceptional internal impression. It is shown, however, that this reflexion of the external impressions on the sexual organs, purely by means of the *vis nervosa*, takes place for the first time at this period of propagation, and because the route thereto is as it were laid down, from the fact, that the external impressions made by the fluttering of the female on the decapitated male butterfly, are not thus reflected, unless they have copulated at least once before decapitation (560).

656. The internal impressions caused by conceptions in sentient animals, or independently of conceptions in the insentient, manifest, at this period, the same new powers of action on the sexual organs as external impressions. The remembrance of a sensation, that in the child would excite no attention whatever to sexual congress, now becomes a sensational excitant of the instinct, and it is probable that the mind repeats the former pure sensation, increased by new sub-impressions [Merkmale] that excite this new instinct, and from which the former sensation was entirely free. This also appears to be imitated in insentient animals by the *vis nervosa*, when the female of insects, if decapitated at the period of sexual excitement, not only continue the sexual functions, without any apparent external excitement, but frequently recommence them after a period of repose, fluttering with their wings, to call as it were the male to sexual congress.

657. In reasoning animals this period of life is not distinguished by all these new movements in the *vis nervosa* and in the cerebral forces, as is the case in sensational animals, but the understanding and will attain to new and higher powers. Every one is aware that these attain the greatest perfection of which they are capable, with adult age. The brain also acquires a higher and more perfect development, in accordance with the greater perfection of the mental powers.

658. As this period of perfection of all the functions is attained sooner in some animals than in others, and continues for a shorter period, it determines the duration of life in different classes of animals; and in this there is the greatest difference, the period in which the sexual organs are active, varying from a day to a hundred years. The interval between the cessation of sexual activity and death, seems only to be an addition to life,—a something given over and above; and we will term it the *period of decline*. But before entering on the consideration of this period, we must consider the whole plan of perfect animal life, the proper knowledge of which is the great object of this system of physiology.

CHAPTER V.

THE SYSTEM OF THE FORCES OF ANIMAL LIFE.

659. THE mode and method by which, in the perfect condition of animal life, the animal forces act with and by each other, and are co-ordinate and subordinate, is termed *the system of the forces* of animal life.

660. The order in which a watchmaker constructs a watch, when at one time he forms a wheel, at another a chain, now the hands, the face, and the spring, and then connects these separate pieces, and inserts the spring, cannot enable a spectator to discover how each of them will contribute its share to the performance of the whole machine, although well known to the master-workman, who has worked according to a previous plan. But when the watch is put together, wound up, and set in motion; in short, when the mechanism is completed and finished, the spectator can understand how all the separate pieces and the motor powers co-operate with each other, so as to attain the intent of the machine, namely, to divide the time accurately. Hitherto, we have seen how the machines and forces of the animal are more and more developed, as it approaches the period of maturity. It is at that period that the complete machine can be investigated in all its relations, and the connection of all its machinery and forces, as a system, be comprehended.

661. The animal functions of animals are effected generally by means of the nervous system and the vital spirits it contains. These do not constitute the only parts which develop animal movements, but in virtue of their relation, are the first that are capable of them. Then all animal functions take place in virtue of impressions on the animal machines (356). It is necessary to the reception of an internal or external impression by a nerve, that it be communicated to it in a certain direction, that it be impressed on the medulla of a nerve, and be propagated therein by means of the vital spirits (32, 121); and if the brain is to receive impressions from conceptions or other causes of irritation, they must take place in virtue of a current [Antrieb] of the vital spirits in its minute tubes (28, 121). But

all these conditions cannot possibly be coincident in an isolated portion of the brain, or of a nerve, since they are dependent on the connection of the whole, and imply the existence of the natural structure of the animal machines.

662. Hence it follows, that although the nerves and brain [the animal machines] daily receive new elements by nutrition and growth, and wear away by daily use, still they can continue their functions, so long as this increase or change of their elements neither alters their structure, so as to render them incapable of their functions, nor prevents the action of the animal-motor forces, for their individual constituent parts have no share in these functions, except under these conditions. Indeed, so far from the gradual and imperceptible growth and change, which the brain and nerves undergo from continued use, rendering them unfit for their functions, and preventing the action of the animal-motor forces, they are the rather rendered more and more capable of new functions (644—648). All plants which daily lose old elements and receive new, their organic functions going on uninterruptedly, are illustrations of these views; the heart in animals, considered as a mere mechanical machine, is another, for although the heart of the old man contains not one of the constituents which made up the heart of the child, the general change of all its constituent parts has in no degree interfered with its functions, they having gone on without a moment's interruption. Thus also it is with the brain and nerves.

663. The structure of the brain and nerves renders them capable of their proper and natural functions, and is necessary to animal life in general, but it does not excite those functions. This is the case with all machines, whether mechanical, organic, or animal. A watch or a mill does not go merely because its machinery is complete in all its parts, but the action of the motor force appropriate to the machinery is requisite. The whole body of the animal is so constructed in its perfect state, that it can perform all the movements to which nature has destined it, but it is endowed with true animal life, solely in virtue of the animal forces which put it into motion; and so soon as these cease to act, animal life ceases, although its nervous structure has undergone no change whatever (638).

664. There may be also such a condition of the animal, that

the nervous system cannot, either wholly or in part, perform its functions, independently of any defect of structure; as, for example, before the animal has an independent existence. It is also a mistake to refer the true animal functions solely to the structure of the animal, since that only renders the functions possible. But while the accomplishment of the functions by the animal forces implies the existence of the requisite structures, the absence or injury of the structures, and everything which renders them incapable of performing their functions, interrupts life, and brings it to a termination. Thus, if the brain be removed or destroyed, sensational life ceases; and animal life would cease too, if all the nerves were destroyed, or all the vital spirits, or their circulation through the nerves entirely arrested, or any means used by which the nerves were rendered unfit to receive any impression, although the same impressions may still be made, which make ordinary circumstances constitute true animal motor forces (356).

665. The animal forces, which give vitality to the whole animal kingdom, are all those impressions of which animal machines are capable, in virtue of their proper animal structure. These impressions have been already fully considered, as well as their co-ordinate and reciprocal action (31, &c., 121, 356, 590, &c.) We must, however, note more specially their mutual subordination, or their dependence on each other.

666. An animal function (the action of an animal force) which is based on another, is subordinate to it (Baumgarten's 'Metaphysics,' § 25). Consequently, this subordinate function implies another animal function and force, namely, that to which it is subordinate. Now, as many animal functions are based on others, as, for example, sentient actions or imaginations, these latter on sensations, and sensations on external impressions, there is doubtless a subordination of animal forces in animal life; and if they can act in the natural condition in no other way than subordinately, it is a *natural subordination*.[1]

667. There are certain animal forces which are not naturally subordinate to any others, namely,—i. External impressions when not in themselves animal actions; for the nerves receive

[1] The term *natural* has here and elsewhere a peculiar meaning, and refers to the *mode of action* of the organism, as resulting necessarily from its organisation. See note to § 27.—ED.

impressions without a previous animal action being necessarily implied (32). ii. Primary internal impressions, independent of conceptions, with the condition just stated. In these no previous animal action is necessarily implied (490). iii. The internal impressions, arising from those conceptions, desires, aversions, &c. that are mental, and not sensational in their nature, when considered independently of their remote sensational origin, since in these the brain receives impressions from conceptions formed solely according to psychological laws, and not necessarily in dependence on any other animal action (76).

668. All the remaining forces are naturally subordinate to others, as for example,—i. The internal impression developed from unfelt and reflected external impressions; for in this case, the internal impressions on the nerve implies the reflexion of an external impression (421). ii. The internal impression from external sensations and sensational conceptions, desires, instincts, &c.; since these are dependent on animal-sentient forces excited from without (66). iii. All those mentioned, § 667, if the condition there stated as necessary be wanting.

669. The animal forces which are naturally subordinate to others, are,—i. Unfelt external impressions, which, by being reflected, excite internal impressions. ii. Those external impressions which excite sensations, sensational desires, aversions, &c. iii. Internal impressions not connected with conceptions, in so far as they are reflected on other nerves in their course downwards (500): and iv. The internal impressions of conceptions, but with similar conditions (137).

670. Those animal forces which are not naturally subordinate to any other, are all those just mentioned, when the conditions are not present; or, in other words, when unfelt external impressions cause unfelt direct nerve-actions simply (418, 443); or if, when they excite no direct nerve-actions (445), are prevented naturally from being transmitted along the nerve, and are either reflected (426, 199), or felt (47, &c.), or, in so far as internal impressions not dependent on conceptions, or those of conceptions, are not reflected on other nerves in their course downwards (485, 124).

671. The animal machines of an animal are all in connection with each other, and constitute a special *system of animal machines.* In those endowed with brain, the nerves are only

prolongations of it, and the current of the vital spirits passes upwards and downwards in both (21); in others, all the animal machines are in general connection, by means of ganglia, branches, and plexuses. Nevertheless, every portion of the system of animal machines is of itself capable of animal forces (31). The brain receives its own impressions at points quite different from those at which the external impressions which are felt are received (124); as well as those from other conceptions (130, i). In like manner, every nerve, every portion of the system of nerves, has the capability of receiving both internal and external impressions, and when there are no natural obstacles present, of transmitting them to other branches, or other nerves, either through the ganglia or plexuses, or communicating nerves, or through the brain itself, by means of conceptions (31, 32, 121). But if the action of an animal force in this system of animal machines shall have another subordinate to it, it must excite another animal force either in the same portion of the system—as when an external impression excites an internal impression in the same nerve, or *vice versâ;* or else it must excite an animal force in another portion—as when an external impression on one nerve excites either an internal or external impression in other nerves, or other branches, &c.

672. This natural subordination of the animal forces does not, therefore, occur in each and every point of the system of animal machines, but (as experience proves) certain points are destined by nature to this end; these may be termed the *natural connecting points of the animal forces*, inasmuch as in these the forces communicate and combine with each other. The external impression continues its course along the nerve, until it arrives where a branch is given off, and which receives it as an internal impression, and thereby other animal actions may be produced; or until the nerve is intermingled with others in the ganglia or plexuses, where its external impression can be received, and act as an internal impression (421); or in sentient animals, until the external impression reaches the origin of its nerve in the brain, and there, by means of a conception (sensation), excites the animal-sentient force to send it back again along the nerve (35, 121, 124); or until one of its nerve-actions excites external impressions, which cause corresponding sensations and sentient actions (184, i, 443). An internal impres-

sion, whether arising from conceptions or other stimuli, continues its course onwards in the system of animal machines from the place of its origin, whether that be in the brain, or in a ganglion or plexus, or at the point of division of a nerve, or any other point of the nerve-medulla, without putting any other animal force into action, until it is conducted along other branches or nerves (which duly receive it), either in a ganglion, a plexus, or point of division, and thus excites animal actions (124, 485); or until its own action excites external impressions in the nerves, which again have their peculiar course and operation (225).

673. Those portions of the system of animal machines which combine several natural connecting points of the animal forces, are termed *centres of the animal forces*. A number of animal machines are put into action, by means of these centres, when external or internal impressions reach them. We will mention the principal of these centres. The *brain* deserves the name in a two-fold manner. Firstly, in its relation to the vital spirits, of which it is the secreting organ, partly sending them to all other animal machines, or communicating internal impressions not caused by conceptions: partly receiving them back again from the machines, or having external impressions communicated to it from the latter (11, 17, 18, 31). Now, although many insentient animals have no proper brain, still all must have animal machines performing this function, because there can be no animal life without the intervention of the vital spirits, and consequently without their secretion and circulation. The ganglia and plexuses are probably, in this respect, the analogues of the brain; and in those animals, a mere section of which has an independent existence, as polypes, or in those in which the head and brain may be removed without injury to life, since they are reproduced, as snails (*vide* Spallanzani), either the whole nerve-medulla of the entire system of animal machines, or a special portion in each limb, has the same function as ganglia and plexuses; so that animals of this class possess several analogues of the brain (362, *vide* Haller's 'Physiology,' part iv, vol. x, sect. vii, § 36). Now, although a brain of this kind may not be so constituted, as to be also capable of the animal-sentient forces, as in sentient animals, still it possesses so much of the structure of a brain, as to be

an animal secreting organ, and consequently may be very properly termed a brain; and thus the unnecessary multiplication of terms be avoided. Many eminent men, seeing that the ganglia are supplied with numerous capillaries, have concluded that they have some beneficial function with reference to the nerves. (*Vide* Haller, vol. cit. sect. 10, § 32.)

In the second place, the brain merits the designation of centre of animal forces, inasmuch as it is so constructed in sentient animals, that it is adapted to the animal-sentient forces; and external impressions which are felt, are generally so reflected in it by the intervention of conceptions, that they put internal impressions from external sensations and sensational conceptions into action (34, 66); the operation of which can be extended throughout the animal machines [nervous system] of the whole body. (Part I, Chap. III.)

Another centre of animal forces found in all animals is the *heart*, and which is specially adapted to be such by the number of its nerves and the varied composition of its plexuses (516). When it is remembered that all conceptions, in so far as they are pleasant or disagreeable, modify its movement (250); that a great number of animal actions in the entire economy of the organism are thus developed, as is particularly shown in the sensational instincts and passions (258); that its natural movement is maintained by means of unfelt external and internal impressions (459, 515); and that by means of the circulation the greater number of the processes necessary to the preservation of the individual are maintained, there can be no doubt as to the importance of this centre of animal forces. Although such a heart as the larger animals possess is not developed in all animals, still there is always a machine which regulates the circulation of the fluids, and to which the term heart may be very fairly assigned. The region of the diaphragm and of the stomach is not unreasonably considered to be a centre of animal forces, because numerous nerves meet and unite there (171, 174); and because it is observed that the impressions reaching there develop nerve-actions and sentient actions in most parts of the body (*vide* § 688). Lastly, the sexual organs occupy an important position amongst the centres of animal forces (687).

674. We know of no animal with a general centre of animal

forces, that is to say a centre wherein all the natural connecting points of the animal forces are collected together, since in all, there are found, at very distinct portions of the nervous system, larger and smaller ganglia, plexuses, and general points of division of nervous trunks into branches. If, however, those centres of the animal forces ought to be termed general, which are common to all animals without exception, then there are many such (673); or if by the expression is meant a certain portion of the animal machines [the nervous system], the injury, destruction, or removal of which terminates life, then there certainly are such general centres, as we shall shortly show (675); but those are in general in greatest number which are mutually subordinate to each other.

675. The heart and brain are essential to animal life in all animals, the latter as the secreting organ of the vital spirits, the former as the first cause of the circulation. Both are the most important and the first visible portions of the germ. It is true, that the brain in the embryo of sentient animals has no apparent function, for its natural visible movement seems to be requisite to the action of its animal-sentient force, because it only occurs with respiration, and consequently not before birth (24); anteriorly to which no animal-sentient force can be shown to be in operation (634). On the other hand, the secretion of the vital spirits is an invisible function (28), and in so far as it is animal is a pure *vis nervosa* (374, 159), which may without doubt be active *in utero*. The heart, or its analogue, manifests a distinct movement in the earliest stage of development of the embryo: these two centres must consequently be considered to be the primary and essential portions of the system of animal machines. We therefore term the secreting faculty of the brain and the natural force of the heart, the *primary vital forces*. We exclude from this designation the animal-sentient force of the brain, which is not common to all animals, and understand solely the two mentioned, the one being that on which all animal forces depend, without exception; and the other that on which the circulation, the secretions, and nutrition are dependent

676. It may happen, that before birth an animal receives its fluids from its mother, elaborating none by its own forces, and secreting none until it has an independent existence. The vital

spirits is the only one of these secretions absolutely necessary to the action of the other animal forces in the economy (21); and as they are secreted from the blood, this primary vital force of the adult and perfect animal is dependent upon the cardiac force. But the influence of the vital spirits on the heart keeps up its continuous action, by means of its unfelt external impressions (515, 532, note); and unless the cardiac nerves be filled with the vital spirits, they cannot respond to the impressions made on them by the blood, and consequently cannot excite its whole motor force (665, 457). The two primary forces are therefore reciprocally subordinate to each other: neither can continue uninterruptedly, independently of the other, and if the one ceases, so must also the other. Therefore, if there be a common point of union of the two forces in an animal, that point is also the general centre of the animal forces in the sense already referred to (674). According to Lorry's observations, this point is situate in that part of the medulla oblongata corresponding to the second cervical vertebra. Animal life suddenly ceases if this portion be injured, destroyed, or removed. (*Vide* Haller's 'Physiology,' part iv, vol. x, sect. 7, § 36.)

677. The objections to this doctrine of the reciprocal subordination of the two forces to each other are easily met.—i. It may be advanced, that in the germ one of the forces must necessarily begin to act before the other, and consequently either the heart can act independently of the vital spirits, or the latter may be produced independently of the heart. As to the former objection, we answer, that both may commence at once; as to the latter, the assertion is only applicable to animals enjoying an independent existence, inasmuch as the fluids may circulate before birth in virtue of extraneous forces, and not of those proper to the germ (Haller's 'Physiology,' § 891).

ii. It is objected, that in sentient animals the heart's action will continue for some time after decapitation. The reply is, that the vital spirits do not drain away immediately after removal of the brain; and so long as the cardiac nerves respond to impressions, so long are the vital spirits retained in them (515).

iii. It is further objected, that the brain can perform sentient actions after the heart has been removed from the body. This may occur for a short time, but only so long as the brain contains the blood sent to it from the arteries, which can continue to act for a short time after excision of the heart.

iv. Another objection is, that insentient animals exist without either brain or heart. According to all probability, in these the vital spirits are not secreted in what is ordinarily termed a brain, but from the nerve-medulla at several points of the nervous system, and consequently the organs of these animals retain their whole animal life until either their fluids are exhausted from the want of nutrition, or can no longer contribute the material of the vital spirits (362, 416). Animals of this kind, which are not only nourished by what may be termed the head, but also by several organs, or by the entire surface of the body, can perfectly retain their whole animal life, and each separate portion of their body must be considered as a whole, having the two centres of primary vital forces, in which an analogue of the brain secretes vital spirits, and acts in reciprocal subordination with an animal machine, the analogue of the heart having the function of carrying on the circulation (*vide* § 699).

678. The *proper motor force of the heart* in the natural adult condition of an animal, is the external impression which the in-flowing blood, or some other general fluid, excites in its nerves, and whereby the movement of the heart is peculiarly a direct nerve-action (456); but at the same time it is continued in its natural order by the internal impression, which the influence of the vital spirits makes on the nerves. The life of the heart, therefore, continues,—i. So long as its nerves are capable of responding to external impressions, especially those made by the blood. ii. So long as these external impressions actually act upon them. These two conditions are alone necessary. But since the cardiac nerves lose this capability, if the continued flow of the vital spirits into them be interrupted, or the secretion arrested, the vitality of the heart is extinguished as soon as the supply of vital spirits contained in them is exhausted, and this is the reciprocal subordination of the two forces.

679. *The primary vital force of the cortical substance of the brain* (362), (not the animal-sentient force, 375), in the perfect condition of an animal, is the impression made by the in-streaming blood on its secretory vessels, whereby they are stimulated to perform their proper function, in so far as it is

animal, namely, to secrete and transmit the vital spirits (374). It is naturally subordinate to the animal force of the heart, and continues so, firstly, so long as the blood continues to flow through the vessels in virtue of the heart's action; and secondly, so long as the vessels respond to the impressions made by the blood circulating through them. These two conditions are alone requisite to the maintenance of this natural vital force of the brain (663, 664). But when the secretion of the vital spirits is arrested, or their flow to the cardiac nerves cut off, then the heart's movements are easily interrupted, and at last stop, so that when the circulation of the vital spirits in the cardiac nerves ceases, (which may result from the interruption of all the cerebral functions, of the connection between the heart and brain, &c.,) this primary vital force of the brain ceases.

680. All other animal forces are naturally subordinate to these two primary vital forces, in so far as the operation of all in the animal machines presupposes the influence of the vital spirits which render the animal machines fit for their functions, and which they cannot be, without the natural subordination of both; and again, in so far as every animal machine is nourished and developed by the circulation of the blood, their natural functions are effected also by it.

681. In especial, the natural functions of all parts of animal organs are naturally subordinate to the combined action of the two primary vital forces of the heart and brain, as may be easily shown. This is manifest with reference to the animal force of the arteries, in forwarding the general circulation of the fluids, since they become fit for their function in virtue of the vital spirits, and are dependent on the heart for receiving the impressions which excite their stroke (460).

682. The animal forces of the capillaries and their terminations stand in the same natural subordination, whereby they excite a flux towards parts duly irritated (207). The circulation must supply the fluids which constitute the flux, and it is through the vital spirits that they are rendered capable of responding to stimuli (462, 463). But a co-operating or co-ordinate force is necessary to this flux, and the subordination of this animal function is also conditional, inasmuch as it only results when an external impression takes place at the same time on the capillaries, or their mouths (207, 462).

683. The natural subordination of excretion and secretion to the two primary vital forces is less direct, because they imply the action of the arteries, for the latter must carry those *materies*, the external impressions of which excite them to the functions of secretion and excretion, and subserve thereto (472).

684. The movements of muscular fibrils, of membranes, of muscles, and of muscular viscera and organs (162), are also subordinate to the two primary vital forces. The influence both of the vital spirits and of the blood is necessary to the natural actions of all these. Although the subordination is more direct than in the glandular system and excretory viscera, co-ordinate forces are required, inasmuch as all muscular action requires also an internal or external impression (162, 448).

685. The function of respiration in breathing animals, being effected by muscular tissue, follows the law of subordination of muscular action in general.

686. Lastly, all compound functions of the viscera are subordinate to the primary vital forces, in accordance with the preceding laws. The functions of the sexual organs, whether male or female,—as copulation, &c., include those of arteries, capillaries, muscles, glands, &c., and are subordinate, according to the age and conditions of the constituent parts.

687. But even these compound animal functions, as respiration, digestion, generation, have a number of functions subordinate to them, inasmuch as their effects extend through the entire animal economy. This is very remarkably the case with the function of generation, which, in those which have sexual congress (633), puts animal forces into operation that are subordinate to it in a wonderful manner.

688. The diaphragm and the stomach (which forms with the intestines one canal) stand in very close relation to each other, and attentive observers have recognised the region in which they are situate, as a very general centre of animal forces; not only because many nerves meet and communicate there, but because many phenomena prove it to be such. Violent injury of this region causes great general changes in the body, and diseases of these parts derange many animal functions. Thus, worms and mucus in the stomach excite convulsions of the extremities; colic induces paralysis; bad digestion causes

hypochondria; inflammation of the diaphragm induces fatal delirium and nervous attacks, &c.

689. There are many other subordinations, but it is not possible to give all in detail in this general sketch; it is easy, however, to deduce them from the general principles laid down.

690. The natural subordination of all animal forces we have considered hitherto, has been considered with reference, it is true, to the most perfect type of animal organisation; but, nevertheless, it is applicable to every species of animal, whether sentient or insentient, provided only that they have some of the organs belonging thereto; for, in the Second Part of this work it has been shown, that the animal functions in question may be performed as well by the *vis nervosa* only, as by the animal-sentient forces; or by both acting conjointly. But in sentient animals, the brain is a special organ and *centre of the animal sentient forces*, and of this we have now to treat.

691. The brain is not capable of an animal-sentient force, without vital spirits (21, 22). Further, its animal-sentient forces are subordinate to the primary vital forces, as regards the secretion of the vital spirits. The proper animal-sentient forces of the brain are the material ideas of conceptions (25), which are always induced primarily by means of external impressions (65), although some of them, namely those of intellectual conceptions, desires, &c. are impressed on the brain by the mind, without their being more immediately dependent on external impressions (579, ii.)

692. As the animal-sentient forces of the brain depend upon external forces that are felt, and all sentient operations in the system are effected through them (97, 6), it follows that the brain, in so far as it is adapted to them, is the centre of the animal-sentient forces (673); although the latter are themselves naturally subordinate to the primary vital forces.

693. Proper animal life endures so long, as, i. The natural functions of the primary vital forces continue, at least in some degree, namely, the secretion of the vital spirits in the brain, and the circulation of the blood (640, 641). ii. So long as the brain is not prevented receiving external impressions, or internal impressions from certain conceptions. iii. So long as external impressions, or sensational or intellectual conceptions, induce material ideas in the brain (663, 664.)

694. Proper animal life, or in other words the connection of body and soul, ceases,

i. When the primary vital forces cease, that is to say when the circulation is altogether arrested, so that no blood is sent to the brain, and that already sent is no longer retained in it; or when the functions of those portions of the brain which secrete the vital spirits is altogether abolished, so that no more is secreted, and that already circulating in the nervous system is used up or destroyed.

ii. When, although the circulation of the blood and secretion of vital spirits go on, the brain itself is so changed, that neither an external impression, even if it reach the cerebral origin of the nerves, nor a conception, can produce a material idea in it. This takes place, when the brain is entirely removed or destroyed, or so under the influence of poisons, that its functions are abolished,—circumstances which change the animal into an insentient animal machine.

iii. When an animal no longer has in the slightest degree, either an external sensation, or a sensational or intellectual conception, or when neither these, nor external impressions, develop any material ideas whatever; for under these circumstances the soul has no connection with the body, whether it have an independent existence or not, and, consequently, the life of the sentient-animal terminates (640).

Note.—In these conditions consist the first principles of our knowledge of the causes of death; of the fatality of wounds, poisons, and other injurious agents; and the question of life or death in disease and in doubtful cases, (*vide* § 710, &c.)

695. All natural functions are subordinate to the animal-sentient forces, in so far as they are sentient actions and forces of other sentient actions subordinate to them; and result (subject to the general conditions of proper animal life) from all conceptions, in so far as they are excited by external impressions, or the sensational or conceptive force.

696. In particular, all the sentient actions enumerated §§ 97—100, and considered in detail in subsequent chapters; and all those developed in the tissues and organs, considered §§ 160—179, and in the capillaries (207), are subordinate to the animal-sentient forces.

697. So soon as the connection of body and mind is abolished, and, consequently, proper animal life ended, all these animal operations cease to be sentient actions, although, in consequence of the maintenance of mere animal life, they may still be produced by the *vis nervosa* only. (Part II, Chap. IV, sect. i.) They may be produced, however, in virtue of the natural co-ordination of the forces of the mind and the nerves, by both acting at the same time in parallel subordination. (Part II, Chap. IV, sect. ii, iii.) But as the animal-sentient forces are subordinate to the primary vital forces towards the close of mere animal life, the animal functions cannot be produced by the former, but all proper animal life must cease at the same time (640).

