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OUTLINES

OF

PHYSIOLOGY AND PATHOLOGY.

BY

WILLIAM PULTENEY ALISON,

M. D., F. R. S. E.

FELLOW OF THE ROYAL COLLEGE OF PHYSICIANS, AND PROFESSOR OF THE INSTITUTES OF MEDICINE IN THE UNIVERSITY, OF EDINBURGH.

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TO

JOHN ABERCROMBIE, M.D.

FELLOW OF THE ROYAL COLLEGE OF PHYSICIANS, AND

PRESIDENT OF THE MEDICO-CHIRURGICAL SOCIETY,

OF EDINBURGH;

FIRST PHYSICIAN TO HIS MAJESTY FOR SCOTLAND;

THIS VOLUME IS INSCRIBED,

IN TESTIMONY OF RESPECT

FOR HIS PROFESSIONAL AND SCIENTIFIC CHARACTER,

AND OF GRATITUDE FOR PERSONAL KINDNESS,

BY THE AUTHOR.

PREFACE.

When the former edition of these Outlines of Physiology was published, I thought some apology necessary for the publication of a new elementary book on a subject on which several very valuable and complete treatises had recently appeared; and I stated, accordingly, that the arrangement of the subject which seemed to me the most satisfactory, and which I had followed in lecturing on it, was different from that followed in any of these treatises; and that in conformity with views in regard to the dependence of the different functions of the living body on one another, which seemed to be legitimate inferences from the facts hitherto known, I thought it possible to give a more systematic form to the subject than had been usual in recent publications.

It does not appear equally necessary to apologise for the publication of Outlines of Pathology; because, notwithstanding the zeal and success with which several departments of that subject have been lately prosecuted, I have felt much difficulty in recommending to Students of Medicine any single work in our language, fitted to give them a comprehensive view of the information which it appears desirable that Lectures on Pathology should convey.

I am aware that the term Pathology has of late years been much employed in this country in a more restricted sense, as nearly synonymous with Morbid Anatomy; and that what were formerly called Morbid Appearances, left after any disease, are now frequently (although with little attention to etymology), termed Pathological Appearances.

But I do not think that this restricted sense of the word Pathology has become so general as to make it incumbent on all authors on the subject to conform to it; and, if it were to be so generally accepted, I would beg to suggest that it would be necessary to devise another more general term, as a general expression for all the information which has been acquired regarding the causes, the essential symptoms, the intimate nature, and the consequences of diseased states to which the human body is subject; because it is quite certain that much important information on these subjects has been acquired by observation and generalization of facts, which is not obtained by, and could not have been inferred from, any examination of morbid appearances; but which, nevertheless, falls strictly under the denomination of Pathology, according to the use of that term, which is suggested by its etymology, and sanctioned by the greater number of the best authors.

The department of the Course of Institutes of Medicine in this University, which has appeared to me, as well as to my predecessors, to demand the fullest consideration, is that of Physiology; but I have always thought it peculiarly the duty of the Professor of the Institutes to deliver a general outline of all the information which has been collected and generalized in regard to the functions of the living human body, as performed during health, as altered by disease, and as influenced by remedies.

There is at present, fortunately, no deficiency of zeal or industry on the part of the medical students in this or, I believe, in any other School of Medicine in this country; but it seems to me that, on the one hand, the number, and the minute details of scientific medical works, are formidable and perplexing to some; and, on the other, that individual portions of the study, which may excite peculiar interest, or promise early distinction, attract a larger share of the attention of others, than their importance in relation to the whole range of medical science, or in reference to the practical objects for which medical science is cultivated, will fairly warrant. On both accounts it seems important, that the whole extent of the studies most intimately connected with the practice of medicine, should be fairly laid before the student, in as small a compass as possible. It is with this intention that the following Outlines have been composed; and I hope that the importance of giving the greatest possible extent to the field of inquiry which is here marked out, will be admitted as an apology for some deficiencies in filling up the details.

The objects which I have had in view, in both departments of the subject, have been, first to state the facts which appear to be ascertained, and the inferences which appear to be fairly deducible from them, in regard to the functions of the living human body, in health and disease; and secondly, to arrange these facts as systematically as possible, in the order in which the functions, as existing in the living body, in the adult state, are dependent on one another.

It is generally avowed, that the principles of medicine may be expected to assume a more systematic form as the science advances; but it seems to me that there is in many medical writings, an indifference to the establishment of such general principles, both in Physiology and Pathology, as the information we already possess sufficiently warrants;—which argues inattention to the value and importance of these principles, not only for the gratification of the desire of knowledge, but for securing the recollection and useful application of individual facts.

It seems to have been thought by some physiologists and pathologists, that a systematic form cannot be given to medical science, until we shall be able to give a complete explanation of all the facts which the science comprises; whereas I think we are entitled to treat the subject systematically or synthetically, if we can follow an order of ascertained dependence of the functions on one another, notwithstanding that, in many parts of the subject, we meet with facts of which the explanation is very imperfect.

It will be generally agreed, that the first important step in medical science is the separation of the phenomena of the living body from all those which are comprised in the sciences of Chemistry and Mechanics on the one hand, and of pure Metaphysics on the other; and the general acknowledgment of the necessity of referring all the facts which the human body presents, in health and disease, to laws of Vitality, exemplified in the history of other living bodies, but not in other departments of nature.

This principle was recognised in the favourite position of CULLEN, that medical science must be founded on a knowledge of the "moving powers of the animal economy." But I think it certain that CULLEN misunderstood the nature of these moving powers in one essential particular, viz. in supposing that the vital power of muscular parts is essentially dependent on an influence derived from the brain.

It has always appeared to me, that the distinctions of Organic and Animal life in general, and of the several subordinate Vital Powers or Properties, drawn by BICHAT, formed an important step towards the formation of a regular system of Medical Science; but some of these distinctions are somewhat arbitrary, and the property of Organic Sensibility in particular, appears to have been vaguely defined, and the share of the Nervous System in determining the phenomena referred to that head, to have been erroneously assumed.

It is not presuming too much on the accuracy of the information which we now possess on these subjects, to assert, that two errors have been very prevalent in general or systematic medical works since the time that Medicine has been separated from other sciences, and cultivated on sound principles. *First*, the "moving powers of the animal economy," and especially the province of the Nervous System in producing the phenomena of life, which were long neglected in certain schools of Medicine, have been erroneously conceived in others; by STAHL, by HOFFMAN, by CULLEN and WHYTT; and to a certain degree by BICHAT, by LEGALLOIS, and even by Dr WILSON PHILIP; and were more accurately understood by HALLER, than by any of these authors.

Secondly, besides the misconceptions which seem to have prevailed, and still to prevail, among many physiologists, as to the essential conditions of Vital movements, and particularly as to the influence of the Nervous System in determining these movements and their immediate effects, it seems now pretty generally admitted, that the influence of the truly Vital properties of the Blood and other animal fluids, on many of the most important changes of the living body, in health and disease, has been until lately very much overlooked. When these vital properties of the fluids are better ascertained, and their importance duly appreciated, there is every reason to believe, that the distinction so often drawn in the Schools of Medicine between Solidists and Fluidists will be effectually obliterated by the admission, that most diseases originate in that part of the system (the capillary vessels) where the animal solids and fluids are most intimately blended together, and are continually interchanging particles; and therefore necessarily extend to both.

These general reflections have led me to hope, that the attempt which I have made to reduce the chief facts of Physiology into a systematic arrangement,—by first stating the laws and conditions of Vital Contractions,—then tracing the different changes observed in the adult body, in the order of their dependence on the fundamental function of Circulation,—marking the departments of the different complex functions, in which the Vital properties of the blood, and the truly Vital Affinities subsisting among the component parts of the animal frame (both solid and fluid) must be admitted as an essential part of the cause of the phenomena,—and defining as accurately as possible the powers exerted by the different parts of the Nervous System, in determining certain of the phenomena, both bodily and mental, which the living body presents,—may be of some use in giving simplicity, precision, and a scientific form, both to our knowledge in Physiology and to its applications in Pathology.

In treating of Pathology, however, I have thought it necessary to point out the evidence, and dwell repeatedly on the importance, of general facts which have been ascertained, as to the influence of external causes on the human body, and the morbid alterations of action assumed by its different parts, and which could no more have been anticipated from their healthy action, than this could have been deduced from the examination of the mechanical or chemical qualities of the textures composing them. And a similar observation may be applied to the study of Therapeutics.

I am very sensible that the pressure of other duties has been frequently injurious to the execution of this work; and in the second part in particular I now regret the omission of a number of references to authorities, which would have given weight to some doctrines which may be considered as doubtful. In a text-book for Lectures this omission is, however, of no great importance, while early publication is essential to its usefulness; and if these Outlines shall be honoured by a more general attention from the profession, I shall spare no pains to correct such deficiencies in a future Edition.

CORRIGENDA.

Page 381 line 20, *for* great nerves, *read* great veins,
—— 417 — 9, — action of blood *read* return of blood
—— 505 — 27, — moderate elevation *read* slight elevation
—— 464 — 27, — after typhoid. *insert*, The acute gangrenous inflammation of the gums and cheek, in children, called *Cancrum Oris*, is another striking example of specific inflammation.

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OUTLINES OF PHYSIOLOGY.

CHAPTER I.

PRELIMINARY OBSERVATIONS.

In treating of Physiology, we first consider the living human body when fully formed, in the adult state, and in the full enjoyment of health; and endeavour to deliver the history and explanation, so far as is yet possible, of all that takes place in it, different from what takes place in the dead body. Afterwards we explain the manner, in which the body gradually attains to the state of perfection in which we first considered it.

In order to have a distinct understanding of the kind and degree of *explanation* of which facts in Physiology admit, and to avoid misapprehensions and controversies which have obscured the first principles of the science, it is necessary to attend to the following considerations.

The word Life, as commonly used, does not denote an individual fact, nor a simple idea, and cannot, therefore, be *defined*. It is applied to a certain assemblage and succession of phenomena, which are seen in a great variety of the objects that surround us, and distinguish them from the other objects of our senses. When these phenomena are examined throughout the whole of Nature, it is found that the most general and characteristic of them is, the continued appropriation and assimilation of surrounding matter, which we call *Nutrition;* a process which maintains a certain definite structure called *Organization*,—which originates, in all cases that can be satisfactorily observed, by *Generation*, —and terminates by *Death*.

Having given this general *description* of what are called Living Bodies, we next observe, that many of the phenomena exhibited by these bodies have been found to be not only inexplicable by, but manifestly inconsistent with, the mechanical and chemical laws that regulate the changes, and have been inferred from the observation, of other departments of Nature. In so far as we can ascertain this to be the case, we say that these phenomena are effects of the *Vital Principle*, or of *Vitality;* and that is our *definition* of these terms. They are the general expression for those of changes occurring in living bodies, which we judge to be peculiar to them; and stand in the very same relation to the science of Physiology, as the terms Chemical Affinity, Electricity, Gravitation, to other departments of Physical Science.

Thus defined, the notion of Vitality is not only admissible in Physiology, but is that which entitles it to the name of a separate science. Those physiologists, accordingly, who object to the substantive term, Vitality, or Principle of Life, are obliged to use the adjective *Vital*, which conveys the very same idea.

This notion of Vitality, extending to all classes of organized beings, has no connexion whatever with the notion of Mind, as distinguished from Matter. The latter is the characteristic mark of the Animal Creation only; and requires the admission into the Physiology of Animals, of a class of facts, and a kind of evidence, that have no place in any other physical sciences. Neither does any opinion, or conjecture, that can be formed concerning the essential nature of Vitality, affect the conclusions in Natural Theology, which are drawn from physiological facts; because these conclusions do not rest on the mode in which Vitality is thought to be communicated to living beings, but simply on the observed adaptation of means to ends, in the economy of living beings.

Some have conjectured, that the phenomena of Life, as they are seen only in bodies more or less organized, depend merely on the circumstance of organization; but when we inquire how organization has been effected, we find that it implies in every instance, where we can observe it, the previous existence of vitality; and therefore must be regarded as one of its effects, not as its cause.

Others have formed the supposition of a *material substance*, such as an ethereal or subtile fluid, superadded to organization during life, and producing the phenomena of life; but this idea is both unsupported by evidence, and useless in the explanation of facts.

Setting aside both these hypotheses, we hold that all physiological inquiries are intended only to *ascertain the conditions, under which the various phenomema of Life take place*, and naturally terminate in a reference to certain *Laws of Vitality*, or ultimate facts in this department of Nature; just as the investigation and explanation of phenomena in the inanimate world terminate in a reference to certain Laws of Motion, of Gravitation, of Chemical Affinity *, &c. Of such first principles in science we can give no other account, than that they depend on the will of the AUTHOR OF NATURE; but the determination of such first principles is the main object, and the applications of them constitute the details, of all sciences; and every science is thus mainly conversant with principles *peculiar to itself.*

In this, as in other sciences, these general laws of nature can only be ascertained *analytically*, i. e. by the slow process of observation and comparison of individual facts; but when they have been ascertained, even partially, in this way, the information acquired is more quickly and easily communicated to others, by stating some of these principles in the outset, with short and simple illustrations, and

* "The true and legitimate object of inquiry for the physiologist ought to be, not what the Vital Principle *is*, but what it *does*; just as the laws and effects of Gravitation are legitimate objects of inquiry, though we know nothing, and probably never shall know any thing, of the principle of gravitation itself."—*Prout on the application of Chemistry to Physiology, &c.*

then tracing the facts which constitute the details of the science *synthetically;* as originating, in part at least, from the operation of the laws first laid down, and then related to each other as physical causes and effects.

The science of Physiology appears sufficiently advanced to be taught on this plan. The physical causes, or conditions requisite for the performance, of each of the functions, will thus appear, in part at least, from the subjects discussed immediately before it, and its final causes or uses, from those discussed immediately after it; and several advantages seem to arise from this arrangement, particularly in a course addressed to students, who have already acquired a considerable knowledge of Physiology in the course of their anatomical studies; but have not been accustomed to regard the functions of the living body systematically, or as connected into a perfect whole.

It seems, indeed, equally expedient, in giving a systematic account of the Animal Economy, to follow the order of dependence of the different functions on each other, as it is, in explaining the actions of a machine made by art, to begin at the point where the moving power is applied, and follow the succession of movements downwards, until we come to that by which the desired effect is produced.

The explanation of many of the phenomena of living animals is still very imperfect: but enough has been done to shew, that the principal laws regulating these phenomena must be ranked under three heads: 1. Those of *Vital Contractions*, by which the visible movements of living animals are chiefly effected: 2. Those of *Vital Affinities*, by which the chemical changes peculiar to living animals are determined, and their physical structure maintained: 3. Those of *Nervous Actions*, by which the physical changes in living animals are placed in connexion with Mental phenomena, and subjected to the control of Mental acts.

Of these, the vital affinities are perhaps the most general and the most fundamental; but they are the least understood, and, in the higher animals at least, their exercise is dependent on internal vital contractions; and the laws of these contractions are, therefore, properly to be considered first.

It will afterwards appear, that the vital affinities and the nervous actions of the living body, are in a great measure subject to the same laws, particularly as to their relations with external agents, as those now to be mentioned as deduced from observation of the vital contractions, which are more easily observed, and better understood.

The most important division of the phenomena of living animals, is into the departments of *Organic* and *Animal Life*, as distinguished by Bichat; *i. e.* into those, which do not imply the intervention or consciousness of the Mind, and those in which some act of the Mind is essentially concerned; and the former are obviously subservient to the latter. This distinction will always be kept in view, but cannot be strictly observed; the more complex functions (such as Respiration and Digestion) comprehending phenomena which come under both heads.

The most general of the laws which regulate the economy of animals, appear to extend throughout the whole range of Creation; and all the vital functions, as occurring in Man, may be illustrated by the corresponding functions, at least in the different divisions of the Vertebrated Animals.

CHAPTER II.

OF THE LAWS OF VITAL CONTRACTIONS.

The first essential peculiarity of the Living Human Body which we consider, is the Existence of a Vital Power of Contraction in certain of its Solids; which is the immediate cause, not probably of all, but of the more conspicuous movements that take place in it during life.

We call this property or power Vital, because we are satisfied of the failure of all attempts to refer it to chemical or mechanical principles; and we regard it as an ultimate fact in Physiology, because, although other functions of the living body furnish the conditions necessary to the maintenance of the organic structures in which it resides, yet we shall find that no other functions afford any explanation of its existence, in the structures so maintained. The following appear to be ultimate facts, or principles, that have been ascertained in regard to this power.

I. It is most distinctly seen, and has been chiefly studied in *muscular* parts, *i. e.* in parts which consist chiefly of fibrin, and have a fibrous structure; the visible fibres being bound together by cellular membrane into fasciculi, which are generally laid parallel; and being divisible by mere separation into primary filaments, of extreme tenuity, which have the appearance, under the microscope, of rows of globules; although it is doubtful whether that appearance is not deceptive.

This general description applies both to the muscles that are subjected to voluntary efforts of mind, and to those that are exempt from such influence. But in some parts, even of the human body, such as the different vessels, some of the excretory ducts, the skin, perhaps other membranes, perhaps the lungs, and still more in lower animals, vital contractions take place in textures considerably different from this.

II. The most obvious and striking vital contractions which take place in muscles, are immediately preceded by the application of certain agents, called *Stimuli,* and necessarily *alternate with relaxation.* To the property thus indicated, the name of *Irritability* is properly restricted. When this contraction takes place, the filaments constituting the muscular fibres assume a zigzag form, the angles formed being always at the same points, and being generally obtuse, but in the case of very forcible contraction, acute; the fibres become rigid and elastic, and it would appear that they have a vibratory motion during the continuance of the contraction; they often appear to swell out towards their centres, but experiments shew that their real bulk is not altered; the change being in the relative position, not in the size or distance, of their ultimate particles.

Even in the most distinctly irritable parts, as the muscles of the limbs, tongue, heart, bowels, bladder, there are manifest differences as to the facility of excitation, the degree, strength, endurance, and tendency to repetition of these contractions. These differences are particularly observed in the contractions, however excited, of the muscles which are destined to Involuntary Motion, as compared with those of the muscles which are destined to be moved by the Will. In the different classes of animals there are still greater varieties in these respects.

Various facts, to be afterwards considered, indicate that there is, in the living body, an *adaptation* of peculiar stimuli to the muscular action of certain organs.

III. There is, farther, distinct evidence of the existence, in certain living solids, of a vital Contractile Power, distinguished by these peculiarities, that, although liable to increase from the action of stimuli, it requires no stimulus to excite it, and that it hardly, if at all, admits of relaxation, but determines a certain degree of permanent contraction, during life, of the parts endowed with it, when no distending cause affects them. This property has been called *Tonicity.* It is exemplified in the condition of the sphincter muscles during life, and in that of the arteries when emptied of blood. The extent of its operation in the living body is uncertain; but several circumstances indicate that all muscular parts possess this property, as well as irritability. Thus, when a living muscle is divided, its cut ends retract permanently, and farther than those of a dead muscle. When a limb is permanently bent by an injury, its flexor muscles are permanently retracted, and remain capable of farther occasional contraction; and during sleep, the limbs are in a state of permanent although varied flexion, probably dependent on predominance of the flexor muscles, and implying a certain exertion of their contractile power.

The temporary stiffening of the limbs after death, appears to be a last exertion of this vital power of Tonicity in their muscles.

IV. The exercise of all vital power of contraction in animal Solids, is essentially dependent on the *penetration of their substance by a nutritious Fluid*, which must have been not merely absorbed from without, but in some degree changed or assimilated within the living body itself. When the supply of the nutritious fluid fails, or is vitiated, the organization of the living solids is injured, and their power impaired. And the circulation, and perhaps also the vivifying power of the nutritious fluid, is still more immediately dependent on its regular *exposure to Air*.

There is great variety in different animals, as to the frequency or rapidity of the supply of this aerated fluid required for maintaining the vitality of the solids. It is on this circumstance that the essential distinction of warm-blooded and cold-blooded animals depends; and a similar difference exists in a still greater degree, in the different states of those animals, which are sometimes in activity and sometimes torpid.

The supply and the purification of the nutritious fluid are accomplished, in the order of things now established on earth, first by the living actions of the progenitor of each organized body, during the time that its own organs are gradually developed; and afterwards by the living action of certain parts of each body itself, viz. of the organs of digestion, respiration, and circulation. These conditions of the vitality of living solids, therefore, enable us to understand the necessary dependence of life on previous life, throughout the generations of living animals; but how these conditions were fulfilled in the commencement of the existence of the first individuals of each species, nothing that we now see of their economy enables us to conceive.

It appears certain that an origin must have been given to each of the tribes of animals now inhabiting the earth's surface, at no very distant time, by an exercise of power, such as had not previously, and has not since been exhibited; independent of, and superior to, the laws which regulate the changes that we now see around us. Nor is this conclusion at all invalidated by the supposition, which some physiologists entertain, of an organizable matter continually existing, and assuming different forms at different times, entering into the composition of other organized bodies immediately on the dissolution of those in which it had previously existed; because, even if that supposition were established as a matter of fact, still the laws by which that organizable matter forms organic compounds, appear, from the consideration above stated, to vary in the different ages of the world, and to be variable at the pleasure of the Author of Nature.

V. The Irritability of many muscles is excited, not only by stimuli applied to themselves, or to the membranes investing them, but also, with equal or even greater facility, by stimuli applied to Nerves which enter them, or to certain parts of the Spinal Cord, or Brain, provided the nervous communications of these parts with the muscles be entire. And farther, certain injuries of the brain or spinal cord have power directly and instantaneously to impair, or even destroy, the vital power of muscles themselves. Voluntary acts of the mind act on muscles precisely on the same footing with physical agents of the first class now described; and certain feelings or passions of the mind seem to act in like manner as those of the second class.

These facts have naturally led to much speculation regarding the connexion between the Nervous System and the vital power of the moving solids of the living body.

Two theories on this subject have been so generally adopted in the Schools of Medicine, that, although unsupported by adequate proof, they demand attention.

The first is, that all muscular parts *derive a supply* of some kind of *influence or energy from the brain or spinal cord*, through the nerves, which enables them to contract, or *renders them irritable.* The second is, that muscles, although not actually drawing supplies of vital power through their nerves, are yet *dependent on nerves for every occasion of the exercise of that power*—all stimuli, which excite muscles to contraction, *acting first on the nervous filaments* which enter muscles, and *through them on the muscular fibres.*

To the *first* of these opinions the following appear to be insurmountable objections.

1. Indications of a vital power of contraction are a much more general fact in nature than the existence of nerves, being seen not only in the lowest class of animals, where the existence of a nervous matter is still doubtful, but also in vegetables.

2. The human fœtus has often come to the full size (implying long continued exertion of contractile power in the organs of its circulation) without a brain, and sometimes without either brain or spinal cord; and in all cases, during the growth of the fœtus, the formation of vessels precedes that of nervous matter, and the organs of circulation are in full operation, when the larger masses of the nervous system are still very imperfectly developed.

3. The involuntary motions of the organs of circulation have been found by many physiologists to continue vigorous, even in warm-blooded animals, after the removal of the brain, or even of both brain and spinal cord, provided that the exposure of the blood to the air is secured, by the substitution of artificial for the natural respiration (which being undoubtedly and directly dependent on the brain, necessarily ceases on its removal). And in these circumstances, when circulation, after some hours, does come to a stand, it is chiefly, as it would seem, because the artificial is only an imperfect substitute for the natural respiration.

4. No interruption of the contractions of the heart, or other strictly *involuntary* muscles, has ever been produced by cutting the nerves, by which they are immediately supplied.

5. Although the muscles destined to voluntary motion are no longer moved by the will, after the section of their nerves, they continue thereafter to shew their irritability, on

the application of stimuli to themselves, or to their nerves below the section, as long as their nutrition and organization continue pretty entire; and contractions may be excited by direct and continued irritation in the muscular fibres, fully as long in muscles of which the nerves have been cut, as in those, the communication of which with the brain and spinal cord, through the nerves, is entire*.

Again, to the *second* of the theories above stated, it appears a sufficient objection to state, that our only reason for supposing an intervention of nerves to be concerned in muscular contraction, is the excitation of that contraction by stimuli applied to nerves. But a conclusion which is rested on this fact, must be limited to the cases in which this fact holds good. Now, there are *many muscles* (viz. all or almost all those that are destined to *involuntary motion* only), which, although exceedingly irritable, *are not excitable by mechanical irritation of their nerves.* Even Galvanism, applied exclusively to the nerves of these muscles, has generally failed to excite them; and in the instances where galvanism, so applied, has had some effect, it appears probable that the nerves acted only as conductors of the galvanism to the muscular fibres themselves. When experience shews, that some muscles are excitable by irritation of their nerves, and others not, we cannot acquiesce in the proposition, that nerves furnish a condition essential to the irritation and vital action of muscles in general.

