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Contributors

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Gold, F.

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BICHAT

ON

LIFE AND DEATH.

PHYSIOLOGICAL RESEARCHES

ON

Life and Death,

BY

XAVIER BICHAT;

TRANSLATED FROM THE FRENCH,

By F. GOLD,

Member of the Royal College of Surgeons, London.

London:

PUBLISHED BY LONGMAN, HURST, REES, ORME AND BROWNE,

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TRANSLATOR's PREFACE.

THE Translator of the Work which is here offered to the Public, feels it quite unnecessary to expatiate upon the merits of its Author, whose ideas and classifications in Physiology are now very generally adopted. He has supposed, however, that the experiments which constitute the Second *Part of the Work, are not so familiar to Professional Men, as many of the conclusions which have been deduced from them, and therefore has presumed that a greater publicity of these experiments will by no means be unserviceable. Dr. Kentish, in his account of Baths, has mentioned the circumstances which led to this translation.*

ERRATA.

Page 11, line 6, for Collosum *read* Callosum.
—— 43, last line, for as, *read* at.
—— 64, line 14, for at one, *read* at once.
—— 67, —— 8, for purpose, *read* the purpose.
—— ibid —— 10, for then, *read* than.
—— 126, —— 10, for glands, *read* gland.
—— 151, —— 3 and 4, for are create, *read* are destined to create, and after the word submitted, omit destined.
—— 163, —— 8, for of brain, *read* of the brain.
—— 164, —— 24, omit the word at.
—— 174, last line, for morieus *read* moriens.
—— 199, line 17, for or *read* of.
—— 200, —— 9, for of, *read* on.
—— 205, —— 16, for his, *read* this.
—— 210, —— 5, for cural, *read* crural.
—— 240, —— 18, for insue *read* ensue.
—— 252, —— 12, for dyspena *read* dyspnœa.

CONTENTS OF THE WORK.

FIRST PART.

SECOND PART.

THE

LIFE OF BICHAT,

FROM THE FRENCH OF

M. F. R. BUISSON.

MARIE FRANCOIS XAVIER BICHAT was born Nov. 11, 1771, at *Thoirette,* in the present department of the *Ain.* He was the eldest son of Jean Baptiste Bichat, Doctor of Medicine, of the University of Monpelliér, and of Marie Rose Bichat.

His Father being a Physician, he was very early, although very indirectly, initiated into the art, of which he was one day to become a luminary. Familiarized from his infancy with the use of the Latin language, and accustomed, without the knowledge of precepts, to witness their application, he had all the advantage of that education of example, which insensibly disposes the mind to study, by presenting its object under an agreeable and interesting aspect.

I shall

I shall not dwell upon that part of the life of Bichat, which was past in the common course of study.— Suffice it to say, that he distinguished himself among his fellow collegians.

It was at Lyons that he first began his anatomical labours. His ardour, his peculiar facility in overcoming the ordinary difficulties of the science, in a short time gained him the esteem of his masters — Associated with them in the chair, he already displayed that method for which he was afterwards characterized by his pupils.

At that period anatomy was hardly cultivated otherwise than a necessary introduction to surgery. As little attention was paid to medicine, properly so called. The names of Petit, of Lapeyronie, of Morand, of Frére Come, resounded in the Schools, not those of the Sydenhams, and the Boerhaaves of the sister science. Of this it is easy to perceive the reason, when we consider the period of which I speak. The celebrated Desault was then at the head of his profession; his active and ardent genius gave a great preponderance to the study of surgery; his pupils had already spread his doctrines among the departments, and the circumstances of the nation were all in favour of his peculiar art; for at that time, France, in a state of anarchy within, sustained herself without, by her astonishing conquests only; her very life consisted in her armies, and for these the succour of the Surgeon was more especially demanded.

Obedient then to the general impulse, Bichat gave himself up at first exclusively to surgery. He studied its principles, and began to exercise its functions under M. A. Petit, first surgeon to the Hotel Dieu of Lyons. Guided by that respectable practitioner, his progress there

there was rapid; but a greater theatre awaited him. The revolution conducted him to Paris, for, after the siege of Lyons, from motives of personal safety, he was obliged to quit a country, where youth itself was a crime, and merit more particularly such.

They, who remember those deplorable times, who know to what a degree, exertion, and endeavor of every kind was repressed, will not be surprised at hearing, that Bichat should have thought but little, at first, of improving his natural talents, or have bounded his projects to the common career of the young practitioner. His intention, said he, was for some time to follow the school of Desault, to become a proficient in his art, and then a follower of the armies.

Accordingly, with a number of other students, he attended the Hotel Dieu, and careless of observation or employment, contented himself with noting the lectures of Desault. In this way was he occupied, when the 9th of Thermidor in some sort calmed the nation, and to the scientific and meritorious, afforded a hope of future tranquillity and encouragement.—Bichat now began to feel his strength, and to extend his views: a fortuitous circumstance some short time afterwards transported him in a moment from obscurity into the most brilliant sphere of observation.

In the school of Desault, some chosen pupils were accustomed, each in his turn, to frame an abstract of the public lecture of the day. On the following day, after the lecture, the second surgeon of the hospital being at such time always present, this abstract was read. It possessed the double advantage of laying before the student those principles, which it was his business in particular to collect, and of making up for the ordinary inattention of the greater number during the

preceding

preceding lecture. One day, when Desault had spoken for a long time on the fracture of the clavicle, and demonstrated the utility of his bandage by its application on a patient, the pupil, whose turn it was to collect the details of the process was absent.—Bichat stepped forward and offered to supply his place. His abstract created the most lively sensation; the purity of his style, the precision, the clearness of his ideas, the scrupulous exactness of his conclusions, announced the professor, rather than the scholar. He was heard with much attention, and left the theatre applauded and admired.

Let us here pay a just tribute of praise to the celebrated school of which I speak. Elsewhere, these eulogiums, these applauses perhaps would have been the only recompense of the pupil. Not so with Desault. An excellent judge of talent, accustomed to distinguish it by its most fugitive traces, he would have thought the neglect of it, when discovered, a neglect of duty. Scarcely had he learnt the anecdote, of which I speak, from Manoury, his colleague, before he became impatient for the acquaintance of Bichat, and from his first conversation with him, appreciated so sagaciously his powers, as at once to be induced to make him an offer of his house, together with the treatment of a son: from that time forward he destined him to become the successor of his reputation.

So much was hardly required by the natural activity of the pupil. His indefatigable ardour may be well imagined; indeed his only recreation consisted in the variety of his occupations; for besides the service of non-resident surgeon, which he performed at the hospital, he was every day charged with visiting a part of Desault's patients, accompanied him every where

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as an assistant in his operations, and answered by letter the numerous consultations of the departments. When in such occupations the day had been consumed, a part of the night also was given up together with his patron to divers points of the art; for Desault, towards the end of his life, had undertaken a very extensive treatise on the diseases of the bones, together with a methodical exposition of the doctrine of the different authors, from Hippocrates downwards, on the several points which it was his intention to discuss. Bichat was charged with this labour, superadded to so many others, and acquitted himself with as much correctness, as if he had devoted all his time to it.

Desault exacted much, Bichat performed still more than was exacted. His prodigious facility procured him moments of leisure in the midst of so many occupations, and these he employed in augmenting his anatomical knowledge by dissection, in exercising himself upon the operations of surgery, in discussing with his friends some point or other of anatomy or physiology. An application so continual, assisted by the most penetrating intellect, acquired him in a short time a fund of knowledge, which enabled him thenceforth to stand upon his own ground, and depend upon himself alone for the means of his advancement.

Thus, the almost sudden death of Desault afflicted Bichat, but did not disconcert him. He felt that his genius would soon surmount every obstacle; and having given to his lost patron the tears of gratitude and friendship, having rendered to his memory a tribute worthy of his affection, in the 4th vol. of the Journal of Surgery, which he finished and published, he directed all his talents towards the prosecution of his career.

Indeed

Indeed, it was at this period, that he properly commenced that series of labours by which his name was to be immortalized; it was then, that abandoned to his own powers, he displayed them in their whole extent, and stood forth, not as the first pupil of a celebrated man, but as one who would make his own way to the greatest celebrity, without assistance. I know not, whether he could at this time have traced the plan of his future labours; such, indeed, might be supposed, were the order and method considered, with which he proceeded as a public teacher, but the idea would hardly be just; his successes were due almost entirely to his discoveries, and these discoveries the rapid and sudden effect of his genius for observation, could not have been promoted by reflection, in whatever manner exercised.

It is an old observation, that modesty is the first virtue of great men. By no means magnificent in his promises, Bichat proposed to himself, at all times, to go beyond them. Thus, when in 1797, he undertook for the first time, a course of anatomy, he contented himself with inconvenient and small chambers, not supposing that any very great number of pupils would attend him. He established no dissecting room, and contented himself with simple demonstrations; but already had he begun to discourse upon physiological subjects; his experiments upon living animals, to determine the truth of facts supposed to be known, were numerous, and on these he entered, with the view chiefly of ascertaining the exact point where science ceased, and where discovery was to begin. It was in this year that he established the first principles of his theory on the synovial membranes, the prelude of his great work on the membranes in general. The intervals of his lectures were almost entirely filled up in

scientific

scientific discussions with his more advanced pupils, and frequently in subordinate courses. Among the latter osteology and the diseases of the bones were not forgotten.

It could have been a matter of little surprise to professional men, that Bichat should have undertaken labours, which before him had been entered on by so many others; but on his announcing a course of operations at the end of his anatomy, his attempt, because unusual, was considered as rash. Till then, it had been the opinion of the public, that a practitioner only could acquit himself of such part of instruction with advantage, and the numerous pupils who attended Bichat about this time were attracted more perhaps by curiosity, than by confidence in his abilities. Indeed he has often asserted that this was one of his boldest attempts; but he wished, said he, to prove that a young man, in a course of operations, might be as exact as was necessary. He did so most effectually. His natural address, developed by an assiduous exercise of the operative process on the body, displayed him, not as the young and timid surgeon, but as a man consummate in practice, and capable of performing at the bedside, or on the body of the patient whatever were the principles of his lectures.

Meanwhile such incessant occupation very sensibly influenced his health. The exercise of speaking in public was too great for him, and brought on a dangerous hemoptysis. Detained for a long time in his chamber, he suffered less from pain than from the necessity of repose. The greater was his ardour on the re-establishment of his health. His past danger was instantly forgotten; assured of success, he established a theatre of dissections, began a more extensive

course

course of anatomy, and had the satisfaction of seeing his rooms immediately frequented by more than eighty pupils.

Scarcely can it be conceived in what way a single man could have been capable of the multifarious labours of Bichat during this winter. The extreme difficulty of procuring subjects for dissection obliged him to extraordinary fatigues, and these united with his public lectures, would have wholly absorbed the time of another man. Notwithstanding which, he was usually present at the demonstrations given in his theatre, though possessed of the most zealous co-operators in the persons of his professional brethren Hai and Rosiére. He dissected for his public lectures himself, continued his experiments on living animals, and when in the evening he returned to his home overwhelmed with lassitude and exertion of mind, his custom was, instead of betaking himself to repose, to pass the greater part of his nights in putting in order the surgical works of Desault, a last tribute to the memory of his respected friend.

At the time of which I am speaking, Bichat conceived the project of throwing new light upon physiology. This science was the especial object of many of his lectures, but as yet he had presented only some few views of it. Anatomy was his almost exclusive occupation. He thought, and with reason, that for entering with success upon the study of the functions, it was necessary in the first place to acquire a perfect knowledge of the organs. His views were principally directed to the membranous system, a system till then neglected by anatomists; his discovery of the synovial membranes conducted him to a careful examination of all the others, and these, though they had been all observed in particular as forming a part of such or

such

such organs, he followed throughout, approximating them by common characters, whatever place they occupied in the economy of the body; his classification was, it is true, suggested to him by the reflections of Monsieur Pinel in his philosophic nosography, but he rendered it his own by the many facts which he discovered, and above all by his distinction of the fibrous membranes which Pinel had not indicated.

These very beautiful considerations however, which form a complete body of doctrine upon the membranes, he had not yet exposed in his lectures. They were given for the first time to the public in two memoirs, which are inserted in the second volume of the collection of the medical society of emulation. To these, our author shortly afterwards added three others on many important points of surgery. In the first, he describes a new trepan, the advantage of which consists in the power of elevating or depressing the crown at will by means of a screw, &c.; in the second he proves from anatomy and facts, the impossibility of any displacement in the fracture of the humeral extremity of the clavicle, and consequently the inutility of the complicated bandage of Desault in this case; in the third he indicates a new manner of proceeding for the ligature of polypi.—Lastly, Bichat taking advantage of the leisure, which the termination of his academical labours left him, in another memoir gave the world his first views of physiology. It was in this, that he established his happy distinction of the two lives of the animal, but founded, for the present on the outward form of the organs, that, which he afterwards established on much more solid proof.

I have spoken at once of these six memoirs, not because they appeared at the same time, but because

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their assemblage presents under one view, a general plan of all the labours which have illustrated the Life of Bichat, and shews us at once all those primitive ideas, of which the discovery and developement have given his name a place among those of the most illustrious men of science. In fact, we here behold him terminating with honour his surgical career on the one hand by adding to the art new facts, and useful inventions, and on the other just indicating the dawn of that light, which he was destined to throw on physiology and anatomy.

Having thus awakened the attention of the public, he thought only of performing his promises, and of enlarging upon the truths, of which he had but just given an insight. In a treatise, which he shortly afterwards published, he displayed more fully his doctrines on the membranes, and considered them with respect to their form, organization, vital properties, functions, and sympathies. These considerations obliged him to expose, at some length, many of his physiological principles; the latter, however, were in many cases the result of his researches upon the organs themselves. Thus the difference of vital power possessed by the mucous membranes which are subject to the contact of external bodies, and the serous membranes which are withdrawn from such contact, conducted him to the distinction of two kinds of sensibility; he had already distinguished two kinds of contractility. The study of the sympathies in the membranes gave him the happy idea of dividing them according to the vital powers, of which they are only the irregular developement, instead of classing them, as is usually done, according to the parts in which they supervene, or from the nature and disposition of the organs, in which they are remarked. He augmented

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the number of the serous membranes, by adding to them the arachnoides, whose folds at the base of the cranium he demonstrated, together with its reflection over the dura mater, and its introduction into the cerebral cavities by an opening placed underneath the corpus collosum. Under the title of unnatural membranes he included cysts of all kinds, and the membrane of cicatrices, the progressive formation of which he explained in a new way, deducing at the same time from his theory the most useful practical consequences.

The treatise on the membranes had the greatest success. Immediately regarded as an elementary and classical book, it was cited in almost every work, and given an honourable place in the libraries of the studious.

About the same time he announced a regular course of physiology. I shall not insist upon his division of the phenomena of life, nor on the advantages, which it offers; they have been proved so often, that I should be reduced to repeat what no one can be ignorant of. I shall only observe, that the best proof of the solidity of his doctrines was the universal approbation with which they were received, and the envy which they excited; for already had this envy been openly shewn enough when his treatise on the membranes appeared, though Bichat despised it, and disdained to answer his injurious opponents. The opinion of the public revenged him sufficiently, and the number of scholars who continued to frequent his amphitheatre was the most victorious answer to men, who in seeking to depreciate his reputation, did not on that account the less adopt his principles.

At last, in a more authentic and universal manner, he gave the world these principles in his physiological researches

researches on life and death. The work was published in 1799. It is divided into two entirely different parts; the first contains the general exposition of his physiological views; the second is composed of a series of experiments upon the mutual connexion of the three principal organs of life, the brain, the heart, and the lungs. These are indeed two separate works; the first explains the second, but is not absolutely necessary to it. The opinion which is formed of the one should be entirely independent of that which is formed of the other.

In his researches on life, he exposes in great detail the distinguishing characters of the two orders of the functions, which serve for the external relations, and preservation of the individual. He examines the developement of the two lives, and lastly, the manner in which they terminate. This plan, which is filled up with the utmost luxuriance of idea, incessantly presents wherewithal to admire the genius of the author. His theory on sleep will never be forgotten, nor his considerations on what has been named the epigastric centre, nor his table of the vital properties, nor his observations on the progressive manner of natural death. But we must allow, that hurried on by a lively and ardent imagination, he was sometimes inexact. Some false, or rather incomplete and badly defined ideas on habit, on the influence of the passions, and on the state of the fœtus in utero from time to time, will offer to the attentive reader some mists which it would have been easy to have dissipated; and this Bichat was ready enough to acknowledge, intending as he did in a second edition of his work, to give a greater degree of precision and care to the different parts of it.

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The same strictures are by no means applicable to his researches on death. Here he was continually armed with the torch of experiment. Accordingly this second part, or rather this second work of itself is above all criticism, and might alone have sufficed for immortalising its author. More fortunate than Goodwyn, he discovered and demonstrated the real mode of connexion between life and respiration; he proved by the most multiplied facts, that the black blood as well as the red blood is capable of exciting the contractions of the left cavities of the heart; he demonstrated on the contary, that it is the red blood only which can produce in the tissue of the organs the requisite excitement for the maintenance of life; from all which he deduced, that the death ensuing from the defect of respiration must happen, not because the heart ceases to act upon the blood, but because the blood continually pushed on with the same force by the heart can no longer, for want of its colouring principle, excite the organs, into which it is thrown. In the work itself may be seen the indisputable proofs, on which this physiological truth is founded. But I should never have finished were I to insist in particular upon those equally curious discoveries, with which it is filled. They were all of them made in presence of a number of pupils, and reiterated by Bichat himself, with Messieurs Hallé and Dumeril.

Many persons will be surprised perhaps, that Bichat should not have taken advantage of the moment when his reputation in physiology was at its height, for publishing on this science an elementary treatise, which was on all sides demanded of him. Such persons will have poorly appreciated the mind of Bichat. He well knew that the honor of writing a classical work can seldom belong to a young man; that a work announced

nounced as such, decides for ever upon the reputation of the author. Doubtless with a good understanding and sufficient knowledge, an author at any age may collect under one view the knowledge of his cotemporaries, and become of utility to mankind; but it is not by such facile labour that the great Haller is to be followed in the road of immortality. Such end can only be attained by the discovery and establishment of a multiplicity of facts, and by the display of those enlarged and solid views which the man of genius only can embrace. Bichat possessed, in many instances, the advantages of Haller; he had established physiology upon new foundations by his division of the functions; he had enriched it also by the important discoveries of which I have spoken; but his divisions were not as yet possessed of all the correctness which might have been desired, and his discoveries were in no considerable number. Of all this he was fully sensible, and thought rather of preparing new materials, than of precipitately employing those which he possessed. It was in anatomy that he sought them.

Indeed it could only belong to the author of the treatise on the membranes, to open in this science, a road as yet unknown, or but very obscurely pointed out. The idea of approximating by common characters the membranous tissues, which serve for the formation of the different organs, was of easy application to the other primitive tissues, which constitute the elements of all organization. This idea forms the entire plan of his general anatomy, a work of immense and successful labour, in which his first ideas on the membranes are revised and enlarged, the differences between living and inert bodies, and consequently, between the physical and physiological sciences established as a fundamental principle, and then an ex-

amination

amination commenced of the vital properties, the characters of which he describes, together with their seat and influence on the physiological phenomena.— The latter in the process of his work he distinguishes from another order of properties independent of life, though belonging exclusively to tissues, which for some time have been animated. Here he is led to remark in the tissues in question, their essential differences with respect to form, organization, and structure; he observes that these tissues enjoying each of them a peculiar and independent life, are united to constitute the organs, and that the organs are in this way an assemblage of different elements. From hence again he infers the necessity of considering separately and abstractedly these tissues, or elementary organic systems, if we wish to have just ideas either in physiology or medicine; and he proves the advantage of the study which he is about to undertake on one side by positive facts from pathological observations, and on the other, by the uncertainty which characterizes the greater part of the physiological and medical theories when deprived of such foundations.

We shall not in this place attempt to follow him in the examination of each particular system. We should pass the bounds which we have prescribed ourselves, and it would be impossible for us to present under a form sufficiently analytic, a work which is equally remarkable for the richness of its details and the precision of its style.

The study of the general tissues, which enter into the composition of all the organs, naturally led to that of the tissues composing each organ in particular. Bichat examined them in his descriptive anatomy, a work which is but a continuation of the preceding one. He himself published the two first volumes of

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it, and left the third almost finished. Monsieur Roux and myself have engaged ourselves to prosecute this his last undertaking.

The same idea, which directed him in his general anatomy, was also his guide in his researches on pathological anatomy. He had examined the organic tissues in their healthy state, he undertook to examine them in their morbid state. This new labour was necessarily much more extensive than the former, in consequence of the multitude of different affections which the same tissue might exemplify. It was requisite to multiply the examination of bodies, and to have noted the course of the previous diseases, in order to profit by such examination. Bichat did both; in some few months he opened upwards of six hundred subjects at the Hotel Dieu and elsewhere, and at the same time observed whatever remarkable diseases the hospital presented him. In a course of pathology, he soon exposed his new fund of knowledge, and with equal success was observed to follow the traces both of Haller and Morgagni. It is to him that we owe our exacter notions of the affections of the peritoneum; affections which were usually confounded with those of the organs, which are covered by this membrane. He proved that each tissue had a peculiar mode of disease, as well as a peculiar character of vitality, and that even in the intestines the morbid state of a membrane might be attended with a healthy state of the neighbouring parts. Of this, indeed, some authors had already given us a suspicion. Walter had exactly described the nature of peritonitis, but they had all of them observed particular facts, and not attached their ideas to any general point of view; besides which, their discoveries were forgotten. Bichat more accustomed to observe than to read, was absolutely igno-

rant

rant of them, and on this occasion, as on many others, he enjoyed all the honours of an inventor, though before him the truths which he advanced, were not altogether unknown.

It was on the materia medica that he was employed during the latter moments of his life. For a long time aware of the uncertainty, and confusion of this science, he had been of opinion, that if cultivated with method and fixed principles, it might attain to perfection as well as the other branches of medicine. In his general Anatomy he had already given his first ideas on the subject; he undertook to explain them, and having proved the necessity of classing medicines from the influence which they exercise over the vital properties, he set about to examine their sympathetic, and direct actions upon the different organic systems. Such a task required the most numerous observations; he collected them at the Hotel Dieu, of which he had just been named a physician. More than forty pupils aided him in these labours, which however he himself directed, and each day gave a regular account in his public lecture of the progress which he was making. The mortal disease which about this time attacked him, prevented the continuation of his endeavours, and deprived us of those hopes which he had in part already realized.

It was very easy to foresee that a man so indefatigable, so little careful of himself, would not live long. This indeed was every day intimated to him; and those frequent affections of the stomach to which he was subject were a good warning that his strength was not inexhaustible. All was useless. During the greatest heats of the summer, he continued his daily examinations of those pieces of pathological anatomy, which he had submitted to maceration for his dissections, and exposed himself with an inexcusable temerity to

their

their putrid emanations. One day when he had particularly felt their influence, an accident completed the determination of a disease, which so many causes had conspired to prepare. He fell on the stair-case of the hotel Dieu, and a slight concussion of the brain, which was the consequence of his fall, for several moments rendered him insensible. Having been taken home with difficulty, he passed the night tolerably well, but the next day was seized with violent head-ache; he arose however and began his usual round, but from extreme fatigue fainted, and was again carried to his bed; he was somewhat relieved by the application of leeches, but soon afterwards his usual gastric symptoms declared themselves with intensity; a continual tendency to coma was the sad prelude of typhous symptoms, and to these he fell a victim on the 3rd day of Thermidor, in the 10th year of the republic. He was assiduously attended by Messieurs Corvisart and Lepreux; the latter of whom pronounced a discourse at his interment.

Few of the literati have been so generally lamented as Bichat; more than five hundred students followed his funeral.

The first Consul informed of the public regret, and what was its occasion, immediately ordered, that a monument erected at the Hotel Dieu, should transmit to posterity in the names of Desault and Bichat, the memory of two great men, remarkable alike by their extraordinary talents and the prematurity of their deaths.

The most amiable qualities of mind augmented in Bichat, the splendour of his abilities. Never were seen more openness and candour, more readiness to sacrifice opinion to reason. Incapable of anger or impatience, in his busy and in his leisure moments he was alike accessible; his generosity too, was the sure

resource

resource of those who at a distance from their relatives, were at any time involved in difficulties, or who from poverty were unable to procure instruction—acute in distinguishing ability, he was the first to encourage it in every possible way. The envy of some few of his fellow practitioners continually followed him; he contented himself with the contempt of attacks so fruitless; repulsed them never, and was always ready to be at peace with his detractors.

Nor could any one be more disposed to confidence than Bichat, wherever he perceived sincere attachment. Thus, the jealous excepted, his friends were made up of all who knew him. His amiable manners could hardly be resisted; in the course of a little conversation his character being easily discernible.—To reserve of expression, and affected politeness, he was equally a stranger. His natural openness was not however inconsiderate, as might at first have been supposed; he well knew how to limit it when he had sufficiently recognized demerit. The plenitude of his affections was enjoyed by his family only, and thus it is to them alone that it can belong to lament him, as he ought to be lamented.

PART THE FIRST.

CHAPTER THE FIRST.

THE definition of life is usually sought for in abstract considerations; it will be found, if I mistake not, in the following general expression:— Life consists in the sum of the functions, by which death is resisted.

In living bodies, such in fact is the mode of existence; that whaetver surrounds them, tends to their destruction. They are influenced incessantly by inorganic bodies; they exercise themselves, the one upon the other, as constant an action: under such circumstances they could not long subsist, were they not possessed in themselves of a permanent principle of reaction. This principle is that of life; unknown in its nature, it can be only appreciated by its phenomena: an habitual alternation of action and reaction between exterior bodies, and the living body, an alternation, of which the proportions vary according to the age of the latter, is the most general of these phenomena.

There is a superabundance of life in the child: In the child, the reaction of the system is superior to the action, which is made upon it from without. In the adult, action and reaction are on a balance; the turgescence of life is gone. In the old man, the reaction

action

action of the inward principle is lessened, the action from without remaining unaltered; it is then that life languishes, and insensibly advances towards its natural term, which ensues when all proportion ceases.

The measure, then, of life in general, is the difference which exists between the effort of exterior power, and that of interior resistance. The excess of the former is an indication of its weakness; the predominance of the latter an index of its force.

§ I.—*Division of Life into Animal and Organic life.*

Such is life considered in the aggregate; examined more in detail it offers us two remarkable modifications, the one common to the vegetable and the animal; the other belonging exclusively to the latter. In comparing two individuals from each of the living kingdoms, the one will be seen existing only within itself, having with what surrounds it the relations only of nutrition, attached to the soil, in which its seed has been implanted, born there, growing there, and perishing there. The other will be observed combining with this interior life, which in the highest degree it enjoys, an exterior life by which it acquires a very numerous series of relations with all surrounding bodies, a life, which couples it to the existence of every other being, by which it is approximated, or removed from the objects of its desires or its fears, and seems in appropriating every thing in nature to itself, to consider every thing with regard to its individual existence only.

Thus it might be said, that the vegetable is only the sketch, or rather the ground-work of the animal; that for the formation of the latter, it has only been requisite to clothe the former with an apparatus of

external

external organs, by which it might be connected with external objects.

From hence it follows, that the functions of the animal are of two very different classes. By the one (which is composed of an habitual succession of assimilation and excretion) it lives within itself, transforms into its proper substance the particles of other bodies, and afterwards rejects them when they are become heterogeneous to its nature. By the other, it lives externally, is the inhabitant of the world, and not as the vegetable of a spot only; it feels, it perceives, it reflects on its sensations, it moves according to their influence, and frequently is enabled to communicate by its voice its desires, and its fears, its pleasures, and its pains.

The aggregate of the functions of the first order, I shall name the organic life, because all organized beings, whether animal or vegetable, enjoy it more or less, because organic texture is the sole condition necessary to its existence. The sum of the functions of the second class, because it is exclusively the property of the animal, I shall denominate the animal life.

The series of the phenomena of these two lives, relate to the individual. Generation, as a function, regards the species, and thus has no place among them, Its connections with the greater number of the other functions are but very indirect; it commences a long time after them, it is extinct a long time before them. In the greater number of animals the periods of its activity are separated by long intervals of time, and during these, it is absolutely null. Even in man, with whom the remissions of its impulses, are much less durable, it has not a much more extensive connexion with the rest of the system. Castration is almost always marked by a general encrease of the nutritive process; the eunuch, enjoying indeed a less degree

of

of vital energy, but the phenomena of his life being displayed with a greater exuberance. We shall here, then, lay aside the consideration of the laws which give us existence, and occupy ourselves alone on those which maintain us in existence. Of the former we shall speak hereafter.

§ II.—*Subdivision of each of the two lives into two orders of functions.*

The animal and the organic life, are each of them composed of two orders of functions, which succeed each other, and are concatenated in an inverse direction.

In the animal life, the first order is established from the exterior of the body, towards the brain; the second from the brain towards the organs of locomotion and the voice. The impression of objects successively affects the senses, the nerves, and the brain. The first receive, the second transmit, the third perceives the impression. The impression, in such way, received, transmitted, and perçeived, constitutes sensation.

The animal, in the first order of these functions, is almost passive; in the second, he becomes active.—This second order is the result of the successive actions of the brain (where volition has been produced in consequence of the previous sensation) of the nerves, which transmit such volition, and of the locomotive organs and voice, which are the agents of volition. External bodies act upon the animal by means of the first order of these functions, the animal reacts upon them by means of the second.

In general there exists between the two orders a rigorous proportion: where the one is very marked, the other is put forth with energy. In the series of living

beings,

beings, the animal, which feels the most, moves also the most. The age of lively perception, is that also of vivacity of motion; in sleep, where the first order is suspended, the second ceases, or is exercised only with irregularity. The blind man, who is but half alive to what surrounds him, moves also with a tardiness which would very soon be lost, were his exterior communications to be enlarged.

A double movement is also exercised in the organic life; the one composes, the other decomposes the animal. Such is the mode of existence in the living body, that what it was at one time it ceases to be at another. Its organization remains unaltered, but its elements vary every moment. The molecules of its nutrition by turns absorbed and rejected, from the animal pass to the plant, from the plant to inorganic matter, return to the animal, and so proceed in an endless revolution.

To such revolution the organic life is well adapted. One order of its functions assimilates to the animal the substances, which are destined to nourish him; another order deprives him of these substances, when, after having for some time made a part of it, they are become heterogeneous to his organization.

The first, which is that of assimilation, results from the functions of digestion, circulation, respiration, and nutrition. Every particle, which is foreign to the body before it becomes an element of it, is subject to the influence of these four functions.

When it has afterwards concurred for some time to the formation of the organs, the absorbents seize on it, and throw it out into the circulatory torrent, where it is carried on anew, and from whence it issues by the pulmonary or cutaneous exhalations, or by the different secretions by which the fluids are ejected from the body.

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The second order, then, of the functions of the organic life, or thatof decomposition, is formed of those of absorption, circulation, exhalation, and secretion.

The sanguiferous system, in consequence, is a middle system, the center of the organic life, as the brain is the center of the animal life. In this system the particles, which are about to be assimilated, are circulated and intermixed with those, which having been already assimilated, are destined to be rejected; so that the blood itself is a fluid composed of two parts; the one, the pabulum of all the parts of the body, and derived from the aliment; the other, excrementitious, composed of the wrecks and residue of the organs, and the source of the exterior secretions and exhalations — Nevertheless these latter functions serve also, at times, the purpose of transmitting without the body, the products of digestion, although such products may not have concurred to the nourishment of the parts. This circumstance may be observed when urine and sweat are secreted after copious drinking. The skin and the kidneys being at such times the excreting organs, not of the matter of the nutritive, but of that of the digestive process; the same also may be said of the milk of animals, for this is a fluid which certainly has never been assimilated.

There does not exist between the two orders of the functions of the organic life the same relation, which takes place between those of the animal life. The weakness of the first by no means renders absolutely necessary a decrease of action in the second. Hence proceed marasmus and leanness, states, in which the assimilating process ceases in part, the process of excretion remaining unaltered.

Let us leave, then, to other sciences, all artificial method, but follow the concatenation of the pheno-

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mena of life, for connecting the ideas which we form of them, and we shall perceive, that the greater part of the present physiological divisions, afford us but uncertain bases for the support of any thing like a solid edifice of science.

These divisions I shall not recapitulate; the best method of demonstrating their inutility will be, if I mistake not, to prove the solidity of the division, which I have adopted. We shall now examine the great differences, which separate the animal existing without, from the animal existing within, and wearing itself away in a continual viscissitude of assimilation and excretion.

CHAPTER THE SECOND.

General Differences of the Two Lives with regard to the outward form of their respective organs.

THE organs of the animal life are symmetrical, those of the organic life irregular in their conformation; in this circumstance consists the most essential of their differences. Such character, however, to some animals, and among the fish to the sole and turbot especially, is not applicable; but in man it is exactly traced, as well as in all the genera which are nearest to him in perfection. In them alone am I about to examine it.

§ I—*Symmetry*

§ I.—*Symmetry of the external forms of the animal life.*

Two globes in every respect the same, receive the impressions of light. Sounds and odours, have also their double analogous organ. A single membrane is affected to savours, but the median line is manifest upon it, and the two segments, which are indicated by it, are exactly similar. This line indeed is not every where to be seen in the skin, but it is every where implied. Nature, as it were, has forgotten to describe it, but from space to space she has laid down a number of points, which mark its passage. The cleft at the extremity of the nose, of the chin, and the middle of the lips, the umbilicus, the seam of the perineum, the projection of the spinous apophyses of the back, and the hollow at the posterior part of the neck are the principal points at which it is shewn.

The Nerves, which transmit the impressions received by the senses, are evidently assembled in symmetrical pairs.

The brain, the organ (on which the impressions of objects are received) is remarkable also for the regularity of its form. Its double parts are exactly alike, and even those which are single, are all of them symmetrically divided by the median line.

The Nerves again, which transmit to the agents of loco-motion and of the voice, the volitions of the brain, the locomotive organs also, which are formed in a great degree of the muscular system, of the bony system, and its dependencies, these together with the larynx and its accessaries, composing the double agents of volition, have all of them a regularity, a symmetry, which are invariable.

Such even is the truth of the character which I am now describing, that the muscles and the nerves immediately

mediately cease to be regular, as soon as they cease to appertain to the animal life. The heart, and the muscular fibres of the intestines are proofs of this assertion in the muscles; in the nerves, the great sympathetic, is an evidence of its truth.

We may conclude then from simple inspection, that Symmetry is the essential character of the organs of the animal life of man.

§ II.—*Irregularity of the exterior forms of the organic life.*

If at present we pass to the viscera of the organic life, we shall perceive a character directly the contrary of the former. The stomach, the intestines, the spleen, the liver, &c. are all of them irregularly disposed.

In the system of the circulation, the heart and the large vessels, such as the upper divisions of the aorta, the vena azygos, the vena portæ, and the arteria innominata have no one trace of symmetry. In the vessels of the extremities continual varieties are also observed, and when they occur, it is particularly remarkable that their existence on one side in no way affects the other side of the body.

The apparatus of respiration appears indeed at first to be exactly regular; nevertheless, the bronchi are dissimilar in length, diameter, and direction; three lobes compose one of the lungs, two the other: between these organs also, there is a manifest difference of volume; the two divisions of the pulmonary artery resemble each other neither in their course, nor in their diameter; and the mediastinum is sensibly directed to the left. We shall thus perceive that symmetry is here apparent only, and that the common law has no exception.

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The organs of exhalation and absorption, the serous membranes, the thoracic duct, the great right lymphatic vessel, and the secondary absorbents of all the parts have a distribution universally unequal and irregular.

In the glandular system also we see the crypts, or mucous follicles disseminated in a disorderly manner in every part; the pancreas, the liver, the salivary glands themselves, though at first sight more symmetrical, are not exactly submitted to the median line; added to this, the kidneys differ from each other in their situation, in the length and size of their artery and vein, and in their frequent varieties more especially.

From considerations so numerous we are led to a result exactly the reverse of the preceding one; namely, that the especial attribute of the organs of the interior life is irregularity of exterior form.

§ III.—*Consequences resulting from the difference of exterior form in the organs of the two lives.*

It follows from the preceding description, that the animal life is as it were double; that its phenomena performed as they are at the same time on the two sides of the body, compose a system in each of them independent of the opposite system; that there is a life to the right, a life to the left; that the one may exist, the other ceasing to do so, and that they are doubtless intended reciprocally to supply the place of each other.

The latter circumstance we may frequently observe in those morbid affections so common, where the animal sensibility and mobility are enfeebled, or annihilated on one side of the body, and capable of no affection whatever; where the man on one side is little

more

more than the vegetable, while on the other he preserves his claim to the animal character. Undoubtedly those partial palsies, in which the median line, is the limit where the faculties of sensation and motion finish, and the origin from whence they begin can never be remarked so invariably in animals, which, like the oyster, have an irregular exterior.

On the contrary the organic life is a single system, in which every thing is connected and concatenated; where the functions on one side cannot be interrupted, and those on the other subsist. A diseased liver influences the state of the stomach; if the colon on one side cease to act, that upon the other side cannot continue in action: the same attack, which arrests the circulation in the right side of the heart, will anihilate it also in the left side of the heart. Hence it follows, the internal organs on one side being supposed to suspend their functions, that those on the other must remain inactive, and death ensue.

This assertion, however, is a general one; it is only applicable to the sum of the organic life, and not to its isolated phenomena. Some of them in fact are double, and their place may be supplied—the kidneys and lungs are of this description.

I shall not enquire into the cause of this remarkable difference, which in man, and those animals which approach him the nearest, distinguishes the organs of the two lives. I shall only observe, that it enters essentially into the nature of their phenomena, and that the perfection of the animal functions is so connected with the general symmetry observed in their respective organs, that every thing which troubles such symmetry, will more or less impair the functions.

It is from thence, no doubt, that proceeds this other difference of the two lives, namely, that nature very rarely

rarely varies the usual conformation of the organs of the animal life. Grimaud has made this observation, but has not shewn the principle on which it depends.

It is a fact, which cannot have escaped any one the least accustomed to dissection, that the spleen, the liver, the stomach, the kidneys, the salivary glands, and others of the internal life, are frequently various in form, size, position, and direction. Such in the vascular system are these vareities, that scarcely will any two subjects be found exactly alike under the scalpel of the anatomist: the organs of absorption, the lymphatic glands in particular, are rarely the same either in number or volume, neither do the mucous glands in any way affect a fixed and analogous situation.

And not only is each particular system subject to frequent aberrations, but the whole of the organs of the internal life are sometimes found in the inverse of the natural order. Of this I have lately seen an instance.

Let us now consider the organs of the animal life, the senses, the brain, the voluntary muscles, and the larynx: here every thing is exact, precise, and rigourously determined. In these there is scarcely ever seen a variety of conformation; if there do exist any, the functions are troubled, disturbed, or destroyed: they remain unaltered in the organic life, whatever may be the disposition of the parts.

The difference with respect to action, in the organs of the two lives, depends, undoubtedly, upon the symmetry of the one, whose functions the least change of conformation would have disturbed, and on the irregularity of the other, with which these different changes very well agree.

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The functions of every organ of the animal life are immediately connected with the resemblance of the organ to its fellow on the opposite side if double, or if single to its similarity of conformation in its two halves: from hence the influence of organic changes upon the derangement of the functions may be well conceived.

But this assertion will become more sensible, when I shall have pointed out the relations which exist between the symmetry and the irregularity of the organs, and the harmony and the discordance of their functions.

CHAPTER THE THIRD.

General Difference of the Two Lives with regard to the Mode of Action of their respective Organs.

HARMONY is to the functions of the organs, what symmetry is to their conformation; it supposes a perfect equality of force and action, between their similar parts, just as symmetry indicates an exact analogy of external form, and internal structure: indeed it is a necessary consequence of symmetry, for two parts essentially alike in structure, cannot much differ in their manner of action. Hence we should be naturally led to the following conclusion, namely, that harmony is the character of the animal, discordance that of the organic functions. But on these points we must be more particular.

§ I.—*Of harmony of action in the animal life.*

We have already observed, that the animal life arises from the successive actions of the senses, the nerves, the brain, the locomotive organs, and the voice. We shall now consider what harmony of action is, in each of these great divisions.

The precision of our sensations appears to be the more complete in proportion as there exists a resemblance between the two impressions, of which they are each of them the a semblage. We see inaccurately when one of the eyes is better formed, and stronger than the other; when it conveys to the brain a clearer image than its fellow does. It is to avoid this confusion that we shut one eye, while the action of the other is increased by the application of a lens, for at such time there can be no harmony of action in the two organs; accordingly, we make use of one of them only in order to avoid the discordance of the impression.—What a lens applied to one eye only produces artificially, is exemplified in a natural way by squinting.—We squint, says Buffon, because we turn the weaker eye from the object on which the stronger is fixed; for in so doing we avoid the confusion, which would arise from the perception of two dissimilar images.

We know that many other causes may contribute to the production of this effect, but we cannot doubt the reality of the reason assigned. We know also, that in some animals each eye may act without the assistance of the other, and that two different objects may be transmitted at the same time by the two eyes of certain other animals; but this circumstance, when the action of both the organs is united upon a single object, should by no means prevent a similarity in the two impressions. A single sensation is the consequence of the combination; but in what way can

such

such sensation be formed with accuracy, if the same body at the same time be pictured both in strong and weak colours on the one and the other of the retinæ ?

What we have said of the eye may be equally well applied to the ear. If, of the two sensations which form a sound, the one be received by a strong and well formed organ, the other by a weak one, the impressions will be unequal ; the brain also, because it is differently affected by each, will be the seat of an imperfect perception. Such conformation constitutes what is called an incorrect or false ear. For what reason does it happen that one man is unpleasantly affected by a dissonance, while another does not even perceive it ? The reason is this, that in the one, the two perceptions of the same sound are identical ; in the other, dissimilar. For the same reason a man with a correct ear will combine his dancing with the cadence of the measure given him ; another without this similarity of organ will be as constantly at variance in his motions with the orchestra.

Buffon has confined his observations on harmony of action, to the organs of vision and hearing ; we shall push our examination of it farther.

In the sense of smelling, as well as in the other senses, we must admit of two impressions ; the one primitive, and belonging to the organ, the other consecutive, and affecting the sensorium : now the latter may vary, the former remaining unaltered. Many odours are disagreeable to some, but pleasant to others ; and this, not because there is any difference in the affection of the pituitary membrane, but because in different individuals, the mind may attach a very different sentiment to the same impression.—Hence a variety of results does not in this case suppose a difference of principle.

But sometimes the impression which is made upon the pituitary membrane does really differ from that which it ought to be, for producing perfect sensation. Two dogs pursue the same game; the one never loses scent, but makes the same turnings and windings with the animal before him; the other follows his game also, but often stops and hesitates, endeavors to recover the scent, proceeds and stops again. The first of these receives a lively impression of the scented emanation; the organs of the second are only confusedly affected. Now it may be asked whether this confusion does not arise from the unequal action of the two nostrils, from the superior organization of the one, and from the imperfection of the other?—the following observations appear to decide the question.