698. Thus then, in the perfect condition of the animal, all its animal forces are both subordinate and co-ordinate in the most wonderful manner; whence in the system of all the forces of the complete animal nature, the concurrence of merely physical, mechanical, or organic forces come into consideration; as, for example, of the commingling of fluid elements, of rigidity or flexibility, shock, compression, elasticity, &c., to which the action of the animal forces is often incidentally, naturally, or contra-naturally co-ordinate and subordinate. All animal operations are naturally subordinate to impressions, through which the primary vital forces are maintained in activity, but only so long as animal life remains (678, 679). It depends on these forces whether an animal life can exist and continue in perfection, be the animal endowed with mind or not, and that a thousand impressions on every part of the nervous system (which act with them in a co-ordination, partly fixed by nature and naturally necessary, and partly incidental) can develop at one time whole series of natural and subordinate animal processes, from distinct centres of animal forces (673, 687—689); at another one such process only, but all subservient to the preservation of the animal and the attainment of the ends designed by nature (674, 681—686). In animals endowed with mind, the animal-sentient forces are subordinate to the primary vital forces, the former being, in fact, impressions of a peculiar kind (356) which act through the brain, (the centre of the animal-sentient forces,) by means of the production or operation of conceptions and material ideas, and which can thereby

develop the same series of subordinate or single processes, produced by the other impressions necessary to the preservation of the animal and the attainment of nature's objects; and with the same partly necessary and natural and partly incidental co-ordination (696). All this takes place, in order that these processes may be caused also at the same time by sensation, perception, volition, effort, desire, aversion, reflection, and choice and satisfaction of the animal, and thus it be rendered more perfect, and capable of a more independent carrying out of its proper objects (370, 371).

699. The doctrine, as to the general subordination of all animal forces to the primary vital force of the brain, may excite doubts which require a solution. In this entire work, we have taught that the most essential and the greater proportion of the animal processes necessary to life, may go on perfectly, even in sentient animals, not only absolutely, but also in their natural connection, without the assistance or co-operation of the brain; and that it is possible animals may and do exist, that have neither brain nor head, nor conceptive force, and yet can perfectly perform all the functions necessary to their animal life, by means of the *vis nervosa* only. How can this agree with the doctrine, that the brain is the centre of all the animal forces of animals? and that the secretion of vital spirits in it, and their circulation through the whole system of animal machines, is a primary vital force of all (675)? The animal machine which secretes the vital spirits, is not in all animals the same as that which is capable of animal-sentient forces, although the term brain has been applied to both kinds (673). All animal functions require the primary vital force of the brain, because it is necessary to the secretion and transmission through the nerves of the vital spirits; but all do not require the animal-sentient forces, inasmuch as they can be replaced by the *vis nervosa* only. In those animals not endowed with animal-sentient forces, the secretion and diffusion of the vital spirits is necessary to their animal processes; and, consequently, a brain endowed with a primary vital force is also necessary, since all the processes are subordinate to it (680, 690). But this brain may be diffused throughout the body, and every part may have its own brain; and their animal processes may be in subordination to the primary vital force of this

diffused brain (677, iv). If, however, the nerve-medulla in the head secretes and transmits the vital spirits only, then life ceases with the removal of the head, except in so far as vital spirits already secreted and transmitted may still remain in the nerves (661, 677, ii); until these are exhausted, various processes may go on in the body in their natural co-ordination, although no sentient actions can take place in sentient animals. The functions of the brain may be compared with a fountain supplied from a brook, which waters flowers and plants: the latter are the nerves; the fountain represents the animal-sentient force, and the brook the primary vital force. The fountain may be removed, and still the flowers may flourish, provided the sources of the brook be not cut off, but the flowers and plants live only so long as the supply of water already in the garden holds out.

CHAPTER VI.

ON OLD AGE AND DEATH.

700. After an animal has attained its growth, and all its natural transformations being completed, it has remained for a period in its state of full development, everything in its nature tends to decline. Its fluid elements are used up, and become more inspissated and earthy; its solid constituents are partly destroyed, partly rendered harder and denser; its canals are filled up and ossified. All this occurs from natural causes existing throughout the organism, and for the most part in virtue of physical and mechanical forces. The consideration of these belongs to the physiology of mechanical nature; we have only to discuss the decay of the proper animal forces.

701. In old age, the brain and nerves appear to dry up, and become flaccid; the nerves even of the organs of sense become hebete from constant use and the growth of impediments to their functions, so that external impressions are less felt, and external sensations are less readily excited. Hence the diminished activity of the sexual instincts and desires, the diminished muscular energy, the insensibility and dullness of age. Internal impressions following the same rule as external, the mental powers become enfeebled, the memory fails, the judgment is impaired and becomes slow and undecided. Hence the appearance of greater wisdom and prudence than the old really possess, &c.

702. Since every kind of animal force decays, whether manifested in the insentient, the merely sensational, or the reasoning animal, destruction naturally impends over all animals, and every animal is naturally mortal. The natural necessity of this interruption of animal life is not only shown by the laws of the economy, but also by the operation of remote physical and mechanical causes, which partly destroy—insensibly and gradually—the structure of the animal machines, partly interrupt the natural action of their forces, as well in themselves as in the mechanical machines, in a way not known. The subject belongs, however, to the physiology of the mechanism of animal bodies (Haller's 'Physiology,' § 31).

703. The termination of animal life is death, which therefore occurs when no animal force whatever exercises the slightest action on the organism (638).

704. The spiritual death of a reasoning animal is the end of its intellectual life, and takes place when not a single higher animal-sentient force exercises the slightest action in the organism. In this kind of death, sensational life and the union of body and soul may still continue (641).

705. Sensational death comprises also spiritual death, and takes place when not a single sensational force exercises the slightest action in the organism. It has been termed peculiarly the *death of the animal*, or the *deprivation of life*, since it completely destroys the connection of body and soul (640); mere animal life may, however, continue.

706. Complete death takes place when not one of all the animal forces any longer acts in the slightest degree, or when the *vis nervosa* has ceased to act. The popular mistake as to this kind of death has been already noticed (643).

707. Natural death occurs from the natural death of the animal forces, after the animal has attained its full growth and perfection, and takes place necessarily. Few animals, and least of all mankind, die a natural death, and death occurring under other circumstances is termed accidental, the causes of which may be found in Haller's 'Physiology,' § 959.

708. Animal death in the strict sense, or the separation of the soul from the body, whether accidental or natural, takes place, either when the natural functions of the primary vital forces altogether cease, others being subordinate to them, or when the animal-sentient forces are abolished. In the former case, it results in consequence of the entire death of the animal, which includes the separation of the soul and body; in the latter case, mere animal life may continue after such separation (640). We will consider the modes in which it may occur.

709, 710. The union of body and mind is sundered when the animal ceases wholly to exist. An animal wholly ceases to exist when its *vis nervosa* is abolished, together with all its natural effects in the economy. No portion of the animal machines is susceptible of *vis nervosa* without a suitable structure, and without vital spirits (661, 663); and cannot be supplied with the latter independently of the primary vital force of the brain or nerves, by which the vital spirits are secreted and diffused (678); and the brain cannot be active if the heart do not, in virtue of its primary vital force, transmit the blood to it, so that the vital spirits may be secreted. Further, the primary vital force of the heart is inoperative, if the vital spirits do not flow to it, and if external impressions be not duly received by it (678, 679).

711. Firstly, complete death may take place when the heart wholly ceases to act, and all the functions dependent on the circulation are entirely abolished; so long, however, as the heart's action continues, in however slight a degree, the animal still lives; or so long as the arteries maintain the circulation, which may occur longer in the capillaries than in the larger vessels, independently of the direct action of the heart; or so long as there is blood remaining in the brain, from which vital spirits may be secreted; or, so long as vital spirits remain in the nerves, and render them capable of duly receiving impressions. It is thus we can understand, why certain animals survive after the heart's action has ceased, or even when that viscus has been entirely removed from the body.

712. Secondly, complete death may result from whatever destroys the primary vital force of the brain, or of its analogue, and prevents the secretion of the vital spirits, and their diffusion through the entire system of animal machines; so soon as the functions dependent thereon are quite abolished, the animal is perfectly lifeless. If, however, the primary vital force of the brain continues to act in the slightest degree, or if there be any vital spirits remaining in the animal machines after the removal or destruction of the brain, so that they are capable of duly receiving impressions, the animal is not absolutely dead.

713. Thirdly, death is complete, when either both the primary vital forces are abolished at once, or when the one is so arrested, that the other is destroyed. So soon as the operations of one or both cease entirely, the animal dies absolutely, because they are mutually subordinate to each other. But if the centres of one of these vital forces be removed from the body or destroyed, without the other being entirely abolished, then death is not complete. Such is the case in those animals in which the arterial system keeps up the circulation for a lengthened period, after removal of the heart; or in those in which several points of the nervous system secrete vital spirits, and thereby maintain

the action of the heart after removal of the head; or in those in which the vital spirits remain for a lengthened period diffused through other portions of the nervous system. Thus, merely animal life may continúe after the removal of both the heart and the brain.

714. Fourthly, an animal is absolutely dead, when its entire system of animal machines is rendered wholly incapable of performing its functions (639). But so long as the structure of that system is not completely destroyed or changed, or the vital spirits contained in it exhausted, so long, in short, as any portion of the system retains the property of duly responding to impressions, the animal is not absolutely dead. It is thus we understand, how animals may be frozen, and yet retain animal life. (*Vide* Spallanzani.)

715. The destruction, division, or injury of portions of the system of animal machines, and the exhaustion of the contained vital spirits, are necessarily followed by the complete death of the whole organism, when the primary vital forces of one or both centres of animal forces are abolished (711—713). Hence mortification, or the loss of entire limbs, only causes death, when it involves one or other of these centres.

716. Lastly, death is absolutely complete, when those impressions are no longer made on the animal machines which maintain the primary animal functions. Thus, if the heart becomes empty from hæmorrhage, its movements cease, the natural stimulus derived from the blood being wanting. Death will not take place, however, so long as either of the primary vital forces are kept active, in some degree at least, by supplying the defective impressions: and this is the art of restoring persons to life apparently dead; for all animals, whether sentient or insentient, which perish suddenly, as those drowned, frozen, strangled, stunned, suffocated, &c., die from a want of those natural impressions that excite the primary vital forces to the performance of their functions.

717. Sentient animals may die in any of the modes in which absolute animal death occurs, but none of these are necessary for proper animal death, or the disseverance of soul and body, because animal life may continue after the latter has taken place (708), just as it existed in the earliest germ independently of mental life (634); and a sentient animal may thus be capable, after death in the ordinary sense has taken place, of those

animal functions which insentient animals perform as perfectly as sentient (609—611). Hence we can comprehend the astonishing persistence of mere animal life in many animals after decapitation, which, inasmuch as they have a head and a brain, and seem to feel, may be considered to be very imperfect sensational animals, such as turtles, frogs, &c. It cannot be doubted that poisons may possibly be administered, which shall put an end to proper animal life alone, and only dissever the connection between the soul and body, so that a mere living machine is left, which, if supplied with nutriment, will continue to live on, and, like an anencephalous infant, be excited to movement without having the least sensation or any conception whatever. But the bodies of sentient animals are not constructed by nature so as to be capable of this continued animal existence, but require, for their preservation and perfection, the co-ordinate action of both the animal-sentient forces and the *vis nervosa.*

718. The separation of soul and body may occur: i, from everything which completely interrupts the functions of the brain (708), so far as it is the centre of the animal-sentient forces (692). The interruption must be, however, complete, as, for example, by the entire separation of the head from the body, the destruction of the brain, every injury which absolutely stops the formation of material ideas in it &c., but the injury or removal of portions only is not sufficient.

719. No one knows how the structure of the brain is adapted to material ideas, how these ideas are formed in it, or what is their nature, or how the vital spirits assist in forming them, or in what the animal-sentient force of the brain differs from its primary vital force (679, 692). It is only possible to suppose, with great probability, however, that the gray portion is the seat of the latter, and appropriated to the secretion and diffusion of the vital spirits; while the white matter is the seat of the animal-sentient forces; and that the distribution of the vital spirits through the entire system of animal machines is a continuous and slow movement, whilst that by which material ideas are produced and their sentient actions excited, is altogether different, being extremely rapid, not continuous, and dependent on the stimulus of impressions (11). (*Vide* Haller's 'Physiology,' § 383.) It is known, that the animal-sentient forces are active at the origins of all the nerves in

the brain (124, 130, i), but it is not known, whether there be one point only in the whole brain appropriated to consciousness and the conceptive force, and which can be termed the seat of the mind. (Consult Haller's 'Physiology,' § 370, sqq.) The difficulties in the way of a correct theory, render it impossible to give any details as to the modes in which the separation of body and soul may take place.

720, ii. The separation of the soul and body may occur independently of entire animal death when the conceptive force ceases to act; that is to say, when those impressions are absolutely wanting, which the brain can duly receive in virtue of its animal-sentient forces. If the soul be considered as a substance distinct from the body, cases may be imagined, in which it may separate itself from the body, the animal-sentient forces of the brain being altogether unaffected, as is supposed to occur in the transmigration of souls. But it is fixed by the eternal laws of nature, that no conception can occur without the co-operation of the animal-sentient force, and no material ideas arise in the brain, without the co-operation of the conceptive force. Consequently, all possible modes of dissolution in the ordinary acceptation of the word, are comprised in those stated, § 718.

721—726. Dissolution of the connection between body and mind must take place, whenever complete animal death occurs, and will be caused—

i. By whatever entirely arrests the action of the heart (711), and thereby arrests the functions of the brain and its animal-sentient forces (718). But so long as interruption of the cardiac action fails completely to effect this, the animal is neither absolutely nor mentally dead. ii. By whatever abolishes the primary vital force of the brain, and, consequently, the secretion and distribution of the vital spirits, so that the action of the animal-sentient force is quite arrested (712). iii. By whatever abolishes both the primary vital forces at once, or by abolishing one destroys the other, and thus complete animal death takes place (713). iv. By whatever at once renders the whole system of animal machines unfit for its function, and, consequently, for the animal-sentient forces (714). If this occurs gradually, the dissolution of the connection of body and soul, may precede complete animal death. In death by lightning, both take place at the same time. If the animal machines be only rendered partially unfit for their function, separation of the body and soul can only take place, when those parts of the brain are involved which constitute the centre of its animal-sentient forces. But inasmuch as these are scattered throughout the brain, often injury of the cerebral medulla only destroys a certain class of animal-sentient forces, and others not naturally subordinate to them, remain uninjured. Thus, it is possible in injuries of the head, or in old age, that one kind of external sense, or the memory, understanding, judgment, &c., may be enfeebled or abolished, while other faculties are unaffected. v. By whatever entirely prevents those impressions, which put the primary vital forces into action, or maintain them in action, in so far as the animal-sentient forces of the brain (which are subordinate to them) are abolished (716).

727. All these various kinds of death are usual in nature. Often mental death precedes mere animal dissolution; often both occur at the same time; but in every case, traces of mere animal life remain after the soul is separated from the body. When all conceptions are abolished, and all sentient actions have ceased, the body still manifests signs of the *vis nervosa;* peristaltic motion continues, the heart makes a few feeble strokes (the right ventricle retaining the power of motion the longest), and the muscles are still irritable. Even when all other tissues are no longer capable of stimulation, the heart's action may be renewed by external impressions, so that to this extent we may consider with Haller (Physiology, § 961), that the moment the heart loses its irritability is the moment of complete animal death. That the moment of interruption of the heart's action is not that moment, is manifest from what has been already stated (711—721). Undoubtedly, every trace of the *vis nervosa* disappears as soon as the parts become cold, or deprived of moisture.

728. After absolute death comes the end of the remaining part of the entire nature of the dead body, that is, of the organic, mechanical, and physical forces, and is termed *putrefaction.* It resolves all the animal machines,—the brain and nerves,—together with all the other components of the animal organism, into their primary elements.

END OF "PRINCIPLES OF PHYSIOLOGY."

DISSERTATION

ON THE

FUNCTIONS OF THE NERVOUS SYSTEM.

BY

GEORGE PROCHASKA, M.D.

A DISSERTATION

ON THE

FUNCTIONS OF THE NERVOUS SYSTEM.

INTRODUCTION.

The nervous system, in which term we comprise the cerebrum, cerebellum, medulla oblongata, and medulla spinalis, and the nerves thence distributed throughout the whole body, is of all organs of the animal economy the most important. It is the seat of the rational soul, and the link by which it is united to the body; it is the instrument by which the soul, so long as it is united to the body, produces its own actions, termed animal, and by which it acts on the rest of the body, and the body in turn acts upon it. But, however great may be the importance of the nervous system in these respects, it is of further importance, because it possesses in addition the singular faculty of exciting in the human body various movements without the consciousness or assistance of the soul; nay, plainly against its will it can and does excite them without intermission through the whole of life. The nervous system also influences other functions of the human body, as digestion, nutrition, and secretion, which functions do not remain long undisturbed if the nerves be injured. I say nothing of the share which the nervous system is well known to have in almost every disease.

From all this it is manifest how valuable results would follow on sedulous inquiry into the structure and functions of the nervous system, inasmuch as much light might be expected to be thrown on medical art; nor ought it to be lightly esteemed as to its results, with reference to those who desire to know themselves. For he who desires to understand more thoroughly his own mind,—the nobler portion of himself,—can understand it only from its operations. But these are never so pure and so unmixed, that the nervous system,—the immediate instrument of the mind,—has no part in them; and consequently it is necessary that the structure and functions of the nervous system should be well understood by those who would determine what should be ascribed in animal actions to the operations and structure of the nervous system, and what should be clearly assigned to the immaterial soul alone.

After all the earnest attempts of the greatest philosophers and physicians from the earliest ages, to explain the functions of the nervous system, we can hitherto only say with Haller,[1] it is but a little that we certainly know, that much remains unknown, and if we may judge of the future by the past, that no little will remain unknown for ever. Nevertheless, I do not think all hope should be abandoned, especially if we should be able to detect and remove the cause of that slow progress hitherto made; and this, in my opinion, partly consists in the difficulties of the subject, which nothing but great labour can overcome; and partly in the love of hypotheses, which have been devised to explain the functions of the nervous system. Many, content with these false resemblances of truth, neglect to inquire into the truth itself, and they who do investigate, unless they discard the prejudices which spring from hypothesis, often fail to perceive the truth, even when it is plain before them.

I have therefore entered on this attempt, to explain the natural functions of the nervous system, without any hypothesis, and by simple facts only; and should the attempt be approved, and by additions and emendations be rendered more complete (and these I well know my labours to stand in need of), it may be readily and usefully applied to an explanation of the preternatural functions of the same system. I have taken certain observations and experiments of celebrated men as a foundation; I have spoken doubtfully of what was doubtful, and I have preferred to acknowledge my ignorance of what was inexplicable, rather than with the itch of explaining everything to have recourse to improbable hypotheses. How nearly I have attained to the truth in other respects let the indulgent reader decide.

[1] Elem. Physiol., tom. v, p. 529.

CHAPTER I.

THE PRINCIPAL OPINIONS OF AUTHORS, REGARDING THE USES AND FUNCTIONS OF THE NERVOUS SYSTEM, CONCISELY STATED.

SECTION I.—THE OPINIONS OF ARISTOTLE.

It is remarkable how widely Aristotle with many others of the philosophers and stoics have erred in assigning a use for the brain, having described it as an inert viscus, cold and bloodless, an organ *sui generis*, not to be enumerated amongst other organs of the body, seeing that it is of no use except to cool the heart. He thus explained how the brain might be the refrigeratory of the heart :[1]—Inasmuch as vapours arise from the waters and earth, and when they reach the cold middle region of the air are condensed into water, which, falling upon the earth, cools it; so also, the hot spirits carried from the heart to the brain with the blood, and there being cooled, are condensed into water, which again descends to the heart for the purpose of cooling it. He placed the seat of the rational soul in the heart, where it can exercise all its functions, and he therefore made the nerves (of the use of which, in sensation and motion, he was not ignorant) to arise from the heart. This opinion of Aristotle as to the heart being the seat of the soul, appears to be preserved, even to our own days, in the popular modes of expression, as when a man of a good disposition is said to have a good heart, and the writers on moral science speak of "the cultivation of the heart."

It would appear, that anteriorly to Aristotle, Hippocrates had formed a more correct opinion as to the functions of the brain, for in his book 'de Insania,' he observes, that that man is sane whose brain is undisturbed; although, in another book, 'de Corde,' referred, however, to the spurious works, he places the mind of man in the left ventricle of the heart. Plato, the preceptor of Aristotle, also thought differently, for he recognised three distinct faculties of the mind, having three distinct seats: one was the concupiscent, whose seat was in the liver; the second, the irascible, seated in the heart; the third, the

[1] De Animal. partib., lib. ii, cap. vii.

rational, seated in the brain. In this doctrine he was followed by Galen, Vesalius, Fernelius, and others, who hence acknowledged three spirits: the natural, which pass from the liver with the blood; the vital, which are carried from the heart to every part of the body through the arteries; and the animal, which are transmitted from the brain through the whole body by means of the nerves.

SECTION II.—THE OPINIONS OF GALEN.

Erasistratus and Herophilus abandoned the doctrine of Aristotle their master, as to the functions of the brain; the former taught, when young, that the sensory nerves arise from the meninges, and the motor from the cerebrum; but when old, he taught that both classes of nerves arise from the medullary matter of the brain; that the animal spirit was from the head, the vital from the heart. Herophilus maintained, that the ventricle of the cerebellum, the calamus scriptorius, is the chief of all the ventricles of the brain, and that the nerves of volition spring from the brain and medulla spinalis. The most important doctrines, however, are those laid down by Galen in the books *de placitis Hippocratis et Platonis* and *de usu partium*, and which it will be well to notice more in detail.

In the first place, Galen refutes the doctrines of Aristotle, by showing that the refrigeration assigned to the brain is abundantly effected by the respiration; that he himself had always found the brain of animals hot to the touch; and that it must be so, is proved by the numerous blood-vessels distributed over the pia mater and throughout the brain. Moreover, in contradiction to the assertion of Aristotle, that all the organs of the senses are not centered in the brain, he shows that nerves are given off to both ears, to both sides of the nose, to both eyes and their motor muscles, and not only four to the tongue, but also nerves to the pharynx, larynx, gullet, and all the viscera, as well as all parts of the face. Consequently he asks, if the brain be only a refrigeratory, of what use are the various parts of the brain, as for example, the choroid bodies, the retiform plexus, the pineal gland, the pelvis, the infundibulum, the fornix, the processus vermiformis, the two meninges, their processes to the spinal marrow, and the branches of the nerves? It would have been sufficient for the purposes of refrigeration, if the brain had been made like a rude and formless sponge, nor need there have been so much artificial construction as is found in the brain.

Subsequently, when he is about to indicate generally the use of the cerebrum and cerebellum, he observes that the brain is of the same substance as the nerves, but softer, as it necessarily should be, inasmuch as it receives all the sensations, perceives all the imaginations, and then has to comprehend all the objects of the understanding, for what is soft is more easily changed than what is hard. Since double nerves are necessary, the soft for sensation, the hard for motion, so specially also the brain is double, the anterior being the softer, the posterior the harder, which is also termed *parencephalis*. These two cerebra are, therefore, separated from each other by nature, because it would not be at all safe, that the soft should be exposed to the contact and pressure of the hard.

The use of the anterior or superior ventricles, he says, is as follows: Firstly, to receive air through the nostrils, the ethnoid bone, and the mamillary processes, and mixing this with the vital spirit brought into the ventricles through the arteries from the heart, to prepare the animal spirits transmitted from the brain to the nerves for the purposes of motion and sensation. Moreover, that the brain had a double movement:—a diastolic, by which it receives the air and vital spirit into the ventricles; and a systolic, by which it distributes the animal spirits to the nerves. Secondly, by the same entrance, sensible objects, and objects of the faculty of smell, are introduced. Thirdly, the excrementa from the bodies contained in the ventricles collect there, the accumulation of which excites apoplexy, unless a suitable outlet be provided; this, however, is double, the one through the meatus of the nostrils, the other through the infundibulum, or pituitary gland, with its two ducts opening into the palate and cavity of the mouth. The superior ventricles are double, in the same way as other parts are ordained to be double by nature, for the purpose, doubtless, that if the one suffers, the other may serve; for this reason, also, the brain is double, and every sensorium is double. He mentions the case of a youth he saw at Smyrna, to prove the usefulness of double ventricles: this youth had one ventricle wounded, and was thought to have escaped death by the help of God, but Galen says that he certainly could only have lived a short time, if he had been wounded in both ventricles.

The animal spirits, he says, are transmitted from the anterior ventricles to the fourth through the opening, now termed the aqueduct of Sylvius. But he afterwards says, (*lib.* 8, *de usu partium*,) that the animal spirits are not contained in the ventricles only, but are diffused throughout the whole substance of the cerebrum and cerebellum.

The use of the fornix, to which also the corpus callosum belongs, is the same, he says, as of the arches of buildings; namely, to support commodiously and safely the whole of the superjacent part of the brain.

The eminences, termed nates and testes, and the vermiform process of the cerebellum, serve to open and shut the passage by which the animal spirits are transmitted from the anterior ventricles to the posterior ventricle. Some have attributed this function of a janitor to the conarium [pineal gland] also, but erroneously, since it is not a portion of the cerebrum, but merely a gland, and hence, doubtless, the conarium has the same functions as other glands, namely, to support the ramified veins amongst which they are introduced.

He agrees with Erasistratus in the opinion, that the plexuses and convolutions are larger in man than in other animals, but he does not admit that the intellect of men depends on this, because asses also have a brain much convoluted.

Although Galen asserts *passim*, that the function of the nerves consists in transmitting the animal spirits from the brain to the other parts of the body, for the purposes of sensation and motion, because parts are deprived of motion and sensation when the nerve is cut, tied, compressed, bruised, or affected with scirrhus, still he does not appear to have been quite certain as to the correctness of his doctrine, since he raises some doubts in the seventh book *de Placitis Hipp. et Platonis.* Firstly, whether the nerves contain animal spirits like the cavities of the brain? Secondly, whether this spirit is innate in the nerves, and when a limb is to be moved, is excited only when acted upon by the spirit contained in the cerebrum? Thirdly, whether this spirit be innate in the nerves at all, but rather when we seek to move a limb, whether it does not flow from the brain into the nerve? Fourthly, whether the matter of the spirits flows into the nerves from the brain in any way? or is it not rather its force, virtue, or faculty, just as the substance of the sun remaining motionless, its light-giving property is poured forth into the ambient air? He observes, however, that he cannot decide absolutely on these questions, but only proposes them for general discussion.

SECTION III.—THE FOLLOWERS OF GALEN.