We must therefore set aside both the hypotheses above mentioned; and in so doing, we necessarily limit the meaning of the terms "Nervous Energy, Nervous Influence, Innervation," &c. in reference to the connexion of vital movements with nerves, to a degree of which many of those who use these terms do not seem to be aware.

It remains that, on this point, we acquiesce in the judgment of HALLER †, as the only generalization yet admissible of the facts known in regard to it, viz. That the *vital power of Muscles is inherent in themselves*, and in no case

* WILSON PHILIP, Experimental Inquiry, &c. p. 99.

† See particularly Elem. Physiol. lib. 17, sect. 2, § 7.

dependent on Nerves; but is liable to affection in two distinct ways, by changes in certain parts of the Nervous System, whether these are produced by physical or mental causes; —being *directly excited in many muscles*, and *increased or diminished*, or *variously altered*, probably *in all muscles*, by such changes.

That sudden increase, diminution, or even destruction, of vital motions, may be produced by certain physical impressions, made on portions of the nervous system which are nevertheless not essential to these motions, and which may be removed from the body without stopping them, is well illustrated by the experiments of LEGALLOIS and of Dr WILSON PHILIP on the brain and spinal cord; and the corresponding effect of certain involuntary mental acts on muscular movements, requires no illustration. Those causes, acting on the nervous system, which augment the contractile power of muscles, and invigorate muscular motion, have been called Stimuli, but are more properly called *Stimulants;* and the opposite depressing power of such causes, is expressed by the term *Sedative.*

The direct excitation of muscular contraction by changes in the nervous system, is seen chiefly, perhaps exclusively, in those muscles that are destined to be moved by the will. The increase or diminution of vital power by such causes, is seen chiefly in those muscles that are unaffected by efforts of the will. The essential difference of these classes of muscles seems to depend on the different endowments of the nerves entering them. And the final cause of all endowments bestowed on nerves in the living body, in relation to muscles, appears to be, *not to make muscles irritable*, but to *subject their irritability, in different ways, to the dominion of the acts and feelings of the Mind.*

VI. In all animals, and indeed in all organized beings, vital movements are seen only within certain limits of Temperature, and are stopped either by its elevation or depression beyond a certain point; which, however, varies greatly in different kinds of animals. This difference is observed not only in the degree, but also remarkably in the permanence, of the effects of the Cold on different animals;—the vital movements in some, when once much weakened by cold, being never restored;—while in many others, they are nearly or quite at a stand for a length of time, in the state of hybernation from cold, and are gradually resumed whenever the temperature is again raised.

Within the limits suited to each animal, it is a general principle that Heat acts as a stimulant, and Cold as a sedative, to all vital motions. But the effect either of heat or cold on these motions appears to depend, not so much on the absolute degree of temperature that is applied on any occasion, as on the amount of change undergone during its application; and is therefore determined in a great measure by the previous state of the temperature. And this is obviously one of the reasons why Cold, itself a sedative agent, should often really and powerfully, though indirectly, invigorate muscular action; viz., by giving a stimulant influence to subsequent applications, even of the usual heat of the body.

The vital power of muscles is also much and variously affected by other agents, particularly by Electricity, and by various Poisons, whatever the channel of communication may be, by which these agents, when applied to the living body, affect the different muscular organs.

VII. The vital power of muscles is found to undergo remarkable alterations, in consequence of the degree in which it is itself exercised. On this point, likewise, important misconceptions and erroneous theories have prevailed.

The immediate effect of frequently repeated excitation of any muscle, by physical stimuli, is a diminution, or what has been called Exhaustion, of its Irritability; and the same effect evidently results from such repeated or long-continued efforts of the Will, as cause fatigue of the voluntary muscles. But it is by no means certain that all increased action, especially such as implies real augmentation of vital power, observed chiefly in involuntary muscles (whether from changes in the nervous system or from other causes), is necessarily followed by any corresponding depression. The peculiar effect of poisons, such as alcohol or opium, which first augment, and afterwards depress, the action of the organs of circulation, does not, as has been often supposed, furnish any proof of the consequences which necessarily result from the mere circumstance of increased action itself; and in the case of exercise,—of mental excitement,—and in the course of different febrile and inflammatory diseases,—we have examples of greatly increased action of the heart, without any decidedly debilitating effect on the heart's actions necessarily following. The doctrine of increased action necessarily in all cases lowering or exhausting the irritability of muscles, particularly as applied to the involuntary motions, is therefore by no means an established principle.

In so far as the irritability of muscles is diminished by excitement, it is restored by rest; but the supposition of farther increase or *accumulation of irritability from long continued rest*, corresponding to its exhaustion by excessive action, although insisted on by various physiologists, appears to be quite unsupported by facts; and the phenomena thought to indicate such accumulation of vital power, in contractile parts kept long at rest, are explained on other principles. For example, the greater stimulating effect of Heat, applied after cold of some duration, is evidently to be ascribed to the greater amount of change of temperature, which its application then implies.

Although the *immediate* effect of strong excitement of muscles is, in many cases, a diminution of their power, yet the *ultimate* effect of repeated excitement, with intervals of repose, is to augment both the bulk and strength of muscular fibres, and facilitate the subsequent excitement of moving parts, whether voluntary or involuntary. The applications of this last principle, both in Pathology and Therapeutics, are very important.

VIII. The Vital Power of muscles undergoes gradual alterations during the whole progress of life, being most easily excited, or shewing the greatest degree of *mobility*, in young animals; becoming gradually stronger, but less easy of excitation, in adults; and afterwards undergoing a diminution both of strength and of mobility. But as these variations are attended by gradual alteration of the organization of the moving parts, it is probable that the primary change is in the vital affinities, by which these are nourished and maintained, rather than in the vital power, by which they are animated.

The movement of the fluids, in all the higher classes of animals, is in a great measure dependent on vital contractions in certain of their solids, and may be therefore regarded as the first and most important consequence of the exercise of the Vital Power which we have considered. This subject naturally divides itself into two parts; *first*, the movement of the mass of blood in the heart, arteries, and veins, or the Function of Circulation; and, *secondly*, the continual evolution of matters from, and absorption of matters into, the mass of blood, or the Functions of Nutrition, Exhalation, Secretion, and Absorption; to which the Circulation is subservient, and on which all the other functions are dependent.

CHAPTER III.

OF CIRCULATION.

A REGULAR supply of a nutritious fluid, recently exposed to the air, is a condition essential to the maintenance of the vital phenomena, not only in the moving solids, as already stated, but in all other parts of living bodies, whether belonging to the organic or animal life, and in all classes of animals. But it is important to bear in mind, that it is only in the higher classes of animals that this essential condition of all vital action is fulfilled by means of a Circulating System;—the nourishment even of complex structures, in the class of Zoophyta, and in many of the Articulated animals, being effected, as is believed, simply by imbibition and transudation through porous solids.

The circumstance in the animal economy, which appears chiefly to impose the necessity of a distinct circulating System, is the appropriation of a separate organ to the office of regularly exposing the fluids to the air; and this again is demanded by such occasion for strength and solidity in certain parts of the frame, as precludes the possibility of free admission of air to the fluids in all parts of the body, such as takes place in some of the lower classes. A complex frame, capable of exertions of strength, and of resistance to injury, a separate respiratory organ, and a regular circulating system, are therefore very generally, if not necessarily, combined throughout the animal creation *. And in all warm-blooded animals, the circulating system is to be regarded as merely the channel of communication between the capillaries of the lungs, where the blood is prepared by the action of the air, for the maintenance of the different functions of life, and the capillaries of the rest of the body, where it is applied to the support of these different functions. The collection and concentration of the blood at the heart are manifestly intended to subject it to the action of a strong muscle, and thereby secure its transmission, with adequate force and precision, through the different sets of capillary vessels; and the juxta-position of the two portions of the heart, which move the blood to and from the lungs, appears to be merely a matter of convenience.

In treating of the Circulation, we first state the course followed by the blood in the living body, with the evi-

* Cuvier, Leç. i. Art. 4.; and Leç. xxiii. Sect. ii. Art. 5.

dence by which this course is demonstrated; and then we consider the nature and efficacy of the agents, by which this movement of the blood is produced.

During the living state, all the blood which is contained in very minute or Capillary Vessels, in every part and in almost every texture of the body, gradually makes its way into Veins, and along them, passing from those that are more numerous and smaller, into those that are less numerous and larger, till it reaches the anterior or right auricle of the Heart, by the venæ cavæ and coronary vein, and distends that cavity. By the contraction of this auricle it is driven into the right ventricle, and by the contraction of this, into the pulmonary artery, by the numerous branches of which it is distributed among the minute capillaries of the Lungs, to be exposed to the air. From these, it again passes along an ascending series of vessels contained in the lungs, until it emerges from them to enter the four pulmonary veins, which lead to the cavity of the posterior or left auricle of the heart. By the contraction of this auricle, simultaneous with that of the right auricle, it is forced into the left ventricle; and by the contraction of this, simultaneous with that of the right ventricle, it is forced into the Aorta, by the numerous branches of which it is gradually conveyed into the capillaries, that pervade the various organs and textures of the body.

That this is the real course of the blood, is proved by various facts, but especially by the following:—

1. By the observation of the successive distention of the venæ cavæ near the heart, of the auricles, and of the ventricles, in living and warm-blooded animals, taking place in the order above stated,—and by the observed passage of the blood through these cavities, in those lower animals that have hearts similarly formed (although single) and translucent.

2. By the observed passage of the blood from the minute capillary arteries into the beginnings of the veins, in the translucent textures of different fishes and reptiles, which

have a circulating system similarly formed to that of the higher classes, although single.

3. By the structure of the valves, at the heart and in the veins, necessarily prohibiting, or greatly impeding, movement along the vascular system in the opposite direction from that above stated.

4. By the effect of ligatures, and of punctures made above and below ligatures, in the larger arteries and veins; the former swelling out and giving a free jet of blood within the ligatures, and the latter beyond them.

5. By the quantity of blood which may be rapidly discharged from a wound below a ligature on the vein of a limb; which is so great as to demonstrate that the vein must have a continual supply of blood from the arteries of the limb.

6. By the effect of injections into living arteries and veins, making their way readily, and easily filling the vessels, when thrown in the direction of the circulation as described, but strongly resisted when forced in the opposite direction.

The structure and actions of the Heart, the chief muscular agent in this process, and the *first* of the powers, by which the movement of the circulating fluids in the adult state are effected, first demand our attention. Its oblique position within the pericardium, in the fore part and left side of the thorax,—its irregular conical form, flattened posteriorly,—its division into two parts by the septum, and the form, size, and relative position of the right or anterior, and of the left or posterior, auricle and ventricle,—the termination of the great veins in the auricles, and origin of the great arteries from the ventricles,—the lining of the muscular texture of the heart by two serous membranes, the external reflected from the inner layer of the pericardium, and the internal continuous with that which lines the bloodvessels,—are all supposed to be made known by the study of Anatomy.

The muscular fibres of the auricles of the heart are quite distinct, and easily separable (after long-continued boiling) from those of the ventricles; and the part of the heart which may be regarded as the fixed point or pivot of its movements, is the point between the posterior groove on its surface and the origin of the aorta, where the muscular fibres, constituting the septum of the auricles, are set upon those which form the septum of the ventricles. The contractions, both of auricles and ventricles, tend to bring all other parts of the heart nearer to this fixed point. The texture found at this point is tendinous; and in immediate connexion with it, are the tendinous rings (partly bony in some animals) which surround the origin of the aorta and pulmonary artery, and the openings between the auricles and the ventricles. From these tendinous parts most of the fibres, constituting the muscular parietes of the heart, take their origin. Those which go to the parietes of the auricles ascend, form loops around these cavities, of various form and size, and then descend to be inserted into other points of the same tendinous rings, and are encompassed at their lower part by more superficial horizontal layers of fibres. Those which go to the parietes of the ventricles have an oblique course downwards, and appear to be reinforced by others which originate in the muscular texture itself, especially along the anterior and posterior grooves, which lodge some of the coronary vessels. The outermost of them converge towards the apex, and, after making a spiral turn round it, pass inwards and ascend along the interior of the ventricles, forming the columnæ carneæ and part of the septum, and arranging themselves in the reticulated form, which is obvious on opening the heart. Others of the fibres descending from the tendinous rings merely form loops around the ventricles, and reascend to the rings. The obliquity of the direction of the fibres is gradually altered towards the interior of the muscular substance, so that about the centre of the thickness of the parietes, the fibres are wrapped round the ventricles nearly transversely; some surrounding both ventricles, while others detach themselves at the septum, and surround the left ventricle only, making its parietes thicker and stronger than those of the right.

This is a general outline of the disposition of the greater part of the muscular fibres of the heart. At its base the arrangement is more complex, but it is always regular and uniform; and evidently such, that a general contraction of the fibres of the heart shall bring all parts of the heart towards the central point above mentioned, and compress the contents of all the cavities, so as to secure their forcible ejection by the openings there situated.

The valves placed at these openings effectually prevent any reflux of the blood that has been ejected. The structure of the membranous folds forming the semilunar valves, at the mouths of the great arteries, sufficiently indicates their use; for they are attached to the interior of the vessels by curved edges, the concavity of which is turned from the heart, and they must therefore be raised and stretched across the opening by any fluid passing towards the heart, but are laid down along the sides of the arteries by any fluid passing out of it. The precise object of the structure of the tricuspid and mitral valves, which descend from the tendinous rings surrounding the auriculo-ventricular orifices, into the ventricles, and are attached by tendinous cords to the ends of the columnæ carneæ, is not so perfectly ascertained; it being doubtful whether the membranous parts of the valves always project into the cavities of the ventricles, and are merely pulled together by the contraction of the columnæ carneæ to close the orifices, or whether they are raised and stretched across the orifices by the blood at the time when the ventricles are full, and contract on their contents. In order to decide this question, it would be necessary to ascertain more precisely than has been yet done, whether the contraction of the columnæ carneæ takes place precisely at the same time as that of the other fibres of the ventricles. But either in the one way or the other, these valves are certainly fitted, and intended, to prevent any reflux of blood from the ventricles into the auricles, at the time when the ventricles contract.

When the heart of a living warm-blooded animal is exposed, the simultaneous contractions, first of the two auricles, and then of the two ventricles, may be distinguished; but, in the natural and vigorous state of the circulation, the former movement (always a comparatively slight one) is hardly over before the latter begins; and the longest pause in the visible contractions of the heart is that which succeeds the systole of the ventricles, and precedes that of the auricles.

The successive contractions of the auricles and ventricles are often observed to go on, for a short time, nearly in the usual way, after the heart of a living animal is emptied of its blood, or even removed from the body; so that there is obviously a tendency to the regular succession of these movements, independently of the successive applications of the stimulus of the blood to these parts.

When the ventricles contract, the apex of the heart is not only pulled upwards, but somewhat raised or tilted forwards; hence it is generally, and no doubt justly supposed, that it is during this systole of the ventricles, that the apex of the heart gives the impulse against the parietes of the chest, which is felt, in the natural state, between the fifth and sixth ribs, and which, just perceptibly, precedes the pulse at the wrist*. The projection of the apex of the heart on the contraction of the ventricles, is seen even when the heart is removed from the body of a warm-blooded animal before its actions have ceased, and is, perhaps, sufficiently explained by the disposition of its muscular fibres, and particularly by the irregular cone which they form, being *flattened posteriorly*.

When the ear is applied to the human chest, over the situation of the heart, a dull and somewhat prolonged sound is observed to precede and accompany the impulse of the heart against the parietes above mentioned; and this is immediately succeeded by a shorter and sharper sound; after which there is a short pause, before the dull sound

* See particularly HOPE's Treatise on the Diseases of the Heart and Great Vessels.

and impulse are renewed. A slighter impulse or succussion, is sometimes observed to accompany the sharper sound likewise. The duller sound, and stronger impulse, are generally ascribed to the contraction of the ventricles, and movement of their fluid contents; and LAENNEC and others have ascribed the sharper sound and feebler impulse to that of the auricles; but this last opinion is probably erroneous; because the sharper sound certainly immediately *precedes* the longest pause in the sounds of the heart; whereas the contraction of the auricles immediately *succeeds* the longest pause in the visible contractions of the heart; as appears not only from experiments on animals, but also from cases occurring occasionally in the human body, both in health and disease, where the contractions of the right auricle are made obvious by a retrograde impulse, communicated to the blood in the jugular veins *.

It is also doubtful, whether the contraction of the columnæ carneæ in the inside of the ventricles, takes place at the same instant with that of the mass of muscular fibres constituting their parietes. It is obvious, that the contraction of these columnæ cannot aid in lessening, but must elongate and enlarge, the cavities of the ventricles. It has therefore been conjectured, that their contraction may precede, and alternate with the general systole of the ventricles, and pull down and stretch the tricuspid and mitral valves during the diastole of these, and so prepare them for the entrance of the blood from the auricles; and that the second or sharper of the sounds of the heart, is caused by this action of the columnæ and valves, or rather, by the sudden entrance of the blood from the auricles, for which preparation is thus made. Perhaps it may also be supposed, that one stimulus which excites the columnæ to act, is the pressure made on them during the previous contraction of the mass of muscular fibres lying exterior to them, in the systole of the ventricles; and that the contraction thus beginning in those internal columns, is afterwards

* See TURNER on the Causes of the Sounds of the Heart. Edin. Medico-Chirurg. Trans. vol. iii.

propagated to that surrounding mass of fibres, many of which are continuous with those in the columnæ themselves. In this manner it seems possible, that the peculiar convoluted form of the muscular fibres of the heart may be concerned in giving the tendency above noticed, to a regular succession of their own contractions.

The contractions of the muscular fibres of the different parts of the heart are clearly sufficient to agitate the blood powerfully, and ultimately to eject it by the arteries with great force. The quantity ejected at each systole of the left ventricle seems to be nearly two ounces in an average-sized man, and the space it must occupy in the aorta nearly eight inches. The calculations of HALES, who states the force exerted by the left ventricle of a human heart as equivalent to $51\frac{1}{2}$ pounds, the velocity of the blood leaving the heart as 149·2 feet per minute, and the quantity of blood passing through the heart every hour as 20 times the whole weight of the blood in the body,—although only approximations to the truth, do not appear to be founded on exaggerated data. The velocity of the circulation is also illustrated by the fact, that in the horse, a fluid injected into one jugular vein has been detected in the opposite vein and even in the vena saphena, within half a minute*.

The diastole, as well as the systole, of the different parts of the heart, especially of the ventricles, is performed with force; the muscular fibres not merely relaxing as the cavities are distended with blood, but springing back directly after their own contraction is over. The tendency thus given to the formation of a vacuum in the auricles, is one cause of motion of the blood towards the heart along the great veins, where it is subject to pressure from various causes.

Although the different parts of the heart have obviously a tendency to regular and successive movements, independently of the stimulus of the blood, yet experiments prove, that the blood, which is in contact with the inner surface of the heart, acts as a powerful stimulus upon it; and we

* HERING, Journal de Progres, &c. t. 10.

cannot doubt that it is by the constant succession of fresh applications of this stimulus, that the nearly uniform succession of the heart's movements, throughout the whole of life, is maintained.

We can go no farther, in assigning a cause for the natural movements of the heart, than to refer them to the application of this stimulus, and to the property of Irritability, in a high and peculiar degree of intensity, resident in its fibres. We cannot ascribe to the heart any feeling or Sensation, in the performance of these actions, without altering the meaning of these words; we cannot liken these actions to any Voluntary movements, without overlooking the most essential peculiarities of both; and we cannot suppose any action of Nerves to be essentially concerned in them, without ascribing to the nerves of the heart endowments, which no experiments or observations shew that they possess.

The blood is conveyed from the heart to the capillary vessels all over the body by the Arteries; and the properties of these constitute the *second* great agent, by which its motion is effected.

These are flexible and elastic tubes, consisting of three coats, of which the exterior, composed of dense cellular texture, is the most distensible and the toughest; the middle, composed of transverse fibres, denser and lighter coloured than those of muscles, is the thickest, strongest, and most elastic; and the internal, on which the blood moves, is very thin and smooth. The arteries are all to a considerable degree extensible, especially in the longitudinal direction; and are of great strength, the smaller branches even more so than the larger.

Every small portion of artery, by reason of its elasticity, has nearly a cylindrical form, and the blood therefore passes along a series of descending cylinders, on its way from the heart to the capillaries. But the sum of the areas of the whole of the smallest branches into which any artery divides itself, is considerably greater than the area of the artery itself; although the ratio of this difference has been very variously stated.

The arteries are subdivided into small branches to a great but very various degree of minuteness in the different textures. In some parts the smallest branches are so minute as not to admit the red globules of the blood ; but various textures appear to be nourished, without so minute a subdivision of their vessels.

The smaller arteries communicate or anastomose freely with one another in all parts of the body; the smallest capillaries the most freely of all; and on this account the characteristic effect of ligatures formerly observed, in emptying the portions of artery beyond them, and distending the portions within them, is only distinctly seen in the larger branches.

The arteries in the living body (with the exception of the smallest branches, in which a greater variety is observed) are always filled, and even somewhat distended with blood, which is moving towards the capillaries. This blood receives a sudden *increase of velocity* from the impulse of each successive jet of blood from the ventricles of the heart; and from the same cause the arteries are slightly *distended*, —and in many parts of the body even somewhat *displaced*. These effects of the systole of the ventricles, constitute what is called the *Pulsation* of the Arteries; but the two last of these effects, in the healthy and tranquil state of the circulation, are scarcely perceived at any single points; and therefore the pulse in an artery is not distinctly felt, unless the artery is somewhat compressed by the finger, to make the impulse, which its contents receive from the heart, perceptible.

The slight distention which the whole arteries experience, from the impetus of each successive jet of blood from the heart, is sufficient to call into action their elasticity, which enables them to react on the blood, in each interval of the heart's pulsation, and gradually to equalize its motion, until it becomes quite uniform and continuous in the capillaries.

There are many and great obstacles to the free motion of the blood along the arteries,—from the friction of their sides,—from their angular and tortuous course and minute subdivisions,—and from their constant tendency to contraction. The effect of these is not, as some have taught, to make the velocity of the blood in the smaller arteries less than in the larger, but to make its velocity, in all the arteries, less than it otherwise would be. As we know that no part of the circulating system in the healthy state is continually becoming fuller of blood, we are sure that the quantity of blood delivered into all the veins in a given time from all the arteries, is equal to that received by them from the heart; and this proves, that the velocity of the blood in the capillaries, on the whole, must be less than that in the aorta, just in the same proportion as the area of the aorta is less than the sum of the areas of all the capillaries.

But although this proportion must hold on the whole, yet many facts inform us, that the velocity of the blood, even in vessels of the same size, in different parts of the system, is habitually different; and that the quantity of blood received into, and its velocity in, the smaller arteries and capillaries of all parts of the body, are liable to much temporary variation. In particular, the blood which enters the brain, as it meets with more of the obstacles above mentioned than that which is sent to most other parts, must have an habitually slower motion. For these varieties in the flow of blood in different parts, and at different times, there is ample provision, in the distensibility of the vessels, and in the possibility of increased velocity in one part compensating for diminished velocity in another, without the general law above stated being perceptibly violated.

Although the ordinary velocity of the blood in different arteries must be very different, it would appear from the experiments of Poiseuille, that the pressure exerted on the blood in different parts of the body (as measured by the column of mercury which the blood in different arteries will sustain), is almost exactly the same.

In attempting to form a judgment on the difficult subject of the efficiency of any action of arteries, in causing, or regulating, the movement of the blood, it is first necessary to consider how far the action of the heart extends, and is efficient as a cause of that movement, throughout the vascular system.

It appears from experiments of different physiologists, and especially of MAGENDIE and POISEUILLE, that when the circulation of a limb, in a warm-blooded animal, is confined to the branches of a single artery and corresponding vein, the blood stagnates in the vein, whenever the artery is emptied by ligature; but flows freely along the vein, when the ligature on the artery is removed; and that its flow along the vein is varied by any cause that affects its movement in the artery; which shews that the action of the capillaries and veins of a limb is insufficient to propel the blood, without the impulse *a tergo*, given by the heart and large arteries. Indeed a little management gives nearly similar results in a common bloodletting.

Farther, the movement of the blood in all the small vessels of a warm-blooded animal, is always speedily arrested when the heart's action ceases; and although there are various examples on record, in which the human fœtus (always imperfect, however, in other respects), has attained a considerable size without a heart, yet every such fœtus has been contained in the same womb, and probably nourished through the same placenta, as another fœtus of the natural structure; and in every such case the heart of the perfect fœtus would, in all probability, be instrumental in maintaining the circulation of the monster. It would appear therefore, that in warm-blooded animals at least, the heart's action is essential to the support of the circulation in every part of the vascular system.