In the coryza, which affects but one of the nostrils, if the two be suffered to remain open, the sense of smelling is confused; but let the diseased nostril be shut, and the smell shall immediately become distinct. A polypus in one of the nostrils debilitates the action of the pituitary membrane on the affected side, the other remaining in its healthy state: hence, as in the preceding case, ensues a want of harmony in the two organs, and the same confusion in the perception of odours. The greater number of the affections of a single nostril have similar effects, which may be all of them corrected by the same means. And wherefore? because in rendering one of the pituitary membranes inactive, we put a stop to the discordance which is occasioned by the deficiency of action in the other. From the above facts (since any accidental cause, which destroys the harmony of action in these organs, is capable of rendering the perception of odours inexact) we may conclude, that when the perception is naturally inaccurate, there is a natural dis-

similarity

similarity in the formation of the organs, and therefore a difference of power in them.

The same reasoning may be applied to the sense of taste. It is often the case that one side of the tongue is affected by palsy or spasm, the median line dividing the insensible half from the other, which continues to preserve its sensibility. But such affection may take place in a variety of degrees, and one side of the tongue retain a power of perceiving savours though in a less perfection than the other side. In such case it is natural to suppose that the taste must be confused; because a clear perception cannot be the consequence of two unequal sensations.

The perfection of the touch as well as that of the other senses, is essentially connected with uniformity of action in the two symmetrical halves of the body, and particularly in the hands. Let us suppose, for instance, a man born blind, to have one hand well organized, the other defective in the power of moving the thumb and fingers, and forming only a stiff and immovable surface; such person would find it a very difficult thing to acquire a just notion of the size and figure of bodies, because the same sensation would not arise from the successive application of each hand to the same substance. Let both of his hands, for example, be supposed [to touch a small sphere; the one by the extremities of the fingers will embrace it in all its diameters, and convey to him the idea of roundness; the other, which will be in contact with it only in a few points, will produce a very different sensation. Embarrassed between these two bases of his judgment, he will scarcely be able to decide, nay, it is even possible that he may form a double judgement from the double sensation which is presented him: his ideas would be more correct were he to use only the perfect

hand

hand, in the same manner as the person who squints, makes use of the perfect eye only. Our hands then assist each other reciprocally; the one confirms the notions which are given us by the other; hence the necessary uniformity of their conformation.

The hands are not the only instruments of the sense of touch. The axilla, the groin, the concavity of the foot and many other parts, may all of them from their application to bodies, afford us so many bases for our judgments with regard to external form. Now, if one half of the body were differently arranged from the other half, the same uncertainty in perception would infallibly be the result. From all that has been said, we may conclude, that in the external organs of sense, a harmony of action in the two symmetrical parts, or the two similar halves of the organ, is a condition essential to the perfection of sensation.

The external senses are the natural excitants of the brain. The functions of the brain succeed to theirs, and this organ would but languish, were it not to find in them the principle of its activity. From sensation follow perception, memory and imagination; from these the judgment. Now it is easy to prove, that these different functions, commonly known by the name of the internal senses, are governed in their actions by the same laws, which influence the external senses; and that like them, they approach the nearer to perfection in proportion to the degree of harmony existing in the symmetrical parts, in which they have their seat.

Let us suppose for instance one hemisphere of the brain to be better organised, and therefore susceptible of livelier affections than its fellow; in such case the perception of the individual would be confused, for the brain is to the soul what the senses are to the

brain;

brain; it transmits to the soul the impressions conveyed to it by the senses, as the senses convey to the brain the impressions made upon them by external objects. But, if the defect of harmony in the external senses confuse the perception of the brain, why may not the soul perceive but confusedly, when the two hemispheres of the brain are unequal in power, and incapable of blending into one the double impression, which is made upon them?

The memory is the faculty of re-producing former sensations, the imagination that of creating new ones, now in the act of remembering or imagining, each hemisphere of the brain appears to re-produce, or to create a sensation of its own. If both do not act alike, the perception of the mind, which ought to be the result of the two sensations united, will be inexact and irregular. But, it is evident, that there will be a disparity in the two sensations, if there be a disparity in the two halves of the brain, in which they have arisen, and since the general foundations of the judgment are made up of the faculties of perception, memory, and imagination, if these be confused, the judgment itself must be confused also.

We have now supposed an inequality of action in the hemispheres of the brain, and inferred, that the functions would in this supposition be imperfect; but what as yet is only supposition, in a variety of instances can be proved to be a fact; for nothing is more common than to find in consequence of compression on either hemisphere by blood, pus, or exostosis, a variety of alterations in the intellectual functions.

Even when all appearances of actual compression have vanished, if in consequence of that which has been experienced, a part of the brain remain enfeebled, the same alterations of mental power will be found to be prolonged. If both hemispheres of the brain, however, be affected equally, the judgment though weaker, will be more exact. Perhaps it is thus, that we should explain those observations so frequently repeated, of an accidental stroke upon one side of the head having restored the intellectual functions, which had long remained dormant in consequence of a blow received upon the other side.

I now conceive myself to have proved, that with inequality of action in the hemispheres, there must be confusion of intellect. I have also pointed out some states of disease, in which such confusion is evidently the effect of inequality of action so occasioned; here we see the effect and its cause; but may we not from analogy, infer a similar cause where we see a like effect? when the judgment is habitually incorrect, and all the ideas wanting in precision, may we not be induced to believe, that there does exist a defect of harmony in the action of the two hemispheres of the brain? We see inaccurately if nature have not given to both eyes an equal power; we perceive and judge inaccurately in like manner, if the two sides of the brain are naturally dissimilar. The most correct mind, and the soundest judgment, pre-suppose in the hemispheres a perfect harmony of action; and what a multiplicity of shades do we not behold in the operations of the understanding? it is probable that they all of them correspond to so many varieties in the proportions of power in the hemispheres. Could we squint with the brain as we do with the eyes—that is to say, could we receive impressions on one hemisphere only, and form from thence our determinations, we might then command at will, a precision in our intellectual operations; but such a power does not exist.

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To the functions of the brain succeed those of locomotion and the voice. The first of these would appear almost to form an exception to the general law. In considering the two vertical halves of the body, we shall perceive that the one is constantly more powerful than the other with respect to the strength and number of its movements. The right half is that, which from custom, is most made use of.

To comprehend the reason of this difference; we must make a difference between strength and agility; strength depends upon the perfection of the organization, on the energy of the nutritive process, on the plentitude of life in the muscular fibre; agility, on the contrary, is the result of habit and frequent exercise.

At present we shall observe, that this disparity of action in the locomotive organs, does not consist in the difference of their actual strength, but in that of the agility, with which these motions are executed.—All is equal in the size, in the number of fibres, and nerves both of the one and the other of the superior, or inferior extremeties; the difference of their vascular systems is scarcely any thing. From hence it follows that the discordance does not exist in nature, but that it is the effect of our social habits, which by multiplying our movements on one side of the body, increase their address without much adding to their power. Such in fact are the wants of society, as to call forth a certain number of general movements, which must be performed by all in the same direction, in order to be understood. It is generally agreed, that this direction shall be from left to right. The letters, which form the writing of most nations, are in this way directed; such circumstance occasions the necessity of our using the right hand to form them in preference to the left, the former being as much better

adapted

to this method, as the latter would be to the contrary one; of this we may convince ourselves by experiment.

The direction of the letters from left to right, imposes on us the necessity also of casting our eyes upon them in the same direction. From this habit acquired in reading, arises that of examining objects in the same manner.

The necessity of similar movements when men are drawn up in line of battle, has induced almost all nations to handle their weapons with their right hands; the harmony too which prevails in the dances of even the most savage people exacts an accord in the limbs, which they constantly preserve by making all their principal movements with the right. We might add to these examples a great variety of others.

The general movements agreed on by society, which, if every one were not to execute them in the same dirección, would be creative of much confusion; these movements, I say, by the influence of habit, oblige us for our own particular movements to use the limbs, which they have brought into action. Hence, the members of the right side of the body are perpetually in action either for our own particular wants, or for those which we feel in conjunction with others.

Now, as the habitude of acting, continually tends to the perfection of action, we may perceive the reason, why the right side acquires a greater facility in the performance of many motions than the left. This increased facility is not original, but acquired.

So remarkable a difference then, in the two symmetrical halves of the body, is not by nature meant as an exception to the general law of harmony of action in the external functions; for those movements, which are executed by the whole of the body, are the more

precise

precise in proportion to the smallness of the difference existing in the agility of the muscles of the two sides. How happens it that certain animals leap from rock to rock with such admirable precision, where the least deviation from the intended direction, would plunge them into an abyss? how happens it that they run with such astonishing address on planes, which are scarcely equal in breadth to the extremities of their limbs? how happens it that the walk of the very heaviest of animals is never attended with those false steps so frequent in the progression of man? The reason must be, that the difference in their locomotive organs in both sides of the body is scarcely any thing, and that in consequence there must be a constant harmony of action in these organs.

He, whose general movements, or those of the whole of the body are the most perfect, has the least command in particular over those of the right side; for, as I shall prove hereafter, the perfection of a part is never acquired but at the expence of that of the whole. The child, who should be taught to make an equal use of all his limbs, would possess a precision in his general movements, which he would find extremely difficult to acquire for those of the right hand, such as writing or fencing.

I can easily suppose, that some few natural circumstances may have exercised upon us an influence in our choice with respect to the direction of those general motions, which the habits of society have established. Such may be the slight excess of diameter in the right subclavian artery, and the sensation of lassitude during digestion, which is more perceived upon the left side on account of the situation of the stomach, and may therefore have determined us to act as such time upon the opposite side

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in preference. Such also may be the natural instinct, by which, to express our feelings we carry the right hand to the heart; but these circumstances are trifling in comparison with the very great difference of the movements which from the state of civilization exists between the symmetrical halves of the body; and from this view of the subject, we cannot but regard this difference as the effect of social convention, and by no means the intent of nature.

The voice, together with locomotion, is the last act of the animal life in the natural order of its functions. Now the greater number of physologists, and Haller in particular, have indicated as the causes of want of harmony in the voice, the dissimilarity of the two portions of the larynx, the inequality of force in the muscles, which move the arytenoid cartilages, the same inequality of action in the nerves, which are distributed to each half of the organ, and the different reflection of sounds in the nostrils and frontal sinuses. Without doubt a defective voice must frequently depend upon a faulty ear; when we hear incorrectly, we sing incorrectly; but when a correct ear is united with a want of precision in the voice, the cause is then in the larynx.

The most harmonious voice is that, which the two portions of the larynx produce in an equal degree; where the vibrations on one side correspond exactly in number, strength, and duration with those upon the opposite side. In the same manner the most perfect singing will be produced by two voices exactly similar in tone, compass, and inflection.

From the numerous considerations which I have offered, the following general conclusions may be deduced—namely, that one of the most essential characteristics of the animal life, is a harmony of action in the

the two analogous parts, or in the two sides of the simple organ concurring to the same end. The relation which exists between this harmony of action, which is the character of the functions, and symmetry of form, which is the attribute of the organs of the animal life, will easily be seen.

I wish to observe in finishing this section, that in pointing out the different derangements, which take place in the animal life, from the want of harmony in the organs, I have only pretended to assign a single isolated cause of such derangements; I am well aware that a thousand other causes besides dissimilarity in the hemispheres of the brain, may affect the operations of the mind.

§ II.— *Of discordance of action in the organic life.*

Along with the phenomena of the animal life, let us now consider those of the organic life, and we shall find that harmony has nothing to do with them. Of what detriment would it be to the general health of the individual, should one of his kidneys be stronger than the other, and secrete more urine; should one of his lungs be better unfolded than the other, admit more venous, and send out more arterial blood; should a less organic force be the lot of the salivary glands on one side than on the other side of his body? The simple function, to which both organs concur, would not be performed less perfectly. Whenever but a slight fulness supervenes on one side of the liver, spleen, or pancreas, the sound part makes up for the defect, and the function is little disturbed. The circulation also remains unaltered among the frequent variations in the vascular system of each side of the body, whether such variations exist naturally, or whether they arise from some

artificial

artificial obliteration of the larger vessels as in aneurism.

Hence we find those numerous irregularities of structure, those malconformations, which as I have said may be remarked in the organic life, and nothing of a morbid nature in consequence arising. From hence we see that almost continual succession of modifications, which lessen or increase the circle of the organic functions. The vital powers, and their exciting causes, are continually varying, and thus occasion a constant instability in the functions of the organs, for a thousand causes may at every moment double or triple the activity of the circulation, and respiration, increase or diminish the quantity of bile, urine, or saliva, and suspend or augment the nutrition of the parts. Hunger, food, sleep, motion, rest, and the passions may all of them impress upon these functions so great a mobility, as every day to make them run through a hundred degrees of strength or weakness.

In the animal life on the contrary, every thing is uniform and constant, the powers of the senses cannot experience these alternate modifications, or at least, not in so marked a manner. Indeed they are at all times in a state of relation with the physical powers, which preside over exterior bodies; now the latter remaining unaltered, such variations would destroy all relative connexion, and thus the functions cease.

Besides, if this mobility, which characterises the organic life, were the attribute of sensation—for the same reason it would be that of all the operations of the mind. In such case of what would man consist? The perpetual sport of every thing surrounding him, he would find his existence at one time little different from that of inanimate matter, at others superior in perfection and energy to that even which he now enjoys, allied at one time to the brute, at another, to spiritual nature.

CHAPTER

CHAPTER THE FOURTH.

General Differences of the Two Lives with respect to Duration of Action.

ONE of the great distinguishing characters of the phenomena of the animal life in opposition to those of the organic life, has just been shewn. That, which I am about to examine, is not of a less importance. The functions of the animal life intermit; the functions of the organic life are performed with an uninterrupted continuity.

§ I.—*Of continuity of action in the organic life.*

Prolong but little the causes which are capable of suspending respiration, or the circulation of the blood, and life itself shall be suspended, nay, even annihilated. All the secretions go on uninterruptedly; if they intermit at all (and those of the bile and saliva for instance, when not immediately required for the purposes of digestion and mastication, may be said to intermit) such intermissions affect the intensity of the secretion only, and not the entire exercise of the function. Exhalation and absorption incessantly succeed each other; the process of nutrition must be continually carried on; the double movement of assimilation and decomposition from which it results, can only be terminated with life itself.

In this concatenation of the organic phenomena, each function depends immediately upon those which precede it. The centre of them all, the circulation, is immediately connected with the exercise of them all, for when this is troubled, they languish, when this ceases, they cease also. Just in the same manner the movements of a clock all stop with the pendulum. Nor only is the general action of the organic life connected with the heart; but there cannot exist a single function of this nature unconnected with all the others, for without secretion, there can be no digestion, without exhalation no absorption, without digestion no nu trition. Hence as a general character of the organic functions may be indicated continuity of action, and mutual dependence.

§ II.—*Of intermission of action in the organic life.*

In the exercise of the functions of the animal life, there will be regularly seen an alternation of activity and repose, complete intermissions, and not remissions only.

Fatigued by long continued action, the senses all alike become for a time, incapable of receiving any further impression. The ear loses its sensibility to sound, the eye to light, the tongue to savours, the pituitary membrane to smells, the touch to the qualities of bodies about which it is conversant, and all this for the sole reason that the respective functions of these different organs, have for a long time been exercised.

In like manner, the brain fatigued by too great an effort in the exercise of any of its powers, in order to regain its excitability, must cease to act for a period proportioned to the duration of its preceding action.

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The muscles also after having been strongly contracted, before they can contract anew, must remain for awhile in a state of relaxation. Hence in locomotion, and the exertion of the voice, there must be intermissions.

Such then is the character peculiar to the organs of the animal life. They cease to act because they have acted. They become fatigued, their exhausted powers must be renewed.

This intermission is sometimes general, sometimes partial. When a single organ, for a long time, has been exercised, the others remaining inactive, it relaxes and sleeps, the others continuing to watch.—Hence, without doubt, proceeds the reason, why there is no immediate dependence among the functions of this order on each other. The senses being shut up against sensation, the brain may still subsist in action, may remember, imagine, or reflect. In such case the power of locomotion and the voice also, may equally well be exercised, and these in like manner may remain unexercised, and the activity of the senses be in no-wise impaired.

Thus the animal at will may fatigue any one of the parts of this life, and on this very account, such parts must all of them possess a capability of being relaxed, a power of repairing their forces in an isolated manner. This is the partial sleep of the organs.

§ III.—*Application of the law of intermission of action to the theory of sleep.*

General sleep is the sleep of all the parts. It fol lows from that law, which with respect to the functions of the animal life, enchains intermission with

periods

periods of action, from that law, by which this life is particularly distinguished from the organic life.

Very numerous varieties are remarked in this periodical state, to which all animals are subject. The most complete sleep is that in which the outward life is entirely suspended. The least perfect sleep is that which affects one organ only; it is that of which we have just been speaking.

Between these two extremes there are many intermediate states. At times perception, locomotion, and the voice only are suspended; the imagination, the memory, and the judgment remaining in action. At other times, to the exercise of the latter faculties are added those of the locomotive organs and the voice.—Such is the sleep, in which we dream, for dreams are nothing more than a portion of the animal life escaped from the torpor, in which the other portion of it is plunged.

Sometimes but very few of the senses have ceased their communication with external objects. Such is that species of somnambulism, in which to the action of the brain, the muscles, and the larynx, are added the very distinct actions of the ear and the sense of touch.

Sleep then cannot be considered as a constant and invariable state with regard to its phenomena.—Scarcely ever do we sleep in the same manner twice together. A number of causes modify it in applying to a greater or lesser portion of the animal life the laws of intermission of action. Its different degrees should be marked by the different functions, which these intermissions affect.

But the principle of it is every where the same from the simple relaxation of a muscle to the entire suspen

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sion of the whole of the animal life. Its application, however, to the different external functions, varies without end.

These ideas on sleep are different, no doubt, from that narrow system, where its cause exclusively placed in the brain, in the heart, in the large vessels, or in the stomach, presents an isolated and frequently an illusory phenomenon, as the base of one of the great modifications of life.

And what is the reason why light and darkness in the natural order of things, coincide so regularly with the activity or intermission of the external functions? The reason is this, that during the day a thousand means of excitement perpetually surround the animal, a thousand causes exhaust the powers of his sensitive and locomotive organs, fatigue them, and prepare them for a state of relaxation, which at night is favoured by the absence of every kind of stimulus. Thus, in the actual state of society, where this order is in part inverted, we assemble about us at evening, a variety of excitants, which prolong our waking moments, and put off until towards the first hours of daylight, the intermission of our animal life, an intermission, which we favor besides by removing from the place of our repose whatever might produce sensation.

We may for a certain time, by multiplying the causes of excitement about them, withdraw the organs of the animal life from this law of intermission, which should naturally cause them to sleep; but at last they must undergo its influence, and nothing can any longer suspend it. Exhausted by watching, the soldier slumbers at the cannon's side, the slave under the whip, the criminal in the midst of torture.

We must carefully make a distinction, however, between the natural sleep, which is the effect of lassi-

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tude, and that, which is the consequence of some affection of the brain, of apoplexy, or concussion, for nstance. In the latter case the senses watch, receive mpressions, and are affected as usual, but these impressions are not perceived by the diseased sensorium; we cannot be conscious of them. On the contrary, in ordinary sleep the senses are affected as much, or even more than the brain.

From what has now been said, it follows, that the organic life, has a longer duration than the animal life. In fact the sum of the periods of the intermissions of the latter, is almost equal to that of the times of its activity. We live internally almost double the time that we exist externally.

CHAPTER THE FIFTH

General Differences of the Two Lives with respect to Habit.

ANOTHER of the great distinguishing characters of the two lives of the animal, consists in the independence of the one, and in the dependence of the other on habit.

§ I.—*Of habit in the animal life.*

In the animal life every thing is modified by habit. The functions of this life, whether enfeebled or exhausted by it, according to the different periods of

their

their activity, appear to assume a variety of characters: to estimate the influence of habit, it is necessary to consider two things in the effect of all sensation, the sentiment, or immediate feeling, which we have of external objects, and the judgment which is the result of one or more comparisons made with respect to them. An air, for instance, strikes the ear; the first impression made upon the organ is, we know not why, agreeable or painful. This is sentiment—at present let us suppose the air to be continued. We may now endeavour to appreciate the different sounds of which it is composed, and to distinguish their accords. In this we exercise the judgment. Now, on these two things, the action of habit is inverse. It enfeebles our sentiment of things, it improves our judgment of them; the more we regard an object, the less are we sensible of its agreeable or painful qualities, the better, at the same time, may we judge of its attributes.

§ II.—*Habit blunts the sentiment.*

Let us dwell a little on the foregoing proposition; we have said that it is the property of habit to enfeeble our sentiments of things, to bring us into a state of indifference, the middle term betwixt pain and pleasure. But before we set about to prove an assertion so remarkable, it will be well to fix the sense of it with some precision. Pain and pleasure are absolute and relative. The instrument which tears us in pieces is a cause of absolute pain. Sexual connexion is a pleasure of the same nature. Again, the view of a beautiful country delights us, but here the enjoyment is relative to the actual state of the mind only; its charms have long since been indifferent to the inhabitant of the spot. A bougie when for the first time passed into the uretha is painful to the patient; eight days afterwards he is no longer sensible of it. Here we have comparative pain. Whatever destroys the texture of the organ is always productive of an absolute sensation; the simple contact of bodies at no time produces any other than a relative sensation.

Hence it is evident that the domain of absolute pleasure or pain, is much less extensive than that of these feelings when relative. The very words agreeable, or painful, imply a comparison made between the impression received by the senses, and the state of mind on which it is received. Now it is manifest that we could have referred only to relative pain and pleasure, as being submitted to the influence of habit. On these we shall occupy ourselves awhile.

And to shew that they are gradually worn away by habit as we have said, to the point of indifference, a variety of proofs may be adduced. Every foreign body in contact for the first time, with a mucous membrane, is creative of a disagreeable sensation, which by repetition, is diminished, and at last becomes altogether imperceptible. Pessaries in the vagina, tents in the rectum, the canula made use of for tying polypi of the nose, or the uterus, bougies, in the urethra in the œsophagus, or trachea, styles and setons in the lachrymal passages, present us every day with these phenomena. The impressions of which the cutaneous organ is the seat, are all of them subjected to the same law. The sudden passage from cold to heat, or from heat to cold, is always the occasion of a disagreeable sensation, but such sensation gradually and at last entirely disappears, if the temperature of the atmosphere be within a certain range and constant. From hence proceed those various sensations, which we have from the change of climate, or season. Similar phenomena in the he same way are the result of our successive perceptions of the dry or humid, the soft, or the hard qualities of bodies, and in general the same may be said of all our relative sensations, of what kind soever.

With respect to pleasure, we shall repeat what we have said of pain. The perfumer and the cook are by no means sensible in their several professions of those pungent enjoyments of which they are dispensers. In them the habit of perceiving has blunted the sentiment. The same is the case with all agreeable sensations whatever. Delightful objects, delicious music are productive of a pleasure, the vivacity of which is soon decreased, for harmony and beauty for this sole reason, that for a long time they continue to solicit our attention, are successively the sources of pleasure, of indifference, of satiety, nay even of disgust and aversion. This remark has been felt by all; Philosophers and Poets have all of them turned it to their account.

From whence arises this facility, which our sensations have of undergoing so many different, so many contrary modifications? To conceive it, let us first remark that the centre of these revolutions of pleasure, of pain, and of indifference, is by no means seated in the organs, which receive or transmit the sensation, but in the soul. The affeetions of the eye, of the tongue, and the ear, are at all times the same from the same objects, but to these affections at different times, we attach a variety of sentiments. In the second place we shall observe, that the action of the mind in each several sentiment of pain or pleasure, which has been the effect of a sensation, consists in a comparison between this sensation, and that by which it has been preceded, a comparison, which is not the result of reflection, but the involuntary effect of the first impression of the object Now, the greater the difference

between

between the actual and the past impression, the livelier will be the sentiment. The sensations which affect us the most, are those which we never before have experienced.

The consequence is, that in proportion as the same sensations are repeated, the less impression do they make upon us, because the comparison between the present and the past becomes less sensible. Pain then and pleasure naturally tend to their own annihilation. The art of prolonging our enjoyments, consists in varying their causes. Indeed were I to regard the laws of our material organization only, I might almost say, that constancy is but one of the happy dreams of the poet, and that the sex to which we at present bend, would possess but a very weak hold upon our attentions were their charms too uniform; I might almost assert that were every female cast in the same mould, such mould would be the tomb of love. But here let us forbear to insist upon the principles of physiology, where they tend to the destruction of those of morality. The one, and the other are equally solid, though sometimes at variance. We shall only notice, that at times the former unhappily are our only guides. It is then, that love disappears, with the pleasure which it has procured, and leaves us but disgust. It is then, that recollection too often carries us aside from our duties in rendering uniform that which we feel and that which we have felt, for such appears to be the essence of physical happiness, that past pleasure enfeebles the attraction of that which we enjoy.

The consequences are clear. Physical pleasure is nothing but a comparative sentiment; it ceases to exist when uniformity supervenes between the actual and past impression. By means of this uniformity habit must bring down pleasure to indifference: Such

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is the secret of the very great influence which it exercises over our enjoyments.

Such also is its mode of action on our pains. Time flies, it is said, and carries away sorrow; time is the true remedy of grief; and wherefore? The reason is, that the more sensations it accumulates upon that which has been painful, the more does it enfeeble the sentiment of comparison between what we are, and what we were. At last this sentiment becomes extinct. There are no eternal sorrows.

§ III.—*Habit improves the judgment.*

I have just now proved that the sentiment is enfeebled by the effect of habit. It is as easy to demonstrate, that habit improves and enlarges the judgment.

When, for the first time, the eye wanders over an extensive country, or the ear is struck by a succession of harmonious proportions; when the taste, or the smell for the first time are affected by any very compound savour or scent, there arise from these sensations only confused and inexact ideas. We represent to ourselves the whole, its parts escape, us. But let these sensations be repeated, and in proportion as they are so, will the judgment become precise and rigorous, and the knowledge of the object be perfected.

Let us for instance observe the man, who a stranger to theatrical amusement of every kind is introduced to the Opera. He will have but a very imperfect notion of it. The dancing, the music, the scenery, the actors, the splendor of the whole will be all confounded within his mind in a sort of delightful chaos. But let him be present at many representations, and whatever in this charming whole belongs to the several arts, will assume its separate place. He will have seized its

detail,

detail, may form a judgment of it, and this he will do the more accurately in proportion to his opportunities of observation.

The above example affords us an abridgment of the picture of the man, who enjoys for the first time the spectacle of nature. The child, at its birth, is only capable of general impressions, but habitude, by gradually blunting these impressions, enables him to seize the particular attributes of bodies, and teaches him to see, to hear, to smell, to taste and to touch, by making him in each sensation descend successively from the confused notion of the whole to the precise idea of its parts. The animal life needs education, and this is one of its great characters.

Habit then while it hebetates our sentiments, improves our judgments of things. An example will render this truth indisputable. Most persons may recollect that in traversing a meadow, embellished with a variety of flowers, they have been sensible of a general fragrance only, the confused assemblage of all the particular odours which are exhaled from each individual flower; but in a short time from habit this first sentiment is weakened, it is soon afterwards altogether effaced. They then may have distinguished the odour of each particular plant, and formed a judgement at first impossible.

The two contrary operations thus of habit on our sentiments and judgments, tend as we see to one common end, the improvement, namely, of the animal life.

§ IV.—*Of habit in the organic life.*

Let us at present compare the above-mentioned phenomena with those of the organic life, and the latter we shall see as constantly withdrawn from the influence of habit, as the former are subject to it.—

Habit

Habit has never modified the circulation, or respiration has never changed the mode of the processes of exhalation, absorption, or nutrition. A thousand causes would every day endanger our very existence, were these essential functions under the influence of habit.

The excretion of the urine and fecal matter may, nevertheless, be suspended, accelerated, and return according to laws determined by habit. The action of the stomach with respect to hunger, and its contact with certain aliments, appears also to be subordinate to habit; but here let us remark, that these different phenomena hold, as it were, a middle place between the two lives, are found on the limits of the one and the other, and participate almost as much of the animal as the organic life. In fact, they all of them take place on mucous membranes, a species of organ, which being at all times in relation with bodies foreign to our nature, is the seat of an inward tact, in every way analogous to the outward tact of the skin. The two must be necessarily subject to the same laws — Can we be astonished at the influence of habit on both of them?

We cannot, and let us remark also, that the greater part of these phenomena, which begin as it were, and terminate the organic life, are connected with motions essentially voluntary, and in consequence, under the dominion of the animal life.

I shall not here enlarge on the numerous modifications of power, taste, and desire, which have their source in habit. I refer to the numerous works which have considered its influence in a different point of view from that which I have indicated.

CHAPTER THE SIXTH.

General Differences of the Two Lives with respect to mental affection.

IT is necessary to consider, under two relations, those acts, which little connected with the material organization of animals, are derived from this principle so little known in its nature, but so remarkable as to its effects, the center of all their voluntary motions, and on the subject of which, there would have been less dispute, if philosophers, instead of attempting to reach its essence, had been contented with analyzing its operations. These actions, which we shall consider more especially in man, with whom they are the most perfect, are either purely intellectual, and relative to the understanding only; or they are the immediate product of the passions. Examined under the first point of view, they are the exclusive attribute of the animal, under the second of the organic life.

§ I.—*Whatever relates to the understanding belongs to the animal life.*

It would be useless for me to insist on proving that meditation, reflection, the judgement, and all the operations of the mind depending upon an association of ideas are under the dominion of the animal life. We judge from impressions formerly or actually received, or from those which we ourselves create. Perception, memory

memory, and the imagination are the principal bases, on which are founded the operations of the mind, but these very bases themselves repose upon the action of the senses.

Let us suppose a man at his birth to be deprived of all that exterior apparatus, which is destined to establish his connexions with surrounding objects ; such man will not altogether be the statue of Condillac, because, as we shall see hereafter, other causes besides the sensations, may occasion within him the motions of the animal life ; but at least will he not be able, a stranger as he is to every thing surrounding him, to form any judgment with respect to things. The intellectual functions with him will be null; volition, which is the consequence of these functions, will not have place, and consequently, that very extensive class of motions which has its immediate seat in the brain, and which itself is but an effect of the impressions made there, will in no-wise belong to him.

It is by means of the animal life that man is so great so superior to the beings, which surround him ; by means of this that he possesses the sciences, the arts, and every thing which places him at a distance from the gross elements under which we represent brute matter ; by this that he approaches spirituality ; for industry and commerce, and whatever enlarges the narrow circle within which the efforts of other animals are confined, are exclusively under the dominion of the animal life of man.

The actual state of society then is nothing but a more regular developement, a more marked perfection of the exercise of the different functions of this life ; for one of its greatest characters as I shall hereafter prove, consists in its capability of being unfolded, while, in the organic life, there does not exist a part, which

which in the least degree may pass the limits which are set to it by nature. We live organically in as perfect, in as regular a way, when infants, as when men; but what is the animal life of the child compared with that of the man of thirty years of age?

We may conclude that the brain, the central organ of the animal life, is the center of whatever relates to the understanding. I might here proceed to speak of its volume in man, and in animals, whose intelligence appears to decrease in proportion as the facical angle is diminished, and expatiate upon the different alterations of which the cerebral cavity is the seat, as well as on the disorders of the intellectual functions arising thence. But these things are all of them well enough understood. Let us pass to that order of phenomena, which though as foreign as the preceding to the ideas which we form of material appearances, are elsewhere seated.

§ II.—*Whatever relates to the passions belongs to the organic life.*

My present object is not to consider the passions metaphysically. It little matters, whether they be all of them the modifications of a single passion, or dependent each of them upon a separate principle. We shall only remark, that many physicians in discussing their influence on the organic phenomena, have not sufficiently distinguished them from the sensations; the latter are the occasion of the passions, but differ from them widely.

It is true that anger, joy, and sorrow, would not affect us, were we not to find their causes in our connexions with external objects. It is true also, that the senses are the agents of these relations, that they com-

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municate the causes of the passions, but in this they act as simple conductors only, and have nothing in common with the affections, which they produce; for sensation of every kind has its centre in the brain, sensation of every kind supposing impression and perception. If the action of the brain be suspended, sensation ceases; on the contrary, the brain is never affected by the passions; their seat is in the organs of the internal life.

It is undoubtedly surprising that the passions, essentially as they enter into our relations with the beings which are placed about us, that modifying as they do as every moment these relations, that animating, enlarging, and exalting the phenomena of the animal life, which without them would be nothing but a cold series of intellectual movements; it is astonishing, I say, that the passions should neither have their end, nor beginning in the organs of this life, but on the contrary, that the parts which serve for the internal functions, should be constantly affected by them, and even occasion them according to the state in which they are found. Such notwithstanding is the result of the strictest observation.

I shall first observe, that the effect of every kind of passion is at all times to produce some change in the organic life. Anger accelerates the circulation of the blood, it multiplies the efforts of the heart. The passion of joy has not indeed so marked an influence upon the circulation, but alters it notwithstanding, and carries it lightly towards the skin. Terror acts inversely; this passion being characterized by a feebleness in the vascular system, a feebleness, which in hindering the blood from arriving at the capillary vessels, occasions the paleness which at such time is so particularly remarked. The effects of sadness and sorrow are nearly analagous.

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So great indeed is the effect which the passions occasion upon the organs of the circulation, as even to arrest them altogether in their functions, where the affection is very powerful. In this way is syncope produced, for the primitive seat of syncope is always, as I shall soon prove it to be, in the heart, and not in the brain. In this the latter organ ceases to act, only because it ceases to receive the excitant necessary to its action. Hence also may happen death itself, the sometimes sudden effect of extreme emotion, whether such emotion as in anger so far exalts and exhausts the powers of the circulation, as not to leave them any further excitability, or whether as in the death occasioned by excessive grief, the powers at one excessively debilitated, are no longer capable of returning to their usual condition.

If the total and instantaneous cessation of the circulation be not occasioned by this debility, a variety of lesions in the blood vessels may be, notwitstanding, the effect of it. Desault has remarked that diseases of the heart, and aneurisms of the aorta, were augmented in number during the revolution, in proportion to the evils which it produced.

Nor does respiration depend less immediately upon the passions ; that oppression, that anxiety, and sense of suffocation, which is the sudden effect of profound sorrow, must imply in the lungs a remarkable change and sudden alteration. In that very long series of chronic or accute affections, the sad attribute of the pulmonary system, must we not often look to the passions to find the principle of the disease ?

And that lively sensation at the pylorus under strong emotion, that ineffaceable impression which sometimes remains there, from whence succeed the schirrhi of which it is the seat, that sentiment of straitness, as it

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were, about the stomach, about the cordia in particular; under other circumstances those spasmodic vomitings, which sometimes follow the loss of a beloved object, the news of a fatal accident, or any kind of trouble, the cause of which are the passions; that sudden interruption of the digestive phenomena either in consequence of agreeable or disagreeable news, those affections of the bowels, those organic lesions of the intestines, of the spleen observed in cases of melancholy, or hypochondria, diseases which are always preceded by sad forebodings and the darker affections of the mind; do not all these indicate the very strict connexion of the digestive viscera with the state of the passions?

They do; and the secreting organs have not a less connexion with them. Sudden fear suspends the course of the bile, and is the occasion of jaundice; sudden anger is often the origin of bilious fever. In a state of sorrow or joy, sometimes even in that of admiration, our tears flow abundantly: the pancreas is not less frequently affected in hypochondria.

But the functions of the circulation, of digestion, respiration and secretion, are those which are most directly under the influence of the passions; those of exhalation, absorption and nutrition appear to be less so. Doubtless, the reason of this is, that these functions have not as the former any principal focus, or essential viscera, the state of which may be compared with that of the mind. Their phenomena disseminated throughout all the organs belong exclusively to none, and cannot be observed as well as those, the effects of which are confined within a narrow compass.

Nevertheless, the alterations, which these functions experience are not less real, do not become less apparent after a certain time; let the man, whose hours are marked by sorrow, be compared with him, who lives in peace of mind, and the difference of the process of nutrition in the one and in the other will easily be seen.

Let us, for a moment, approximate the times, when the terrible passions of sorrow, of fear and revenge seemed to brood over our country, and those, when safety and abundance continually supplied us with the gayer ones so natural to us ; we may then recal what at the two periods were the outward appearances of our countrymen, and appreciate the influence of the passions on the process of nutrition. The very expressions which are continually in our mouths that such a one is dried up with envy, preyed upon by remorse, consumed and wasted away with sorrow, do not even these announce how much the nutritive functions are modified by the passions?

I know not for what reason the powers of absorption and exhalation should not be subject to the same influence, though they appear to be less so; may not dropsies, and all infiltrations of the cellular membrane, the peculiar vices of these two functions, depend on mental affection ?

In the midst of these disturbances, of these partial or general revolutions which are produced by the passions in the organic phenomena, let us consider the actions of the animal life; they constantly remain unaltered, or if they do experience any derangement, such derangement has ever its source in the internal functions.

From so many considerations we may conclude that it is upon the organic and not upon the animal life that the passions exercise their influence. Accordingly, whatever serves to paint them must relate to the former. Of this assertion, our gestures which are the mute expressions both of the sentiment and under-

standing

standing are a remarkable proof. Thus if we indicate any operation of the memory, imagination or judgement, the hand is carried to the head; do we wish to express either love or hatred, or joy or sorrow, it is to the seat of the heart, the stomach or intestines, that it is then directed.

The actor, who should mistake in this respect, who in speaking of sorrow should refer his gestures to his head, or carry them to his heart, for purpose of announcing an effort of genius, would be ridiculed for a reason which we should better feel then comprehend.

The very language of the vulgar, at a time when the learned referred to the brain, as the seat of the soul, affections of all kinds, distinguished the respective attributes of the two lives. We have always said a strong head, a head well organized to denote perfection of mind; a good heart, a sensible heart to indicate proper feeling. The expressions of fury circulating in the veins, and stirring up the bile; of joy making the heart leap, of jealousy distilling its passions into the heart, are by no means poetical expressions, but the enunciation of that which actually takes place in nature. In this way do all these expressions, the language of the internal functions enter into our poetry, which in consequence is the language of the passions or the organic life, as ordinary speech, is that of the understanding or the animal life. Declamation holds a middle place between the two, and animates the cold tongue of the brain by the expressive language of the inward organs.

I shall even venture to assert that anger and love inoculate, if I may so express myself, into the humours, into the saliva particularly, a radical vice, which renders dangerous the bite of animals at such times; for these passions do really distil into the fluids a poison,

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as we indicate the fact by our common expressions. The violent passions of the nurse have frequently given her milk a pernicious quality, from whence disease has followed to the child; and in the same way shall we explain (from the modifications namely, which the blood of the mother receives under strong emotion) the manner, in which these emotions operate on the nutrition, the conformation, and even on the life of the fœtus. And not only do the passions essentially influence the organic functions, in affecting their respective viscera, but the state of these viscera, their lesions, the variation of their forces concur in a decided way to the production of the passions themselves. Their relations with age and temperament, establish incontestably this fact.

Who does not know for instance, that the individual of the sanguine temperament, whose expansion of lung is great, whose circulatory system is large and strong; who does not know that such a man is possessed of a disposition to anger and violence? that when the bilious system prevails, the passions of envy and hatred are more particularly developed? that when the lymphatic system is pronounced, are pronounced also the inactivity and dullness of the individual?

In general that which characterises any particular temperament, consists in a correspondent modification on one hand of the passions, and on the other of the stâte of the organic viscera. The animal life is almost always a stranger to the attributes of the temperaments.

The same may be said of age; the weakness of the organization of the child coincides with his timidity. The developement of the pulmonary and vascular system, with the courage and temerity of the youth; that of the liver, and the gastric system with the envy ambition, and intrigue of manhood. In

In considering the passions as affected by climate and season, the same relations are observed between them and the organic functions; but physicians have sufficiently noticed these analogies, and it would be useless to repeat them.

At present, if from man in a state of health, we look to man in a state of disease, we shall see that the lesions of the liver, of the stomach, of the spleen, the intestines and heart produce a variety of alterations in our affections, which all of them cease together with their causes.

The ancients, better than our modern mechanicians, physicians then were acquainted with the laws of the economy, in supposing that our bad affections were evacuated by purgatives, together with the noxious humours of the body. By disembarrassing the primæ viæ they got rid of these affections. In fact how dark a tint does the fulness of the gastric viscera cast upon the countenance! the errors of the first physicians on the subject of the atrabilis, were a proof of the precision of their observations on the connexion of these organs with the state of the mind.

In this way every thing tends to prove, that the organic life, is the term, in which the passions end, and the centre from whence they originate. But we shall be asked perhaps, why vegetables, which live organically, do not offer any vestige of them? the reason seems to be, that besides their want of the natural excitants of the passions, namely the external apparatus of the senses, they are wanting also in those internal organs, which concur most especially to their production, such as the digestive system, that of the general circulation, and that of the great secretions, which are remarked in animals.

Such are the reasons also why the passions are so obscure in the Zoophytes, in worms, &c. and why in proportion as the organic life becomes more simple in the series of animals, and loses its important viscera, the passions are less observable.

§III.—*The passions modify the actions of the animal life though seated in the organic life.*

Although the passions are the especial attributes of the organic life, they nevertheless exert an influence over the animal life, which it is necessary to examine. The muscles of volition are frequently brought into play, and their actions sometimes exalted, sometimes lowered by them; the strength for instance of the man in anger is doubled, and tripled; is exercised with an energy, of which he is not himself the master. The source of this augmented power is manifestly in the heart.

This organ, as I shall prove hereafter, is the natural excitant of the brain, by means of the blood, which it sends thither. The energy of the cerebral action is in proportion to the energy of the stimulus applied to it, and we have seen that the effect of anger is to impress a great vivacity upon the circulation: hence, a larger quantity of blood than usual is thrown upon the brain in a given time. The consequence is an effect analogous to that which happens in the paroxysm of ardent fever, or the immoderate use of wine.

It is then, that the brain being excited strongly, excites as strongly the muscles which are submitted to its influence; accordingly their motions must be involuntary, for the will is a stranger to those spasms, which are determined by a cause which irritates the medullary organ. Such cause may be a splinter of bone,

bone, blood, pus, the handle of a scalpel as in our experiments; in short of various kinds.

The analogy is exact, the blood being transmitted to the brain in greater quantity than usual, produces upon it the effect of the different excitants above-mentioned. In these different motions then, the brain is passive; it engenders indeed at all times the necessary irradiations for producing such motions, but these irradiations in the present instance are not the effect of the will.

It may be observed also, that under the influence of anger, a constant relation exists between the contractions of the heart and the locomotive organs; they both increase at the same time, and at the same time resume their equilibrium. In every other case on the contrary there is no appearance of this relation; the action of the heart is uniformly the same, whatever the affection of the muscular system. In convulsion and palsy, the circulation is neither impeded or accelerated.

In the passion of anger, in fact, we see the very mode of the influence, which the organic life exercises over the animal life. In the passion of fear also, where on the one hand the enfeebled heart directs a less quantity of blood, and consequently a smaller cause of excitement to the brain, and where on the other hand a debility may be observed in the external muscles, we may perceive the connexion of cause and effect. This passion offers in the first degree the phenomenon, which in the last degree is shewn by those lively emotions, which suspending altogether the efforts of the heart, occasion a sudden cessation of the animal life and syncope.