The Arabs distributed the animal functions amongst the ventricles of the brain, so that one of the anterior ventricles they made the seat of common sensation, the other of the imaginative faculty, the third ventricle was the seat of the understanding, and the fourth of memory. This was also the doctrine of Benivenius, who, in confirmation of it, relates the case of a certain thief, often caught stealing, who never remembered his previous offences; after death it was found that he had no cerebellum. This doctrine was also maintained by Duns Scotus, Thomas Aquinas, and other theologians; and although disavowed by Vesalius and other physicians, was again adopted by others.

The Italian and other anatomists who flourished after the Arabians and the revival of learning, scarcely deviated from Galen's views in assigning the function of the nervous system, and in particular of the encephalon. Berengarius, Massa, Fernelius, Vesalius, Stephanus, Fuchsius, Columbus, Valverda, Fallopius, Coiter, Vidus Vidius, Varolius, Felix Platerus, Piccolhomineus, Laurentius, Riolanus, Spigelius, Cartesius, &c., agree with Galen *passim*, although some have their peculiarities. Fernelius followed the doctrine advocated by Erasistratus in his youth, that the sensory nerves arise from the membranes and the motor from the substance of the brain. Vesalius was not anxious to determine whether the animal spirit is conducted through certain channels of the nerves, or along the sides of the nerves, or whether the vis cerebri reaches the parts merely by the continuity of the nerves. Fallopius denied that the brain is moved by a systole and diastole, since he had never witnessed the movement, either in animals or in wounded men. Columbus said that the use of the circumvolutions of the brain was for the sake of lightness, so that it might the more readily be agitated by systole and diastole; and that the animal spirits derived from the air drawn in through the nostrils and commingled with the vital spirit, arise into the upper ventricles from the motion of the brain and of the plexus choroides; this he published as his own discovery, for which he was reproved by Piccolhomineus. Des Cartes maintained that the animal spirits were secreted from the brain through pores opening into the ventricles, and that there accumulating, the slightest disturbance of them excites the soul seated in the pineal gland; and contrarily that the animal spirits in the ventricles are moved by the will acting through the pineal gland, and distributed thence through the nerves to all parts of the body.

SECTION IV.—THE ANIMAL SPIRITS ARE DISLODGED FROM THE VENTRICLES.

Caspar Bauhin was amongst the first who denied that the ventricles are the laboratory and storehouse of the animal spirits, and who taught that these are generated in the substance of the brain, and dispensed directly from thence through the nerves to the organs of sensation and motion. He maintained that the ventricles are more properly accidental structures, which have no other use than to receive the excreta and residuum formed in the nutrition of the brain and in the production of the animal spirits, and to pass them away through the infundibulum to the fauces. Platerus, Varolius, Spigelius, Moebius, &c., were also of this opinion.

Caspar Hoffmann, Professor at Altorf, more particularly opposed the ancient doctrine as to the use of the ventricles in preparing and retaining the animal spirits, and used six leading arguments against it, which he considered to be wholly irrefragible. 1st. That all the nerves of the body and cerebrum arise from the spinal cord, either within or external to the cerebrum. 2dly. That if it be necessary to the action of the spirits that they be under the control of the mind in the vessels, what compels them into the straits of the nerves after having entered into the ocean of the ventricles? 3dly. That the ventricles are lined internally with the pia mater which prevents ingress and egress. 4thly. That since the two superior ventricles open into the third, and the third into the infundibulum, and this into the palate, who will say that the spirits might not pass out by this way? 5thly. That the ventricles are not continuous with the nerves, but with the body. 6thly. That the ventricles have already a function incompatible with that of the spirits, namely, to collect and excrete the effete matters. These arguments, whatever validity they might have, were sufficient to lead many from the doctrines of Galen, and to convince them that the ventricles of the brain are not the factories and storehouses of the spirits, but only established for the collection and expulsion of the effete matters. Riolanus the son,[1] endeavoured to remedy this neglect of the doctrine, and tried to weaken and explode the arguments of Hoffmann, and while he defended the doctrine of Galen, he in some measure adopted that of Aristotle. He taught that the animal spirits are generated from the vital in the ventricles of the brain alone, and diffused thence through the whole cerebrum; that the air inspired through the nostrils does not enter the ventricles, nor is it mixed with the spirits, but being diffused round the dense membrane [dura mater] cools the brain, as the inspired air cools the lung; and that the convolutions are so constructed for the sake of lightness and the distribution of the arteries. He more particularly blamed Hoffmann, and charged him with ignorance, because that by his new dogma he unsettled both the whole pathology and therapeutics of the brain, for he fixed the seat of epilepsy and apoplexy in the whole substance of the brain, and not in the ventricles, as Galen taught. And this argument is that with which physicians are accustomed to meet new dogmas, when opposed to their own, even if true, lest they should be compelled by shame to unlearn when old those things which they have learnt in youth. Harvey was met with almost a similar argument, and considered as an audacious man, a disturber of medical peace, and a seditious citizen of the medical republic, who first dared to unsettle the doctrine established by unanimous assent for many ages, confirmed by the writings of so many physicians, and handed down, as it were, from generation to generation, as if no one knew any thing for so many ages.[2]

Wepfer fully refuted Riolan in his 'Auctarium Historiarum Apoplecticorum et Exercitationis de loco Apoplexia affecto,' and duly interred the doctrines as to the use of the ventricles in producing and retaining the animal spirits.

[1] Enchirid. Anat.

[2] In Zacchar. Sylvii præfat. ad Harveii Exercit. Anat. de Circulatione Sanguinis. *Vide* Biblioth. Anatom. Mangeti.

SECTION V.—ANOTHER OFFICE ATTRIBUTED TO THE VENTRICLES OF THE BRAIN BY GALEN, IS ALSO SHOWN TO BE ERRONEOUS.

After it had been fully decided, that the animal spirits are not generated in the ventricles of the brain, nor generated in the brain, to be collected in the ventricles, still all believed in this use of the ventricles at least, that they are cloacæ, and receptacles appointed to receive the effete matters which flow towards the ventricles after the secretion of the spirits and the nutrition of the brain. They asserted that the finer portion of these excreta escape through the sutures of the cranium, but that the denser portion trickle down partly through the mamillary processes and cribriform bone into the nostrils, partly through those peculiar ducts pointed out by Galen and Vesalius, which lead from the pituitary gland through the sphenoid bone to the fauces. It then became the theory of the day, that these effete matters passing down continually formed the mucus of the nostrils and fauces; coryza and catarrh were said to be caused by these effete matters trickling down more freely and in larger quantity, and that the brain in those affections purged itself from humidities, which if left to accumulate in the ventricles, induce cold in the head, vertigo, headache, epilepsy, apoplexy, &c.

Conrad Victor Schneider, professor at Wittenberg, whom Haller has praised in the highest terms,[1] essayed to refute these errors in the happiest manner by means of anatomy. In his tract 'De Osse Cribriformi,' he combats by dissection two epidemic errors, as Haller terms them, the one which taught that odoriferous particles enter the ventricles of the brain, and there excite sensation; the other, that the effete matters descend from the brain through the cribriform bone; for the olfactory nerves are not hollow in man, as they are in brutes. In his work 'De Catarrhis,' he fully demonstrates by anatomy, that nothing could pass from the nostrils into the ventricles of the brain, neither air nor fumes, because all the foramina of the cribriform bone are closed, and the dura mater adheres strongly everywhere to the bones and also to the cribriform plate; that nothing could pass down to the fauces through the infundibulum, through the pituitary gland, or through its

[1] Bibl. Anat., tom. i, p. 413.

imaginary ducts; that no vapours could exhale from the ventricles through the sutures of the cranium; that catarrhs never collect in the ventricles of the brain, but have their seat in the pituitary membrane of the nares and fauces, which, from being more exactly described by him, was called the Schneiderian membrane. In confirmation of this, he states a case of coryza equina, in which both the anterior and posterior portion of the pituitary membrane was affected, but the mamillary processes of the brain were perfectly healthy.

This demonstration by Schneider, however lucid, could not convince every one, and there were still some who preferred the old doctrine; amongst these, were Diemerbroeck, Bartholin,[1] and Otto Horstius.[2] Lower,[3] Willis and others, were convinced indeed, that nothing could pass from the ventricles to the nostrils, or trickle through the infundibulum and pituitary gland to the fauces, but they thought, nevertheless, that the serum of the ventricles passed through the infundibulum to the pituitary gland, and hence through peculiar ducts to the jugular veins, where it was mixed with the blood. With these Adolphus Murray may be classed,[4] who found the infundibulum hollow, and transmitting a serous fluid from the ventricles; but what change this serum underwent in the pituitary gland he found it difficult to say; yet he affirms that he once found two ducts, which arose on each side of the pituitary gland, and terminated in the cavernous sinus. He therefore thought it possible, that the superfluous serum of the brain might pass off by this route; but on his repeating the experiment, he did not succeed in finding these ducts. The opinion of Haller as to this controversy,[5] whether the infundibulum be hollow or solid, is, that we must agree with Murray, who found it hollow, but that he strongly suspected the two ducts passing from the pituitary gland to the cavernous sinuses were only veins; nor, in fact, do the ventricles require a special outlet, by which the serum may be evacuated, because in every part of the body a secreted vapour is reabsorbed by its proper veins,

[1] Anat. Reform.
[2] Presid. Slevogtio defendit. *Vid.* Halleri disput. Anat., tom. ii, p. 849.
[3] Tract. de Corde, Capite de Catarrhis.
[4] Dissert. Inaug. de Infundibulo Cerebri, &c. Upsal, 1772.
[5] De Usu et Fabrica Part. Corp. Human., tom. viii, p. 92, &c.

and just as the fluid of the pericardium, thorax, abdomen, scrotum, generated from the arterial exhalation, does not require special excretory ducts, but is absorbed by the absorbent veins, so also beyond all doubt, is it with the fluid of the ventricles of the brain. Haller conjectures, with probability, that the pituitary gland is an appendix of the brain, as in fishes he has seen filaments like those of nerves to pass out of it.

SECTION VI.—IT IS PROPOSED, WITH OTHER SPECIAL FUNCTIONS OF THE NERVOUS SYSTEM, THAT THE CORTICAL PORTION OF THE BRAIN BE SUBSTITUTED FOR THE VENTRICLES AS THE PART WHERE THE ANIMAL SPIRITS ARE SECRETED, AND THAT THE MEDULLARY MATTER HAS THE FUNCTION OF COLLECTING AND DISTRIBUTING THEM TO THE NERVES.

The animal spirits, being ejected from the ventricles, were placed in the cerebral substance; so that Malpighi, Willis, and Sylvius de le Boi, were unanimous that they are secreted in the cortical substance of the brain; that, when secreted, they are received into the medullary substance, and distributed thence through the nerves to the whole body; and this doctrine is maintained by many physiologists and pathologists to the present day. The faculties of the mind, such as perception, imagination, understanding, and memory, were banished from the ventricles together with the vital spirits, and were located by some in the solid mass of the brain; by others were affirmed to be properties of the immaterial and rational soul alone, and in no wise dependent on the body. Lest I should weary the reader by a lengthened enumeration of the almost innumerable authors of this opinion, I will only adduce the doctrines of Malpighi and Willis, and then state, in general terms, how far their successors followed these celebrated men, and how far they departed from their doctrine.

Marcellus Malpighi, in his letters to Fracassatus, 'De Cerebro et Cortice Cerebri,' maintains that the cortical portion secretes, by means of a glandular structure, which he pretends it contains, a coagulable serum from the arterial blood, and that it is necessary to sensation and movement, that this fluid be transmitted from the cortical to the medullary matter. It does not seem possible to him, that there can be a reflux of this serum in the nerves to the brain so as to cause sensation, since the new serum perpetually secreted resists the retrograde movement.

He confirms the ancient opinion of Plato, that the brain is an appendage to the spinal cord, in which medullary fibres, collected together, radiate towards the brain, until they end in the cortical portion, just as the fibres in the stem of a cauliflower radiate into the leaves. Confirmatory of this doctrine are the small brain and large spinal cord of fishes. Fracassatus also adopted this opinion, and Thomas Bartholin, in his 'Anatome quartum renovata,' says this opinion is both new and peculiar, and that by it he can understand how fishes, on account of their small brain, are dull as to sensation, but agile as to movement, from their large spinal cord; especially since in the incubated egg also the anterior part of the brain is developed at a much later stage than that in which if the chick be touched it contracts. It is well known, however, that Plato had already stated, that the spinal cord is first formed, and the brain is an appendix to it.[1]

Thomas Willis, a celebrated member of the chemical sect, advanced, with some ingenuity, many new hypotheses as to the uses of the nervous system; with these he commingled some ancient doctrines, as for example, that serous effete matter in the ventricles trickles partly through the olfactory nerves into the nostrils, partly through the infundibulum to the pituitary gland, and thence by peculiar ducts to the veins which return the blood to the heart from the brain; he also agreed with Galen in considering the use of the fornix to consist in supporting the hemispheres. His own peculiar doctrines chiefly are: that the cerebrum subserves to the animal functions and the voluntary motions, the cerebellum to the involuntary; that a perception of all the sensations takes place in the ascending fibres of the corpora striata, and that through the descending, voluntary movements are excited; that the understanding is seated in the corpus callosum, and memory in the convolutions, which are its storehouses; that the animal spirits are generated in the cortex of the cerebrum and cerebellum from the arterial blood; that they collect in the medulla, are variously distributed and arranged to excite the animal actions, and distil through the fornix as if through a pelican: that the animal spirits secreted in

[1] Haller, Bib. Anat., tom. i, p. 30.

the cerebellum are ever flowing, equably and continuously, into the nerves which regulate involuntary movements; but those of the cerebrum tumultuously and irregularly, according as the animal actions are vehemently performed or quiescent. To excite sensation, the spirits flow along the nerves to the brain. He distinguishes between a thick nervous fluid, suitable to nutrition, and the extremely volatile animal spirits, subservient to sensation and movement, and commingled in the preceding as their vehicle. He maintains, that there are two souls in man, the one rational, the other corporeal; the latter alone is given to brutes. The corporeal, or brute soul, consists partly of a fiery or sulphureous element, which is located in the blood; and partly of an ethereal element, which is the animal spirit secreted in the cerebrum. That the corporeal soul, thus composed, forms a fœtus from the semen of the parents like to the parents, increases with the body, preserves the body until death, causes the perception of sensations in the corpora striata, and thence reflected, excites desires and voluntary movements; in the corpus callosum excites imagination, and in the convolutions memory. It differs from the rational soul in this, that the latter uses the corporeal soul as the instrument whereby it performs all things more quickly and readily in man than they are done in brutes, and because in virtue of the rational soul man is rendered capable of contemplating things not belonging to the senses, as God, angels, himself, infinity, eternity, &c. He explains the unity of the nerves by their communications and connections with each other, or their anastomoses, as anatomists term them: and he also explains, that the union of the cerebrum and cerebellum is attained by the tubercula quadrigemina, or nates and testes. As to the loops of nerves with which the arteries here and there are encircled, he states their use to be, to relax or close the arteries, and thus during various emotions of the mind to admit the blood in greater or less quantity to certain parts. He decided that the pineal gland is not the seat of the soul, but a lymphatic gland, having no relation with the substance of the brain, which absorbs lymph, and carries it off again through other vessels, and keeps the plexus choroides expanded.

His successors, especially of the school of Boerhaave, embraced some of these doctrines of Willis, but some were exploded.

For example, it was shown by anatomy, that all the nerves are not of involuntary motion which arise from the cerebellum, as the fifth pair of cerebral nerves is wholly derived from the medulla of the cerebellum, the pons varolii. Ruysch, in opposition to Malpighi, earnestly endeavours to prove, by his injections, that the cortex of the brain is not glandular, but consists of parallel vessels: however, Albinus clearly showed, that it was not altogether vascular. Mayow attempted to show, that the animal spirits consist of nitro-aërial particles; Boerhaave, that they consist of a very refined aqueous fluid, having also a nutrient property, which was disputed afterwards by Haller. Some thought they are æther, some electron; Vieussens placed the seat of imagination in his centrum ovale; Lancisi and Peyronie maintained, that all sensation is felt and motion excited in the corpus callosum. Meyer placed the seat of memory in the cortical matter, sensation at the origin of the nerves, and abstract ideas in the cerebellum; many, however, acknowledged that it was not possible to determine the seat of the mental faculties with any accuracy, although there could be no doubt that nature had not formed so many and so various divisions of the cerebrum and cerebellum without an object. Haller thought that the only prospect of attaining to any knowledge of the uses of these portions (if it were possible) was in diligently availing ourselves of every opportunity for dissecting fatuous, oblivious, or maniacal persons, or in accurately comparing the cerebra of animals whose faculties are well known with the human brain, &c.[1] Meckel, Gasser, and others agreed with Willis in affirming, that the consentience of the nerves is effected by the communicating branches; Whytt, Kaauw, Astruc, objected to this doctrine, and maintained that consentience takes place in the sensorium commune only, and Haller adopted this opinion. Haller, and some of his disciples, amongst whom the celebrated Meckel, also conjectured that the nervous loops had the function attributed to them by Willis, but Haller subsequently retracted this opinion, being taught by his own experiments, that nerves when torn or irritated do not contract in the least. Vieussens, Ridley, Nuck, and others, following Willis (and this indeed was the opinion of Galen) classed the pineal gland with the lymphatic glands.

[1] Elem. Phys., tom. v, p. 529.

Nuck plainly subscribes to this doctrine in his 'Epistola Anatomica de novis inventis;' but, however, in the present day we are certain, that the pineal gland is really a part of the cortical substance of the brain, connected by two medullary peduncles with the thalami nervorum opticorum, and, consequently, not a lymphatic gland.

The ganglia of the nerves were known to Galen, Fallopius, Eustachius, and Willis, but their function was first taught by Vieussens; who considered them to be receptacles of the animal spirit, in which it could be nourished, preserved, and rectified, by the arterial blood flowing through them; others, however, amongst whom was Winslow, looked upon them as little brains, from which fresh animal spirits are secreted, and new nerves given off. Lancisi assigned to them a muscular coat, by which the animal spirits contained in them might be impelled forwards; Tarin considered them to be accidental callosities; Meckel and Zinn were of opinion that they divided the larger nerves into smaller, and gave them another direction. Johnstone maintained that ganglia were peculiar to those nerves not subject to volition. Various objections were raised against this doctrine, especially by the illustrious Haller, and Haase, but Tissot and Pfeffinger approved of it. There will be an opportunity of discussing this again; and since Tissot has fully treated of the matter in his work on the nerves, I will not abuse the patience of the indulgent reader by the repetition of things well known.

SECTION VII.—THOSE WHO HAVE DENIED THE EXISTENCE OF ANIMAL SPIRITS.

The existence of the animal spirits being received, from the most remote period, descending by tradition, as it were, no one proved or attempted to prove it as it ought to be. Celebrated men began, however, to call in question the existence of these animal spirits, especially since the doctrine seemed to be a gratuitous assumption; amongst whom were Argenter, Alexander Benedictus, Quercetanus, Nymman, Fernel, Avicenna, Felix Plater, Helmont, Cabroli, Back, Bidloo, Lister, Brini, Parisinus, and many others: of these some attempted to substitute for the discarded hypothesis one not more demonstrable, namely, that the nerves acted as solid tense-cords, alternately contracting and relaxing, or only oscillating. But it was easy to demonstrate to these, that the nerves are soft, pulpy, and not tense-cords, and therefore unsuitable to the functions assigned to them: this hypothesis being rejected, the authority of the other, as to the animal spirits, increased. In the next place, opponents of the animal spirits were found in the Stahlians, who maintained that all the functions of the nerves depended directly on the soul, and who rejected the animal spirits (whose existence was not proved) as useless. But the defenders of the animal spirits silenced these opponents also, not by proving the existence of the spirits, but because they overturned the foundations of the Stahlian doctrines, which, it appears to me, Haller especially accomplished. After this second victory over the opponents of the animal spirits, some distinguished men of the mechanical school attempted to prove their existence by various and far-fetched arguments; the principal were Boerhaave, Haller, and Tissot, the latter plainly endeavouring to establish the hypothesis as a truth. Notwithstanding the authority of these great names, the love of truth excited distinguished men, who advanced doubts as to this hypothesis of the animal spirits, and who showed that the arguments adduced in its favour proved nothing when carefully analysed, and that the whole hypothesis was altogether devoid of truth. Of these the illustrious Caldani, so highly esteemed by Haller, on account of his great merit in medical art, led the way; and whose arguments have, I think, the greater weight, because, although a most dear friend to Haller, yet led by the love of truth, he did not hesitate, in this case, to think and act in opposition to him. Afterwards Metzger,[1] Azzoguidi,[2] Mayer,[3] Michelitz,[4] Marzari,[5] and Fiorati, in the notes to his Italian edition of 'Tissot on the Nerves,' joined their arguments to undermine and entirely overthrow the hypothesis; and if we consider these with a mind free from prejudices, we cannot but forget the hypothesis as we would a dream, and be excited to inquire after truth in another way than through hypotheses and conjectures.

[1] Adversar. Med.
[2] Instit. Med.
[3] Abhand. vom Gehirn, Rückenmark, und Ursprung der Nerven.
[4] Scrutin. hypoth. Spirit. Anim.
[5] Dissertazioni Accadem. delle Ipotesi, &c.

SECTION VIII.—THE FUNCTIONS OF THE NERVOUS SYSTEM ARE EXPLAINED BY THE VIS NERVOSA.

At length we abandon the Cartesian method of philosophising in this part of animal physics also, and adopt the Newtonian, being persuaded that the way to truth through hypotheses and conjectures is tedious and altogether uncertain, but far more certain, more excellent, and shorter, through the inductive method. Newton designated the mysterious cause of physical attraction by the term vis attractiva, observed and arranged its effects, and discovered the laws of motion; and thus it is necessary to act with reference to the functions of the nervous system: we will term the cause latent in the pulp of the nerves, producing its effects, and not as yet ascertained, the *vis nervosa*: we will arrange its observed effects, which are the functions of the nervous system, and discover its laws; and thus we shall be able to found a true and useful doctrine, which will undoubtedly afford a new light, and more elegant character to medical art. The illustrious Haller has already used the phrase *vis nervosa*, in designating the agent which the nerves employ in exciting muscular contractions; but the celebrated and ingenious J. A. Unzer has thrown the greatest light on the subject;[1] for although he continues the use of the term animal spirits, that he may the more conveniently and intelligibly express himself, yet, as he himself observes, his whole system is complete without them.[2]

[1] *Vid.* Grundrisz eines Lehrgebäudes von der Sinnlichkeit der thierischen Körper, &c. 1768. Also, Erste Gründe einer Physiologie der eigentlichen thierischen Natur thierischer Körper, 1771.

[2] Prochaska thus explains in what sense he uses the term *vis nervosa*, in the "Address to the Reader," prefixed to the edition of this dissertation, published in his 'Opera Minora,' part 2. (Vienna, 1800.) "I had already (in 1780) published this dissertation, in the third fasciculus of my '*Adnotationes Academicæ*;' at which time many philosophers, and the distinguished Tissot himself, still used the hypothesis of a nervous fluid, to explain the functions of the nervous system in accordance with the opinion of Boerhaave. Convinced of the insufficiency of this hypothesis, I resolved to use the inductive method in this dissertation, and explain those functions by facts only; using the term 'vis nervosa' to designate that agent (as yet unknown) by which the nervous system is rendered fit for the performance of its functions, and which I have used more extensively in my public lectures, and in my institutes of human physiology ('Lehrsätze aus der Physiologie des Menschen,' 1797)."—ED.

CHAPTER II.

THE NERVOUS SYSTEM IN GENERAL.

SECTION I.—WHAT PARTS IT INCLUDES.

The nervous system, as well in man as in the animals in any way related to him, comprises the cerebrum, cerebellum, medulla oblongata, medulla spinalis, and all the nerves distributed thence to every part of the body. These divisions are manifestly dissimilar in structure; those portions whose functions are more numerous and complicated seem to require a more composite and complicated structure than those whose functions in the animal economy are of a simpler kind; in particular, the brain of man is larger and of a more complex structure than the cerebellum, and other portions of the nervous system. This large cerebrum is divided into two hemispheres, united in the middle principally by the corpus callosum: the gray cortical matter entirely surrounds the white internal medullary matter, which is in much greater quantity in the cerebrum than in the cerebellum: the external surface appears as if divided into convolutions, having a resemblance to the intestines. The cerebrum has three cavities, or ventricles, in the two superior of which are seen the plexus choroides, then the corpora striata and thalami nervorum opticorum; behind these, are the pineal gland and corpora quadrigemina. The septum lucidum divides these ventricles, beneath which is the fornix divided posteriorly into two crura, termed pedes hippocampi and cornua ammonis. In the third ventricle, are the anterior and posterior commissures; also, posteriorly, the opening into the fourth ventricle, which is in the cerebellum, and, anteriorly, the orifice into the infundibulum, which is inserted into the pineal gland. Posteriorly to the infundibulum, are seen the corpora mamillaria, and here are also situate the two great crura cerebri into which all the medullary matter from both hemispheres seems to be collected. The cerebellum is much less than the cerebrum, and presents on its surface highly-curved and slender convolutions; its medullary matter is much less in proportion to the cortical than in the brain, and gives off its medulla, partly upwards to the corpora quadrigemina, and partly downwards to the medulla oblongata, but principally to the pons varolii of which it constitutes the greater portion. Beneath the pons varolii the *caudex medullaris* takes its origin, and passes through the occipital foramen. It has been specially designated the medulla oblongata by late anatomists, and consists of the anterior and posterior pyramids, with the olivary bodies between them, in which the cortical matter is so peculiarly interwoven, that a transverse section of an olivary body presents serpentine lines, having somewhat the appearance of a small tree. The composition of the medulla oblongata is of a simpler character; it is a thick nervous cord, occupying the cavity of the vertebral column: on its anterior surface there is a groove (some call it a fissure) which divides it perpendicularly into two columns, internally in its centre there is, as some think, something of a cortical substance. The origin of the nerves of the brain, and of the medulla spinalis, is different as to situation and size, more simple in some, in others compounded of many roots; of these are some which are enlarged near their origin by a ganglion, as in the fifth pair of cerebral nerves, and in all the spinal nerves, but others more distantly, as is particularly the case in the intercostal nerves. As to other points, all the nerves passing out from the cranium and vertebral canal are furnished with a double investing membrane, and contain a continuation of the medullary substance of the brain and spinal cord, but are of a firmer consistence. In their course to various parts, the fasciculi of which they are composed enter into remarkable plexuses and connections, until they terminate variously in various parts; in the eye, the optic nerve expands into a membrane; in the ears, in the Schneiderian membrane, in the papillæ of the tongue, in the skin, in muscles, and in various secreting viscera they probably terminate differently; but as to this point nothing is known, for they escape the most acute vision.