On the other hand, that the pressure of the coats of arteries may act as a powerful cause of motion in the blood, appears from the effects of an opening made in an artery, in which case a current of blood is established towards the opening, from the artery and anastomosing branches beyond it, as well as from those nearer the heart; and the same is shewn by the rapidity with which the portion of an artery beyond a ligature is emptied of its blood.

Dr MARSHALL HALL has ascertained, that in some cold-blooded-animals, there are arteries which pulsate nearly as a heart does, after the heart has been cut out*; and POISEUILLE and GUILLOT have described, in some of the lowest class of animals, which have vessels, but not hearts, movements of these vessels resembling the peristaltic movements of the bowels, and manifestly propelling their contents †; but in the arteries of warm-blooded animals, no such unequivocal indications of vital action have ever been observed. In all these animals, the action of arteries on their contents seems to be always of the same *kind* as that which results from the physical property of elasticity called into action by a distending force; but the following facts appear sufficient to prove that they possess the vital power of Tonicity, as formerly defined, which will determine a *greater degree* of re-action on their contents, than mere elasticity would occasion.

1. In experiments made by many physiologists, particularly by VERSCHUIR, THOMSON, GIULIO and ROSSI, PARRY, HASTINGS, and WEDEMEYER, it appeared, that by various stimuli applied to arteries, chiefly small arteries, which could not affect their mechanical properties, constriction of those arteries, at the points irritated, lasting some time, and then gradually relaxing, were induced.

2. In experiments made by WEDEMEYER, it was found, that when stimulating fluids (such as alcohol or vinegar of a certain strength) are injected into the arteries of living animals, there is great difficulty in pushing them forward into the veins; whereas mild fluids in the living body, and these irritating fluids in the dead, pass forward readily ‡.

3. In experiments made by Mr HUNTER and Dr PARRY, it appeared distinctly that the arteries of dying animals, especially those dying from hæmorrhage, when emptied of

* Essay on the Circulation, p. 82.

† Journal de Physiologie, t. 10 and 11.

‡ Edinburgh Medical and Surgical Journal, vol. xxxii. p. 10.

their blood, contract immediately after death, and in some instances before death, to a calibre considerably less than that which they afterwards gradually assume, and then maintain till putrefaction begins; which proves, that the tendency of living arteries to contraction is greater than their merely physical properties can occasion.

4. In experiments made by POISEUILLE, where an artery from an animal just killed was distended by water urged by the pressure of a given column of mercury, and then the force of its reaction measured by the height of a column of mercury which the water expelled from it could support, it appeared that the force of reaction, excited by the distention of the recent artery, was greater than the force used to distend it; and greater than an artery could exert some time after death, but before any decomposition of its texture had commenced *.

These facts leave no room for doubt that arteries possess, and must occasionally, if not habitually, exert on their contents a truly vital power of contraction.

This being ascertained, we next observe, that various facts shew the course of the blood to be variously modified, and probably much promoted on the whole, by causes acting at a distance from the heart;—in modes which the merely physical properties of arteries cannot possibly explain. The most instructive of these facts are the following:

1. The great amount of the obstacles which oppose the free flow of the blood into and through the small capillaries of the system; and the force therefore found requisite in the dead body to imitate the flow of blood by injection, especially when injection is attempted in an animal just killed, when, as it would appear, the property of tonicity remains in the bloodvessels.

2. The small amount of force found sufficient to stop the flow of blood along the chief artery of a limb, when compared with those obstacles, which the blood, moving along

* MAGENDIE, Journal de Physiologie, t. 8.

that artery, must encounter in its passage through the smaller vessels *.

3. The immediate diminution produced in the flow of blood through the arteries of a limb, by some attacks of Palsy, in which the heart's action is unaffected.

4. The greatly increased determination of blood to various organs at particular times, without corresponding alteration of the heart's action; *e. g.* in many cases of partial inflammation or hæmorrhages,—in the case of blushing, and other effects of mental emotion,—in the case of occasional or periodic secretion or nutrition at individual parts, whether natural or morbid, often observed without increase of the heart's action, and contrasting strongly with other instances, where, from mental emotion, exercise, febrile disease, &c. the heart's action is strongly excited, while secretion and nutrition are every where diminished.

5. The alteration which is gradually produced on the arteries of any part of the body, when any cause is applied, which greatly and permanently augments the action going on at *their extremities only*; the influence of which cause is manifestly *retrograde* along the vessels;—*e. g.* the increased size given to the anastomosing branches of a limb, of which the principal artery has been tied,—when contrasted with the shrunk condition of all the arteries of the stump of a limb which has been amputated;—the increased size and tortuous course of the arteries of the uterus during gestation, and of the arteries of any part of the body, where the growth of a tumour has been excited †; and again the deficient circulation in, and nourishment of, a limb of which the sensitive nerves are palsied, or which is long kept completely at rest (as by disease of a joint) without palsy.

These facts shew, that the flow of blood in the arteries, and especially in the capillaries, of different parts, is in a great measure determined by causes acting at the extremities of the circulation, and bears no fixed relation to the state of the heart's action.

* Sir Charles Bell, Essay on the Powers that move the Blood.

† Sir Charles Bell, *loco citato*.

The question that next presents itself is, how far the additional power, which plainly affects the motion of the blood, at a distance from the heart, is referable to the vital contractions of the coats of arteries?

The influence exerted on the circulation by any such action of the *largest* arteries is certainly of no great amount; because the circulation has often been observed to be well maintained, when those arteries had become rigid and inflexible, and lost both their elasticity and vital power. But the vital properties of arteries probably reside chiefly in their *smaller branches*, as would appear from the following facts:—

1. From the coats of the smaller arteries bearing a much larger proportion, on the whole, to their fluid contents than those of the larger.

2. From the fibrous coat of the smaller arteries more nearly resembling muscular texture.

3. From experiments of Mr HUNTER, which shew that the smaller arteries contract more at the moment of death than the larger.

4. From many experiments of BICHAT, BUNIVA, PARRY, &c. which shew that an injection thrown into the arteries immediately after death, while tonicity remains in them, passes by the largest of the arteries that communicate with veins, but does not fill the smaller capillaries; and from the observation of HUNTER, that an injection forced into the arteries of an animal just killed, which retain their tonic power, is apt, after a time, to be forced back into the larger.

5. From the observation of HALLER and others, that in animals just killed, and of which the hearts have been cut out, the blood in the arteries, as well as the veins, is apt to move chiefly from the smaller to the larger branches *.

It cannot, therefore, be doubted, that this vital power of the arteries must, to a certain degree, modify the motion of the blood; but it is more difficult to understand how *an increase* of this tonic power can, in any case, pro-

* Memoires sur le Mouvement du Sang, p. 160.

mote the flow of the blood; and it has therefore been supposed, that it is by a *relaxation* of this kind of contraction, giving additional effect to the impetus from the heart, that local determinations and congestions of blood are effected.

To this opinion there are the following objections:

1. The amount of the obstacles already noticed to the flow of blood in the arteries, renders it probable, that whatever vital powers affect the motion of the blood at a distance from the heart, must on the whole assist, instead of opposing, the effect of its contractions.

2. If local and occasional congestions of blood resulted simply from diminution of the vital action of the arteries, allowing a fuller effect to the impulses given from the heart, the blood in the capillary arteries of parts where congestion has taken place, might be expected to have always an intermitting motion, which is not the case.

3. The causes which usually excite local congestions of blood, are very generally causes, which, in all other instances, *excite*, instead of depressing or weakening, vital action.

These statements render it probable that vital contractions, chiefly of the smaller arteries, do come in aid of the actions of the heart in maintaining and regulating the circulation; but it must be added, that in the warm-blooded animals, we have no evidence of any powerful action of this kind being habitually exercised; and the following reasons may be given for thinking that causes distinct from any vital contractions of vessels, are concerned in producing the flow of blood in the extreme branches of the arteries; *i. e.* that there is a *third* power concerned in producing and regulating the movement of the blood, besides any mechanical action of the heart and arteries.

1. The smallest arteries, or true capillaries, in which the greatest variety as to the quantity and velocity of the blood is observed, do not shew any fibrous structure; and when the circulation in them is examined with the microscope, in

ordinary circumstances, no contractions of their coats are perceptible.

2. Haller and others have described varying movements of globules of blood in living animals, such as do not appear to be explicable by mechanical laws, seen under the microscope, especially when these globules had escaped from the bloodvessels into surrounding textures *.

3. Movements of other fluids contained within living textures, and even currents in fluids placed in contact with living textures, have been observed, which cannot be traced to the influence of any contractions of solids †.

4. On minute examination of the progressive development of parts in the fœtal state of different animals, it appears that various parts are in progress of organization (implying regulated movements in the fluids) before the heart acts, or the arteries are distinctly formed ‡.

5. When the blood has been delivered into the capillary vessels of any living part, although still influenced by the contractions of the heart and arteries, it must be supposed to come likewise under the dominion of the laws, whatever these be, by which the movements of the nourishing fluid are effected, in those animals that have no circulating system, and in vegetables. In particular, it may fairly be presumed, that the *Vital Affinities*, which regulate the chemical changes that are wrought on the blood in the capillaries, must likewise be a cause of its movement there §.

* Dollinger, Journal de Progrès, &c. vol. ix. Schultze, Journal Complementaire, &c. vol. xix. Tiedemann, Traité de Physiologie, § 265, 461, 567. Kalcbrunner, in Magendie's Journal, t. 8. p. 85.

† Dutrochet, L'Agent du Mouvement Vital devoilé, &c. and Annales des Sciences Naturelles, t. xv. Grant, Edin. Phil. Journal, vols. xiii. and xiv. Sharpey, Edinburgh Medical Journal, vol. xxxiv.

‡ Baer in Breschet's Repertoire, 1818. Prevost and Dumas, Annales des Sciences Naturelles, t. 12. Tiedemann, op. cit. § 265.

§ Le sang est destiné à porter la vie sur tous les points du système, à nourrir et à reparer les organes. Il faut donc qu'une partie du torrent soit absorbée par les surfaces qu'il arrose ; il faut donc que ces surfaces soutirent ces liquides nutritifs. Or supposez un grand cercle de tuyaux pleins d'un liquide, appliquez aux parois des tuyaux, des pipes aspirantes, mais qui ne puissent aspirer que des quantités infiniment minces, et

To this we should probably refer the striking fact (to be afterwards more fully considered), that when the chemical changes at the lungs are arrested, by obstruction to the access of air thither, the contractions of the right ventricle and pulmonary artery, although continuing vigorous for a time, fail of their wonted effect; and the blood stagnates in the capillaries of the lungs and right side of the heart; but its motion is instantly resumed, if, within a short interval of time, the access of air to the blood be again permitted.

It must, however, be observed, that the experiments of MAGENDIE and of POISEUILLE, already noticed, as they prove that the flow of blood along veins is dependent on, and continually modified by, the flow along the arteries communicating with these veins, sufficiently demonstrate that the powers residing in the capillaries, although they may promote the movement, and determine the distribution, of the blood in them, are inadequate to the propulsion of masses of blood along the larger veins *.

Since it has been ascertained that Galvanism, transmitted through a fluid, is a cause, not only of its decomposition, but of its movement, through any porous substance, from the positive towards the negative side of the apparatus, it has been conjectured that the electrical relations of arterial and venous blood (the first of which is, in a slight degree, positively, and the last negatively, electrified), may be an important cause of the motion of the blood in the capillaries †. But if this be a cause which promotes, as has been stated, the flow of blood in the capillaries throughout the body, where the arterial blood becomes venous, it ought to retard its motion in the capillaries of the lungs, where the venous blood becomes arterial. Yet we know, from the fact above stated, that the change of the blood from venous

par ce seul mecanisme vous allez faire circuler le liquide dans les tuyaux. —See RASPAIL in Repertoire d' Anatomie et de Physiologie, &c. t. vi. p. 150.

* See Recherches sur les Causes du Mouvement du Sang dans les Veines, in Journal de Physiologie, 1831.

† REUSS, Comment. Societ. Physico-Medicæ Moscov. vol. i.

to arterial at the lungs, is a very powerful cause of its motion there.

The power or property, by which various fluids attract others with unequal force, through the intervention of any porous substance, lately described by DUTROCHET and others under the names of Endosmose and Exosmose (in whatever way it is to be explained), must certainly operate as a cause of motion in the fluids in different parts of the animal system. But neither this, nor any other principle, which is found to apply equally to dead matter, can suffice for the explanation of the *variations*, especially of the sudden and partial variations, observed in the motion of the blood in the capillaries in different parts, and in different circumstances of the body; for example, of those which result from mental acts or feelings. Whether the auxiliary powers, residing in the small arteries, consist merely in contractions of solids, or partly (as is more probable) in *peculiar attractions* of solids and fluids, we cannot doubt that they are in a great measure truly *vital.*

No termination of arteries has ever been distinctly demonstrated, except that in Veins. This is seen on microscopical examination, in the translucent parts of various living animals, and may be traced, after injection, in different textures of the human body. The capillary arteries which are turned backwards and form veins, vary considerably in size, some admitting three or four globules of blood abreast, and others probably not admitting one. It appears, however, from the microscopical observations of Dr M. HALL, that in most parts of animals there is a numerous set of minute vessels, of nearly equal calibre and anastomosing freely, in which most of the smaller arteries terminate abruptly, in which the motion of the blood is much slower than in the gradually tapering arteries, and from which nearly all the veins originate. These are strictly the capillary vessels.

The veins become gradually, though not uniformly, larger when traced towards the heart, and terminate ultimately in the venæ cavæ and coronary vein. Those which are of sufficient size to be examined, are found to consist only of two coats, corresponding to the outermost and innermost of the coats of arteries, but possessed of greater strength. Hence they are thinner and less elastic, but more distensible and tougher, than the arteries. Near the heart, and in various other parts of the larger veins, thin irregular layers of fibres, more or less resembling those of muscles, are interposed between their coats.

The veins in the extremities, and generally in muscular parts of the body, are provided with valves, constructed nearly in the same manner as those at the mouth of the aorta, with their free edges towards the heart.

There are two important singularities in the venous system; *first*, The Sinuses within the cranium, formed by separation of the laminæ of the Dura Mater, into which the veins of the Pia Mater open obliquely in a direction opposite to the current of the blood, the effect of which is to lessen the effect on the vessels of the brain, of any stagnation and congestion of blood in the great veins near the heart; *secondly*, The distribution of the Vena Portæ, (which is of great size and strength, and collects the blood from the stomach, intestines, pancreas, and spleen), through the substance of the liver, after the manner of an artery. In many of the lower animals, the venous blood from the lower extremities is, in like manner, diffused through the kidneys*.

Besides being more distensible, the veins are considerably more numerous and more capacious than the arteries, and their larger branches anastomose much more freely. Hence the quantity of blood in the veins is always much greater, and is liable to greater variations, both locally and generally, than that in the arteries.

From the smaller capacity of the arteries, and from the pretty uniform distention, on the whole, of all parts of the vascular system, it follows, that the velocity of the blood in the veins must, on the whole, and in the same proportion, be less than that in the arteries. And from the sum

* Jacobson, Edin. Med. Journ. vol. xix.

of the smallest veins of the body having a much larger capacity than the venæ cavæ, it follows, that the velocity of the blood in these smallest veins must, on the whole, and in the same proportion, be less than that in the venæ cavæ. But the circumstances stated as to the structure of veins, admit of greater local and temporary variations of the velocity of the blood in them, without perceptible deviation from these general laws, than can occur in the case of the arteries. Absolute stagnation, and even retrograde movement, for a time, of blood in individual veins, have often been observed in experiments on animals.

The ordinary motion of the blood in the veins is continuous, with these exceptions, *first*, That, in a state of great weakness, when the arteries are very little distended by the stroke of the heart, the blood in the smallest of the veins retains somewhat of the intermitting motion; *secondly*, That the flow of blood in the great veins, even independently of disease, is slightly retarded at each systole of the auricles, and accelerated on their diastole; *thirdly*, That the flow of blood in the great veins is somewhat retarded by each act of expiration, and accelerated by each inspiration; the natural effect of the enlargement of the shut cavity of the chest, in inspiration, being to draw towards it, (*i. e.* to cause the pressure of the atmosphere to urge towards it), not only air by the trachea, but also blood by the great veins. This last is the Respiratory Pulse of HALLER and others, which is distinctly seen to communicate a movement to the brain and spinal cord, when they are exposed.

The motion of the blood in the veins is manifestly determined by various causes.

1. Probably the most efficacious is the impulse *a tergo* communicated by the heart and arteries, the effect of which is unequivocally shewn by the experiments mentioned at page 27. But when we consider the great distensibility of the veins, and the very moderate degree of distention observed in them in the healthy state, we cannot doubt, that the motion of the blood along them must be much aided by causes acting in this part of the circulation itself.

2. The experiments of several physiologists, particularly VERSCHUIR, HASTINGS, and BECLARD, seem sufficiently to indicate a vital power of Tonicity in the veins, similar to that which we ascribed to the arteries. But in several parts of the body, as in the interior of bones, and in the substance of the liver, where the coats of the veins form the internal lining of unyielding canals, it is obvious that this power cannot be exerted; and in any individual part it is probably a feeble power.

3. Gravitation manifestly affects the flow of blood in the veins, especially of the extremities; but cannot materially, on the whole, promote the flow towards the heart.

4. The action of neighbouring muscles, and probably the pressure of other adjacent and especially elastic textures, such as the skin, aided by the effect of the valves, frequently and greatly promote the flow of blood in many veins, chiefly of the extremities.

5. It appears that the "suction influence" of the diastole of the auricles of the heart, promotes the flow of blood along the veins somewhat more than their systole retards it *. But the rapid distention of a vein below a ligature, where this cause cannot act, shows that the other causes of the motion in the veins are much more powerful.

6. It appears from the experiments of Dr BARRY, that the motion of the blood along the veins is promoted also, in animals of which the respiration is similar to the human, by the "suction influence" of the acts of inspiration above mentioned. But, besides what was observed in the last paragraph, the facility with which circulation is carried on in the fœtus, which does not breathe; in animals, of which the pericardium has been opened, and the heart exposed to the air (so that no influence of this kind can affect the motion of the blood); and even in cases of artificial respiration, where no such influence can be exerted by the chest —sufficiently demonstrates that this cause likewise is of comparatively inconsiderable amount.

* See particularly WEDEMEYER in Edin. Med. and Surg. Journal, vol. xxxiv. p. 89.

The effect of the more violent respiratory actions on the flow of blood in the veins, and particularly the retardation of the blood's motion, and congestion in the great veins, from forced or prolonged expiration, accompanied by muscular effort, are very important in Pathology. Muscular exertion, especially of the respiratory muscles, has the additional effect of accelerating the flow of blood in the arteries, which will be considered afterwards.

The Pulmonary Artery and its branches are similar to the other arteries of the body, and the pulmonary veins to other internal veins. The termination of the smallest branches of the artery in the capillary veins of the lungs, has been ascertained as distinctly, and in the same manner, as in other textures; and the smallest branches of the bronchial arteries, which bring arterial blood from the aorta, have been found to inosculate with those of the pulmonary artery.

As the whole of the pulmonary circulation is carried on within the cavity of the chest, it cannot derive any aid, on the principle of suction, from the movements of the chest. But the motion of the lungs in inspiration and expiration promotes the flow of blood through their substance, for reasons which will appear afterwards.

The fibrous middle coat found in the pulmonary artery and its branches, as well as in the aorta, is probably chiefly useful by resisting the strong and variable impulse given by the heart's contractions, and thus preventing morbid dilatation of the arteries. And it is with the same intention, no doubt, that the great veins are strengthened by muscular fibres near their termination, where they are exposed to the retrograde impulse from the stroke of the auricles.

According to the most probable estimates, the whole quantity of blood in the body may be in general about 1-5th of the weight of the whole body, and of this, it is generally thought that about 1-4th may be in the arterial, and 3-4ths in the venous system.

CHAPTER IV.

OF THE COMPOSITION AND PROPERTIES OF THE BLOOD.

This subject demands attention before we can proceed to state the uses of the Circulation.

The Blood in the living body, or immediately on emission from the vessels, consists of a clear fluid, in which a very great number of red particles are suspended. Its specific gravity is about 1050, and its temperature about 98°. Within a few minutes after emission, in the natural state, it divides itself into a yellowish fluid called *Serum*, and a dark red spongy mass called *Crassamentum*.

In some cases, chiefly morbid, the crassamentum is spontaneously divided into two parts, the *colouring matter*, which lies lowest, and a whitish tenacious substance called *Fibrin*, which covers its surface. And in all cases, this division of the crassamentum into two parts may be accomplished, either by carefully stirring fresh drawn blood with a stick, to which nearly all the fibrin, and little of the colouring matter, adheres; or more completely, by repeated affusions of cold water and pressure, by which the colouring matter is carried off and the fibrin left.

Of the three substances into which the blood is thus divided, it has been generally believed that the Serum and Fibrin are combined *in the clear fluid* of the living blood, and that coagulation depends on their separation, and on the red globules attaching themselves more or less completely to the fibrin. But the microscopical observations of Prevost and Dumas * lead them to believe, that the fibrin is combined with the colouring matter *in the globules* of the living blood, and that coagulation consists in the adhesion of the globules to one another, with more or less complete sepa-

* Ann. de Chimie, tom. xviii. and xxiii.

ration of these, their constituent parts; and the same opinion is held by the other recent inquirers on the Continent. On the other hand, the opinion which has been more general in this country (viz. that the Fibrin is in solution in the Serum in living blood) is maintained by Dr BABINGTON *, and is thought to be supported by the fact, that the separation of the Fibrin takes place so very uniformly from the whole colourless fluid of the blood, as to form an exact mould of a vessel into which that colourless fluid, in the case of blood coagulating slowly, may be transferred before the concretion has commenced.

Until it be more clearly ascertained what is the true relation of the fibrin to the other principles in the living blood, the account we can give of this fluid is necessarily very imperfect. And farther, when we state the chemical composition and properties of these or any other animal substance, two cautions must always be kept in mind.

1. The proximate principles which are procured from these substances, have not necessarily existed in them just in the form in which they appear, but may be in part the products of the chemical operations, however simple, by which they are shewn.

2. As we know that the peculiar combinations of Carbon, Hydrogen, Oxygen, and Azote, which form the animal principles, tend continually to dissolution, and cannot be recomposed by art, we cannot doubt that the chemical affinities of these elements are somehow modified, in those vital actions in which the animal principles are formed; and until we know something of the Laws according to which chemical affinities are controlled and altered in the living body, we cannot expect that the chemical examination of dead animal matter will give much assistance to Physiology.

The following are the most important results of Chemical Examination of the three substances into which fresh drawn blood divides itself:

* Medico-Chirurgical Transactions, vol. xvi.

1. The serum has a specific gravity of about 1030. When it is heated to 160°, an abundant coagulum of *Albumen* is formed in it, just similar to that which is formed in the same way from the glaire of the egg. This coagulated albumen once formed from either fluid, is insoluble in water, —soluble, by the aid of heat, in the caustic mineral alkalis,—is formed into a substance resembling gelatin by the long-continued action of acetous acid, or diluted nitric acid, —and is little prone to putrefaction.

The fluid which drains or may be expressed from coagulated serum is called the Serosity. It consists of water holding in solution a little of an uncoagulable animal matter, which has been called Muco-extractive; which shews itself on evaporation, is soluble both in water and alcohol, and may be precipitated by acetate of lead; and also a little of the following salts,—Soda or its Sub-carbonate, Muriate of Soda, Sulphate and Muriate of Potass, and Phosphates of Lime, Magnesia and Iron.

A fixed oil is often suspended in the serum, in such quantity as to give it a somewhat milky appearance, and in smaller quantity is now known to exist always in it. It is most easily shewn by agitating the serum with æther, which dissolves it, and then allowing the æther to evaporate; and it spontaneously separates into two parts, one a fatty somewhat crystalline matter, which has been likened to the substance of the brain, the other a fluid oil *.

The proportions of these different ingredients in the serum are,

According to Marcet,

Water, ...	900
Albumen, ...	87
Muco-extractive, ...	4
Salts, ...	9
	1000

* See Babington in Medico-Chirurgical Transactions, vol. xv., and Le Canu in Journal de Pharmacie, 1831.

According to Le Canu,

Water,	901
Albumen,	81.2
Animal matter soluble in Water,	4.6
Animal Oil,	3.4
Salts, and loss,	9.8
	1000

2. The *Fibrin* has a peculiar tendency to assume the fibrous form. In chemical relations it differs very little from coagulated albumen *. Both are resolvable, as the products obtained from them by the full action of heat shew, into Carbon, Hydrogen, Oxygen, and Azote, and the chief difference between them lies in the fibrin containing rather less oxygen and more azote. The proportions have been thus stated,

	Carbon.	Hydrogen.	Oxygen.	Azote.	
Albumen,	52.8	7.5	22.8	15.7	
Or,	17	13	6	2	atoms.
Fibrin,	52.3	7.0	19.6	19.9	
Or,	18	14	5	3	atoms.