But in what way shall we account for those modifications of the motions of the animal life, which are the effect of the passions? In what way shall we explain

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the cause of those infinite varieties, which succeed each other in the moveable picture of the face?

All the muscles which are the agents of these motions receive their nerves from the brain and lie under the influence of the will. What is the reason then, that when acted on by the passions, they cease to do so, and enter under the class of those motions of the organic life, which are put forth without our direction or consciousness. The following if I mistake not is the best explanation of the fact.

The most numerous sympathies exist between the internal viscera, and the brain or its different parts. Every step which we make in practice presents us with affections of the brain originating sympathetically from those of the liver, stomach and intestines. Now as the effect of every kind of passion is to produce a change of power in one or the other of these viscera, such change will sympathetically excite either the whole of the brain or some of its parts, whose re-action upon the muscles, which receive from thence their nerves, will produce the motions, which are then observed. In the production of these motions the cerebral organ accordingly must be passive, it is active only when the will presides over its efforts.

The effects indeed of the passions are similar to those diseases of the internal organs, which by sympathy are the causes of atony, palsy, and spasm.

But perhaps the inward organs act upon the voluntary muscles, not by means of the immediate excitement of the brain, but by direct nervous communication. Of what importance to us is the manner? We are not at present occupied on the so much agitated question of the manner of sympathetic communication.

The essential thing is the fact itself. Now in this fact, there are two things evident; the affection of an internal

internal organ by the passions, and secondly a motion produced in consequence of such affection in muscles, on which this organ in the common series of the phenomena of the two lives has no kind of influence. This is surely a sympathy, for between it, and those with which convulsion, or spasm of the face present us, when occasioned by any lesion of the phrenic center, or the stomach, the difference is only in the cause, which affects the internal organ.

Any irritation of the uvula, or the pharynx convulsively agitates the diaphragm. The two frequently repeated use of fermented liquors occasions a general trembling of the body. But that which happens in one mode of gastric affection, may happen in another. What matters it, whether the stomach or liver be irritated by passion or by some material cause? It is from the affection, and not from the cause of the affection that results the sympathy.

Such in general is the manner in which the passions withdraw from the empire of the will, those motions which by nature are voluntary. Such is the manner in which they appropriate to themselves, if I may so express myself, the phenomena of the animal life, though they possess their seat essentially in the organic life.

When very strong, the very lively affection of the internal organs produces so impetuously the sympathetic motions of the muscles, that the action of the brain is absolutely null upon them; but the first impression past, the ordinary mode of locomotion returns.

A man is informed by letter and in presence of company, of a piece of news, which it is his interest to conceal. All on a sudden his brows become contracted, he grows pale, and his features are moulded according

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to the nature of the passion, which has been excited. These are sympathetic phenomena produced by the abdominal viscera which have been affected by the passions, and which in consequence belong to the organic life. But in a short time the man is capable of putting a constraint upon himself, his countenance clears up, his colour returns. Meanwhile the interior sentiment continues to subsist however, but the voluntary have overpowered the sympathetic motions, the action of the brain has surmounted that of the stomach or the liver; the animal life of the man has resumed its empire.

In almost all the passions the movements of the animal life are mingled with those of the organic life, or succeed to them; in almost all the passions, the muscular action is in part directed by the brain, in part by the organic viscera. The two centers alternately overpowered the one by the other, or remaining in a state of equilibrium, constitute by the modifications of their influence, those numerous varieties which are seen in our mental affections.

And not only on the brain, but on all the other parts of the body also do the viscera affected by the passions exercise their sympathetic influence. Fear affects the stomach in the first place, as is proved by the sense of straitness felt there at such time. But when thus affected, the organ re-acts upon the skin, with which it has so strict a connexion, and the skin immediately becomes the seat of the cold and sudden sweat, which is then so often felt. This sweat is still however of the same nature with that which is occasioned by tea, or warm liquids. Thus a glass of cold water, or a current of cold air, will suppress this excretion by means of the relation, which exists between the skin, and the mucous surfaces of the stomach or bronchiæ. We

must

must carefully distinguish between sympathic sweating, and that, of which the cause is directly made upon the skin.

Hence though the brain be not the only term of the re-action of the internal viscera which are affected by the passions, it is nevertheless the principal one, and in this respect may always be considered as a focus at all times in opposition to that which is centered in the internal organs.

§ IV.—*Of the epigastric centre.—It does not exist in the sense, which Authors have pretended.*

Authors have never been at variance with respect to the cerebral focus. The voluntary motions have ever been regarded as an effect of its irradiations. They do not equally agree upon the subject of the epigastric focus; some of them place it in the diaphragm, others in the pylorus, others in the plexus of the great sympathetic nerve.

But on this point, they appear to me to be all of them in the wrong. They assimilate or rather identify the second with the first focus— they think, that the passions, as well as the sensations have their seat in an invariable center. That, which has led them to this opinion has been the sentiment of oppression, which is felt at the cardia under all painful affection.

But it is to be remarked, that in the internal organs, the sentiment produced by the affection of a part is always an unfaithful index of the seat and extent of such affection. For example, hunger must undoubtedly affect the whole of the stomach, but the sensation of hunger is transmitted to us only by the cardia. A large inflamed surface in the pleura for the most part gives rise to a pain, which is felt only in a point.

point. How often does it happen that in the head or the abdomen a pain which is referred but to a very limited space coincides with a largely disseminated affection, with an affection possessing even a different seat from that which is presumed. We should never consider the place to which we refer the sentiment as a sure index of that which the affection occupies, but only as a sign that it exists either there or thereabouts.

From all this it follows, that to form a judgment of the organ, to which such or such a passion relates, we ought to recur to the effect produced in the functions of the organ by the influence of the passion, and not to the feelings of the patient. In setting out from this principle it will be easy to see, that it is sometimes the stomach and alimentary canal, sometimes the sanguiferous system, sometimes the viscera belonging to the secretions which experience a change.

I shall not repeat the proofs of this assertion, but supposing it to be demonstrated, I shall assert that there does not exist for the passions as there does for the sensations a fixed and constant center; that on the contrary the liver, the lungs, the spleen, the stomach, and the heart, are turn by turn affected, and at such time form that epigastric center so celebrated in modern works; and if in general we refer to this region the sensible impression of all our affections, the reason is that all the important viscera of the organic life, are there concentrated. In fact, if nature had separated these viscera, had the liver for instance been placed in the pelvis, and the stomach in the neck, the heart and spleen remaining as they now are seated, in such case the epigastric focus would disappear, and the local sentiment of our passions vary according to the part affected.

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In determining the facial angle, Camper has thrown much light upon the proportion of intelligence enjoyed by the several classes of animals. It appears that not only the functions of the brain, but that all those of the animal life which are centered there, have this angle for the measure of their perfection.

It would be a very pleasing thing could we indicate in the same way a measure, which assumed from the organs of the internal life, might fix the rank of each species with regard to the passions. The dog is much more susceptible than other animals of the sentiments of gratitude, of joy, of sorrow, of hatred, and of friendship; has he any thing more perfect in his organic life? the monkey astonishes us by his industry, his disposition to imitate, and by his intelligence; his animal life is certainly superior to that of every other species. Other animals, such as the elephant, interest us by their attachment, their affection, their passions; they delight us also with their address, and the extent of their intelligence. With them the cerebral center and the organic viscera are perfect alike.

A rapid glance over the series of animals will shew us also, that in some of them the phenomena, which arise from sensation predominate over those which have their origin in the passions; in others we shall see the latter superior in power to the former, and in others again, a balance established between the two. These circumstances, which we remark in the long chain of animated beings, we may remark in the human species alone. In one man the passions are the great principle of motion; the influence of his animal life is continually surpassed by that of his organic life, and incessantly induces him to act in a way to which the will is almost a stranger, and which often entails upon him the bitterest regret, when his animal life resumes

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its empire. In another man, the animal life is the stronger of the two. In such case, the understanding seems to be augmented at the expence of the passions, the latter remaining in that silence, to which the organization of the individual has condemned them.

That man enjoys the happiest constitution in whom the two lives are balanced, in whom the cerebral and epigastric centers exercise the one upon the other an equal action, whose intellect is warmed, exalted, and animated by the passions, but whose judgment makes him at all times master of their influence.

It is this influence of the passions over the actions of the animal life, which composes what is named the character. Character as well as Temperament depends upon the organic life; possesses all its attributes, and is a stranger to the will in all its emanations; for our exterior actions form a picture of which the ground and design do indeed belong to the animal life, but upon which the organic life extends the shading and colouring of the passions. The character of the individual is constituted by such shades and colours.

The alternate predominance of the two lives has been remarked by almost all philosophers. Plato, Marcus Aurelius, Bacon, St. Augustine, St. Paul, Leibnitz, Van Helmont, Buffon and many others, have recognized in man two principles, by one of which we become the masters of all our moral actions, by the other the contrary. We have nothing to do with the nature of these principles. Our business is with their phenomena; we shall analyze the relations by which they are united

CHAPTER

CHAPTER THE SEVENTH.

GENERAL DIFFERENCES OF THE TWO LIVES WITH RESPECT TO VITAL POWER.

THE greater number of Physicians, who have written upon the vital properties, have begun by researches on their principle, have endeavoured to descend from the knowledge of the nature of this principle to that of its phenomena, instead of ascending from observation to theory. The Archæus of Van Helmont, the soul of Stahl, the vital principle of Barthez, the vital power of others, have each in their turn been considered as the sole center of every action possessing the character of vitality, have each in their turn been made the common base of every physiological explanation. But these bases have every one of them been sapped, and in the midst of their wrecks have remained the facts alone which rigorous experiment has furnished upon the subject of sensibility and motility.

So narrow indeed are the limits of the human understanding, that the knowledge of first causes has almost always been interdicted. The veil, which covers them envelopes with its innumerable folds whoever attempts to rend it.

In the study of nature, principles are certain general results of first causes, from whence proceed innumerable secondary results. The art of finding the connexion of the first with the second is that of every

judicious

judicious mind. To seek the connection of first causes with their general effects is to walk blindfold in a road from whence a thousand paths diverge.

Of what importance besides to us are these causes? Is it necessary to know the nature of light, of oxygen and caloric to study their phenomena? Without the knowledge of the principle of life, cannot we analyse its properties? In the study of animals let us proceed as modern metaphysicians have done in that of the understanding. Let us suppose causes, and attach ourselves to their general results.

§ I.—*Difference between vital power and physical law.*

In considering the powers of life, we shall perceive in the first place a remarkable difference between them and the laws of physics. The first incessantly vary in their intensity, in their energy, in their developement, are continually passing from the last degree of prostration, to the highest pitch of exaltation, and assume under the influence of the most trifling causes a thousand modifications; for the animal is influenced by every thing which surrounds him; he wakes, he sleeps, reposes or exercises himself, digests, or is hungry, is subject to his own passions, and to the action of foreign bodies. On the contrary the physical laws are invariable, the same at all times, and the source of a series of phenomena at all times similar. Attraction is a physical power; it is always in proportion to the mass of brute matter in which it is observed; sensibility is a vital power, but in the same mass of matter, in the same organic part its quantity is perpetually changing.

The invariability of the laws which preside over the phenomena of physics, enables us to apply the formulæ of calculation to all the sciences, which have them

them for their object. Applied to the actions of the living body, the mathematics can never give us formulæ. The return of a comet, the resistance of a fluid in traversing an inert canal, the rapidity of a projectile may be calculated; but to calculate with Borelli the force of a muscle, with Keil the velocity of the blood, with Jurine and Lavoisier the quantity of air, which enters into the lungs, is to build upon a quick sand, an edifice solid of itself, but necessarily decreed to fall for want of a foundation.

This instability of the vital powers, this disposition, which they continually have to change, impress upon all the physiological phenomena a character of irregularity which particularly distinguishes them from those of physics. The latter for ever the same, are well known when once they have been analyzed; but who can say that he knows the former, because he has analyzed them under the same circumstances, a multitude of times. The urine indeed, the saliva, or the bile indifferently taken from such or such a subject, may be analyzed, and hence results our animal chemistry; but such a chemistry is the dead anatomy of the fluids, not a physiological chemistry. The physiology of the fluids should be composed of the innumerable variations which they experience according to the different states of their respective organs.

The urine after taking food is not the fluid, which it is after sleeping; it contains in winter, principles which are foreign to it, during summer, when the principal excretions are made by the skin. The simple passage from heat to cold, in suppressing sweat, and the pulmonary exhalation, will change its composition. The same is true of the other fluids; the state of the vital powers in the organs, which are the sources of them, changes at every moment; and therefore, the secreted which entirely depend upon the mode of action in the organs, must be as various.

Who will venture to assert, that he knows the nature of a fluid of the living economy if he has not analyzed it in the infant, in the adult, and the aged, in the male and in the female, at every season, during the calm of the mind, and the storm of the passions, which so manifestly influence its nature? To know such fluid perfectly, will it not be requsite also to examine the different alterations of which it is succeptible in consequence of disease?

The instability of the vital powers, is the quicksand on which have sunk the calculations of all the Physicians of the last hundred years. The habitual variations of the living fluids, dependent on this instability, one would think should be no less an obstacle to the analyses of the chemical physicians of the present age.

From this reasoning it is easy to perceive, that the science of organized bodies should be treated in a very different manner from that of inorganic bodies. To the former a different language almost is requisite; for the greater number of the words, which we transfer from the physical sciences, into those of the animal or vegetable economy, incessantly recall ideas, which are by no means consistent with their phenomena.

Had physiology been cultivated by men before physics, I am persuaded that many applications of the former would have been made to the latter; rivers would have been seen to flow from the tonic action of their banks, crystals to unite from the excitement, which they exercise upon their reciprocal sensibilities, and planets to move because they mutually irritat each other at vast distances. All this would appear unreasonable to us, who think of gravitation only in the

the consideration of these phenomena; and why should we not in fact be as ridiculous when we arrive with this same gravitation, with our affinities and chemical compositions, and with a language established upon their fundamental data begin to treat of a science, with which they have nothing whatsoever to do. Physiology would have made a much greater progress, if all those who studied it, had set aside the notions which are borrowed from the accessary sciences, as they are termed. But these sciences are not accessary; they are wholly strangers to physiology, and should be banished from it wholly.

Physics and chemistry are related to each other in many points, because the same laws in a variety of instances preside over the phenomena of both of them; but an immense interval divides them from the science of organic bodies; because a very great difference exists between the laws which are proper to them, and those of life. To say that physiology is made up of the physics of animals, is to give a very inaccurate idea of it; as well might we say that astronomy is the physiology of the stars.

But the present digression has already been much too long. We shall now consider the vital powers with respect to the two lives of the animal.

§ II.—*Difference between the vital properties and those of texture.*

In examining the properties of every living organ, we may distinguish them into two two kinds. Those of one kind are dependent immediately upon life, begin and finish with it, or rather form its principle and its essence. Those of the other are connected with it only

indirectly,

indirectly, and appear rather to depend upon the organization and texture of the parts of the body.

The faculties of perceiving and spontaneously contracting are vital properties: extensibility, and the faculty of contraction upon the cessation of the extending power, are properties of texture; the latter it is true, are possessed of a greater energy when existing in the living fibre, but they remain with the organ when life has ceased; the decomposition of the organs, is the term of their existence. I shall first examine the vital properties.

§ III.—*Of the two kinds of sensibility; of the animal and organic sensibilities.*

It is easy to perceive, that the vital properties can be only those of perception and motion, but in the two lives they possess a very different character. In the organic life, sensibility is the faculty of receiving an impression; in the animal life, it is the faculty of receiving an impression plus that of referring such impression to a common center. The stomach is sensible to the presence of aliments, the heart to the stimulus of the blood, the excreting tube to the contact of the fluid, which is peculiar to it; but the term of this sensibility is in the organ itself. In the same way do the eyes, the membranes of the nose and the mouth, the skin, and all the mucous surfaces, at their origin, receive an impression from the bodies which are in contact with them, but they afterwards transmit such impression to the brain, which is the general center of the sensibility of these organs.

There is an animal sensibility then, and an organic sensibility. Upon the one depend the phenomena of digestion, circulation, secretion, exhalation, absorption, and

and nutrition. It is common to the plant, and the animal: the Zoophyte enjoys it as perfectly as the most perfectly organized quadruped. On the other depend sensation and perception, as well as the pain and pleasure which modify them. The perfection of animals, if I may so speak, is in proportion to the quantity of this sensibility, which has been bestowed upon them. This species of sensibility is not the attribute of vegetable life.

The difference of these two kinds of sensitive power is particularly well marked in the manner of their termination, in the case of violent and sudden death. In such case, the animal sensibility is at once extinguished; there can no longer be found any trace of it at the moment which succeeds to strong concussion of the brain, to great hæmorrhage or asphyxia; but the organic sensibility survives such accidents more or less. The lymphatics continue to absorb, the muscle is still sensible to stimuli, the nails and the hair continue to be nourished, and in consequence are sensible of the fluids which they imbibe. It is often a considerable time before all traces of this sensibility are effaced; the annihilation of the other is instantaneous.

Though at the first glance, the two sensibilities present us so remarkable a difference, their nature nevertheless appears to be essentially the same. The one perhaps is only the maximum of the other, is the same force, but according to its intensity is shewn under different characters. Of this the following observations are proofs.

There are different parts in the economy, where these faculties are concatenated, and succeed each other insensibly. The origin of all the mucous membranes is an example of such parts. We have the sensation of the passage of aliments in the mouth, and the back part of it; this sensation becomes weaker at the beginning of the æsophagus, decreases still towards its middle, and disappears at its end, as well as in the stomach, where the organic sensibility only remains. The same phenomenon may be observed in the urethra, &c. In the neighbourhood of the skin, the animal sensibility exists; it gradually diminishes, however, and becomes organic in the interior of the system.

Divers excitants applied to the same organ may alternately produce the one, and the other mode of sensibility. When irritated by acids, by very concentrated alkalis, or by a cutting instrument, the ligaments do not transmit to the brain the very strong impression which is made upon them, but if they be twisted, distended or rent, a lively sensation of pain is the result. I have established this fact upon a number of experiments in my treatise on the membranes. The following is another of the same kind, which I have since observed. The parietes of the arteries as we know are sensible to the blood by which they are traversed, but at the same time are the term of this sentiment. If a fluid, however, which is foreign to this system, be injected into it, the animal will immediately discover by his cries, that he is sensible of the presence of such fluid.

We have seen that it is a property of habit, to weaken the sentiment, to transform into indifferent sensations all those of pleasure, or of pain. Foreign bodies, for example, will make upon the mucous membranes a painful impression during the first days of their application to it; they develope in such parts the animal sensibility, but by little and little this sensibility decreases, and the organic alone subsists. In this way the urethra is sensible of the bougie as long as

it

continues there, for during the whole of such time, the action of the mucous glands of the passage is augmented, from whence arises a species of catarrh, but the individual for the first moments only had a painful conciousness of the presence of the instrument.

We every day observe, that inflamation in exalting the organic sensibility of a part, transforms the organic into the animal sensibility: the cartilages thus, and the serous membranes which in their ordinary state have only the obscure sentiment, which is necessary to their nutrition, in an inflammatory state are possessed of an animal sensibility, which is frequently stronger than that of the organs to which it is natural. And why? Because the essence of inflammation consists in accumulating the powers of the part, and this accumulation suffices for changing the mode of the organic sensibility, which differs from the animal sensibility in quantity only.

From these considerations it is evident that the distinction above established with respect to sensibility consists in the different modifications of which this power is susceptible, and not in its nature, which is every where the same. This faculty is common to all the organs; they are all of them possessed of it; it forms their true vital character; but more or less abundantly distributed to each, it gives to each a different mode of existence. No two parts enjoy it in the same proportion. In these varieties there is a degree, above which the brain is the term of it, beneath which the organ alone is sensible of the impression.

If to render my ideas on this head I were to use a vulgar expression, I should say that distributed in such a dose to an organ sensibility is animal: in such another dose organic. Now that, which varies the dose of sensibility, is sometimes the order of nature,

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(in which way the skin and the nerves are more sensible than the tendons, and cartilages;) at other times, disease; thus in doubling the dose of sensibility to the cartilages inflammation renders them equal in this respect, and even superior to the former, and as a thousand causes may at every moment exalt or diminish this power in any part of the body it may be changing at every moment from the animal to the organic type. Hence proceeds the reason, why authors, who have made it the object of their experiments, have come to results so different; and why some of them have observed the periosteum and dura mater to be insensible, while others have put them down on the contrary as endowed with an extreme sensibility.

§ IV. *Of the relation which exists between the sensibility of each organ, and foreign bodies.*

Although the sensibility of each organ be subject to continual variations, it is nevertheless distributed to each by nature in a determined quantity; in a quantity to which it ever returns after its alternatives of augmentation or decrease. In this respect it resembles the pendulum, which in each of its different oscillations resumes the place to which it is brought down by gravitation.

It is this determined sum of sensibility, which especially composes the life of each organ, and fixes the nature of its relations with foreign bodies; in this way the ordinary sum of sensibility in the urethra fits it for the passage of the urine, but if this sum be augmented, as in strong erection of the penis, the above relation ceases: the canal refuses itself to the urine, and suffers itself to be traversed by the semen only,

only, which in its turn has no relation with the sensibility of the urethra when the penis is not erected.

From hence proceeds the reason of the puckering up and spasm of the parotid, the cystic, and pancreatic ducts, as well as of the excreting tubes in general, when the molecules of any other fluid than that, which they are destined to convey are present within them. The sum of their sensibility corresponds exactly with the nature of their respective fluids, but is disproportioned to that of any other. The spasmodic contraction of the larynx when irritated by any foreign body is produced in the same manner; for the same reason the ducts, which open upon the mucous surfaces, though at all times in contact with a variety of different fluids, are never penetrated by them. The mouths of the lacteals however patulous within the alimentary canal will take up the chyle only, they reject the fluids, which are mixed with it; for with these their sensibility has no relation.

Such relations do not exist only between the different sensibility of the organs, and the different fluids of the body; but they may be exercised also between exterior substances, and the various parts of the living system. The sum of sensibility in the bladder, the kidneys and the salivary glands has a peculiar analogy with cantharides and mercury. It might be thought that the sensibility of each organ is modified, that it assumes a peculiar nature, and that it is this diversity of nature, which constitutes the difference of the relations of the organs with regard to bodies in contact with them; but a number of considerations tend to prove that such difference is occasioned, not by any difference in the nature, but in that of the sum, the dose, the quantity of the sensibility, if such words

may

may be applied to a living property. I shall adduce the following instances:—

The absorbent orifices of the serous surfaces, are sometimes bathed for months together in the fluid of dropsies, and take up nothing. But if the sensibility of these orifices be exalted by tonics, or an effort of nature, in such case it will place itself, if I may so say, in equilibrium with the fluid, and absorption will be made. The resolution of tumours presents us with the same phenomena; as long as the powers of the parts are weakened, the lymphatics refuse admittance to the extravasated substances; but if the sum of these powers be augmented by the use of resolvents, in a short time, from the action of the lymphatics, the tumour will disappear: from the same cause the blood, and other fluids are taken up with a sort of avidity at times, and at others, not at all.

The art of the physician, then, in the use of resolvents, must consist in ascertaining the degree of sensibility which he requires in the vessels for the purpose which he has in view; and in exalting or depressing this power accordingly. In this way, in different circumstances, resolvents may be taken from the class of the debilitating or stimulating remedies.

The whole of the theory of inflammation is connected with the above ideas. It is well known that the system of the canals, which circulate the blood gives birth to a number of other small vessels, which admit only the serous part of this fluid. Why do not the red globules pass into the serous vessels, though there exist a continuity of canal? The cause by no means consists in the disproportion of the vessels to the globules as Boerhaave has taught. The breadth of the white vessels might be double or triple that of the red vessels, and still the globules of the latter colour would

not

not pass into them, if there were not to exist a relation between the sum of the sensibility of the vessels, and the nature of the globules. Neither will the chyme pass into the Choledochus, though the diameter of this canal be very much larger, than that of the attenuated molecules of the aliments. Now in the healthy state, the quantity of sensibility in the white vessels being inferior to that in the red ones, it is evident that the relation necessary to the admision of the coloured globules cannot exist. But if any cause should exalt their powers, their sensibility will be on a par with that of the latter set of vessels, and the passage of the fluids till then refused, will take place with facility.

Hence it happens, that those surfaces, which are the most exposed to such agents as exalt the sensibility, are also the most subject to local inflammation, as may be remarked in the conjunctiva and the lungs; at which time such is usually the increase of sensibility in the part, that of organic, which it was, it becomes animal, and transmits to the brain the impressions, which are made upon it.

Inflammation lasts as long as there subsists an excess of sensibility; by degrees it diminishes, the red globules cease to pass into the serous vessels and resolution takes place.

From this it may be seen that the theory of inflammation is only a natural consequence of the laws, which preside over the passage of the fluids into their respective tubes; hence also it may be easily conceived how unfounded are all hypotheses, which are borrowed from hydraulics, a science, which never can be really applied to the animal œconomy, because there is no analogy between a set of inert tubes, and a series of living ducts.

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I should never have finished were I to enumerate the consequences of this principle in the phenomena of the living man. The reader will easily enlarge the field of these consequences, the whole of them will form almost all the great data of physiology, and the essential points of the theory of diseases.

But no doubt it will be asked, why the organs of the internal life have received from nature, an inferior degree of sensibility only, and why they do not transmit to the brain the impressions, which they receive, while all the acts of the animal life imply this transmission? the reason is simply this, that all the phenomena, which establish our connexions with surrounding objects ought to be, and are in fact under the influence of the will; while all those, which serve for the purpose of assimilation only, escape, and ought indeed to escape such influence. Now for a phenomenon to depend upon the will, it is evidently requisite that the individual be possessed of a consciousness of such phenomenon, to be withdrawn from the influence of the will, there should exist no such consciousness.

§ V.—*Of the two kinds of contractility, the animal, and the organic contractility.*

Contraction is the ordinary medium, by which the motion of the animal organs is effected; some parts, however, move by dilating themselves, as the iris, the corpora cavernosa, the teat and others; so that the two general faculties, from whence spontaneous motion is derived, are contractility and active extensibility: the latter of these should be carefully distinguished from passive extensibility, of which in a short time we shall speak. The first is a property of life, the second a property of texture; but as yet there exist too

too few data upon the nature and mode of the motion resulting from the former; it is exemplified in too small a number of organs, for us to be enabled to pay much attention to it in these general considerations.—Accordingly we shall occupy ourselves only upon the subject of contractility; with respect to that of active extensibility, I refer to the writings of the physicians of Montpellier.

Spontaneous motility, a faculty inherent in living bodies, as well as sensibility, possesses two great modifications, which differ very much from each other, accordingly as it is examined in the phenomena of one or the other life. There is an animal contractility, and there is an organic contractility.

The one being essentially subject to the influence of the will, has its principle in the brain, receives from the brain the irradiations, which put it in action, and ceases to exist when the organs, in which it is observed, communicate no longer with the brain; it participates besides at all times with the state of the brain, has exclusively its seat in the voluntary muscles, and presides over locomotion, the voice, the general movements of the head, the thorax and abdomen. The other, which is not dependent on a common center, has its principle in the moving organ itself, is a stranger to the influence of volition, and gives rise to the phenomena of digestion, circulation secretion, absorption, and nutrition.

The two are quite distinct in all cases of violent death; such death annihilates at once the animal contractility, and allows, for a longer or shorter time, the organic contractility to be exercised; they are essentially distinct also in all cases of asphyxia; in these, the first is entirely suspended, the second remains in activity; lastly they are distinct both in artificial palsy and in that which is brought on by disease. In

these,

these, the voluntary motions cease; the organic motions are unaltered.

Both the one and the other kind of contractility are connected with their corresponding kinds of sensibility. They are a consequence of them. The sensation of external objects puts in action the animal contractility; before the organic contractility of the heart can be exercised, its organic sensibility must be excited by the influx of the blood.

Nevertheless, the concatenation of these two kinds of faculties is not always the same. The animal sensibility may be exercised, and not be necessarily followed by the exercise of its analogous contractility. There is a general relation between sensation and locomotion, but this relation is not direct and actual. On the contrary, the organic contractility can never be separated from the sensibility of the same species; the re-action of the excreting tubes is immediately connected with the action, which the secreted fluids exercise upon them: the contraction of the heart must necessarily succeed the influx of the blood into it. But authors have by no means separated these two things, either in their considerations or their language. Irritability denotes at the same time the sensation excited in the organ from the contact of bodies, and the contraction of the organ in re-acting upon its excitants.

The reason of this difference in the relation of the two sensibilities and contractilities to each other is very simple. In the organic life, there is nothing intermediate in the exercise of these two faculties. The same organ is the term, in which the sensation ends, and the principle from whence the contraction begins In the animal life, on the contrary, there exists between these two acts two intermediate functions, those of

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the brain namely, and the nerves, and these by not being brought into action may interrupt the relation in question.

To the same cause must we refer the following observation. In the organic life there always exists a rigorous proportion between the sensation, and the contraction. In the animal life the one may be exalted or lowered, and the other not affected by such change.

§ VI.—*Subdivision of the Organic contractility into two Varieties.*

The Animal contractility is always the same in whatever part of the body it is situated. But there exist in the organic contractility two essential modifications, which would seem to indicate a difference in their nature, though there be only diversity in outward appearances. This difference is sometimes visible, at other times though really existing, in cannot be seen by inspection.

The sensible organic contractility may be observed in the heart, in the stomach, intestines, bladder, and other organs. It is exercised upon very considerable quantities of the animal fluids.

The insensible organic contractility is that, by virtue of which the excreting tubes re-act upon their respective fluids, the secreting organs upon the blood, which flows into them, the parts where nutrition is performed upon the nutritive juices, and the lymphatics upon the substances which excite their open extremities ; upon all these occasions, wherever the fluids are disseminated in small quantities, or are very much divided, this second species of contractility is brought into exercise. A tolerably precise idea may be given of both, by comparing the one with attraction, a power which

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is exercised upon the great aggregate of matter, and the other with the chemical affinities, the phenomena of which take place in the molecules of different substances. For the purpose of explaining this difference, Barthez has compared the one to the second hand of a watch, which traverses the circumference in a very apparent manner, and the other to the hour hand, which moves also, but whose motion is not distinguishable.

The sensible organic contractility nearly answers to the irritability of authors; the insensible organic contractility to what is called tonicity. But these words seem to suppose in the properties, which they indicate a difference of nature, while this difference exists only in appearance. I therefore prefer employing for both a common term. It designs their general character, that of appertaining to the interior life, and their independence with regard to the will. To this term I join an adjective expressive of the particular attribute of each.

In fact we should possess a very inaccurate idea of these two modes of action, were we to consider them as proceding from different principles. The one is but the extreme of the other; they are both connected by insensible gradations. Between the obscure but real contractility, which is necessary to the nutrition of the nails, and the hair, &c. and that which we see in the motions of the stomach, and intestines, there exist innumerable shades of this property, which serve as transitions betwixt its perceptible degrees; such are the motions of the dartos, of the arteries, and of certain parts of the cutaneous organs.

The circulation will give us a very good idea of this graduated enchainment of the two kinds of organic contractility. The sensible organic contractility presides over this function in the heart and large vessels,

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by degrees it becomes less apparent, in proportion as the diameter of the vascular system decreases; and lastly, it is insensible in the capillary tubes, where tonicity only is observed.

Should we consider irritability as a property inherent exclusively in the muscles, as being one of the characters by which they are distinguished from other organs, and should we call this property by a name expressive of its peculiar seat in the muscle, we should conceive it, if I mistake not, in a very different way from that in which it naturally exists.

It is true, that in this respect the muscles occupy the first rank in the scale of the animal solids; they possess the maximum of the organic contractility; but every living organ acts, as they do, though in a manner less apparent upon the excitant when artificially applied, or on the fluid, which in the natural way is carried to it for the purpose of supplying the matter of secretion, nutrition, exhalation, or absorption.

Nothing in consequence is more uncertain than the rule, which is commonly adopted for pronouncing upon the muscularity of any doubtful part; for the rule consists in ascertaining whether such part does or does not contract under the action of stimuli.

It is thus, that a muscular tunic is admitted in the arteries, although their organization entirely differs from that of the muscles; it is thus, that the womb is pronounced to be fleshy, however foreign to such structure; it is thus, that a muscular texture is admitted in the dartos, in the iris, and other parts, although no such structure be observable there.

The faculty of contracting under the action of irritating substances like that of the sensibility, is unequally distributed among the organs; they enjoy it in different degrees. We do not properly conceive it, if we suppose that it belongs exclusively to some of them. It does not, as some have imagined, possess its peculiar seat in the muscular fibre. Life is the sole condition necessary to all the fibres for enjoying it; their peculiar texture influences the sum only, which they receive of it; it appears that to such an organic texure, is attributed, if I may so express myself, such a dose of contractility; to such another texture, such another dose, and so on; so that to employ the expressions, which I have used in treating on the subject of sensibility (however improper they may be, yet capable alone of rendering my ideas) the differences in the organic contractility of our different parts, consist in the quantity only, and not in the nature of this property: indeed it is with respect to quantity only that this property varies, accordingly as it is considered in the muscles, the ligaments, the nerves, or the bones.

If a special mode of contraction ought to be designed for the muscles by a particular expression, such expression could be only derived from the property which they have of contracting from the influence of the will; but this property is foreign to their texture, and comes to them from the brain only; for as soon as they cease to communicate with this organ directly by means of the nerves, they cease also to be the agents of voluntary motion.

These considerations lead us to examine the limits which are placed betwen the one and the other kind of contractility. We have seen that those which distinguish the two modes of sensibility, appear to be derived only from the greater or less proportion of this power; that in a certain proportion sensibility is of the animal kind, in a certain inferior proportion, of the organic kind, and that frequently from an augmentation, or diminution of intensity the two sensibilities reciprocally borrow their respective characters. We

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have seen a phenomenon almost analagous to this in the two subdivisions of the organic contractility.

But this is not the case with regard to the two great divisions of contractility considered in general. The organic can never be transformed into the animal contractility. Whatever be its increase of energy, it constantly remains the same in its nature. The stomach, the intestines frequently assume a susceptibility of contraction, so as to be excited to the most violent motions by the most simple stimuli, but these movements preserve at all times their peculiar type, their primitive character; and have never been regulated by the brain. From whence proceeds this difference in the phenomena of sensibility and contractility? I cannot in a precise and rigorous manner resolve this question.

§ VII.—*Of the extensibility and contractility of texture.*

I shall now proceed to examine the properties, which depend on texture only, on the organic arrangement of the fibres of the different parts. These are extensibility and contractility.

They both succeed each other, and are connected in the same way, as in the vital phenomena, the organic and animal sensibilities are related to their respective contractilities.

Extensibility of texture, or the faculty of being distended beyond the ordinary state by external impulse (and in this it is distinguished from the extensibility of the iris, the corpora cavenosa, &c.) This extensibility, I say, belongs to many organs. The extensor muscles are very much lengthened in strong tension flexor
of the limbs; the skin accommodates itself to tumours; the aponeuroses, as we see in ascites and pregnancy, are distended by what is accumulated beneath them

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The mucous membranes of the intestines, of the bladder; the serous membranes of the greater number of the cavities present us with similar phenomena, when these cavities are full. The fibrous membranes, the bones themselves are susceptible of distension. Thus in hydrocephalus the pericranium, and the bones of the cranium, in spina ventosa and other analogous diseases, the extremities or the middle of the long bones experience a similar distension. The kidneys, the brain, and the liver, when abscesses are formed in their interior, the spleen and the lungs, when penetrated by a great quantity of blood, the ligaments in articular dropsies, in short all the organs, under a thousand different circumstances, exemplify this property; a property inherent in their texture, and not precisely depending on their life; for as long as their texture remains untouched, their extensibility subsists also, though they themselves have ceased to live.—The decomposition of the part, from whatever cause it happens, is the sole term of this extensibility, in which the organs are passive at all times, and subject to the mechanical influence of those bodies which act upon them.

There exists for the different organs a scale of extensibility, at the top of which are those which have the greatest laxity in the arrangement of their fibres, as the muscles, the skin, and cellular substance; at the bottom of the scale are those which are characterized by their density, as the bones, the cartilages, the tendons, and the nails.

We must not, however, be deceived by appearances, with regard to the extensibility of parts of the body; for the serous membranes, which at the first glance would seem to be capable of great distension, do not yield so much of themselves, as from the developement of of their folds. Thus the displacement of the skin, which abandons certain parts, while it spreads over tumours in the vicinity, might easily give rise to the supposition of its being capable of a much greater distension than that of which it is really susceptible.

With extensibility of texture, there corresponds a certain mode of contractility, which may be designed by the name of contractility of texture. This can only take place after a previous distension.

In general the greater number of our organs are maintained in a certain degree of tension from different causes; the locomotive muscles by their antagonists, the hollow muscles by the different substances which they enclose; the vessels by the fluids, which circulate within them, the skin of a part by that of the neighbouring parts, the alveolary parietes by the teeth which they contain. If these causes be removed, contraction supervenes; thus, if a long muscle be cut, its antagonist will be shortened; if a hollow muscle be emptied, it will contract; if an artery be deprived of its blood, it will become a ligament; if the skin be cut into, the borders of the incision will retire from each other; if a tooth be drawn, its cavity will be obliterated.

In these cases it is the cessation of the natural extension, which occasions the contraction; in other cases it is the cessation of an unnatural extension which does so. Thus, the lower belly is straitened after puncture or delivery; the maxillary sinus, after the extirpation of a fungus; the cellular texture, after the opening of an abscess, the tunica vaginals, after the operation of hydrocele, the skin of the scrotum, after the extirpation of the voluminous testicle, by which it was distended; the sac of an aneurism, after the evacuation of the fluid.

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This mode of contractility is not by any means dependent on life; it belongs only to the texture, to the organic arrangement of the part, yet still receives from the vital powers an encrease of energy. Thus the retraction of a muscle, which is cut in the dead subject, is much smaller than that of a muscle divided in the living animal; in the same way, the retraction of the skin varies; but though less pronounced, this contractility subsists always, and like its corresponding extensibility has no other limit than that of the decomposition of the part.

The greater number of authors have confounded the phenomena of this contractility with those of the insensible organic contractility, or tonicity. Of these I might reckon Haller, Blumenbach, Barthez and others, who have referred to the same principle the return upon themselves of the abdominal parietes, after distension, the retraction of the skin, or a divided muscle, and the contraction of the dartos from cold. The first of these phenomena are due to the contractility depending on texture, which does not suppose the application of an irritating substance; the second, to tonicity, which is never exercised excepting when influnced by such application.

Neither have I myself, in my treatise on the membranes, sufficiently distinguished these two modifications of contraction, but we evidently ought to establish between them the most decided limits.

An example will render this more sensible. Let us take for it an organ, in which there may be observed all the kinds of contractility, of which I have hitherto spoken; a voluntary muscle for instance: In distinguishing the species with precision we may acquire a clear and precise idea of each of them.

Now such muscle may enter into action first by the influence

influence of the nerves, which it receives from the brain; here it shews its animal contractility. Secondly, it may be brought into action by the stimulus of a physical or chemical agent applied to it, a stimulus, which artificially creates a motion, analogous to that, which is natural to the heart, and other involuntary muscles;—here we have the sensible organic contractility or irritability. Thirdly its action may be produced by the influx of fluids, which penetrate all its parts for the purpose of carrying thither the matter of nutrition, and which at the same time are the occasion of a partial oscillatory movement in each fibre, in each molecule, a movement as necessary to the function of nutrition, as in the glands it is indispensable to the process of secretion, or in the lymphatics to that of absorption. Such action we refer to the insensible organic contractility or tonicity: Fourthly by the transverse section of the substance or body of the muscle, may be determined the retraction of its two ends towards their points of insertion. Here the contractility of its texture is displayed.

Each of these kinds of contractility may cease to exist in a muscle and the other kinds of it be not affected. Cut its nerves, and there will be no longer any animal contractility; but the two modifications of its organic contractility will continue to subsist. Impregnate the muscle with opium, suffer its vessels to be well penetrated with this substance and it will cease to contract under the impression of stimuli, it will lose its irritability, but it will continue to possess the tonic movements, which are occasioned by the influx of blood into it. Lastly, kill the animal, or rather let it live, but tie the vessels, which go to the limb and the muscle will in such case lose its tonic power and possess its contractility of texture only. The latter will only cease on the supervention of sphacelus.

By these examples the different kinds of contractility may be appreciated with respect to the organs where they are assembled in a smaller number than in the muscles of volition; in the heart for instance and in the intestines, where there exist a sensible and insensible contractility, the organic being retrenched; and again in the tendons, aponeuroses, and bones, where the animal and sensible organic contractilities are wanting, the insensible organic and the contractility of texture only remaining.

In general these two last are inherent in every kind of organ, the two first belonging to some in particular only; hence for the general character of living parts we must choose the insensible organic contractility or tonicity, and for the character of all organized parts whatsoever, whether living or dead, the contractility of texture.

We shall farther remark, that this last inthe same way as its corresponding extensibility possesses them, has its different degrees, its scale of intensity, the skin and the cellular substance on the one hand, the tendons, the aponeuroses, and the bones on the other, forming the extremes of this scale.

From all that has been said, it is easy to perceive, that in the contractility of every organ there are two things to be considered, namely the contractility, or the faculty, and the cause, which puts it in action. The contractility is always the same, belongs to the organ, is inherent in it, but the cause which determines its exercise may be various.

§ VIII.—*Recapitulation of the properties of living bodies.*

A recapitulation of these properties may be seen in the following table:

	Classes.	*Genera.*	*Species.*	*Varieties.*
Properties.	1st Vital	1st Sensibility	1st Animal	
			2d Organic	
		2d Contractility	1st Animal	
			2d Organic	1st Sensible
				2d Insensible
	2d of Texture	1st Extensibility		
		2d Contractility		

I have not inserted in this table that modification of motion, which takes place in the iris, the corpora cavernosa, &c. a motion, which precedes the influx of the blood, and which is not in such way occasioned, neither have I mentioned the dilation of the heart, and in a word that species of active and vital excitability, of which some parts appear to be susceptible, and my reason for this neglect, although I recognise the reality of the modification, is my want of clear and precise ideas on the subject.

From the properties, which I have now explained, are derived all the functions, all the phenomena, which are exemplified in the living œconomy. There is not one, which may not be traced to them after a strict analysis, in the same manner as in the phenomena of physics we recur to the properties of attraction, elasticity, &c.

Wherever the vital properties are in action, there is a disengagement, and a loss of caloric peculiar to the animal, which compose for him a temperature independent of the medium in which he lives. The word

caloricity

caloricity will hardly serve for the expression of this fact, which is a general effect of the two great vital powers in a state of action, and not produced by any especial faculty distinct from them. We do not make use of the words, digestibility, or respirability, because digestion and respiration are the results of functions derived from the common laws of the system.

For the same reason the digestive power of Grimaud suggests an inaccurate idea. The assimilation of heterogeneous substances to our organs, is not the effect of any peculiar power. The same may be said of the different principles admitted by a number of authors, who have attributed to results and functions denominations expressive of laws, and vital properties.