All these portions of the nervous system, which I have only cursorily enumerated for the sake of brevity, and of which anatomy furnishes an accurate description and delineation,[1]

[1] Monro, Winslow, and Haller, have published most accurate descriptions of the nerves; and their works are so well known and received with such general approval,

abundantly shows how wonderfully and diversely the machine of the nervous system is constituted, and how skilfully protected; and if it be compared with any other part or organ of the body, testifies that nature nowhere else has adopted such a variety and number of parts, nowhere else framed such singular forms, nowhere else used such a delicate and fragile material, no other structures so skilfully protected as that system; whence it follows that its functions in the animal economy must be of the highest importance, and at the same time the most complicated. However composite the machine of the nervous system may be, I think it may be divided into three portions, just as its functions are most conveniently arranged in three divisions: namely, in the first place, the animal organs, or the organs of the mental faculty, the cerebrum and cerebellum; secondly, the general sensorium which appears to consist of the medulla spinalis and medulla oblongata, together with that portion of the medulla of the cerebrum and cere-

that it would be superfluous to quote them. Besides these, a most accurate description of the nerves of the human body, containing all the recent discoveries appropriately arranged, may be read in the new Latin edition of the 'Institutiones Neurologicæ,' 1781, by Martini, President of the Royal Academy of Sciences of Sweden, and formerly Professor of Anatomy and Surgery. They who desire to see correct delineations of the nervous system, may consult, for this purpose, the 17th to the 23d inclusive of Eustachius's plates, and the 'Anatomica Adversaria' of Tarin (Paris, 1750). Mayer, the celebrated anatomist and professor of Frankfort, in his work entitled 'Anatomisch-Physiologische Abhandlung vom Gehirn, Ruckenmark, und Ursprung der Nerven' (Berlin, 1779), as also in another on the vessels of the human body, has published most beautiful and accurate views of the cerebrum, medulla oblongata, and medulla spinalis, together with the origin of the nerves. Consult also the excellent work of S. T. Soemmering, 'De Basi Encephali et Originibus Nervorum Cranio Egredientium' (Göttingæ, 1778). The celebrated Meckel, in his 'Tractatus de quinto pare Nervorum Cerebri' (Gött., 1748), and his tract 'De Nervis Faciei' (Berolini, 1755), has dissected the most minute filaments with inimitable skill, and most admirably depicted it. Neubauer, Professor at Jena, snatched away by premature death, published (1772) a work entitled 'Sectio prima Nervorum Cardiacorum,' which could only have come from the hands of one equally skilled as an anatomist and draughtsman; also Camper's 'Demonstrationes Anatomico-Pathologicæ;' Lobstein's 'Dissert. de Nervo Spinali ad par Vagum Accessorio' in Sandifort's Thesaurus, 1: George Asch's 'Diss. de primo pare Nervorum Spinalium; Wrisberg's 'Observ. Anatomicæ de 5to pare Nervor. Cer.' (Gött., 1777); Boehmer's 'Commentatio de nono pare Nervor. Cerebri (Gött., 1777). To these might be subjoined my tract 'De Structura Nervorum' (Viennæ, 1779). Consult also Ludwig's 'Dissert. de Cinerea Cerebri Substantia' (Lipsiæ, 1779), and the beautiful plates of the nerves lately published by Walther, Professor at Berlin.

bellum, from which the nerves directly arise; and, thirdly, the nerves distributed from the general sensorium to all parts of the body.

SECTION II.—HOW THE NERVOUS SYSTEM IS CONSTITUTED IN OTHER ANIMALS, AND HOW FAR IT EXTENDS THROUGH THE WHOLE ANIMAL KINGDOM.

That the nervous system is not constituted in all animals as in man, is proved by the observations of eminent men; but all the differences which the almost innumerable species of animals present, have not as yet been fully investigated: to observe and tabulate all would require almost an age, although much light might be hoped to be thrown by them upon the functions of the nervous system. Many of the able observers, who have undertaken the investigation of these differences by means of comparative anatomy, have directed their attention solely to the cerebrum, and the sum of their observations has been set forth by Ludwig, in his dissertation 'De Cinerea Cerebri Substantia.' For the sake of brevity, I will only glance at the more manifest differences derived from the trustworthy observations of distinguished men.

Man has the largest brain; all other animals have less, except certain apes, in which the brain is not less proportionally than that of man.[1] In fishes and animals of cold blood, the brain is so small, that some writers have not hesitated to look upon it as only an appendix to the spinal cord. There is a great difference in the structure and composition of the brain of animals: in many the olfactory nerves are thick and hollow, and termed mammillary processes, while the contrary is observed in man; the convolutions are absent in dormice and birds;[2] in birds and fishes, the thalami nervorum opticorum are hollow and distinct from the cerebrum; birds and many fishes have no true corpus callosum, or fornix, or pineal gland; according to the observations of Haller,[3] birds and fishes have bodies similar to the corpora quadrigemina, but of simpler character than those of quadrupeds. Other divisions of the brain, as the medullary and

[1] Haller, de Part. Corp. Hum. Fab., tom. vii.
[2] Ludwig, Diss. cit.
[3] Oper. Min., tom. iii, p. 214.

cortical substance, the ventricles, together with the calamus scriptorius, the plexus choroides, commissures, &c., are more constantly present, and from this Haller concludes that these divisions are the most essential.[1] The brain is of the simplest form in insects, in which there is little medullary matter, except at the origin of the optic nerves;[2] in some, it is bifid; in others, semibifid; and, in others, only a nodule, called a brain, little different from the nodules of the spinal cord.[3] When it is of this great degree of simplicity, it follows, that in the lowest class of insects it is altogether wanting, and these also have no eyes, according to Haller, nor does he think that in any animal, eyes are unaccompanied by brain, or brain by eyes.

It is manifest from these observations, that nature proceeds gradually from the most perfect and highly complex brain to the simpler and the simplest; and that at last animals exist altogether devoid of brain; but what variety is there in the nerves of various animals? or whether in all animals their structure, number of fibrils, plexuses, and ganglia are the same as in man? or whether (as it is probable) they become more simple? We have not as yet collected sufficient observations to answer these questions. What proportion the brain bears to other parts of the body has been attempted to be shown by observations and experiments, but what proportion the nerves bear, as well to the brain, as to those parts not nerves, remains unsolved. It was a conjecture only of Boerhaave and other distinguished men, who taught that the brain in the fœtus is larger in proportion to the rest of the body than in the adult, and that this is the case also as respects the nerves, of which they believed the whole fœtus, at its first formation, to consist, so that the bones, cartilages, ligaments, muscles, tendons, and all the viscera at their origin were merely nerves. Haller scouted this doctrine,[4] while many distinguished men adopted it too much, and he observes: "Nor do the nerves constitute the common material from which nature fabricates the other

[1] Oper. Min., tom. iii, p. 214.

[2] Haller, de Part. Corp. Hum. Fabr., tom. viii, p. 3.

[3] Ibid., p. 6.

[4] El. Phys., tom. iv, p. 271. Marherr also rejected the opinion in his 'Prælect. ad Boerhaavii Instit.,' tom. iii, pp. 9—11, &c.; and A. Murray, in his 'Diss. de Sensibilitate Ossium morbosa.' Upsalæ, 1780.

parts of the embryo, but from all time, doubtless, the bones, muscles, and membranes had each their own material."

Seeing that sensation and voluntary motion in man, and many animals, are obtained through the nervous system, we conclude from analogy, that all animals which feel and have voluntary motion, possess a nervous system; and so essential is that structure, that no animal exists without it, from man down to the smallest microscopic insect. Haller, however, correctly shows, that this analogy does not hold good, and observes,[1] that in some animals, as polypi and zoophytes, no nervous system has been discovered; and since these animals manifestly belong to the animal kingdom, their difference from vegetables does not consist in having nerves. Spallanzani more fully illustrates the abuse of the argument from analogy.[2] He says that if we examine the whole animal chain, it will appear to us at first, passing from man to quadrupeds, that each have their organs of digestion, circulation, various secretions; and each also their nervous system, muscles, bones, and organs of the senses; and although they diverge not a little from man as to form and structure, yet as they agree in their essential use, the analogy may still be allowed; but if we gradually descend to fishes, insects, and infusory microscopic animalcules, the force of the analogy is very much weakened or altogether lost, for we see that in insects, the bones, the heart, arteries, and veins, carrying red blood, are wanting; they have, besides, no brain, although endowed with nerves, and their organs of respiration resemble those of vegetables. But if we descend the animal scale still lower, we find creatures in whom this entire apparatus of organs is wanting, and which are entirely destitute of nerves as well as of brain. This is seen in such animals as many polypes, whose body is nothing more than an oblong sac made up of small granules; or such as many aquatic animalcules, whose whole body is simply a membrane, or vesicle; or such as many marine zoophytes, whose whole body consists only of a sort of simple jelly. This astonishing simplicity of structure induced Bonnet and Needham to conclude, that these animalcules are not true animals endowed with an immaterial sentient principle, but merely living entities endowed with irritability only. But they

[1] De Part. Corp. Hum. Fabr., lib. x, sect. vi, § 1.

[2] Opuscules de Physique Animal. et Vegetal., tom. i, chap. xii.

are clearly proved to be true animals by Spallanzani, who says: "I am much more inclined to look upon them as true animals, rather than as being solely vital and irritable, and I think my opinion well founded, because I find in them that union of qualities, which constitute (as I have previously stated) the characteristics of a true animal nature. I have already had occasion to state some of those qualities in my Essay, and I include among them the power of avoiding any obstacles, or individuals of their own kind, that they may meet with; of suddenly changing their course and taking the opposite direction; of passing suddenly from movement to rest, without any apparent external shock. I spoke of their darting towards particles in the infusions, of the property they possess of turning incessantly upon themselves, of going contrary to the course of the fluid, of going to the spots where a little moisture is left, and collecting there in numbers, when the infusion has been dried up." From these and other facts advanced by the author, it is manifest that these infusory animalcules feel, and have volition, and possess the character of the true animal; consequently, they are endowed with a sentient and volitional principle, however destitute they may be of a nervous system.

Such being the facts, it follows that a nervous system is not present in all animals, but that many insects have not cerebra, and that infusory animals and creatures much larger than these, are destitute of brain and nerves. But because these creatures feel and move voluntarily like other animals, we must not conclude that the nervous system in man and many other animals, is not the immediate instrument of sensation and animal motion. Man and other animals endowed with that system, feel and move by means of that system, nor, their organism being such as it is, would sensation and motion be possible without nerves. Insects, that have no cerebra naturally, are nevertheless endowed with nerves, and perform their functions by means of nerves only, and by the *vis nervosa* contained in them, which exists without a brain; and by this *vis nervosa* the acephalous fœtus lives in utero, and when born gives no slight signs of life. Polypes, zoophytes, and other infusory animalcules that have neither brain nor nerves, feel and move without a nervous system, because the Author of Nature appears to have endowed the pulp of which their bodies are composed with the faculty of sensation and motion; just as the medullary pulp of the nervous system alone, of all organs of our body, is endowed with that faculty, the muscular machine being an auxiliary hereto.

It cannot be correctly objected to these remarks, that insects have a cerebrum, and that a complete nervous system exists even in infusory animalcules, and that it is their minuteness alone which conceals them from our researches, however aided by the microscope, for Haller meets these objections at once with the statement,[1] that in the larger insects at least, in tæniæ, in sea-nettles, and other zoophytes, the cerebrum could scarcely escape observation, inasmuch as they are large, and their other organs are obvious enough, even without the microscope; and since we can distinguish nodules or globules in polypes by the microscope, and in others fibrils also, there seems no reason why the cerebrum should not be observed as well. Bohadsch clearly illustrates this in his description of the lernæa,[2] an animal six or eight inches long and three in breadth, which has many stomachs, an intestinal canal, sexual organs, a heart, and a circular spinal cord, furnished with many knots or ganglia, from which nerves are sent off to adjoining structures, but no cerebrum. It appears to possess very small eyes, but these probably are not true organs of vision. In this creature, in which so many organs are conspicuous, and the medulla spinalis itself, the cerebrum would be visible also, if there was anything more than the ganglionated spinal cord. In the fimbria, an animal six inches long, he detected a tubular mouth, œsophagus, stomach, furnished with muscular fibres, intestines, uterus, epididymis, but no eyes, or lungs, or heart, no vessels or nerves: he observes, however, that these may have escaped his observation. In the *hydra*, called by others *mentula maris* [holothuria], with a cylindrical body a foot long and an inch broad, he could not detect either heart, cerebrum, or spinal cord, nor any viscus except the œsophagus, intestinal canal, and anus. If then a nervous system can be discovered in much smaller animals, it would not have escaped observation in those of a sufficient size, if it had existed. Therefore, although nature produces sensation and animal motion in man and many other animals by means of a nervous system, there are nevertheless not a few creatures to which it

[1] De Part. Corp. Hum. Fabr., tom. viii, p. 2.
[2] De quibusdam Animalibus Marinis. Dresdæ, 1761.

has known how to assign these animal faculties without the aid of a nervous system: nay more; nature has granted even to certain irritable vegetables a sort of sensation and motion, analogous to the motion and sensation of animals, and that without a nervous system.

SECTION III.—WHAT IS UNDERSTOOD BY THE VIS NERVOSA, AND WHAT ARE ITS GENERAL PROPERTIES.

All the functions of the nervous system are as dependent upon its structure and nature, as the accurate indication of time upon the construction of the chronometer. In inquiring into the structure of the nervous system, our senses, however well assisted by the microscope, teach us nothing more than that the principal portion of it, the medullary, is supplied with numerous arterial and venous capillaries, distributed both to the cerebrum and to the nerves. We cannot say, however, that the whole is vascular, because, after the most successful injection of a coloured fluid into the cortical substance of the brain, and the medullary substance of the brain and nerves, the larger portion remains uninjected; and this is not vascular, but inorganic in a manner, being composed of a mass of very small globules as seen under the microscope, not unlike the globules seen to compose the whole organism of polypes and zoophytes, and the pulp of fruits. Albinus long ago refuted the doctrine of Ruysch,[1] that every part of the body is composed of nothing but vessels, by showing that in bone, cartilage, muscle, nerve, and in the medullary and cortical portions of the brain, there was a large proportion of matter which was not vascular. Malpighi seems to intimate the same opinion, with reference to the cortex of the brain, and also the medulla,[2] when he says, that he found no organisation in the cortex, except in the sanguiferous vessels with which it is pervaded; and if a parenchymatous substance should be at any time assigned to the brain, in which the vessels and other organised products might be supported, the cortex is the proper part, inasmuch as it would seem to resemble moss mixed with deep coloured clay. In another epistle, however, he tries to show that it is glandular.

If any reliance is to be placed on our senses, the structure

[1] Adnot. Acad., lib. iii, cap. i; et lib. i, p. 52.

[2] Epist. ad Fracassatum de Cerebro. In Bib. Anat. Mangeti.

of the medullary pulp of the nervous system is almost inorganic; but much is still wanting, to enable us to understand its admirable functions. We may assert, however, without fear of contradiction, that an invisible element enters into its composition, and that this constitutes the producing cause of all the functions of the nervous system. Since this is as mysterious and unknown as the *vis attractiva* of matter, it seems to me that it may be termed with propriety the *vis nervosa*. I leave the inquiry, as to its nature, to the very sagacious and ingenious men already engaged in philosophical experiments. I shall only attempt to determine some of its general properties, before I enter upon the special functions of the nervous system.[1]

1. *A stimulus is necessary to the action of the vis nervosa.*—i. Although this *vis nervosa* is a property inherent in the medullary pulp, it is not the chief and sole cause that excites the actions of the nervous system, but is ever latent, and exists as a predisposing cause, until another exciting cause, which we term stimulus, is brought to bear. As the spark is latent in the steel or flint, and is not elicited, unless there be friction between the flint and steel, so the *vis nervosa* is latent, nor excites action of the nervous system until excited by an applied stimulus, which continuing to act, it continues to act, or if removed, it ceases to act, or if re-applied, it acts again.

ii. *This stimulus is divided into stimulus of the body and of the mind.*—This stimulus is double: either it is some fluid or solid body applied internally or externally to the nervous system, and termed corporeal, or mechanical stimulus; or else is a mental stimulus present in a portion of the nervous system, and by means of this portion controls the rest of the nervous system, and the rest of the body, as far as it is allowed. Whether this mental stimulus takes place through a system of occasional causes, or pre-established harmonies [harmonia præstabilita], or, as assumed by many, by a physical influx, matters little to our object; it is sufficient for us that the soul can excite the nervous system to the performance of certain actions, and this power we call a mental stimulus.

iii. *The relations of the actions of the nervous system to the*

[1] I have conjectured, however, that there is an analogy between the vis nervosa and electricity, in my Inst. Physiol. § 206.

vis nervosa and stimulus, generally considered.—As effects are proportionate to their causes, so the operations of the nervous system are proportionate to the *vis nervosa* and the *vis stimuli.* The operations of the nervous system, for example, will be the more powerful and extensive in proportion as the *vis nervosa* is more active and the stimulus efficient: and contrarily in proportion as the *vis nervosa* is less active and the stimulus feebler, in that proportion will the operations of the nervous system be more languid. A less energetic stimulus is sufficient for a more active *vis nervosa,* just as a more powerful stimulus will compensate for a less active *vis nervosa;* so that in both cases, the effect on the operations of the nervous system may be equal. The *vis nervosa* is not, however, indifferent to the kind of stimulus, for it is more readily excited by one than by another, although they may appear to be equally forcible; nay, it sometimes responds more actively to apparently a very mild than to a very powerful stimulus. Thus the heart and intestinal canal, according to Haller,[1] are thrown into more powerful contractions by inflated air than by water, or any poison; and, on the other hand, a drop of water getting into the trachea excites a violent cough, while the air is insensibly inspired and expired through it. I shall adduce many such examples hereafter as illustrations of idiosyncrasy.

iv. *Under what circumstances the vis nervosa is increased.*—It is evident that the stimulus may be greater or less, longer or shorter, more or less general, or quite local; and the same is true of the *vis nervosa.* This, in fact, differs in degree according to the difference of age, sex, temperament, climate, the condition of the body as to health or disease, and other circumstances, and in a portion of the nervous system as well as in the whole, which it will suffice to prove by a few examples.

a. In the first place, the *vis nervosa* is generally greater in childhood than adult age; for a slight stimulus at that age will act violently upon the nervous system, which scarcely affects the nerves in more advanced years, a truth abundantly proved by the testimony of celebrated men. Young animals are the more sensitive,[2] and organs which in the newly-born are irritable, become insensible through age,[3] and languid in motion

[1] El. Phys., tom. iv, p. 575.
[2] Haller, Ibid., p. 456.
[3] Whytt apud Haller, Ibid., p. 184.

and sensation. Sensation is more acute in the young man than in the aged.[1] The pupil is more contractile in the infant, less readily acted on by light in the aged. And the same principle illustrates the cause of senile impotence. That the sensibility of the genital organs is diminished with age is proved by the fact, that the seminal emissions so readily excited in youth, cease to take place about the fiftieth year or somewhat later, even in able and strong men. Since the female sex has a more excitable nervous system, it is established as a general rule that the feeble, or rather the tender organisms, feel more acutely than the robust.[2] Observations also show, that the amount of *vis nervosa* varies with the climate, since those who inhabit hot climates indulge more in ease and pleasure than the inhabitants of colder regions; Montesquieu[3] thinks we may distinguish climates by the degrees of sensibility, just as we distinguish by degrees of latitude. Often in diseases, the sensibility or *vis nervosa* of the whole nervous system, is increased in a very remarkable manner; whence it happens, I think, that we cannot then bear a slight degree of cold in the atmosphere, on account of the shiverings and unpleasant sensations excited through the whole body, that in health we should not notice. Thus, also, a moderate draught of wine greatly increases the fever of a fever-patient, but which, if taken by a person in health, would produce no change whatever in the pulse. For the same reason it happens, that in hemicrania, gout, or any painful affection, we are impatient, and cannot endure any noise or light, or a variety of objects. All nerves that have become too sensitive can no longer tolerate even the most common impressions.[4] If it were not altogether superfluous, many other instances of increased *vis nervosa* in the whole nervous system might be adduced.

b. Frequently an increased degree of *vis nervosa* is observed in a portion only of the nervous system, and not in the whole; in the animal organs alone, or only in the sensorium commune, or in one or other of the nerves. Thus, I imagine, there is an increased degree of *vis nervosa* in the delirious and maniacal,

[1] Haller, El. Phys., tom. iv, pp. 293, 294.

[2] Battie apud Haller, El. Phys., tom. iv, p. 459.

[3] Esprit. de Loix. *Vid.* La Roche, 'Analyse de Fonctions du Systême Nerveux,' tom. i.

[4] Tissot. von Nerv., 2 Band, ii Th., § 77, s. 165.

which keeps them fixed to their ideas. That condition of some decrepid old people, in which they are more pusillanimous and timid and ready to weep than children, seems to be referable to this increased decree of the *vis nervosa*. So also may be explained the case of a man of weak mind in health, who was rendered talented by a blow on the head, but when cured relapsed into his previous simple-mindedness.[1] The serene state of mind of dying persons, which has been aptly compared with the crackling of a dying taper,[2] seems dependent, for the moment at least, on increased *vis nervosa*. When the *vis nervosa* is increased in the general sensorium, it seems also to have this effect,—that external impressions made on the sensitive nerves, and transmitted to the sensorium, are too suddenly and violently reflected, and pass over into the motor nerves, and excite movement and convulsions in spite of the will, as happens in the frights of infants, and also of some adults, who are terrified by any slight crash or noise. Further, that the *vis nervosa* may be locally increased in one nerve or another, is proved by innumerable examples of contused, lacerated, wounded, and inflamed parts, a slight touch of which excites much suffering, although in the natural condition it would scarcely have been felt, and this while other sound parts of the body possess their natural sensibility. Thus the amount of *vis nervosa* is greatly increased in the gouty foot, but the other limbs are in their natural condition. Inflammation is the most frequent cause of a topical increase of the *vis nervosa*, as Haller observes, who says[3] that the increase of the sentient nature in nerves is wonderful, as observed in inflamed parts, in certain acute diseases, in inflammation of the brain, or in rabies canina; that the younger Albinus experienced the greatest annoyance from sounds so slight, as not to be audible to other persons; and that a certain man could see by night so long as his eye was inflamed, but lost the faculty along with the inflammation. Nor were these very remarkable, for parts of the body in which sensation in the natural state is so imperfect that it may scarcely be said to exist, experience from disease such an increase of the *vis nervosa* in the

[1] Haller, El. Phys., tom. iv, pp. 293, 294.
[2] Kemme von der Heiterkeit des Geistes bey einigen Sterbenden. Halle, 1774, Seit. 89.
[3] Loco citato.

very few nerves distributed to them, that they become extremely painful: of this class are tendons, ligaments, and the bones, which in the natural state have no sensation, but when diseased, become so sensitive that a touch gives pain. Thus in a case observed by Martini,[1] a denuded tendon had no feeling, but being rendered black by an ointment applied to it, it became, at the same time, so sensitive, that a touch could not be borne, and not without great pain could the black and dead fibre be torn from the healthy. Since, then, mortification in this tendon rendered its nerves so very sensitive, the same result may be expected in the ligaments of the joints, when a gouty matter is deposited in them. Richter is of this opinion.[2] A man having many schirrous tumours beneath the skin, one was removed from the dorsum of the hand by Klinkosch,[3] on account of its hindering the movements of the fingers. The patient bore the removal of the tumour tolerably well, but not the denudation of the tendon, the irritation of which caused such a trembling of the body generally, that he would for no consideration suffer a repetition of the experiment. In this case it appears, that the tendon had acquired greater sensibility from disease of the superjacent skin. Plenk also asserts,[4] that a divided tendon at first causes no bad symptoms, but when, after a while, it becomes inflamed, it is then painful. Adolph Murray confirms the remark,[5] observing, that if healthy ligaments be pricked, wounded, or burnt, they feel no pain; but if the structure of the ligament be affected, either by fungus or pus, or any other acrid humour, then incisions into them are not only painful, but often cause so much suffering that it excites convulsions. And thus also bones, when not diseased, have no sensation, although nerves are manifestly distributed here and there; and this he ingeniously explains by the hypothesis, that the nerves are constricted by the accumulation of earthy matter in the foramina, through which they enter the bone;

[1] Versuche und Erfahrungen über die Empfindlichkeit der Sehnen. Copenhagen, 1770.

[2] Chirurg. Biblioth., 1te Band, 1te Stück.

[3] Observ. de Sensibilitate tendinis et raro Cutis Morbo. It is in his 'Collectio Diss. Select. Med. Pragensium.'

[4] Chirurg. Lehrsätze.

[5] Diss. de Sensibilitate Ossium morbosa. Upsalæ, 1780.

but when the bones are softened by some morbific cause, the constriction of the foramina is relaxed, and the nerves no longer strangulated again become sensitive. That bones morbidly softened are rendered sensitive, is proved by the observations of Deidier and Petit. He also found that the slightest touch of a carious bone excited intense pain.[1] Murray rightly observes, that the following questions are worthy the diligent investigation of physiologists:—how does it happen that nerves entering the substance of bones, are compressed and strangulated in the narrow foramina for many years, and thus rendered unfit to excite sensation, yet when the bone is softened and the constriction of the nerves diminished, they again become fit for sensation, nay, acquire the most exquisite sensibility? If the nerves be small channels for a nervous fluid, they are compressed so long that the channels ought to coalesce, and the nerves be impermeable ever after to the nervous fluid. Then this author seems to ask, why is it that in disease of the bones we often find so much more sensibility than could be expected from so few and such minute nerves? The increased sensibility, or *vis nervosa*, seems to compensate for this paucity of the nerves.

v. *When the vis nervosa is diminished.*—The *vis nervosa* is diminished in proportion as we observe the vital powers which are dependent on the *vis nervosa*, to be diminished and weakened; and which becomes so weak in death, that the natural stimuli, as for example, the influence of the inspired air, and of the blood in the heart, can no longer excite it, and a mortal repose of all the vital and animal movements results. In this ordinary termination of life, the *vis nervosa* is undoubtedly at a minimum, but it is not quite lost, for a few sparks can still be excited, if a strong stimulus be applied to the nerves. Vesalius was taught this fact by sorrowful experience, for when dissecting a body shortly after death, he excited the heart to renewed action. Brunner[2] succeeded in doing the same thing in the bodies of men and various animals, by forcing air into the heart, through the thoracic duct or veins. In many experiments on frogs, I observed, that when the heart was still and

[1] Brambilla, Surgeon in Ordinary to the Emperor Joseph II, and First Surgeon to the Guards, &c., also demonstrated the sensibility of diseased bones before the author at Vienna.