3. The colouring matter is quite insoluble in the serum, but readily unites with water, as is shewn by the means of separating it from the fibrin. The solution, or intimate mixture, of this matter in water, is acted on by heat nearly as serum is; and the solid matter deposited from it, does not appear to differ materially from coagulated albumen, except in colour, and in yielding a small quantity of oxide of iron, not only when burnt, but, after the application of chlorine, by its liquid tests.

4. Carbonic acid is usually disengaged from fresh drawn blood, but in variable, and generally very minute quantity; in some cases it is not obtained, even by the action of the air-pump.

The colouring matter, although it cannot maintain the solid form without the assistance of fibrin as a cementing medium, and although it is probably impossible to separate

* Hatchett, Phil. Trans. 1800. Berzelius, View of Animal Chemistry.

it completely from the other constituents of the blood, constitutes the greater part, and the densest part, of the crassamentum;—its quantity has been stated at nearly ten times that of the fibrin, in a portion of crassamentum properly dried; and its specific gravity as 1126 or 1130, that of the whole crassamentum being 1077 or 1084 *.

In order to ascertain the comparative quantities of the solid matter of the serum, and solid matter of the crassamentum, in blood, it is necessary to evaporate slowly to perfect dryness a given weight, first of the serum, and then of the crassamentum, and weigh the residuum in each case; and then to allow as much of the residuum, in the second experiment, to be solid matter of the serum, which had been contained in the crassamentum, as the result of the first experiment shews to be the proportion in the pure serum, corresponding to the quantity of water that has been driven off. The remainder of the last residuum only, is the weight of the solid matter of the crassamentum itself. It is important to attend to these proportions, because they appear to be liable to much variation in disease. The average results of trials made in this way by different experimenters, give these proportions in human blood:

	Prevost and Dumas.	Le Canu.
Water, - - -	784	789.3
Solid matter of Crassamentum,	129	132.5
Solid matter of Serum,	87	78.2
	1000	1000

Of the whole blood, therefore, more than one-fifth is solid matter, and of the solid matter nearly three-fifths are in the crassamentum.

The proportion of solid matter of the crassamentum in the blood is found to vary remarkably according to the quantity drawn, when that is considerable,—being much less in the last drawn blood than in the first; probably because the evacuation causes the return into the larger ves-

* Davy, De Sanguine. Edin. 1814.

sels of much of the thinner part of the blood, previously diverging into the smallest capillaries *.

The quantity of the Fibrin contained in blood, when thoroughly dried, has been stated at less than 1 part in 1000, but the numerous experiments of Le Canu give an average of 4.3 in 1000 parts of blood †.

The Globules of the blood in the living body, whether they contain the fibrin in their composition or not, possess very singular properties. They contain the whole colouring matter, though in varying proportion. They have, in every species of animal where they exist, a determinate form, circular and flattened in man, and a uniform size, stated at from $\frac{1}{3000}$ to $\frac{1}{5000}$ of an inch in diameter in man; and when in motion in the living and healthy body never coalesce. They have such tenacity as to regain their form and size after being compressed and flattened, as they sometimes are in narrow bloodvessels; and when at rest tend to arrange themselves in somewhat determinate forms ‡. But these properties they seem gradually to lose after they are removed from the living body.

The phenomena of the coagulation of blood, whether dependent on a change in the aggregation of the matter composing the globules, or on the separation of the fibrin from the serum, demand consideration. This change generally begins in two minutes, and extends to the whole mass in six or seven, after blood is drawn, but the cohesion of the coagulum formed continues to increase often for many hours after. It consists in the fibrin becoming concrete, and assuming a filamentous reticular form,—in the interstices of which the colouring matter is lodged,—and then gradually contracting; and as the fibrin is of somewhat less specific gravity than the colouring matter, the coagulum appears first, and is firmest at the upper part.

The coagulation of blood is not attended with any de-

* Davy, De Sanguine, Edin. 1814. Schræder Van Der Kolk, Commentatio De Sanguine Coagulante. Groningen, 1820.

† Journal de Pharmacie, 1831.

‡ Prevost and Dumas, Annales des Sciences Naturelles, t. 12.

cided elevation of temperature, nor is it necessarily, although frequently, attended by any evolution of carbonic acid. It is promoted by heat, by exposure to air, and by rest or gentle agitation only, but is not prevented by the opposites of these. It takes place very slowly, even when blood is at rest, in the living body. It is promoted by separation of the particles of blood from one another on a flat surface, even *in vacuo*; and more remarkably by an increase of the serous part of the blood; and this is the reason why blood drawn from the veins of persons weakened by loss of blood, or fainting, or of dying animals,—being, as already observed, more serous,—coagulates much more rapidly than the blood drawn previously *. From this cause the last blood drawn from the vein of an animal bled to death, may coagulate almost instantly, while the blood in the large vessels of the same animal may be found fluid after death, and then coagulate slowly.

Two distinct peculiarities of the blood, as to its disposition to coagulate, are often observed, both in disease, and in other circumstances of the body. These are most commonly seen in very different states of the body, but are not opposed to each other; and in a few cases even coexist with with one another. The *first* is, the state in which coagulation is imperfect, and the coagulum formed unusually large, loose, and flocculent. This is observed after violent muscular exertions, and in various diseases, particularly those which arise from a virulent contagion or malaria, and are attended by typhoid symptoms. The extreme case of this condition of the blood is its perfectly and permanently fluid state, where no separation of its constituent parts takes place, and all the fibrin is found in minute particles diffused through the mass; and this is seen after sudden death, from suffocation, from blows on the stomach, diseases of the heart, lightning, muscular exertion, or mental emotion;—likewise after the most rapidly fatal diseases, such as tetanus, or the worst forms of fever.

* Davy, Thesis 1814. Schræder Van der Kolk, l. c.

The *second* peculiar state of the blood as to coagulation is, where the fibrin and colouring matter separate from one another, as well as from the serum; of which the extreme case is, the formation of the firm thick buffy coat seen in various inflammatory diseases. This does not depend on the circumstance of slow coagulation of blood, and consequent separation by gravity, of the colouring matter from the fibrin, but on an unusual tendency to separation between these substances; of which there are two simple proofs. 1. That the formation of the buffy coat (though no doubt favoured or rendered more complete by slow coagulation) is often observed in cases where the coagulation is more rapid than usual; and the colouring matter is even observed to retire from the surface of the fluid in such cases, before any coagulation has commenced. 2. That the separation of the fibrin from the colouring matter in such cases takes place in films of blood, so thin as not to admit of a stratum of the one being laid above the other;—they separate from each other laterally, and the films acquire a speckled or mottled appearance, equally characteristic of the state of the blood, as the buffy coat itself *.

It does not appear possible to explain the fluidity of the blood in the vessels of the living body, the phenomena of its coagulation when emitted, the variations of this progress now mentioned, and especially the modes in which these variations are produced,—by reference to any mechanical or chemical principles; and if not, then it becomes incumbent on us to ascribe Vital Properties to the Blood as it exists in the living body, as well as a vital character to the processes by which it is formed. (See p. 41.)

As the aggregation of the particles of the fibrin in the coagulum, when once produced, continues until putrefaction begins, it would seem, on first consideration of the subject, sufficient to ascribe the fluidity of the blood during life to its vitality, giving a tendency to the particles of the fibrin to repel one another, and keep separate, and coagu-

* SCHRÆDER VAN DER KOLK, Commentatio, &c.

lation to the loss of vitality, and their consequent cohesion. But on the other hand, the varieties observed as to this aggregation of the fibrin, and as to its separation from the colouring matter, and the total absence of any such tendency in the cases, particularly of sudden death, where coagulation never takes place,—as they appear inexplicable by any mechanical or chemical principles,—would seem to indicate that the act of coagulation itself is a last exertion of the vital properties of the fibrin; and it has accordingly been likened to the stiffening of muscular fibres after death. However, these two processes are not, as has been supposed, necessarily connected with each other; the stiffening of muscles being well marked in some cases where the blood remains fluid after death.

Intestine movements of the particles of blood and of these among themselves, may be seen in various circumstances, and have been minutely described by different microscopical observers *. These have been judged to be vital, and to be concerned in producing its fluidity; and coagulation has been considered as the last effort of the powers by which these movements are effected. Perhaps it is not absolutely ascertained that these movements in the blood are inexplicable by merely physical laws; but the statements of Tiedemann, as to the manner in which these movements in blood and other living fluids are affected by stimulants and by poisons, appear nearly decisive as to their truly vital character †.

The vital properties of the blood probably reside in its globules, which seem to differ from any thing seen in unorganized matters; and more especially in the truly coagulating part of the blood, *i. e.* the fibrin; and their existence there is still more clearly indicated by the changes which fibrin effused from the vessels in inflammation undergoes; for it has been ascertained that it is in pure fibrin effused

* Treviranus, Schræder, Schultze, Du-Trochet, Tiedemann, &c.

† Traité de Physiologie, § 569, *et seq.*

from this cause, much more than in coagulated entire blood, that new vessels are formed, and organization established *.

The varieties observed as to the formation and properties of this effused and organizable lymph, in different diseased conditions of the body, are likewise, in all probability, indications of its vital properties, and of changes to which these are liable.

Arterial blood has been ascertained to differ from venous not only in its colour being scarlet, instead of purple, but also,

1. In coagulating both more quickly and more firmly.

2. In the crassamentum formed in it, and especially the fibrin of that crassamentum, bearing a larger proportion to the whole blood †.

These peculiarities, after what has been stated above, naturally lead us to suppose that the vital properties will exist in arterial more than in venous blood; and accordingly, it is with the circulation of arterial blood through the different textures, almost exclusively, and with the separation of portions of the arterial blood in them, that the other vital phenomena of the living body are connected.

CHAPTER V.

ON NUTRITION, EXHALATION, AND SECRETION IN GENERAL.

The fundamental and essential function of Nutrition is carried on in the different classes of animals with a rapidity nearly proportioned to the complexity of their structure, and to the energy and variety of vital actions of which they are susceptible ‡. Wherever a circulating system exists, it

* Thomson on Inflammation, p. 216, *et seq.*

† According to Prevost and Dumas, about 1 per cent. more. See also Shræder Van der Kolk.

‡ See Tiedemann, Traité de Physiologie, § 298, *et seq.*

is the agent employed for that purpose. For although the existence of arterial branches, terminating in exhalent surfaces, in secreting organs, or in the solid textures, has not been proved; and although the observation of the actual escape of particles of blood from the circulating vessels, and their application to any of the animal textures, has been described by very few microscopical observers, and may be held liable to fallacy; yet the following considerations leave no room for doubt, that portions of the circulating blood are continually applied to the formation and support of the solids and other fluids of the body, and that, in so far as these are dependent on such supplies, they receive them from the blood.

1. The formation of many of the fluids, and some of the solids of the body, is continually going on; as that of all parts of the body is, during the time of growth. There is also good evidence, to be afterwards stated, of continued absorption from all parts of the body, without loss of substance, which implies continued deposition.

2. While these facts show that something is continually added to the solids, and other fluids of the body, it is equally clear that something is continually abstracted from the blood; because continual additions are made to it from the organs of digestion, without permanent increase of its quantity; but this is quickly diminished when those supplies fail.

3. The blood is continually applied to the solids, and to the prepared fluids of the body, in capillary vessels which must easily admit of transudation; and is materially changed by that application.

4. The blood is fitted, by its composition, for supporting the different animal solids and fluids; and we have actual proof of its application to these purposes, in the case of increased exhalation or artificial dropsy, produced by injection of water into the vessels, in many experiments of MAGENDIE and others; and in many cases of wounds healed, swellings formed, or adhesions contracted, evidently by

* MASCAGNI De Vasis Lymphaticis.

blood or lymph effused from vessels in a state of inflammation, and becoming organized.

5. Increased growth, natural or morbid, of any part, is always attended by enlargement of its vessels, and the vascularity of those textures, in which fluids are continually formed, is always much greater than that of those, in which solid matter only is contained.

The term *Nutrition* is generally applied to the deposition of solid matter from the blood, and the term *Secretion* to the formation of fluids; this last being divided into *Exhalation*, where the fluid is thrown out on an extended surface, and Secretion properly so called, where it is prepared in a gland, and carried off by a duct.

All that is known of the course of the portions of blood destined to these purposes is this: It passes, in all these cases, in numerous capillary vessels, with very thin coats, not to be distinguished from the surrounding textures, along the surface of membranes, along the septa of cells, or in the interstices of fibres. A membrane, on which many vessels ramify, seems all that is necessary to any kind of secretion; and all the varieties of secreting organs to be only "contrivances for conveniently packing a large extent of such a surface in a small compass *." These vessels, so far as they can be traced, either in the living bodies of animals, or after the most successful injections with size and vermilion, pass on to the veins. It is very doubtful whether the particles of vermilion ever escape from them except by rupture; and any extravasations from them in the natural state, would seem to be, not through visible outlets, but by *lateral pores* †.

It is an important question, whether the different textures and secretions of the body are actually *formed* from the circulating blood, at the parts of the body where they appear, or are formed in the blood itself, and only *evolved* or separated at these parts. The following facts seem to favour the last opinion.

* Mayo.

† Mascagni, Schultze, Du-Trochet, Prevost and Dumas, &c.

1. It is a general law of living animals, and probably of vegetables * also, that all nourishment received from without must be mixed with secretions of the organized body itself, and so far elaborated in its interior, before it is applied to the support of any part of the organization; which makes it probable that an important part, at least, of the process which fits it for giving that support, is completed before it reaches the organs where it is so applied.

2. As the blood contains, or shews after the simplest chemical processes, Fibrin, Albumen, Muco-Extractive Matter resembling Osmazome, Water, Oil, the phosphates of Lime and Magnesia, and most of the other salts found in the secretions, it appears fitted to yield, by mere separation of its constituent parts, by far the greater part of the substances found in the textures and secretions of the body.

3. There are various instances, in disease, not only of textures widely extended over the body, such as Bone and Fat, being deposited in unusual situations, but also of substances usually secreted in special organs only, such for example as Cholesterine, being deposited in parts distant and very different from those where they are commonly found; and even independently of structural disease, there are various well authenticated cases on record, where secretions, especially those of urine and of milk, have been thus established, and passed off for some time, " per aliena cola †."

4. It has been ascertained, first by Prevost and Dumas, that, when the secretion of urine is suppressed by extirpating the kidneys of animals, the Urea, which is the characteristic part of that secretion, may, after a time, be detected in the blood; and the same has been found in the human body, in some cases where the secretion of urine

* See Knight, Philosophical Transactions, 1805.

† Setting aside, as inapplicable here, many of the cases recorded under this head by Haller (Elem. Lib. 7. C. 1.), there remain several which seem to justify this observation; and various similar cases have been recorded since, *e. g.* in Magendie's Journal de Physiologie, vol. vii.; and London Medical and Physical Journal, June 1828.

has been much obstructed by disease, whether functional or organic, of the kidneys *.

5. It is often observed, in cases of disease resulting from the introduction, or retention within the body, of noxious or unassimilable matter, that this morbific matter, certainly mixed with the whole blood, is evolved from the circulation at certain parts, or in certain textures rather than others; which implies a peculiar relation of foreign matters, circulating with the blood, to the vital properties of peculiar textures, and makes it probable, that there will exist similar relations of textures to the different natural constituents of healthy blood.

But, on the other hand, it is to be observed,

1. That a conclusion resting on observations made on the secretions of urine, bile, and milk, which are destined to excretion, is not necessarily applicable to the case of those formations from the blood which are destined to useful purposes in the animal economy.

2. That it is doubtful whether the Fat of the animal body or the Nervous Matter, can be recognised in the Blood, and certain that the Gelatin, which is easily procured in abundance from any animal textures, cannot be recognised there; and several of the other elements of the animal textures, found in small quantity in the blood, may be supposed to be the products of *Absorption*.

3. That in Insects and Zoophyta, where secretion and nutrition are seen in their simplest forms, the general nourishing fluid, formed and contained in one internal cavity, appears to furnish a variety of products very different from itself, by a process hardly more complex than mere transudation through a living membrane †.

These facts lead us to believe, that, although many of the products formed in the living body are so far elaborated in the blood itself, yet, in various instances, a material

* BOSTOCK's System of Physiology, vol. iii. p. 412. CHRISTISON, Edinburgh Medical and Surgical Journal, vol. xxxii. pp. 271 and 274.

† CUVIER, Leçon 23, sect. 2. art. 5.

change is effected in these products at the time and place of their escape from the circulation.

It has been doubted, whether Transudation takes place at all through textures in the living body, and been supposed by some, that all Secretion and Nutrition must be by branches of arteries specially designed for that purpose; but the occurrence of transudation through living textures, which was maintained by Dr W. Hunter and by Mascagni, has been put beyond doubt by the experiments of Magendie and others. It appears, however, that it takes place to a less extent than in the dead body: and the escape of fluids from the vessels, in particular, must be impeded, and may probably be variously modified, by the exercise of their tonic power, formerly considered.

There has been much farther speculation as to the explanation of the formation of so many different compounds in the living body from the same blood; but inquiries on this subject have led to results, which, though very important, are for the most part negative.

I. The blood, in its passage to the different organs, is propelled through canals of extreme minuteness, variously contorted, and of very various length, and endowed, perhaps variously, with the power of acting mechanically upon it; and the frequent alterations of the distances and positions of its particles, thus effected, have been supposed to be a sufficient cause for the variety of products which it yields. But the insufficiency of this explanation is shewn by the following facts.

1. It appears from the cases mentioned, that Secretions may pass out for a time, by organs distinct from those at which they generally appear, and this without perceptible change of structure, or subsequent alteration of the functions, of the parts that take on this new kind of action.

2. Substances the most widely different in composition from the blood, such as Bone and Cartilage, are formed in parts of the human body where there is no very complex arrangement of vessels; and very complex arrangements,

in various parts, yield products but little different from the serum of the blood. In many of the lower animals, and in vegetables, no system of vessels, nor even any perceptible variety of cellular structure, is employed for the formation of very various compounds.

3. Even in different parts of the human body, and still more on examination of various animals, it appears, that products very nearly resembling each other, and answering the same ends, are formed in organs where the structure and the disposition of the vessels are very various; and again, that substances the most widely different are formed in organs that are in these respects extremely similar*.

II. As Secretion is much influenced by causes acting on the Nervous System, and especially by injuries there inflicted, it has been and still is supposed by some physiologists, that it is necessarily dependent on some power communicated through the nerves from the brain and spinal cord. But to this theory of *dependence* on the brain and nerves, the following appear nearly insurmountable objections.

1. Secretion and Nutrition are phenomena observed much more generally in nature, than any vestiges of nervous matter; viz. not only in those animals where no nervous system has been detected (which must be allowed to be a doubtful case), but in the whole vegetable kingdom; in which they are at least as numerous, varied, and striking, as in the economy of animals.

2. Secretion and Nutrition take place after the usual manner, in the case of the human fœtus without a brain,—in that of the fœtus without either brain or spinal cord,—nay even in the fœtus which has hardly a vestige of nervous matter in its composition†.

3. It appears from the inquiries of different anatomists, and particularly of TIEDEMANN and GMELIN, and of SERRES, that the formation of the larger masses of the nervous system in the fœtus, is always posterior to many acts of nutrition and secretion; and that vessels ramify, and different

* CUVIER, Leçons, t. 5. p. 214.

† CLARK in Phil. Trans. 1793.

textures are already nourished in every part, before nervous matter is distinctly formed there.

4. Such injury or disease of the nervous system as destroys all voluntary motion and sensation of a limb, and materially affects the pulse there, although it usually modifies, does not stop the nutrition or the secretions there, nor prevent the usual effects of inflammation, which are analogous to secretion, from taking place; and in different experiments of physiologists, when the nerves of secreting organs were cut (*e. g.* of BICHAT on the Testicle, and MAYO on the Kidney), secretion in these organs, although sometimes altered, was not suspended.

In opposition to these facts, the experiment (familiar to HALLER, but often repeated and varied by Dr WILSON PHILIP and others), of cutting the 8th pair of nerves in the neck, and thereby arresting the digestion of food, which implies suspension of the secretion of the stomach, is surely too slender a foundation for the general assertion, that a nervous influence is essential to all Secretion.

Farther, the conclusion thus drawn from that experiment is liable to the following objections:

1. The result of the experiment is not uniform; for the trials of BRESCHET and EDWARDS, and more especially those of LEURET and LASSAIGNE*, seem sufficient to establish the positive fact (necessarily much more conclusive in this inquiry than any negative fact), that after the section of those nerves, with loss of substance, in the neck, and without the aid of galvanism, digestion may, in certain circumstances, be carried on.

2. The secretion at the stomach is peculiarly under the influence of Sensation, as well as of emotions of Mind; and the effect of this operation is not only to cause pain, but to excite much nausea and dyspnœa, which are fatal within two or three days. Such sensations, however caused, will materially affect that and other secretions, without proving the necessary dependence of the secretions, on the parts by the

* Recherches pour servir à l'Histoire de la Digestion, p. 133.

injury of which they are excited. When the branches of the 8th pair going to the stomach were cut on the œsophagus by Magendie, the effect on the lungs and the dyspnœa not being produced, the secretion at the stomach was not arrested.

3. In all experiments made by cutting the nerves in the neck, it has appeared, that while the secretion at the stomach was suspended or diminished, the secretion in another part, equally supplied by these nerves, viz. the bronchiæ, was altered and *greatly increased.*

4. In Dr Wilson Philip's experiments, the secretion of the stomach, suspended by the operation in the neck, was restored by Galvanism. The result is therefore conclusive *against* any influence from nerves being essential to secretion, unless it were proved that nervous influence is identical with galvanism. Now this is not proved; and if it were, it would give little assistance in explaining secretion; because galvanism is a *single* known chemical agent, and the difficulty is, to explain the evolution of *many and various* chemical compounds, in different parts of the body, from the same blood.

III. The reference made by Bichat, of the phenomena in question, to the property which he called Organic Sensibility, and likened to Sensibility properly so called, is also quite unsatisfactory; because the term sensibility, and all principles connected with it, are inapplicable to changes which are unattended by any Sensation.

It appears, on the whole, beyond doubt, that the phenomena of Secretion and Nutrition are inexplicable by, and inconsistent with, any principles that can be deduced from the observation of dead matter, or of other functions of the living body. At the same time, it is obvious that they do not take place fortuitously, or at random, but according to fixed laws. We refer them, therefore, to a Vital Property, known to us only by its effects, and our notion of which is, as yet, necessarily vague and imperfect;—which modifies chemical affinities in the living body;—varying in different parts of the body, and causing these to be differently affected by, and produce different effects on, the blood that pervades them;—influencing likewise, no doubt, the chemical nature and relations of the blood itself. To this property, the best name that has been given is Vital Affinity. Its existence will always be an ultimate fact in Physiology; but the limits of its agency, and the laws according to which it modifies the chemical relations of the substances subjected to it, may be ascertained; and their development will probably constitute the next great discovery in this Science.

Dr Prout has lately laid down the following principles, as to the formation of organic compounds in living bodies, which, if duly established by observation, will be so many steps in this inquiry.

1. That all organic compounds are formed by the same affinities, which exist among their elements when existing in inorganic forms, but that, in the vital processes by which they are formed, some of the ultimate particles of bodies are excluded, and others brought into contact, according to the object to be attained, so as to give a different *effect* to these affinities, from those which they can produce in other circumstances.

2. That it appears to be essential to the formation of organic compounds, that the elements composing them should not unite so as to form crystalline substances, and that probably no crystallizable body is capable of constituting a portion of a living organized being; such products, when they do occur, being either the result of excretion, or of disease, or of some artificial process.

3. That the small quantities of earthy and saline substances existing in all organized bodies are probably essential to their organization, and that by their union with the other elements of the organic compounds, these last may probably be effectually deprived of the power of crystallization, or *merorganized.*

4. That all organized beings appear to be essentially constituted by compounds which may be referred to three

great natural classes or groups, the Albuminous, the Saccharine, and the Oleaginous; and that in each of these the elements are combined, not according to certain definite proportions only, but in proportions varying as the terms of certain series of numbers (such as the series 3, 6, 9, 12, &c.) *

In the mean time, several well-known facts, besides the phenomena of Secretion and Nutrition themselves, illustrate the general principle, that the vessels, and the powers that move the blood in the vessels, in different organs and textures of the body, are differently affected by the blood that pervades them, or by substances conveyed to them by that blood. Of this kind are,

1. The difference, already mentioned, between the flow of arterial and venous blood through the vessels of the lungs; while both pervade with ease the substance of the liver.