The proper life of each organ is composed of the different modifications, to which are submitted in each of them the vital sensibilities and mobilities, modifications, which invariably are productive of others in the circulation and temperature of the organ. Let it be noticed however, that each organ independently of the general sensibility, mobility, temperature, and circulation of the body, has a particular mode of sensation and heat, together with a capillary circulation, which being withdrawn from the influence of the heart, receives the influence only of the tonic action of the part. But we may pass over a point so frequently and sufficiently discussed by other authors.

Let it here be understood that I offer what I have said on the subject of the vital powers, only as a simple view of the different modifications, which they experience in the two lives. These detached ideas will in a short time from the basis of a more extensive work.

Neither have I recapitulated the different divisions of the vital powers, which have been adopted by authors; the reader will find them in their works, and

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will easily perceive the differences, which distinguish them from those, which I have adopted. I shall only observe that were these divisions clear and precise, did they suggest to all the same meaning, we should not have to regret in the writings of Haller, Lecat, Wyth, Haen, and all the physicians of Montpellier, a number of disputes of no importance to the interest of science, and surely fatiguing to the student.

CHAPTER THE EIGHTH.

OF THE ORIGIN AND DEVELOPEMENT OF THE ANIMAL LIFE.

If there be any circumstance, which establishes a real line of demarcation between the two lives, this circumstance undoubtedly is the mode and epoch of their origin. The organic life is active from the very first moment of our existence; the animal life begins after birth only; for without external excitants the latter is as necessarily condemned to inaction, as without the fluids of the œconomy, which are its internal excitants, the former would become extinct. But the subject, on which we are now engaged deserves a more particular discussion, and in the first place let

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us examine, in what manner the animal life, which for some time is absolutely null, is born as it were and developed.

§ I.—*In the fœtus the first order of the functions of the animal life is not as yet in action.*

The instant, at which the fœtus begins to exist, is nearly that of its conception; but this existence, the sphere of which is every day enlarged, is not the same as that, which the child is destined to enjoy after birth.

The state, in which the fœtus exists while in the womb, has been compared to that of a profound sleep. Such comparison is inexact. In a state of sleep the animal life is only in part suspended. In the fœtus it has not commenced. We have seen in fact, that this life is made up of the simultaneous or distinct exercise of the senses, of the nerves, of the brain, of the organs of locomotion, and the voice. Now in these different functions every thing in such state is inactive.

Every sensation supposes the action of exernal bodies upon our own, together with the perception of such action; a perception which takes place by virtue of the sensibility of the system, which is either general or particular, for the tact is the faculty of perceiving general impressions, and has for its object to warn us of the presence of bodies, together with their common attributes, such as heat, cold, dryness, or humidity, hardness or softness. To perceive the particular modifications of bodies is the business of the senses.

Has the fœtus in utero any general sensations? To decide this question, let us enquire whether any impressions are capable there of exercising its tact. The fœtus lives in a temperature at all times the same, swims

swims in a fluid, and is thrown from time to time against the parietes of the womb: such are the three sources of its general sensations.

We shall now remark, that the two former are next to nothing, and that the fœtus cannot have a consciousness of the medium, in which it is nourished, nor of the heat, by which it is penetrated, for every sensation supposes a comparison between an actual and a past state of being. We are sensible of cold, only because we have experienced an antecedent heat; were the temperature of the atmosphere invariable, we should have no idea whatever of temperature. The Laplander enjoys himself in a climate, which would be pain, and death to the Negro, if suddenly transported thither. It is not at the time of the solstices, but at that of the equinoxes, that our sensations of heat, and cold are the most lively. The reason of which must be, that at the latter seasons, their varieties are more numerous, and occasion more frequent comparisons between that, which we feel and that which we have felt.

What we have now said of temperature, we may repeat with respect to the waters of the amnios: the fœtus cannot be sensible of their influence, because the contact of any other medium is unknown to it. Before bathing, we are not sensible of the air, after bathing, the impression made by it upon us is unpleasant. It then affects us because there has been an interruption of its action upon the cutaneous organ.

Is the shock of the parietes of the matrix a more real cause of excitement, than the waters of the amnios, or temperature? At first we might be inclined to answer this question in the affirmative, because the fœtus being only at intervals subject to such stimulus, there should appear to result from thence a sensation. But

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let us remark that the density of the uterus in a state of pregnancy being little greater than that of its waters, the impression must be trifling. In fact the more the consistence of bodies resembles that of the medium in which we live, the less powerful will be their action upon us. Water for instance, when reduced into vapour in our common fogs, and mists, affects the tact but slightly; in proportion as it is condensed it is the cause of a livelier affection.

The air then to the animal which breaths, is truly the general comparative term, to which he refers all the sensations of tact. If the hand be plunged into carbonic acid gas, such substance will not affect the tact because its density is little different from that of the air.

The variety then of these sensations is in proportion to the difference existing between the density of the air, and that of the bodies, which are the occasion of such sensations. In the same way, the measure of the sensation of the fœtus must be the excess of density in the matrix above that of its waters. Now such excess being very inconsiderable, the sensation of it must be very obtuse.

This assertion with respect to the fœtus will become more general if we add to it the following: namely, that the mucous membranes, which are the seat of an inward tact have not as yet begun to exercise their functions. These membranes, after birth, being continually in contact with extraneous substances, possess in these bodies so many causes of irritation, which being continually repeated, become excitants to the organs: but in the fœtus there is no succession in these causes. The same urine, the same meconium, the same mucus at all times exercise their action upon the bladder, the intestines, and pituitary membrane.

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From all this we may conclude, that the general sensations of the fœtus are very inconsiderable, though it should appear that the child in this state is surrounded by many of the causes, which are hereafter to beget sensations. Neither are the particular sensations of the fœtus more active; indeed they cannot be so for their causes are absent.

The eye which is closed by the pupillary membrane, and the nostrils, which are scarcely indicated, would not be capable of receiving impressions, even in the supposition that light and odour could act upon them. Applied against the palate, the tongue is in contact with nothing capable of producing savour. Were it in contact with the waters of the amnios: the effect would be the same, because as we have said, there is no sensation, where there is no variety of impression. The saliva of one person to another person possesses savour, to the individual himself it is insipid.

The ear in like manner is awakened by no sound. All is calm, every thing reposes with the little individual.

Here then we have proved, that four of the gates of sensation are shut in the fœtus; and let us now observe that the nullity of action in the senses which we we have mentioned, must occasion very nearly the same nullity with respect to that of the touch.

In fact, this sense is especially destined to confirm the notions which are acquired by the others, and to rectify them, for the latter are frequently illusory—the touch is always the agent of truth. In attributing to the touch such use, nature has submitted it directly to the will; light, odours, and sounds affect their respective organs independently of the will.

The exercise of the other senses precedes that of the touch, they are the occasion of it. If a man were born

without

without sight, hearing, smell, or taste, can we conceive in what way, he would be possessed of the sense of touch?

The fœtus resembles such a man; it possesses wherewithal to exercise the touch in its hands, which are already developed, and in the parietes of the matrix. Nevertheless the fœtus is never in action, because in seeing, in hearing, in smelling, and in tasting nothing, it is not disposed to exercise the touch in any way. Its members are little better than what to the tree are to its branches, which do not transmit the impression of the bodies, with which they are entangled.

I shall here notice a great difference between the tact and the touch; they were formerly confounded by physiologists; the impressions of the latter are alwas directed by the will, those of the former do not depend on it. We shall conclude that the portion of the animal life which constitutes sensation, does not exist in the fœtus.

This nullity of action in the senses supposes the same deficiency of action in the nerves, which belong to them, and in that of the brain from whence they issue; for the business of the former is to transmit, of the latter to receive. Now without objects for transmission and reception, the two functions cannot have place.

From perception are immediately derived the memory and imagination; from these the powers of the judgement and the will. All this series of faculties then has not had a beginning in the fœtus, because the fœtus has not perceived, or had sensation. The brain exists in a state of expectation, it possesses all that is requisite for action: It does not want excitability, but stimulus. The first division of the animal life in consequence, or that, which relates to the action of exterior bodies,

bodies on the animal, has scarcely an outline in the fœtus. Let us examine whether the same be true of the second division of the animal life, or that which relates to the reaction of the living body.

§ II.—*Locomotion exists, but belongs in the fœtus to the organic life.*

When we see the strict connexion which there exists in animals, between sensation and their voluntary efforts, we might be induced to believe, that voluntary motion increases or diminishes with the increase or diminution of sentiment; for as sentiment furnishes out the materials of the will, when it does not exist, volition cannot exist: from induction to induction, it might thus be proved that in the fœtus the muscles must be totally inactive.

Nevertheless the fœtus moves, and sometimes even very strong shocks are the result of its motions. The reason why it does not produce sound, is because the medium for the production of sound is wanting.—But how can we ally the inertia of the first part of the animal life with the activity of the second. It is thus.

We have seen in speaking of the passions, that the muscles of locomotion are brought into action in two manners. 1st, by the will; 2dly, by sympathy. This last mode of action occurs, when from the affection of an inward organ the brain is affected also, and occasions a motion which, in such case, is involuntary. A passion, for instance, affects the liver, the liver the brain, the brain the voluntary muscles. Here it is the liver, not the brain, which is the principle of motion: so that the muscles, though always thrown into action, immediately from the irradiations of the brain, belong nevertheless, as to their functions, sometimes to the one life, sometimes to the other.

Hence it is easy to conceive in what way the fœtus moves: with the fœtus, locomotion is not a portion of the animal life; its exercise does not suppose a pre-existent will; it is purely a sympathetic effect.

In utero the phenomena of the organic life succeed each other with an extreme rapidity; a thousand different motions are incessantly connected in the organs of circulation and nutrition. In these, every thing is energetically in action. But this activity of the organic life supposes a frequent influence exerted upon the brain by the inward organs, and consequently as many reactions on the part of the brain by sympathy upon the muscles. Besides, the brain is at such time more susceptible of such sort of influence, being much more developed than the other organs, and entirely passive on the side of the sensations.

We may now conceive what the motions of the fœtus are. They belong to the same class as many of those of the adult, which have not been as yet sufficiently distinguished. They are the same as those which are produced in the voluntary muscles by the passions; they resemble those of the man who sleeps, and who moves without dreaming, for nothing is more common than violent agitation in sleep succeeding after difficult digestion. The stomach is in strong action: it acts upon the brain; the brain upon the muscles.

I might find a number of other involuntary organic motions taking place in the voluntary muscles of the adult, and consequently adducible to my present purpose; but what I have said on this subject will suffice.

suffice. Let us remark only, that the organic motions, as well as the sympathetic affection of the brain, which is the seat of them, must gradually dispose this organ, and the muscles of the fœtus, the one to the perception of sensations, and the other to the motions of the animal life, which are to commence after birth. But on this head I shall refer to the memoirs of Monsieur Cabanis.

From what has been said, then, I believe we may confidently assert, that in the fœtus the animal life does not exist, and that all the actions which take place at this age, depend upon the organic life. The fœtus, indeed, has nothing of the especial character of the animal. Its very existence is that of the vegetable; and its destruction can only be said to be that of a living body, not of an animated being. Thus, in the cruel alternative of sacrificing the life of the mother, or that of the child, the choice cannot be doubtful.

The crime of destroying a fellow-creature is much more relative to his animal, than to his organic life.—We regret the being who feels, who reflects, who wills, who acts accordingly, and not the being which breathes, which is nourished, which is the seat of the circulation and the secretions. It is the former, whose violent death is accompanied with those images of horror, under which we look on homicide. In proportion then as in the series of animals, their intellectual functions diminish, is diminished also the painful sentiment which we feel at sight of their destruction.

If the blow, which terminates by an assassination the life of a man, were to destroy his organic life only, and suffer the other to subsist without alteration, such blow would be regarded with indifference, would excite

cite neither pity for the victim, nor horror against the aggressor.

§ III.—*Developement of the animal life, education of its organs.*

A new mode of existence commences for the infant after birth; a variety of functions are added to its organic life; their aggregate become more complicated; their results are multiplied. As for the animal life, it only begins; and at this period a number of relations are established between the little individual and what surrounds him. It is then that every thing assumes with him a different mode of being, but at this remarkable epoch of the two lives, where the one is augmented by almost the half, and where the other commences only, they take upon them both a distinct character, and the aggrandisement of the first by no means follows the same laws as the developement of the second.

We shall soon remark, that the organs of the internal life attain at once to their perfection, and that from the instant at which they begin to act, they act with as much precision as they ever will do. On the contrary, the organs of the external life require a species of education; they arrive only by degrees at the perfection which we afterwards see in them. This important difference should be thoroughly examined. Let us begin by appreciating of what the animal life at first consists.

In examining the different functions of this life, which start at once into existence, we shall observe in their developement a slow and graduated progress.—We shall see, that it is insensibly and by means of a real

real education that the organs attain a precision of action.

The sensations are at first confused; they transmit only general images; the eye has only the sensation of light; the ear that of sound only; the nose only that of smell. As yet there is nothing distinct in these general affections of the senses; but from habit the strength of the first impression is lessened and the particular sensations take place. The great differences of colours, sounds, smells, and savours, become perceptible; by little and little their secondary differences also are perceived, and after a certain lapse of time the child has learnt to see, to hear, to smell, to taste, and to touch.

After successfully undergoing the operation for the the cataract, the patient, who has previously been totally blind, is sensible of light only, and learns by gradation to distinguish the objects which reflect it. Another person, before whom, as I have said, for the first time is exhibited the magnificent spectacle of an opera, at the first glance, perceives only a whole, which delights him, and only by degrees is able to isolate the enjoyments of which the dance, the music, and the decorations are productive.

The education of the brain is similar to that of the senses. Whatever depends upon its action, acquires the perfection, to which it is destined, by degrees only. The powers of perception, memory and imagination, which are all of them preceded and occasioned by the sensations, increase and extend in proportion as by repeated excitement they are brought into exercise.—The judgment, of which they form the triple base, associates but irregularly at first its motions, which themselves are but irregular. In a short time a greater de-

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gree of perspicuity is observed in its operations, and lastly they become precise and rigorous.

The voice and the agents of locomotion exemplify the same phenomenon: the cries of young animals at first are only an inform sound, which possesses no sort of character: by age they are gradually modified, and after long repeated exercise affect the peculiar consonances of the species, by which, and particularly during the season of their loves, the individual of the same species is never deceived. I do not instance the speech of man, for this is evidently the fruit of education.

In examining the newly born animal, its muscles will be seen continually in action. As every thing is new to it, every thing is an excitant to it, and makes it move; it endeavours to touch every thing, but neither progression, nor the power of standing can have place when the contractions of the voluntary muscles are so numerous. It is necessary for such, that habit shall have taught it to combine particular contractions with other particular contractions; until then it stumbles, and falls at every moment.

Undoubtedly the inclination of the pelvis in the fœtus, the disposition of the femora, and the want of curvature in the spine, adapt it but little for standing immediately after birth; but with these causes is certainly also combined the want of exercise. Who does not know, that if a limb be suffered to remain immoveable for a length of time, it loses the habit of moving, and that when afterwards its service is required, it requires a new kind of education before it can exercise its movements with any regularity or precision. The man, who for a long time should condemn himself to silence, would experience in like manner the same embarrassment in his first attempt at utterance.

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From these considerations we may conclude that our exterior life, to allow myself the expression, is learnt, and requires before it can be perfected, a sort of apprenticeship.

§ IV.—*Of the influence of society over the education of the organs of the animal life.*

Over this sort of education, which the organs of the animal life receive, society exercises a very great influence; it enlarges the sphere of action of some of them, lessens it for others, and modifies it in them all.

I shall first remark, that it constantly gives to some of the organs a perfection greater than naturally should be their portion. Such in fact is the nature of our occupations as always to require the especial action of some one, or other of these organs. The ear of the musician, the palate of the cook, the brain of the philosopher, the muscles of the dancer, and the laryux of the singer, receive in addition to the general education of the exterior life, a particular education.

Unnder these considerations, the occupations of mankind might be divided into three classes. The first would comprehend all those, which especially regard the senses, such as painting, music, and sculpture, the acts of the perfumer and the cook, and in a word all those the results of which are productive of pleasure to the senses. In the second would be ranged the occupations, wherein the brain is chiefly called into action; such as poetry, the sciences of nomenclature, the mathematics and metaphysics. The occupations of dancing, equitation, and the mechanic arts would form the third class.

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Each several occupation then of the individual, brings into permanent activity, some one organ in particular, and gives it a peculiar perfection. The ear of the musician in a piece of harmony, and the eye of the painter in a picture, distinguish many things which entirely escape the vulgar. It frequently happens that this perfection of action, is accompanied in the more exercised organ with an excess of nutrition: this we may frequently observe in the muscles of the arm of the baker, in those of the inferior limbs of the dancer, and in those of the countenance of the player.

In the second place I have asserted that society contracts the sphere of action, which should naturally belong to many of the external organs. Indeed, for the sole reason that any one of them is the more occupied, the others must be less so, and lose in aptitude what is gained by the single organ. The most common observation will prove this truth at every moment.

Examine the philosopher, who in his abstract meditations, and in the silence of the closet condemns to inaction his external and locomotive powers. Examine him by chance attempting any exercise of the body, and you will laugh at his awkwardness and air of constraint; his sublime conceptions astonish, the heaviness of his movements is amusing.

Examine on the contrary the dancer, who by the lightness of his steps exhibits apparently to the eye whatever the graces of fable have set before the imagination. It might be imagined perhaps that the profoundest meditations have been productive of such felicity of motion; but let him be conversed with, and nothing very surprising will be found in the man.

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The observing mind, which analyses the different individuals of society at every moment, will be led to similar remarks. Perfection of action in the locomotive organs, concurring with a like perfection of intellect, will seldom be found.

§ V.—*Of the laws, which regulate the education of the organs of the animal life.*

It is manifest then that society inverts the natural order of education in the animal life, and that it irregularly distributes to the different organs of this life, a perfection which they would otherwise enjoy in a more uniform proportion.

A determined sum of power, has been attributed to every individual, which sum must always remain the same, whether it be equally or unequally distributed, accordingly the activity of one organ must imply more or less inactivity in the others.

This truth will conduct us to the fundamental principles of all social education whatever; namely, that no individual at the same time, should be applied to many studies, even if it be wished that he should succeed in all of them. Philosophers have long insisted upon this maxim, but I doubt whether the moral reasons on which they have founded it, are all of them together worth this single and beautiful physiological observation by which it is demonstrated, that for the purpose of augmenting the powers of one organ, there are no other means than those of diminishing the powers of the others. On this account I shall dwell upon this observation, and prove its truth by a variety of facts.

The ear, and especially the touch, acquire in the blind man, a perfection which would hardly be credit-

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ed, were not its reality proved by daily observation. The deaf and dumb possess in the eye an accuracy of sight, which is unknown to those, with whom the powers of the ear and utterance are unfolded. Little connexion with external objects, enfeebles the senses of persons who are subject to extacy, but gives the brain a power of contemplation, such as to make it appear, that every part of the animal life, excepting that organ, during such affection is in a state of sleep.

But what occasion is there for seeking in extraordinary facts, the proof of a law which the animal in its healthy state exemplifies at every moment. Let us consider in the series of animals the relative perfection of each organ, and it will be seen at once, that where any one of them is excellent, the others are less perfect. The eagle, which has a very piercing sight, has but a very obtuse sense of smell; in the dog, the latter sense is extremely fine, the former dull. The sense of hearing is particularly acute in the hare, that of touch in the bat; the cerebral action predominates in the monkey, and vigour of motion in the feræ.

Every species then possesses some particular division of its animal life, in a degree of excellence superior to that of the others. Not a single instance will be found, where the perfection of one organ does not appear to be acquired at the expence of the others. Man in general, abstraction being made of every other consideration, has the ear particularly good, and in the natural order of things, this must be so; because his speech, which exercises the ear incessantly, is for this organ a permanent cause of activity, and therefore of perfection. And not only in the animal life is this law remarkable; but it appears to have place also, in all the phenomena of the organic life. The morbid affection of one of the kidneys, of one of

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the parotid glands, will double the secretion of the other.

Let us now examine what happens in the process of digestion. Each system at such time is the seat of an exaltation of the vital powers. Immediately after the entry of the aliments into the stomach, the action of all the gastric viscera is augmented, the powers of life are concentered about the epigastrium, and abandon the organs of the external life; from thence arise, as authors have observed, the lassitude, the inaptitude of the senses to the reception of external impressions, the tendency of the individual to sleep, and the cold which is so frequently felt in the integuments.

The gastric digestion being completed, the vascular succeeds, and the chyle is introduced into the circulatory torrent, for the purpose of undergoing the influence of this system, and that of respiration; accordingly the blood-vessels and lungs become in their turn, the focus of an increased action, the pulse rises, and the movements of the thorax are precipitated. accelera

It is then the glandular, then the nutritive system which enjoy a marked superiority in the state of their vital powers. Lastly, when these powers have been successively developed, over all the system, they return to the organs of the animal life, the senses resume their activity, the functions of the brain their energy, the muscles their vigour,. Whoever reflects upon what he has experienced after a somewhat copious repast, will be easily convinced of the truth of these remarks.

In this way, the whole of the functions represent a species of circle, of which the one half belongs to the organic, the other to the animal life, the vital powers seem successively to traverse these two halves. When they

they are found in one half, the other is proportionably deprived of them, nearly in the same manner as every thing appears to languish and be reanimated in the two portions of the globe, accordingly as the sun refuses, or sheds down his beneficent influence.

Should any farther proof be required of this inequality of distribution with regard to the vital powers, we may find it in the process of nutrition. This process has always an excess of action in some one of the organs, which at such time may be said to live more than the others do. In the fœtus, the brain and the nerves, the inferior members after birth, and at the age of puberty, the genital parts and breast appear to grow, at the expence of the others.

From such a variety of considerations, we may establish the following to be a fundamental law of the distribution of the vital powers, namely, that when they increase in one part, they decrease in the rest of the living œconomy, that the sum of them can never be augmented, and that they only transfer themselves successively from one organ to another. By the help of these general data, it is easy to perceive why we cannot at the same time attain to perfection in the various parts of our animal life, why we cannot at the same time excel in all the sciences.

Universality of knowledge in the same individual is a chimæra; it is repugnant to the laws of our organization, and if history afford us some few instances of extraordinary men, who have thrown an equal light upon many of the sciences, such instances are but so many exceptions to the common laws of nature; for who are we, that we should venture on the pursuit of many things at once, and hope to attain in all of them a perfection, which for the most part, even when we have but a single object in view, escapes us?

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Were we capable of following at once a number of occupations, such occupations would be those which have the greatest analogy among themselves with respect to the organs which they bring into exercise; and by restraining ourselves in this way within a narrow circle, we may, indeed, with a greater degree of facility excel in many parts; but even here the great secret of being superior in any one of them, is that of possessing but a mediocrity in the others.

Let us take, for example, the sciences, which bring into action the functions of the brain. We have seen that these functions relate especially to the memory, which presides over nomenclature; to the imagination, under the empire of which, is poetry; to the attention, which is chiefly excited by the details of calculation; and to the judgment, whose dominion embraces the whole of the sciences of reasoning. Now it is manifest from daily observation, that not one of these different operations of the mind is to be developed but at the expence of the others.

The habits of reciting the beauties of Corneille or Racine, we might naturally suppose would enlarge the mind of the actor; what can be the reason that from such habit he does not acquire an energy of conception beyond that of the vulgar? The reason depends in part, no doubt, upon the natural disposition of the man, but at the same time may be deduced from the greater efforts of memory, and the faculty of imitation, which such a person is obliged to exert: for the purpose of enriching these, the other parts of the brain are in a manner plundered.

Accordingly, when I perceive an individual, desirous at the same time of excelling by address of hand, in the operations of surgery, by depth of judgment in the practice of medicine, by extent of memory in botany,

tany, and by force of attention in metaphysical contemplation, methinks I see a physician, who, for healing a disease, for the purpose of expelling, according to the old expression, the morbific humour, at the same time undertakes to augment the whole of the secretions by the simultaneous use of sialagogues, diuretics, sudorifics, emmenagogues, &c. &c.

But would not the slightest acquaintance with the laws of the economy, suffice for hinting to such physician, that one glands pours forth a greater quantity of fluid, only because the others secrete a lesser one? Should he not know that such a variety of medicines can operate in no decided way, and that to exact too much of nature, is frequently the means of obtaining nothing? The same may be asked of the individual who is desirous of simultaneous perfection, both in the bodily and mental exercises, who should pretend to double or triple his relative life, when nature has willed that he should only have the power of detaching from some few of his organs, some few degrees of force, which may be added to one or more of his other organs, and by no means that of encreasing the sum of these powers.

Do we wish that any one organ in particular shall attain to perfection, we must condemn the others to inaction. We castrate men to change their voices; it is astonishing that the barbarous idea of depriving them of sight, has not been found out also for the purpose of rendering them musicians, since it is well known how acute the sense of hearing is in the blind. The child, who should be destined to music, ceteris paribus, would make a much more rapid progress, were his ears to be assailed by harmonious sounds only, and every thing removed which might be capable of exercising his other senses.

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It is a truth, then, that our superiority in such or such an art and science, may almost always be measured by our inferiority in other respects; and that this general maxim which the greater number of the ancient philosophers have insisted on, but which many of our modern ones would willingly overturn, has for its foundation one of the great laws of the animal economy, and will ever be as immutable as the base on which it rests.

§ VI.—*Of the education of the animal life as to duration.*

The education of the organs of the animal life, is prolonged for a time which we cannot determine, as it is influenced by such a variety of circumstances; but the peculiarity of this education consists in its being the business of each age, to bring to perfection certain organs in particular.

In childhood, the senses more especially are educated; every thing seems to relate to the developement of their functions. Environed with bodies which are new to him, the little individual seeks to know them all; he maintains in a sort of perpetual expectation those organs by which his connexions with what is near him are established, and undoubtedly his sensibility is excessively pronounced. His nervous compared with his muscular system, is proportionally very great; accordingly for the desection of the nerves, we always prefer the bodies of children.

With the education of the senses, the improvement of the functions of the brain which relate to sensation, is necessarily connected. In proportion, then, as the sum of the sensations becomes enlarged, the memory and imagination begin to come into play. The age which

which follows infancy, is that of the education of those parts of the brain in which these faculties are seated.—It is then, that there have existed a sufficient number of antecedent sensations for the exercise of the memory, and for the discovery of the type of those illusory sensations which it is the business of the imagination to assemble. On the other hand, the little activity of the judgment at this epoch is much in favour of the energy of these two faculties; and then the revolution which puberty brings on, the taste which it developes, and the desires which it creates, contribute very much to extend the sphere of the latter of them.

When perception, memory, and the imagination have been perfected, when their education is finished, that of the judgment commences, or rather becomes more active, for the judgment begins to be exercised upon the very first materials, with which it is presented. At this epoch the functions of the senses, and partly those of the brain have nothing more to acquire, and all the powers of the individual, are concentrated upon the education of the judgment.

Hence it is manifest, that the first portion of the animal life, or that by means of which we are acted on from without, and reflect such action, has at each age a division, which is then particularly unfolded: The first age is that of the education of the senses, the second that of the enlargement of the imagination, the third that of the developement of the judgment.

We should never then prescribe the study of the sciences, which exact the exercise of the judgment, at an age when the senses are especially in action; but follow in our artificial methods of education, the same laws which preside over the natural education of the organs. The child should be applied to music and design;

design; the adolescent, to the sciences of nomenclature, and the belles lettres; the adult, to the exacter sciences, where facts are connected by a process of reasoning. The study of logic and the mathematics, terminated our ancient plan of education; it was one advantage at least among its numerous imperfections.

As to the second portion of the animal life, or that by means of which the animal reacts upon external bodies, the state of infancy is characterized by the number, the frequency, and feebleness of its motions; adult age by their vigour; and adolescence by a mixture of the two. The voice, however, does not appear to follow these proportions, but is subject to an influence which proceeds especially from the organs of generation.

I shall not dwell upon the different modifications, which with respect to the animal life are derived from sex, climate, and season. So many have treated of these questions, that it would be difficult to add to what has been said upon them.

In speaking of the laws of education, as they affec the organs of the external life, I have supposed thes organs to be in a state of complete integrity, and pos sessed of whatever is necessary to their perfection.– If they be feeble or delicate, if any vice of conforma tion exist in them, these laws will only be applicab more or less; for it is manifest that the habit of jud ing will not rectify the judgment, if the brain badly constituted; and that the frequent exercise the larynx and voluntary muscles, will never make for the irregularity of action occasioned by irre larity of conformation.

CHAPTER THE NINTH.

OF THE ORIGIN AND DEVELOPEMENT OF THE ORGANIC LIFE.

WE have just now seen that the animal life, which is inactive in the fœtus, is developed after birth: we have also followed up the particular laws of its developement. On the contrary, the organic life comes into action almost as soon as the fœtus is conceived; for as soon as the least organization is apparent, the little heart will be seen protruding its blood on all sides. The heart is the first formed part, the first in action: now, as all the organic phenomena depend upon it, we may readily conceive in what way the functions of the inward life are thrown into exercise.

§ I.—*Of the mode of the organic life in the fœtus.*

Nevertheless, the organic life of the fœtus, is not the same as that which the adult is destined to enjoy. Let us enquire into the reason of this difference.

We have said that the organic life is the result of two great orders of functions, of those namely of assimilation and decomposition, so as to form an habitual circle of creation and destruction. Now in the fœtus this circle is singularly contracted.

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For in the first place, the functions of assimilation are much fewer in number; the molecules before they arrive within the organs which they are create, are not submitted destined to so many actions; they penetrate the fœtusalready elaborated by the digestion, circulation, and respiration of the mother. Instead of traversing the apparatus of the digestive organs, which at this age appear to be almost inactive, they enter at once into the system of the circulation; the road which they have travelled is less, it is not requisite that they should be presented to the influence of respiration; and accordingly the fœtus of the mammalia has in its preliminary organization a near analogy with that of the adult reptile, in which but a small part of the blood at its issuing from the heart, is sent into the vessels of the lungs.

The molecules of nourishment in this way pass almost directly from the circulating torrent into the nutritive system. The general process of assimilation, then, is much less complicated than that of the following age.

On the other hand, those functions which habitually decompose the organs, which clear the system of substances already become injurious and foreign to its nature, are at this age but very inactive. Neither the pulmonary exhalation, nor sweating, nor transpiration have as yet commenced: the bile, urine, and saliva are but small in quantity, if compared with what they are destined at a future time to be, so that the portion of blood from which they are to be made in the adult, in the fœtus is almost entirely expended on the system of the nutritive organs.

The organic system of the fœtus, then, is remarkable—on the one hand, for the extreme promptitude of its assimilation, a promptitude depending on the very

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small number of the functions concurring to that end; and on the other, for the extreme inertia of its decomposition, an inertia depending on the little activity of the different functions, which are the agents of this great process.

It is easy from the foregoing considerations to account for the rapidity which characterizes the growth of the fœtus; a rapidity which is manifestly out of all proportion with that which takes place at any other age. Indeed, while every thing is in favor of the progression of the nutritive matter towards the parts where it is destined to be put down, every thing at the same time seems to oblige such matter to remain in the place where it has been deposited, the emunctories of the system being wanting.

To the great simplicity of assimilation in the fœtus, we may add the great activity of the organs which contribute to it an activity, which depends upon the more considerable sum of vital power which they then partake. All the powers of the economy, indeed, appear to be concentrated upon the system of the circulation and nutrition; the functions of digestion, respiration, secretion and exhalation, are exercised but obscurely.

If we now observe that the organs of the animal life, which are condemned to a necessary inaction, are the seat at the same time of a very small portion only of vital power (the surplus of this being thrown upon the organic life) it will be easy to perceive, that almost the whole of the powers which are afterwards to be developed upon the two systems in general, will be then concentrated upon those which serve to nourish and compose the different parts of the fœtus, and that in consequence the functions which concur to the process of nutrition and growth, must at that age be the seat of an extreme energy.

§ II.—

§ II.—*Developement of the organic life after birth.*

Immediately after birth, the organic life of the child has a great addition made to it; its extent is almost doubled, for not only are many of the functions which did not before exist at such time added, but those which existed previously are much enlarged. Now in this remarkable revolution of things, a law directly the contrary of that which presides over the animal life is observed; for the organs of this life, whether they be newly brought into exercise, or simply receive an increase of action, need no education; they suddenly attain to a perfection, which those of the animal life do not acquire, otherwise than by long habitude. A rapid glance upon the developement of this life, will be sufficient to convince us of the truth of the above observation.

At the instant of birth, digestion and respiration, with a great part of the exhalations and absorptions commence. Now after the first inspirations and expirations; after the elaboration in the stomach of the first milk, which is taken in by the infant, as soon as the exhalants of the lungs and the skin have once rejected some small portions of their respective fluids, the respiratory, the digestive and exhalant organs, have as perfect an action as they ever will have.

At the same time all the glands, which slept as it were, which poured forth but a very small quantity of fluid, are awakened from their torpor by the stimuli of the various substances which are applied to the mouths of their excretory ducts. The passage of the milk at the extremities of the stenonian and wartonian ducts, of the chyme at the end of the choledochus and the pancreatic duct, the contact of air with the orifice of the

the urethra, awaken into action the salivary glands, the pancreas, the liver, and the kidneys. The air in like manner upon the inner surface of the trachea and the nostrils, and the aliments upon that of the digestive passages, are the excitants which rouse these parts into action.

It is then also that begin the various excretions of the system: now if we examine well the different organs which concur to the above-mentioned phenomena, we shall find that they require no sort of education.

I shall not enquire into the reason of this difference in the developement of the two lives. I shall only observe that it is out of the power of any one of the inward organs, to acquire a marked degree of superiority over any other, for the same reason that they all of them attain, immediately upon entering into action, as great a perfection as at any time they are destined to possess.

Nevertheless there is nothing more common than the predominance of one system of the organic life over the other systems; this is sometimes the vascular, sometimes the pulmonary apparatus, at other times the organs of digestion, and the liver especially, have the greater degree of developement, and decide on the particular temperament of the individual; but the cause of this sort of constitution depends on primitive organization, on the structure of the parts, on their conformation. Such superiority is by no means the effect of exercise or habit, for the fœtus and the child display the same phenomena, in as much reality though less apparently indeed, than adolescence, or manhood.

In the same way, the debility of any particular system of the internal functions, may depend either on original constitution, or on some accidental vice or disease, by which, while the others have remained untouched, its constitution may have been impaired.

Such then is the great difference of the two lives of the animal, with respect to inequality of perfection in the organs. In the animal life, the predominance or inferiority of one system, with relation to the others, depends almost entirely upon its activity or inertia, on its habitude of acting or not acting. In the organic life on the contrary, such states are immediately connected with the texture of the organs, and never with their education.

From hence also we have the reason why physical temperament, and moral character, are not susceptible of change from education, which so prodigiously modifies the actions of the animal life, for as we have seen, they both of them belong to the organic life.

The character is, if I may so express myself, the physiognomy of passions; temperament, that of the internal functions: now the one and the other being at all ages the same, having a direction which habitude and exercise can never alter, it is manifest that they must ever be withdrawn from the influence of education. The violence of the temperament may indeed be moderated, for the powers of the judgment, and reflection may be augmented, and the animal life strengthened in such way as to give it a capacity of resisting the impulses of the organic life; but to attempt an immediate alteration of the character, or of the passions, which are its habitual expressions, is an enterprize analogous to that of the physician, who should attempt to elevate or depress, (and that, for the entire life of the patient,) the ordinary contracting powers of the heart and arteries.

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We should observe to such physician, that the circulation and respiration, are not under the dominion of the will; and that they cannot be modified excepting in passing into a state of disease. The same observation might be made to those, who imagine that the character, and consequently the passions may be modified.

CHAPTER THE TENTH.

OF THE NATURAL TERMINATION OF THE TWO LIVES.

We have just now seen, that the two lives commence at distant epochs; we have seen them developing themselves according to laws, which are exactly the reverse of each other. I shall now attempt to describe them, as they terminate; and this they do in a very different manner also, assuming characters at such time as distinct and separate, as those which they possess during the periods of their activity. In this place, I shall speak of natural death only; those deaths, which originate in accidental causes, will be the object of the second part of this work.

§ I.—

§ I.—*In natural Death the animal life is the first to cease.*

Natural death is remarkable for the following reason chiefly:—it terminates the animal life, a long time before it puts an end to the organic life.

He who dies in consequence of a very prolonged old age, dies in detail; his exterior functions are finished, one after the other; the senses are shut up successively; the ordinary causes of sensation pass over them, and do not affect them.

The sight grows dull and confused; it ceases at length to transmit the images of objects: this is the blindness of old age; sounds also, after a certain time, affect the ear confusedly; the organ at last becomes entirely insensible. The cutaneous covering of the body grows hard and dry; it is the seat of an obscure and imperfect touch. Besides which, the habitude of feeling has blunted the power of feeling; at the same time all the other organs which are dependent on the skin, grow weak and perish; the hair falls, it is deprived of the juices by which it was nourished: to continue our description, odours make but a feeble impression upon the nostrils.

The taste indeed is a little more kept up; but let it be remarked that this sense is connected with the organic as much as with the animal life, and is therefore necessary to the internal functions: In this way, when all agreeable sensations have fled the old man, when their absence has already broken in part the connexions, which attach him to the world, his taste remains him still; it is the last thread to which is suspended the pleasure of existence.

In this way, isolated in the midst of nature, already deprived

deprived of the greater number of the functions of the sensitive organs, the old man is soon to suffer the loss of the common action of the brain, for it is manifest, that there can scarcely be any farther perception, for the very reason that there is nothing farther coming from the senses. Meanwhile, the imagination lessens and is soon annihilated.

The memory of present things is destroyed: the old man in an instant forgets what is told him, because his external senses enfeebled and already dead, as it were, in no wise confirm what is intimated to him by the mind alone. Ideas escape him when the images, which are traced by the senses, do not keep their hold. On the contrary, the remembrance of the past remains with him, that which the old man has formerly known, has been taught him or at least confirmed to him by his senses.

He differs from the child in this respect; the child judges only from the sensations which he experiences, the old man from those, which he has experienced.

The result of the two states is the same, for the judgement is equally uncertain, whether founded exclusively upon actual or past sensation. Its accuracy depends upon the due comparison of the two. No one can be ignorant, that in the judgement which we form from visible objects, the actual impression would frequently deceive us, were we not to rectify the error by what we are enabled to recollect, and may we not observe that past sensations, in a short time grow confused, if the features of the picture, which they have left with us, be not retraced by new and analogous impressions?

The present then, and the past with regard to sensation, are equally necessary for the perfection of the judgement. If either the one or the other be wanting there

there cannot be any comparison made between the two, and in consequence there must be a want of precision in the judgement.

For these reasons, the first and the latter ages of man, are equally remarkable for imbecility. Old age is second infancy. The two periods of life resemble each other with regard to want of judgement; they differ only as to the cause of such defect.

The interruption of the functions of the brain of the old man, is a consequence of the almost entire annihilation of the sensitive system with him; in the same way does the weakness of the locomotive power, succeed almost inevitably to the inactivity of the brain. This organ in fact re-acts upon the muscles, in proportion only as the senses act upon it.

The movements of the old man are few and tardy: he changes with difficulty the attitude, into which he has thrown himself; seated near the fire, and concentrated within himself, a stranger to every thing without him, he passes his days there, deprived of desire, of passion, and sensation; speaking little because he is determined by nothing to break his silence, yet happy in feeling that he still exists, when almost every other sentiment is gone.

The rigidity of the muscles however, and the diminution of their contracting powers, is another cause of inactivity in the old man, and doubtless has its influence; but it is by no means the principal one, since the heart and the muscular fibres of the intestines, contract the same rigidity, and are deprived of their powers of moving, in a very different way from that, in which the voluntary muscles lose it. With the voluntary muscles, it is not so much the power as the excitant of the power which is lost. If it were possible to compose a man with the senses and brain of old age, and the muscles of youth, the voluntary motions of such man, would hardly be more developed for the reasons which I have given.

From the above it is easy to see that the external functions of the old man are extinguished by degrees, and that his animal life has almost entirely ceased, while his organic life is still in activity. Under this consideration, the state of the animal about to suffer a natural death, is nearly similar to that of the fœtus in utero, or of the vegetable which lives within itself only, and for which external nature is absolutely silent.

If we now recollect that sleep entrenches more than a third upon the duration of the animal life, if we add to this the total absence of such life for the first nine months of existence, and its almost entire inactivity during the latter period of existence, it will be easy to calculate the great disproportion of its duration, when compared with that of the organic life which is exercised uninterruptedly.

But wherefore when we have ceased to exist without, do we continue to exist within, since our sensations and above all our powers of locomotion, are especially destined to place us in relation with those substances, which are to nourish us. Wherefore are those functions enfeebled in a greater disproportion than the internal functions, and why is there no exact relation in the times of their cessation.

I cannot entirely resolve this question. I shall only observe that society has an especial influence in creating this difference; for man in the midst of his fellow-creatures makes a very great use of his animal life; the springs of it are habitually more fatigued than those of his organic life, and worn away under the influence of society; the eye by artificial light, the ear by sounds too frequently repeated, and above all by those of speech, which are wanting to other animals; the smell in like manner is debilitated by factitious odours, the taste by savours, which certainly are not natural, the touch and the tact by constant attrition, and the brain by too incessant thinking.

We live then externally with excess. We abuse our animal life; it is circumscribed by nature within limits which are too much enlarged by us for its duration; thus it cannot be surprising that it should cease so soon. In fact we have seen the vital powers divided into two orders, the one appertaining to this life, the other to the organic life. These two orders may be compared to two lights which burn at the same time, and which have only a determined quantity of materials for aliment. In which case, if the one be agitated by a stronger wind than the other is, it must necessarily be the sooner extinguished.

Yet social influence notwithstanding is very advantageous to man. It gradually disengages him from those bonds which attach him to life, and renders the instant of death less terrible.

The idea of our last hour, is painful only because it puts an end to our animal life. The borders of the tomb are beset with terrors, which will all be found to originate in the thought of such privation.

It is not the pain of death, which we fear; how many dying men are there for whom the gift of existence would be precious, though purchased at the expence of an uninterrupted series of suffering! If we look at the animal which lives but little externally, he by no means trembles at beholding the instant of his death.

Were it possible to suppose a man, who in dying should lose his internal functions only, such man would look upon his death with an indifferent eye, because he would feel that the blessings of existence, are attached to the powers of feeling the influence, of nature and society.

If the animal life then be terminated gradually, if each of the bonds by which we are capable of the pleasures of living, be broken by little and little, such pleasures will escape us imperceptibly, and the old man will have forgotten the value of life, when it is about to be taken from him; such destruction will resemble that of the vegetable only.

§ II.—*The Organic Life in natural death does not terminate as it does in accidental death.*

The organic life remains with the old man after the almost total loss of his animal life, and terminates in a very different manner from that which is exemplified in the case of violent and sudden death. The latter has two periods, the first of which is marked by the sudden cessasion of respiration and the circulation, the second by the slow and gradual extinction of the other organic functions.

The parieties of the stomach for instance continue to act upon the aliment which may be found there, the juices of the stomach continue to dissolve it. The experiments of the English and Italian physicians upon absorption, (experiments the whole of which I have repeated) have proved that this function not unfrequently remains in a state of activity, after the general death of the body, and if not as long as some have supposed, at least for a very considerable interval. Discharges of urine and fœces are often observed to take place many hours after sudden death.