[2] Parerg. Anat. Genevæ, 1681. Miraculum anatomicum in cordibus resuscitatis, &c.

could no longer be excited by a stimulus, that the muscles of the thigh continued to be slightly contracted, whenever the sciatic nerve was punctured or compressed. We hence conclude, that a certain portion of the *vis nervosa* remains for a time in the nerves after death, which, although insufficient to maintain life, is sufficient to develop movements in the heart and some muscles, if excited by a powerful stimulus. For they contract, although so feebly, that weak jerking rather than contractions are only produced, and these cease after awhile, however strongly the nerves or muscles may be stimulated. When after death no muscle responds to a stimulus, are we to conclude that all *vis nervosa* has left the nerves, or is it that it cannot display itself on account of the muscles being rendered unfit for action? We cannot determine these questions. The *vis nervosa* is also diminished by opium, according to the observations of Whytt. Haller and Sprögel[1] found that opium destroyed the *vis irritabilis* of the stomach and intestinal canal, and since (as will be hereafter shown) irritability presupposes a *vis nervosa*, the *vis nervosa* is also diminished by it. Smith[2] observed, that opium or nitre applied to the nerves destroyed the irritability of the muscles to which the nerves were distributed. Monro also observed, that narcotics diminished the contractility of the heart.[3] Many celebrated men, and amongst them Tralles, were, on the other hand, of opinion, that opium had not a cooling but a heating property, increasing the motion of the humours, and they attempted to prove the doctrine by experiments. Wirtenson advanced a curious and ingenious argument for the purpose of reconciling these conflicting statements: it was certain, he said, as proved by his own experiments, that opium diminished the power of the heart, but since it also had the remarkable property of relaxing the capillaries or terminations of the arteries, thus by a diminution of resistance, the circulation might be increased, although at the same time the force of the heart were somewhat diminished. Opium does not increase the motion of the humours in the Turks habituated to it, nor heats them, but refrigerates them, because their capillaries, being already relaxed by the climate and by the continual use of opium, are not susceptible of further relaxation; the resistance

[1] Haller, Op. Min., tom. i, p. 485.
[2] Diss. de Motu Musculari. Edinburg., 1767.
[3] Act. Götting., vol. ii, pp. 147, 154.

being therefore undiminished, a slower motion of the humours and an agreeable coolness from the diminished action of the heart only ensues.[1] The celebrated Fontana infers, from his experiments, that opium does not diminish the amount of that power by which the nerves move the muscles, but that it is the spirit of wine which, whether used as a solvent of opium, or alone, renders them insensible to irritation, and destroys that property of the nerves which controls the muscles.[2] The latest opinion of Haller as to these experiments is, that they partly require confirmation, and partly admit of another explanation; and he ends his opinion with these words: "Lastly, from the remarkable effect which opium produces on the stomach and intestine, there is ground for suspecting that the *vis insita* is diminished by opium as well as the *vis nervosa*."[3] But it has already been abundantly proved by distinguished men (and it will be shortly rendered more evident), that the *vis insita* of Haller, or irritability, is dependent upon the *vis nervosa*, and cannot exist without it; and, consequently, as opium diminishes the *vis nervosa*, it is thus only that it diminishes irritability, or the *vis insita*.

vi. *The vis nervosa is divisible, and exists in the nerves independently of the brain.*—*Vis nervosa* is as divisible as the nervous system, so that it remains in each portion of a bisected nerve, as if it were still entire and connected with the brain. Nor does the *vis nervosa* of the nerves require continual supplies from the brain, since nerves possess their own *vis nervosa*, which never had a connection with the brain. The experiments that prove this have long been perfectly well known; namely, that if a nerve be cut or tied, although by these means its connection with the brain be destroyed, it is still as able, if irritated, to cause the muscles to contract as if its connection with the brain were entire. Haller clearly states this fact in many places.[4] He observes: "a nerve compressed or tied, and then irritated below the ligature, excites those muscles to convulsive contraction, to which it is distributed, just as if it was

[1] Dissert. Demonstrans Opium vires Fibrarum cordis Debilitare, et Motum tamen sanguinis augere. Monasterii, 1775.

[2] *Vid.* Halleri Oper. Min., tom. i, p. 487.

[3] De Part. Corp. Hum. Fabr. et Usu, tom. ii, pp. 391, 392.

[4] El. Phys., tom. iv, p. 337.

perfectly free." And elsewhere: "if the nerve of a muscle be compressed, or tied, or divided, and then irritated, provided it be fresh and moist, the irritation will produce in the muscle to which the nerve is distributed the same movements as it would have produced, if the continuity of the nerve with the brain had remained unbroken. This proposition having been proved with regard to the voluntary nerves, is here shown to be applicable to the organic nerves."[1] In the same work (p. 237), he observes: "it is not necessary to the excitation of muscular action by irritation of the nerves, that the nerve be in connection with either the brain or spinal cord; for irritation of a nerve entirely separated from the spinal cord and brain, excites the same muscular contractions as irritation of a nerve in unbroken connection with them." And in a sentence before quoted,[2] he remarks: "Thus, when after the destruction of that part of the spinal cord from which it proceeds, a nerve is irritated, it still, as before, throws the limb into contractions, to which it is distributed. The same thing takes place in the medulla spinalis after division of the medulla oblongata. In short, if the head or whole brain be removed, and the heart taken away, and the animal be apparently dead, on irritating individual nerves, or the spinal cord, the muscles are convulsed." This *vis nervosa*, which remains in the nerves when separated from the brain, is not exhausted by one or two muscular contractions they excite when irritated, but is equal to the production of numerously repeated movements, as I observed in a frog, the spinal cord of which I divided in the back. It survived this wound several days, and during the whole of that period, by irritating that portion of the spinal cord which was below the section, I excited innumerable convulsions in the lower extremities, nor did these die sooner than the whole frog. I am compelled to defer a more detailed and accurate account of these and similar experiments to another opportunity, as this is not the proper place. That the *vis nervosa* can remain a long time in the nerves, independently of the brain, seems to be proved by the state of paralytic limbs, the nerves of which are deprived of all connection with the brain on account of some preternatural compression, and yet for a long period the paralysed muscles are

[1] Mémoires sur la Nature Sensible et Irritable, tom. i, p. 245, exper. 225.
[2] Elem. Phys., tom. iv, pp. 337, 338.

convulsed by the stimulus of the electric spark.[1] The *vis nervosa* of the spinal cord, and of the nerves given off by it, remained in a case after atheroma of the medulla oblongata, pons varolii, and entire cerebellum had destroyed the connection between the spinal cord and a dropsical brain.[2] Moreover, the *vis nervosa* not only continues in the spinal cord and nerves long separated from their connection with the brain, but exists in nerves that never had any connection with the brain whatever. This is proved by the histories of acephalous fœtuses, which lived during the whole period of intra-uterine life, were nourished, increased in growth, and when born evinced no obscure signs of vitality, without having a brain, and by the sole *vis* of the nerves and spinal cord, if the latter was not also defective. Animals which have nerves but no cerebrum also demonstrate the same fact.

From these facts it is obvious, that the *vis nervosa* remaining in the nerves after the severance of their connection with the brain, must be considered as the cause whereby the heart was able to continue its movements, in the experiments instituted by Haller and other distinguished men, after the brain and cerebellum were destroyed, the head cut off, and even all the nerves of the heart divided. For the stimulus of the blood, alternately flowing into the cavities of the heart, irritated its nerves still endowed with *vis nervosa*, although separated from the brain, and thus excited it to alternate contractions. But another interpretation has been given to these facts; and especially by Haller, namely, that it is manifest, that if the heart's action continues after decapitation, or destruction of the whole cerebrum and cerebellum, the cardiac movements are not in connection with the nerves, but with an irritability innate in the heart, and not dependent on the nerves. But the fallacy in this conclusion is most manifest, since it can only be fairly inferred that the heart can continue its action without the brain and spinal cord, but not without its own nerves, which, although entirely separated from the brain, are still united to the heart, and still as endowed with the *vis nervosa*, and as impatient of a

[1] Caldani excited movements of paralysed muscles by the electric spark. Consult Haller's Bib. Anat.

[2] De Haen. Rat. Med. Contin., tom. iii, section i, cas. ix, the dissection of which I performed before my lamented teacher.

stimulus, as when in connection with the brain. If any other muscle, the nerve of which is divided, contracts when the nerve is irritated, why not also should the heart alternately contract, though its nerves be divided, when alternately stimulated by the inflowing venous blood? These same nerves are the cause why the heart, or any other muscle, when separated from the body, or even when cut into pieces, continues to contract at each irritation; for with each portion there are nerves also cut away, since they cannot be separated from the substance of the muscle, being lost in it as invisible filaments. These minute invisible nerves are also endowed with their own *vis nervosa*, are irritated when the muscle is irritated, and feel the stimulus, and cause the muscle or fragment of a muscle to contract. This continues longer in the heart and intestines, according to the experiments of Haller, than in other muscles, and only ends when the animal heat being dissipated, the cold coagulates the fat, and seems also to diminish the flexibility of the fibres, to lessen the fluidity of the blood remaining in the vessels of the muscle, and to fix the *vis nervosa* itself. It is now placed beyond doubt by many distinguished men, that the irritability of muscles is dependent on the nerves, and cannot exist without them;[1] although it is certain that some have incorrectly confounded irritability with sensibility. Irritability belongs solely to muscle, and sensibility to nerve; but irritability is the effect of the muscle as a compound instrument, into the composition of which enter muscular fibres enveloped in their proper

[1] Whytt, 'Essays. Phys.;' also, 'Von den Nerven und Hypochondrischen Krank.' (Leipzig, 1766), Seit. 4; Unzer, 'Erste Gründe einer Physiologie,' Seit. 435—437, und §§ 382—387; Rehfeld, 'Diss. an Vis Irritabilis Fibrarum Muscularum Innata ipsis inhæreat, an aliunde accedat' (Gryphiæ, 1770). Winterl, 'Inflammationis theoria Nova' (Viennæ, 1767), cap. iii; Crantz in 'Trabucchy Diss. de Mechanis. et Usu Respirationis' (Viennæ, 1768); Trzebiczky, 'Diss. de Irritabilitate et Sensibilitate' (Pragæ, 1770); Marherr, 'Prælect. in Boerhaavii Instit. Med.,' tom. ii, p. 131; Thaer, 'Diss. de Actione Systematis Nervosi in Febribus' (Gött., 1774); Isenflamm, 'Praktische Anmerkungen über die Nerven' (Erlang., 1774), § 16; also 'Praktische Anmerkungen über die Muskeln' (Erlang., 1778), Seit. 73. Ern. Platner, 'De Principio Vitali' (1777), also speaks of it in 'Anton von Haen's Heilungsmethode,' 3ten Band, 1781; übersetzt von Ern. Platner, Prof. zu Leipzig, im 1 Aufsatze über einige Schwierigkeiten des Hallerischen Systems; Prochaska, 'De Carne Musculari' (Viennæ, 1778); La Rosch, 'Analyse des Fonctions du Sys. Nerv.' (Genéve, 1778), tom. i; Cremadel's 'Nova Elem. Physiol.' (Romæ, 1779); and many others who are quoted in Haller's 'Elem. Phys.,' tom. iv, p. 456.

sheaths, arteries and veins, together with their fluid contents, and nerves. Not only can no part of this machine be wanting, but it is also necessary to its due action that there be flexibility of the fibres, fluidity of the fluids contained in the vessels, and *vis nervosa* remaining in its nerves, which may perceive the stimulus, and excite contractions of the muscle. The celebrated Tissot recognised this truth;[1] for although he maintained irritability to be a property innate in muscles, and independent of the nerves, yet he observes, that it is probable no muscle is perfectly organised without nerve. Consequently, if irritability be the effect of a well-organised muscle, irritability cannot exist without nerve in the muscle. The illustrious Haller seems also to have felt the force of truth, for he altered much of par. ii, section v, book iv, in the new edition of his 'Elementa Physiol.':[2] and although he heads it with "*cordis motus non a nervis*," he nevertheless says, that it must be granted, when his own and the opposing experiments are well weighed, that "it is possible that some property of the nerves is necessary to the due action of the heart, and to maintain the power of the fibres. Nevertheless, another motive power is more influential in the heart, namely, its irritability, which cannot be excited when the nerves are entirely wanting." And in many other places he acknowledges, that the motion of the heart depends on the nerves, which, however, he elsewhere declares is independent of the nerves.[3] So long as a nerve is continuous with the brain, if it be irritated, it produces sensation, and excites

[1] Abhandl. über die Nerven, &c., 1te Band, 2 Th., Seit. 176, § 267.

[2] De Part. Corp. Hum. Fabrica et Usu, tom. ii, p. 392.

[3] Ibid., p. 439, Haller further says: "Another conjecture is, that the heart is more irritable, because the sentient nerves of the heart being in close relation with the inner membrane of the heart, are stimulated by the contact of the blood; and that thence a more active movement arises than from irritation of the external portion of another muscle. The external surface of the intestines is, in like manner, almost insensible to stimuli, the internal most sensitive, and when irritated, continually excites extensive movements. Is it that the auricles are more excitable than the heart, and more apt for motion, because being so delicate the nerves are almost naked, and consequently exposed to the immediate stimulus of the blood? If any one will advance any other cause for the greater aptness of the heart for motion on being irritated, I will willingly listen," &c.

At page 158 of vol. iv of this same work, he continues: "Lastly, another cause of the more rapid and frequent contraction of the heart is latent in the stimulus. Whether the nerves be vehemently excited by any cause whatsoever, or whether the *vis sanguinis* by which the heart is put in motion, shall have been increased. Consemotion in the muscle under its control; no sooner, however, is it tied or cut, than it loses the power of producing sensation when irritated, but retains the power of exciting the muscles to movement. No one will, I think, infer from this, that by that division any portion of the *vis nervosa* escapes when the power of exciting sensation is taken away: certainly the power to produce both motion and sensation remains in the divided nerve, but it cannot excite sensation, because on account of the division or ligature, it cannot communicate its external impressions to the brain, in which organ the perception of sensations takes place. It is certain that the divided nerve retains the power of producing motion, but it is necessary to this, that there be an uninterrupted connection between the muscle and the irritated point of the nerve; if this be broken by division or ligature, no movement is excited in the muscle, however much the nerve may be irritated above the ligature or section; and the same holds good as to the production of sensation.

vii. *A peculiar affection of the vis nervosa, or idiosyncrasy.*—That state, termed idiosyncrasy, is evidently a peculiar affection of the nervous system, which may indeed be referred to an increase or diminution of the *vis nervosa*, yet not in respect to all, but rather to certain peculiar stimuli. This causes us to regard some things with the greatest love, and with an insatiable longing, and others with the greatest aversion; the one is termed sympathy, the other antipathy. That idiosyncrasies are diverse in different men is evident from this, that some desire just what others are averse to. There are idiosyncrasies proper to each age, temperament, and sex; or, more properly, to each individual; some of these are altered by time, the manner of life or temperament being changed in some respects; many are modified by habit, and some remain companions for life; some again are excited by pregnancy, and others by diseases, and disappear when these are removed. Consequently, it would appear that idiosyncrasies may be divided into idiosyncrasies of the healthy, of the pregnant, and of the sick. As to other points, if we be igno-

quently, the pulse is accelerated by affections of the mind, anger, terror, shame, and various passions. Van Helmont was not ignorant of the quicker pulse, which is said to accompany every violent pain, as in the instance of a thorn sticking in the finger," &c. And in 'Elem. Physiol.,' tom. iv, p. 356, he adds: "In many (acephalous fœtuses) there was only so much of the spinal cord as was sufficient to maintain the motions of the heart," &c.

rant of the nature of the *vis nervosa* in general, much more may this peculiar *vis nervosa* be unknown to us, the visible effects of which can only be observed. If any person would collect these from his personal observation and from medical writings, and arrange them well, he would certainly accomplish a useful work, from which we might hope to obtain much light for understanding the functions of the nervous system, and much for the cure of its diseases. And Haller spoke truly of idiosyncrasy, when he said: "As yet this field has certainly not been sufficiently cultivated, and there is the prospect of an abundant harvest from it."[1] As in this dissertation I propose only to give an introduction to the functions of the nervous system, rather than to work out a complete treatise, I shall only enumerate a few examples of idiosyncrasy, hoping from others a full systematic account.

It happens to some men, in other respects perfectly healthy, that they cannot see, taste, or even hear certain things, but they are affected unpleasantly, and sometimes to fainting. Some cannot be present at a venesection, and see the blood flow, without fainting away. I know a female who, when young, could never see the beet-root that is usually placed on the table, without swooning and fainting; she was at last by habit enabled to look at it, but could never eat it. The exhalations of a cat, although concealed, excite in some men disquietude, perspiration, and fainting; an example of this kind is narrated by Kaaw;[2] and also the history of a man who was always affected with a bleeding at the nose, from the odour of cheese. Fainting, in some, is induced by the fragrance of roses; and the pale rose of a pleasant odour, the red, unpleasant.[3] Fainting has also been excited by the odour of apples.[4] Strawberries have produced remarkable symptoms.[5] Musk and civet can excite in some persons violent hysterical attacks, which in others are induced by the fetid gums. We may meet every day with illustrations of idiosyncrasy of taste, for we see some persons esteem articles of diet as delicacies which others abhor: I myself, when young, had such an aversion for spinach, beet-root, and cod-fish, that

[1] Elem. Phys., tom. iv, p. 575.
[2] Impet. Faciens dictum Hippocrati, § 408, p. 358.
[3] Eph. Nat. Cur., Dec. ii, An. v, observ. 8.
[4] Ibid., An. I, observ., 72.
Ibid., An. v, observ., 214.

by taking the smallest particle of them, I could have excited nausea and vomiting; becoming habituated to them all, that disposition gradually disappeared. Tissot observed in one of his friends, that he could not bear the smallest quantity of sugar, and would presently vomit it, even if taken unknowingly.[1] Music, so pleasant to us, is very disagreeable to most dogs, as is shown by their disquietude and howlings. I knew a female, on whose skin a plaster of any kind excited redness, swelling, and pustules. Many persons cannot sit with their back to the horses in a carriage without experiencing vertigo, nausea, vomiting, and swooning. Tissot rightly maintains, that the antipathy between certain animals, as for example, between the hare and the dog, the cat and the mouse, depends on idiosyncrasy of the nerves;[2] and he shows that the sympathies and antipathies between men are due to the same cause, as when a person at the first glance finds something in another person which pleases or displeases him, and impels him to love or hate that person.

Pregnancy frequently induces idiosyncrasy of the nerves of the pregnant, so that they are affected with a dislike for various foods and drinks, or have the greatest desire for other things, even the most absurd. Many recorded examples of this extraordinary appetite, which is termed pica, or malacia, are current. Schenk relates the history of a pregnant female, in whom the sight of the bare arm of a baker excited such an inexplicable desire to bite and devour it, that she compelled her husband to offer money to the baker to allow her only a bite or two from his arm. He also mentions another female, who had such an urgent desire to eat the flesh of her husland that she killed him, and pickled the flesh, that it might serve her for several banquets. But it is also true that this detestable appetite for human flesh has affected men and unimpregnated females, as well as the pregnant, and these have also been impelled to commit murder, when not restrained by reason or humanity. This happened with Elizabeth of Milan, who allured boys to her by caresses, killed them, and ate their pickled flesh every day. A Scotch girl, the daughter of an anthropophagous robber, had the same wicked desires as her father, and although long separated from him, and educated apart, she still, from an innate depraved disposition remained prone to the same crime.[3] We have a recent

[1] Von Nerven, 2 Band, 2 Th., § 58. [2] Loc. cit., §§ 58, 59.
[3] See Gaubius in Orat. I, de Regimine Mentis, quod Medicorum est.

example in the case of a cannibal of Berg [Westphalia], who being a man in other respects of a depraved disposition, and incited by an appetite for human flesh, did not hesitate to slay certain innocent persons, namely, a girl, and a traveller.[1]

Idiosyncrasies have been frequently observed to arise from disease; thus, a person affected with fever arising from internal putrescence, dislikes flesh, fish, eggs, and broths made from them, but has a great desire for acids; as the disease declines, the appetite returns for the things that were previously rejected. Persons, who in health esteem tobacco as a great luxury, when sick, neglect and dislike it, but with returning health, regain their desire for it. Pale girls, commonly affected with acidity, have a taste for chalk or lime, or for charcoal and ashes, or for vinegar and salt. Hydrophobic patients are horrified even at the sight of water. To this class of examples, belong those cases in which remedies having been applied in vain, suddenly an appetite is excited for some particular thing, which, being taken, the patients are happily cured.

The influence of habit on the *vis nervosa*, and especially on idiosyncrasy, deserves to be noticed here. By means of this the nerves become easily tolerant of those things, by which they were at first violently affected. Thus, those who are habituated to wine and the smoke of tobacco, can imbibe a large quantity with impunity, while in those unaccustomed to their use, they excite vertigo, drunkenness, and other unpleasant symptoms. Thus, also, a seaman habituated to the sea is not annoyed with the nausea and vomiting which the motion of the ship will excite. These and many other instances show, that the degree of sensibility of the nerves is diminished by habit, not indeed with regard to any stimuli, but only in respect of those which are frequently applied, the nerves remaining equally sensitive to other stimuli. Thus, also, an idiosyncrasy may be diminished, or entirely overcome by habit alone; just as on the other hand, by habit alone, the nervous system becomes accustomed to certain things, and acquires a true idiosyncrasy, so that we cannot easily do without those things, as, for example, in the case of a man accustomed to the use of tobacco. It is from hence, that the proverb has originated—" habit is second nature."

[1] See this history in the inaugural dissertation of Jacobi, defended at Jena in 1781.

CHAPTER III.

THE FUNCTIONS OF THE NERVES.

INASMUCH as I have already divided the nervous system into three principal portions, namely, the animal organs, sensorium commune, and the nerves properly so called, I shall also divide its functions into three classes, namely, into animal operations, operations of the sensorium, and operations of the nerves. The functions of the nerves are first to be considered; then the operations of the common sensory, and lastly, the animal operations.

SECTION I.—ON THE ACTION OF THE NERVES IN PRODUCING SENSATION AND MOTION.

Since the nerves represent cords commencing in the cerebrum, medulla oblongata, and medulla spinalis, and thence extended throughout the whole body, two extremities are noted in each nerve; of these, the one is internal and continuous with the cerebrum, or medulla oblongata, or medulla spinalis, and termed the origin or beginning of the nerve; the other is external where the nerves terminate in various parts of the body, and termed, therefore, the end of the nerve. It is besides certain, that the nerves have the property of most readily receiving impressions, however great or of whatever kind they may be, and of transmitting them when received with great rapidity along their whole length. Consequently, if an impression be made at the termination of a nerve, which is termed an external impression, it is very rapidly transmitted along the whole length of the nerve quite to its origin; and *vice versâ*, if the impression be made at the commencement of the nerve, which is termed an internal impression, it is transmitted with the same rapidity to the termination of the nerve. But if the impression be made midway on the trunk of the nerve, it is rapidly transmitted a the same moment to both its origin and termination. This aptitude of the nerves to receive impressions, and when received of transmitting them either way with great rapidity, appears to be that called the *vis nervosa* of the nerves, which is also correctly designated, the sensibility or mobility of the nerves, and which is also well designated by Unzer, "corporeal sensation without concomitant perception."

This property of the nerves does not depend solely on their medullary pulp, (which possibly is capable of some slight vibration, or oscillation, although the nerves do not appear at all tense,) but it appears, as I have already observed in § 3 of the preceding Chapter, to be rather some other principle added to the medullary pulp, the conjunction of the two constituting the whole *vis nervosa*; and possibly the diligence of the very sagacious observers of nature may discover whether that principle be electricity, or phlogiston, or some species of air, or the matter of light, or a something compounded of these. That other principle, whatever it may be, seems to come to the nerves with the arterial blood, by means of the numerous blood-vessels which accompany the nerves of the whole body throughout their whole course; or to be attracted from the air through inorganic pores; or in both these ways, and not to be sent into the nerves from the brain, as its only source, although the brain itself appears to acquire a suitable portion of the same principle through its own vessels. For, as I have before shown, the nerves when separated from the brain have equally *vis nervosa* as the nerves in connection with the brain, and in proof hereof may be mentioned the nerves of acephalous fœtuses and of brainless animals, which are endowed with the *vis nervosa*, although they could not possibly derive it from a brain. Nevertheless, a certain cohesion of the medullary pulp of the nerves is necessary to the *vis nervosa*, because if we so injure the pulp of a nerve by strong compression, that the connection of its globules is destroyed, and their relations broken up, the *vis nervosa* ceases in the portion of the nerve thus compressed, neither can impressions be propagated through it, nor can that portion of the nerve produce motion or sensation, if pricked or irritated.

Although a nerve be necessary to sensation and motion, it does not excite motion or feel alone, but feels by means of the brain, which, when an impression made on a nerve is brought to it, communicates the impression to the mind; and the nerve produces motion by means of a muscle, when an impression made on the nerve descends to the muscle, and excites it to movement. Consequently, a nerve separated from the brain, and no longer able to communicate impressions to it, can no longer produce sensation, just as a nerve separated by division from a muscle can no longer excite motion in the muscle, however much it may be irritated. Consequently, a nerve has a similar office in exciting sensation and motion, namely, to receive the impression of a stimulus, and to transmit it with the greatest rapidity along its whole length, which, when it arrives at the brain, produces the perception of a sensation, but when it arrives at a muscle, excites its contraction.

SECTION II.—THE ACTION OF THE NERVES ON THE VESSELS AND THEIR FLUIDS.

Another function of the nerves consists in a certain power over the blood-vessels, and specially the capillaries, in virtue of which, when the nerves are stimulated, they excite in that part to which they are distributed a much more copious accumulation of blood than would have taken place in the normal condition of the circulation. This phenomenon is termed congestion of the humours, afflux, derivation, abnormal direction, descent of the humours. Stahl termed it the tide of the microcosmic sea, or the ebb and flow of the blood.