2. The fact, that textures which shew nearly an equal degree of vascularity after fine injection in the dead body, habitually admit very different quantities of blood in the living body †.

3. The specific effects of various poisons, and contagious effluvia, circulating in the blood, on individual glands or individual membranes only.

The widely different effect of various substances (*e. g.* of Air) applied externally to the vessels of serous and of mucous membranes, must be referred to the same general principle.

* See Lectures in London Medical Gazette, vol. viii.

† See Bichat, Anat. Gener., tom. ii. p. 479.

CHAPTER VI.

OF ABSORPTION.

THAT Absorption, both of solids and fluids, takes place frequently, and to a great extent, in the living body, is easily proved,

1. By the wasting of the whole body, or of individual parts of it, which no external agents can affect, observed in various circumstances of health and disease.

2. By the disappearance, whether spontaneous or determined by art, of fluids which had been perceived in various parts of the body, or been injected into the cavities of the body.

3. By the effects produced by various substances placed in contact with any living surfaces, exactly similar to those produced by them when received into the stomach or injected into a vein.

We first state what is known of the agents by which Absorption is effected, and afterwards endeavour to estimate the extent to which it is carried on, in the living body.

I. The vessels called Absorbents were, for a time, thought to be the only agents, and are still thought to be important agents, in this work of absorption.

These vessels are similar in appearance to the smaller veins, but are of more delicate texture; their coats are not distinctly divisible into different layers, but are very distensible, tough, and elastic. They are also more fully provided with valves, and of more irregular diameters, than the veins. Their smaller branches anastomose very freely, and are very numerous in many textures of the body; but there are some textures, as the Bones, in which they can hardly be traced, and others, as the contents of the Cranium and the Nervous System generally, in which they have not been detected. They are divided into the Lacteals, which come from the intestines, and the Lymphatics, which come from other parts of the body. The origin of the lymphatics has never been distinctly demonstrated in warm-blooded animals; but in fishes, where they have no valves, anatomists have satisfied themselves, by injection, that they have open mouths on the surface of membranes. The origin of the lacteals by little openings in the villi of the internal membrane of the intestines, has been seen in a few cases, as by CRUIKSHANKS and MAGENDIE, when they were distended by chyle.

In the human body, all the vessels which can be distinctly recognised as lacteals or lymphatics, pass somewhere through the small oval-shaped bodies called Conglobate Glands, most of which are set together in clusters in the hams, groins, axillæ, on the sides of the neck, in the posterior mediastinum, beside the iliac arteries and aorta in the pelvis and abdomen, and in the mesentery. Several branches of these vessels enter and pass out of every such gland; and they are so intimately subdivided and reunited within its substance, that every branch leaving it appears to be in communication with every branch that entered it.

Every gland is likewise fully supplied with blood from arteries, which are minutely subdivided, and convoluted within it. It is doubtful whether any of the lymphatics leaving a gland can be injected from the arteries entering it, without rupture; but that some intermixture, by transudation, of the contents of these minute vessels within the glands must take place, can hardly be doubted. And according to the observations of Mr ABERNETHY *, the organs in the whale, which correspond to mesenteric glands, are so constructed as to ensure a perfect intermixture of the contents of all the vessels entering them.

These vessels unite after the manner of veins, and, when traced to their termination, lead to two points in the vascular system; those where the internal jugular and subcla-

* Phil. Trans. 1796.

vian veins meet, on each side of the neck. The trunk, which terminates here on the left side of the body, has its chief supply from the thoracic duct, which ascends beside the aorta in the abdomen and thorax, from the vertebræ of the loins. But it is now ascertained, by the observations of ABERNETHY, BRACY CLARK, TIEDEMANN, FOHMAN, LAUTH, LIPPI, PORTAL, and others, that in Man, and others of the Mammalia, vessels which have the characters of lymphatics, and pass through glands, occasionally terminate in the veins in their own neighbourhood.

The contents of the lacteal vessels will be considered under the head of Digestion. The fluid contained in the lymphatic vessels of animals, and in the thoracic duct of those that have fasted long, has been found very various in quantity, and somewhat various in qualities; but in general, of fully as low specific gravity, and containing as little animal matter, as the serum of the blood, and nearly resembling it in chemical composition; with these remarkable differences, however, that a number of globules, similar to those of the blood, are observed in it; and that it contains a small quantity (not more than ½ per cent.) of fibrin, and therefore coagulates where emitted. It has sometimes a reddish colour, and becomes florid on exposure to air, especially in animals that have fasted long. In such animals it is most abundant; but when weakness has been brought on by inanition, its quantity is again diminished *.

That the movement of the fluid contained in these vessels must be towards the great veins, is shewn by the structure of the valves, which will not admit of motion in an opposite direction, unless the vessels are much dilated. Although the motion is slow, the fluid is propelled with force. The vessels contract and empty themselves when punctured; and when the thoracic duct has been tied, it has generally been ruptured by the distention below the ligature †.

* COLARD DE MARTIGNY in "Journal de Physiologie," 1829.

† Sir E. HOME, Phil. Trans. 1811.

Supposing all these vessels to arise (as all allow the lacteals to do) by open mouths, from the surface of membranes, the interior of cells, &c. the principle of Capillary Attraction is a sufficient cause for the ascent of fluids along them; but the influence of this cause alone can never call into action the elasticity of the vessels, to promote that ascent; because the effect of capillary attraction is fixed and uniform; and in order that the elasticity of a tube may be a cause of motion in its contents, it is necessary that the other forces propelling these should be variable or intermitting.

Neither can the ascent of the fluids contained in these vessels, in so far as it depends on capillary attraction, be aided by the action of the valves; because a fluid drawn up into a set of tubes by this cause alone, has no tendency to recede; and the only use of a valve is to prevent recession of fluids.

The structure and the elasticity of these vessels, therefore, and the principle of capillary attraction, are quite inadequate to explain the momentum, which the facts above stated show, that the contents of these vessels in the living body possess; and no other cause can be assigned which, on merely mechanical principles, will explain these phenomena. We are therefore constrained to believe, that the fluid in these vessels is moved by powers which are strictly Vital; but how far vital contractions of the vessels may suffice for the explanation of this motion, or how far, as in the case of the capillary circulation, other vital powers may be supposed to operate, is doubtful.

We shall see reason to think likewise, that some of the absorbent vessels take up certain fluids in preference to others, and even of others of which the particles are smaller; and for this preference, it is obvious that the principle of capillary attraction offers no explanation.

Some doubt has been thrown over the general opinion as to the origin of Lymphatics strictly so called, from the general uniformity of their contents, and from the fact, of their frequently receiving a part of injections thrown into arteries. But the following reasons may be given for thinking, that the whole of this system of vessels is engaged in the work of absorption.

1. The whole of these vessels are constructed exactly alike, and they lead to the same termination; and the origin and absorbing power of the lacteals is undoubted.

2. Although these vessels have often been filled by matters injected into arteries, yet, after the most minute and successful injections made by MASCAGNI with size and vermilion, and where no rupture of vessels could be detected, it was found that the matter existing in these vessels was only the colourless size, which had transuded on the surface of membranes, and into the cellular texture; and *this colourless size was found in these vessels only*, all vessels which contained coloured matter being traced to arteries and veins; so that the evidence of these injections favours the belief that the lymphatic vessels are not continuous with arteries, but may be filled by any matters that are effused from arteries.

3. The well known morbid phenomenon, of those lymphatic glands very frequently becoming inflamed which lie in the course of the lymphatic vessels leading from ulcerating surfaces (where it is certain that absorption is going on, and where noxious substances are often absorbed from without) strongly indicates that it is through these vessels, at least in part, that this process is carried on.

4. In some cases, a striking correspondence has been observed by MASCAGNI and others, after death, between the contents of the lymphatic vessels of parts of the body and various morbid effusions or secretions existing at those parts *.

The absence of any peculiar matters from the *larger* branches of the lymphatics, remarked by ANDRAL and others, in many subjects where extensive suppurations or other effusions had existed, is not decisive evidence against

* See particularly MASCAGNI Vasor. Lymphat. Historia, p. 20. The most important cases recorded by him are not noticed in the commentary on this passage by MAGENDIE.

this doctrine; particularly as it is known that the contents of these vessels are often moved forwards, after most of the functions of life have ceased.

But we have now satisfactory proofs that the function of Absorption is carried on likewise by Veins, and to a much greater extent than the small number of vessels having the character of lymphatics, which have been found to terminate in the smaller veins, can explain.

The experiments of HUNTER, made by exposing and isolating small portions of the intestines of living animals, filling them with different fluids, chiefly milk and a solution of indigo, and then examining the contents of the lacteals, and of the veins leading from these, may be allowed to prove two points: 1*st*, That absorption, at least of milk, and probably of other fluids, different from chyle, took place in his trials by the lacteals; 2*dly*, That no absorption could be ascertained, in his trials, to have taken place by the veins.

The first of these, which is a positive observation, although opposed to the results obtained by MAGENDIE and others, agrees with the results of many other experiments, by LISTER, HALLER, BLUMENBACH, TIEDEMANN and GMELIN, LAWRENCE and COATES, and FODERA, in which it appeared that a certain portion of different fluids, introduced into the intestines, was taken up by the lacteals; and the possibility of their absorbing fluids different from chyle may, therefore, be held to be decided. But the second observation of Mr HUNTER, which is a negative one, is quite an insufficient ground for the general conclusion, that veins do not absorb; and the reality of venous absorption is now put beyond all doubt, by the positive observation of many physiologists, particularly by the following.

1. The experiments of Sir E. HOME and Mr BRODIE * prove, that when the great lymphatic trunks are tied in warm-blooded animals, substances injected into the sto-

* Phil. Trans. 1808.

mach, nevertheless quickly find their way into the circulation, and may be detected in the urine.

2. Experiments made by MAGENDIE, FLANDRIN, TIEDEMANN and GMELIN, and others, prove that odoriferous substances, known by their smell, and saline substances, indicated by their tests, after being taken into the stomach, are detected in the veins on the mesentery, both larger and smaller, and in the vena portæ, much more than in the lacteals and thoracic duct.

3. Experiments made by MAGENDIE, prove that a poison introduced into an isolated portion of intestine, communicating with the rest of the body only by an artery and vein, or into the cellular texture of a similarly isolated limb, acts in the usual way, and nearly in the usual time, when the circulation is free.

4. In experiments made by SEGALAS, it appeared that a poison introduced into a portion of intestine between two ligatures, failed of effect as long as the artery and vein leading to that portion were tied, or the venous blood allowed to escape by a wound in the vein, although the lacteals and other textures were uninjured; but took effect as soon as the circulation was set free, and the venous blood allowed to return to the heart *.

5. In experiments made by Professor MAYER, it appeared that saline substances introduced in small quantity into the bronchiæ of animals, found their way very quickly into the blood, although the thoracic duct was tied; and were detected in the left side of the heart much sooner than in the right side †.

6. In experiments by FODERA ‡, it appeared that two saline solutions, applied to the inner and outer membrane of an isolated portion of intestine in a living animal, *were united in the small veins* leading directly from that portion of intestine.

7. In experiments by MAGENDIE, it appeared that a poison applied to an isolated vein, with all precautions to avoid

* Journal de Physiologie, 1822.

† Bibliotheque Universelle, Jan. 1818.

‡ Recherches Experimentales sur l'Absorption et l'Exhalation.

contact with other textures, or even to an isolated artery, gradually transuded into the interior of the vessel, and then produced its usual effects.

In cases of disease where large deposits of morbid matter have taken place within a short time,—in cases of Suppuration, of Fungus Hæmatodes, and of Melanosis, the veins of the affected parts have been found loaded with the morbid matter, more generally than the absorbents; which has been also regarded as a proof of venous absorption; but it will appear from facts to be afterwards stated, that the most probable explanation of this appearance is different.

It would appear, however, from what has been said, that the veins are concerned in the function of absorption in all the following ways:—1. They themselves absorb, chiefly by their smallest branches, at least fluid matters. 2. The contents of the lacteals and lymphatics are probably partially intermixed with those of the veins in lymphatic glands. 3. Some of the smaller lymphatic trunks terminate in veins. 4. The largest lymphatic trunks terminate in the great veins of the neck.

From the inner membrane of the intestines, it would seem, from the observations of many experimenters, that the absorption of thin fluids is chiefly by veins, and that of the chyle, which is a thicker fluid, by the open mouths of the lacteals only.

Two facts of much importance may be stated here, as natural consequences of the principle of absorption, in most parts, taking place chiefly by transudation into the interior of vessels, in which a current of blood is continually flowing.

1. That the absorption is much diminished by unusual fulness of the sanguiferous vessels, and increased by their inanition, as appeared particularly in experiments of Magendie, where the effects of poisons introduced into cavities of the body were observed, first after an artificial plethora had been induced by injections of water into the vessels, and then after the vessels had been partially drained of their blood, and found to be much retarded in the former case, and accelerated in the latter.

2. That absorption from any surface of the body is much diminished, or suspended, by greatly diminishing the pressure of the atmosphere on the part; as is shewn by the actions of a cupping-glass in many experiments of Dr Barry and others, preventing the absorption and injurious action of poisons.

II. That absorption of the fluids of the body is continually going on, is evident from familiar facts;—as to the contents of the Alimentary Canal, from the disproportion between the ingesta and egesta;—as to the Fat, from its diminution in consequence of fasting;—as to the Bile and Urine, from their higher colour and greater density when they are long retained;—as to the Contents of the Thorax and Abdomen, from the rapid disappearance of any fluid introduced there artificially, &c.

That a continued Absorption of the solids of the body likewise takes place, is concluded chiefly from the following considerations.

1. The same kind, and nearly an equal amount, of supplies from without, go to the blood during the adult state, and when the solids are apparently stationary in bulk, as during the period of the most rapid growth.

2. The penetration of the solid textures by arterial blood is necessary to preserve them from putrefaction, and it seems probable that this preservation is effected by a perpetual change of their particles.

3. In various circumstances, both of health and disease, absorption of animal solids is easily caused, and shews itself unequivocally; *e. g.* in the muscles in consequence of rest;—in all textures, and especially in the Bones, in the decline of life;—in the Thymus Gland after birth;—in the Uterus after delivery; in the gradual alteration of the form of several bones and other organs, both during their growth, and in the subsequent progress of life;—in the gradual diminution of the size of various organs, by *interstitial absorption*, in consequence of fasting, and of different diseases;—and of almost all organs, by *progressive absorption*, when they are subjected to unusual pressure from tumors or ab-

scesses;—and in the process of Ulceration. In all these cases, as the vascular organization of the parts, in which the increased absorption is going on, undergoes no material change, it cannot be supposed that the vessels have assumed an unwonted office.

There is, however, great variety as to the facility and rapidity of absorption in different textures. The permanence of the marks on the surface of the body produced by gunpowder, and by tatooing, and the long duration of the colour produced by the full internal use of nitrate of silver, sufficiently indicate that the renewal of the particles of the true skin is a very slow process. But the facts stated leave no room for doubt, that those of the animal solids which are provided with vessels, and are dependent for their properties on the constant flow of blood through these vessels, are subject to a continual although slow process of absorption and renewal of their particles.

CHAPTER VII.

ON THE PROPERTIES OF THE TEXTURES AND SECRETIONS FORMED FROM THE BLOOD IN THE LIVING BODY.

The different Textures and Secretions which are formed from the blood, are the materials, which are variously combined in the constitution of the different sets of organs, the functions of which are considered in the other departments of Physiology; and a knowledge of the *general anatomy* of these is essential to a right understanding of the uses to which they are applied. We introduce here, therefore, a short summary, in regard to each texture, *first*, of its merely physical properties, the purposes these serve, and its distribution over the body for these purposes; *secondly*, of its chemical properties and composition; and, *thirdly*, of the vital phenomena it exhibits, and the peculiarities of any secretions that may be formed in it.

Almost all the solid textures have appeared to several observers, under the microscope, to consist ultimately of minute globules, of the same size with those existing in the blood. But the investigations of Mr Brown and Dr Hodgkin render it doubtful whether that appearance is not deceptive.

The knowledge of the chemical composition of the different textures, and of the fluids formed in them, gives at present but little assistance, either to their Physiology or Pathology; but will no doubt assume a greater importance, when we shall have more precise ideas as to the modifications which chemical principles undergo in living bodies.

The strictly vital phenomena presented by most of the textures, are nearly confined to the vascular parts included within them; but the most important vital properties of some of the textures, particularly the muscular and the nervous, reside evidently in parts exterior to the vessels.

We omit, for the present, all mention of the sensibility of the different textures; that being in fact a part of the Physiology of the Nervous System.

We consider here, first, those textures which have originally a cellular structure, and may be made to shew somewhat of that structure by maceration in water; and afterwards those which shew a fibrous, but not a cellular structure.

I. Of Bone.

This, the hardest and densest of the animal solids in man, as in other vertebrated animals, gives the general form to the body, and the requisite strength and support to many of its parts. It gives protection to the most important viscera, and firm attachments to most of the muscles, and to ligaments, tendons, and fasciæ; and the articulations of the different bones are essential to most of the muscular movements.

All the bones are composed of laminæ, so arranged as to form cells, which in the long bones have the form of minute longitudinal canals. All have a firm investing membrane externally, and a more delicate membrane lining the cavities in their interior, in which the medulla is lodged. There are important differences as to the arrangement of the cellular structure in different bones. The external parts are the most compact; in the short and flat bones, the internal cellular structure is pretty uniform; whereas the broad extremities of the long bones of the limbs are composed of a spongy texture throughout, and their narrower shafts have a thicker compact structure externally, and a long cavity in their interior. By these arrangements these bones have sufficient strength, combined with lightness; their articulating ends have sufficient breadth; and they give both sufficient room for the fleshy bellies of the muscles, and advantageous attachments for their tendinous extremities.

The bones consist of earthy and animal matter, which are intimately incorporated, even in the minutest particle of their substance *. The earthy matter constitutes nearly 2-3ds of their weight. It consists almost entirely of Phosphate with a little Carbonate of Lime. These may be freed from the animal matter by burning bone, or they may be dissolved from it by diluted muriatic acid, and successively precipitated from the solution by Ammonia, and Carbonate of Ammonia.

When bone has been deprived of all its animal matter by the action of fire, it retains its hardness, but has become brittle and inelastic; when all its earthy matter has been extracted by acid, it retains its form, but has become soft and flexible.

Two animal principles are contained in, or may be easily procured from bone,—Gelatin and solid Albumen. The gelatin is obtained by the long continued action either of diluted muriatic acid or of boiling water; and by the continued application of these agents, particularly by water

* See Gordon's System of Anatomy, p. 253, and Craigie's General and Pathological Anatomy, p. 531.

heated under pressure to above 212°, its quantity is so much increased, that it is probably in part formed by the process. The albuminous contents of bone remain after both these processes.

The Gelatin which is procured from bones and from various other animal textures, by these means, is distinctly characterized by its ready solubility in hot water, and its forming a tremulous mass when cooled, by its solubility in diluted mineral acids, by combining with caustic alkalies, but not forming a compound like soap; by its being convertible, by the action of sulphuric acid, into a saccharine matter; by the copious precipitate it forms with the vegetable astringent principle called Tannin; and also, by being more putrescible than the other animal principles already mentioned. It differs from the others chiefly in containing more Oxygen, and less Carbon, its analysis being,

Carbon.	Hydrogen.	Oxygen.	Azote.
47.8	7.9	27.2	16.9

These differences may give us a general idea of the manner in which this substance may be formed in the living body, from the albuminous contents of the blood.

The effects of injury, and particularly of fracture of bones, the effects of pressure, from whatever cause, exerted on them, and the effects of various diseases, sufficiently indicate, that the vital processes of nutrition and absorption are performed in this texture with activity; and may go on to a greater extent than in almost any other texture, although they take place more slowly than in many of the soft textures.

But the vessels that can be traced into the substance of bones are minute; and their nutrition is very dependent on the vascular membranes which invest them internally and externally, and on which their vessels ramify, until they are much reduced in size. Hence the destruction of either of these membranes causes always the death, at least of the adjoining portions of bone; and in the reparation of bone the adjoining soft textures are always, although not exclusively, employed.

The nutrition of bone takes place chiefly beneath the periosteum, on its surface; and in the case of fracture it would even appear, that a part of the lymph, which is converted into bone, is thrown out, in the first instance, by the vessels of other soft textures, exterior to the periosteum *.

The absorption of bone in the living body, is so easily produced by pressure, that bones are obviously modelled, in a great measure, by the pressure even of soft living parts (*e. g.* arteries) within or beneath them; and it would seem, particularly from the medullary cavities within the bones gradually enlarging after their growth is completed, that the presence of the medulla determines absorption to go on habitually from their interior, more than from their surface.

The red colour which is given to bones, by mixing madder with the food of animals, particularly when young,—and the rapid disappearance of that colour, especially from their outer part, after the use of the madder is discontinued,—are proofs of their vascularity, and of the ready escape of substances from, and subsequent re-entrance into, their bloodvessels; and farther indicate that these changes take place most readily on their outer surface. But these experiments do not prove, that the earthy matter of the bones is deposited and reabsorbed with such rapidity as the colouring matter of the madder; because the union of this with the earthy matter of the bones, and its subsequent solution in the serum, appear to be simply chemical phenomena †; and in advanced life particularly, the renewal of the bony texture, in the healthy state, seems to be a very slow process.

The Medulla, which is contained in the cavities within the bones, and confined by laminæ of the internal membrane

* Dupuytren and Cruveilhier. See Dict. des Sciences Medicales, Art. Ossification.

† Gibson, Manchester Memoirs, New Series, vol. i.

passing across these cavities, does not materially differ from fat or other animal oils. Like the others, it has been found to consist of two oils, one fluid and the other solid at ordinary temperatures, which are mechanically separable from each other, and to which the names of Oleine and Stearine have been given. It has no connexion with the synovia of the joints; nor is its use understood, except in so far as it contributes to the combination of strength and lightness in the bones, and may assist in determining their forms.

The Teeth, in the adult state, divided by their form and position into four incisores, two cuspidati, four bicuspides, and six molares in each jaw, are distinguished from other bones by their position—being implanted in the maxillary bones, and invested only as far as the neck by periosteum—by the cavities within them, which contain a vascular pulp, and communicate with the rest of the body by the apertures at the extremities of the fangs;—and by the peculiarity of their composition, the bone which forms the greater part of each tooth containing above 70 per cent. of earthy matter, which is more than any other bones contain; and the enamel, which coats the crown of the teeth, containing, according to BERZELIUS, not less than 98 per cent. of earthy matter, including above three per cent. of fluate of lime.

As the bony matter of the teeth in ordinary cases, not only shews no vessels after the finest injection, but undergoes, in the adult state, no change of size or form by any vital process,—is never repaired after injury,—is unaffected by diseases of the other bones,—and appears subject to no alteration except simple decomposition,—this texture, or at least as much of it as exists in the crown of the teeth, cannot be regarded as possessed of vitality, after the period of its growth is over; but there may be a few cases in which strictly vital phenomena are exhibited in it at a later period *.

* See BELL on the Teeth.

II. Of Cartilage.

This texture is found in those parts of the body in which there is occasion for the physical qualities of strength and firmness, combined with more or less of flexibility, and with elasticity, which are its characteristic properties. From these qualities, and from its smooth surface, arise its great importance and utility in the formation of the joints, and in the junctions of various bones,—in the composition of the spine,—in the nostrils, larynx, and trachea,—external ear, &c.; but in these different situations it is found under considerable variety of density and flexibility, and, in some parts, approaching to the flexibility and toughness of tendinous substance, has received the name of Fibro-cartilage. The structure of the harder cartilages, as those at the ends of bones, is almost perfectly homogeneous.

Its chemical composition appears to be nearly identical with that of the animal matter of bones. By long continued boiling in water, under pressure, it may be almost entirely converted into a gelatinous solution, but the ordinary operation of boiling leaves a considerable albuminous residue.

Cartilage is invested with a membrane nearly resembling the periosteum, but no vessels can be traced into its substance, excepting where it is about to undergo conversion into bone. That it possesses vessels, however, may be inferred from various changes which it occasionally undergoes in the progress of life, and still more in disease; especially from its being sometimes partially absorbed, and sometimes altered in structure, without alteration of the adjoining bones.

As it contains little or no earthy matter, cartilage, in the dead body, resists decomposition much less than bone does; but, on the other hand, as it is so much less vascular than bone, it undergoes changes dependent on vital actions much more slowly, and offers much more resistance, in the living body, to the processes of progressive or ulcerative absorption.