The process of nutrition also continues to be mani-

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fest in the hair and in the nails; the same would doubtless be the case in all the other parts, as well as in the secretions, could we observe the insensible movements of which their functions are the result. The heart of the frog being taken away, the capillary circulation may still be seen under the influence of the tonic powers. The body is very slow also in losing its animal heat.

I might augment the above observations with a number of others, which would go to prove the same assertions; on the contrary, in the death which is the effect of old age, the whole of the functions cease, because they have each of them been successively extinguished. The vital powers abandon each organ by degrees, digestion languishes, the secretions, and the absorptions are finished, the capillary secretions become embarrassed; lastly, the general circulation is suppressed. The heart is the ultimum moriens.

Such, then, is the great difference which distinguishes the death of the old man, from that which is the effect of a sudden blow. In the one, the powers of life begin to be extinguished in all the parts, and cease at the heart; the body dies from the circumference towards the center: in the other, life becomes extinct at the heart, and afterwards in the parts. The phenomena of death are seen extending themselves from the center to the circumference.

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BICHAT ON LIFE AND DEATH.

SECOND PART.

CHAPTER THE FIRST.

General Considerations on Death.

IN the first part of this work, I have explained the two great divisions of life, together with the remarkable differences, which distinguish the animal existing without, from the animal existing within. I have discussed the characters which are exclusively proper to the two lives, and the particular laws, according to which they both of them commence, are developed and end in the natural order.

In this second part I shall enquire in what way they accidentally finish, in what way their course is prematurely arrested.

The influence of society suffers us but rarely to live out the period which was intended us by nature; while almost every other animal attains his natural end, such end in the human species is become a sort of phenomenon. The different kinds then of accidental death,

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should engage the particular attention of the physician and Physiologist. Now this sort of death may happen in two ways: sometimes it is the result of great disturbance excited in the economy; and sometimes it is the effect of disease.

In general it is easy enough to discover, according to what laws the functions are terminated in consequence of any violent or sudden attack; of apoplexy, for instance, great hemorrhagy, concussion of the brain, or asphyxia; because in such cases the organs of the body, excepting that which is immediately affected, are not the seat of any peculiar lesion, and cease to act from causes diametrically the contrary of those, which according to the common course of things maintain them in action. Now as these causes are partly known, their contraries may be inferred; besides, we are capable of imitating these sorts of death upon animals, and consequently of analyzing, experimentally, their different phenomena.

On the other hand it is seldom in our power to produce artificially in the bodies of animals the diseases of the human species. Were we even possessed of such power, we should gain but little knowledge from it: the laws of life in fact are so changed, so modified, so altered in their very nature, by the various morbid affections to which the parts are subject, that but very seldom can we depart from the known phenomena of the living animal, when we undertake to enquire into those which it exhibits in its dying moments. For such enquires it would be necessary to know what is that intermediate state between health and death, in which the functions experience so remarkable a change; a change, which has such infinite varieties, and produces such innumerable sorts of disease. But, where shall we find the physician, who will assert that from

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the actual data of his art, he understands in such intermediate state, the profoundly hidden operations of nature?

In these researches then, we shall occupy ourselves more especially on those sorts of death which I first enumerated. Those, which have been mentioned in the preceding paragraph will engage us only now and then: besides, at my age I cannot be supposed to have acquired a sufficient degree of medical knowledge to treat of them with advantage.

The first remark, which the observation of the different kinds of sudden death suggests, is, that in all of them the organic life to a certain point may subsist, the animal life being extinct; but that the latter is entirely dependent, and lasts not for a moment after the interruption of the former. The individual, who is struck with apolexy may live internally for many days after the stroke, externally he is dead: In this case death commences with the animal life: if on the contrary it exerts its influence in the first place upon any of the essential organic functions—as on the circulation in wounds or on respiration in the asphyxiæ—the animal life is gone at once, together with the sensible actions of the organic life.

The red and warm-blooded animal, loses his external life at the moment when he ceases to exist internally, the cessation of the phenomena of his organic life is a sure index of his general death; indeed the reality of death can be pronounced only from such datum; the interruption of the external phenomena of life is in almost every instance fallacious.

On what depends this difference of the manner in which the two lives accidentally end? It is owing to the mode of that influence, which they exercise the one over the other, to the kind of bond, by which they are connected.

This mode of influence, this bond, appears to exist between the brain on the part of the animal life and the lungs, or heart on the part of the organic life. The action of one of these three organs is essentially necessary to that of the two others; and as they constitute the three centers, in which are terminated all the secondary phenomena of the two lives, whenever they cease to act, the phenomena which depend upon them must cease also, and general death ensue.

Physiologists have been at all times acquainted with the importance of this triple focus; and have given the name of vital to all those functions, which have their seat in it. Under the point of view which at present engages our attention their ideas on this head are well worthy of notice, for every species of sudden death begins by the interruption of the circulation, the respiration, or action of the brain. In the first place, one of the three functions ceases, then the others successively; so that to expose with precision the phenomena of sudden death, we must consider them as they take place in the three principal organs, which we have mentioned.

We shall first enquire into those deaths, which begin at the heart, and afterwards into those, which begin in the lungs and in the brain. I shall explain in what way, when one of these organs is affected, the others die; and then demonstrate by what sort of mechanism the death of the various other parts of the body ensues. Lastly I shall determine from the principles, which I shall then have laid down, the nature of the different species of disease, which are peculiar to the heart, the lungs, and the brain.

CHAP.

CHAPTER THE SECOND.

Of the Influence of the Death of the heart, over that of the brain.

I shall evidently have determined what is the mode of this influence, should I be enabled to establish in what way the action of the heart is necessary to that of the brain; for in this instance the cause of death will be no other than the privation of the cause of life. Now the heart can only act upon the brain in two ways; by the nerves, or the vessels which serve as their connecting medium. In fact these two organs have no other means of communication.

It is evident that the nerves cannot be the agents of such actions; it is the province of the brain to act by means of the nerves. The different parts of the body never influence the brain by such means, excepting in the sympathies. If a bundle of nerves belonging to the voluntary muscles be tied, the muscles indeed will ceaseto act, but nothing will be changed in the cerebral mass.

I have ascertained by many experiments that the phenomena of galvanism, which are propagated so energetically from the brain towards the organs, which descend, if I may so express myself, along the nerve, will

will hardly ascend in a contrary direction. Apply the apparatus to a nerve of the loins and the muscles of the upper limbs, and when the communication is made, there will be scarcely any contraction; but on the establishment of a communication between the same nerve and the lower limbs, a violent convulsive motion will instantly be occasioned. I have even observed, on placing two metallic plates, the one under the lumbar nerves, and the other under the upper limbs, that the communication of the two plates by means of a third metal, will cause a contraction of the lower limbs, while the upper limbs remain inactive, or move but feebly.

These experiments are particularly applicable to the relation of the heart with the brain; for not only is it true that the section, ligature or compression of the cardiac nerves are of little effect with regard to the functions of the latter, but it is true also, as we shall presently see, that they do not directly modify the movements of the former. We may conclude that the vessels are the exclusive agents of the influence of the heart upon the brain.

The vessels, as every one knows, are of two sorts—venous or arterial—they carry black or red blood, the latter answer to the left side, the former to the right side of the heart. Now their functions being very different, the action of one of the portions of this organ on the brain, can never be the same as that of the other portion. We shall enquire in what way they both of them act upon it.

In naming these two portions, I shall not make use of the expressions of right and left to distinguish them, but of those of the red-blooded and the black-blooded heart, for each of these portions of itself is an isolated organ, distinct from that to which it is applied, and in

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the adult especially so. In fact there are two hearts, the one arterial, the other venous, notwithstanding which, we can hardly employ these adjectives for the purpose of designing them, since they both alike possess their arterial and venous appendages. On the other hand, they are neither of them situated exactly to the right or to the left, are neither of them exactly forwards or backwards. Besides which these latter denominations would not apply to animals.

§ 1.—*In what way does the cessation of the functions of the red-blooded heart interrupt the functions of the brain?*

The red-blooded ventricle and auricle, exert their influence upon the brain by means of the fluid which they send thither through the carotid and vertebral arteries. This fluid may excite the cerebral organ in two ways. 1st. By the movement, with which it is directed. 2nd. By the nature of its colouring principle.

It is easy to prove that the movement of the blood is necessary to the life of the brain. Expose the brain of an animal in part, and tie the carotids. In such case the cerebral movement will be sometimesweakened, and then the animal will be stupified, at other times the vertebral arteries will exactly supply the place of the carotids, and then there will be nothing deranged in the principal functions of the brain; for there is always a relation existing between the alternate rise and fall of the cerebral mass, and the energy of life which it displays.

In general, the obliteration of the carotids is never suddenly mortal. Animals will live without them, at least for a certain time. I have kept dogs in this state

state for several days aud have afterwards made use of them for other experiments: two however died in the course of six hours, after the application of the ligatures.

After having made the above experiments which go very far to the establishment of the principle which I am labouring to prove, let a piece of the cranium be taken from another animal and tie the vertebral and carotid arteries. The movement of the brain will then be entirely interrupted and the animal immediately die.

The impulse, which proceeds then from the influx of the blood into the brain, is a condition essential to the fnnctions of this organ, but other proofs may be adduced, for the establishment of the truth of this assertion.

1st. There are a number of compressions, which can only act in preventing the brain from being duely affected by such impulse. A collection of pus, or blood, will often put a stop to all the functions, which relate to the perception, memory, and voluntary motions of the individual. Let such compression be removed and his sensibility will immediately re-appear. In such case, it is manifest that the brain was not disorganized, but only compressed, and in a state incapable of being excited by the heart.

I do not think it necessary on this subject to cite cases. All authors, who have treated of wounds of the head, are full of them. I shall content myself with remarking, that the same effect may be artificially produced in our experiments upon animals, and that accordingly as the brain is compressed or free, the creature will be insensible, or the contrary. According to the degree of the compression, will be the degree of the stupor.

2dly. There are reptiles, in the brain of which no motion whatever is occasioned by the heart. The frog is of this species. On raising the upper portion of the cranium, and exposing the brain, there cannot be perceived the slightest motion. Now in this species, and that of the salamander, the influx of blood may be cut off from the cerebral organ without occasioning the immediate death of the animal. The voluntary muscles for instance continue to act; the eyes to exhibit a lively appearance, the tact also of the creature is manifest for some time after the heart has been taken away, or the double branch which proceeds from the single ventricle of these animals has been tied. I have frequently repeated these experiments, and have constantly found the effect the same.

3rd. It is a general observation, that those animals which have a long neck, and in which the heart for that very reason is not so capable of exerting a lively influence over the brain, have a more limited intellect, and the cerebral functions less marked. On the contrary a very short neck, and the approximation of the heart to the brain very generally are found to coincide with the latter. Similar phenomena are sometimes observed in men. They who have the neck particularly long are dull, they who have it short, for the most part intelligent and lively.

From these many facts we may confidently assert, that one of the means, by which the heart maintains the brain in action, consists in the habitual movement, which it impresses on it.

But this movement is essentially different from that which in the other viscera, such as the liver, or spleen, is derived from the same cause. In these it is little manifest, in the brain it is very apparent; the reason is evident; the large arterial trunks of the brain, are

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situated at its base, between the brain and its bony parietes; in consequence of which, at each diastole, the vessels experience a resistance from the bone, which is communicated immediately to the cerebral mass. At such time the brain is really lifted, just in the same way as we see a tumour lifted by the arteries which creep along the bones beneath it; and instances of this are frequent. So apparent indeed is the motion of tumours when they are situated over the carotid, as it lies upon the vertebral column, or over the femoral artery, immediately after its passage under the crural arch, as often to occasion doubts with respect to their nature.

But no other organ is enclosed within a bony cavity; the motion of the arteries every where else, is lost in the surrounding cellular substance, or soft parts. Such motion, then, is unessential to the functions of the liver, the kidney, and other analogous viscera.

The integrity of the functions of the brain, is not only dependent on the mere motion, but on the sum also of the motion communicated. It is equally impaired by too much, or by too little motion. Of this assertion the following experiments are proofs.

1st.—Inject water by the carotid of a dog; the presence of this fluid in the brain is not pernicious, and the animal will live very well, when the injection has been skilfully made. But if it be pushed with violence, the cerebral action will immediately be troubled, and often cannot be restored. In every experiment, there will be found to exist a relation between the force of the impulse and the state of the brain; if the pressure be but a little augmented, its effects will be instantly seen in the agitation of the countenance of the creature; if relaxed, a corresponding calm will succeed;

succeed ; if increased to the highest pitch, it will immediately occasion death.

2dly.—If the brain be exposed, and an artery afterwards opened, so as to produce a considerable hemorrhage, the motion of the brain will be diminished in proportion as the afflux of the blood to it is diminished, and finally will cease entirely. Now, according to all these various degrees of diminution, which may be observed in the movements of the brain, will be the corresponding weakness of the cerebral influence as it is discoverable in the state of the eyes, the tail, and the voluntary motion of the animal.

Hence it is easy to see, why a state of prostration and languor is always the consequence of great hemorrahage—and from what has been said above we may conceive the reason, why the arterial system of the brain has been at first concentrated at its base, while the larger venous trunks are almost all of them situated on the convexity of its surface. The base of the brain is small and easily moved, the convexity large and little capable of transmitting motion, such as could be made upon it by vessels. Besides, it is at the lower part of the brain that exist its particular and essential forms. The lesions of these are mortal, and consequently their functions must be important. On the contrary, experiment and observation alike have proved, that very little derangement follows, from cutting or rending the substance of the upper part of this organ. Hence also we may see the reason, why its natural defences towards its base, are constituted in such way as to be almost impenetrable, and why at its upper surface, it is less protected. Now, where its life is indispensable, and its action absolutely necessary, it should naturally receive the first and undiminished impulse of its excitant. We may conclude, that

that the interruption of the action of the red-blooded heart is the occasion of interruption in the action of the brain by annihilating its movement.

But this movement is not the only means by which the influence of the heart is exerted on the brain; for if it were so, we might easily reanimate the enfeebled functions of the latter, by injecting it with water at the same time through both the carotids. If pushed with an equal force, the black blood and the red blood alike would be capable of keeping up its action; but this, as we shall presently see, is not the fact.

The heart, then, acts upon the brain by the nature of the fluid which it sends thither; but as the lungs are the focus, where the blood undergoes an alteration, we shall refer the examination of its influence upon the cephalic system, to the chapter in which we shall treat of the relation of this system, with that of the lungs.

§ II.—*In what way does the cessation of the functions of the black-blooded heart interrupt the functions of the brain?*

It very rarely happens that general death commences by that of the venous auricle and ventricle. On the contrary, they are almost always the last in action, and when they cease to act, the brain, the lungs, and the red-blooded heart have already ceased to exhibit their respective phenomena. Nevertheless the contraction of these cavities may be annihilated, or rendered at least inefficacious with regard to the circulation, from the rupture of an aneurism or similar causes; in which case the brain becomes inactive and dies, as we have shewn it to do in the preceding section, from want of movement.

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There is another kind of death of the brain depending on the interruption of the transmission of blood from the head to the heart, as when the jugulars are tied. The venous system, in consequence, is glutted and the brain compressed, from the continued afflux of the red blood into its arteries; but the phenomena of this sort of death are sufficiently known already.

In the present chapter it is my intention to examine a species of death, the principle of which by many physiologists has been placed in the heart, but which appears to me to affect the head only; I mean that death which may be occasioned by the injection of air into the veins.

It is generally known, that as soon as any quantity of this fluid is introduced into the vascular system, the movements of the heart are accelerated, that the creature is much agitated, cries with pain, is convulsed, and soon after deprived of its animal life, but lives organically for a certain time, and then invariably dies. Now, what is the organ so readily affected by the contact of air? I affirm it to be the brain, and not the heart; and maintain that the circulation is annihilated, only because the cerebral actions have previously been so.

For, in the first place, in this kind of death, the heart continues to beat for some time after the cessation of the animal life, and consequently for some time after that of the action of the brain.

Secondly, By injecting air into the brain through one of the carotids, I have caused the death of the creature just in the same way as when air is introduced into the veins; excepting only with a previous palpitation of the heart.

Thirdly, Morgagni has cited a number of cases of sudden death, the cause of which should appear, from

from

his remarks, to be the repletion of the blood vessels of the brain by air, which had been developed there spontaneously, and which says he, by its rarefaction, compressed the origin of the nerves. I cannot suppose that auch compression can be effected by the very small quantity of air, which, when injected into the carotid, is sufficient to occasion death; accordingly, I should doubt whether this compression were real in the cases adduced, but for this, they are not the less important. Whatever be the manner in which it kills, air is mortal whenever introduced into the brain, and this is the essential point. It is with the fact that we have to do and not the manner.

Fourthly, As often as an animal is killed by the insufflation of air into one of its veins, I have ascertained that the whole of the red-blooded, as well as the black-blooded heart, is full of a frothy blood, mixed with air bubbles; and that the carotids, and vessels of the head, contain a similar blood; such blood must act upon the brain, in the same manner as it does in the two sorts of apoplexy, of which we have just been making mention.

Fifthly, If air be pushed into one of the divisions of the vena portæ from the side of the liver, it oscillates in the greater trunks of that organ for a considerable length of time, and arrives but slowly at the heart.—In this instance I have observed, that the animal experiences, only after a certain interval, those affections which are sudden when the fluid is injected into the viens of the principal system.

Sixthly, The rapidity with which, in certain experiments, the annihilation of the cerebral action succeeds to the insufflation of air into the veins, might almost persuade us that such phenomenon is occasioned, as it is in wounds of the heart and syncope;—but

but 1st. the most simple inspection is sufficient to shew us that the heart continues to act after the apparent death of the animal—2dly, as the motions of the heart are prodigiously accelerated by the contact of the foreign fluid, they push on the frothy blood with an extreme velocity, and hence we have the reason, why the brain in such case is so rapidly affected.

Seventhly, Were the crebral action in this sort of death interrupted for want of movement from the heart, it would happen as it does in great hemorrhages of the aorta; that is to say, without violent convulsion. But here, on the contrary, the convulsion is extremely violent, immediately after the injection, and consequently, announces the presence of an irritating substance on the brain.

We shall conclude, that in the accidental mixture of air with the blood of the venous system, it is the brain which dies the first, and that the death of the heart is the consequence of the death of the brain. I shall explain in another place, in what way this phenomenon is occasioned.

CHAPTER THE THIRD.

Of the Influence of the Death of the Heart over that of the Lungs.

THE lungs are the seat of two very different sorts of phenomena. The first, which are entirely mechanical, are

are relative to the rise and fall of the ribs and diagphragm, to the dilatation and contraction of the air vessels, and to the entry and exit of the air, which is the effect of these movements. The second, which are purely chemical, may be referred to the different alterations, which the air and blood experience.

These two sorts of phenomena have a mutual dependence on each other. Without the mechanical, the chemical changes could not be made; without the chemical changes, the blood would cease to become an excitant to the brain, in consequence of which that organ would no longer operate upon the diaphragm or intercostal muscles; the muscles themselves would then become inactive, and the motions of the thorax be annihilated. These phenomena, however, are put an end to in a different manner by the death of the heart, accordingly as it happens on one or the other side.

§ I.—*In what manner are the actions of the lungs interrupted when the black-blooded heart ceases to act?*

The heart has certainly no influence over the mechanical functions of the lungs, but it contributes essentially to produce the chemical changes which are made there, by sending thither the fluid which is destined to undergo a change. When its functions then, are interrupted, as may happen from wounds or be occasioned by ligature, the chemical changes which should be made in the blood, are suddenly suppressed; though the air continue to enter into the lungs, from the dilatation and contraction of the chest.

Meanwhile there arrives nothing at the red-blooded heart, or so little as to be insufficient for the produc-
tion

tion of the cerebral movements. The functions of the brain are consequently suspended, and of course the movements of the diaphragm and ribs..

§ II.—*In what manner are the actions of the lungs interrupted, when those of the red-blooded heart are suspended.*

Whenever from wound, ligature, or aneurism, the functions of the red-blooded heart or aorta cease, the functions of the lungs are terminated in the following order :

1st. There is no further impulse made upon the brain. 2dly, No further movement of that organ.—3dly, No further action exercised upon the muscles.—4thly, No further contraction of the intercostals or diaphragm. 5thly, The mechanical functions of the lungs cease. 6thly, Their chemical functions cease.

In the former case, the chemical changes could not be made for want of blood. Here they cannot be made for want of air. Such is the difference in the death of the lungs, in consequence of that of the heart, accordingly as the latter is affected. But as the circulation is very rapid, there cannot be but a very short interval between the interruption of the chemical and the mechanical functions of the lungs.

CHAPTER THE FOURTH.

Of the Influence of the Death of the Heart over that of all the Organs.

I shall divide this chapter, as the preceding one, into two sections. In the first I shall examine, how the death of the red-blooded heart, in the second how the death of the black-blooded heart, is the cause of the death of all the parts of the body.

§ I.—*On the death of the red-blooded heart, in what manner is that of the organs occasioned.*

All the functions belong either to the animal, or to the organic life. Hence the difference of their classes Now the death of those of the first class, in consequence of lesions of the red-blooded auricle and ventricle, is caused in two ways, and first, because the brain in such case is rendered inert from want of impulse, and can neither have sensations, nor exercise an influence over the locomotive and vocal organs.

Accordingly, all this order of functions is stopped, as when the encephalic mass has experienced a violent concussion. It is in this way that a wound of the heart, or the bursting of an aneurism, annihilate all our relations with external objects.

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So strict a connexion between the movement of the heart, and the functions of the animal life, is not observable in those animals in which the brain, in order to act, does not require the habitual stroke of the blood. Tear away the heart of a reptile, or tie its large vessels, and it will continue for a long time to move and have sensations.

Besides, supposing even that the action of brain were not to be suspended from lesions of the red-blooded heart, the animal life would not, on that account, be the less put an end to; because to the exercise of the functions of this life, is attached as a necessary cause, the excitement of its organs by the afflux of blood into them : now this excitement, both here and every where else, depends upon two causes.— 1st. on the movement impressed, and 2dly, on the nature of the blood. At present I shall only examine the first mode of influence; the latter will come under our consideration, when we speak of the lungs.

Habitual motion is necessary to all the parts of the body alike, is a condition essential to the functions of the muscles, the glands, the vessels, and the membranes, &c. But this movement, which is partly derived from the heart, is very different from that which is communicated by the blood to the brain.

The latter organ receives an impulse by which the whole of its mass is visibly raised, an impulse, in the intermission of which the whole of its mass subsides. On the contrary, the interior movement, by which its particles are affected, is scarcely marked at all : and this depends upon the smallness and the delicacy of the vessels by which its substance is penetrated.

The contrary of this appearance is observed in the movement occasioned in the other organs by the influx of the blood into them : we see them neither rise

nor

subside ; there is nothing like a general impulse made upon them, because, as I have said, such impulse is lost from the little resistance of the surrounding parts. On the contrary, they are penetrated by vessels of considerable magnitude, which create an intestine motion, oscillations, and impulses adapted to the actions of the tubes, lamellæ, or fibres, of which they are composed. This difference of movement may be easily conceived, by comparing the manner in which the brain on one hand, and on the other the liver, the spleen, the muscles, or the kidneys receive their blood; indeed it is requisite that the brain should be distinguished from the other organs, in the manner of receiving its impulses, because it is enclosed in a case of bone, and consequently abstracted from the thousand other causes of agitation, to which the other parts of the body are exposed.

For we may remark, that all the other organs have about them a number of agents, which are destined to supply the place of that general impulse, which is wanting to them on the part of the heart. In the breast, the intercostals and diaphragm are continually rising and falling ; the lungs and the heart are successively the seat at of a dilatation and contraction. In the abdomen, there is an uninterrupted agitation produced, by the influence of respiration upon its muscular parietes ; an incessantly variable state of the stomach, intestines and bladder. Lastly, from the various contractions of the muscles, the limbs have a still more evident cause of movement.

Nevertheless, it is probable that every one of the organs, as well as the brain, has a general though obscure movement impressed upon it, from the pulsation of the arteries ; and hence, perhaps, we have the reason, why the greater number of the viscera, receive

the

impulse of the red blood upon their concave surfaces, as may be seen in the kidneys, the liver, the spleen, and the intestines. By such disposition, the impulse of the heart is less divided.

From what has now been said, we may add another reason to that which we have before given, for establishing in what way the functions of the animal life are interrupted from cessation of action in the red-blooded heart. We may now also begin to explain the same phenomenon in the organic life. The reason of such interruption in both the lives is the same. It is as follows:

1st. In the case of death affecting the red-blooded heart; the intestine movement, which proceeds from the manner in which the arteries are distributed within the substance of all the organs, both of the one and the other life, is suspended; hence there exists no farther cause of excitement for the organs: they must consequently die.—2dly. The causes of the more extensive and general movements of the organs are abstracted; for almost all these causes depend upon the brain. We respire and move, only while the brain is alive: but as the brain must be in a state of collapsus, as soon as it ceases to receive the impulse of its blood, its influence must be evidently annihilated.

Hence it follows, that the heart exercises over the different organs two modes of influence; the one direct and immediate, the other indirect, and made through the medium of the brain, so that the death of the organs in consequence of the death of the heart, is immediate or mediate.

We have sometimes examples of partial death, analogous to this sort of general death. Thus, when the circulation is impeded in a limb, and the red blood no longer distributed to its parts, such parts become at

first

first insensible and paralytic, then gangrenous. The operation of aneurism furnishes us with too many instances of this phenomenon, which by ligature, may be produced also in the living animal. Undoubtedly the principal cause of death in these cases, is the want of that stimulus which it is the business of the particles of the red blood to create, in contradistinction to those of the black blood, but the absence of the intestine movement in question, is by no means a less real cause of such death.

As for the interruption of the nutritive process, it cannot be admitted as a cause of the symptoms which succeed after the obliteration of a large artery. The slow, the gradual, and insensible way, in which this function is performed, does not accord with the sudden and instantaneous production of those symptoms, especially as they affect the animal life; for this is annihilated in the limb at the very instant when the blood ceases to flow into it, just in the same way as it is, when by the section of its nerves, the influence of the brain is abstracted.

Besides the preceding causes, which, when the heart is dead, suspend in general the whole of the animal and organic functions; there is another cause of death which especially affects the greater number of the latter, such as the processes of nutrition, exhalation, secretion, and therefore digestion, which is only performed by means of the secreted fluid. This cause of death to which I refer, consists in the necessary stop which is put to these different functions, in consequence of their no longer receiving the materials upon which they are exercised. Nevertheless, such term arrives by degrees only, because they receive the materials on which they act, from the capillary, and not from the general circulation. Now the capillary circulation,

culation, is only subject to the influence of the insensible contractile powers of the parts in which it is performed; and is exercised independently of the heart, as may be seen in the greater number of reptiles, where the heart may be taken away, and the blood be notwithstanding observed to oscillate for a long time afterwards in the minuter vessels. It is manifest, then, that whatever quantity of blood is left in the capillary system at the period of the death of the heart, will for some time afterwards be sufficient to keep up the functions in question, and that such functions in consequence will only gradually cease.

The following is a general view of the manner in which the annihilation of all the functions succeeds to the interruption of those of the heart.

The animal life is terminated—1st. Because the organs of which it is composed, are no longer excited without, by the movement of the neighbouring parts, nor within, by the blood.—2dly. Because the brain, from want of excitement, can no longer be a cause of excitement.

The organic life is terminated—1st. Because, as in the animal life, there is a want of external and internal excitement for its different viscera.—2dly. Because there is a want of the materials on which its functions are particularly exercised.

There are a number of other considerations, however, besides those which we have mentioned, which prove the reality of the excitement of the organs, from the movement communicated to them by the blood, as well as the reality of the cause, which we have asserted to be that of their death, when such excitement ceases.

For, 1st.—The organs which are penetrated only by the serum of the blood, such as the hair, the nails, the tendons,

tendons, and cartilages, enjoy a less degree of vitality, and a less energetic action, than those in which the blood is made to circulate, either immediately by the heart, or by the insensible contractile powers of the parts themselves.

2dly.—When the white organs are inflamed, they receive an augmentation of life, a superabundance of sensibility, which frequently put them on a level in many respects with those organs, which in their natural state are endowed with the highest degrees of life and sensibility.

3dly.—Those organs which habitually receive the influx of the red blood, when inflamed, exhibit, in every instance, a local exaltation of the phenomena of life. In the two preceding instances, it is true, indeed, that the change of vital powers, precedes in point of time, the change which is made in the circulation; the organic sensibility of the part, has been augmented before the blood is carried thither in greater quantity; but afterwards it is the afflux of such encreased quantity of blood, which keeps up the unnatural action which has been established. A determined quantity of blood in the ordinary state of the part, is necessary to the maintenance of that state; but when the part receives a double or triple increase of energy, its excitant also must be doubled or tripled; for in the exercise of the vital powers, there are always three things to be remarked; the power inherent in the organ; the excitant which is foreign to it; and the excitement which is the product of the two.

4thly.—It is doubtless, for this reason, that the organs to which the blood is habitually carried by the arteries, enjoy a degree of life, proportionate to the quantity of fluid by which they are injected. Such phenomenon may be observed in the glans penis, in the

the corpora caveruosa, in the nipple, in the skin of the face, and the actions of the brain, whenever the blood is directed with impetuosity towards them.

5thly.—The whole of the circulatory system, is thrown into greater action from the exaltation of the whole of the vital phenomena, just in the same way as the particular circulation of any part is augmented, when the particular phenomena of the life of that part are encreased. The use of spirituous liquors, and spices to a certain quantity, is followed for a time by a general increase of energy in the powers of the system. The access of inflammatory fever will double and triple the intensity of life.

In these considerations I have only regarded the movement which is communicated to the organs by the blood. In another place I shall call the attention of the reader to that species of excitement, which is produced by the nature of the blood, by the contact of its component particles when in a state of oxydation or otherwise, with the different parts of the body. The reflections which I have offered, will be amply sufficient to convince us how much the blood, independently of the materials which it conveys with it, by its simple influx, is necessary to the activity of the organs, and consequently how much the cessation of the functions of the heart, must influence the death of the organs.

CHAP.

CHAPTER THE FIFTH.

Of the Influence of the Death of the Heart as to the Production of General Death.

WHENEVER the heart ceases to act, general death is produced in the following manner:—1st. For want of excitement the cerebral actions are annihilated, and consequently an end is immediately put to all sensation, locomotion, and utterance. Besides, for want of excitement on the part of the blood, the organs of these functions would cease to act, even supposing that the brain were to remain intact, and exert upon them its accustomed influence. Thus the whole of the animal life is suddenly suspended, and at the instant of the death of the heart, the individual is dead for what surrounds him.

The interruption of the organic life, which has commenced by the death of the heart, is produced at the same time by that of the lungs. The brain being dead, the mechanical functions of the lungs must cease: the chemical functions of the lungs must cease also, for want of the materials on which they are exerted: the latter are directly interrupted, the former through the medium of the brain.

After

After this the progress of death is gradual. The secretions, the exhalations, the nutritive actions are put an end to. The latter are first arrested in those organs which receive the more immediate impulse of the blood, because in these, such impulse is necessary to the performance of the function. The paler organs are less dependent on the influence of the heart, and consequently must be less affected by the cessation of its action.

In the successive termination of the latter phenomena of the internal life, the vital powers continue to subsist for some time after the loss of the functions: thus, the organic sensibility, and the sensible and insensible contractilities survive the phenomena of digestion, secretion, and nutrition.

The vital powers continue to subsist in the internal life, even when the corresponding powers of the animal life, have suddenly become extinct: the reason is plain: the power of perceiving and moving organically does not suppose the existence of a common center; for the animal perceptions and motions, the action of the brain is requisite.

The phenomena of death are concatenated in the above order in all aneurismal ruptures, in all wounds of the heart or larger vessels, in all cases of polypi formed in the cardiac cavities, of ligature artificially applied, of compression exercised on the parietes of the heart by humours, abscesses, &c. &c.

It is in this manner also that we die from sudden affections of the mind. The news of a very joyful, or a very melancholy event, the sight of a fearful object, of a detested enemy, of a successful rival, are all of them causes capable of producing death. Now in all these instances, it is the heart, which is the first to die,

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the heart, whose death successively produces that of all the other organs, the heart, on which the passion is exerted.

And hence we are led to some considerations on syncope, an affection exemplifying in a lesser degree the same phenomena, which in a greater one, is offered us in cases of sudden death.

The causes of syncope are referred by Cullen to two general heads: Of these there is one set which according to him affect the brain, another set which affect the heart. Among the first, he places the more violent impulses on the mind, and various evacuations, but it is easy to prove, that the brain is only secondarily affected in syncope produced by passion, and that it is the heart, whose functions in all these cases are the first to be interrupted. The following considerations, if I am not mistaken, will leave but little doubt on this head.

First,—I have proved, in speaking of the passions, that they never affect the brain in the first place; that the action of this organ, in consequence of their development, is only secondary, and that every thing relating to our moral affections has its seat exclusively in the organic life.

Secondly.—The phenomena of syncope when produced by lively emotion, are similar in every respect to those of syncope, the effect of polypi or dropsy of the pericardium, but in the latter, the affection of the heart is the primary one, and should in consequence be the same in the former sort of syncope.

Thirdly,—At the moment when syncope takes place, we feel the attack at the heart, and not in the brain.

Fourthly,—In consequence of lively passions, which may have occasioned syncope, we find that the heart and not the brain becomes diseased, nothing is more common

common than organic affections of the former from sorrow, &c. The different sorts of melancholy, which are produced by the same cause, for the most part have their principal seat in some of the viscera of the epigastrium, and in such case, the irregularity of the cerebral action is the sympathetic effect of the profound affection of the internal organ.

Fifthly,—I shall prove hereafter, that the cerebral system does not exert any direct influence over that of the circulation; that there is no reciprocity between the two, and that the changes of the first are not followed by similar changes in the second, however much the changes of the second may modify the first. Destroy all nervous communication between the brain and the heart, and the circulation will go on as usual; but if the vascular communications be intercepted, the cerebral action vanishes at once.

Sixthly,—Palpitations and other irregular movements of the heart are often the effect of the same causes, which in some individuals are the occasion of syncope. In such cases, it is easy to discover the seat of the affection, and such smaller effects of the passions on the heart, are very well calculated to throw light upon the nature of the greater.

From these many considerations, we may conclude that the primitive seat of the attack in syncope, is the heart, which does not cease to act, because the action of the brain has been interrupted, but because it is the nature of some of the passions in such way to affect it, the brain at the same time, suffering a temporary death, because it no longer receives the fluid, which is necessary to its excitement. The nature of syncope is well enough illustrated, by the vulgar expression of being sick at heart.

It is of no importance to our present purpose, whether syncope depend on polypi on aneurism, or be the result of some violent emotion. The successive affection of the organs is always the same. They die for the moment in the same way, as they really perish when the heart is wounded, or a ligature put upon the aorta. In the same manner also are those sorts of syncope produced, which succeed after any great evacuation of blood, pus, or water. The heart is affected from sympathy, the brain for want of its excitant.

Those cases of syncope which are occasioned by peculiar odours, by antipathies, &c. appear also to be attended with the same progression of symptoms, though their character be much less easily understood. There is a great difference between syncope, asphyxia, and apoplexy, in the first it is by the heart, in the second by the lungs, in the third by the brain that begins the general death of the body.

Death, as it happens in consequence of disease, in general exemplifies a concatenation of these different symptoms. The circulation, respiration, or cerebral action cease, the other functions are afterwards interrupted of necessity, but in these sorts of death, it rarely happens that the heart is the first to die. This however is sometimes the case. After long continued suffering, great suppuration, and sometimes, in dropsy, certain fevers, and gangrenes, one fit of syncope comes on after another, at last a longer one succeeds, and the patient dies, but whatever be the part affected, whatever the diseased viscus or organ, whenever the phenomena of death commence by the heart, they succeed each other as we have described them to do in sudden death, from lesion of that organ. In other cases, the heart is the last to act, is the ultimum moriens.

In general, in morbid affections, we much more commonly observe the ingress of death to be made by the lungs, than either by the heart, or the brain.

Whenever disease is terminated by syncope, the lungs are found to be almost empty, and if not affected by any organic vice, are collapsed, occupy a part only of the cavity of the thorax, and are of their natural colour.

The reason of this anatomical fact is simple. The circulation which has been suddenly interrupted, has not had time to fill the vessels of the lungs, as happens when death begins, by affecting the lungs or the brain. The truth of this fact I can vouch for, having frequently ascertained it by dissection, and in general, as often as death commences by the heart, or the larger vessels, such vacuity of the lungs may be considered as universal.

I have remarked it in the bodies of persons who have died from great hemorrhagy anurismal rupture and violent passion, as well as in those who have been punished by the guillotine. The same phenomenon may been seen, by inspecting the lungs of any animal, which is killed in our butcheries.

In killing the animal slowly by the lungs, that organ might be filled with blood. Its taste would then be different from that which it naturally possesses, and resemble that of the spleen. Our cooks know well how to take advantage of that state of infiltration in which the latter viscus is generally found.

CHAPTER THE SIXTH.

Of the Influence of the Death of the Lungs over that of the Heart.

We have already said, that the functions of the lungs are of two kinds, mechanical and chemical. Now the activity of this organ ceases sometimes by the former, and sometimes by the latter of these functions.

Any wound, which exposes the lungs on both sides, for a considerable extent, occasions their sudden collapse ; any division of the spinal marrow, which suddenly paralyses the intercostals, and the diaphragm ; any very strong compression exercised at the same time upon the whole of the thorax, and the parietes of the abdomen, any sudden injection of a large quantity of fluid into this cavity, are all of them causes which begin the death of the lungs, by putting an end to their mechanical functions. Those which influence in the first place their chemical functions, are the different sorts of asphyxia, strangulation, submersion, and a vacuum, in whatever manner produced.

§ I.—

§ I.—*In what manner is the death of the heart occasioned by the interruption of the mechanical functions of the lungs.*

The interruption of the functions of the heart, can only succeed in two ways to that of the mechanical functions of the lungs: First, directly, because a mechanical impediment is put to the circulation of the blood, by a state of collapse in the lungs. Secondly, indirectly, because in such state the lungs no longer receive the materials, upon which their chemical functions are exerted, and therefore cannot transmit them to the heart.

Physiologists have all of them admitted the first mode of interruption in the Pulmonary circulation. Reflected on themselves, the vessels of the lungs have not appeared to them, to be capable of transmitting the blood, on account of the numerous angles which they make. This idea they have borrowed from the phenomena of hydraulics, and it is their reason for the death which ensues, in consequence of a too long continued expiration.

Notwithstanding all which it has been proved by Goodwyn, that in such case there remains a sufficient quantity of air in the air vessels, for dilating them enough to allow of the mechanical passage of the blood; he proves in consequence, that an unnatural permanence of the state, in which the lungs are placed from the act of expiration, does not affect the blood in the way, which is commonly believed. This is one step towards the truth, but we shall approach it much more nearly, and even attain it should we be able to prove, not only that there remains a sufficiency of air in the lungs to permit the transmission of the blood, but that the very folds produced in the vessels by a state of collapsus in the organ are not a real impediment to its course. The following observations and experiments will assuredly determine this fact.

1st.—I have already proved, that a state of fulness or emptiness in the stomach, and in all the hollow organs in general, produces no apparent change in the state of their circulation; and that the blood in consequence, will traverse the vessels, when bent or doubled upon themselves, as easily, as when they are distended in every direction. For what reason should a different effect be produced in the lungs, by the same disposition of the parts?

2dly.—There are different vessels in the œconomy which we may alternately bend or extend at pleasure: such are those of the mesentery, when exposed by an incision into the abdomen of the animal. Now in this experiment, which has been already made to prove the influence of the tortuous direction of the arteries upon the mechanism of their pulsation, if one of the mesenterics be opened, and then either bent or extended, in either case the blood will be thrown out with the same degree of violence, and in equal times will be emitted in equal quantities. I have always obtained the same result in this experiment which I have many times repeated. From analogy we might expect the same from the vessels of the lungs; and from the following experiment it may be proved.

3rdly.—Take a dog, cut the trachea, and adapt the tube of an injecting syringe to it, then make a vacuum in the lungs, and cut the carotid artery. It is evident, that according to the common belief, the circulation should be immediately suspended, in this experiment, since the pulmorary vessels from their ordinary state of distension, must have passed to the greatest possible degree

degree of collapsus, in consequence of the total abstraction of air; notwithstanding which the blood will be violently thrown out from the divided arteries for a certain time, and must consequently traverse the lungs: it will afterwards cease by degrees, but this, from causes which I shall explain hereafter.

4thly.—The same effect may be produced by opening, on both sides, the breast of a living animal, because the warm and rarified air of the lungs, will be more than balanced by the pressure of the colder air without; now, neither in this case does the circulation experience any sudden change. For the sake of greater exactness, the little air remaining in the cells of the organ may be voided by a syringe.

Along with these observations let us place the facility with which the pulmonary circulation continues to be made, when collections of water, pus, or blood, are lying within the pleura, or pericardium. In these cases the air vessels are often prodigiously contracted, and consequently the vessels of their parietes doubled and bent. If this state be taken into consideration, we shall have sufficient data for concluding that the tortuous disposition of the vessels, can never be an obstacle to the passage of the blood; and therefore, that the interruption of the mechanical functions of the lungs, can never directly put a stop to the action of the heart, though it may do so indirectly, in impeding the exercise of the chemical functions of the lungs.

If then we can determine why the heart remains inactive, when the latter phenomena are annihilated, we shall have resolved a double question.

Many authors have asserted that the death, which ensues after a too long continued inspiration, is owing to the mechanical distension of the pulmonary vessels by the rarified air, a distension impeding the circula-

 tion.

tion. But this reason also is as false a one, as that which we have already disproved. Inflate the lungs as powerfully as may be, then tie the trachea and open the carotids, and the blood will flow as impetuously, as when the respiration was perfectly free.

§ II.—*Why does the heart cease to act, when the chemical functions of the lungs are interrupted.*

According to Goodwyn, the reason why the contractions of the heart are stopped, when the chemical functions of the lungs have ceased to be performed, consists in the want of that excitement which the red blood only can produce upon the red-blooded ventricle. This ventricle, says he, has not a sufficient stimulus in the black blood, and death is occasioned because it no longer is capable of transmitting any thing to the different organs. In this case death must happen, as it would from ligature of the aorta—precisely in the same way as when its source is exclusively in the heart. The other parts die only for want of blood, just as when in a machine, the principle spring being taken away, the others cease to act, because they are not put into action.

On the contrary, I am persuaded that there is a general affection of all the parts, whenever the chemical functions of the lungs are suspended; I am persuaded that the black blood continues to be pushed on for some time by the aorta, and that its influx into the organs is the occasion of their death; that the organs die in fact, not because they do not receive blood, but because they do not receive red blood; in a word, that they are penetrated by the material cause of their death; so much so, that we may asphyxiate any isolated part at will, by injecting it with venous blood

while

while all the others shall continue to receive the red blood of the heart. At present I shall enquire into the phenomena of the contact of the black blood with the parietes of the ventricle, and refer the reader to the following chapters, for its effects upon the other parts.