The causes that determine a more copious derivation of the humours into any part of the body, are usually considered to be twofold; the one, a mere mechanical cause, consists in a diminished resistance of the vessels of the part, so that the humours contained in the vessels being forced on by the power of the heart and the vessels themselves, flow to the point of least resistance, according to the laws regulating other fluids, and cause congestion of the humours; for this reason, when a vein or artery is divided, the blood rushes from the adjoining vessels, even against its natural direction and gravity; for this reason, also, congestion takes place, when vessels are relaxed by emollient cataplasms and pediluvia.[1] Thus also the blood is con-

[1] Haller, De Part. Corp. Hum. Fabr., tom. iv, pp. 93, 289.

gested under a cupping-glass when the usual atmospheric pressure is removed from the part; a local derivation of the humours takes place also when a compression of the vessels occurs in any part, and the blood is repelled into other parts; as occurs, for example, when the stomach is filled, by which the abdominal vessels are compressed and the lungs forced into less room, and, consequently, a greater quantity of blood goes to the head, rendering the face redder. The other cause is a stimulus to the nerves; which when applied to the nerves excites a more copious flow of humours. Innumerable phenomena of daily occurrence show this. Thus a stimulus applied to the nerves is the cause why the cheeks, ears, and nose, become intensely red, and a sense of heat is felt when exposed to a cold wind in winter. No one is ignorant how much the stimulus of sinapisms and blisters cause derivation of the humours to the stimulated part; an acrid smoke or fine powder getting into the eyes excites a copious flow of tears, and the vessels of the conjunctiva, previously invisible, become distended with blood. The smoke of tobacco, or any other acrid aroma, retained in the mouth, excites a copious flow of saliva; purgatives and emetics bring off much gastric and intestinal mucus; titillation of the nipple of the mamma causes it to become turgid and erect; the touch, or the stimulus of the semen or urine, or a gonorrhœa, cause the penis to be distended and erected by exciting a more copious flow of blood into the corpora cavernosa. These phenomena take place if the nerves be stimulated locally; but the same thing happens when the nerves are excited not directly, but indirectly, through the brain. We know, that thus the face is suffused with the blush of modesty; grief causes a copious flow of tears, congestion of the vessels of the conjunctiva, and redness and swelling of the whole face. The sight of agreeable food provokes a flow of saliva; it is not unusual for some persons to vomit, or be purged by only seeing a medicine; a lascivious idea erects the penis, &c.

Although it is placed beyond a doubt, that stimulated nerves cause congestion and derivation of the humours to the part stimulated, the mode in which the nerves accomplish this is as yet unknown. Distinguished writers have advanced various conjectures, by which they have attempted to explain this influence of the nerves on the vessels. Some have supposed that there are nervous loops and nooses at the termination of the arteries and roots of veins, similar to those which are seen to surround the larger arteries in many places; and they opined that these loops could be tightened or relaxed, and so be able to admit blood to the part or retain it. Haller, together with some of his disciples, followed Willis in adopting this opinion; but when he learnt, from experiments, that the nerves do not contract when stimulated, he rejected the doctrine. Some located muscular sphincters at the terminations of the arteries and roots of the veins, which constricting the vessels, and causing the blood to accumulate above the constriction, so inundated the lateral vessels: Boerhaave in particular propounded this opinion in his theory of obstruction,[1] and also founded his theory of inflammation upon it. But many and weighty objections have been raised against this production of accumulation and inflammation by obstruction and constriction only; for obstruction of a vessel does not cause such an accumulation of fluid, anterior to the obstruction, because it easily finds an exit through the lateral vessels so obvious in every part of the body; and the comparison of a river swelling from an obstruction, and inundating the adjoining parts, does not apply to our vessels; for if one, or even many of them, be obstructed, there still remain innumerable lateral vessels, through which the fluids find a free outlet. For this reason, Haller found that the trunk of an artery, when tied, became swollen indeed for a moment, between the ligature and the heart, and manifested one or two pulsations; but so far is it from the fact, that the impetus of the fluids is directed against the ligature, that rather the canal is contracted, and it impels the blood into the communicating arteries, until that which was tied is quite empty. The same thing is shown by the umbilical arteries, which also become empty, and impervious. Winterl[2] fully sets forth these and other arguments of distinguished men, and proves that the fluids do not rush towards an obstruction, but rather prefer to pass away by the lateral and unobstructed vessels; consequently, no congestion and no inflammation can arise from an obstruction only, but the stimulus of the nerves is the cause, which immediately excites the fluids to accumulate more copiously in the vessels subjected to them. Moreover,

[1] Aphoris., 113.
[2] Nova Theoria Inflammationis, p. 19.

that distinguished man propounds a peculiar and singular conjecture, which appears to me, however, unfounded, to the effect that since a stimulus has quite a different result on the muscular arteries, than on the heart and other muscles—inasmuch as the arteries appear to be dilated by a stimulus, whereas we see that the heart and other muscles to be contracted—he thinks that the blood is attracted, and flows from all sides into the arteries dilated by a stimulus. An opinion of other eminent men, as to the cause of the derivation of the fluids to a stimulated part is, that the stimulus renders the arterial action more frequent and powerful, consequently that the arteries carry a greater quantity of the fluids onwards than the veins can return, and thus they explain why the fluids should accumulate more copiously in a stimulated part.[1] But even this doctrine does

[1] I may be permitted to make some observations here on the irritability and muscular contraction of arteries. The experiments of Haller appeared to render the irritability of arteries doubtful, as he never found them irritable; and to show that the systole of the pulsating arteries in the natural state arises solely from their elasticity, by which they are restored to their former condition after being distended by the blood projected from the heart, and enabled to transmit the blood thus received inwards into the veins, so that along with the eminent men who have repeated the experiments, I expressed my assent to their validity in 'Controversis Quæstionibus Physiologicis,' p. 30. The experiments of Verschuir on the irritability of arteries, were not then known to me; they are contained in his Dissertation 'De Arteriarum et Venarum vi irritabili ejusque in vasis excessu; et inde oriunda Sanguinis directione abnormi,' printed at Gröningen in 1766, and fully demonstrate that sometimes arteries and veins manifestly contract on the application of a powerful stimulus, as scraping with a scalpel, oil of vitriol, spirit of sal ammoniac, &c.; but generally the contractions were very indistinct, and not unfrequently neither responded to these acrid stimulants, nor, as in the experiments of Haller, could irritability be detected. It is also shown from all these experiments of Verschuir, when properly collated, that although arteries were found to respond to these acrid stimulants in one or more places, in another part of the same animal it was the least possible. Further, it is to be observed, that those contractions which were excited continued for some time before they ceased, and the artery was restored to its former condition; consequently the contraction and relaxation of the artery did not follow each other so quickly as the systole and diastole of the artery in its natural condition, nor as quickly as the heart, when irritated, contracts and then immediately relaxes. Lastly, it also appears from the experiments of this distinguished physiologist, that a portion of an artery, which an acrid poison had caused to contract, was hard and rigid, and no longer pulsated; while, at the same time, other portions of the same artery, untouched by the acrid stimulus, continued to repeat their pulsations. But are the results of these experiments opposed to the doctrine, that the elasticity of the arteries is the cause of their systole? By no means; for the elasticity of the arteries is ever demonstrable in any animal, whether

not appear to have the real stamp of truth, which I leave, however, to be decided on by other perspicacious men, to whose attention I would also commend this conjecture, namely, whether when the *vis nervosa* is increased by a stimulus, it does not render the force of attraction of the fluids circulating through the vessels greater, so that by this means the fluids are attracted from every side to the centre of stimulation, as occurs, for example, when sealing-wax is gently rubbed on a piece of cloth, and made electrical, and attracts sand and particles of various kinds? Speculations of this kind are not vain and useless, because if the true reason be known why the nerves when stimulated cause accumulation of the fluids in the tissues to which they are distributed, much light will be thrown on the nature of the *vis nervosa* itself, for one truth leads to another.

living or dead, and is so great that it appears to be a power quite sufficient to restore the artery to its former condition after being dilated by the blood sent into it from the heart, and to pass that blood onwards to the veins: it is by this elasticity only, that the systole of the arteries so immediately and quickly follows the systole of the heart, as happens in the regular and natural pulse; while, on the contrary, the irritability of arteries is small, requiring the strongest stimulus, and not always responding to this, so that it obviously appears inadequate to the repeated natural systole of the arteries. According to the experiments of Haller (De Part. Corp. Hum. Fabr. et Funct., tom. iv, pp. 93, 289), it is only the elasticity of the arteries, which, after the death of an animal, impels the blood from every point through a wound, since all irritability had disappeared. As the irritability of arteries, according to the experiments of Verschuir, is hardly excited even by very acrid stimuli, it will scarcely be developed by the unstimulating blood sent from the heart into the artery; but it seems to presuppose great disturbance of the nervous system, by which it is excited. This takes place differently in different parts, and to it, perhaps, ought to be ascribed those abnormal pulsations, different in different parts, and even complete pulselessness; examples of which, given by authors worthy of credit, are cited by Verschuir in the Dissertation just noticed, and by Gruber in his Dissertation 'De Excessu Vis Vitalis,' published in Klinkosh's collection of disputations at the University of Prague. Consequently, it appears to me, that the natural systole of the arteries ought to be attributed to their elasticity only; but as to the cause of the different pulses in different parts, observed in the same individual at the same time, and also as to the want of pulsation in pulselessness, it is clearly demonstrated by the experiments of Verschuir to be the irritability of the arteries. Whence it therefore follows, that arteries in their natural condition react solely by their elasticity, and are not irritable; but that they become irritable and contract, in a preternatural condition, when the *vis nervosa* of the nerves distributed to the arteries is preternaturally increased; or when a very powerful stimulus, as in the experiments of Verschuir, is applied to them; and we have additional confirmation of this, when we remember that some parts of our bodies, which are without sensation in the natural state, become extremely sensitive in disease.

SECTION III.—BY THIS DERIVATION OF THE FLUIDS TO THE STIMULATED PART, THE MUSCLES ARE MADE TO CONTRACT, AND MANY OTHER PHENOMENA PRODUCED.

The fasciculi of the muscles are made up of fibres and carneous filaments, and bound together by sheaths, and are so traversed by blood-vessels, that these are everywhere intermingled with the fibres and filaments, and decussate with them more or less transversely; and since the fibres and carneous filaments are closely compressed together by their sheaths, the least congestion and distension of the vessels distributed amongst them cannot take place without the filaments and the fibres which they constitute being thrown into many serpentine inflexions, and thus their length be diminished. Since, therefore, irritation of the nerves causes congestion of humours in the vessels, it is easy to infer that in this same manner nerves, when irritated, excite the muscles to which they are distributed to contraction, that is to say, by the greater accumulation of the humour alone, caused in the vessels of the contracting muscle. When the cause, originating in the nerves, which attracts fluids more freely to the muscle, ceases to act, the distended vessels and deflected fibres react by their elasticity on the accumulated fluids, and propel them into the larger blood-vessels not entangled amongst fibrils and muscular filaments; this process is facilitated by the raising of the weight, which resists the contraction of the muscle that raises it, by the action of the over-stretched muscles antagonistic to it; and thus the contracted muscle is again relaxed. It is now four years since I submitted this theory of muscular action to the criticism of the learned public, in my Tract, 'De Carne Musculari.' It is founded on the intimate anatomy of the muscular tissues, is well adapted to the phenomena, and I am not aware that any one has opposed the theory, or advanced any doubts regarding it; nor in meditating upon it myself have I been able to discover any arguments against it, except that irritability exists more extensively than muscular structure. But it appears to me that this argument, when rightly considered, is not an objection to my theory; for if we observe that polypes and other zoophytes are irritable, in whose structure the microscope enables us to detect only a granular mass, but no muscle, no bones, no vessels, no nerves; if, moreover, there are vegetables, and portions of vegetables, which display no doubtful irritability, and yet cannot be suspected of containing muscles and nerves, it does not, therefore, follow, that the irritability of muscles is not produced by the mechanism described above; it does follow, however, that that irritability, which in the greater and more perfect animals ought to be adapted to the development of greater strength, is necessarily dependent on the mechanism described by me; while, again, irritability in plants and polypes is not so powerful, and can be produced by the Author of Nature by another and different mechanism than that of muscles. If this appear incredible to any one, let him reflect that the function of generation is more widely extended than irritability, yet, nevertheless, that Nature accomplishes it, not in one way always, but by many and by the most varied methods. Some animals are viviparous, others oviparous; and of these latter some have the ova fecundated by the male after extrusion from the female, and some before extrusion; some incubate their ova, some abandon them to be incubated by others; some deposit fecundated ova, without the coitus of the sexes; some propagate by shoots; the polypus tintinabuliformis is reproduced by dividing its body into two;[1] the polypus plumosus propagates both by shoots and by ova, which are always fecundated without coitus.[2] Why, then, might not nature be able to produce irritability by different mechanisms—in muscles by the method described by me—and in polypes, zoophytes, and plants, devoid of muscular fibre, in some other way as yet unknown? I am persuaded that these things being weighed, my theory of muscular contraction is very near the truth; and I should be much delighted if any attempts of mine should avail anything in elucidating such a difficult subject, since I am not ignorant of the very great anxiety of very learned men to understand the cause of muscular contraction; who to this end have not only spared no labour, but have also endeavoured to stimulate other inquirers by great and most honorable rewards to perfect this

[1] Spallanzani Opus. Physique, Tom. i, tab. i, fig. vii. (This figure represents a vorticella.—ED.)
[2] Reaumur.

department of physiology: I need only mention the prizes offered by the Royal Academy of Prussia,[1] and William Croon of London.[2]

Verschuir, in the dissertation already quoted, has attempted to explain the flow of the menses by this same derivation of the blood, excited every month through the nerves, since this phenomenon cannot be accounted for either by the theory of a general plethora, which Van Swieten has already fully refuted in his 'Comments on Boerhaave's Aphorisms,' or by the notion of a partial uterine plethora. Marherr in particular, following Haller, has attempted to show, that the cause of the flow of the menses is a special plethora of the uterus. He asserts, for instance, that the arteries of the uterus are more capacious and less contractile than the veins, consequently the arteries receive more blood than the veins can return; that the veins have no valves, and consequently, as the veins cannot so well support the pressure of the blood, its return from the uterus is rendered more difficult; and thus, from these causes, the blood accumulates for a period in the uterine arteries and venous capillaries, until by that time a sufficient quantity being present, it bursts forth. But these distinguished writers do not appear to have considered how much the weight and size of the uterus must be increased every month before the flow of the menses, if it contains the whole quantity of blood that is thus discharged. If we estimate its weight at 4, 5, 6, 7, 10, 12 ounces, and this be accumulated in the uterine arteries just before menstruation, the uterus ought at that period to appear manifestly increased in weight and size, a fact which has not been as yet observed or recorded by anatomists. It is thus manifest, that the menstrual blood is not contained in the uterine vessels previously to menstruation, but is derived to the vessels and cavity of the uterus at the time of menstruation, and this by means of the nerves, which seem to be irritated by some stimulus as yet

[1] *Vide* M. Le Cat's 'Dissertation, qui a remporté le prix proposé par l'Académie Royale de Prusse, sur le principe de l'Action des Muscles,' &c. Berlin, 1753.

[2] Lectures are delivered every year at the College of Physicians of London, on the nature of the muscles and the functions of the nerves, a handsome sum being bequeathed to the Lecturer. See Thomas Lawrence, 'De Natura Musculorum Prælectiones tres in Theatro Collegii Medicorum Londinensium habitæ anno 1759.' Recusæ Venetiis, 1766.

unknown, recurring periodically, and thus produce the derivation of blood to the uterus. Probably it is some latent peculiarity of the *vis nervosa*, which recurs periodically, and causes a derivation of blood to the uterus, just as we observe intermittent fevers to return periodically.

Not only is dilatation of the minute radiated vessels of the iris produced by congestion, but also elongation and deflection from a serpentine to a straight line, in consequence of which the iris is dilated and the pupil contracted, when the retina is irritated by a strong light, and this again acts on the ciliary nerves by consentience.[1] The cause ceasing, which through the nerves induced congestion, the congested fluids appear to be driven into the larger vessels by the elastic and tense capillaries, and thus the minute radiated vessels of the iris are again shortened, and arranged in serpentine folds, and so the iris is contracted and the pupil dilated.

By a similar but greater accumulation of blood in the corpora cavernosa of the penis and clitoris, excited by the nerves, these parts become turgid, hard, and erect, when their nerves are excited, either locally by a mechanical stimulus, or by lascivious ideas.[2]

Thus also the papillæ of the mammæ swell, become hard, and those which are retracted into their fossæ protrude, when rubbed with the tip of the finger, or taken within the lips of the infant, because their nerves being vellicated, excite a greater flow of fluids into the vessels (for a corpus cavernosum is not found in them), and produce the whole phenomenon.[3]

That appearance of the human skin termed *cutis anserina*, arises also from a greater derivation of the fluids caused by the cutaneous nerves, for the spongy bulbs of the hairs become turgid by the blood attracted more copiously to them, and produce those small eminences on the skin, from which the term *cutis anserina* is derived, and by which also the hairs proceeding from them are rendered erect. When that greater derivation

[1] Haller, 'Elem, Phys.,' tom. v, lib. xvi, sect. ii, § xii; Caldani, 'Instit. Physiol.,' Nro. 320; and my tract, 'De Carne Musculari,' may be consulted, p. 10.

[2] Caldani, loc. cit., Nro. 494; Winterl, 'Inflamm. Theor. Nov.,' p. 143.

[3] Kölpin's Dissertation, 'De Structura Mammarum,' may be consulted, translated into German (Berlin, 1767), p. 16, where the translator in a note supposes a congestion of humours into the irritated part, by oscillation of the vessels increased through the nerves.

to the bulbs of the hairs ceases, the small prominences subside and disappear, and in their place there are little depressions, in consequence of which the hairs cease to be erect.

Other phenomena, occurring in the natural state, besides those mentioned in the preceding paragraphs are intelligible by this congestion arising in the irritated part. And in diseases there are frequently opportunities for observing the operation of that nervous influence on the vessels, in virtue of which fluids flow more copiously and immediately to the irritated part. Inflammation itself is nothing else than a powerful attraction and derivation of blood from a stimulus, by which the vessels become filled, swell, are rendered tense, red, painful, &c.; for eminent writers[1] have already demonstrated the incorrectness of the doctrine of Boerhaave, that obstruction is the only cause of inflammation, and all recognise the cause to be a stimulus which attracts the fluids more powerfully to the stimulated part, and produces inflammation. If this stimulus be sufficiently powerful, it draws the nerves of the heart into sympathetic action, and by increasing the movements of the latter produces fever, the concomitant of inflammation. Eminent men have already taught, that the motion of the blood cannot be so much accelerated through free vessels by the obstruction alone of other vessels, as to excite fever. Thus also hæmorrhoids continually arise from the stimulus of hard and acrid fæces in the rectum and other similar causes, since the vessels gradually give way, and dilate into varices, from the frequent derivation of blood to that part. And those deposits, termed metastases by physicians, are probably owing in a great degree to a stimulation of the nerves.

SECTION IV.—DOES AN OPPOSITE PROPERTY EXIST IN THE NERVES, SO THAT THEY CAN REPEL THE BLOOD FROM THE VESSELS UNDER THEIR INFLUENCE INTO OTHER PARTS?

The face of a man struck with sudden terror is pale, and some men become pale when in a paroxysm of rage, which paleness is without doubt owing to a repulsion of the blood from the cutaneous blood-vessels, to those in the interior of the body. Inasmuch as the nervous system is affected in terror or rage,

[1] Galen, Senac, Gorter, Haller, in Winterl's 'Inflammationis Theoria Nova, (Viennæ, 1767); and Caldani in his 'Institutiones Pathologiæ,' cap. ix.

the question arises whether the cutaneous nerves then affected completely repel the blood from the cutaneous vessels, by contracting them, to the inner vessels of the body? or whether, the heart disturbed at the time and not contracting, ceases for a moment to impel the blood to the surface of the body, the cutaneous vessels acting at the same time as in fainting, and by virtue of their own elasticity repelling the blood to the internal organs? Often if one kidney be affected with calculus, or inflammation, a true ischuria comes on, for the other kidney, although healthy, ceases to secrete urine. Physicians are aware that this takes place from sympathy of the nerves of the two kidneys. Do the renal nerves in this case drive away and repel the blood that comes to the kidneys to be subservient to the secretion of urine? or do they not rather totally prevent the secretion from the blood by causing spasm of the secreting vessels? Truly, although there are numerous facts which teach us that a stimulus may cause the fluids to be drawn to a locality, there is hardly one to show that the nerves have the opposite property of repelling the fluids.

SECTION V.—HAVE THE NERVES ANY INFLUENCE IN SECRETION?

In considering the causes which operate in producing such varied secretions from the same blood, Boerhaave does not detail how great a share the nerves may have in that function of the animal economy.[1] The illustrious Haller, in his notes to the lectures of Boerhaave,[2] conjectures that the nerves operate in the secretion of the fluids, since they surround the vessels of the viscera like sphincters, and thus either delay or promote secretion. It has already been stated why this eminent man withdrew the doctrine as to the sphincters and loops of the nerves, but he shows that the secretions and excretions have a close connection with the nerves, when he treats on the greater or less irritability of the excretory ducts.[3] The celebrated Tissot also devotes an entire section of his work on the functions and diseases of the nerves, to the secretions, for the purpose of demonstrating how much these latter are dependent on nervous influence.

[1] Instit. Med., Nro. 253. [2] Note (14) vi.
[3] De Part. Corp. Hum. Fabr. et Usu, lib. vii, sect. iii, § xii.

In truth, since it has been shown how great is the influence of the nerves on the vessels, in virtue of which stimuli can excite a more copious flow of fluids to a part, we infer that the same thing occurs in the secreting viscera, which consist almost entirely of vessels. So soon, therefore, as by nervous action the fluids are more copiously attracted to secreting viscera, the secretions are necessarily increased. Moreover, since the nerves have the property of causing spasms, or contraction of the capillaries, it is manifest that the secretions may be diminished, or entirely interrupted by the influence of the nerves, the secreting vessels being entirely closed by constriction. Illustrations, confirmatory of this doctrine, have been already brought forward.

But it may further be asked, is the influence of the nerves on the fluids so great, either at the time of secretion, or when secreted, that it can modify, or alter them, or entirely change their nature? Thaer[1] seems to have held an opinion somewhat to this effect, when he observes, that in fevers the blood becomes sometimes putrid and dissolved, sometimes acrid, again imperfectly coagulable, or in some other way altogether changed from the healthy condition preceding the fever. Musgrave[2] attempts to prove, from many facts, that the fluids are vitiated by irritation of the nerves. In the first place, he brings forward the experiments of Haller, who observed the contents of the stomachs of rabbits to become putrid and thoroughly tainted, in a short time, after tying the eighth pair of nerves; and that a very offensive suppuration was also brought on in the foot by tying the nerve. Next, he shows that a vomiting of fetid bilious matter has been excited by an affection of the head, and by the irritation of calculi passing along the ureters. Further, diarrhœa is often excited by mental emotion, and this, indeed, because that affection of the nerves renders the secretions more acrid and loose. The milk of a nurse, affected with anger, immediately acquires an unpleasant taste, and becomes injurious to the child. The bite of an enraged animal is difficult to cure, and is often followed by bad consequences. He thinks he can explain why, when blood is drawn, it is often inflammatory in the first cups, and less so in the later,

[1] De Usu System. Nervosi in Febribus, § xxxviii.

[2] Betrachtung über die Nerven, 3ten Hauptst.

on the hypothesis that the febrile irritation being diminished after the first cupfuls are drawn, the blood that remains in the body is very similar to healthy blood. Clearer illustrations are given by the celebrated Gaubius, and which prove that all the fluids of the body may be rapidly altered and vitiated through the nerves. He observes,[1] "Ye wonder, my hearers, and justly, at the great number of evils, which anger only sheds over the body, as from Pandora's box. Nor is it difficult to discover the origin of so great an evil, for in addition to the fact, well established, that the motive forces diffused through all the organs of the body are very powerfully excited by that affection of the mind, and consequently that the whole organism and the internal viscera, as well as the vessels and their contained fluids, are agitated by most violent movements, it is shown, beyond doubt, by an almost incredible number of observations, that the natural properties of the juices may be so altered, that with astonishing rapidity, the bland becomes acrid, and the salubrious, hurtful,— nay, truly virulent. Do you doubt this? I give you the example of a hysterical woman, who being seized, when in a passion, with her disease, vomits vitiated bile of every colour and acridity; of a nurse, whose breasts, when angry, supply poison instead of food to the infant, causing death with horrid convulsions. Tame domestic animals, when provoked, not only contract rabies themselves, but transfuse it with the foaming poison of their saliva into the man bitten by them. Two dunghill cocks fight ferociously with each other, as is their habit; a man interferes to separate them; he is bit by one of them, and dies of hydrophobia. You will, perhaps, allege in reply, that there is a difference between man and brutes; I will therefore give you examples of our own species. A soldier quarrels with a woman, who bites him in the hand; he is seized with rigor and dies. An Italian youth, excited by rage, and unable to revenge himself, bites his own hand, and is seized with a deadly fear of water, as if bitten by a rabid dog. I am aware, and I do not hesitate to confess it, that I am ignorant of the mode in which such pestilent corruptions of the fluids are so suddenly excited; but this I think to have been attained by me, that you can understand that the whole foundations of life are shaken by this

[1] Sermo alter de Regimine Mentis quod Medicorum est. Edit. Argent., 1776, p. 96.

passion, and consequently that there is no function of the human economy, which can easily resist so great an evil." It seems, indeed, possible, that the nerves, when irritated by anger, may, in virtue of their influence on the secreting viscera, render the secretions irregular, disordered, and impure, although we cannot determine in what that impurity may consist, which is added to the secretions by the nerves, when irritated by anger; and, consequently, the saliva secreted and excreted under such circumstances, and inserted in a wound inflicted by an enraged animal, may possibly prevent its cicatrization, and subsequently induce horrid evils. Thus, also, the milk of an angry nurse being disordered and rendered impure, may become hurtful to the infant. It appears more difficult to explain what share the nerves have in inducing a morbid coagulation of the blood, or a putrid deliquescence, acrimony, putridity, and impurity of the fluids in a cancerous or gangrenous part, &c.; these things posterity may inquire into.

SECTION VI.—DO THE NERVES EXERT ANY INFLUENCE IN THE PRODUCTION OF ANIMAL HEAT?