III. Of Tendinous or Fibrous Substance.

This substance composes not only the tendons, but the ligaments and certain membranes, viz. the Periosteum, Dura Mater, Tunica sclerotica of the eye, and Aponeuroses or Fasciæ. All these consist of delicate white fibres, of a shining or silvery appearance, differently disposed. This texture possesses more tenacity or toughness than any other in the body: and, with the exception of the periosteum and dura mater (the importance of which to the nourishment of bones was already stated), it appears to be useful in the animal economy only by this mechanical property of toughness, which renders it a sufficient attachment for the origin of certain muscles; the best medium of connexion by which muscles can be attached to bones, and bones to each other; and the firmest bond by which the movements of muscles, tendons, or other parts, can be confined to the proper places and directions. That it may answer these purposes, it has, in many parts of the body, firm connexions with bones. Most parts formed of this substance resist the action of boiling water more than many other textures do; but gelatin may be obtained from them all, and the tendons are almost entirely resolvable into it. The portion that resists the action of boiling water, does not seem to differ essentially from solid albumen.

The membranes of this class are fully provided with vessels, and give frequent evidence of alterations of the vital process of nutrition; but the vital actions of ligaments, and more especially of tendons, are slow and feeble, and all parts formed of this texture exhibit in disease, and particularly in inflammation, less violent and rapid changes than other membranous parts. Being little liable to absorption, they often set bounds to ulceration, or other diseased actions; and by their physical qualities, they often compress inflamed parts, and confine, or alter the direction of, morbid effusions. Hence the practical importance of acquaintance with their anatomical disposition in the body.

IV. Of Cellular and Adipose Substance.

The first of these names is given to the soft filamentous substance very generally extended over the body, which connects together the various soft parts of the animal frame, and fills up all interstices; and the slender laminæ of which are so interwoven with each other, that when raised or distended, they appear to form numerous irregular cells communicating freely with each other. It varies much in density in the various parts, where it is interposed between the more determinate forms of other textures, *e. g.* beneath the integuments, around and between the fasciculi of muscular fibres, between membranes, around vessels, and in the substance of glands; but gives a free passage, in almost all parts, either to liquids or air. It is everywhere lubricated by a little serous fluid; and its degree of tenacity, with its softness, flexibility, and moisture, make it the best cement for holding together such parts of the body as do not require, or would be injured by, firm constraint.

This texture yields gelatin abundantly, though not readily, to boiling water. It is not only penetrated by numerous larger bloodvessels, but shews, on injection, more numerous capillary bloodvessels and absorbents, than any of those textures in which no fluids are formed.

The quantity of serous fluid exhaled into the general cellular texture, in the healthy state, is very small. But in many parts of the body, cellular membrane, of a more determinate form, encloses within it a quantity of animal oil, and this has the name of Adipose Texture. This appears to be in a fluid or semi-fluid state, in the living body, but is retained in the cells, even in the dead body, and when rendered quite fluid by heating, until these are ruptured *.

This adipose texture is found in the greatest quantity beneath the true skin, about the kidneys, and in the mesentery and omentum, in the orbits, within certain glands, about the heart, &c. There is little or none beneath the integuments of the head, in the male organs of generation, about the joints, or in the substance of most of the viscera. The composition of the animal fat has been thus stated:

Carbon.	Hydrogen.	Oxygen.
69	21.34	9.66

This and others of the animal oils, are easily distinguished by these marks, that they melt at about 96°, are very inflammable, are insoluble in water or alcohol, and form soap with the alkalies.

This texture is useful in those insterstitial spaces in the body where a certain quantity of soft but tenacious substance is required, to obviate pressure, or preserve symmetry. The subcutaneous fat is manifestly useful in preserving the heat of the body. It is obvious likewise, from the growth of this texture usually going on long after all other healthy growth in the body is over, and sometimes, in healthy and well-fed persons, to a late period of life, that it serves as a receptacle for superfluous nutritious matter; but we know nothing of the principle which determines the formation of this rather than any other animal product, in these circumstances. There is reason to think, that fat deposited in, and again absorbed from, the cellular texture, is the cause of the unusual oily appearance occasionally seen in the serum of the blood; but it is very doubtful whether the fat that has been deposited from the blood, and again taken into the circulation, can be applied to the nourishment of any other parts.

The cellular and adipose textures are very often the seat of rapidly increased deposition from the bloodvessels, as in cases of Anasarca, local or general, in persons previously

* BECLARD, Anat. Gen. p. 161.

healthy, and in the rapid increase of bulk of persons convalescent from acute diseases, or recovering from the effects of labour and fasting. They are frequently the seat of active absorption, as is seen in the rapid disappearance of anasarcous effusions, or of mild fluids injected into healthy cellular substance, and in the speedy wasting of the body from fasting, fatigue, or acute disease. They are also the frequent seat of inflammation and other local diseases, in the course of which both deposition and absorption are greatly increased and altered. These facts leave no room for doubt, that in the natural state, these processes continually take place, and balance each other, in the fluid contents of these textures. The adipose texture can itself only be formed, in the healthy state, in certain parts of the system; but the formation of a dense cellular substance from the blood appears to take place readily, after injuries and inflammation, in almost all parts of the body; and even to be a general preliminary to the original formation, and to the reparation, of other textures.

V. Of Serous Membrane.

This is the thin pellucid texture that lines the parietes of the great shut cavities of the body, and is reflected to form the covering of the viscera. Its free surface, towards these cavities, is perfectly smooth and moist; its attached surface graduates insensibly into adjacent cellular membrane, from which it appears to differ only in greater condensation. It shews, in most parts of the body, no fibrous structure; but in some parts, as the Pericardium and Tunica Albuginea Testis, it approaches to the nature of fibrous membrane; and in general, is of considerable strength, and gives a firm, smooth covering to parts that are always in contact, but destined to separate movements, in which they slide on one another; admitting likewise of much greater distention than the fibrous membranes do.

In chemical composition these membranes do not appear to differ from cellular texture, but they yield gelatin sparingly and slowly to boiling water, and they resist putrefaction long. They shew hardly any bloodvessels in the living state, but very numerous capillaries and absorbents on injection; many of which, however, are really lodged in the cellular substance just beneath them.

Some physiologists attribute to these membranes, and even to cellular textures, a degree of the vital property of Tonicity, but its existence in them has not been clearly ascertained. Their chief vital function is the formation of the small quantity of fluid which lubricates them, and which contains the same animal and saline matters as the serum of the blood; but the animal matter in proportions always less than in that fluid, and various in the different cavities. The proportion of albumen in the serous effusion on the pia mater, and in the ventricles of the brain, is very small.

That a continued exhalation of this fluid on the serous membranes is always going on, may be concluded from the rapidity with which increased effusion sometimes takes place in disease, or may be produced, in experiments on animals, by injecting water into the arteries *; and that a continued absorption is going on, may be concluded from the rapid disappearance of fluid effusions there in some cases of disease; and especially from the uniformly rapid disappearance of fluids that may be placed in contact with serous membranes in living animals, as in experiments by HUNTER, MAGENDIE, and many others.

These membranes are likewise easily increased in thickness, and altered in composition, by disease, and adventitious organized structures are often formed on them, by inflammation and otherwise; but they are not nearly so liable to absorption, either from pressure, or in consequence of disease, as some other soft textures; and these peculiarities of their vital properties are of great importance in Pathology.

* MAGENDIE, Precis Elementaire.

The Synovial membranes, which line the inside of the capsular ligaments of joints, and are reflected in a very attenuated form over the articulating cartilages,—and similar membranes which line the sheaths of tendons, where these pass over bone or cartilage,—resemble the serous membranes in most respects, and have the same use in regard to the firm textures which play on one another in these parts, as the serous membranes have, in regard to the motions of the viscera. But they are less flexible, in the natural state less vascular, and form a more viscid fluid, containing not merely the constituents of the serum, but another animal substance which has been likened to mucilage. The alterations of their vital properties in disease are likewise less rapid than those of serous membranes; but the changes, or even destruction, of their substance, in some instances go to a greater length.

VI. Of Mucous Membrane.

This is the texture which lines all those cavities within the body which open on its external surface; it is therefore every where continuous with the skin, but nowhere, except at the ends of the Fallopian tubes in the female, continuous with any other membrane. It varies very much in thickness, and considerably in other respects, in the different parts of the air passages, alimentary canal, and organs of urine and generation; but in all parts is distinguished by the fluid effused on it being more viscid and less translucent than serum. In most parts it is thicker, and in all parts of softer and more spongy consistence, than serous membrane, and its free surface is more completely supplied with capillary bloodvessels and absorbents, and is beset with numerous very minute prominences or *villi*. The whole membrane is in many places longer than the surface to which it is attached, and is therefore thrown into folds, increasing its surface. In most parts of the body it is studded by openings, leading to minute glands and follicles, which effuse a mucus on its surface similar to that which it secretes. This kind of membrane likewise receives the outlets, and lines the interior, of the ducts of all the true glands in the interior of the body.

This texture is more acted on by cold water, and less by boiling water, than any other of the animal membranes, and is more rapidly decomposed after death than any other. The fluid found in it contains not only the animal and saline constituents of the serum, with a very small proportion of albumen, but also a quantity (according to BERZELIUS above 5 per cent.) of a peculiar animal matter, to which it owes its viscidity; which is obtained by filtering and drying, and varies somewhat in the different mucous membranes, but is distinguished by being easily diffused through cold water, little affected by boiling water, and not precipitated by the tests, either of albumen or gelatin, nor soluble in alcohol.

In this fluid, likewise, globules similar to those of the blood have been detected.

The surface of these membranes is the scene of continued secretion, which is obvious to the senses in various parts; and of continued absorption, which is made manifest by the change, in quantity and quality, which is speedily effected in any substances placed in contact with them. There is also, in the healthy state, very great occasional variation in the quantity of blood sent to them, and in the quantity of secretion formed on them; and, in the case of the stomach particularly, in the quality of that secretion. The causes and purposes of these variations will be considered afterwards.

The characteristic qualities, and especially the vital properties, of all the mucous membranes, appear to be immediately connected with the circumstance of their forming the surface over which all foreign substances taken into the body, and formations in the body destined to excretion, must necessarily pass. By these, the vital actions of secretion and absorption going on in them are continually stimulated; the increased secretion of mucus, occasioned by any unusual irritation, appears to answer the same purpose, of defending the membrane, as the permanent covering of the cuticle does to the surface of the body, which is more permanently subjected to such foreign irritation; and such is the adaptation of the vitality of these membranes to the action thus exerted on them, that the same substances which only excite them to healthy and salutary action, no sooner touch the surface of serous or synovial membranes, or even of cellular texture, than they excite violent inflammation.

The activity of the vital actions that take place in these membranes, is farther attested by the frequency of increase and alteration, both of their secretion and of their nutrition in disease, and by the peculiar liability of those of the alimentary canal, at least, to ulcerative absorption.

VII. Of Glands and their Secretions.

Confining the term Gland to those organs of the body which separate peculiar fluids from the blood and discharge them by ducts, we find much variety as to the disposition of these ducts or their branches.

The simplest kind of gland is a short membranous canal, opening on the surface of a mucous membrane, or of the skin,—such as the lacunæ of the urethra, and the sebaceous, Meibomian, and ceruminous glands or follicles. Even by so simple an apparatus, very various substances are formed.

Most of the glands that pour out mucus on the mucous membranes, consist of a pulpy vascular substance surrounding a little canal, and these are often set together in clusters, as in the Tonsils, glands of Peyer and Brunner, &c.

In all the larger glands, the excretory duct is formed by the union of smaller tubes within the substance; but in the arrangement of these smaller tubes there is much variety. The smallest divisions of the glands, which have the secreting power, or the *acini*, seem to be similar in structure to the mucous glands just mentioned. In the strictly conglomerate glands, as the salivary glands and Pancreas, these acini are connected into lobules, and the lobules into lobes, by distinct layers of loose cellular substance; and each lobule has its own duct passing along its central part. In the liver and kidneys, there is no such internal division into lobules, the acini being connected uniformly with each other, by dense interstitial cellular texture throughout the secreting parts of these glands. A large portion of the substance of the kidneys consists of the excretory tubes exclusively, set close together, and converging very gradually to the papillæ, which pour the urine into the calices. The excretory ducts of the Mammæ aro so coiled up in the substance of the nipples, as to require the erection or extension of these, befere they give free exit to the milk. The seminiferous tubes, which terminate in the vasa deferentia, are distinguished by their very numerous contortions, first in the body of the Testis, and afterwards in the Epididymis.

All the excretory ducts have probably a certain amount of vital contractile power, though muscular fibres have been detected only in a few. In several cases, the fluids secreted are retained for a time in peculiar organs, before they are applied to the purpose to which they are ultimately destined. The tears formed in the lachrymal gland, are effused over the eye-ball, and absorbed into the lachrymal sac, before passing into the nostrils; the urine is lodged in the bladder long after its secretion is accomplished; the bile regurgitates in part into the gall-bladder; and perhaps the semen into the vesiculæ seminales.

All the glands are very fully furnished with bloodvessels and with absorbents; their arteries are stated to be of peculiar strength *, and are very minutely subdivided in their substance.

The supply of blood to all the glands, as to the mucous membranes, is also liable, in the healthy state, to great and sudden variations, from different causes, mental and physical. These are attended by great differences in the amount

* WINTRINGHAM.

of the secretions formed there ; and there is also great variety in the quantity and quality of the secretions in various diseased states. The nutrition of the glandular substance itself is, in some instances, subject to change in the progress of life, and in general is easily increased or perverted in disease. Absorption of the secreted matters takes place readily from the whole course of their outlets, as is obvious when the excretions of bile, urine, or milk, are unusually long retained, or their excretion obstructed; and absorption of the substance of glands themselves is easily effected, apparently by pressure, in those cases where their ducts are long obstructed, or where preternatural deposits take place in their neighbourhood, or in their own interstitial cellular substance.

The most important distinction of the secreted fluids, as regards physiology, is into the *recrementitious* and *excrementitious*; *i. e.* into those which are destined to some ulterior purpose in the animal economy, and those which are immediately excreted.

To the former class, besides the mucus of the mucous membranes and glands, have been referred the tears, which moisten the tunica conjunctiva of the eye-ball and membrane of the nostrils; the cerumen, which is found in the meatus auditorius externus; the saliva, coming from the parotid, submaxillary, and sublingual glands, which is mixed with the food in the mouth ; the secretion of the stomach, which is the chief agent in digestion ; the pancreatic fluid and bile, which descend from the liver and pancreas, to be mixed with the aliment in the duodenum ; and likewise the semen, and the fluid of the prostate gland, which is mixed with it at the origin of the urethra. These are stated by BERZELIUS to contain always the same saline ingredients as the serum of the blood, but little or no albumen,—and, instead of it, a single animal substance, varying of course in each instance : but subsequent observations do not entitle us to attribute so great simplicity to all these fluids. These secretions are generally, like the serum, slightly alkaline; but to this there is a remarkable exception in the secretion of the stomach, to be afterwards considered; and likewise, according to TIEDEMANN and GMELIN, in the secretion of the pancreas. The chemical qualities and composition of the animal matters which they respectively contain, have been but imperfectly investigated, and cannot, as yet, be connected with their uses.

The most peculiar is that which is contained in the Bile, forms nearly 8 per cent. of it, and causes its bitter taste, and is most simply obtained from it, first by sulphuric acid, which precipitates it, and afterwards by baryta, which separates the acid. This has been likened to the vegetable resins, and stated to contain a small portion only of hydrogen, and no azote; its analysis being, according to THOMSON,

Carbon.	Oxygen.	Hydrogen.
54.53	43.65	1.82

But whether there is in reality only a single animal principle in this fluid, or whether the picromel, cholesterine, and other substances which have been obtained from it by different processes, or separate spontaneously from it in biliary calculi, exist in it at all times, is doubtful.

In regard to the bile, there are two important physiological questions which may be stated here; 1st, Whether it is simply destined to excretion, or necessarily employed in digestion? 2d, Whether it is formed from the arterial or the venous blood of the liver?

1. It appears from various facts, that the peculiar animal matter at least of the bile, is destined to excretion only. This matter has never been found, in the healthy state, in the fluids absorbed from the intestines by the lacteals or veins; it is found in full quantity in the lower part of the intestines; it has been found to increase in quantity where the secretion of urine has been suppressed in animals by extirpation of the kidneys; and, where this secretion is repressed, the urine is increased and altered *; and it appears to be similar to a secretion in certain animals (of the class

* PREVOST and DUMAS, in the Annales de Chimie, t. xxiii. and SIMON, in the Annales des Sciences Naturelles, t. xiii. p. 110.

Mollusca), which is thrown out into the lower part of the intestine only, and immediately excreted *. The use of the other constituents of the bile, in digestion, will be considered afterwards.

2. Instances have undoubtedly happened in the human species, where the vena portæ had not entered the liver, and bile been nevertheless secreted. But on the other hand, the experiments of MALPIGHI and of SIMON, shew that tying the hepatic arteries in different warm-blooded animals, had little effect on the secretion of bile, but that it was suppressed by tying the vena portæ. The only other instance known of venous blood going to a gland, is the case of those animals where large veins enter and are dispersed through the kidneys, and where any thing that escapes from them must be immediately excreted †.

The most reasonable conclusion from these facts seems to be, that the liver can form bile both from arterial and venous blood; but that the latter is its chief source.

The formation of the Milk, secreted at the mammæ, is dependent on conditions to be afterwards stated. It is one of the fluids destined to excretion only, and which cannot be retained in the system without more or less of injury; and demands attention on account of its analogy to the composition of the blood on the one hand, and to the materials of digestion on the other.

Its specific gravity is about 1033, greater than that of the serum, but considerably less than that of the blood. Its basis is water, holding in solution several salts, chiefly salts of potash, with an excess of lactic acid; but it contains also three animal matters, *first*, the Butter, which separates spontaneously, or by agitation, and does not differ materially from other fixed oils; *secondly*, the Curd, or Caseous Matter, stated at 28 parts in 1000 in cow's milk, which separates spontaneously, but very slowly, and is precipitated most easily by acids,—closely resembling albumen, but not so easily coagulated by heat; and, *thirdly*, the Sugar of

* TIEDEMANN and GMELIN, Recherches sur la Digestion.

† JACOBSON, Edin. Med. and Surg. Journ. vol. xix.

Milk, stated at 35 parts in 1000, which remains in the whey after the separation of the curd, and is obtained by evaporation and crystallization, and hardly differs in composition from vegetable sugar. Of these three, the curd only, containing Azote, is similar to most articles of nourishment from the animal kingdom ; the oil and the sugar are analogous to the greater part of vegetable nourishment. The curd yields, when burnt, about 6 per cent. of earthy phosphates, and is, therefore, supposed to be useful in the formation and nourishment of bone.

The proportion of curd appears to be less, and its mixture with oil more intimate in human milk than in cow's milk; and in all animals, the proportion of curd is less in the milk formed soon after parturition, than in that formed subsequently.

The most important excretion formed in glands is the Urine, which passes along a mucous membrane in its way from the kidneys, and is lodged for some time in the bladder, and is therefore mixed with a small proportion of mucus when passed; which mucus is somewhat heavier than the urine itself.

Urine has an average specific gravity of about 1025 ; 933 parts in 1000 of it are stated to be water; above 30 are the peculiar animal matter called Urea ; and the remainder consists of salts in greater proportion and greater variety, than in any other fluid of the body, with a little of another animal matter, probably similar to that in the serosity of the blood. The salts generally allowed to exist in it are, the Sulphates of Potass and Soda, Phosphates and Muriates of Soda and Ammonia, Phosphates of Lime and Magnesia, Lactic Acid, and Lithic Acid, or Super-Lithate of Ammonia. Minute quantities of Fluate of Lime and of Silica have been recognized in it; and Carbonic Acid has been obtained from it by the air-pump only. Of these, the acids are in excess, and hence the Lithic, being a weak acid, is frequently deposited, and is apt to attach itself to and lead to decomposition of the mucus. But in other circumstances of the urine, and particularly, when there is not the usual excess of acid, the phosphates are most easily deposited from it; and the Oxalic Acid, and other substances not detected in healthy urine, have been frequently found in gravelly deposits.

The Urea is dissolved from the Extract of Urine, by alcohol, and obtained by evaporation, partly separated from the saline matters; it has a peculiar taste and smell, and is characterized by the bulky flaky compound it forms with nitric acid. By putrefaction, or by the heat of boiling water, as it exists in the urine, it is almost entirely converted into carbonate of ammonia; and it has been found to consist of

	Carbon.	Oxygen.	Hydrogen.	Azote.
	19·99	26·66	6·66	46·56
or	1	1	2	1 atoms.

containing therefore a much larger proportion of azote than any other animal principle.

The average quantity of urine evacuated in 24 hours may be about 40 ounces; but is liable to very great variations. The average quantity of solid matter that passes off by this excretion has been found to be not less than 15 drams in 24 hours*; and is apparently much less subject to variation, excepting in disease: the density of the urine, in the healthy state, being always diminished as its quantity is increased, and *vice versa*.

The appearance, already noticed, of urea in the blood, when the kidneys have been extirpated, or obstructed by disease, shews that the formation of this substance is at least so far advanced, before the blood, from which it is separated, enters the kidneys. And the conjecture of BERZELIUS, that it is furnished by the animal matter of the serosity of the blood, is rendered probable by two circumstances,—*first*, that the qualities of that portion of the blood

* Dr BOSTOCK (Medico-Chirur. Trans. vol. iii.) makes the quantity only 10 drams, but the experiments of Dr HENRY (ditto, vol. ii.) shew, that even at the specific gravity of 1020, a pint of urine yields above 6 drams of solid extract, and therefore 40 ounces must yield above 15.

(particularly its solubility both in water and alcohol) approach nearer to those of the urea than the qualities of the albuminous contents of the blood do; and, *secondly*, that after the extirpation of the kidneys, the animal matter of the serosity is first increased in quantity, and afterwards assumes the character of urea*.

It has also been supposed that the animal matter of the serosity, thus apparently convertible, at least in part, into urea, is not intended for nutrition, but is the product of that absorption from the component parts of the animal frame, which we saw reason to believe to be a necessary accompaniment of all vital action, and is destined to excretion only. And this opinion is farther supported by the phenomena of Diabetes, where there is ample evidence of very general absorption, from the wasting and dryness of the body, notwithstanding that more than the usual quantity of nourishment and drink are taken,—and in which the animal matter of the urine is enormously increased; and appears, from the observations of Drs Bostock and Henry†, to retain, at least in some cases, the properties of urea for a time, and afterwards to assume, for the most part, the character of sugar: which conversion is probably in some way connected with the chemical relation, discovered by Dr Prout, between urea and sugar, viz., that the latter contains the same number of atoms of carbon and of oxygen as the former, with half as many atoms of hydrogen, and no azote ‡.

Whatever be the source of the urea, which is separated from the blood at the kidneys, the necessity of this excretion appears distinctly from the fact, that when the blood is unusually loaded with this principle, it gradually acts as a poison on the system, and especially on the Nervous System; as has appeared uniformly when the kidneys of ani-

* Prevost and Dumas, Annales de Chimie, t. xxiii.

† Medico-Chirurgical Transactions, vol. iii.

‡ Medico- Chirurgical Transactions, vol. viii.

mals have been extirpated; and also, although in a less uniform manner, in the human body, when the secretion of urine has been either wholly suppressed, or more gradually and partially obstructed.

The facts now stated are already important in Pathology and in Practice; but the Physiology of Excretion, as well as of Secretion, will always be obscure and unsatisfactory, until we shall have some information as to the laws according to which chemical principles are modified in the economy of animals.

VIII. Of the Substance of the Lungs.

Although the mutual action that takes place between the air and the blood at the lungs, the manner in which it is effected, and its uses in the animal economy, demand a separate consideration, yet some statements, as to the texture of the lungs, and the nature and amount of the excretions from them, are more properly introduced here.

This texture, although varying much in density in different subjects, in consequence of the different quantities of blood it contains, is always, in the healthy state, of less specific gravity than water, because, from the time of birth, it always contains within it a large quantity of air, which is lodged in innumerable small cavities or air-cells, formed by little expansions of the ends of the ramifications of the bronchiæ which enter it. The texture may be said to be composed of mucous membrane, cellular substance, and serous membrane, with very numerous bloodvessels and absorbents. The membrane forming the cells, and on which the innumerable branches of the pulmonary artery and veins ramify, is continuous with that which lines the larger, and partly cartilaginous, branches of the bronchiæ, that enter the lungs from the trachea; and, although of extreme tenuity, is believed to secrete a mucous fluid. The air-cells are bound together, and covered exteriorly by cellular substance, the cells of which, in the natural state, do not communicate with the bronchiæ. It is probable, though not completely ascertained, that the air-cells in the natural state do not communicate with each other, otherwise than by the branches of the bronchiæ, which open into them. The exterior cellular substance is bounded by the Pleura pulmonalis, which is everywhere in contact with, but in the natural state nowhere adherent to, the serous membrane that lines the inside of the parietes of the chest. The compound texture thus formed is endowed with a high degree of distensibility and elasticity, which are its most important physical qualities.