The movements of the heart may be stopped and made to cease altogether from the influence of the venous blood in two ways.—1st, As Goodwyn has said, because the left ventricle is not excited by it upon its internal surface.—2dly, Because such fluid, when carried into the substance of the heart by the coronary vessels, must act upon the muscular fibre of the heart in the same way as it does upon the other muscles. Now, for my part, I am assured that the black as well as the red blood, will excite into contraction the internal surface of the aortic ventricle. The following observations and experiments will confirm my assertion.

1st. If asphyxia were to be followed by the consequences which Goodwyn has supposed, it should influence the heart in the first place; the annihilation of the functions of the brain, as in syncope, should be only secondary; nevertheless, asphyxiate an animal, by stopping up the trachea, by placing him in a vacuum, by opening the chest, or plunging him into carbonic acid gas, and it will in every instance be observed, that his animal life is the first to be interrupted, and that the creature externally is dead; but that within the heart continues for some time afterwards to act, and the pulse to be felt.

In this way the symptoms of asphyxia are not the symptoms of syncope. In the latter the cardiac and cerebral actions are suspended at the same instant, in the former the heart survives, as in cases of strong

concussion

concussion of the brain for many seconds. It follows, that in asphyxia, the different organs do not cease to act, because the heart has ceased to supply them with blood, but because it no longer supplies them with that sort of blood by which they can be stimulated.

2dly, If the trachea of an animal be stopped, and an artery opened, the colour of the blood which it emits, will gradually be changed, and at last become as black as that of venous blood. Now, notwithstanding this phenomenon, which is as apparent as it can be, the fluid for some time afterwards is thrown out full as strongly as it would be, were it red. I have seen a quantity of black blood discharged in this way, more than sufficient to kill the creature from hæmorrhage; were it not already dead, in consequence of its asphyxiated state.

3dly, In the last-mentioned experiment, it may, indeed, be alledged, that some remains of air in the air cells, might, as long as the black blood continued to flow, have communicated to it a principle of excitement; but to put it out of all doubt, that the venous blood does really pass into the aortic ventricle, unaltered in its passage from the corresponding cavity, the air may be entirely pumped out of the lungs with a syringe, by exposing the trachea, in the first place, and then adapting the instrument to the transverse section of the tube; after this, let the carotid be opened; now as soon as the red blood contained in this artery is exhausted, the black blood will succeed to it, and that, without undergoing a variety of gradations in colour; in this case also for a time, the jet will be very powerful, and only be gradually weakened; but if the black blood were not an excitant to the heart, its interruption should be immediate.

4th

4th. The following is another proof of the same nature. Expose the breast on one side by sawing exactly through the ribs before and behind: when this is done, the lungs on that side will collapse. Proceed to open one of the pulmonary veins; fill a syringe warmed to the temperature of the human body with venous blood, then push it into the red-blooded ventricle. Now, according to the common opinion upon the subject of asphyxia, such fluid should at least diminish in a sensible way, the movement of that cavity, notwithstanding which, in four successive experiments, I could not observe any such diminution. On the contrary, in one of them, on pushing the piston, the strokes of the heart were augmented in number.

5thly. If the black blood be not an excitant to the heart, it can only want such power, because it contains more carbon and hydrogen, than the red blood; but if the heart of an animal which has been killed expressly for the experiment, by lesion of the brain or of the lungs, has ceased to beat, it may, notwithstanding, be made to contract as long as it preserves its irritability, by throwing into the aortic ventricle either hydrogen gas, or carbonic acid gas. It follows, that neither hydrogen gas nor carbon can act as sedatives to the heart.

The experiments which I made and published last year, on the emphysemata, produced in different animals with these gasses, have established the same truth with respect to the muscles, since they do not cease to move in consequence of such experiments, and after death, preserve their irritability as they usually do.

Lastly, I have often succeeded in re-establishing the contractions of the heart, which have been annihilated in different sorts of violent death, by the injection of

black

black blood into the red-blooded cavities, with a syringe adapted to one of the pulmonary veins.

Thus it is proved, that the red-blooded heart does actually push the black blood into all parts of the body; and in this way is the colour given to the different surfaces, of which, in one of the following chapters, I shall offer a sketch.

Neither does the simple presence of the black blood act in a more sedative way upon the internal surfaces of the arteries. If, in fact, while the tube adapted to the trachea is shut, the blood be made to flow from an artery of the foot, it will be thrown out for some time, with the same force which it would have were the pipe to be open. The action, then, which it exercises in its passage from the heart, upon the parietes of the arteries, does not diminish the energy of these parietes. When this energy decreases, it is at least in part from a different cause.

From the above experiments we may conclude, that the black blood arriving in mass at the red-blooded ventricle, and correspondent arterial system is able, from its sole contact with them, to occasion the action of these cavities; we may be equally certain, that were not the functions of these parts suppressed from other causes, the circulation would continue to be made in a very sensible manner, at least, if not with force.

Of what nature, then, are the causes which interrupt the circulation in the heart and arteries, when they are supplied with venous blood? for when this has been flowing for some time, the jet of it is gradually weakened, and ceases at last entirely; yet if the cock of the pipe be opened, it will be restored with vigour.

I am persuaded that the black blood acts upon the heart as it does on all the other parts, as we shall see

that

that it affects the brain—that it affects the voluntary muscles, the membranes, and the system in general; the tissue of which it penetrates and operates within it as a debilitant upon each individual fibre. I am fully of opinion, that the circulation would be almost as quickly interrupted as in the preceding cases, were it even possible to supply the coronary arteries of the heart with red blood, while the black blood is transmitted to the various parts of the body by the aortic auricle and ventricle.

The black blood operates by its contact with the fleshy fibres, at the extremity of the arterial system and not by its contact with the internal surface of the heart. Thus it is only by little and little, and when each fibre has been as it were injected, that the powers of such fibres diminish and cease. In the contrary supposition, their cessation and diminution should be almost sudden.

It may be demanded in what manner the black blood acts at the extremities of the arteries, upon the fibres of the different organs. Is it upon the fibres themselves, or upon the nerves which are distributed to them? I am rather inclined to suppose the latter to be the fact, and to consider asphyxia as an effect produced in general by the black blood upon the nerves, which every where accompany the arteries of a certain diameter: for as we shall presently see, the debility which in such case the heart experiences, is only a particular symptom of a disease in which the organs in general are the seat of a like debility.

It might be demanded also in what way, that is to say, by what manner of influence, the black blood acts upon the nerves or fibres. Is it from the principles which it actually contains, or from the absence of those which are proper to the red blood? Is oxygen the

the principle of irritability—are hydrogen and carbon the inverse?

These questions have been sufficiently disputed.—Let us stop when we arrive at the limits of rigorous observation. Now, I think, that we shall establish an assertion the most strictly conformable with such principle, in saying generally and without determining the manner, that the heart ceases to act, when the chemical functions of the lungs are interrupted, because the black blood with which its fleshy fibres are penetrated, is not of a nature to keep up their action.

From this manner of regarding the phenomena of asphyxia with relation to the heart, it is evident that both the ventricles should be equally affected by it, because their parietes must be equally injected with venous blood. Nevertheless, it is constantly observable, that the movement of the red-blooded heart is the first to stop; that the black-blooded heart is in every case the ultimum moriens; but this phenomenon does not suppose a more real, a more decided debility in the one, than in the other heart; for as Haller observes, the fact is common to every kind of death in the red-blooded animal, and not the case particularly in asphyxia.—Besides, were the red-blooded heart the first to be absolutely affected, as the theory of Goodwyn supposes, the following would be the appearances on opening the asphyxiated subject.—1st. A distension of the corresponding auricle and ventricle, by the black blood which they would not be able to expel into the aorta.—2dly. An equal fulness of the pulmonary veins and lungs.—3dly, a consequent fulness and swelling of the pulmonary artery and the black-blooded cavities. In a word, the congestion of the blood should be the greatest in that of its reservoirs, whose action is the first to cease.

But

But this is contrary to observation—for 1st. In the asphyxiated subject, the red-blooded cavities and pulmonary veins, contain but a very small quantity of blood in proportion to that which distends the opposite heart. 2dly. The place where the blood has stopped, is found to be principally in the lungs, in the lungs must we begin to follow its accumulation into the venous system. 3dly. The arteries are as full of blood as their correspondent ventricles, and consequently it cannot be in the ventricle, more than elsewhere, that death has been begun.

But what is the reason why the black-blooded heart is the last to beat? because, says Haller, it is the longest excited; because it contains a greater quantity of blood; because the blood is sent into it from the largest veins of the system, and regurgitates from the lungs. The famous experiment is well known by which in emptying the black-blooded cavities, and tying the aorta so as to retain the blood within the red-blooded cavities, the contractions of the latter are prolonged so much beyond the contractions of the former. But in this experiment it is manifestly the black blood which accumulates in the aortic auricle and ventricle, because the breast must be preliminarily opened, and therefore the lungs collapse.

Should a more direct proof be required, immediately before the experiment, let the trachea be closed with a syringe, and the air of the lungs be voided; the experiment will just as well succeed; besides, the operator to be sure of the colour of the blood in the aortic cavities, has nothing more to do than to open them, as soon as he has finished his experiment.

We shall conclude that the black blood is almost as powerful a stimulus as the red blood to the inner surface of those cavities, which usually contain the latter only:

only: the reason why they are the first to be arrested in their action, is, because they do not receive so large a quantity of blood as the others.

Notwithstanding what I have said, I do not entirely reject the idea of the red-blooded ventricle being not excitable by the black blood. It may indeed be less excitable by this sort of blood, than by the other; but I believe that the preceding considerations will reduce this difference of excitement to a mere trifle.

The following, however, is an experiment where such difference would appear to be very manifest. If a stop cock be adapted to the trachea, and an artery opened, the blood will blacken, aud continue for some time to be thrown out with its ordinary force, but at last the jet will gradually grow weaker. If, after this, the air be admitted, the blood will almost immediately become red and its jet be visibly augmented. In this case the sudden augmentation appears at first to depend upon the simple contact of the red fluid with the sides of the aortic ventricle, since it has not had the time to penetrate the tissue of the heart; but let things be a little attentively examined, and it will soon be seen that this impetuosity of impulse, depends on the movements of inspiration and expiration, to which the animal is obliged, on the admission of air into the lungs. The heart excited at its exterior, and perhaps a little compressed by these movements, is the occasion of such phenomenon, and expels the blood with a force which is far beyond that which results from its habitual contractions.

What I have here advanced is proved, by the manifest diminution of the jet, as soon as once the lungs have taken on their accustomed degree of action. Besides, the influence of a series of full expirations may be manifested without dividing the trachea. Open

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the carolid and precipitate the respiration of the animal by tormenting it (for pain will constantly have this effect) and the jet of blood will be visibly increased. The same augmentation may be artificially produced, by suddenly compressing the parietes of the thorax. These experiments succeed best on animals already weakened by the loss of a certain quantity of blood.

In the ordinary state of health however, a series of strong expirations will not be found to quicken the pulse. Of this I cannot assign the reason.

From what we have now said, it follows, that the experiment, in which, on the opening of the cock of the syringe, the blood is thrown out with augmented force, is not so conclusive as might at first be imagined. I confess that it embarrassed me much for many days, I hold then my former conclusions to be good.

In the red and cold-blooded animals, the action of the lungs has not so immediate a connexion with that of the heart, as it has in the red and warm-blooded animals.

I tied the lungs of two frogs at their basis, having previously exposed them, by incisions made laterally into the breast, the circulation however continued as usual for a considerable time. After this experiment, I have seen on opening the breast, the movements of the heart precipitated, a circumstance depending no doubt upon its contact with the air.

I shall finish this chapter by the examination of an important question, and enquire into the reason, why when the chemical functions of the lungs are stopped, the pulmonary arteries, the black-blooded cavities of the heart, and in a word all the venous sytem, are found so much more full of blood, than the aortic system. In such case the circulation appears at first to

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be interrupted in the lungs, and then in the other parts, according to their proximity to the lungs.

This phenomenon must have been observed by all who have opened the asphyxiated subject. It has been explained by Haller and others, from the tortuosity of the vessels; but this opinion I have sufficiently refuted.

But before I proceed to assign a more real cause, I shall observe, that the lungs, (when the blood is first arrested, because it finds in them the first obstacle to its progress,) are found in a singularly various state, according to the kind of death of which the individual has died. In sudden, in instantaneous death, neither the lungs, nor the black-blooded heart are very much distended.

I have observed this fact, 1st, in the bodies of two persons who had hanged themselves and were brought into my amphitheatre. 2dly, On two subjects who had fallen into the fire, and were instantly suffocated. 3rdly, On dogs which I have suddenly drowned. 4thly, Upon guinea-pigs, which I have killed in a vacuum, or in different gasses, or otherwise.

On the contrary, arrest the phenomena of respiration in a gradual manner; drown the animal by plunging him in water, and taking him out alternately, asphyxiate him by placing him in a vessel of gas imperfectly closed, continue as long as possible such state of pain and anguish, and the lungs will be found extremely full of blood.

Between the extreme fulness, and the almost complete emptiness of the pulmonary vessels, there is a variety of degrees; now by the manner in which we kill the animal, we can determine any one of these degrees at will: It is in this way that we must explain that state of fulness in the lungs of such subjects, as are

usually

usually brought into our amphitheatres : in the greater number of cases, the attacks of death are slow and gradual.

But whatever be the state of the lungs in the asphyxiated subject, the venous system is full of black blood, especially about the heart. In this respect, there is always a very wide difference between the veins and the arteries, and accordingly the blood must find in the lungs the principal obstacle to its circulation: such obstacle as we have said, does not proceed from the tortuosity, and state of collapse in the pulmonary vessels; its causes are relative, first to the blood, secondly, to the lungs, thirdly to the heart.

The principal cause depending on the blood, consists in the great quantity of this fluid, which passes from the arteries into the veins. In fact we shall soon see, that the black-blood when it circulates in the arteries, is not capable of furnishing the materials of secretion, exhalation, or nutrition, or if it be so, that it is not a stimulus to the organs which are the agents of these functions.

It follows as a necessary consequence, that the portion of fluid which is usually taken up from the arterial system by these different functions, flows on into the venous system, together with the portion which should naturally pass thither ; hence there must be contained a greater quantity than usual in the veins ; and therefore a greater difficulty be experienced in its passage through the lungs. Practitioners in opening the bodies of asphyxiated persons, have always remarked the abundance of blood which is met with there. The fact has been particularly remarked by Portal, and I have always found it in my experiments.

The causes of obstacle to the passage of the blood proceeding from the lungs, are first the non-excitement

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of this organ by arterial blood. In asphyxia, the bronchial arteries are penetrated by the black blood as well as the rest. Hence its obscure and dusky colour in this case. This colour and its successive shades, may be easily remarked in the collapsed lung, when the chest is opened; but in asphyxia, such blackness is principally owing to the colour of the blood, contained in the pulmonary veins.

The black blood when circulating in the bronchial vessels, produces upon the lungs the same effect which it does in the heart, by penetrating the coronary arteries; it weakens the different parts —impedes their action, and the capillary secretions which should be made there, from the tonic powers of the organ.

The second cause of obstacle to the circulation, when the chemical functions of the lungs are interrupted, is the non-excitement of the organ by vital air. The first effect of such air upon the mucous surfaces of the air-cells, is to stimulate them, and so to keep them up in a sort of perpetual erethism. In the same way are the powers of the stomach brought into action by the presence of aliment there, and those of every reservoir of the body, by the influx of their accustomed fluids. Again, such excitement of the mucous surfaces by foreign substances keeps up their tone. The privation of such excitement, therefore, must put a stop to their capillary secretions, which depend upon their tonic powers.

The different aeriform fluids which replace the atmospheric air in the different sorts of asphyxia, appear to act very differently upon the tonic powers, or the insensible organic contractility of the lungs. Some of these put a sudden stop to the circulation, others not. Compare the asphyxiæ produced by nitrous or sulfu-

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sulfurated hydrogen gas, with those which may be occasioned by pure hydrogen, or carbonic acid gas, and the difference will instantly be seen. This difference indeed, as well as the various other phenomena observable in the various asphyxiæ, depends on causes which we have not mentioned, but the affection of the air-cells, is evidently one of them.

Lastly, the third cause of stagnation of the blood in the venous vascular system, is that debility, which takes place in the ventricle and auricle of this system, when penetrated with venous blood: on the influx of the blood from the cava, they are consequently distended, and this is the case also with the cava itself, for the very same reason. The causes which are now assigned, are sufficient to shew why the black-blooded system, is gorged with fluids in asphyxiæ. The following considerations will shew why the red-blooded system contains a lesser quantity of fluid.

1st.—The obstacle commences in the lungs; therefore the aortic heart must receive a less quantity than usual: hence, as we have seen, proceeds the quicker cessation of the contractions of this ventricle.

2dly.—The natural strength of the arteries, though enfeebled by the influx of blood into their parietes, is much superior to that of the veins, which besides are subject to the same cause of debility. Accordingly, these vessels and the aortic ventricle, are capable of surmounting the resistance of the capillary vessels of the body in general, much more easily than the veins and the venous ventricle, are of vanquishing the capillaries of the lungs.

3dly.—In the general capillary system, there is only one cause of want of action, viz. the presence of black-blood in it; to this in the lungs there is added another cause, the want of that habitual excitement which this organ receives on the part of the atmospheric air: accordingly in the lungs, there is a greater resistance offered to the influx of the blood, and with respect to the heart, a less capability of surmounting such resistance. In the other parts, the contrary of all this is observed, a less resistance to the influx of the blood from the arteries into the veins on the one hand, and on the other a greater capability of overcoming such resistance.

4thly.—In the general capillary system, which is continued on from that of the arteries, if the circulation be embarrassed at first, in any organ in particular, it may still continue to go on in the other organs, more or less, in which case the blood regurgitates by these others into the veins. On the contrary, as all the capillary system, which is the continuation of the general venous system, is concentrated in the lungs, the venous circulation must be suppressed, whenever this organ loses its powers.

The preceeding considerations, if I am not mistaken, explain why the vascular systems are so unequally full of blood after death, a circumstance, which is common to almost every disease, as well as the asphyxiæ.

In the latter sort of death however, although the general capillary system present a less degree of resistance than is made by the capillary system of the lungs, nevertheless such resistance arising from the influx of the black-blood into the organs in general is very manifest, and produces two remarkable phenomena.

The first is a greater quantity than usual of black-blood in the arteries, and therefore a greater difficulty of injecting these vessels. Such blood is seldom coagulated. Indeed in all cases the venous blood is much less coagulable than arterial blood. This fact is proved,

proved, 1st, by the experiments of modern Chemists. 2dly, by the comparison of the blood of varices with that of aneurisms. 3rdly, by the inspection of that which usually stagnates after death in the veins of the neighbourhood of the heart.

The second circumstance, to which I have referred, is the general livid colour of the greater number of the surfaces, with the fulness of divers parts, such as the face, the tongue and lips. These two phenomena indicate a stasis of the blood at the extremities of the arteries, in the same way as they denote the same effect in the pulmonary vessels; here there is a much more evident repletion, because as I have said, the capillary system is there concentrated within narrow limits.

The reflux of the blood of the veins towards the extremities is the reason assigned by authors for the livid appearance of asphyxiated persons. There is little reality in this cause: in fact, this reflux, which is very sensible in the trunks of the veins, diminishes continually towards their ramifications, where it is impeded and rendered impossible by the valves, besides which, the following experiment is an evident proof, that we must attribute the lividity in question, to the impulse of the black-blood from the aortic ventricle.

1st.—Adapt a syringe with its stop-cock to the divided trachea. 2dly, open the abdomen so as to distinguish the intestines and epiploon. 3rdly shut the cock. At the end of two or three minutes, the red tint which animates the peritoneum, and which is borrowed by this membranne from the vessels, which creep underneath it, will be changed into a dull brown color. This colour may be made to disappear and re-appear at will, by opening or shutting the syringe.

Here we cannot, as if the experiment were made upon other parts, suspect that a reflux is propagated from the right ventricle towards the venous extremities, since the mesenteric veins, together with the other branches of the vena portæ, form a system apart, independent of the great black-blooded system, and having no communication with the cavities of the heart which correspond with this system.

But I shall touch again upon this subject. The above experiment is amply sufficient to prove, that the lividity of the surfaces of the body is owing to arterial impulse.

At present we are in a condition to explain how the lungs are more or less gorged with blood, more or less livid, and how the livid spots upon the different parts of the body are more or less marked accordingly as the asphyxia has been more or less prolonged: for it is evident, that if before death, the black blood have gone round the two systems ten or twelve times, it will inject the extremities much more that if it had made such circulation only two or three times; at each revolution, a greater or lesser quantity will be left in the extremities, for want of action in the capillary vessels.

In finishing this chapter I shall take occasion to observe, that the spleen is the only organ of the economy susceptible like the lungs of assuming a very great variety of volume. Scarcely is it ever found in the same state. It has been falsely supposed that there is a relation between the plenitude or vacuity of the stomach, and the inequalities of the spleen; but this is not the case, as I have said elsewhere. Such inequalities during the life of the body do not exist, and supervene only at the instant of death.

It appears to me, that they depend especially upon the state of the liver, the capillary vessels of which,

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are the continuations of all the branches of the vena portæ as the capillaries of the lungs are those of the great venous system. Thus, when the hepatic capillaries from any cause whatever are enfeebled, the spleen must swell and be filled with the blood, which cannot traverse the liver. In such case, if I may so express myself, there is an isolated asphyxia of the abdominal vascular apparatus. The liver being to the spleen, what the lungs are to the black-blooded cavities in common asphyxia. The resistance is in the former, the stagnation in the latter. But this matter may be better understood hereafter. Experiments upon animals killed in different manners, would throw much light upon it, and these I purpose undertaking. By these means we may rigorously establish the analogy xisting between the stagnation of the blood in the different branches of the vena portæ, and that which is observed in the general venous system, in consequence of various kinds of death. With respect to the spleen and its system of veins, in ordinary asphyxia, I have never remarked in it any peculiarity.

CHAPTER THE SEVENTH.

OF THE INFLUENCE OF THE DEATH OF THE LUNGS OVER THAT OF THE BRAIN.

WE have just seen, that in asphyxia, the movements of the heart are paralyzed, because its fleshy fibres are penetrated

penetrated with venous blood. This fact should indicate the same to be the case with reference to the action of the brain. It is indubitably proved by experiment.

Whatever be the manner in which the pulmonary functions are interrupted, it is always the interruption of the chemical changes, which troubles the functions of the brain. What I have said upon this point with respect to the heart, is exactly applicable to the cerebral mass: I shall not repeat it. It remains to shew by experiment, and the observation of diseases, that when the chemical functions of the lungs are put a stop to, it is the black blood which interrupts the action of the brain and that of the nervous system. In the first place let us examine our experiments.

I first began by transfusing into the brain of an animal, the arterial blood of another, that this essay might serve as a point of comparison for others. Open one of the carotids of a dog; tie the extremity towards the brain, and fasten a tube to that which is next the heart; then open the carotid of another dog, tie the extremity of the vessel next the heart, and fix the other end of the tube into that which is next the brain; then let the assistant, who meanwhile should have had his fingers upon the artery of the first dog underneath the tube, remove his compression, and the carotid of the second dog will be seen beating under the impulse of the blood injected from the heart of the first. This operation fatigues but little the animal which receives the blood, particularly if one of the veins be previously opened, to prevent too great a fulness of the vessels. It will live very well afterwards. This experiment has been often repeated, and always with the same results.

After this experiment, I opened the carotid, and the jugular vein of another dog, and after tying the ex-

tremity

tremity of the carotid next the heart, received the blood of the jugular into a warm syringe, and injected it into the brain. The creature appeared immediately to be agitated, breathed quickly, and seemed to be in a state of suffocation, similar to that of asphyxia. Its animal life became entirely extinct; the heart, however, continued to beat, and the circulation to go on for half an hour afterwards; at the end of which time the organic life was terminated also.

This dog was of a middle size, and about six ounces of blood were injected with a gentle impulse, for fear of that being attributed to the shock, which ought to have been the result of the nature and composition of the fluid. I repeated this experiment upon three dogs the same day, and afterwards at different times upon others; the result was invariable, not only as to the asphyxia or the animal, but even as to the concominant appearances.

It might be thought that out of its vessels, and exposed to the contact of the air, the blood might imbibe a pernicious principle, or be deprived of that which is requisite for the maintenance of life. It might be imagined, that to this cause was owing the sudden death of the dog, on the injection of the brain with venous blood. To shew that this was not the case, I made a small opening in the jugular of a dog, to which I adapted a moderately warm syringe, and pumped the blood immediately from the vein.—It was afterwards thrown into the carotid; the symptoms were the same as the preceding, but less marked, and the death of the creature induced more slowly.—It is probable, then, that the air when in contact with the living blood without its vessels may alter it a little, but the essential cause of death is still the same.

Hence it appears that the black blood either is not an

excitant

excitant capable of keeping up the cerebral action, or that it acts in a deleterious manner, upon the brain. The injection by the carotid of different other substances will produce analogous effects.

I have killed animals in this way with ink, oil, wine, and water coloured with Indigo. The greater number of the excrementitious fluids, such as urine, bile, the mucus of catarrhs, occasion death also by their simple presence of the brain. The serosity of the blood is fatal, but not so quickly so. Now it is certainly upon the substance of the brain, and not upon the internal surface of the arteries, that these different substances exert their influence. I have injected them all into the crural artery. In this way they are none of them mortal, but occasion always a torpor, amounting even to paralysis at times.

The black-blood is doubtless fatal to the brain, the brain becoming at once atonic from its presence. In what way does it act? I do not pretend to assign the manner; for this were only to begin a series of conjectures.

By this time we are authorised to conclude, that in asphyxiæ, the circulation which continues for some time after the interruption of the chemical functions of the lungs, interrupts the cerebral functions, from its being composed of black-blood only. The fact is proved in another manner, for the movements of the brain continue to be made as usual.

If the cerebral mass be exposed, and the creature asphyxiated, the animal life will be extinguished, but the motion of the brain apparent still. Since then the latter cause of life subsists, the cause of death must be in the nature of the fluid, by which the organ is penetrated.

Nevertheless, if any affection of the brain coincide with asphyxia, the death which is occasioned by the latter

latter, will be quicker than is usually the case. Strike a dog a violent blow upon the head, and then if he be deprived of air, he will die on the instant. In asphyxiating another animal already in a state of stupor, from compression of the brain, I observed that the vital functions were interrupted somewhat sooner, than when the brain is intact during that operation; but the consequences hitherto deduced, may be supported by other experiments.

If in asphyxia the black-blood supend the action of the cerebral mass, it is evident that the black-blood taken from the arteries of an animal dying of asphyxia, and injected into the brain of another, will be the cause of death.

The experiment will be found to succeed—cut the trachea, of a dog, and tie it up hermetically; then in the course of two or three minutes, open the carotid and receive into a syringe the blood, which flows from the vessel; inject it into the brain of another animal, and it will die.

The following experiment is very similar, but offers a somewhat different result. 1. Adapt a tube with a stop-cock to the trachea of a dog, and a tube of silver to the carotid, next the head, after dividing this vessel, and tie up the extremity towards the heart. 2dly. Fix the other end of the tube to the divided carotid of another dog next the heart, and tie the extremity of the vessel towards the head. 3dly. Shut the cock of the tube in the trachea, and the black-blood of the one dog in a short time, will be injected into the brain of the other.

The appearances above described will shortly afterwards succeed, but not so soon as in the former experiment, and if the transfusion be stopped, the animal which has been asphyxiated in this way, may recover and live. In the preceding experiment he will always die.

die. It appears then that some extraneons pernicious principle is imbibed by the venous blood, when in contact with the air. Observe that for the latter experiment the dog from which the brain of the other is to be injected, must be stronger and more vigorous than the other. The reasons are evident.

I was desirous of trying whether the venous blood would not be capable of keeping up the cerebral action, if reddened artificially. For this purpose I opened the jugular and the carotid of a dog, and received the blood of the vein in a vessel filled with oxygen; it immediately became of a vivid purple, but on its injection into the brain, the animal was very suddenly killed. I was much surprised at this result, but ceased to be so on remarking, that a great quantity of air was mixed with the fluid, and that it arrived upon the brain, in a state of foam: now we know that a very small number of bubbles are sufficient to kill an animal, whether they be introduced on the side of the brain, or on that of the heart.

From this reflection, I was induced to repeat my experiments upon the injection of black blood, suspecting as I did that some small quantity of air might in these cases have been contained in the extremity of my syringe. I soon however recollected that if this cause were real, it should produce the same effect in every instance whatever were the fluid employed, now when water is injected there is nothing of the kind observable.

We may be thus assured that the black blood is either incapable of keeping up the action of the brain, or that it acts in a deleterious manner upon that organ, from the very nature of the principles, which it contains. From such datum it should appear that the life of the asphyxiated person might be restored, by pushing on into the brain a sufficient quantity of arte-

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rial blood, but here we must make a distinction of two periods in asphyxia: 1st. That in which the cerebral functions are only suspended: 2dly. That in which the circulation and the movments ofthe breast are stopped (for this disease is ever characterised by the sudden loss of all animal life, and consecutively by that of the organic life.) Now, as long as the first period of asphyxia continues, I have observed that, by the transfusion of red blood into the brain, from the heart of another animal, the movement of the creature which is dying will be restored by degrees, and the cerebral functions resume in part their activity; but this is only a temporary thing, and the animal will fall again into its previous dying state, if the asphyxiating cause be continued.

On the other hand, if during the 1st period, to which we have alluded, the air be readmitted, into the trachea, the lungs will be reanimated, the blood be coloured, and the creature be revived without the assistance of any transfusion; and such transfusion again is of no avail, after the second period of asphyxia, so that this experiment offers only a proof of what we already know; with respect to the difference of the influence of arterial and venous blood upon the brain, and not a remedy in case of asphyxia.

Again, whenever I have injected venous blood into the brain, by the help of a syringe, I have universally found that such proceeding is mortal. Though the cause of asphyxia be removed, and arterial blood injected, either with the syringe, or immediately from the heart of another animal, it is of little effect, and frequently of none whatever. And in general asphyxia when produced by blood, which has been taken from the venous system itself and pushed into the brain: is much more certain and more decided, than that which is occasioned by ligature of the trachea, or the introduction of different gasses into the lungs.

After having established by different experiments, how fatal the influence of the black blood is upon the brain, which receives it from the arteries whenever the chemical functions of the lungs are suspended, it will not be amiss or out of place to shew, that the phenomena of the asphyxiæ, which are observed in the human subject, accord with the experiments of which I have given the detail.

1st. It is generally known that every kind of asphyxia affects the brain in the first instance; that the functions of this organ are the first to be annihilated; that the animal life, and particularly the sensations cease; that all our relations with exterior objects are instantly suspended, and that the organic functions are only consecutively interrupted. Whatever be the mode of asphyxia, by submersion, strangulation, gasses, or a vacuum, the same phenomena occur at all times.

2dly. It is known that the greater number of those who have escaped suffocation, have been sensible only of a general stupor, the seat of which has been evidently in the brain. It is known also, that death is almost always certain in these cases, while the pulse and the heart have ceased to be felt.

3dly. It is affirmed by almost all such persons as have survived this accident, especially when caused by the vapour of charcoal, that the first thing of which they were sensible, was more or less pain in the head, an effect in all probability occasioned by the first influx of the black blood into the brain. This fact has been noted by the greater number of authors, who have written on asphyxia.

4thly. The vulgar expression that "charcoal flies to the head" is surely a proof that the brain, and not the heart,

heart, is the first affected in the asphyxia occasioned by this deleterious substance. The unprejudiced vulgar, oftentimes observe more correctly than we do, who frequently see only what we wish to see.

5thly. There are many examples of persons, who after escaping the pernicious effects of the vapour of charcoal, have been subject afterwards to paralytic affections, and loss of memory. Such changes have evidently their seat in the brain. Convulsion also is frequently the effect of the impression of mephytic vapour: head-ache is a common symytom, and for the most part remains after the others have disappeared In every book of cases may be seen examples of these affections.

In cold-blooded animals, and in reptiles especially, his influence of the black blood on the brain, thought real, is much less apparent. Make an incission into both sides of the breast of a frog, then tie the lungs at their root, and the animal will live notwithstanding for a considerable time. Cut away the lungs entirely, and the same phenomenon will be remarked. In fish, the relation between the lungs and the brain, is somewhat more direct, for by the organization of the branchiæ, they differ essentially from reptiles. I have taken away the cartilaginous plate which covers the gills of the carp, the motion of the gills however continued to be made as before, and the animal lived without any apparent injury done to its functions. I afterwards put a ligature about the cartilaginous rings which sustain the branchiæ, so as to hinder all motion in the pulmonary apparatus. The effect was, that the animal languished, his fins dropt, his muscular movements soon grew weak, then ceased entirely, and the creature in the course of a quarter of an hour was d ad. The same phenomena with some little variety, were observable in a carp from which I cut away the ranchiæ.

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After all however, the particular nature of those relations, which unite the heart, the lungs, and the brain, both in the red and cold blooded animals, is well worthy the farther investigation of physiologists. The latter sort of animals, can neither be subject to syncope or apolexy, or at least the character of these diseases must be very much modified in them. They are with much more difficulty asphyxiated. We shall now return to those species which bear a nearer resemblance to man.

From the influence of the black blood over the heart, the brain, and the rest of the organs, it was my opinion, that persons affected with varicose aneurisms, would perish less quickly from asphyxia than others; because the red blood passes into the veins, and traverses the lungs without requiring alteration. Accordingly, it should be capable of keeping up the cerebral action.

To be assured if this suspicion were well founded, I made a communication between the carotid artery and jugular vein of a dog, by means of a curved tube. The pulsation of the artery was thus communicated to the vein. I afterwards asphyxiated the animal by stopping the trachea, but the phenomena of death were little different from those of common asphyxia.

We may conclude with certainty, from the various considerations and experiments exposed in the present chapter,

1st. That where the chemical phenomena of the lungs are interrupted, the black blood acts upon the brain, as it does upon the heart, by penetrating the tissue of that organ, and depriving it of the excitement, which is necessary to its action.

2dly. That its influence is much more rapid upon the first, than on the second of these organs.

3dly.

3dly. That it is the inequality of such influence, which occasions the difference in the cessation of the two lives in the case of asphyxia. The animal life is always annihilated before the organic life.

We may conceive from what has been said in this and the preceding chapter, how unfounded are the suspicions of those who have supposed that the brain, after the separation of the head from the body by the guillotine, might live awhile and have sensation. The action of this organ is immediately connected with its double excitements.—1st, by motion; 2d, by the nature of the blood which it receives. Now, when the interrution of such excitement is sudden, the interruption of every kind of feeling must also be sudden.

When the chemical functions of the lungs are suspended, the disturbance induced in the functions of the brain, has indeed a very considerable influence on the death of the other organs; nevertheless, such dirturbance is the beginning of death only in the animal life, and even then is connected with other causes. The organic life ceases from the sole presence of the black blood among the different organs. The death of the brain is only an isolated and partial phenomenon of asphyxia, which does not take place in any particular organ, but in all alike. We shall explain this assertion in the following chapter.

CHAPTER THE EIGHTH.

OF THE INFLUENCE OF THE DEATH OF THE LUNGS OVER THAT OF THE ORGANS IN GENERAL.

I HAVE just shewn in what way the interruption of the chemical phenomena which take place in the lungs, annihilates the functions of the heart and brain. It remains me to shew, that the other organs of the body are as much affected by such cessation; so that asphyxia, as I have said, is a general disease, and not an affection of any one organ in particular.

But before I proceed to analyze the effects of asphyxia upon the organs in general, and consequently the mode of action of the black blood upon them, it may be of use to explain the phenomena of the production of this kind of blood, at the instant when the functions of the lungs are suspended. This paragraph will possess, perhaps, some interest; it might have belonged indifferently to either of the preceding chapters.

§ I.—*Exposition of the phenomena of the production of black blood, when the chemical functions of the lungs are suspended.*

It is known in general, that the blood is coloured in traversing the lungs, that of black it becomes red; but this very interesting fact, has not been hitherto the

the object of any precise or rigorous experiment. The lungs of the frog, of which the air vessels are large, and the membranes thin and transparent, would serve very well for the purpose of observing the process of the phenomenon in question, but for the slowness of respiration in these animals, the difference of organization in their lungs, and the too small quantity of blood by which they are traversed. On such account there can be little analogy between them and the more perfect animals, and then again our experiments upon these little amphibiæ, are all of them rendered incomplete, by the tenuity of their pulmonary vessels, and the impossibility of observing the correspondence of the change of velocity in the circulation, with the colour of their blood.

The phenomena of the respiration of man, and those of the functions which are dependent on it, can be illustrated only by experiments made upon animals with a double ventricle, with a complete pulmonary apparatus, possessed of a temperature superior to that of the atmosphere, and the two separate systems of venous and arterial blood ; but on the other hand, in the mammifera resembling man, their respiratory apparatus, the thickness of the vessels and cavities of the heart, impede the view of the blood which they contain ; and experiments made without an absolute inspection of the fluid there, can only give us approximations. The indecisive experiments of former physiologists on this subject were my motives for the present enquiry.

One of the best methods of judging of the color of the blood, consists as I have often said, in fixing a tube with a stop-cock to the trachea. By this, the influx of air into the lungs, may be regulated or altogether stopped. By this, we may distend the organ, or en-entirely evacuate it ; it gives us also the facility of in-

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troducing whatever gas we please. The animal breathes very well by such pipe when it is open, and would live with it for a considerable length of time without any very great alteration in its functions.

In the second place, an artery, the cural or carotid for instance, must be opened with the view of observing the varieties of color in the blood projected from it. A small artery should not be chosen. From such a one the course of the blood would be suspended by the slightest accident; and on the other hand, the larger arteries expend in a little time too large a quantity of blood; this inconvenience may be remedied, by adapting to these vessels a tube of a small diameter, or a stop-cock.

All things being thus prepared, on a dog, for instance, let us see what are the phenomena which take place, when the colour of the blood is altered. In my indication of these, however, I shall speak only of what I have seen, and by no means pretend that in man their duration should be similar or uniform, or even that in animals of the same species, under the different circumstances of sleep, digestion, exercise, and passion, &c. if it were possible in such way to repeat them, they should be alike. The instability of the animal functions, as I have said, is extreme; they cannot be submitted to calculation; they remain indeed the same, but their variations as to plus or minus are innumerable.

Let us now return to our subject:

1st. If the cock of the pipe be shut immediately after the animal has inspired, the blood begins to be altered in colour at the end of about thirty seconds.— At the end of a minute its colour is dark; at the end of a minute and half or two minutes, it is perfectly similar to venous blood.

2d. If the cock of the pipe be shut immediately after the

the animal has expired strongly, the blood receives its tinge of black some seconds the sooner.

3dly. If the air of the lungs be pumped out entirely with a syringe, the blood will suddenly pass from red to black. In such case it appears that the artery immediately throws out a black stream, after it has expelled the red blood which it previously contained.—There is no gradation. The blood is expelled by the arteries, such as it is in the veins.

4thly. If, instead of making a vacuum in the lungs, we inflate the air cells to the full, the blood is a longer time in becoming black, a minute at least, and is not completely black before the end of three minutes.—This will vary according to the quantity of air injected.

From all these experiments it follows, 1st, that the length of the interval, during which the blood retains its red colour, is in direct proportion to the quantity of air contained in the lungs; 2dly, that as long as there remains any quantity however small of respirable air in the cells of the lungs, the blood will preserve more or less of its crimson colour; 3dly, that this colour diminishes in proportion as the respirable air diminishes; and 4thly, that the blood is exactly similar to that of the veins, as soon as the whole of the vital air in the extremities of the bronchiæ has been exhausted.

In my different experiments with regard to asphyxia, I have remarked, that if after shutting the cock of the syringe, the animal agitate the chest by similar movements to those of inspiration and expiration, the blood is a longer time in losing its red colour, than in the case where the breast remains at rest. Such motion and agitation must cause a circulation of air in the cells, in consequence of which, a greater number

of

of its points must be presented to the circulating fluid. My experiments which I shall presently detail on the breathing of animals in bladders, will prove the truth of the above explanation.

At present I pass to a contrary set of phenomena—to those which are exemplified when the blood regains its arterial colour during the period, which, from a state of asphyxia, restores the animal to life.

1st. When the cock, which for some minutes has been shut, is opened, the air immediately penetrates into the bronchiæ; but previously the animal expires strongly. Six or seven large inspirations and expirations follow each other precipitately. The artery being now examined, a jet of a very vivid colour is seen succeeding to the efflux of black blood, and takes place in thirty seconds at most, from the time of opening the tube. This is the inverse of the phenomenon above described. There are no successive shades perceived from black to red; the passage is instantaneous. The brightness of the colour seems even to be greater than is natural.

2dly, If instead of suddenly turning the cock, a very strong stream of air only be admitted, the colour is less lively indeed, but just as quickly regained.

3dly, If there be adapted to the stop-cock a syringe full of air, and this fluid be pushed into the lungs, on opening the pipe, and then the pipe be suddenly shut again, the blood will become red, but much less evidently so than when the entrance of the air is owing to voluntary inspiration. Here the portion of air injected must repel into the bottom of the cells whatever is already vitiated, while on the contrary, if the tube be simply opened, the vitiated air is at once rejected,

and

andthen replaced from without. The following experiment appears to confirm this idea.

4thly, If instead of pushing air upon that which is contained in the lungs, we pump out the vitiated air in the first place, and then inflate the organ, the coloring process will be more rapid, and the colour of the blood itself especially, more lively than in the preceding case, though less so than in the first of this latter suite of experiments.

5thly, The lungs being exposed on both sides by a lateral section of the ribs, the circulation will continue to go on for a certain time. Now, if by means of a syringe adapted to the stop-cock in the trachea, the pulmonary vesicles be alternately emptied and dilated, the changes from red to black, and from black to red, will be observed as in the above experiment, as long as the circulation lasts.

The following consequences may be inferred from the facts, which I have mentioned.

1st, The rapidity with which the blood becomes red again, on opening the pipe in the trachea, is a plain proof, that the principle from which this colour is gained, must pass into the blood across the membranous parietes of the air cells, and not by means of the absorbents. I shall establish this fact hereafter upon other proofs.

2dly, The celebrated experiment of Hook, in which the enfeebled movements of the hearts of animals in a state of asphyxia are accelerated by injecting air into the lungs, is very well explained. The red blood penetrates into the fibres of the heart, and puts an end to the debility induced, by the influx thither of the black blood.

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3dly, I do not believe, that motion can ever be restored to the heart, when once it has been wholly annihilated by the presence of venous blood. In this I have never succeeded, though I have often attempted it. Many authors, however, pretend to have done so. If the heart be reanimated by arterial blood, it is necessary at any rate, that such blood should pass into it, now in what way can it arrive there, if the circulation have entirely ceased.

We must observe, however, that there are two cases of interruption in the action of the heart from asphyxia. Sometimes there supervenes a syncope which arrests the movement of this organ, before the black blood has been able to produce such effect; and here it is manifestly capable of excitement, from the presence of the red blood, just as it is from the application of any irritating cause; but when it has been injected with venous blood, it then contains within itself the principle of its inertia, which can be removed only by the contact of arterial blood with it; but such contact is become impossible.

I was very desirous of knowing what the influence might be of the different gasses when inspired upon the colour of the blood. Accordingly I successively adapted to the pipe different bladders, containing hydrogen and carbonic acid gas.