What opinions various authors have expressed concerning the source and maintenance of animal heat are well known; I think, therefore, I need not detail them. Among them all, that was best received which maintained that animal heat arises from the attrition of the particles of blood with each other, and with the walls of the vessels. After Haller had weighed all the various views, he adopted the theory of Boerhaave, according to which animal heat is acquired by friction, observing: "Hitherto it seems to me by far the most probable, that the blood acquires heat from motion."[1] In the meanwhile, he appears not to have disagreed altogether with the opinion of those who maintained that the nerves have some share in the production of animal heat; for he observes, in another place: "I refer heat, which arises from friction, to stimulus."[2] The objections to the doctrine, that friction is the sole cause of animal heat, raised by De Haen,[3] seem to have particularly influenced recent

[1] De Part. Corp. Hum. Fabr. et Usu, tom. iv, p. 253.
[2] Ibidem, p. 159.
[3] Rat. Med., tom. iv, p. 248.

eminent writers, who have sought for the source of animal heat in the nerves, and not in the friction of the particles of the blood with each other, or with the sides of the vessels. Amongst these were Caverhill[1] and Roederer.[2] Wrisberg[3] followed the latter, and seems to have wished to corroborate his doctrine by his own arguments and observations. In comparing animals with vegetables, he saw that it was the nervous system that was wanting in the one and present in the other; and since animal heat was enjoyed by animals, and not by vegetables, it seemed to him that there existed some connection, between a nervous system and animal heat. Further, he thought this was confirmed by the fact, that the passions, which excite the nervous system, increase animal heat, but that those which depress the nervous system induce cold. In further corroboration he observes, that if the back be turned towards the fire, and the spinal marrow warmed, warmth is rapidly transmitted along the nerves arising from it to all parts of the body; while, on the contrary, if the front of the body be towards the fire, the body is not warmed so quickly. Thaer also thought that this theory of the dependence of the animal heat upon the operation of the nerves, was not deficient in probability.[4] Musgrave also maintained, that animal heat arises neither from the intestine motion of the fermenting blood, nor from the friction of the blood against the sides of the vessels, but from irritation of the nerves, whether from an external agent applied to the nerves, as in inflammation, or an internal irritant, as anger.[5] La Roche was of the same opinion, and attempted to reconcile his views with those of Haller, for he conjectured, with Newton, that the nervous fluid is ætherial, and that its oscillatory motion in the nerves is the proximate cause of animal heat, the circulatory motion of the blood in the vessels being only secondary, and by continually stimulating the nerves, exciting the oscillation of the nervous fluid in them;

[1] In Haller. de Part. Corp. Hum. Fabr. et Usu, tom. iv, p. 248.

[2] In Programmate de Animalium Calore. Ad Diss. Cl. Grimm. de Visu. Göttingæ, 1758.

[3] In Program. de Respiratione prima, Nervo phrenico, et Calore animali. Göttingæ, 1763. It has also been printed in Sandifort's 'Thesaurus Diss. Med.,' tom. ii.

[4] De Actione Systematis Nervosi in Febribus. Göttingæ, 1774, p. 83.

[5] Op. citato.

which oscillatory motion is the proximate cause of heat.[1] Cremadells[2] may be also mentioned, who maintained that animal heat is directly generated, kept up, and increased by the vital principle, by which principle he explains all those phenomena of the animal economy, which by others are attributed to the nervous system. Schäffer[3] is another writer, who rejecting the doctrine that the cause of animal heat consists in the fermentation of the blood, or in its friction against the sides of the vessels, refers it to a certain vital principle, which is in the nerves.

Although the doctrine, which teaches that the nerves have a share in the production of animal heat, is not destitute of probability, yet the arguments hitherto advanced do not fully establish it. Perhaps the cause of animal heat is more complex, and cannot be attributed to the nerves only. Undoubtedly there remain many things to be known before we can determine what is the true cause. Especially we ought to wait and see what the industry of distinguished men may discover[4] respecting inflammable bodies, fire, light, heat in general, and animal heat in especial; taught by these, posterity may be enabled to decide more accurately respecting the cause of animal heat.

SECTION VII.—ARE THE NERVES NECESSARY TO NUTRITION?

By the term nutrition, all physiologists understand the conservation of the body, which is accomplished by the action of certain powers inherent in our body, and which have the power of converting food and drink into a fluid, analogous to the constituents of our body, termed the nutritive juice, and thereby

[1] Analyse de Fonct. du Syst. Nerv., tom. ii, chap. xviii, xix. Genéve, 1778.

[2] Nova Elem. Physiol. Romæ, 1779.

[3] Erster Versuch aus der theoretischen Arzneikunde über Bewegung und Mischung der Säfte. Nürnberg, 1782.

[4] Crawford, 'Experiments and Observations on Animal Heat, and the Inflammation of Combustible Bodies.' London, 1779. This little work is reviewed in the Göttingen Magazine, part v, of the past year. The celebrated Forster also quotes it in a very beautiful article inserted in the same periodical. (See Götting. Magazin, 1ten Jahrgangs, 2tes Stück: "A theory proposed to explain the cause which occasions the leaves of plants to purify the foul air in sunlight, but to vitiate the air in the shade.") The celebrated Baldinger promises (in the new Magazine) that the illustrious Landriani is about to give his experiments on light and animal heat.

to maintain its continued existence by restoring[1] the solid and fluid particles worn away and dissipated by the movements going on. It is necessary to the proper performance of this function, that there be not only a due supply of food of a proper quality, but also that those various viscera be healthy, which carry on digestion, and by the combined function of which, the food is converted into chyle, and rendered fit to be mixed with the blood. Yet when this process is completed, nutrition is not accomplished, but only the nutritive materials supplied to the blood, from which the wasted portion of our body may be restored; and the reparation of the lost material takes place by some admirable arrangement, and by a power as yet unknown, which knows how to restore to each portion of the body its lost particles, to apply them, and cause them to adhere.

Many physiologists, both ancient and modern, have maintained that nutrition is carried on through the nerves. Thus Sylvius, Willis, Glisson, and others, considered that there were two fluids in the nerves, one thick and albuminous, subservient to nutrition, the other very thin and spirituous, intimately connected with the former, and subservient to sensation and movement. The school of Boerhaave allowed one nervous fluid only, and that most refined and active; and held, not only that sensation and motion were performed by this, but nutrition also accomplished, when that fluid experienced the final elaboration by which it was rendered similar to our organism. Haller denied this nutritive property of the nervous fluid, because he thought that our body must be nourished with a less spiritual and more viscid fluid than the nervous fluid.[2] Marherr followed Haller, and maintained the same doctrine.[3] Tissot also adopted it,[4] although in another place he attributes with Boerhaave a

[1] This doctrine of attrition, and the destruction of the solid particles thence arising, has been maintained by many distinguished persons, but too exclusively, I think, as has been correctly shown by Kemme in his Essay entitled, 'Zweifel und Errinnerungen wider die Lehre der Aerzte von der Ernährung der festen Theile.' Halle, 1778. This wearing away and loss of substance manifestly does not occur in the nerves and brain, since the abrasion of so sensitive a substance could not occur without pain, or, at least, without an unpleasant sensation.

[2] Elem. Phys., tom. iv, p. 405.

[3] Prælect. ad Boerh. Inst., tom. ii.

[4] Von Nerven, 1ten Bandes, 2ter Theil, § 271.

nutritive property to the nervous fluid, observing:[1] "If the nerves were not tubuli pervious to the nervous fluid, they could not be nourished; for the vessels surrounding the nerves on all sides give nutrition to their cellular investment only, but the medullary tubuli are nourished by the nervous fluid." Tissot, moreover, specifies three modes in which the nerves co-operate in nutrition. In the first place, they pour animal spirits into the stomach, intestine, lacteal vessels, &c., carry on digestion conjointly with the gastric juice, impress an animal character on the food, and act as a stimulus to the stomach itself. Secondly, they cause the animal spirits to concur in nutrition by exciting muscular action, and promoting digestion: thirdly, they promote the secretion of gastric juice, saliva, &c.[2] Tralles has lately again promulgated the doctrine denied by Haller and others, of a nutrient property in the nervous fluid, observing that if a nerve be tied, compressed, or destroyed, not only are motion and sensation in the muscle destroyed, but also nutrition, and atrophy comes on; whence he thinks, the conclusion is undoubted, that some fluid passes from the brain along the nerves to the muscles, by which not only the muscles but the nerves also are nourished.[3] But all theories founded on the hypothesis of a nervous fluid are untenable, if the hypothesis itself be demonstrated to be untrue.

For the better understanding what share the nerves have in nutrition, it is advisable with Tissot to divide the nutritive process into the two processes of assimilation, and the application of the nutrient materials. No one can deny that the nerves concur, at least remotely, in the assimilation and transformation of food into nutrient material; promoting, for example, the secretion of saliva, of the gastric, intestinal, and pancreatic juice, and of bile; by producing action of the muscles subservient to mastication and deglutition; by exciting the movements of the stomach and intestines, nay, even those of the heart, of respiration, and of the whole body, inasmuch as all these actions concur in the elaboration of the nutrient fluid. But the question arises, have the nerves also a share in restoring the lost particles, and therefore in forming and

[1] Ibid. in 1ten Bande, 1ten Theile, § 153.
[2] 1ten Bandes, 2ter Theil, § 269.
[3] See Kemme's Zweifel und Errinnerungen.

repairing our bodies? Wonderful, indeed, is that property whereby the adaptation of nutrient material to each portion of the body is effected. This is done with such skill and wisdom, that suitable and analogous particles are applied to every part, and thus neither the composition nor character of their constituent particles, nor the form or structure of the nourished parts themselves, are disturbed by the continuous apposition of new molecules. Particles which are adapted to the composition of muscles or cartilage, are not deposited in bones, otherwise bones would gradually lose their proper character, and become cartilaginous or muscular. For these reasons, Blumenbach correctly maintains,[1] that generation, nutrition, and reproduction are effects or modifications of one and the same force, which forms in the first, maintains in the second, and restores in the third.[2]

[1] Von dem Bildungstriebe, § 7. Göttingen, 1781.

[2] This expression, that the fœtus is formed by generation, and not evolved from a germ created from the beginning of the world, should not appear to the indulgent reader altogether new; for Casper F. Wolff has long ago much weakened the system of evolutions set up by Bonnet and Haller, and established in its place the doctrine of epigenesis of the ancients. Haller, it is true, continued to maintain his views in his 'Element. Physiol.,' tom. viii; but after having carefully weighed his arguments, I do not think them sufficient to establish the doctrine of evolution, and confute that of epigenesis. Hybrid animals, malformations of the parent transmitted to the offspring, the reproduction of whole structures, especially of certain animals, as well as the generation of polypes and certain vegetables by cuttings, all confute the doctrine of evolution, and prove that those germs in which, from all time, entire animals or parts of them are marked out, do not exist; but that there must be some *vis structrix*, which constructs the bodies of animals, however complicated, from suitable materials that it has ready at hand. I have treated of this more fully in my dissertation on the system of generation, inserted in the Second Fasciculus of my 'Adnotationes Academicæ' for 1781. In the same year in which my dissertation appeared, that elegant tract by Blumenbach, Professor at Göttingen, was published, in which this *vis structrix*, or *nisus formativus*, as he terms it, is proved to exist, and the doctrine of evolution by germs is rejected. This essay gives the greater support to the doctrine of epigenesis, because the distinguished author himself brought forward much in favour of the hypothesis of evolution in his work 'De Generis Humani Varietate Nativa,' (Gotting., 1776;) but now, having had an opportunity of observing the phenomena of reproduction in polypes, and feeling the weight of the arguments in favour of epigenesis, has adopted it in place of the system of evolution. He maintains that in every animal and vegetable organism, there is intimately connected with it, during its whole life, a certain innate and ever-acting instinct, which he terms the *nisus formativus*, in virtue of which animals and vegetables attain their proper and fixed form; when this is attained, the same force maintains it;

For that wondrous force, which forms a fœtus similar to the parents, out of the semen of the male projected into the uterus, and that part which the female contributes, whether it be an ovum or semen—that force, I say, is not exhausted in the formation of a puny fœtus,[1] but continues active in it, and thus carries forward the human body through all its phases of growth and age, to the perfect state, fittingly replaces from the nutrient material, the particles worn away and dissipated by the continual movements and operations of life, nay, regenerates in a great measure portions of skin lost by violence, consolidates wounds, forms the callus of bones, &c. To this are owing those so-called efforts of nature, by which she attempts to preserve health and remove disease. In some animals, as lizards, for example, this *vis structrix* is so efficient, that it reproduces in them tails, extremities, and jaws, together with their bones, muscles, vessels, and nerves.[2] Eminent philosophers readily perceived, that these and many other phenomena observed in the animal organism, and also in the vegetable, can be referred neither to the wisdom of a rational soul, nor to any mechanical and physical laws as yet known; and, consequently, they have very properly termed that wonderful cause innate in the animal and vegetable organism, the vital principle, inasmuch as to that, as a proximate cause, both animal and vegetable owes its life; which is also distinct from the thinking principle, for it far excels this in wisdom, and is not subject to it, and has higher faculties, than it has hitherto been agreed that bodies possess. The vital principle is not some simple force, but seems to be compounded of various unknown forces co-operating together; amongst which unknown forces so co-ope-

and when injured, repairs it as much as may be. Very lately, also, Metzger, Professor at Königsberg, in the first volume of his work entitled 'Vermischte Medicinische Schriften,' (Königsberg, 1782,) weakens the force of the arguments adduced by Haller in favour of evolution; and in the supplement to the second volume, declares his assent to the views of Blumenbach. He differs, however, in thinking that the *nisus formativus* cannot be considered as distinct from the *vis plastica* of the ancients and the *vis essentialis* of Wolff, since it so much resembles them; so that the *vis essentialis* is primary, and analogous to the *vis vitalis* of physiologists, which constitutes life, both in animals and vegetables: secretion, nutrition, generation, and reproduction, are portions, or rather branches, of this.

[1] See Fasciculus ii of my 'Acad. Adnot.,' p. 31.

[2] See my 'Comment. de System. Generat.'

rating for the formation of the vital principle in man and many animals, the *vis nervosa* seems to claim an important position, since in many operations ascribed to the vital principle, the function of the nerves is predominant. The nerves appear also necessary to the application of nutrient material, and the reproduction of cut off parts, because if the nerves of a part be injured, its nutrition is impaired, and because the animals which are tenacious of life and of irritability, also possess a remarkable property of reproducing separated parts.

Since vegetables and some animals generate, are nourished, and reproduce cut-off parts, and, consequently, possess a vital principle, although they appear to be destitute of a nervous system, it follows that the vital principle may exist independently of the *vis nervosa* in plants and certain animals not endowed with nerves; but it does not hence follow, that the vital principle can exist without the *vis nervosa* in man and animals endowed with a nervous system. For nature seems to have bound all parts of our body together by such an agreement and combination, that one part assists another, and one cannot easily exist without another; and especially the *vis nervosa* seems to be necessary to the constituting of the vital principle in our own body and in the bodies of animals endowed with a nervous system, although it appears that the principle may exist without the *vis nervosa* in plants and animals that have no nervous system. There are certain animals and vegetables which reproduce their kind without distinction of sex, but is the congress of both sexes, therefore, not necessary to generation in man and other animals and vegetables?

CHAPTER IV.

THE FUNCTIONS OF THE SENSORIUM COMMUNE.

SECTION I.—WHAT IS THE SENSORIUM COMMUNE, WHAT ITS FUNCTIONS, AND WHAT ITS SEAT?

THE external impressions which are made on the sensorial nerves are very quickly transmitted along the whole length of the nerves, as far as their origin; and having arrived there, they are reflected by a certain law, and pass on to certain and corresponding motor nerves, through which, being again very quickly transmitted to muscles, they excite certain and definite motions. This part, in which, as in a centre, the sensorial nerves, as well as the motor nerves, meet and communicate, and in which the impressions made on the sensorial nerves are reflected on the motor nerves, is designated by a term, now adopted by most physiologists, the *sensorium commune*.

Distinguished men have not agreed as to the seat of the sensorium commune. Bontekoe, Lancisi, De La Peyronie have placed the sensorium commune in the corpus callosum; Willis derived the perception of sensation and the source of movements from the corpora striata; Des Cartes attributed the function of the sensorium commune to the pineal gland; Vieussens to the centrum ovale; Boerhaave decided that aggregate of points to be the sensorium commune, in which all the sensory nerves terminate, and from which all the motor nerves arise, and accordingly placed it in the medulla fornicata, surrounding the cavity of the ventricles.[1] In a later work, 'De Morbis Nervorum,' Boerhaave places the sensorium commune in the boundary line of the medullary and cortical substance, which opinion Tissot thought to be extremely probable, regarding it as confirmed by the observations of Wepfer.[2] Mayer seems to place the sensorium commune in the medulla oblongata;[3] that distinguished man, J. D. Metzger, appears to be also of

[1] Prælect. Acad. in proprias Inst. cum Notis Halleri, tom. iv, § 574.
[2] Abhandl. über Nerven und Nervenkrankh. 1ten Bandes, 2ter Theil, § 236.
[3] Abhandlung vom Gehirn, Rückenmark, &c., Seite 34—38.

the same opinion;[1] the celebrated Camper said, that if the sensorium commune has a seat at all, it ought to be in the pineal gland, and in the nates and testes, and that, therefore, the opinion of Des Cartes was not so very absurd.[2] It certainly does not appear that the whole of the cerebrum and cerebellum enters into the constitution of the sensorium commune, which portions of the nervous system seem rather to be the instruments that the soul directly uses for performing its own actions, termed animal; but the sensorium commune, properly so called, seems not improbably to extend through the medulla oblongata, the crura of the cerebrum and cerebellum, also part of the thalami optici, and the whole of the medulla spinalis; in a word it is co-extensive with the origin of the nerves. That the sensorium commune[3] extends to the medulla spinalis is manifest from the motions exhibited by decapitated animals, which cannot take place without the consentience and intervention of the nerves arising from the medulla spinalis; for the decapitated frog, if pricked, not only withdraws the punctured part, but also creeps and leaps, which cannot be done without the consensus of the sensorial and motor nerves, the seat of which consensus must necessarily be in the medulla spinalis —the remaining portion of the sensorium commune.

The reflexion of sensorial into motor impressions, which takes place in the sensorium commune, is not performed according to mere physical laws, where the angle of reflexion is equal to the angle of incidence, and where the reaction is equal to the action; but that reflexion follows according to certain laws, writ, as it were, by nature on the medullary pulp of the sensorium, which laws we are able to know from their effects only, and in nowise to find out by our reason. The general law, however, by which the sensorium commune reflects sensorial into motor impressions, is the preservation of the individual; so that certain motor impressions follow certain external impressions calculated to injure our body, and give rise to movements having this object, namely, that the annoying cause be averted

[1] Advers. Med., p. 15; Vermisch. Schrift., 1ten Bandes, Seite 56.

[2] Kleine Schriften, (Leipzig, 1782,) 1ter Band; Nachricht von der Zergliederung eines jungen Elephanten., § 21.

[3] Marherr contends that the medulla spinalis ought also to be referred to the sensorium commune in 'Prælect. ad Inst. Med. Boerhaavii,' tom. ii, p. 404.

and removed from our body; and *vice versâ*, internal or motor impressions follow external or sensorial impressions beneficial to us, giving rise to motions tending to the end that the agreeable condition shall be still maintained. Very many instances which might be adduced, undoubtedly prove this general law of the reflexions of the sensorium commune, of which it may be sufficient to mention a few. Irritation being made on the internal membrane of the nostrils excites sneezing, because the impression made on the olfactory nerves by the irritation is conducted along them to the sensorium commune, there by a definite law is reflected upon motor nerves going to muscles employed in respiration, and through these produces a strong expiration through the nostrils, whereby the air passing with force, the cause of the irritation is removed and ejected. In like manner it happens that when irritation is caused in the trachea by the descent of a particle of food, or a drop of fluid, the irritation excited is conducted to the sensorium commune, and there reflected on the nerves devoted to the movement of respiration, so that a violent cough is excited, a most suitable means for expelling the cause of irritation, which does not cease until the irritant be ejected. If a friend brings his finger near to our eye, although we may be persuaded that no injury is about to be done to us, nevertheless the impression carried along the optic nerve to the sensorium commune is there so reflected upon the nerves devoted to the motion of the eyelids, that the eyelids are involuntarily closed, and prevent the offensive contact of the finger with the eye. These and innumerable other examples which might be brought forward, manifestly show how much the reflexion of sensorial impressions into motorial, effected through the sensorium commune, has reference to maintaining the conservation of the body. Wherefore, Tissot justly enumerates the action of the sensorium commune amongst those powers, the sum and co-ordination of which constitute the nature of our living body.[1]

Since the principal function of the sensorium commune thus consists in the reflexion of sensorial impressions into motor, it is to be noted, that this reflexion may take place, either

[1] Von Nerven, 2ten Bandes, 2ter Theil, § 55, in the first note; and ibidem, § 6 No. 6; Thaer's dissertation already referred to, 'De Actione Systematis Nervosi in Febribus,' and especially §§ viii, ix, &c., should also be read.

with consciousness or without consciousness. The movements of the heart, stomach, and intestines, are certainly in nowise dependent on the consciousness of the soul, for whilst no muscular movement can be excited, unless a stimulus applied to the sensorial nerves passes by a peculiar reflexion to the motor nerves, and excites contraction of the muscle, it is at the same time certain that the reflexion of the impressions suitable for exciting those movements, if it takes place in the sensorium commune, is effected without consciousness. But it is a question whether these impressions, in order that they may be reflected, do really travel so far as the sensorium commune, or, without taking this long circuit, are reflected nearer in the ganglia, from whence these parts derive many nerves? This matter is further to be considered afterwards. But that reflexions of sensorial impressions into motor are effected in the sensorium commune itself while the mind is altogether unconscious, is shown by certain acts remaining in apoplectics deprived entirely of consciousness; for they have a strong pulse, breathe strongly, and also raise the hand, and very often unconsciously apply it to the affected part. The sensorium commune also acts independently of consciousness in producing the convulsive movements of epileptics, and also those which are sometimes observed in persons buried in profound sleep, namely, the retractions of pricked or irritated limbs, to say nothing of the motion of the heart and the respiratory acts. To this category also belong all those motions which remain some time in the body of a decapitated man, or other animal, and are excited when the trunk, and particularly the medulla spinalis, are irritated, which motions certainly take place without consciousness, and are regulated by the remaining portion of the sensorium commune existing in the medulla spinalis. All these actions flow from the organism, and by physical laws peculiar to the sensorium commune; and are, therefore, spontaneous and automatic. The actions taking place in the animal body, with accompanying consciousness, are either such as are independent of volition, or such as the mind can restrain and prohibit at pleasure; the former being governed by the sensorium commune alone, independently of the mind, are as much automatic as those of which the soul is unconscious. Of this character are sneezing from an irritant applied to the nostrils, cough from an irritant fallen into the trachea, vomiting from a titillation of the fauces, or after taking an emetic; the tremors and convulsions in St. Vitus's dance, and in a paroxysm of intermittent fever, &c. Those actions, however, which the soul directs or limits by its own power, even although the sensorium commune has its share in producing them, are nevertheless called animal, and not automatic, and concerning them we treat in the next chapter.

SECTION II.—DOES EVERY CONSENSUS OF THE NERVES TAKE PLACE THROUGH THE SENSORIUM COMMUNE ONLY?

Since the nerves depend so much on each other in performing their functions, so that one is required to regulate the action of another, and one to come to the help of another as it were, it is manifest how necessary it is that there should be a consensus of the nerves, and how necessary is that part of the nervous system in which this consensus takes place; for if this part be destroyed, presently all those actions to the production of which the consensus of many nerves is required necessarily cease. I will not waste time in narrating examples of consensus of the nerves, for the latter is abundantly treated of in physiology and pathology, and examples of it are *ex professo* related by those highly distinguished men Whytt[1] and Tissot.[2] I will, however, direct consideration to one question, namely, whether the nerves communicate with each other in the *sensorium commune* only, or whether there be other localities besides the sensorium commune, in which the consensus of at least some nerves takes place? Willis taught, that the consensus took place not only through the brain, but through the connections and communicating branches of the nerves, which we perceive to be pretty numerous in their course; Vieussens ascribed the consensus of the nerves to both their ganglia and anastomoses, and Boerhaave, Bergen, Vater, Buchner, &c., were also of a similar opinion, as well as the celebrated Meckel in his essays, 'De Nervo Quinti Paris,' and 'de Nervis Faciei.' Gasser followed him;[3] and lastly, Camper also explained the consensus of the nerves by their communicating branches. Eminent

1 On Diseases of the Nerves. See all his practical works in German.

2 Von Nerven, 2ten Bandes 2ter Theil, 10tes Kapit.

3 In the dissertation of George Egger, 'De Consensu Nervorum.' Viennæ, 1766.

men were also of a contrary opinion; that is to say, that the nerves do not communicate with each other through their anastomoses, but in the brain only. Amongst these were Perault, Astruc, Kau Boerhaave, Haller, Whytt, Van Swieten, Monro, Marherr, Thaer, La Roche, and Martin;[1] add to these Tissot,[2] who specially lays stress on the following arguments of Whytt: firstly, that all the nerve-fibrils from their commencement to their termination are entirely separate from each other, so that they have no communication, and are connected with each other by their investing membrane only. Secondly, that there is sympathy between parts, the nerves of which have no anastomoses with each other. Thirdly, that there ought to be many sympathies of parts, the nerves of which are seen to be closely interwoven and connected with each other, and yet no such sympathies are manifested. Fourthly, he adds also to these arguments of Whytt, another, namely, that if the trunk of a nerve be divided, the consensus of its branches is destroyed. That eminent man, therefore, attempts by these arguments to establish the doctrine, that consensus of the nerves takes place in the *sensorium commune* only, and in no degree in the nerves. Yet nevertheless, in the next page[3] he observes, that it may be assumed as a demonstrated truth, that consensus is most frequently noted in the nerves between which the communicating branches are numerous; still he does not believe that consensus takes place through these communicating branches, but that they contribute something to it, of the nature of which we are as yet ignorant.

It is difficult to decide on a point regarding which so many persons have disagreed, and which is as yet involved in so much obscurity. The first glance at the anastomoses or communications of the nerves leads us to think, that they are constituted to maintain some consensus and interchange of their functions, and no other probable reason can be assigned for so many anastomoses of the nerves and of their funiculi.[4] With regard to the arguments which eminent men have advanced in favour of a contrary doctrine, they establish nothing as far as I

[1] Instit. Neurolog., sect. i, p. 87.
[2] Loc. cit.
[3] 2ten Bandes 2ter Theil, § 6, Nro. 4.
[4] These may be seen delineated in my treatise 'De Structura Nervorum.'

perceive, for the first argument of Whytt is founded on this, that every nerve-fibril is a canal continued from its commencement to its termination without any connection with another; but since this supposition is nothing more than an improbable conjecture, to which anatomy is opposed, for the pulp of the nerves is found to be rather granular than tubular, we cannot allow it to have any demonstrative force. The second argument, which alleges that there are nerves which are consentient in their functions, but have no anastomoses in their whole course, proves, indeed, that these nerves communicate only in the *sensorium commune*, but does not prove that the anastomoses of other nerves do not contribute to their necessary intercommunication. As to the third argument, that there should be many sympathies displayed by those nerves which have many anastomoses, and yet are these not displayed, we would answer in the words of Tissot himself,[1] that we are not as yet informed as to all the sympathies and consensus of nerves, and therefore there may be many which have hitherto escaped the diligence of observers. From which, therefore, I think we may conclude, that although the principal and greatest consensus of the nerves takes place in the *sensorium commune*, it is not possible to deny some share in connecting and combining the functions of the nerves to their anastomosing and communicating branches.