It is generally thought that this texture possesses no vital power of contraction; but several phenomena, to be afterwards mentioned, render it probable that such a vital power does exist, to a certain degree, in it; or at least in the smallest branches of the bronchiæ that can be distinguished.

Air which has been in the cells of the lungs during life, is always found to be loaded, in an unusual degree, with water and carbonic acid, much of which is evidently derived from the air-cells; and the mode of their formation will be considered under the head of Respiration. From some experiments by Dr Gordon, it would appear that no saline or animal matter can be detected in air that has been breathed, the water and carbonic acid being the only excretions, or exhalations, from the membrane of the cells.

That absorption goes on with great facility and rapidity from the internal surface of the lungs may be concluded from experiments, already mentioned, in which saline solutions, introduced into the bronchiæ, have been very soon thereafter detected in the blood, and likewise from the certainty and rapidity with which vapours, such as those of mercury and oil of turpentine, introduced into the lungs, come to produce the usual effects of those substances on the secretions. The effects of poisons introduced into the lungs, although rapid and decided, are not so clear proofs of absorption.

The average loss of weight in a full grown man, in the day, which can be ascribed to the excretion at the lungs, appears, from experiments to be mentioned afterwards, to be not less than fifteen ounces; and the facts now stated prove, that that this must be only the excess of the excretion over the absorption at the lungs.

The black colour of portions of the lungs, and of the bronchial lymphatic glands connected with these, has been ascribed with some probability to absorption of carbonaceous powder from the internal membrane.

The changes which take place in the form and size of a healthy lung, from the pressure of adjoining parts, and the expansion of one lung observed in cases where the other has been rendered unfit for its office, are sufficient proofs of the facility with which both absorption and nutrition of the pulmonary texture itself may be accomplished. The latter function is probably performed by the bronchial arteries only. There is good evidence, from the phenomena of different diseases, that the function of absorption in this texture is adequate, when other circumstances are favourable, to the removal, at least of serum and of blood, and perhaps of other matters morbidly effused into it.

IX. Of the Skin.

This is commonly described as consisting of three layers; the True Skin which lies innermost, the Cuticle which is external, and the Rete Mucosum which connects these; but this last is not easily distinguished, except in blacks, in whom it is the seat of the colour. Both it and the cuticle are extravascular and inorganic.

The *true skin* is a firm dense membrane, of a fibrous and reticulated texture, extremely elastic, at least in youth and middle age, marked with varied lines externally, and with very numerous depressions internally, which receive processes of the adipose texture beneath; very fully supplied both with minute bloodvessels and absorbents; containing, in many places, the sebaceous glands or follicles, and perforated obliquely in many others by the hairs, which spring from little bulbs beneath it. It is almost entirely resolvable into gelatin, but requires long-continued boiling for this purpose.

A degree of vital contraction would appear to take place in this texture occasionally, particularly from the influence of cold, and of certain mental emotions.

The facts mentioned at p. 69, shew that the change of this texture by nutrition and absorption, in ordinary circumstances, must be very slow; but in different diseases, it is obvious that these vital actions in it take place rapidly and extensively.

The surface of this membrane is certainly the scene of three vital processes; the formation of the Cuticle, Perspiration, and Absorption.

The Cuticle is easily detached from the true skin, by the action of a blister, in the living body, and by putrefaction in the dead. It is a thin, very elastic membrane, composed almost entirely of solid albumen. Its formation is no doubt continual, as it is obviously subject to continual waste from friction, and is much increased or excited by irritation or pressure, as in the palms of the hands or soles of the feet. Although an inconsiderable texture in the human body, when compared with the corresponding parts of many other animals, it is of great importance in the animal economy, particularly by restraining the amount of the vital actions which take place on the surface of the true skin. For this purpose it is especially fitted by the cohesion of its parts, which is such as to transmit any fluid substance very slowly, as appears in the dryness of its surface when it is raised in a blister; and again in the rapid drying of the surface of the true skin, whenever the cuticle is removed from it in the dead body. The analogy, formerly remarked, between the Cuticle, which defends the surface of the true skin, and the mucous secretion which defends those internal membranes that are exposed to the irritation of foreign matters, is most clearly exemplified in cases where a portion of the upper lip has been employed by surgeons to restore a lost part of the columna nasi, and the mucous membrane of that portion of lip, exposed to the air, has gradually acquired the properties of the rest of the integuments *.

The Nails consist of the same material as cuticle, with very little earthy matter, but of much firmer consistence, and more firmly attached to the true skin beneath them, than any other parts of it, and are remarkable for the mode of their growth; their outer layer seems to be formed entirely in the folds of skin at their roots, and pushed forward by continued accretion there, while other layers are added to their inner surface by the portions of skin over which they pass.

Although the Hair is usually regarded as equally inorganic with the cuticle and nails, yet there are some facts which appear well ascertained, particularly sudden changes of the colour of the hair, from mental emotion, or other causes, which seem to indicate that vital processes of nutrition and absorption go on in this substance itself, although its growth seems to be confined to the bulb beneath the cutis vera.

The colour of the hair depends on exposure to the light, and is no doubt connected either with the formation, or with some alteration, of an oil which is found in their texture. Hair is partially resolvable by boiling in water under pressure, although with different degrees of facility, into a gelatinous matter; but part is decomposed by this process, and gives distinct evidence of containing sulphur.

The vital processes by which the cuticle, hair, and nails are constantly formed, are liable to alteration from heat and cold, and other causes; and especially by those diseases in which inflammation of the skin takes place. The hair drops off sooner, or is sooner changed in colour, in those persons and circumstances, where there is much sweating. The shedding of the hair is a common effect of long-continued febrile action, even independently of cutaneous inflammation; and the separation and renovation of the cuticle, after the specific inflammations of the skin have run their

* See Liston, Elements of Surgery, Part ii.

courses, appear to be essentially connected with the recovery of health.

The passage of fluids outwards through the cuticle, appears to take place more easily when it retains its connexion with the true skin, through the rete mucosum, than when it is detached by a blister; and is determined by various causes; by external heat, exercise, and other means of exciting the circulation; by mental emotion; and also remarkably by failure of the heart's action, as in fainting. In this last case, it coincides with the appearance of an unusual proportion of serum in the blood of the large veins *; and both are probably to be ascribed to a tonic constriction of the smaller bloodvessels, no longer distended, as previously, by the impulse from the heart.

The sensible perspiration, or Sweat, appears to contain an excess of lactic acid, a small quantity of the same alkaline and earthy salts, and the same uncoagulable animal matter as the serum, and also of an oil, probably in part, but not wholly, formed in the sebaceous glands. The quantity of these substances seems to be much less variable in the healthy state than that of the water which passes off from the skin; because the sweat, like the urine, becomes much attenuated when its quantity is increased.

Even when no fluid is visible on the surface of the skin, a quantity of watery vapour is always exhaled from it, as appears when the hand and arm are confined in a glass jar. The air in immediate contact with the skin has also appeared, in many experiments, as those of CRUICKSHANKS, JURINE, and some of those of Mr ELLIS and Dr C. MACKENZIE, to contain an unusual proportion of carbonic acid; but the formation of this acid could not be recognized at all in some experiments, such as those of Dr KLAPP and Dr GORDON; and in all cases, appears to be so small, that this excretion cannot be regarded as an important part of the functions of the skin. Its very small quantity has prevented physiologists from ascertaining whether it is essen-

* DAVY, De Sanguine.

tial to the appearance of this acid, that the skin should be in contact with a gas containing oxygen; but, in some experiments by SPALLANZANI and by Mr ABERNETHY, this condition did not appear necessary.

The average quantity of exhalation from the human body by the skin and lungs together, *i. e.* the whole loss of weight from these sources, taken together, is stated by HALLER, on comparison of the results of many observations, to vary from 30 ounces in the 24 hours in the colder climates, to 60 in the warmer, of Europe; and by LAVOISIER and SEGUIN it is stated at 45 ounces in the climate of Paris; but it is liable to very great variation, not only according to the temperature and humidity of the atmosphere, but also according to the diet and habits of individual persons, and the state of repletion of their vessels.

Of this exhalation, it appears from the experiments of LAVOISIER and SEGUIN, that about 2-3ds or 30 ounces are from the surface of the skin, and 1-3d or 15 ounces from the lungs.

The amount of loss sustained by the exhalation from the lungs has been already stated as in reality only the excess of the exhalation over the absorption habitually taking place there; but it is more doubtful whether any compensating absorption habitually takes place at the skin.

Many familiar facts illustrate the great absorbing power of the vessels of the true skin, over such matters as are either mechanically forced through the cuticle, or introduced where it has been abraded; but the possibility of absorption through the entire cuticle is much more doubtful.

Various observations made by RYE, LINNING, FONTANA, and others prove, that, in certain circumstances, and especially during fasting, when absorption is unusually active, not only the usual waste of the body by exhalation from the skin and lungs may be suspended, but an absolute increase of weight may take place during a time when no food or drink has been taken, only to be explained by absorption at the skin or lungs; and observations on the comparative amount of the ingesta and egesta, and on the loss of weight, of patients in diabetes, have also led to the conclusion, that there must be an excess of absorption over exhalation at these surfaces *. But these observations do not prove that any part of the absorption in question is at the skin.

Of the many observations made by the warm-bath to ascertain this point, the general result may be stated thus;—That the rate of waste of the body, previously existing, has been generally lowered, sometimes the waste altogether stopped, and, in a few cases, an absolute increase of weight to a small amount, has resulted from immersion for half an hour or more; and this where there was at least probable evidence that the absorption at the lungs had not increased †. These experiments shew, that a certain quantity of fluid may be at least imbibed by the cuticle, and probably absorbed from it.

But in the experiments of SEGUIN, ROUSSEAU, DANGERFIELD, and GORDON, made chiefly by applying liquids to the surface of the body, which have a known effect when taken into the blood, on certain secretions (care being taken that the vapours of these should not be inhaled), no evidence of absorption from the skin, when the cuticle was entire, could be procured; and the different result of two experiments made in the same way by Dr YOUNG, is not enough to set aside the conclusion, that the amount of absorption of liquids in the human body, through the entire cuticle, where no pressure is used, is in general trifling; particularly when compared with the activity of absorption at the lungs.

More recent experiments, shewing the facility with which gases either intermix with each other, or penetrate

* See DILL on Absorption by the Skin, Edinburgh Medico-Chirurgical Transactions, vol. ii.

† See particularly Dr DILL's paper, and Dr YOUNG's Thesis, Edin. 1817.

into fluids, through the medium of animal membranes *, render it highly probable, that an absorption, as well as exhalation, of gaseous matter may take place through the cuticle; but we have no reason to think that this absorption is important to the animal economy, or its amount considerable, when compared with that at the lungs.

The whole amount of watery excretion from the skin and lungs manifestly alternates, in the healthy state, with that by the kidneys; the effect both of external heat, and of exercise, which increase the former, being to diminish the latter. But the quantity of the secretion of bile, and probably also of mucus in the intestines, though apparently diminished by violent excitation of the circulation, as by hard exercise, does not alternate with the amount of the exhalation at the skin and lungs; being usually increased, simultaneously with these exhalations, both by moderate exercise and by warm seasons or climates.

X. Of Muscular Texture.

The external aspect and vital properties of this texture, the chief seat of vital contractions, have been stated already; and its distribution over the body, and the purposes to which it is applied, appear in the account of the different functions in which it is employed; but some facts may be stated here, chiefly in relation to its chemical composition, and its nutrition and absorption.

Although the smallest muscular fibres appear every where similarly constituted, there is much variety as to their arrangement and connexions in different parts of the body. Those which are destined only to involuntary motion, are generally attached to soft parts; their course is more complex; they are generally of looser texture, and more distensible, than those of voluntary muscles; but

* See Mitchell on the Penetrativeness of Fluids. *American Journal of Medical Sciences*, vol. vii.

their vital contractions appear at least as forcible. Those destined to voluntary motion are generally of denser texture, and redder colour; they are, for the most part, attached to bones and fibrous parts, and are divided by the disposition of their fibres, into straight, radiated, penniform, compound penniform, &c.

By boiling water on muscles, a quantity of albumen, which takes the solid form; of gelatin, which becomes solid on cooling; and of extractive matter or osmazome, which remains in solution; and several salts, are obtained from them; and the fibrin that remains still preserves the original form, though, when perfectly dried, stated not to exceed 17 per cent. of the whole weight. The Osmazome is the principle which gives taste and smell to muscular flesh; it is the most putrescible part of the substance, and is distinguished by its solubility both in water and alcohol: nearly resembling, in this and other respects, the uncoagulable matter of the serosity of the blood.

The subdivision of bloodvessels in the substance of muscles, is not so minute as in those textures where fluids are secreted, and their nutrition and absorption are slow. They are often seen gradually to acquire great increase of bulk, particularly in consequence of frequent excitation; and to waste from inaction, from disease, and from the effects of certain poisons. But their substance is not easily, if at all repaired, by similar texture, after laceration or rupture; and they are very little liable to any such alterations in disease as imply rapid deposition and absorption.

According to Sir E. Home, and to Prevost and Dumas, the muscular fibres are composed of globules precisely similar to those of the blood; and it has been lately stated by Dutrochet, that galvanism applied to a drop of blood, kept fluid by the addition of a little alkaline solution,—or to the yolk of an egg diffused in water, determines the formation of rows of globules, which contract after the manner of muscular fibres *. But the analogy of

* Annales des Sciences Naturelles, t. xxiii.

this to the formation of muscular fibre out of the blood, is not to be relied on.

It may be stated here, in general terms, that muscles are useful in the animal economy, by vital contractions, directed to one or other of the three following ends. *First*, To diminish a cavity which they surround, as in the case of the heart, stomach and intestines, bladder, &c. *Secondly*, When both of their extremities are fixed, or nearly fixed, to alter their own direction, and thereby expand or compress adjoining parts, as in the case of the diaphragm, buccinator muscle, &c. *Thirdly*, Where one of their extremities is fixed, and the other moveable, to draw the latter towards the former, as in the case of almost all the strictly voluntary muscles of the trunk and extremities.

XI. Of Nervous Substance.

It is necessary here, in the first place, to recollect the different parts of which the Nervous System, in man, and other vertebrated animals, consists; the Brain, Cerebellum, Medulla Oblongata, and parts connecting these, enclosed within the cranium; the Spinal Cord, situate in the canal of the vertebræ: and the Nerves, originating from these, and extending, by innumerable ramifications, probably to all parts of the body in which vessels can be traced: next, the protection given to the larger masses of the nervous system by the bones of the head and spine, and by the three membranes which envelope them within these bones; and to the nerves, by their concealed situation in most parts of the body, and by the firm membrane investing them; and lastly, the division of the nervous matter into grey or cineritious, and white or medullary, and the general disposition of these; the grey matter covering the white in the convolutions of the brain and cerebellum, lying within it in the spinal cord, and alternating with it, in different forms, in the tuber annulare, and in various of the central parts of the brain.

The outer surface of the serous membrane which immediately invests the brain and spinal cord, is always moistened by an attenuated serous fluid, which is confined beneath the arachnoid on their exterior, and contained within the ventricles in the interior of the brain; and these two portions of the fluid, in the natural state, appear to communicate by the small opening at the extremity of the fourth ventricle.

As membranes continuous with the pia mater descend between the convolutions, and into the cavities or fissures of the brain, no part of the nervous matter there is distant from the vascular membrane, from which it derives its blood, and on which the vessels ramify minutely before they penetrate it; and the same holds of the nerves, all of which are composed of great numbers of very slender filaments, bound together by cellular substance, which receive minute vessels from the neurilema.

The nervous matter, both grey and white, appears, under the microscope, to be composed, in a great measure, of minute globules; and these, in the medullary substance, are arranged into fibres, which are in few places distinctly perceptible in the recent state, but become obvious after hardening by alcohol, boiling oil, diluted nitric acid, &c.

The following general facts, in regard to the anatomical distribution of the nervous system, appear to be those which most immediately connect themselves with its physiology.

1. The nerves may be divided, as was pointed out by Mr Bell, into Symmetrical and Irregular; the distinctions of which are, that the former arise from the larger masses of the nervous system, by double roots, an anterior and a posterior; that there is a ganglion on the posterior, where it passes through the dura mater; that they pass out, in general, nearly at right angles to the surface from which they arise, and do not cross each other, nor inosculate till they are at some distance from that surface; and that they form a complete system, supplying all parts of the body, whether these have other nerves or not; whereas the irre-

gular nerves have no such regular arrangement of double roots, pass out in more various directions, several of them cross, and some inosculate freely with the other class of nerves, and so unite the different divisions of the frame; and they always go to parts which have likewise nerves of the symmetrical class.

The first class comprehends all the pairs of the spinal nerves, thirty in number, and the fifth pair of the cerebral. There is more difficulty as to the arrangement of the cerebral nerves; but physiological facts, to be afterwards stated, seem clearly to indicate that those cerebral nerves which go to muscles only, the third, probably the fourth, the sixth, portio dura of the seventh, and ninth, as well as the smaller or anterior branch of the fifth, correspond to the anterior portionsof the spinal nerves, and are to be ranked in the symmetrical system. The nerves strictly belonging to the irregular class, are the eighth pair, the spinal accessory nerves, the phrenic and external respiratory nerves of Mr Bell, and the great sympathetics. The first, second, and portio mollis of the seventh, the functions of which are well known, may be either ranked as irregular nerves, or be separated from both classes.

2. Some of the nerves pass to the organs to which they are destined, and are subdivided there, without inosculating with any others on the way; but by far the greater number of the nerves are connected with others, either by Plexuses or Ganglia. The former are multiplied unions and separations of the larger branches of nerves, without any intervening substance; and the most striking instance is the axillary plexus, formed by the nerves of the symmetrical system, going to the arm; but a similar intermixture of filaments no doubt takes place in the sciatic and crural nerves, which are formed by the lumbar and sacral nerves; and the irregular nerves of the trunk of the body are very generally connected in this way. The ganglia are oval or roundish bodies, formed in part of a vascular pulpy substance, within which there is a separation and reunion of nervous filaments entering them, as close and

intimate as that of the absorbent vessels within a lymphatic gland. These are found on the posterior roots of the symmetrical nerves ; but the greater number, and most characteristic examples, of the ganglia, are found on the great sympathetic nerve, the course of which is parallel to the spinal column,—at the points where it crosses and communicates with the symmetrical nerves that pass out from the spinal cord. Many internal parts have their nerves exclusively from these ganglia ; and these are thereby connected with the whole extent of the spinal cord, and hardly with any individual point of it more than with another.

3. All the nerves, symmetrical and irregular, have their origin either from the Spinal Cord itself, or from parts at the base of the brain, not higher than the tubercula quadrigemina and crura cerebri, which are easily shown to be its prolongations; *i. e.* they arise from what has been called the *Cerebro-Spinal Axis*, on which the brain and cerebellum are superimposed.

4. The Spinal Cord is obviously divided into two similar portions by its anterior and posterior median fissures; and each of these halves of the cord is again, though less obviously, divided into an anterior, middle, and posterior column. The anterior and posterior roots of the spinal nerves come off just where the anterior and the posterior join with the middle column; and the small quantity of grey matter within the cord projects towards the same points. The anterior columns appear to lead up to the corpora pyramidalia, the middle to the corpora olivaria, and the posterior to the corpora restiformia. The course of the chief fibres of all the columns of the spinal cord, as traced after hardening the nervous matter, is longitudinal and uniform, as high as the medulla oblongata ; but at the lower part of the corpora pyramidalia, the course of the fibres, especially of the anterior and middle columns, becomes more complex, and is traced with difficulty ; and a partial decussation of the fibres below and behind the corpora pyramidalia, is observed. But it is obvious, that the greater part of the medullary fibres from the spinal cord,

and especially those from its anterior and middle columns, pass forward, through and behind the tuber annulare, to form the crura cerebri; and also that another portion of them, chiefly from the posterior columns, pass through the corpora restiformia into the cerebellum.

5. The Brain proper, may be considered as composed of a central nucleus, and of folded laminæ or convolutions set around it at right angles to its surface. The convolutions consist of plates of medullary substance, with coverings of cineritious matter, not strictly continuous with any of the fibres composing these plates.

From the descriptions of those who have examined the fibrous structure of the brain the most accurately, and particularly of Reil, it would appear that the central nucleus consists of two sets of medullary fibres, one of which has been called vertical, the other horizontal, from their most general directions, though both are much convoluted in some parts of their course. These intersect one another variously in different parts of the brain, and have portions of grey matter, of various size and figure, interposed among them.

The vertical fibres are continuous with those that ascend from the spinal cord, through the crura cerebri, after crossing the tuber annulare. They pass up on the outer side of the thalami nervorum opticorum, and radiate thence, in all directions, to the bottom of the convolutions; many of them, on each side, passing obliquely through the corpus striatum, in a broad band (the inner wall of the capsule of Reil), which divides it into two parts; and some of them terminating in the grey matter of the corpus striatum. The thalami and corpora striata, as well as the corpora quadrigemina, are appendages to this vertical portion of the fibres. It is probable, though not distinctly demonstrable, that these vertical fibres are continuous with, and terminate in, the plates that form the central medullary portion of the convolutions.

The horizontal fibres are confined to the brain, not descending to the spinal cord: the principal parts which they constitute in the central part of the nucleus are, the corpus callosum, and the different commissures, where they run transversely; and the fornix, and its crura, where they run longitudinally. Towards the exterior of the nucleus, there are found not only the prolongations of the transverse horizontal fibres, but also other fibrous bands, which are wrapped around the base of the convolutions, and connect these with each other *.

The lobes and lobules of the cerebellum consist, like the convolutions of the brain, of medullary fibres arranged into laminæ or plates, which are set around an irregular nucleus. In that nucleus, there are transverse or horizontal medullary fibres uniting the laminæ at their base; but the greater part of the central nucleus of the cerebellum consists of fibres continuous with the medullary plates of the lobules, which pass forward to connect themselves with the cerebro-spinal axis by three columns; *first*, By the corpora restiformia, which connect themselves with the posterior columns of the spinal cord; *secondly*, By the crura cerebelli, which form the tuber annulare, by crossing and encompassing the larger portion of the spinal cord on its way to the crura cerebri; *thirdly*, By the valve of Vieussens, and its pillars (originating partly in the corpus dentatum, within the medullary portion of the cerebellum), which connect themselves with the crura cerebri, below the corpora quadrigemina.

The Ventricles or Central Fissures of the Brain and Cerebellum, may be said to result from the separation of the vertical portions of the two hemispheres from one another, and from the apposition of the horizontal portions over them.

The apparent implantation of the vertical fibres of the brain and cerebellum on the grey matter of the convolu-

* See Reil's Papers, translated by Mayo, in his Anatomical and Physiological Commentaries. Gordon on the Structure of the Brain. Report of a Committee of the French Institute on Gall and Spurzheim's Anatomy of the Brain, in Edinburgh Medical and Surgical Journal, vol. v.; and Report by Cuvier on Flourens' Experiments on the Nervous System, in Journal de Physiologie, t. ii.

tions and lobules, and on that of the corpora striata—the origin of some of the fibres of the crura cerebri in the corpus dentatum,—and the extension of the grey matter of the spinal cord towards the origins of most of the nerves,—have led to the opinion, that it is essential to the functions of medullary fibres that they should terminate, by one extremity, in cineritious substance. But strong objections to this opinion have been stated by MAGENDIE and DESMOULINS, particularly that in many fishes and reptiles cineritious matter exists in the brain, but not in the spinal cord, yet the nerves arising from the spinal cord are fully adequate to their functions; and, again, that the functions of the spinal cord, in regard to sense and motion, appear, from experiments to be afterwards stated, to reside in its surface chiefly, and not in its interior, but the grey matter is found in the interior only.

The nervous matter appears to be of more complex chemical composition than many other animal solids. By the action of hot alcohol, are obtained from it a quantity of albumen which remains undissolved, a quantity of oil which is deposited on cooling, and a quantity of extractive matter resembling osmazome, which remains in solution, along with some salts. A small quantity of phosphorus, and of sulphur, have also been obtained from brain. The whole of these, when perfectly dried, constitute only 20 per cent. of recent cerebral substance.

No movements have ever been seen in any small portion of nervous substance, even under the microscope, and when examined at the time when its peculiar functions were undoubtedly in exercise. But the whole brain and spinal cord, when exposed, may be seen to be slightly agitated by the impulse of the blood at each systole of the ventricles of the heart; and more distinctly, to be elevated by the retardation, and depressed by the acceleration, of the flow of the blood in the great veins, in expiration and inspiration.