The animal alternately swells and straitens the bladder by the different motions of the thorax. It is calm at first, but at the end of three minutes, begins to be agitated; its respiration is now hurried and embarrassed, and at the end of four or five minutes, the blood of the carotid is black.

Whichever of the two gasses be employed, there is little difference in the above phenomena. This

remark

remark should be compared with those of the members of the institute, who have assured us that complete asphpxia supervenes only after an interval of ten minutes, with pure hydrogen, and at the end of two minutes with carbonic acid gas. The black blood must continue, therefore, to circulate for a longer time in one than in the other kind of asphyxia here spoken of. This circumstance confirms some reflections which I shall have occasion to offer upon the difference of asphyxiæ.

For what reason should the blood be a longer time in losing its colour, when bladders of non-respirable air are fixed to the pipe, than when the cock is simply turned? The reason of this is evident. By the different motions of the lungs, the air is expelled and reabsorbed, the respirable portion of it must consequently be successively presented to the capillary orifices, by which it is transmitted to the blood.

On the contrary, when the pipe is simply shut, the air it is plain has not the same influx and efflux; in comparison with such motion, it may be said to stagnate, so that the respirable portion of that which is enclosed in the bronchial cells is exhausted, and the blood ceases to be coloured, though there remain in the trachea and its larger divisions, a considerable quantity of fluid, which has not been despoiled of its vivifying principle. Of this we may be certified, after the death of the animal, by cutting the trachea under the pipe, and plunging a bougie into it. The process by which the blood gains its red colour appears to take place only at the extremities of the bronchiæ, the inner surface of the larger aerial vessels, has nothing to do with this phenomenon.

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We may convince ourselves of the reality of the explanation which I have offered, if we pump out the air of the lungs, before we fit the bladder to the trachea; for in such case, the animal must breathe the air of the bladder without mixture. Here the change of the blood to black is almost sudden, but here also, as in the preceding experiment, there is littledifference in the phenomena, whatever gas we employ. I have chosen the two gasses above mentioned, because they enter into the phenomena of natural respiration.

When we adapt to the pipe a bladder full of pure oxygen, the blood is very long in becoming black, but does not at first assume a redder tint than it usually has.

§ II.—*The blood which has been blackened in consequence of the interruption of the chemical functions of the lungs penetrates into the organs, and circulates for some time in the vascular system of the red blood.*

WE have just established what are the phenomena of the alteration of colour in the blood, when the chemical functions of the lungs are suspended. Before we consider the influence of this change upon the death of the organs, let us prove, that they are really penetrated by the blood when so altered.

I have proved it to be a fact, that the force of the heart subsists for some time, notwithstanding the influx of the black blood into it, and have shewn that the black blood is thrown out with a jet, similar to that of the red blood, &c. &c. Hence I might already conclude, 1st, that the arterial circulation continues for a certain time, though the arteries contain a fluid, to which they

they are not accustomed, and 2dly, that the necessary consequence of such circulation, must be the injection of the different parts of the body with black blood; but we shall deduce the latter couclusion from precise and rigorous experiments. To be certain of this important fact, we have only to expose successively the different organs, while the animal is suffering a death of asphyxia. I have in this way examined the muscles, the nerves, the membranes and the viscera. The following are the results of my observations.

1st. The colouring matter of the muscles, exists in the body in two states—at liberty, or in a state of combination; in the vessels, where it circulatates with the blood, or in the fibres, with which it is combined. It forms especially the colour of the muscles, and in such state undergoes no alteration from asphyxia; in its free state it is blackened. The divided muscles furnish an infinity of black drops, which are no other than indices of the divided vessels. Such drops contrast with the red of the muscles; but when circulating within them, are the cause of that livid tint which they then present.

2dly. The nerves are habitually penetrated by a number of small arteries, which creep along within their tissue, and carry to them both excitement and life. In the state of asphyxia the black blood by which they are traversed, is announced by the dull brown, which succeeds to the rosy-white, which is natural to them.

3dly. There are few parts, where the influx of the black blood is more visible, than in the skin; the livid spots so frequent in asphyxia, are only the effect of the obstacles which it meets with, in its passage towards the general capillary system, to the organic contractility of which it is not a sufficient excitant. To this cause also is owing the tumefaction of certain parts, such as the cheeks and lips. This phenomenon we have seen already in the lungs, they cannot be traversed by the blood and therefore become in the last moments of life, the seat of a fulness, which affects the whole of the capillary system there; but for the reasons, which I have assigned, such fulness is always more evident in the capillary system of the lungs, than in that of the system in general.

4thly. The mucous membranes also, when the chemical functions of the lungs are interrupted, exemplify a similar phenomenon. The swelling of the tongue, observable in those that have been drowned or hanged, or asphyxiated by the vapour of charcoal, the lividity of the membrane of the mouth, of the intestines, and the bronchiæ which have also been remarked, depend on no other cause. The folllowing is a proof of this assertion:

Drag out of an animal a portion of the alimentary canal and divide it in such way as to expose its inner surface. Then shut up the pipe which has been previously adapted to the trachea, and at the end of four or five minutes, a brown tint will succeed to the red one, which is natural to this surface.

5th. I have made the same remark upon the fleshy granulations of a wound, inflicted on an animal, for the purpose of observing the manner in which they are coloured by the black blood. In the two last experiments, this phenomenon is slower in taking place than in many other circumstances.

6th. The alteration of colour in the serous membranes is much more quickly effected than it is in the mucous membranes. Of this we may assure ourselves

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by comparatively examining the outer and inner surfaces of the intestines, while the pipe in the trachea is shut; in the serous membranes, the livid tint which they assume, depends upon the vessels, which creep underneath them, and not on the blood by which they are penetrated. Now as these vessels are considerable, the black blood must flow into them almost as soon as it is produced. In the mucous membranes on the contrary, and in all cicatrices, the colour which they take on in asphyxia, is made by the capillary system of the membrane itself, which system is much more tardy than the other, to receive the black blood, and to be penetrated by it; so much so indeed, as to refuse it in some parts. I have many times seen the membrane of the nasal fossæ very red in asphyxiated animals, while that of the mouth has been quite livid, for there are parts into which as I have said the black blood will not penetrate at all, and then they preserve their natural colour. 2dly. There are others into which it evidently passes, but where it stops, and then a simple change of colour is observed, if it have penetrated but in small quantity; and again, if it have penetrated in a considerable quantity, together with such change of colour, there will be observed a tumefaction of the part. 3dly. In other cases, the black blood merely traverses the parts, without stopping in the capillary system, and passes at once into the veins, as the red blood does.

In the first and second case, the general circulation experiences an obstacle which puts a stop to it in the general capillary system. In the third, which is much more universal, it is in the capillaries of the lungs that the blood is at last arrested, after having circulated in the veins.

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These two sorts of impediment coincide with each other, in many instances. Thus in asphyxia, a part of the black blood which circulates in the arteries, stops in the face, upon the mucous surfaces, in the tongue, and in the lips, while the other, and much the larger quantity, finds no impediment in the general capillary system, and is finally arrested in the lungs.

What is the reason, why certain parts of the capillary system, refuse to admit the venous blood, or if they admit it, do not pass it on to the veins; while others are less enfeebled by it, and transmit it as freely as ever. All this must certainly depend on the relation existing between the sensibility of each part and the venous blood.

I was desirous of making use of the power, which we possess, of changing the colour of the blood, for getting some insight into the influence of the circulation of the mother, upon that of the fœtus; accordingly I procured a bitch big with young, and asphyxiated her, by closing a tube, adapted to the trachea. About four minutes after she had ceased to breath, I opened her; the circulation was going on. I then cut into the matrix, and exposed the cord of two or three of the fœtuses. The artery and the vein, were both of them full alike of venous blood.

Had I been able to procure other bitches in a similar state, I should have repeated this experimentin another manner. I should in the first place have compared the natural colour of the vein, with that of the artery. In many of the young of the guinea pig, the difference appeared to me to be much less than it is in the adult animal. In many circumstances indeed I could perceive no difference whatever. Both the arterial and venous blood were equally black, though the respira-

tion

tion of the mother was in no wise impeded by the opening of the belly. Secondly, I should have closed the tube in the trachea, and then have observed whether the change in colour of the umbilical artery of the fœtus (supposing the blood of the artery to be different from that of the vein) were correspondent with that, which would inevitable take place in the blood of the mother. Experiments made with a view to these circumstances, and on large animals, might probably throw much light upon the mode of communication, between the mother and the fœtus. Observations are also much to be desired, with respect to the colour of the blood in the human fœtus, and the cause of its passage from a livid colour, to the very marked red which it assumes, some little time after birth.

I might add a number of examples, to these, which I have already related of the blackening of the organs by the venous blood. Thus, the kidney of a dog exposed, while the animal is dying of asphyxia, is much more livid than in its natural state, the spleen also and the liver, when divided, emit only black blood, instead of that mixture of red and black blood which is observable, in the section of these organs, upon an animal which breathes freely.

But I trust that we have facts enough to establish it as a certainty, 1st, that the black blood after the interruption of the chemical functions of the lungs, continues for some time to circulate, and 2dly, that it penetrates into the organs, where it replaces the red blood; these circumstances explain the reason, why on opening the body we always meet with black blood even in the vessels which are destined for the circulation of arterial blood.

In the last moments of existence of whatever death the individual may have died, we shall always observe the lungs become embarrassed and cease to perform their office, for some time previous to the total suspension of the functions of the heart. The blood makes its circle through the system, after ceasing to to receive the influence of the air, and consequently in its venous state ; accordingly it must remain so in the organ in every case, although the circulation be much less evident, than in asphyxia, for it is in this circumstance that cousits, the great peculiarity of asphyxia. The following phenomena may now be easily understood.

1st. When the left auricle and ventricle together with the large divisions of the aorta, on opening the body, are found to contain blood, such blood is always black. The fact is familiar to those who are in the habit of dissecting. In exercising my pupils on the surgical operations, I have always observed that when the open arteries are not entirely empty, their contents are composed of venous blood.

2dly, The corpus cavernosum is always gorged with this sort of fluid, whether flaccid or in a state of erection. For I have seen it in the latter state in two subjects brought to my amphitheatre. One of these men had hanged himself, the other had died of concussion of the brain.

3dly, The blood which is found in the spleen is never red ; but sometimes on the exterior, and sometimes on the concave surface of this organ, I have observed spots of a scarlet colour, for which I cannot account.

4thly, After death, the mucous membranes lose the red colour by which they are characterized during life They assume a black and livid hue.

5thly.

5thly, Blood extravasated in the brain of persons in a state of apoplexy, is almost always found to be black.

6thly Some times, instead of accumulating inwardly the blood injects the surface of the body. In such case the face, the neck, and shoulders swell, and are infiltrated with blood. I have frequently remarked this sort of phenomenon in the subject, but have never found it coincide with any internal extravasation.— The colour of the skin is then of a purple or deep brown, an evident sign of the sort of blood with which it is injected, and is evidently produced by the stagnation of the black blood in the external capillary system; not by the reflux of the blood from the veins.

I shall not dwell any longer upon the numerous consequences of the above established principle. I shall only observe, that when death commences by the circulatory system, the preceding phenomena are not to be remarked, or at least very little perceptible.

Let us now pass on to the influence of the black blood upon the organs of which it penetrates the tissue.

§ III.—*The black blood which penetrates the organs, as soon as the chemical functions of the lungs have ceased, will not maintain them in a state of life and activity.*

To determine what the influence of the black blood is upon the organs, I shall first remark, that the property of the red blood is to stimulate them, and keep up their vital actions. This will be proved by the following observations:

1st, Compare phlegmon, erysipelas, and inflammatory

tumours

tumours (to the formation of which the red blood is essentially requisite) with scorbutic spots, and petechiæ, produced by the black blood. The first will be found connected with the exaltation of the vital powers, the second with their depression.

2dly, Examine two men, the one with a rosy coloured skin and large breast, announcing vigour of lungs, the other with a pale and sallow countenance, and narrow chest: in these the vigour of the chemical combinations which are made in the lungs, should certainly be very different.

3dly, The greater number of gangrenes in old men, begin with a lividity in the part, a lividity which is evidently the index of the absence or diminution of the arterial blood in the part.

4thly, The redness of the branchiæ of fish is always the sign by which their vigour may be recognised.

5thly, The redder the granulations of wounds, the more healthy is their nature; the paler or browner they are, the less has the part a tendency to citatrise.

6thly, The lively colour of the face, and the ardent eye, coincides with the energy of the cerebral actions in certain fevers.

7thly, The more developed the pulmonary system of animals, the more active are the chemical processes of the lungs, and the more developed and perfect the general life of their different organs.

8th, Youth, which is the age of vigour, is that also when the red blood predominates in the system. The arteries of old people are smaller, the veins larger than those of the young. It is a fact universally known, that at the two extremes of life the proportions of the two vascular systems are inverted.

I am ignorant of the manner in which the red blood excites

excites and keeps up the life of the parts. Perhaps the principles by which it is coloured become combined with the different organs to which it is distributed. In fact there is a considerable difference between the phenomena of the general and those of the capillary system.

In the first, the blood in changing its colour, leaves behind it the principles which made it red; in the second, the elements to which its blackness is owing, are rejected by respiration and exhalation. Now, this union of the colouring principles of the arterial blood, may probably constitute a material part of the excitement which is necessary to the action of the organs.—If such be the case, the black blood as it does not contain the materials of such union, cannot act as an excitng cause. This idea, however, I offer only as a probability, and am by no means prepared to defend it as a truth; it may be ranked on a par with that of the sedative action, which I have said may be excited by the black blood on the different parts—for, however probable an opinion may appear, there should be no real importance attached to it as an opinion only.

Abstraction made then of all system, let us enquire how the black blood, from its contact with the various parts, is the occasion of their death; how it acts on the parts of the animal life, and how it acts on those of the organic life.

All the organs of the animal life depend upon the brain; now, we have seen that the black blood paralises the cerebral powers almost suddenly. In the state then of asphyxia, the locomotive, the vocal and sensitive organs, must be inactive. From the same cause, their exercise must be suspended in all those different experiments where black blood is injected into the brain, the other parts receiving the red blood as usual. But when the black blood circulates throughout all the system, when the whole of the organs, as well as the brain, are submitted to its influence, then there are two other causes of death connected with those which have been mentioned.

1st, The nerves, which are penetrated by it, for that very reason are no longer capable of keeping up the communication between the brain and the senses on the one hand, and on the other, between this same viscus and the locomotive or vocal organs.

2dly, The contact of the black blood with these organs themselves annihilates their actions. Inject the crural artery of an animal with the black blood taken from one of its veins, and the movements of that member will be shortly afterwards enfeebled, or wholly paralyzed. In this experiment, the upper part of the artery, for manifest reasons, should be that to which the pipe of the syringe should be fixed.

I am aware that as to this experiment, it may be asserted that the ligature of the artery, of itself, is capable of paralyzing the limb. In fact, such circumstance has happened twice with me, but I have also had occasion to observe, that it does not necessarily follow the ligature of this vessel, as it does the ligature of the aorta: when the latter vessel is tied, all movements cease at once; notwithstanding all which, the result of the injection of black blood, is almost constantly that which I have asserted it to be;—I say almost, 1st, because I have once seen it fail in its effect, though done with the requisite precautions; 2dly, because the debility, which is induced, both in duration and degree, will be according to the strength of the animal on which the experiment is made.

There is also occasioned in this experiment, a manifest suspension of the sensibility of the animal; it is not

not indeed so ready to appear as the loss of motion; but it always comes on, especially if the injection of the black blood be repeated three or four times, with small intervals.

A similar, but a more tardy effect may be produced by adapting to the canula, which has been placed in the crural artery of an animal, a tube which has been previously fixed to the carotid of another animal, and then by asphyxiating the latter. The organs of the internal life are not dependent on the brain, and therefore are not affected by the suspension of the cerebral action in asphyxia. It is the influx of the black blood which is the immediate cause of their death.

I have already demonstrated what the influence is of this blood upon the organs of the circulation. We have seen how the heart ceases to act, as soon as it is penetrated by it; it is owing in part to the injection of the arterial and venous parietes themselves, by the vasa vasorum, that the vessels are forced to suspend their actions.

It will be always a difficult thing to prove, that the secretions, the exhalations, and the process of nutrition, could not be made from venous blood, because the circulation of this sort of blood in the arteries, does not continue for a sufficient time, to allow of observations, or the manner in which these functions would be affected by it. On this subject, however, I have made some essays. 1st, I exposed the inner surface of the bladder of a living animal, after having previously divided the symphysis pubis, and opened the lower belly, I then examined the oozing of the urine from the orifices of the ureters, while I asphyxiated the animal. 2dly, I divided the vas deferens, with the view of observing, whether the semen would flow or not, during such state.

In

In general, I have had occasion to remark, that during the circulation of the black blood in the arteries, no fluids appear to issue from the different secreting tubes. But I confess, that in all these experiments, and in other similar ones which I have made, the animal is too much agitated, and the limits of the experiments too circumscribed, for any thing like a well founded judgment to be formed on the subject in question. It is chiefly from analogy, then, thát I am led to conclude, that the black blood is unfit for the purposes of exhalation and nutrition; such supposition also accords well with divers of the phenomena of asphpxia.—1st, the want of exhalation from the skin during the state of asphyxia, is probably the reason of the phenomena of the animal heat in such sort of death. 2dly, in asphyxiating animals very slowly during digestion, I have uniformly observed, that the bile ducts, and duodenum, contain a much less quantity of bile, than they do at such time, when these parts are exposed in the living animal.—3dly, as the blood loses nothing from the exercise of these functions, it must of course accumulate in the vessels; and in fact it is very fatiguing and unsatisfactory, to dissect the bodies of those who have been hanged or asphyxiated with the vapours of charcoal, from the fluidity and abundance of their blood. But this abundance, perhaps, may depend upon the weakness of the absorbents. In other sorts of death, the absorbents continue for some time to act upon the serous portion of the blood remaining in the vessels. In asphyxia there is neither secretion nor absorption.

The excretions also appear to be affected much in the same way. The bladder of asphyxiated persons has been observed by Portal, to be very much distended. Such distension, no doubt is occasioned by

the

urine already secreted before the accident which was the cause of their deaths. In general, the asphyxiæ which are occasioned by the circulation of the black blood unmixed with any deleterious substance, are not accompanied with those spasms, which in so many other sorts of death, are so frequent. These spasms, which evacuate the organs of their fluids, should be carefully distinguished from the simple relaxations of the sphincters, by which analogous effects are produced. In asphyxia, all is debility, in asphyxia, we never see that augmentation of life, that developement of power, which so frequently mark the latter movements of the dying.

Hence also perhaps, the great flexibility of the members of asphyxiated persons. The stiffness of the muscles appears to depend in many cases, on the circumstance of death having come on precisely at the moment of their contrations. The fibres remain approximated, and coherent among themselves; in asphyxia, on the contrary, as there exists an universal relaxation and want of action in the parts, they remain so after death, and yield to whatever impulse may be communicated to them.

I confess, however, that this explanation is subject to a difficulty which I cannot solve. Persons asphyxiated by mephitic vapours, perish nearly in the same way as those who are drowned; if the cause of their death be different, its effects are the same, as may be seen by opening the carotid of two dogs at the same time, that into the lungs of the one are injected the vapours of charcoal, and into those of the other, a certain quantity of water, which water, as in the drowned, is soon reduced into a state of foam.

Notwithstanding this similitude of the last phenomena of life in the two cases, the members in the first

remain

remain for a certain time warm and supple, while those in the second, especially if the body be plunged into water during the experiment, become very suddenly stiff and frozen. Let us return, however, to our subject. We may conclude from the various facts and considerations related in this chapter, 1st, that when the chemical functions of the lungs are suspended, the functions of all the other organs are suspended also, from the presence of black blood within their substance. 2dly, that the death of the organs in general, coincides with that of the brain, and the heart, but is not immediately derived from them. 3dly, that if it were possible for the brain and heart to receive an influx of arterial blood, while the others were dying, from that of the venous blood, they would doubtless continue to exert their accustomed actions. 4thly, that, in a word, asphyxia is a general phenomenon, developed at the same time in all the organs, but especially in none of them.

From this manner of regarding the influence of the black blood upon the different parts of the body, it appears that death is very soon the result of its circulation in the arteries. Nevertheless, certain organic vices have sometimes prolonged after birth, the mixture of the two sorts of blood, a mixture which is known to be made in the fœtus. Such was the malconformation mentioned by Sandeford, in a child, the aorta of which arose by a branch from each of the ventricles. Such also appears, at first sight, to be the opening of the foramen ovale in the adult.

We shall remark, however, that the existence of this foramen, does not suppose the passage of the black blood into the red blooded auricle, as is generally believed. For the two semi-lunar valves, between which it is situated when met with after birth, are necessarily

applied

applied to each other by the pressure which the blood contained in the auricles, exercises upon them, when these cavities are simultaneously contracted. The foramen must be at such time shut, and its obliteration much more exact, than that of the opening of the ventricles, by the mitral and tricuspid valves, or that of the aorta and the pulmonary artery, by the sigmoid valves. With all this, the foramen ovale is actually very often found open in the subject, and when not so, nothing is easier than to destroy the species of adherence which is contracted by the two valves which close it. This may be done with the handle of a scalpel, without any solution of continuity, the parts appear to be unglued.

The oval hole when in this way artificially made, presents the same disposition, with that which is sometimes exemplified in the carcase. Now if this disposition be examined, it will be seen that when the auricles contract, the blood must make an obstacle to itself, and that it cannot pass from one into the other of these cavities. It is an easy thing to be certified of the mechanism of which I speak, by means of two injections of a different colour, made at the same time from both sides of the heart, from the vena cava, namely and the pulmonary veins.

From what we have said of the influence, which is exercised by the movement and the different principles of the blood, it is evident that the death of the white organs must be different from that of the red ones. Asphyxia can hardly reach them, but of the manner in which they die I confess that I know but little.

CHAPTER THE NINTH.

OF THE INFLUENCE OF THE DEATH OF THE LUNGS, OVER THE GENERAL DEATH OF THE BODY.

IN recapitulating what has been said in the preceding chapters, with respect to the influence of the lungs over the heart, the brain, and all the organs, it is an easy matter to form an idea of the successive termination of the whole of the functions, when the phenomena of respiration are suspended either mechanically or chemically.

The following is the manner in which death supervenes, when the mechanical phenomena of the lungs are interrupted, either from the causes mentioned in the 5th Chapter, or from similar ones, such as the rupture of the diaphragm, which I have twice had occasion to observe, or from a fracture of a great number of the ribs, or the sternum.

1st. The mechanical functions of the lungs cease. 2dly. The chemical functions of the lungs cease also. 3dly. The cerebral actions are put an end to. 4thly. The animal life is interrupted. 5thly. The general circulation is interrupted. 6thly. The capillary circulation is interrupted.

The phenomena of death, are differently concatenated, when they begin by the suspension of the chemcical chemical functions of the lungs: which may happen, 1st, from breathing in a vacuum: 2dly, from the obliteration of the passage of the trachea, by foreign substances introduced into it, or by tumour from without, or strangulation, accumulation of fluid in the air cells, &c.; 3dly, from different inflammatory affections, schirrhi, &c. of the cavities of the mouth or throat. 5thly. From want of respirable air, as on the summit of high mountains. 6thly. From the introduction into the air cells, of non-respirable gasses, &c. &c. In all these cases, the following is the order of the phenomena of death.

1st. The chemical functions of the lungs are suspended. 2ndly. The functions of the brain are interrupted. 3rdly. Sensation, locomotion, the voice, the mechanical phenomena of respiration cease. 4thly. The action of the heart, together with the general circulation is annihilated. 5thly. The capillary circulation is put an end to, together with the processes of secretion, exhalation, absorption, and digestion. 6thly. The animal heat of the system dies away.

§ 1.—*Remarks upon the differences of asphyxiæ.*

The influence of the black blood as I have said, is always the great agent in this double sort of death, but it is not the only one: if that were the case, the phenomena of all the asphyxiæ would be alike. It is true that in every sort of asphyxia, the black blood ceases to become red blood, and circulates in the arteries, such as it is in the veins; but notwithstanding the uniformity of this phenomenon, there can be nothing more varied, than the symptoms and progress of these accidents. In some of them, death is long in taking place; in others, almost instantaneous: the phenomena developed in the last moments of existence, are alike in

none

none of them. The state of the organs, and that of the powers which they preserve after death, are as various.

1st, Asphyxia varies with respect to its duration; in sulphurated hydrogenous gas, in nitrous gas, and certain vapours arising from gouts and sewers, it is quick in taking place. In carbonic acid gas, azot, in pure hydrogen, water, and a vacuum, its progress is slower.

2dly, Asphyxia varies with respect to its attendant phenomena. At times, the animal is violently agitated and suddenly convulsed; at others, it appears to lose its powers gradually; to pass into a state of sleep, and from sleep into a state of death. In comparing the numerous effects arising from the vapours of sewers from those of charcoal, from the different gasses, from drowning, and other causes of asphyxia, we find them almost as various, as the causes themselves.

3rdly. The phenomena which make their appearance after death, are as variable. Compare the cold and frozen carcase of a drowned man, with the remains of one who has been suffocated. Read the result of the different experiments of the Institute, upon the affections of the galvanic fluid in the different asphyxiæ; examine Halle's detail of the symptoms which accompany the mephitism of sewers; approximate the the numerous observations, which are scattered about in the works of Portal, Louis, Haller, Troja, Pechlin, Bartholin, and Morgagni; repeat the most common experiments on the submersion, strangulation, and suffocation of animals; and you will observe the greatest difference in all these sorts of asphyxia, they are each of them characterized, by a peculiar state of the bodies of the animals, which have been submitted to the experiment.

To

To enquire into the causes of such differences, we must first divide the asphyxiæ into two classes. 1st, Into those which happen from the simple want of respirable air, and 2dly, into those, where to this first cause is joined also that of the introduction of some deleterious substance into the lungs.

In the first class, the immediate cause of death, appears to be the simple presence of the black blood, in the various parts of the body, the general effect of which is always the same, in whatever manner produced; accordingly, the attendant symptoms and secondary results of all these sorts of death, are nearly alike, their duration the same, and if it varies, it varies only in consequence of the more or less complete interruption of the passage of air into the lungs.

This variety in the duration and intensity of the asphyxiating cause, may nevertheless occasion some variety in the symptoms also; such as a greater or less lividity and swelling of the face, a more or less considerable embarrassment of the lungs; but all these differences indicate only so many modifications of the cause. 1st, a man who is hanged, does not die as a man who is suffocated by an inflammatory tumour, or a pea or bean which perchance may have fallen into the trachea. 2dly, An animal will perish much more slowly under a vessel of air, than when the trachea is tied. 3dly, The symptoms of asphyxia, when occasioned by a great rarefaction of air, or by a suffocating heat, are much less slowly produced, than where the cavity of the lungs is opened.

In all these cases the cause of death, namely the absence of red blood in the arterial system, is simple and unique, but according to the greater or less oxygenation of the venous blood, will be the appear-

ances

ances after death, for the longer the process of asphyxia endures, the less irritability will there be found in the system.

But if the cause of asphyxia, have been the introduction of some deleterious fluid into the lungs, then the variety of the symptoms will depend upon the difference in the nature of the fluid. In these cases the cause is of two kinds: 1st, there is no red blood in the system. 2dly, a pernicious fluid is present in the system. All the gasses however do not act as deleterious substances: in pure hydrogen for instance, the animal perishes only as it would from the want of respirable air.

But when a man in descending into a common sewer, into a cellar, or into any place where putrid matters are accumulated, falls into asphyxia at the moment when he inspires their exhalations, and when such state is attended with convulsive movements and extreme agitation, then indeed, there must be something more in the cause of his death, than a simple suspension of the chemical functions of the lungs.

In fact, together with the mephitic vapour, there continues to enter into the lungs a sufficient quantity of air to keep up life and its different functions. 2dly, supposing even that the quantity of mephitic air were such as to leave no place for the entrance of respirable air, still the death ensuing should only be gradual, without agitation and convulsion, were it occasioned only by the absence of such air: now the very different way in which it supervenes, very evidently indicates the action of a deleterious substance, upon the animal œconomy.

These two causes then act together, in those asphyxiæ which are produced by certain gasses, sometimes the one predominates, sometimes the other. If the deleterious

terious substance be violent, it kills before the action of the black blood can have produced much effect, if weak, it is the black blood, which is principally the cause of death.

The asphyxiæ then, which are produced by the gasses, differ only, in consequence of the nature of the deleterious substance, which varies ad-infinitum. In some of the aeriform fluids indeed it is supposed to be known, but in the greater number of them it is not so: I shall notice therefore in a general way the effects, which result from the action of the deleterious substance, remarking at the same time, that the symptoms by which they are displayed, are strongly or weakly marked, according to the age and temperament of the individual.

Deleterious substances introduced into the lungs, together with the mephitic vapours of which they form a part, can act only in two ways. 1st, by affecting the nerves of the lungs, which re-act on the brain. 2dly, by passing into the blood, and exercising their influence, by means of the circulation on the various organs of the system.

I can easily believe that the simple action of such a substance on the nerves of the lungs, may have a very marked effect on the economy, and be capable of troubling the functions of the sytem very sensibly; much indeed in the same way as with some individuals a mere odour, or the sight of a hideous object, will occasion syncope, in the same way that an irritating enema will suddenly awake the system into life, or the introduction of certain substances within the stomach, will be felt throughout the body, before such substances can have passed into the circulatory torrent. We meet at every moment with examples of these very remarkable phenomena, produced by the simple im-

pressions

pressions of foreign bodies on the mucous surfaces; I cannot deny that deleterious substances may act in the same way upon the nerves of the lungs, though we must not exaggerate the sphere of this mode of action.

In fact, I am not acquainted with any one example, where the contact of a deleterious substance with a mucous membrane, has been the sudden cause of death. It may indeed be productive of such effect after a certain time, but never at the moment of its action; nevertheless, in those asphyxiæ which are produced by mephitic vapour, so rapidly does death come on, that the black blood can scarcely have had the time to exert its influence upon the body. The principal cause of the cessation of the functions is manifestly the action of the pernicious substance.

These considerations, then, incline me to believe, that these substances pass into the blood through the lungs, and that in circulating with the blood they carry to the organs the immediate cause of their death. Such passage into the blood has already been suspected by many physicians; the truth of the fact appears to be indubitably proved by the following reflections.

1st, It can hardly be doubted, that the poison of the viper and many other venomous animals, and that the saliva of rabid animals, pass into the system of the blood, and are taken up either by the veins or the lymphatics.

2dly, It appears to be very certain, that a portion of the atmospheric air is actually absorbed through the mucous membrane of the lungs itself, and not by means of the absorbent system. Now, if this be the case, I know not what should hinder the passage of mephitic vapour in the same way. We are not sufficiently acquainted with the limits of the particular sensibility of the membrane of the air cells, to say that it cannot give a passage to such vapour.

3dly,

3dly, The respiration of an air which has been charged with the exhalations arising from oil of turpentine, communicate a particular smell to the urine. It is thus that this fluid is affected from the residence of the persons in a newly varnished room. In this case it is evidently by the lungs in part, that the odoriferous fluid has its passage into the blood, and so on to the kidneys. In fact, I have often assured myself by breathing out of a bottle through a tube, air so charged (in which case it could not act on the cutaneous surface) that the smell of the urine undergoes a change. If, then, the lungs will admit a variety of substances, which do not enter into the composition of respirable air, for what reason should they not admit the mephitic vapour of mines and subterraneous places.

4thly, The respiration of humid air produces dropsy. The extent of the fact has been exaggerated, indeed, but the fact itself is true. It proves, that an aqueous fluid may pass into the blood, and consequently that other substances may pass into it also.

5thly, If an animal be asphyxiated in sulfurated hydrogenous gas, and a plate of metal some time after its death be placed under one of its muscles, the surface of the plate contiguous to the muscle, will be sensibly sulfurated. The foreign principle, then, which is here united with the hydrogen, must have been introduced into the circulatory torrent by the lungs, and have penetiated with the blood into all the parts. The deputies of the institute have observed this phenomenon in their experiments. I have made a similar remark in asphyxiating animals with nitrous gas. A phenomenon of the same nature accompanies the exhibition of mercury.

From the above, we have nearly a right to conclude, that the different deleterious substances of which the

gasses

gasses are the vehicles, do actually pass into the blood, and so affect the organs. Of this matter, however, I shall adduce some further proofs.

I have ascertained by a number of experiments, that atmospheric air, or any other aeriform fluid, may be made to pass into the blood without alteration.

Divide the trachea of a dog, inject the air-cells strongly with common air, and continue to retain it in the lungs. The animal will immediately discover signs of great distress and agitation; if an artery now be opened, the blood will be emitted in a frothy state.

If hydrogen have been employed, it may easily be ascertained that the nature of the fluid is unchanged, by placing a candle over the bubbles which are disengaged.

When the blood for the space of thirty seconds has flowed in this state, the animal life of the creature will be finished, and death insue, with all the symptoms which accompany the insufflation of air into the black blooded system of vessels. The re-admission of air into the lungs, will have no effect in restoring the animal to life, for as soon as frothy blood can flow from any one of the arteries, it must already have affected the brain with its pernicious influence.

In this case it may be perceived, that the causes of death are the same as those which proceed from the insufflation of air into a vein. In the one instance the air passes at once from the lungs into the arterial system. In the other, from the veins across the lungs and then into the arteries.

When we open the bodies of animals, which have been killed in these experiments, the whole apparatus of the red blooded vascular system, is found to be filled with air bubbles of various sizes. In some circumstances, the blood will be transmitted in the same state into the general capillary system, and from thence into the veins; in others it will be stopped in the capillary system, and in such cases, though the circulation may have continued for some time after the suspension of the animal life, not a single particle of air will be discovered in the veins.

In these experiments which I have frequently repeated, I have never found that the least fissure has been made in the bronchiæ; nevertheless, I confess that it is difficult to say, whether this be so in their last ramifications. The following phenomenon, however, may throw some light upon the subject; for as often as air is pushed into the lungs with great violence, there will be produced an emphysema of the breast, or neck, from the infiltration of this fluid among the cellular texture, in addition to its passage into the blood. But if the impulse be moderate, and the quantity of air injected not much beyond the measure of a full inspiration, it will pass into the blood only, and not into the cellular texture.

The experiments of which I have given the detail, exemplify phenomena which do not indeed take place in the ordinary process of inspiration, and therefore I allow that no very rigorous induction can be drawn from them, with respect to the passage of deleterious substances into the mass of the blood; nevertheless it appears to me, that they very much confirm the probability of such fact, which besides is demonstrated by many of the preceding remarks. I shall conclude, then, that such passage is real. In fact, we have seen 1st, that the sole transmission of the black blood into the arteries, will not account for the infinitely various phenomena exemplified in the different sorts of asphyxiæ; 2dly, that the simple contact of the deleterious substance with the nerves of the lungs, can by no means be the cause of a death so rapid as that which is occasioned by these accidents; 3dly. that, therefore, we are forced as it were to suspect the passage of the poison itself into the blood; 4thly, that a number of considerations are in favor of such suspicion, and thus that the fact is proved both directly and indirectly.*

This principle being once established, a variety of results must flow from it. Of the first of these, of the mode of action, namely, which the deleterious substance must exercise upon the different organs, I shall say nothing, having nothing to offer but conjecture.

I shall accordingly content myself with enquiring what system it is which is particularly influenced by these substances, when mingled with the blood.—Now, 1st, this system appears to be the nervous one, and that portion of it especially, which presides over the the parts of the animal life, the organic functions being only secondarily affected; 2dly, of all the nervous system, the brain is that part which is the most affected; 3dly, under this relation Monsieur Pinel appears to me to have been right, in placing some of the asphyxiæ (those for instance which are occasioned by the presence of a deleterious substance) among the neuroses. On this head the following considerations should leave us little doubt.

1st, In all the asphyxiæ, when the presence of a deleterious substance cannot be doubted, the symptoms consist of two general and opposite sets of phenomena, of spasm and torpor. Of two workman who had come up out of the sewer of the street St. André dés Ares, the one

* The above experiments explain the manner in which emphysema is produced from any very violent exertion of the muscles of the chest.

one sat himself down upon a bulk, and fell into a state of asphyxia; the other with irregular convulsive movements, proceeded as far as the rue Battoir, and then fell down asphyxiated. The Sieur Verville, in consequence of inhaling the breath of a man who was lying in a state of asphyxia from the vapour of lead, fell down suddenly, and in a short time became convulsed. The vapour of charcoal intoxicates, as it is said. I have seen animals asphyxiated with other gasses, and perishing with a stiffness, such as could be produced only by the most violent spasm. The center of all these symptoms, and the organ from which they emanate, undoubtedly is the brain, and they depend upon its irritation or compression.

2dly, The animal life is always interrupted before the organic life, wherever the asphyxiating cause has been of a compound nature. Now the center of the animal life is the brain.

3dly, I have proved when the animal perishes from the circulation of the black blood in the arteries, that the brain is especially affected even then; but in the same way, that is, by the cephalic arteries, the delerious substance itself, may be introduced into the brain.

4thly, I have pushed a variety of deleterious gasses (for example, sulphurated hydrogen) into the brain, and also some of those substances which vitiate the nature of these gasses. The animal has always perished with symptoms of spasm, or torpor, and in general the death which is occasioned by the different gasses, is always similar to that which is produced by the introduction of pernicions substances into the brain.

5thly, The consequences of these asphyxiæ, when life has been restored, invariably suppose a lesion of the cerebral system, such consequences consist of palsy,

tremor,

tremour, wandering pains, and derangements of the exterior apparatus of the senses.

From all these multiform experiments and considerations, we may surely conclude, that it is on the brain and nervous system that the deleterious principle, introduced into the blood, must act; from the death of these parts, that of the others is derived.

In this case the different organs no doubt are directly enfeebled, and may perhaps be immediately affected by those principles, which flow into them together with the blood, but all such phenomena, are even more visible in the animal, than in the organic life.

Let us not forget however, that a part at least of the cause of this sort of death, consists in the influence of the venous blood upon the organs, and that this influence must ever be in proportion to the length of time that such blood continues to circulate. The differences then which are found in the asphyxiæ, may be said to proceed from the greater or less effect of the venous blood upon the system, from the different nature of the various deleterious substances inspired, and from the age and temperament of the individual affected.

§ II. *In the greater number of diseases, death commences in the lungs.*

I have just spoken of sudden death. I shall now enlarge a little on that which is the slow effect of disease. Physicians must be well persuaded, that by far the greater number of diseases, put an end to life by an affection of the lungs. Whatever be the seat of the principal affection, be it either an organic lesion, or a general disorder of the system, the action of the lungs in the latter moments of existence, becomes

embarrassed,

embarrassed, the respiration difficult, and the oxydation of the blood, but slowly effected; accordingly this fluid must pass into the arteries, almost in the venous state.

The organs therefore which are already enfeebled, must be much more readily affected by the pernicious influence of such blood, than those which are subject to it, in the different cases of asphyxia. In this way the loss of sensation, and intellect, are very shortly the effect of embarrassment in the lungs; and ensue as soon as the brain begins to be penetrated with the fluid which is so transmitted to it.

By degrees the heart and all the organs of the internal life, cease also to move. It is here the black blood which arrests these vital motions, which have already been enfeebled by the disease. Such weakness, the consequences of the disease, is very rarely the immediate cause of death, it only prepares it, by rendering the organs more susceptible of the alteration in the healthy state of the blood. Such alteration is almost always the immediate cause of death. The disease, then is only an indirect cause of death in general, it kills the lungs, and the death of the lungs occasions that of all the other parts.

From hence it may be easily conceived, why the small quantity of blood contained in the arterial system of the subject, is almost always black. For 1st, the greater number of deaths begin by the lungs. 2dly, We shall see that those which have their commencement in the brain, are equally the cause of this phenomenon. Accordingly there can be only those, in which the heart ceases suddenly to act, after which the red blood can be found in the aortic ventricle, and auricle. Such appearance is seldom found, excepting in the bodies of persons who have perished from extensive hemorhagy.

From

From the frequency of deaths beginning with an embarrassment of the lungs, may be conceived also the reason, why this organ is so frequently gorged with blood in the carcase in general, the longer the agony, the heavier and fuller are the lungs. When such fulness is found, together with black blood in the red blooded system, whatever the disease may have been, it may be pronounced that death has begun in the lungs. In fact the concatenation of the phenomena of death is from one of the three organs, from the lungs, brain, or heart, to all the others. Now when death begins in the heart, the pulmonary vessels are generally empty, and there is red blood in the aortic system. On the other hand, if death have began in the brain, there is then indeed a certain quantity of blood in the arteries, but the lungs are empty, unless, when gorged with blood, by some antecedent affection.

CHAPTER THE TENTH.

Of the Influence of the Death of the Brain over that of the Lungs.

AS soon as the human brain ceases to act, the functions of the lungs are suddenly interrupted; this phenomenon, which is constantly observed in the red and warm blooded animals, can happen only in two ways. 1st, Because the action of the brain, is directly necessary to that of the lungs, or 2dly, because the latter receives from the former, an indirect influence by means of the intercostal muscles and diaphragm, an influence, which ceases with the activity of the cerebral mass. Let us try to determine which of these two modes is that of nature.

§I. Is *it directly that the lungs cease to act upon the death of the brain?*

I shall have proved that the death of the brain, is not immediately the occasion of that of the lungs, if I can determine that there is no immediate influence exercised by the first, upon the second of these organs, now, this essential principle may be easily demonstrated by experiment.

The brain can exercise an immediate influence on the lungs, only by means of the par vagum or the great sympathetic nerve, the only nerves, which according to the common opinion, establish a communication between the two organs (an opinion however which is erroneous, as the great sympathetic is only an agent of commnnication between the organs and the ganglions of the system.) Now 1st, the influence which is derived by the lungs from the par vagum, is not actually necessary for them to act. The following experiments will show the truth of this asssertion.

1st, Irritate the par vagum on one or both sides, and the respiration of the animal will be somewhat quickened ; but such appearance is no proof of an immediate influence, for any wound of the neck, or any wound

wound whatever, provided that it be the occasion of considerable pain, will be the cause of a similar phenomenon.

2ndly, Cut one of the nerves, and the respiration will be at once affected, as when the nerve is irritated; but as soon as the pain ceases, the embarrassment of the lungs will disappear; and at the end of four and twenty hours, the phenomena of life be concatenated with their accustomed regularity.

3dly, Divide these nerves on both sides. In this case the breathing will be much more precipitated, and will not return to its ordinary state, as in the preceding experiment; it continues laborious for four or five days, and the animal perishes.

From the two latter experiments it follows, that the par vagum is indeed necessary to the phenomena of respiration, and that the brain must exercise, of course, an influence over this function, but at the same time, it may be seen, that without the immediate influence of the brain, the lungs will continue in play, and consequently that the interruption of such influence, as when the brain is injured, will not be an immediate obstacle to the continuation of the pulmonary actions.

The question whether the functions of the lungs are more immediately connected with the influence derived from the ganglions, may be decided by the following facts.

1st, If on the one and the other side of the neck, the nervous thread be cut, which is usually regarded as the trunk of the great sympathetic, there follows little or no alteration in the phenomena of respiration.