SECTION III.—DOES CONSENSUS OF THE NERVES ALSO TAKE PLACE IN THE GANGLIA?

The functions of the ganglia of the nerves have also been hitherto involved in much obscurity; so that, after the labours of such great men to determine their nature and use, scarcely a spark of the light necessary to elucidate that mystery of nature has appeared. The celebrated Tissot[2] has so learnedly and elegantly treated of this matter, as well as of the consensus of the nerves, that I think it altogether superfluous to consider the structure and functions of the ganglia in complete detail. Having weighed all the opinions that have been advanced regarding the functions of the ganglia, he esteems that which Johnston has propounded as the most probable, namely, that the ganglia ren-

[1] Instit. Neurolog., § 6, No. 5.

[2] 1ten Bandes 2ter Theils, Eilfter Artikel.

der the nerves which arise from them independent of the will, and therefore that the heart and intestinal canal are not subject to volition, since they receive their nerves from the ganglia of the intercostal [great sympathetic] nerve. Tissot thinks, that the doubts advanced by Haller, and more fully entered into by Haase, are not at all unanswerable, and are indeed of that character, that they may be easily made to comport with the doctrine of Johnston. Pfeffinger has also studiously investigated this theory as to the uses of the ganglia, and approved of it in an elegant dissertation, 'De Structura Nervorum,' published in 1782.

It is not an improbable conjecture, therefore, that the ganglia found around the nerves act as a sort of gentle ligature or compress, so that the connection between the two extremities of a nerve is so far interrupted, as to prevent the impressions made on the one extremity of the nerve being communicated through the ganglion to the other extremity; yet the communication of all impressions is apparently not altogether interrupted; for if they be powerful, they appear to pass through the ganglia, and to be transmitted forward along the length of the nerves, but with broken and diminished force. From this it appears to be possible to understand, why the mind has no immediate control over the movements of the heart, stomach, and intestines, namely, because the impressions made by the will on the origins of the nerves do not appear to pass through the ganglia of the intercostal, or great sympathetic nerve, to the parts mentioned, which derive their nerves principally from the intercostal. For this reason it also appears, that although, when the *medulla spinalis* is irritated, all the muscles are spasmodically contracted, yet the movements of the heart, stomach, and intestines, are scarcely, if at all, accelerated, since the impression of the stimulus applied to the *medulla spinalis* cannot be transmitted to the intercostal [great sympathetic] nerve through its ganglia. But eminent men testify, that they have seen the motion of the heart increased, and the heart when at rest excited into action by irritation of the *medulla spinalis*, as also certainly that from too great emotion,—anger, for example, —the heart's action is immediately accelerated; whence it necessarily follows, that the impressions of a stimulus from the brain and spinal cord may pass through the ganglia of the intercostal nerve; but that it is necessary that these impressions be more powerful. Hence we have an explanation, why the heart is so obtuse as regards sensation, and the stomach and intestine not acute, namely, because impressions made on the nerves of those parts do not penetrate the ganglia of the intercostal nerve to reach the brain, where the perception of sensations takes place. As regards the impressions, however obtuse they may be, that do reach the brain from the heart, stomach, and intestines, is it not rather that they reach the brain through the branches of the eighth pair distributed to those viscera, than that they pass through the intercostal [great sympathetic] ganglia? The conjecture is difficult. Further, the structure of the ganglia, as described by eminent inquirers, is not opposed to this doctrine of the functions of the ganglia, but if anything rather appears to confirm it. Meckel, Haase, and Zinn maintain, that the ganglia are made up of the nerves entering into them, which divide into very minute filaments, so that they are variously subdivided, and make a sort of net-work. Condensed cellular tissue is intermingled with this net-work of nervous filaments, and the whole is enveloped in a somewhat tense external membrane; whence may arise a somewhat gentle compression of the nerves entering the ganglion, which is sufficient to stifle, or rather intercept the less powerful impressions propagated along the nerves, and manifestly to obtund the more powerful. The whole of this doctrine, as to the uses of the ganglia, can however be brought forward only as a conjecture not manifestly improbable, but meriting the investigation of the learned, and possibly containing a spark of truth, from which some acute genius may be able to produce greater light for us. He who shall unravel the uses of the ganglia will also give a reason why the fifth pair of cerebral nerves pass through the semilunar [Gasserian] ganglia, with the exception of a fasciculus which joins the third division without touching the ganglion;[1] and why only the posterior roots of the spinal nerves enter the ganglia, whilst the anterior roots pass by without any communication with them.[2]

Further, it may be asked, whether the external impressions made on the terminations of the nerves and passed onwards to

[1] See my treatise 'De Structura Nervorum,' tab. ii, figs. v, vi.

[2] Ibidem, tab. iii, figs. i, ii.

the ganglia are extinguished in the ganglia themselves? or whether being reflected there by a fixed law, they return again along the nerves to the parts to be moved? The celebrated Unzer,[1] and the eminent Winterl taught, that external impressions are reflected in the ganglia, as they are reflected in the *sensorium commune,* and that the ganglia are special sensoria,—a doctrine which does not appear altogether destitute of probability. For, if we consider that the minute and invisible nerves disseminated over the internal membrane of the heart and auricles, perceive the stimulus of the inflowing venous blood,[2] and although they cannot transmit the impression of that stimulus to the *sensorium commune* through the ganglia of the intercostal [great sympathetic] nerve, yet communicate it to the motor nerves distributed through the substance of the heart [ventricles] and auricles, it follows that there is necessarily a consensus between the sensory nerves distributed on the inner membrane of the heart and the motor nerves disseminated through the substance of the heart [ventricles] and auricles, which must take place either in the ganglia of the intercostal nerve or below them, in the communicating branches or plexuses of nerves. It seems probable, therefore, that besides the *sensorium commune,* which we conjecture to be in the *medulla oblongata, medulla spinalis, pons varolii,* and *crura* of the *cerebrum* and *cerebellum,* there are special *sensoria* in the ganglia and plexuses of the nerves in which external impressions ascending along the nerves are reflected, that need not ascend all the way to the *sensorium commune,* to be reflected thence.

[1] Erste Gründe einer Physiologie, &c.
[2] Haller, De Part. Corp. Hum. Fabr.

CHAPTER V.

THE ANIMAL FUNCTIONS.

SECTION I.—A SHORT ENUMERATION OF THEM.

In that portion of the nervous system which we have termed the *sensorium commune*, such a mechanism lies concealed, that external sensory impressions of the nerves are reflected in it upon the motor nerves in a singular manner, and by unerring and peculiar laws, so that they produce distinct and definite movements of the muscles. It has already been stated, that many motions truly automatic take place in man by means of this *vis nervosa* of the *sensorium commune* only; nevertheless, although many animals which are destitute of brain, and the higher endowments of animals are regulated and live only through this vis of the sensorium commune, and therefore may be termed true automata, in man and many allied animals the nervous system is increased by the addition of a brain; and moreover, with a certain principle which we call the soul, an *ens* of incorporeal origin, and which we are taught by faith to have been granted to man alone, to constitute him an immortal creature by the special favour of God. So long as the soul is joined with the body, it manifestly produces no operation which depends solely and exclusively upon itself, but all take place by means of the nervous system as the instrument; so that in all the animal functions, the nervous system has a share as the instrument, and the mind a share as the acting and determining principle.

Animal actions under the name of internal senses, or under the name of faculty of thought, or of reason, or of intellect, come continually under the observation of physicians. I by no means propose to treat of these so accurately and profoundly as has been done by metaphysicians and psychologists, but only to touch on those points with which it behoves physicians to be fully acquainted. The principal divisions into which the animal functions may be conveniently divided, are perception, understanding, and will, to which may be added imagination and recollection, or memory.

The mind perceives the external impressions made on the nerves, and communicated to the *sensorium commune,* by acquiring certain notions and images of them termed ideas.[1] These differ according as they are brought from the various organs of the senses to the *sensorium commune,* for vision excites one kind of ideas in the mind, hearing another kind, taste, smell, and touch other kinds. Ideas also differ in their degree of vividness, for the more vivid ideas presuppose a more impressible nervous system, that many impressions are not communicated at the same time to the sensorium, (for the mind clearly perceives one idea after another,) or an impression more powerful, repeated, continuing longer, or new and unusual.

Whilst engaged in the examination of ideas, the mind judges whether there be discrepancy or agreement amongst them, whether they be new or often-repeated ideas—whether they threaten anything injurious to our body, or promise anything beneficial. When engaged in this judgment, the mind must remember the idea first perceived, when it compares it with another for the purpose of seeing their agreement or discrepancy, and consequently the faculty of judging presupposes memory. If many compound ideas be compared one with another, a compound judgment is made, and this is termed reasoning.

The mind wills, when it endeavours to retain or remove that which by the ideas is understood to be good or evil.

It imagines, when the ideas of things formerly present but now absent are excited, voluntarily or involuntarily, either from some internal disposition of the brain, or from some similar or associated idea excited in the mind. Those ideas

[1] I do not here treat of the hypotheses as to the formation of ideas in perception and imagination, whether they be impressions traced on the brain, which Haller defends in his 'Elem. Phys.,' tom. v, p. 541, &c.; or whether they are a certain motion and minute vibrations or oscillations, which, being different, are suitable to the excitation of different ideas, as Bonnet ingeniously supposes. (See his 'Analytischer Versuch über die Seelenkräfte.') Reimarus (see Göttingen Magazine for the past year, part vi,) strongly disapproves of the doctrine, that there are material tracings of the ideas impressed on the brain, since the memory being lost in disease could never be restored, as it often is, if, indeed, the tracings of the ideas, once obliterated, cannot be restored when the disease terminates, with the same facility as the fibres of the brain can be re-excited into similar oscillations on the opportunity being afforded; and because, as the traces are always present, there could be no reason why the representation of ideas should cease during profound sleep. In this matter those more acute than I will decide.

which arise from imagination are less vivid than those from perception; but by continual meditation and fixing of the attention upon them, they become gradually more and more vivid, until at last they may become equal to those ideas which arise from perception; so that the mind cannot distinguish them, and confounds things present with things absent, when it is said to wander.

When an idea arising from perception or imagination, is accompanied with the consciousness that it is not new, but has been perceived by us formerly, the circumstances also occurring in which it was formerly perceived, the mind is said to remember or recollect.

We are conscious, when the animal actions are in actual operation (as takes place during waking); and consciousness is abolished in the same proportion that the animal functions cease to be exercised, as for example, in sleep, apoplexy, or fainting. Thus consciousness seems properly to belong to the actual exercise of the faculty of thought.

The mind does not enjoy an equal degree of freedom in all these mental operations. It does not perceive voluntarily but compulsorily, since it is not able, for example, not to see if the object be placed properly before it. Nor does the mind perceive the harmony or discordance of ideas more voluntarily. The mind has the greatest freedom in willing, for it can desire a pleasing object, or neglect, or refuse it; nevertheless, if what is pleasing or displeasing becomes an object of any great pleasure or pain, the mind loses much of its freedom in willing, nay, is compelled to desire or dislike, and passions arise of which we are not the masters but the obsequious slaves, since we may often see and approve the better, and yet unwillingly follow the worse. For this reason they are rightly termed passions of the mind, since in them the mind scarcely acts, but is impelled to action by the body. I avoid adducing here special instances of the passions, and examining them with reference to their causes and effects, since I think that this has already been fully done by others, nor can I add anything new or particular; I will only treat on some questions relating to the animal functions, respecting which distinguished men have entertained opposing opinions.

SECTION II.—IS THE FACULTY OF THOUGHT THE SPECIAL PROPERTY OF THE MIND, OR IS IT NECESSARY TO THOUGHT THAT THE MIND USE THE BRAIN AS AN INSTRUMENT?

Many philosophers and physicians have asserted, that the mind alone thinks, and the body takes no part in that operation; on the other hand, some have maintained that thought itself is a faculty belonging to matter, and denied that the soul is immaterial; others, thinking that both were far wide of the truth, have imagined they could set the matter at rest by stating that certain operations of the thinking faculty are partly owing to the body, as memory, for example, but that others are performed by the mind alone, and independently of the body.

If we consult daily observation, we learn that the faculty of thought is subject to various viscissitudes, and corresponds closely with the condition of the brain. The fœtus hid in the uterus of its mother, neither sees, nor hears, nor tastes, nor smells, nor scarcely feels the fluids that surround it. Thus destitute of ideas, it neither judges nor imagines, nor remembers. On emerging into light, the fœtus, indeed, begins to perceive objects through the organs of the external senses, but it cannot as yet correctly judge between ideas, and quickly forgets its perceptions, for the semi-fluid brain seems unfit to retain them, and consequently, we remember nothing of that period. The same mind in the youth, with a firmer and more condensed brain, retains ideas readily and with remarkable facility, and is endowed with somewhat of the power of judgment as to serious matters, although but feebly. In manhood, the solids generally, and therewith the brain, being consolidated, it commits new ideas to memory, and retains them with less facility, but enjoys by so much the more a riper judgment. In old age, new ideas are retained with still greater difficulty, but the old being indurated, as it were, like the brain, pertinaciously adhere to it; yet some aged persons lose even these, and return to the state almost of plants, oblivious of the world, their friends, and themselves.[1] The mental endowments differ

[1] Haller, in his notes to the 'Prælect. Instit. Med.' of Boerhaave, and in his 'Elem. Phys.,' tom. v, p. 538.

not only according to age, but also in persons of every age, according to the varying constitution of the brain proper to each individual; for just as an equally vigorous stomach, lungs, and other viscera is not seen in all men, so the brain does not acquire the same strength and perfection in all men; and hence we should expect a diversity in the faculty of thought, of which the brain is the instrument, in different men; and this, in fact, we daily find to be the case. For some persons endowed with a more fortunate condition of the brain, are quick in perception, sound in judgment, prompt in willing, happy in retaining and recalling ideas; others with little talent, as the phrase is, owing to a less fortunate condition of the brain, are dull in perception, weak in judgment, slow to action, unfortunate and imperfect in the exercise of memory. Some, again, perceive quickly, and remember most felicitously, but judge foolishly; whilst others who are endowed with an excellent judgment, have by so much the more imperfect a memory. Some, in consequence of a congenital defect of the brain, are stupid and fatuous throughout their whole life; "many of whom," says Haller,[1] "have a face scarcely human, large mouth, dribbling saliva, numerous strumous swellings, harsh voice, and a mind unfit for all the duties of life. Another equally numerous class spend their whole life in bed, incapable of any corporeal movement: they pass a long life in a condition not much superior to brute animals, and having rather less intelligence for the functions of life; and, indeed, their senses are so dull, that lately one of them perished from a collection of fæces, which distended the rectum to the diameter of a foot and a half, and of which he felt nothing." This effect of a vitiated state of the brain in depraving the intellect is so well known that it cannot be doubted that if the state of the brain of Newton and Alexander had been changed in infancy by slight concussion or compression, the one might have been a stupid man, and the other a wise king. Who, in short, does not daily observe the faculty of thought to be disturbed, impaired, and even extinguished by disease, and all consciousness for a time abolished? If his kinsfolk be placed before a man delirious in fever, he often does not recognise them, for either the perception is affected,

[1] Elem. Phys., tom. v, p. 570.

or the understanding, or the memory, which does not retain the old idea of the kinsfolk to be compared with the new perception. The organ of the understanding seems to have been especially affected in the patient of Wepfer,[1] who mistook a piece of paper for a handkerchief, and the handle of the spoon for the bowl. The organ of memory is not unfrequently so disordered by disease that individuals lose the recollection of their past life, and forget acquired knowledge; of this, the illustrious Linnæus lately afforded an example. Not unfrequently, all the organs of the animal functions are so affected that none of them can be exercised, and for the time at least consciousness is entirely abolished, as is seen not only in persons affected with apoplexy, carus, fainting, and epilepsy (during the paroxysm), but also in profound sleep in which all the animal functions enjoy a full holiday, since the brain requires rest for itself after having been wearied with the exercise of thought throughout the day. Nay, frequent use has no slight effect in changing and perfecting the animal functions. By use alone the perception becomes more acute, for the musician perceives the least discord, and is annoyed by that which a person, not a musician, never notices; use renders the memory more tenacious, the judgment more acute, the will more prompt; all which may also be observed in musicians, who acquire so much readiness and facility by practice, that they perceive the notes, judge what time and tone they denote, will, and apply the fingers in fulfilment of the volition, almost at the same moment.

From all these things it evidently follows, that thought cannot depend solely and entirely upon the mind, nor is the whole essence of the soul exempted from thought; otherwise we must conclude that a soul of an inferior nature is given to dull persons, and of a superior to the intelligent; that it can increase with age, be perfected by exercise, become sick, and be deprived of one faculty or another,—as memory, for example, and consequently, that the substance is material, and may be increased or diminished. But these changes and defects may be attributed to the brain, when in a state more or less imperfect, as being the instrument of the soul, and necessary to thought, so long as the soul is connected with the body; if it

[1] Hist., 98.

be injured, thought is injured; if destroyed, thought is destroyed, and consciousness abolished.

Eminent men of all ages have acknowledged this dependence of the faculty of thought upon the body: of these I need only mention Hippocrates[1], Galen,[2] Des Cartes,[3] Abraham Kau Boerhaave,[4] and Gaubius[5]. The force of truth also made Tralles subscribe to this opinion[6], for although he carried the doctrine that the mind is independent of the body too far, yet he observes: "It is indeed certain that experience teaches us that so long as the soul is connected with the body, a well-constituted brain is absolutely necessary for it to think, imagine, reproduce ideas, and judge concerning them." Ernest Platner, also, in his elegant essay, 'De Vi Corporis in Memoria,'[7] observes: "Since such are the facts, it is manifest from the observations already made as to the mode of perception, that every one of our senses is put in action by the common agency of the body and mind, so that no sensation or thought can be produced by the mind without the body, nor by the body without the mind." And this doctrine, that the soul, so long as it is connected with the body, can neither think, nor have self-consciousness without a properly-constituted brain, derogates certainly in no degree from the immateriality and immortality of the soul, which God, by special favour, can endow with an eternal consciousness of itself and of things external to it, although the body it had inhabited be destroyed,—a doctrine we are taught to believe by religion, which also in every age has been desired by mankind, and which great philosophers have approved by their assent[8].

[1] In the Epistle of Democritus, 'De Natura Hominis,' which is extant among the works of Hippocrates.

[2] Cap. ix, Libri quod animi mores corporis temperamenta sequantur.

[3] Diss. de Meth., n. vi, p. m. 38.

[4] Impetum faciens dictum. Hippocrati, cap. i, he says: "The Supreme Ruler has associated the mind with the body by such a law, that without a suitable state of body the mind is evidently inactive, and becomes so disconsolate and unlike itself, that you in vain search for mind in the mind itself."

[5] De Regimine Mentis quod Medic. est, Sermo i.

[6] De Animæ existentis Immaterialitate et Immortalitate, p. 31.

[7] In Baldinger, Syloge Selector. Opusculor. Argum. Medico-Pract., vol. iii, p. 86.

[8] This closing sentence is omitted in the edition published in the *Opera Minora*; the reference to the doctrines of Christianity at the commencement of Section I, is also omitted.—ED.

SECTION III.—DO EACH OF THE DIVISIONS OF THE INTELLECT OCCUPY A SEPARATE PORTION OF THE BRAIN?

It is our consciousness and a certain peculiar feeling which convinces every one that he thinks with his brain. But since the brain, as well as the cerebellum, is composed of many parts, variously figured, it is probable, that nature, which never works in vain, has destined those parts to various uses, so that the various faculties of mind seem to require different portions of the cerebrum and cerebellum for their production. Since, however, the *sensorium commune* reflects the sensorial impressions into motor by definite laws peculiar to itself, and independently of consciousness, and since we have laid down that the *sensorium commune* comprises the medulla oblongata, medulla spinalis, and the origin of all the nerves, it follows that the cerebrum and cerebellum, together with their connections, the *sensorium commune* excepted, constitute the organs of the faculty of thought; and as in some animals these organs are entirely wanting, it is fair to conjecture that the faculty of thought is also wanting, and that they exist solely in virtue of the *vis nervosa* of the *sensorium commune* and of the nerves with which they are endowed. Hitherto it has not been possible to determine what portion of the cerebrum or cerebellum are specially subservient to this or that faculty of the mind. The conjectures by which eminent men[1] have attempted to determine these are extremely improbable, and that department of physiology is as obscure now as ever it was; and we think with Haller that no light can be thrown upon it in any other way than by a careful dissection of the brains of fatuous persons, apoplectics, and such as have other disorders of the understanding. There are indeed, many observations extant bearing upon this point, but few have been rightly made, and with many there is interwoven a preposterous judgment on what has been observed. As hitherto there has been so much reason to lament the dearth of judiciously-made observations, I hope more ingenious men may be incited to note, as occasion

[1] The sentiments of the Arabians may be seen in § iii of chap. i; and in § vi, the opinion of Willis, Lancisi, De la Peyronie, and Mayer.

offers, what has been observed during life in cases of this kind, and having duly examined, after death, the cerebrum and cerebellum, together with the remainder of the nervous system, to make the facts public, with or without a suitable judgment on the case. The distinguished Metzger has promised[1] to watch diligently for such observations, and has raised our hopes, since much may be expected from his genius and dexterity.

It is, therefore, by no means improbable, that each division of the intellect has its allotted organ in the brain, so that there is one for the perceptions, another for the understanding, probably others also for the will, and imagination, and memory, which act wonderfully in concert and mutually excite each other to action. The organ of the imagination, however, amongst the rest, will be far apart, I should think, from the organ of perceptions, since the organ of perceptions being asleep and at rest, the organ of the imaginations may be in action, a condition which produces dreams. There is this peculiarity in dreams, however, that the ideas represented are often very absurd, and are continually combined and judged of erroneously, and we are not convinced of their falsity and emptiness, until all these phantasms are discovered to be false and corrected by the waking up of the organ of the perceptions.

SECTION IV.—WHAT MOVEMENTS ARE PROPERLY TERMED ANIMAL?

There are only two kinds of muscular action in the human body, according to the cause which excites it; the one kind is termed voluntary or animal, because according as the mind commands and wills, it may be excited, increased, diminished, and arrested; the other involuntary, of which the mind is either unconscious, or if conscious, the motion is performed without its consent, and is excited only by a mechanical corporeal stimulus applied to the nervous system, for which reason it is also termed spontaneous and automatic. Nerves are necessary to produce both kinds of movement.[2] The nerves do not act, however, without a stimulus, which is either produced by the mind willing, or, if unconscious and unwilling, by

[1] Vermischte Medicinische Schriften, 1ten Bandes, Seite 58.
[2] See Chap. II, § III, (6).

some body applied to the nerves. Whence, therefore, it is manifest, that those movements ought alone to be termed animal which depend upon the untrammelled control of the soul, and which it produces or restrains by its own free will; on the other hand, those which in no degree depend on the will, but are performed when the mind is unconscious or unwilling, cannot be termed animal, but are purely mechanical and automatic.

Observation teaches, that there are some muscles in the human body over which the mind has no control whatever, and the movements of which are purely automatic during the whole of life; these are the heart [the ventricles], the auricles, œsophagus, stomach, and intestinal canal; with these may be mentioned the motion of the iris. There are other muscles which are ordinarily subject to the control of the will, and for this reason are termed voluntary, such as the muscles of the limbs, trunk, head, face, eyes, tongue, genitals, and the sphincter of the anus and urinary bladder. It sometimes happens, however, that all these muscles renounce the authority of the mind, and while it is either unconscious or unwilling, are violently agitated by some preternatural mechanical stimulus, as is seen in hysterical, epileptic, or infantile convulsions, or in those affected with St. Vitus's dance; and these movements, although performed by muscles designated voluntary, can only be termed automatic. In the fœtus *in utero* and in the newly-born these muscles are not moved voluntarily, but for the most part automatically, for at that age the cerebrum is not as yet capable of thought, until the organs of the faculty of thought being gradually evolved, the mind learns to think, and to use the muscles subjected to its control. The raising of the hand and the application of it to the head in apoplexy belong also to the class of automatic movements, also the turning of the body in sleep, and partly even somnambulism itself, which, however, it would seem is partly also to be ascribed to obscure sensations and volitions which the mind instantly forgets. In the third place, there are muscles which continually act independently of the will, being excited thereto by a mechanical stimulus only, but over which the mind possesses voluntary command, and can at will accelerate, or retard, or entirely stop their movements for a time; the action of these is termed mixed. Of this kind are the muscles of respiration, which almost constantly act automatically, but over which, however, the mind has such control, that it can accelerate, retard, or even stop the respiratory movements for a time. But if a mechanical stimulus be too powerful, then the muscles of respiration are excited into action in spite of the will; for example, if a crumb slips into the trachea, a violent cough ensues altogether uncontrollable by the will; thus also the mind cannot prevent sneezing when the pituitary membrane of the nostrils is stimulated by an acrid stimulus.

In establishing that no action and no movement can be termed animal, of which the mind is not conscious, and which does not depend upon its free will, I shall possibly seem to have restricted the influence of the soul over the body too much, since there are very distinguished men, especially of the Stahlian School, who have taught that not only every movement is directly regulated by the soul, but also other functions of the animal body; adopting this fundamental principle, that consciousness is not necessary to each function of the mind. But it is certain that as yet we know nothing more of the human soul than that it thinks,[1] and that it cannot do this, so long as it is connected with the body, without the assistance of the brain. It is not proved, as assumed by the Stahlians, that the soul is the immediate cause of other animal functions which do not involve thought. But although we were to concede the assumption, deductions follow from it which must be pronounced absurd, and which admit of no defence, as has been fully shown by Haller,[2] and Platner,[3] who, although an eminent supporter of the Stahlian doctrine, says that it is true that muscles continue to act, the nerves of which have been tied, or divided, and that some Stahlians have gone too far, since they wished to attribute these movements also to the soul, which to this end they maintain to be diffused through the body, and spoke of the remaining portions of the soul as if it were divisible, and as if they continued the movement that originated from the divided

[1] See Van Swieten's Commentary, tom. i, § 1.
[2] Elem. Physiol.
[3] See De Haen's Heilungsmethode, 3ter Band. In the first division, on some difficulties in the system of Haller.

nerves. Moreover, that he was of opinion that Stahl either held the soul to be material, or confounded the rational soul with the *anima sensitiva* or *vegetativa* of the ancients, which alone we can affirm to be diffused through the whole body.

Si quid novisti rectius istis
Candidus imperti; si non, his utere mecum.

END OF 'FUNCTIONS OF THE NERVOUS SYSTEM.'

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TO

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