2dly, If the par vagum and the great sympathetic be divided at the same time on both sides of the neck, the animal will die after a certain time, and much in the ame way, as wh e n only the par vagum is divided.

3dly,

3dly, When we divide the sympathetic nerve in the neck, we do not deprive the lungs of the nerves which come from the first thoracic ganglion; now these nerves may contribute to keep up the action of the lungs, since, as I have said, each ganglion is a nervous center, capable of emitting its own peculiar irradiations, independently of the other centers, with which it communicates.

But whether the nerves, which are derived from the first thoracic ganglion, do really assist the functions of the lungs, I have not been able to ascertain by experiments on the nerves themselves, for such is the position of the first thoracic ganglion in most animals, that it cannot be taken away without doing so much injury to the parts as would kill the creature, or throw it into such agitation, as wholly to confound the phenomena of which we are in search, with those of a general distress and trouble. From analogy, however, and from the destruction of other ganglions, by which the internal organs are supplied, we should not have a right to suppose that the lungs would cease to act, when the ganglion in question is destroyed.

Besides, the following reasons appear to me to prove unquestionably, the principle which I advance. If great lesions of the brain have the effect of suddenly interrupting respiration, because this organ can no longer influence the lungs by means of the nerves, which come from the first thoracic ganglion, it is evident that if all communication between the brain and this ganglion be taken away, such influence must cease, and respiration be suspended; but if we divide, as Cruikshanks has done, the spinal marrow on a level with the last of the cervical vertebræ, the animal will continue to live and breathe for a length of time, notwithstanding the want of communication between the brain

brain and the lungs, by means of the first thoracic ganglion. From the above experiments, we may conclude, that the brain does not exercise any direct and actual influence over the lungs, and consequently that other causes must be sought for, if we mean to account for that sudden and instantaneous cessation of the functions of the latter of these organs, when those of the former are suspended.

There exists, notwithstanding, a phenomenon which seems to cast some doubt upon the conclusion which I have deduced, and in the principle which it establishes. I speak of the sudden difficulty of respiration, and that impeded circulation which are occasioned by violent pain. This distress appears to indicate that the heart and the lungs are dependent immediately upon the brain; for the distress is in the brain, say the greater number of authors, and the affection of the heart and lungs, a consequence of the reaction of the brain; but here let it be remembered, that almost all pain is made up, first of sensation, and secondly of some emotion or passion. Now as I have proved at length, in the former part of this work, all passion and emotion have their seat in the internal viscera, and thus it will appear, that the trouble which in such case is felt in the heart and lungs, does not depend upon the brain for its cause, but is the immediate effect of the passion, or emotion, which accompanies the sensation. The following considerations will bear me out in this conclusion.

1st, In many instances the dyspnea and impeded circulation, precede the pain. Examine the thorax, and place your hand upon the heart of a man about to undergo an operation, and you will be easily convinced of this truth.

2dly,

2dly, There is sometimes a manifest disproportion between the sensation of pain, and the distress which is experienced about the heart, and in breathing. I have known the operation of cutting away the prepuce immediately fatal. Now in this case, it surely could not be pain which killed the man.

3dly, There are many persons who are capable of supporting violent pain, with resolution. Place your hand upon the heart of such persons, and no agitation whatever will be felt there. Nevertheless, their perception of pain must be what it is in other persons.

4thly, In the course of an operation, we are not to judge of the patient's state of mind, from his cries, or silence. This sign is very deceitful; because a man may be sufficiently master of himself to overpower the influence of his internal organs. We must examine the heart and lungs; their functions, if I may allow myself the expression, are the therometer of the affections of the mind. It is not without reason, that the actor who plays the part of a courageous man, takes hold upon the hand of him whom he wishes to set at ease, and lays it on his heart. The exterior movements of the passions, are not a fair criterion of of the inward feelings of the individual, for these movements may be feigned as well as real: feigned if they originate in the brain: real if they have their sources in the heart;—in the first case voluntary, in the second involuntary. Touch the pulse of the angry man, if you wish to know whether he really is in anger. When I see a woman weeping or convulsed at any distressing news, and find her pulse in its natural state, I know what to judge of her affliction.— On the contrary, if her grief be concentrated, but her heart beat strongly, or her pulse have been suddenly depressed, I know that she feigns a calm which she does

not

not feel. To judge correctly, we must always compare the external movement with the state of the internal organs. There could be no deceit, were it possible to distinguish the involuntary movements produced in a state of passion, by the action of the heart upon the brain, and then by the reaction of the brain upon the muscles, from the voluntary movements which are occasioned by the simple action of the brain upon the locomotive system.

However strong may be the pain which has been the occasion of the dyspnea, and impeded circulation, of which we have been speaking, this dyspena and distress about the precordia, will cease, provided only that the pain be continued. Nevertheless, if the re-action of the brain were the real cause of the distress in question, the contrary should be the case; for the continuation of the affection of the brain, should continue also to cause its re-action. But here the effect of habit is evident, though the pain subsists; the brain indeed continues to be affected, but the internal organs cease to be so. It may be easily perceived, that I am not here speaking of those cases, where the action of the heart and lungs has been deeply troubled by the effect of pain.

To the above considerations I might add many others, with the view of proving, 1st, that although the brain be the seat of the pain, it is not the source of those affections of the internal organs, which are occasioned by such pain; 2ndly, that these affections depend upon an emotion, which is absolutely distinct from sensation of whatever kind, both in its nature and effects.

§ II. *Is it indirectly that the lungs cease to act upon the death of the brain.*

Since the death of the lungs, upon the cessation of the cerebral action, is not direct, there must exist between the brain and the lungs, some intermediate agents, the cessation of whose functions, occasion the cessation of those of the lungs. These agents are the diaphragm, and intercostal muscles; for they depend immediately upon the brain by means of the nerves, which they receive from it, and consequently become paralytic on the death of the brain; the following experiments are a proof of the fact.

1st, Cruikshanks divided the spinal marrow of a dog between the last cervical, and the first dorsal vertebræ. The intercostal muscles accordingly were immediately paralyzed, and the breathing of the animal continued to be made by the diaphragm only, which receives the phrenic nerve from a point above the section. In this experiment, it is easy to judge of the strong action of the diaphragm, by that of the abdominal muscles.

2ndly, If the phrenic nerves only be divided, the diaphragm becomes immoveable, and then the respiration of the animal is effected by the intercostal muscles only.

3rdly. After the two preceding experiments, the animal will live for a considerable time, but if the phrenic nerves, and the spinal marrow, towards the end of the neck, be divided at the same time, or what comes to the same thing, if the spinal marrow be cut above the origin of the phrenic nerves, then all communication between the brain and the active agents of respiration is cut off, and death follows of course.

4thly,

4thly. I have frequently observed, that half an inch of difference in the place where the spinal marrow is divided, produces such a difference in its consequences, that in the one case the death is sudden, and supervenes in the other only, after an interval of fifteen or twenty hours. In dissecting the carcases of animals killed in this manner, I have constantly observed that the difference depended always upon the circumstance, of the phrenic nerve being cut or not.

From these experiments then it is evident, that respiration ceases on a sudden, and in the following manner, in all lesions of that part of the nervous system, which is placed above the origin of the phrenic nerves. 1st, There is an interruption of action in the voluntary nerves, which are placed below the point of lesion, and consequently in the phrenic and intercostal nerves. 2dly, A paralysis of almost all the muscles of the animal life, and particularly of the diaphragm and intercostal muscles. 3rdly, A cessation of the mechanical phenomena of respiration. 4thly, A suspension of the chemical phenomena of respiration. The interruption of all these movements, is as rapid as their concatenation is prompt, in the natural order.

It is thus that those persons perish, who experience any great lesion of the spinal marrow, between the brain and the origin of the phrenic nerves. Physicians have been very much embarrassed, in fixing with precision the spot, when a wound of the medulla ceases to be mortal; from what I have advanced, the limit is easily assigned. From the same causes, concussion, and compression of the brain, are also fatal.

We should observe notwithstanding, that these different causes of death, may act with various degrees of intensity. If they act but feebly, they affect the intellectual functions only, for these functions are

always

always the first to be altered, in all lesions of the brain however small. If the lesion be greater, the affection extends to the muscles of the limbs, and convulsion or palsy ensue. Lastly, if the lesion be very great, the whole of the muscles of the animal life, the intercostals and diaphragen, as well as the others, are paralyzed, and death follows.

We now can reply to the question proposed at the begining of this section, and affirm that the death of the lungs is occasioned indirectly, by the death of the brain.

It follows also, from the principles which are above established, that respiration is a mixed function, a function placed as it were between the two lives, to which it serves as a point of contact, belonging to the animal life by its mechanical functions, and to the organic life, by its chemical functions; and hence we have the reason no doubt, why the existence of the lungs is as much connected with that of the brain, as with that of the heart.

It may be observed in the series of animals, that in proportion as the organization of the brain is straitened, a number of the phenomena of respiration also are lost. In birds, and the mammalia, this function as well as the brain, is much more developed than it is in the classes of fish and reptiles. It is known, that the nervous system of those animals which breathe by tracheæ, is less perfect than in those which breathe by lungs; and that in those, where there is no nervous system, that of respiration disappears also.

In general, there is a reciprocal relation between the brain and the lungs, especially in birds and the mammalia. The first of these occasions the action of the second, by raising the ribs and favoring the entrance of air into the bronchiæ; the second also keeps up the

activity

activity of the first, by means of the red blood which it sends thither.

It would be an interesting speculation to enquire into the relation of the nervous system with that of respiration in the class of insects, for as they receive the air by points, which open externally, there seems to be no mechanical action in the process of their breathing, and thus the function appears with them to belong entirely to the organic life.

CHAPTER THE ELEVENTH.

Of the influence of the Death of the Brain over that of the Heart.

IN the preceding chapter we have shewn how the lungs remain inactive, when the brain ceases to act.—The same phenomenon, under the same circumstances, takes place also in the heart, and must happen either immediately or mediately.

§ I. *Does the Heart cease to act immediately in consequence of the interruption of the cerebral action?*

The greater number of medical men, speak in much too vague a manner of the cerebral influence. They do not

not sufficiently determine its extent and limits, with respect to the different organs of the system.

It is evident that we shall have answered the question proposed at the head of this section, if we can determine what the influence of the brain is with regard to the heart. Now, we have every reason to suppose, that no direct influence is exercised by the former over the latter of these organs, which, on the contrary, is immediately dependent with regard to its operations, on the movement communicated to it by the blood. This assertion is by no means a new one. It has been admitted by all sound physiologists; but as many opinions in medicine are founded upon a contrary principle, it will not be amiss to dwell upon it a little. It is equally demonstrated both by observation and experiment—and to begin with the former:

1. All violent irritation made upon the brain, produces either partial, or general convulsion in the muscles of the animal life. Examine those of the organic life, on the contrary, and little will be found amiss in their actions.

2dly, All compression of the cerebral mass, whether made by pus, water or blood, has ordinarily the effect of paralyzing the voluntary muscles; but so long as the affection does not extend to the muscles of the breast, the action of the heart is in no degree diminished.

3dly, Opium and wine, when taken in a certain quantity, diminish the cerebral energy for the moment, and render the brain unfit for the functions of the animal life. The action of the heart, on the contrary, is increased.

4thly, In palpitation, and the different irregular movements of the heart, it is not observable that the principle of these derangements exists in the brain.—

In this respect, as well ason the subject of syncope, Cullen has been mistaken. The brain during such time, continues in action as usual.

5thly, The numerous phenomena of apoplexy, and epilepsy, and concussion, &c. do certainly all of them tend to shew, how independent the heart is of the brain.

6thly, Every organ which is subject to the direct influence of the brain, is for that very reason an organ of volition. Now, I should suppose, that few persons of the present day, would be inclined to maintain with Stahl, that the heart is among the number of such organs. What would life be, were we able at will, to suspend the action of the organ, by which the system is animated? From simple observation, then, we might conclude, that it is not immediately that the heart ceases to act, when the functions of the brain are interrupted, but this fundamental datum of physiology and pathology, we shall further establish, upon actual experiment.

1st, If the brain of an animal be exposed, and irritated either with mechanical or chemical agents, a variety of alterations will, indeed, be produced in the organs of the animal life, but none in the heart, so long as the muscles of the breast continue to perform their functions.

2dly, Experiments made in the same manner upon the spinal marrow of the neck, present the same results.

3dly, If the eighth pair of nerves be irritated, the movements of the heart will not be accelerated; they will not be arrested if these two nerves be divided. In all these experiments, however, we must be careful to make a proper distinction between the emotions and

passions

passions of the animal, and what it really suffers from the experiment.

4thly, The nature of the great sympathetic nerve, I suppose to be known; now if the same experiments be made on the cardiac branches of this nerve, as were made upon the eighth pair, the same results will follow.

I do not offer in detail the whole of these experiments; the greater part of them are well known: I was induced to repeat them, as authors are not agreed upon their consequences.

The experiments of galvanism, are well calculated to throw light upon the relations existing between the heart and the brain; these I have taken care to repeat with the utmost exactness, and whatever authors may have advanced, they are all in favour of the above opinions—for 1st, If the galvanic apparatus be applied to the brain, and to the heart, and inferior extremities of a frog, and the communication made between the metals, there will constantly be seen a strong contraction in the muscles of the limb, and little or none in the heart. The same will be the case, to whatever voluntary muscle the zinc be applied. 2dly, The same results will be had, on the communication being made between the metals applied on the one hand to the spinal marrow above the giving off of the sympathetic, and on the other hand to the heart, and any of the voluntary muscles.

3dly, On establishing a communication between the metals applied to the cardiac nerves, and to the heart of the animal, there has been no contraction in the heart. In all these essays, the natural disposition between the parts which serve to unite the two organs, is preserved: there are other experiments which consist in detaching the heart from the breast, 2dly, In placing two points of its surface in contact with two different metals

metals, 3dly, In making the communication between them with a third. From this experiment, Humbolt and other physicians, have procured contractions, but I have taken care to repeat it with the greatest accuracy, and must assert, that I have seen little or nothing of the kind; indeed, if I had, I should have concluded nothing from it; for it appears to me, that to decide upon the influence of the brain over the heart, a portion at least of the nervous system, should be in contact with one of the metals.

I shall now pass to my experiments on red and warm blooded animals. They are necessary for the decision of the question before us, as the mode of contractility in these animals differs much from that of the animals submitted to the experiments already mentioned.

An VII !

1st, In the winter of the year 1807, I was authorised to make different essays on the bodies of persons who had been guillotined. I had them at my disposal thirty or forty minutes after they had undergone the punishment. In some of them, all mobility was extinct; in others, this property could be reanimated in all the muscles by the common agents, and in those of the animal life, by galvanism especially. Notwithstanding which, I could never occasion the least motion, in applying the apparatus either to the spinal marrow and the heart, or to this latter organ and the nerves, which it receives from the ganglions of the sympathetic, or the par vagum. Nevertheless, the common mechanical excitant, immediately applied to the fleshy fibre, occasioned its contraction. Could this have happened in consequence of the separation of the nervous fillets from the brain? assuredly not; because the voluntary muscles were equally separated from it, and yet affected strongly. If any doubt remain, the following experiments will clear it up.

2dly,

2dly, In dogs and guinea pigs, I have repeatedly applied the metals, first to the brain and the heart, then to the trunk of the spinal marrow, and the heart; then to the par vagum and the heart. The communication being made, was followed by no apparent result.

3dly, On making the communication between the metals, when applied to the cardiac nerves and the heart, there was no very sensible motion.

4thly, Humbolt has asserted, that when the heart is speedily detached with some of its nervous threads about it, a contraction may be excited, by arming the nerves with a metal, and then by touching this metal with another. I have many times tried this experiment in vain. I confess, however, that once it appeared to me to succeed.

5thly, On the contrary, I have almost always succeeded in producing contractions in the heart, by cutting it away from the breast, and making a communication between a couple of metals, applied to different points of its surface. This, if I am not mistaken, is the only means of evidently producing the phenomena of galvanism in this organ, but with respect to our present question, the experiment is wholly inconclusive.

All these experiments I have repeated many times, and with the most scrupulous precautions, nevertheless I do not pretend to call in question the reality of those results, which other physicians have remarked. It is well known how very variable those experiments are, which have the vital powers for their object. Besides, in admitting even these different results, I do not see how it is possible to refuse acknowledging, that with respect to the stimulus of galvanism, there is a wide difference between the susceptibility of the muscles of the animal life, and those of the organic life. Again, supposing that the galvanic phenomena were the same in

both

both sorts of muscles, the fact would prove nothing more, than that these phenomena with regard to their succession, follow laws directly the contrary of those, which are displayed in the phenomena which take place, when any common cause of irritation is applied to the nerves and their corresponding muscles.

The proofs adduced, will allow us to conclude, that the brain exercises no direct influence over the heart, and consequently, that when it ceases to act, the functions of the latter must be interrupted indirectly.

§ II. *In case of lesion of the brain, is the death of the heart occasioned by that of any intermediate organ?*

When the brain dies, the heart dies, but not directly. There must be some intermediate organ then, the death of which occasions that of the heart. That intermediate organ is the lungs. In this sort of death, the following is the series of the phenomena which may be observed.

1st, The cerebral action is interrupted. 2dly, The action of all the muscles of the animal life, and consequently of the intercostals and diaphragm, is annihilated. 3dly, The mechanical functions of the lungs are suspended. 4thly, The like ensues with respect to their chemical functions. 5thly, The fibres of the heart are penetrated with black blood. 6thly, The fibres when so penetrated, die.

Such sort of death then, has much resemblance with that which is occasioned by the different asphyxiæ. It is only more sudden, and that for reasons which I shall presently point out. The following experiments are an evident proof that the phenomena take place as I have described them to do.

1st, I have always found black blood in the red-blooded system of all animals, killed by concussion or compression of the brain; the heart livid, and the different surfaces coloured as in asphyxia.

2dly, I opened the carotid artery of a dog; the red blood instantly gushed out, but was immediately suppressed, and the artery tied. I then killed the creature, by striking him with violence on the occipital bone. The animal life, and consequently both the mechanical and chemical functions of the lungs, were suddenly suppressed. The artery was then untied. It poured forth the black blood with a feeble jet, for some little time, and after some minutes, the heart entirely ceased to move.

3dly, I have always obtained a similar result in opening the arteries of different animals which I afterwards killed, either by dividing the marrow between the first vertebra and occiput, or by strongly compressing the brain, which I had previously exposed.— It is thus also that animals perish, by the carotids of which a deleterious substance has been injected.

4thly, The preceding experiments explain the reason why the blood is black which flows from the arteries of animals, which are bled in our slaughter-houses, after having been knocked in the head. If the blow has been violent, the blood issues such as it was in the veins, but if the action of the diaphragm and intercostals has only been weakened by the blow, the redness of the blood is only diminished.

The state in which the respiration may be (and it is altered from a variety of circumstances during profuse hemorrhagy) occasions a great variety in the colour of the arterial blood: hence we have the reason why it is found of so many different shades in the great operations of surgery. At the beginning of these, it often

flows

flows out quite red; at the end of them, is sometimes almost black. The easy or embarrassed state of the respiration of the patient, is the occasion of these varieties. This I have frequently remarked, when attending Dessault, and was often struck with the appearance, before I knew the cause of it.

I have never found any relation whatever, between the obscure colour of the blood, and the compression exercised above the artery, as some have asserted to take place. There is, indeed, a connection between the colour and the impetuosity of the jet, but the reason of this is evident to any one who has read the foregoing pages.

To return to the point of doctrine on which we are at present occupied, I am persuaded from the considerations and experiments which are adduced in the course of this chapter, that the manner in which the heart ceases to act, when the cerebral functions are suspended, can no longer admit of a doubt, and that we may resolve the question proposed, in affirming that under such circumstances, the death of the heart is occasioned through the medium of that of the lungs.

There is this difference, then, between the death of the heart, in consequence of that of the brain, and the death of the brain in consequence of that of the heart, that the one is indirect, the other direct, as we have already seen. If some men, as Stahl asserts, have really been able to suspend the movements of the heart, the fact is not a proof of the influence of the mind over the muscles of the organic life, but of its power over the mechanical, and consequently, the chemical phenomena of respiration.

In red and cold blooded animals, the death of the heart does not succeed the death of the brain so

quickly

quickly as it does in red and warm blooded animals. Cut off the head of a frog, and the heart will continue to beat for some time afterwards. This phenomenon will be easily accounted for, if we recollect that respiration with these animals may be suspended a length of time, without arresting the movements of the heart.

In fact, as the heart dies only because the lungs die in the first place, when the cerebral functions are interrupted, it is plain that there ought to exist between the violent death of the heart and that of the brain, an interval nearly equal to that during which, in the natural state, there may be a suspension of respiration.

CHAPTER THE TWELFTH.

Of the Influence of the Death of the Brain over that of all the Organs.

WHEN the brain dies, the animal life dies, for the functions of this life, either directly or indirectly, have their seat in the brain. It is manifest, that all the operations and affections of the mind, together with sensation, locomotion, and the voice, must be put an end to in such case. The difficulty then respects the functions of the organic life.

§ I.

§ I.—*Is the interruption of the functions of the organic life a direct consequence of the cessation of the cerebral actions?*

We shall here adduce both observation and experiment to prove, that the internal functions are all of them, as well as the action of the heart, withdrawn from the immediate influence of the brain.

1st, There are a number of diseases affecting the brain, which occasion so general a suspension of the animal life, as to leave neither sensation nor voluntary motion, excepting some feeble oscillations of the intercostals and the diaphragm. In this state the individual has lost the half of his existence, but the one half composed of the organic functions, continues in the meanwhile to subsist, and in many cases with energy. This phenomenon is exemplified continually in apoplexy, in concussion of the brain, and extravasation of blood upon its surface.

2dly, During sleep the secretions certainly go on, though Bordeu insists upon the contrary opinion, with the view of proving the influence of the nerves over the glands. During a state of sleep, digestion goes on as usually it does. The exhalations of the body are made with perfect freedom, and often augmented beyond their natural quantity; the process of nutrition continues to be effected, and is probably under such circumstances, increased. There are many proofs in favor of this opinion ; but a state of sleep is a state of collapse in the brain. Then, neither is the relaxation of the functions of the internal organs the consequence of a relaxation of action in the brain, nor the death of the former the immediate effect of the death of the latter.

3dly

3rdly, The sleep of animals, which pass a certain part of the year in a state of torpor, is a very strong proof of the co-existence of a suspension of the cerebral functions, with a permanent action of those of the organic life.

4thly, In the different palsies; in those for instance which affect the lower limbs, and the viscera of the pelvis, in consequence of some concussion or compression of the medulla spinalis, the communication of the paralyzed parts with the brain, is either entirely cut off, or only enfeebled. It is entirely interrupted when all feeling and power of moving have ceased—it is enfeebled, when the one and the other of these properties are only enfeebled. But in these two cases the general and the capillary circulations continue. The exhalations from the cutaneous surface and in the cellular substance, are made as usual; the process of absorption goes on, for without absorption, we should soon see dropsy. The secretions also are effected, for nothing in such sort of palsy is more common than a copious secretion of mucus from the bladder. As for nutrition if it be diminished in energy, the process is certainly never entirely arrested.

5thly, Spasms and convulsions, which proceed from an unnatural energy of the cerebral action, have little influence over the exhalation, secretion, and nutrition of the parts in which they make their appearance. The trouble and excessive agitation of the animal life of such parts, compared with the calm of their organic life, are facts well worthy of remark.

6thly, Fœtuses without heads, in the uterus, possess as active an organic life, as those which have no vice of conformation whatever, and sometimes at the time of birth, are monstrous even in bulk; this circumstance I have frequently had occasion to observe at my amphitheatre,

amphitheatre, the functions of nutrition then and circulation may take place with activity, though deprived of the influence of the brain:

7thly, In animals, which have no cerebral mass, and in those (the polypes for instance) where not even a nervous system is apparent, these organic processes are admirably well conducted, the greater part of them indeed are common to the vegetable, and the animal.

8thly, If the different proofs, which Bordeu has given of the influence of the brain over the functions be well examined, it will seem that no one of them is decisive. The sudden interruption of the secreted fluid, in consequence of the division of the nerves of the part, would be the only proof which I should be inclined to admit as positive. Now I am not acquainted with any means of making such division with exactness. We have heard much of an experiment of this nature upon the parotids; but the disposition of the nerves distributed to these glands is such, that I have not been even tempted to repeat the experiment. The testicle is better adapted for the attempt, and accordingly without touching the vessels, I divided the spermatic nerves, but an inflammation and a deposit of matter took place in the gland, and with respect to the secretion of the semen, I could not judge of the effect of the division of the nerves. But here this very inflammation coming on without the influence of the brain, appears to me to infer a possibility of the seminal secretion under the same circumstances. In this experiment, the spermatic artery cannot be separated from the plexus which it receives from the great sympathetic, so intricate is the network of these nerves about it; their division however is of little consequence, as they come from the ganglions. It is easy to break off all communication with the brain, by destroying the lumbar fillets of nerves.

I might add a number of other considerations to the above, but here I have to remark that the distinction of the sensibility and contractility into their two kinds is particularly worth attention. In fact, the idea of sensibility in our usual way of seeing things, suggests the idea of the nerves, the nerves again make us think upon the brain, we associate the three ideas, but excepting for the animal life they should not be associated. In the organic life at least their union is not immediate.

I do not mean to say that the cerebral nerves have no influence whatever over the organic sensibility, but I maintain that such influence is not direct and not of the nature of that which is observed in the animal sensibility.

Many authors have already discovered a number of difficulties resulting from the opinion which makes the nerves the exclusive seat of sensibility, they have even sought for other means of explaining the phenomena of great living bodies. But of its agents we know as little as we do of its nature, and have no means of elucidating questions of this sort. Let us be contented with analyzing, collecting and comparing facts with seizing their general results; the aggregate of these researches will compose the true theory of the vital powers; the rest is only conjecture: but besides the considerations which I have offered, there is another which manifestly goes to prove that the organic functions are not under the immediate influence of the brain, and this is, that the viscera, which perform such functions do not receive their nerves from the brain but from the ganglions.

This anatomical fact is observable in the liver, the kidney, the spleen, pancreas, intestines, &c. even in the organs of the animal life there are nerves which serve for the external, and nerves which serve for the internal functions. In such the former come directly from the brain, the latter from the ganglions. Thus the ciliary nerves, which come off from the opthalmic ganglion, are those which preside over the secretions and nutrition of the eyes, the optic nerve which is derived from the brain is the nerve of vision. In the same way the olfactory nerves of the pituitary membrane are the agents by which we have the perception of odours, the threads which come off from the ganglions of Mekel, relate only to the organic phenomena of the membranes.

Now the nerves of the ganglions cannot transmit the action of the brain; for we have seen that the nervous system derived from these bodies should be considered as entirely independent of the nervous system of the brain; and that the great sympathetic does not derive its origin from the brain, from the spinal marrow, or from the nerves of the animal life; but from the ganglions exclusively; this nerve indeed does not exist, it is only the aggregate of so many small nervous systems as there are ganglions, which are the particular centers of the organic life, just in the same way as the brain is the great and only center of the animal life.

To establish it as a fact that the great sympathetic such as it is understood does not in reality exist, I might add a number of proofs to those, which I have already mentioned. The nervous communications, which are taken for it, are nothing more than accessories to the system of the ganglions; for 1st, these nervous communications, as Cuvier has observed, are not met with in the necks of birds; between the upper cervical and first thoracic ganglion there is no vestige of a sympathetic. In birds then, the upper cervical ganglion is that which in man the opthalmic ganglion,

the

the ganglion of Mekel and others are. This disposition, which is natural in birds, agrees with what I have sometimes observed in the human subject between the first lumbar and the last thoracic ganglions, as well as between the lumbar and sacral ganglions themselves. 2ndly, In many instances there are no ganglions in the spot where the pretended sympathetic nerve communicates with the spinal marrow. This may be seen in the human neck, and in the abdomen of fish, but such disposition should be thus regarded. The inferior cervical ganglion furnishes a great branch which ascends to the superior cervical ganglion, and establishes between the two a direct communication; but in ascending it distributes many branches to each of the cervical nerves, which form a secondary communication.

If we reflect on these considerations, together with those which have been already offered, we shall be more and more convinced—1st, That the great sympathetic is only an assemblage of small nervous systems, having each of them a ganglion for its center, and all of them independent of each other, though generally communicating with the spinal marrow and between themselves. 2dly, That the nerves belonging to these small systems, cannot be considered as a part of the great nervous system of the animal life. 3dly, That the organs, which are provided exclusively with the nerves, are not under the immediate influence of the brain.

Notwithstanding which, we must not suppose that all the organs which serve for the internal functions, receive their nerves exclusively from the ganglions: many of these organs are furnished from the brain, and yet from experiment, it is found that they are not under the immediate influence of the brain.

As yet we have only observation and reasoning for the

the basis of the important principle which we are laboring to establish, namely, that the organic functions are not directly put a stop to in consequence of the death of the brain; but experiments upon living animals are not a less evident demonstration of this principle.

1st, I have always observed, that in producing palsy or convulsion, I have never been able to impair in any very sensible or sudden manner, either the exhalation, the absorption, or the nutrition of the convulsed or palsied part.

2dly, It has been for a long time known, that no spasm of the muscular fibres of the stomach, bladder, or intestines, can be produced by irritating the nerves of the ganglions which go to these organs.

3dly, The division of the nerves of the ganglions, will not immediately paralyze the hollow organs: Their vermicular motions continue for a long time after the experiment.

4thly, With respect to the stomach, intestines, bladder and uterus, I have repeated the galvanic experiments which, with respect to the heart; have already been mentioned at length; but never could obtain contractions.

5thly, The same experiments being made upon the organic muscles, and the great sympathetic nerve of a dog, there was no contraction.

6thly, The issue of the latter operation may be easily conceived, according to our manner of regarding things. In fact, the ganglions, which are situated between the gastric organs and the nervous trunk of the chest, might possibly have interrupted the series of the galvanic phenomena. With a view, then, to remove all doubt of this kind, I exposed the nerves, which go from the ganglions immediately to the stomach, bladder

der and rectum, and in this way galvanised the organs but no contraction appeared to me to be the result of the experiment; at least no contraction, which I could suppose to be the effect of galvanism, for here I cannot too much recommend a proper distinction to be made between that which should be the effect of this fluid, and that which results from the mechanical contact of the metals.

7thly, These experiments are not easily made upon the intestines, on account of the tenuity of their nerves; but as these nerves compose a very perceptible plexus about the mesenteric artery, the intestine may be galvanized by surrounding the artery with one of the metals, while the other is placed under the intestinal tube. This experiment I have made, but could not obtain any sensible result.

8thly, The preceding essays were made upon warm and red-blooded animals. Similar attempts were repeated on cold and red-blooded animals, but with no effect.

9thly, The nerves which immediately supply the gastric organs of the frog, are so delicate as to make it an extremely difficult matter to get them into proper contact with the zinc: a small contraction of the stomach was, however, obtained by Jadelot on operating directly on these nerves; but this contraction was similar, no doubt, to those which I have so frequently observed in other experiments, and not to be compared to the astonishing effects which are observable in the voluntary muscles. I shall conclude, therefore, that with respect to the galvanic phenomena, there exists a wide difference between the muscles of the animal life and those of the organic life.

I have now collected proof enough, I trust, for resolving, with certainty, the question proposed in the above chapter, and for establishing it as a fundamental principle—1st, that the brain does not directly influence the organs and the functions of the internal life; and 2dly, that, therefore, the interruption of these functions, in case of any great lesion of the brain, is not an immediate effect of such lesion.

Nevertheless, I am far from considering the cerebral action as foreign entirely to the organic life. I only maintain that its influence upon it is indirect, and as yet but little known. I have been somewhat prolix upon this subject; for certainly nothing in medicine is more vague than the sense which is commonly attached to the words *nervous action, cerebral action*, &c. There is never a proper distinction made between that which belongs to one life, and that which is the attribute of the other. Cullen, in particular, may be reproached with having exaggerated the influence of the brain.

§ II.—*Is the interruption of the functions of the organic life, the indirect effect of the cessation of the cerebral action?*

The organic life continues to subsist for a certain time, after the apparent death of the individual. There must be some intermediate agents then, the cessation of the action of which, occasions the death of the inward organs. Such agents are chiefly the mechanical organs of respiration. The series of the phenomena are the following:

1st, The cerebral actions are interrupted.—2ndly, the mechanical functions of the lungs are put an end to.—3rdly, There is an annihilation of their chemical functions.—4thly, The black blood circulates in all the parts.—5thly, The movement of the heart and the action of all the parts is weakened.—6thly, Suspended.

All

All the inward organs then, die nearly as they do in asphyxia; that is to say—1st, Because they are penetrated by the black blood.—2dly, Because the circulation ceases to communicate that motion which is essential to their life.

Nevertheless, there are many differences between death from asphyxia, and death from lesion of the brain. 1st, The animal life in the latter sort of death, is generally interrupted at the very instant of the shock or blow. In the former it is terminated only in proportion as the black blood penetrates the substance of the brain.—2dly, In the greater number of the asphyxiæ, the circulation does not immediately cease, the blood is only gradually blackened, and continues for some time to be moved onwards by the agitation of such parts as are still under the influence of the brain, On the contrary, in lesion of the brain, the interruption of respiration is sudden; the blood also loses its red colour at once: on the other hand, the animal life being suddenly arrested, the organs of volition become immovable on the spot, and are capable no longer of favoring the motion of the blood. This remark is particularly applicable to the breast, the parietes of which facilitate very much the pulmonary circulation, and even the movements of the heart by their rise and fall, for in such alternation of motion consists the true influence which the circulation receives from the respiratory process.

But after all, these two sorts of death may be more or less similar to each other according to the way in which they happen. The differences which I have pointed out are by no means general. Thus, when asphyxia is sudden, as when for instance the air of the lungs is pumped out with a syringe, there are neither livid spots, or fulness of the lungs to be met with.

The circulation ceases quickly, and the phenomena of death are such as are observable when the brain is suddenly destroyed.

On the contrary, if the death of the brain be slow, and the process of respiration for a certain time continued, the capillary system of the lungs will be gorged with blood, and the general capillary system be filled also. The circulation in such case will be slow to cease, and the phenomena of death like those of many of the asphyxiæ. Thus the promptitude or slowness of death, proceeding from lesion of the brain, will occasion all the differences.

It has been often a question in what way criminals die, who are hanged. In some, the vertebral column is luxated, and in others, want of respiration is the cause of death. But whenever there is luxation, there is at the same time asphyxia, and in such case asphyxia is produced, both because the pressure of the cord intercepts the passage of the air, and because the intercostals and diaphragm are paralyzed.

From what I have now said, a comparison may be made between the three kinds of death upon which I have expatiated. This comparison, according to my ideas, is of importance: I shall give some features of it. Generally speaking, there is a greater similarity in the two modes by which the death of the brain, or that of the lungs produces the death of the organs, than between either of these modes, and that, where the death of the heart is followed by the same effect.

But 1st, There is always black blood in the red-blooded system, when death begins either by the brain or the lungs. When the functions of the heart are uddenly suspended, the arterial system contains a ortion of red blood only.

2dly, In the two first cases, the circulation continues for awhile; in the third, it is immediately suppressed.

3dly, When the death of the organs is a consequence of the death of the heart, they die, because they cease to receive that excitement to which they are accustomed from the motion of the blood. When their death is produced by that of the brain or lungs, they die not only because they lose the excitement abovementioned, but because they are penetrated by a fluid which is incapable of keeping up their actions, &c. The reader will easily finish the parallel which I have thus begun.

In red and cold blooded animals, the death of the organs succeeds much more slowly to that of the brain, than in red and warm-blooded animals. We cannot assign the reason of this fact, because we do not know the difference of the arterial blood from the venous blood of these animals, nor the effect which is produced on their organs by the contact of either sort of blood with them.

When reptiles remain for a length of time under water, does the arterial blood become black? is the influx of such blood into their organs, pernicious or not? or is there a sufficient quantity of air contained in the large vesicles of the lungs of these animals to oxydate their blood for a length of time, as but little blood is capable of passing into the pulmonary artery, which is only a branch of the aorta. The latter opinion appears to be confirmed by the experiment of injecting the lungs of a dog with a large quantity of air, in which case the blood of the creature is reddened for a greater length of time. But all these questions, notwithstanding the essays of Goodwyn, require much elucidation.

CHAP.

CHAPTER THE THIRTEENTH.

Of the Influence of the Death of the Brain over that of the Body in General.

From the consideration of what has been said in the preceding chapter, nothing can be more easy than to form an accurate idea of the manner in which the phenomena of general death, commencing by the brain, are concatenated. The series is as follows :

1st, The cerebral action is annihilated. 2dly, There is a sudden cessation of sensation and voluntary motion. 3dly, A simultaneous paralysis of the intercostals and diaphragm. 4thly, An interruption of the mechanical phenomena of respiration and the voice. 5thly. An annihilation of the chemical phenomena of the lungs. 6thly, A passage of black blood into the arteries. 7thly, A slowness of circulation owing to the influx of such blood into the arteries, and the absolute immobility of all the parts, of the intercostals and diaphragm in particular. 8thly, The heart dies and the general circulation ceases. 9thly, The organic life vanishes. 10thly, The animal heat, which is the product of all the functions, disappears. 11thly, The white organs die.

Though

Though in this kind of death, as well as in the two preceding kinds, the functions are suddenly annihilated; the parts retain, for a certain time, a number of the properties of life. The organic sensibility and contractility, continue for some time, to be manifest in the muscles of the two lives; and in those of the animal life, the susceptibility of being affected by the galvanic fluid is very pronounced in the muscles of the animal life.

This permanence of the organic properties, is nearly the same in every case; the only cause which affects it, is the slowness with which the phenomena of death have succeeded each other. In every case where their duration has been the same, whatever may have been the cause of death, experiments instituted upon these properties, are attended with similar results; for it is evident that concussion of the brain, luxation of the vertebræ, the section of the spinal marrow, apoplexy, compression of the brain, or inflammation, are all of them causes which are attended with a like effect.

The same, however, is not the case with respect to the asphyxiæ produced by the different gasses. We have shown the reason of this in the more or less deleterious nature of the gasses which produce asphyxiæ.

The state of the lungs also, is very various in the bodies of persons who have died from lesions of the brain. This organ is sometimes gorged and sometimes almost empty: it shews, however, whether the death of the individual has been sudden or gradual. The same indication may be had from the state of the exterior surfaces.

The death, which is the consequence of disease, commences much more rarely in the brain, than in the lungs. Nevertheless, in certain paroxysms of accute fever

fever, the blood is violently carried to the head, and is the occasion of death. The concatenation of its phenomena, are then the same as take place in sudden death.

There are a great number of other cases besides those of fever, where the commencement of death may be in the brain, though the brain itself may not have been previously affected by the disease. In these cases, the state of the lungs is very various; but little can be learnt from it with respect to the nature of the disease. It is only an indication of the manner in which the functions have been terminated.

FINIS

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ADDENDA.

The following Note is inserted as explanatory of BICHAT's *manner of considering the great sympathetic nerve:*

THIS nerve, says he, is considered as a medullary cord, extending from the head to the sacrum;—in this course it is represented by anatomists, as sending different ramifications to the neck, breast, and abdomen, as having a distribution analogous to that of the nerves of the spine, and as deriving its origin, either from these nerves, or those of the brain. Whatever be the name by which it is designed, sympathetic, intercostal, or trisplanchnic, the manner of regarding it is invariably the same.

But there exists no such nerve as that which is described under these names. That which is taken for a nerve, is nothing more than a series of communications between different nervous centers placed at different distances from each other.

These nervous centers are the ganglions. Disseminated in different regions, they have all of them an independent and isolated action. They are, each of them a focus, which sends out in different directions a number of ramifications, which in the several organs to which they are distributed, are the conductors of the irradiations of the focus from whence they escape.—Of these ramifications, there are some which go from one ganglion to another, and as these branches, which unite the ganglions, compose by their aggregate a sort of continuous cord, such cord has been considered as an isolated nerve, but it is no such thing; these branches are nothing more than communications, simple anastomoses, and not a nerve.

This will be evident, when it is considered that the communications are frequently interrupted. There are subjects, for example, where a very distinct inter space is found between the pectoral and lumbar portions of that, which is called the great sympathetic; it seems to be divided at this spot. Every anatomist must have remarked, that sometimes a single branch, and sometimes many, pass from one ganglion to another, and this particularly between the last cervical and first dorsal ganglion. Besides the volume of these branches is singularly various, and after giving out a number of branches, the sympathetic is larger than ever.

These different considerations, are a manifest proof that the communicating branches of the ganglions, should no more be considered as a continued nerve, than the branches, which pass from each of the cervical, lumbar, and sacral nerves, to those which are immediately above and below them. In fact, notwithstanding these communications, each pair of the latter mentioned nerves is regarded as a separate pair.

In like manner each ganglion should be considered separately, and the branches be described which proceed from it.

For this reason, continues Bichat, in my descriptions in future, I shall divide the nerves into two great systems; the one emanating from the brain; the other from the ganglions, &c. The first has a single center, the second a number of centers. This manner of considering them, will present them such as they actually are in nature.

What anatomist, for instance, can there be found, who has not been struck with the difference which exists between the nerves of these two systems. Those of the brain are larger, but less numerous;—are whiter, denser and less subject to variations than the others. On the contrary, the general character of the nerves of the system of the ganglions consists in extreme tenuity, great number, a greyish colour, softness of texture, and great variability.

Besides, this division of the general system of the nerves into two secondary systems, agrees exactly with my division of life. The external functions, sensation, locomotion and the voice, depend on the cerebral system. On the contrary, the greater number of the organs of the internal functions have their nerves, and consequently their principle of action from the ganglions. From the former are derived, the animal sensibility and contractility; where the latter only are found, there are only to be found the organic sensibility and contractility.

I have said elsewhere, that the term of this species of sensibility, and that the origin of the corresponding contractility, reside in the organ in which they are observed; but perhaps this term and origin are to be found at a greater distance; perhaps they exist in the ganglion from which the organ receives its nerves, just in the same manner as the brain is the term and origin of the animal sensibility and contractility. If this be the fact, as the ganglions are very numerous, we may easily conceive why the powers of the organic life have not a common center.

From all this, it is manifest, that there exists no great sympathetic nerve, &c. &c.

THE END.

centages, the general character of the nerves of the system of the ganglions [illegible] [illegible], [illegible] [illegible] [illegible] and [illegible].

Besides, the division of the general system of the nerves into secondary systems, agrees exactly with the division of life. The external functions, sensation, locomotion, and the voice, depend on the cerebral system. On the contrary, the greater number of the organs of the internal functions have their nerves, and consequently their principle of action from the ganglions. From the former are derived the animal sensibility and contractility, whereas the latter only furnish those in which are found the organic sensibility and contractility.

I have said elsewhere, that the term of the organic sensibility and that the origin of the corresponding contractility reside in the organ in which they are observed; but perhaps the term and origin are to be found at a greater distance; perhaps the ganglions are the common term, as each organ receives its nerves, just in the same manner as the brain is the term and origin of the animal sensibility and contractility. If this be the case, as the ganglions are very numerous, we may easily conceive why the powers of the organic life have no common centre.

From all this, it is manifest, that there exists no great sympathetic nerve, &c. &c.

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