Besides the peculiarities formerly noticed as to the arterial and venous circulation in the brain and cerebellum,—the effect of which is to diminish the impetus with which the blood enters the brain, and diminish the pressure on it from stagnation of the blood leaving it,—there is this farther peculiarity as to the circulation within the head, that, being carried on within a cavity with unyielding sides, it is protected from the pressure of the atmosphere, which acts on the vessels leading into it and out of it; and the consequence of this is, that the quantity of fluids within the cranium must be always almost exactly the same; no unusual quantity either leaving it, or entering it, without an equal quantity being introduced or expelled; unless some of the solids within the cranium either suffer compression (which they hardly admit), or else undergo alteration of quantity, which they cannot do quickly.

But although the whole quantity of fluids within the head can hardly be changed, within any short space of time, yet the impulse of the blood on the nervous substance, and pressure thereby caused, are no doubt very liable to change; and farther, various facts shew, that the relative proportion of blood in different parts of the encephalon, and even the relative proportion of blood in the vessels, and of serum exterior to them, are occasionally much and rapidly altered*.

Increased nutrition of the substance of the brain or cerebellum, after growth is over, cannot take place without disease, from the pressure on the cranium it must occasion; but appears evidently to occur in a particular diseased state, described as Hypertrophy of the Brain. Alterations of the nutritive process in this texture from disease are not uncommon; but do not seem to take place so rapidly as to indicate frequent change of the substance of the brain in the progress of life. The facility of increased absorption appears in many cases of disease, where tumors grow on the surrounding membranes or bones, where blood is effused into the brain, and where fluid is effused into the ventricles, especially in the case of Chronic Hydrocephalus, where the sutures of the skull are enlarged; for, in what-

* Kellie, Edinburgh Medico-Chirurgical Transactions, vol. i.

ever manner it may be that the apparent unfolding of the convolutions in that case is accomplished, it is certain that a quantity of the substance intervening between the ventricles and convolutions must be absorbed away; and that, in some such cases, the brain is considerably reduced in weight *.

It is certain, especially from the experiments of Cruickshanks, Haighton, Flourens, and Prevost, that injuries of the nervous substance may be gradually repaired in the living body by materials which shall assume the true vital properties of this texture, now to be considered. An observation of Mr Mayo on the apparent want of such power of reparation where the fifth nerve has been cut within the dura mater, where it has no neurilema, makes it probable, that the nerves at least are very dependent, for such power of reparation, on the vessels of surrounding cellular texture.

It is next to be observed, that Nervous Matter, in the living body, possesses very peculiar and strictly Vital Properties, which are made known to us by the effects, on the functions of other organs, produced by physical impressions made on various parts of the Nervous System. These have been already briefly and incidentally noticed, but demand fuller consideration here.

I. Certain muscles are *directly excited* to contraction by irritation of certain parts of the Nervous System, without any impression being made on the muscles themselves. In regard to this general fact, the following things are to be observed.

1. The fact in question is fairly exemplified, only when those stimuli are applied to nervous matter in an animal stupified or just killed, or to an amputated limb, when no effects of sensation embarrass the results.

2. The chief physical stimuli that answer this purpose, when applied to the Nerves, Spinal Cord, or Brain, are mechanical impulse or sudden pressure, chemical acrids (the effect of which, in exciting muscular contraction when

* See Gordon on the Structure of the Brain.

applied to *nerves* only, is unequivocally a vital phenomenon), and electricity or galvanism.

3. This effect of irritation of nervous matter is prevented from taking place whenever the communication, by sound nerve, between the point irritated and the muscle to be excited, is interrupted; but not when the communication between the point irritated and the brain is interrupted.

4. This phenomenon is observed, as has been already stated, on irritation of the nerves of certain muscles only; many muscular parts, especially the Heart and Intestines, having appeared in the experiments of HALLER, FONTANA, BICHAT, and many others, quite unaffected by irritation of their own nerves, and not distinctly excitable (though their movements may be modified), by irritation of other parts of the Nervous System. And from Mr MAYO's experiments particularly, it appears that the distinction between the muscles that are, and those that are not, excitable in this way, coincides very nearly, if not exactly, with that between muscles destined to voluntary and involuntary motion *.

5. This phenomenon is not seen on irritation of all the nerves of those muscles that are subject to it, but on irritation of certain of these nerves only. For it has been ascertained by the experiments, first of Mr BELL, and afterwards of MAGENDIE, BECLARD, MAYO, and many others, that hardly any muscular contractions can be excited by irritation of the posterior portions of the spinal nerves, or of the ganglionic portion of the 5th nerve, although strong contractions may be excited in this way through the anterior portions of the spinal nerves, and the 3d, 4th, anterior portion of the 5th, the 6th, portio dura of the 7th, 8th, and 9th cerebral nerves. And Mr BELL has farther shewn, from what is seen on tracing the nerves of the face, that this difference does not depend on the nerves first mentioned not supplying muscles,—but that they supply muscles which they cannot excite †.

6. Muscles which have nerves from the spinal cord are excited to contraction, not only by irritation of their nerves,

* MAYO's Outlines, p. 50.

† Phil. Trans. 1826.

but also of the spinal cord itself, between the origin of these nerves and the brain. This irritation acts most powerfully on those muscles which have nerves from the immediate neighbourhood of the points irritated. But it has been further shewn by experiment, that this power of exciting muscular contraction, when itself irritated, does not reside in all parts of the spinal cord, but chiefly in its anterior surface, in a slight degree only in its posterior surface, and hardly at all in its internal parts *.

Irritation of the posterior surface of the spinal cord, and posterior roots of the spinal nerves, has appeared in some experiments to cause contractions, although feeble, confined to those muscles which *extend* the body and limbs, while irritation of the anterior surface, and anterior roots, acted chiefly, and more forcibly, on the flexor muscles †.

7. Muscular contractions have been very often directly excited, in experiments on animals, and in cases of injury or disease in the human body, by irritations of the parts of the nervous system situate within the cranium. But it has been long known, from experiments by ZINN, LORRY, HALLER, and others, that much of the brain and cerebellum may be injured without any such effects resulting; and more recent experiments, particularly those of LEGALLOIS, Dr WILSON PHILIP, and of FLOURENS, MAGENDIE, and FODERA, have led to the conclusion, that *no irritation of the Brain proper, or Cerebellum, is necessarily* effective in producing muscular contraction; but that this effect *uniformly* results from irritation of the *medulla oblongata*, and parts inferior to the corpora quadrigemina,—no doubt therefore of the fibres which ascend to the brain from the spinal cord through these parts; and that all irritation or injury of parts superior to this, excite muscular contraction only in so far as they extend directly or indirectly to, and affect, the medulla oblongata ‡.

* MAGENDIE, Journal de Physiologie, tom. iii.

† BELLINGERI, Archives de Medecine, 1825.

‡ See particularly FLOURENS, Recherches Experimentales sur le Systeme Nerveux; FODERA in Journal de Physiologie, tom. iii.; and MAGENDIE, do. do.

When muscular contraction, or convulsive movement, is produced by injury or disease of either hemisphere of the brain or cerebellum, it has generally been observed on the opposite side of the body; and this has been ascribed to the decussation of the fibres at the lower part of the corpora pyramidalia. But the decussation of nervous fibres at this point cannot explain all the facts of this kind, which have been often observed; because this *crossing* of the effect of injury to the opposite side has been observed, in the human body, from disease of the brain, in muscles moved by the seventh and ninth nerves, which arise nearer the brain than the decussation of the pyramids.

To the effects of injury or irritation, either of the spinal cord or brain, on muscular contraction, equally as to those of injury of individual nerves, it is an essential condition, that there be a communication, by sound nervous substance from the point irritated, to the muscle that contracts.

8. In all these cases, the effect of injury of nervous matter, in exciting muscular contraction, is chiefly observed when it is produced *suddenly*,—gradual alteration, by injury or disease, even of the nerves or spinal cord, and still more of the brain and cerebellum, having often been observed where no convulsive motions had ever taken place.

II. The contractile power of many, perhaps of all moving solids, is *liable to alteration* from physical causes acting on the Nervous System, which act, not as simple irritants, exciting contraction, but as stimulants or sedatives *(see p.* 11.) exalting or depressing the vital power. This effect of physical impressions on the Nervous System is chiefly seen in the involuntary muscles. It is imperfectly understood, and is with difficulty distinguished from the effect of sensations; but the following facts leave no room for doubt as to its existence.

1. It appears from the experiments of Legallois, that by a certain amount of mechanical injury of any part of the spinal cord, the heart's action may be very much and instantaneously weakened, or even suddenly suppressed;

and from the experiments of Dr WILSON PHILIP, that the same may happen from a certain degree of injury of the brain: but that from slighter injury, either of brain or spinal cord, inflicted on an animal in a state of insensibility, the heart's action is sensibly quickened *.

2. It appears also from the experiments of these authors, and especially of FLOURENS †, that great mechanical injury of the brain or spinal cord weakens the circulation in the capillaries sooner, and in a greater degree, than that in the large arteries, and even, that such injury of the spinal cord is often seen to affect immediately the flow of blood in the capillaries of those parts only, which have their nerves from the injured portions of the spinal cord.

3. Those mechanical injuries of the human body, which cause insensibility by general concussion of the system, at the same time manifestly and sometimes irretrievably depress the circulation; which effect it is reasonable to refer to an impression on the nervous system, because of the accompanying insensibility (which, as we shall see, implies affection of that system); and because it is just similar to the effect produced, in the experiments now mentioned, by injuries of the nervous system, without much general concussion of the body. In some such cases of concussion in the human body, as well as in such experiments, violent convulsions of voluntary muscles attend the insensibility, and the failure of the heart's action;—the same impression on the nervous system which excites the voluntary muscles, acting as a sedative on the vital power of the heart.

The inordinate action of the bladder, and consequent incontinence of urine, which ensue, in many cases, after injury or disease of the spinal cord, have also been regarded as an example of increased vital power in a muscular part, from physical irritation of nervous matter; but where this effect on the bladder has taken place gradually from this cause, it ought probably to be ascribed to the inflammatory action

* Experimental Inquiry, Exp. 26, 21, 22, 34, 38.

† Recherches Experimentales, p. 190 & 196.

which in these circumstances is apt to supervene in the mucous membrane, and the cause of which will be considered under the next head.

It appeared in the experiments of Dr WILSON PHILIP, that the effect produced on the heart's action, by impressions made on the nervous system, was nearly in proportion to the extent of nervous matter on which these impressions were made, and was nearly the same, in whatever part of cerebro-spinal axis the injury was inflicted *; and accordingly, both in the case of concussion, and in several diseases (*e. g.* in hydrocephalus and some cases of apoplexy), in which the heart's action is peculiarly influenced by changes in the nervous system, it may be observed that these changes extend to a large surface of nervous matter. But it is certain that the circulation in the arteries of a limb may be sometimes observed to be much weakened immediately after a paralytic stroke, when there may be no evidence of more than a very small portion of nervous substance being injured; so that we cannot, as yet, lay it down as a principle that this kind of influence on contractile parts, results only from impressions made on large portions of the nervous matter.

III. Although we gave reasons for thinking that Secretion and Nutrition are truly independent of nerves, yet several facts show, that physical impressions on, or injuries of, the nervous system, materially and variously *influence these functions*, as well as the circulation in the small vessels which are their seat. This kind of influence of physical impressions on nervous matter, is also imperfectly understood, and not easily distinguished from the effects of mental acts; but it seems exemplified in the following instances:

1. The effect of section of the eighth nerve in the neck, in not merely suspending the secretion of gastric juice at the stomach (which is a somewhat ambiguous case), but also in exciting a degree of inflammatory action there; in

* Experimental Inquiry, p. 114 and 115.

preventing the usual effusion of mucus in the intestines, even when arsenic has been swallowed *; and, on the other hand, in exciting inflammation, and increasing the mucous secretion, in the lungs and bronchiæ †.

2. The effects (viz. inflammation, ulceration, and sloughing,) produced on the eye-ball, and in some instances on the membrane of the nose, and on the gums, as was first ascertained by MAGENDIE, by section of the fifth nerve, which supplies these parts; and likewise, in a less degree, by section of the sympathetic nerve in the neck ‡,—effects which have also been seen in some cases in the human body, from disease of the fifth nerve.

3. The inflammatory condition, with increased and altered secretion, of the mucous membrane of the bladder, in many cases of paraplegia, dependent on injury of the spinal cord.

The diminished nutrition and diminished secretions (*e. g.* by the skin), often observed in a limb which has been for some time palsied, by section of its nerve, or disease of the brain, may be thought to illustrate the same point; but these effects are perhaps sufficiently explained by the total inactivity of such a limb.

It is to be observed, that such effects as those now stated, on secretion and nutrition, have been observed only in certain parts of the body, and chiefly from injury of certain of the nerves supplying these. These are the sentient nerves of the parts in question; and the secretions which are changed, are generally mucous secretions, which are habitually excited by irritations producing sensation. It may therefore be reasonably conjectured, that the effect of the section of the nerve is merely to suspend the sensations of the part, and thereby greatly diminish or alter its usual secretions; and, as these secretions serve as a defence

* BRODIE, Phil. Trans. 1814.

† WILSON PHILIP, l. c. SWAN, Essay on the Connexion between the Action of the Heart and Arteries and the Nervous System.

‡ See DUPUY, Journal de Medecine, t. xxxvii.

from the irritation of foreign matters, to which these parts are habitually exposed, the effect of their diminution or change is to dispose the parts to inflammation from that irritation. This conjecture is supported by the fact, that inflammation of mucous membranes, and among others of the Tunica Conjunctiva of the eye, is observed in other cases, where there is great debility of the circulation, deficient secretion, and insensibility, as in animals kept long fasting, and in the last stage of Fever. On this supposition, changes in secretion or nutrition are not the direct effect of the injuries of the nerves, but are to be ascribed to the loss of the sensations by which certain secretions are habitually excited and modified.

These statements of physical phenomena, however, illustrate the very peculiar powers, known only by their effects on other parts of the animal frame, which the Nervous System in living animals possesses. Only one theory, in explanation of these powers, appears to deserve attention, viz. that which ascribes them to Galvanism, evolved in the animal frame, especially by the contact of nervous with muscular substance. It is known that, by the contact of these substances, galvanic phenomena, in a slight degree, may be produced; and that galvanism, however evolved is a powerful stimulant of muscular contraction, —in an excessive degree, is a powerful sedative,—and has also appeared frequently to influence the capillary circulation and secretions.

It appeared also, in some experiments by Dr EDWARDS, that when the nerve and muscle of a frog were laid on a good conductor of electricity, irritation of the nerve had much less effect in exciting the muscle, than when they were laid on a non-conductor; which he ascribed to the galvanism supposed to be excited in the nerve being carried off by the conductor of electricity in the former case, and therefore not affecting the muscle *.

But whatever be the true explanation of this fact, the

* Ann. des Sciences Naturelles, t. v.

following general objections may be stated to the Galvanic theory of Nervous actions, such as we have hitherto considered them.

1. The causes which excite, in the highest degree of intensity, those changes in nerves by which muscles are excited (*e. g.* such causes as bruising with a probe, or pricking with a pin), seem quite inadequate to the production of a sudden and powerful galvanic influence.

2. We have seen that these causes do not act on all nerves, and through them on all muscles which they supply, but only on the nerves of certain muscles, and only on certain of these nerves.

3. We have seen that the power of exciting muscular contraction is so far from residing in nervous substance in general, that it resides on one surface of the spinal cord, and not on the other,—nor in its centre; nay, it resides in one part of a nervous fibre, in the medulla oblongata, and not in another part of the same fibre, half an inch higher in the brain.

4. While the changes in the nervous system, which excite muscles to contraction, take place only in certain parts of the nervous system, those which exalt or depress the vital power of muscles, appear to take place especially in others, and therefore affect especially other muscles; and the same cause (*e. g.* a violent concussion) which produces one of these effects exclusively in one nerve, may produce the other in another nerve immediately adjoining it.

The experiments of Person and of Muller have shewn farther,

1. That no galvanic action can be detected by the finest galvanometer in a nerve, at the moment when some change, consequent on its irritation, and transmitted along it, is exciting a muscle to contraction.

2. That a sensitive nerve, going to a muscle, is equally capable as its motor nerve, of conducting a galvanic current to that muscle, and thereby exciting it, although no irritation, confined to that sensitive nerve, has any power of exciting the muscle to contraction.

3. That such an injury of a nerve, as completely prevents any irritation, above the injured part, from exciting the muscle supplied by it, has no effect in preventing the transmission of a galvanic current from the upper part of the nerve through the injured part, so as to excite that muscle *.

These facts unequivocally indicate, that if it be galvanism which enables nerves to act on muscles in the living body, it is galvanism excited by means, and subjected to laws, very different from what we observe in examining the galvanic phenomena of dead matter. And this is equivalent to saying, that nerves act on muscles in the living body, in virtue of certain *vital powers*.

The most comprehensive and least theoretical general name that we can give to the changes in the nervous system that are referable to these powers, is that of Nervous Action, or Nervous Agency.

CHAPTER VIII.

OF THE ANIMAL FUNCTIONS IN GENERAL.

We have attributed peculiar Vital Properties to the Nervous System, in consequence of the observation of certain merely physical phenomena. But these phenomena are the effects of injury and violence; and we have no reason to think that, in the natural and healthy state, those properties are frequently, if at all, called into action in this way. We believe the phenomena last stated to be only indications of the powers which are given to the Nervous System in living animals, in order that it may be the seat, and the instrument, of Mental Acts.

These Mental Acts, and all the functions in which they have a necessary share, constitute the Animal Life, or Ani-

* See Journal de Physiologie for 1830, and Annales d'Histoire Naturelle, 1831.

mal Functions, as distinguished by BICHAT and others. Some general observations on these functions may be introduced here, and will simplify the discussion of the remaining departments of Physiology.

I. As the words Sensation and Thought express simple ideas, it is impossible to define them; but no man can be at a loss as to their meaning, who is told that they apply to those changes which all men continually experience within themselves; and to which all have been in the habit of applying such terms as Sight, Touch, Recollection, Judgment, Joy, Sorrow, Hope, Fear, &c. The word Mind is defined by saying, that it is that which undergoes the changes, or performs the acts, or exists in the states, to which these different terms are applied.

Neither does any man feel any difficulty in understanding the difference between what are strictly called Sensations, and what are called Thoughts, when he is told that the former term is applied to the changes which he experiences, when an impression is made on any of his external senses, and the latter to those other changes of which he is internally conscious, when no impression is made on his senses, *e. g.* Recollections, Emotions, or Judgments.

When we reflect on the essential nature of this difference, which every one must have habitually recognised, long before he has made it an object of attention, we find that the name Sensation is given to those changes which (in the adult state at least) are attended with an instantaneous conviction, that they depend immediately on a cause that is *independent of, and external to, the sentient mind* that undergoes the change. How this conviction of the independence of its immediate cause is acquired, *i. e.* in what circumstances it first arises in the mind, we do not now inquire; but it is a part of the Natural History of our mental constitution, and is the attendant, and the essential characteristic, of that mental change, to which we give the name of Sensation.

The immediate cause, independent of, and external to, the sentient mind, to which we naturally ascribe the excitation of sensation, is what we call Matter; and we attribute to it different qualities, corresponding to the different sensations which it excites in our minds; or, as it is otherwise expressed, we *perceive* it, and its qualities, by our senses.

If this account of the strict meaning of the terms Mind and Matter be correct, no more need be said in order to shew, that it is illogical and absurd to speak of these, otherwise than as separate existences; because any one, who has correctly apprehended the meaning of the two terms, has already formed the judgment, that the one is independent of the other.

The one term is applied to the individual being, which we naturally and intuitively judge to be the *subject*, or *seat*, of those changes which we call Sensations or Thoughts; it is that which actually exists in the different states, to which we give these names; and we cannot apply the term to any thing which we judge to be separate from, and independent of, these feelings. The other is known to us only as the *object* of sense: the cause, judged to be independent of our sentient minds, of certain of the changes of which these minds are susceptible; and unless we have already formed the judgment of its independence, we cannot apply the term. Those who distrust that judgment, will not believe in the existence of Matter; but those who believe in the existence of Matter, (unless they can explain how they got that notion, otherwise than as above stated), cannot, without absurdity, identify it with Mind.

The same facts are expressed by saying, that for the existence of Matter we have the *Evidence of Sense*, for that of Mind the *Evidence of Consciousness;* and that we inquire into the one by *Observation*, and into the other by *Reflection.* For the existence of any other sentient and thinking minds but our own, we never can have either of these kinds of evidence; it is not known to us, either by consciousness or observation, but is always a matter of *inference.*

It is to be observed, then, that we give the name Object of Sense,to those things only which we judge at the moment when we apprehend their existence, to be external to, and independent of, the sentient mind that perceives them; and we distinguish the acts themselves, of Sensation and of Thought, from any attributes of matter, simply because they are not objects of sense; and accordingly, we distinguish them from all attributes of matter, not in Man only, but throughout the whole of Creation; and say, without hesitation, that every living being in which we judge that any act of Sensation or Thought takes place, *i. e.* that every Animal, is the residence of Mind.

When we speak, as physiologists generally do, of Sensation and Thought as functions of the Nervous system, it must be obvious, from what has now been said, that we use this term Function in a sense somewhat different from that in which we apply it to other textures or organs of the body; because, in all other instances, we apply the term to a change which may be made, in some way or other, perceptible to our senses; and the changes now in question are, from their very nature, imperceptible to our senses; and known to each of us, as existing in any living body but his own, by inference only.

When we say that Sensation and Thought are Functions of the Nervous System, we mean only that this system *furnishes the conditions* under which Sensation and Thought in the living body take place; and when we say that Instinctive and Voluntary Motion are, in part, functions of the Nervous System, we mean that this system *forms the Medium*, through which certain acts of mind, called Instincts and Volitions, are enabled to excite certain muscular contractions.

How it happens, that, under certain conditions of the Nervous System, in the living body, the different mental phenomena should be connected with it, we have no reason to expect that we ever shall know. When we examine the structure of the Brain, we see nothing which could have led us to anticipate, that it would be the residence of

Sense or of Intellect; and when we reflect on the powers of the human mind, and compare them with the indications of a Superior Intelligence which we see around us in the world, it appears inconceivable to us that they should be linked with the existence, grow with the growth, and change with the changes of a piece of soft white matter. But in all other inquiries into the works of Nature we meet with ultimate facts, that are equally beyond our comprehension.

The true objects of this department of Physiology are only these,—to distinguish and arrange the different Mental Phenomena themselves; to ascertain the conditions in the state of the Nervous System, on which their manifestation depends; and to trace the effects on the various functions of the body, which result from them.

II. Sensations may be divided into those which are felt in consequence of impressions made on individual organs only, such as Light and Colour, Smells, and Sounds, called the Higher or Special Sensations; and those which are felt pretty generally over the body, as Touch, Heat, Cold, Pain, to which the name of Common Sensation is given. Acts of Thought, again, may be divided into those which not only proceed from no immediate cause, but are followed by no immediate effect, external to the mind itself,—such as Recollections, Judgments, Acts of Imagination;—and those which are immediately followed by changes in the body. Of this last class, Instincts and Volitions, which are uniformly followed, in the natural state, by contractions of certain muscles, are the most unequivocal instances; but certain Sensations and Emotions are likewise naturally followed, either by muscular contractions, or by alterations in the circulation, or in the secretions of various organs. We do not enter as yet into any details regarding these mental acts; but the distinctions now stated are easily recognised.

That the Nervous System is essentially concerned in, or furnishes necessary conditions to, all these phenomena, we conclude from the following facts :

1. It is shewn by unequivocal experiments, and by the uniform result of observations on the human body, that Sensation in every part of the body, and the effects of Instinctive or Voluntary efforts on the muscles which these affect, are essentially dependent on Nerves distributed to those parts, and are prevented from taking place, when the communication of these nerves with the cerebro-spinal axis is interrupted by compression or destruction of the nerves. How the different portions of these nerves are concerned in, and how far the Spinal Cord and Brain are essential to, these functions, will be considered afterwards.

2. Although we cannot say that the indications of mental phenomena, in organized beings, coexist exactly with the existence of a Nervous System, yet in general, throughout the animal kingdom, and especially in vertebrated animals, which have a spinal cord, similarly formed as the human, and organs corresponding to brain and cerebellum, —the greater development of the Nervous System is proportioned to the greater perfection in which the acts of Sensation and Thought take place; and the greater development of the Brain proper in particular, to the greater intelligence of the animal.

3. All Sensations, Thoughts, and their effects on the body, are liable to alteration from injury or disease of the nervous system, especially of the Brain and upper part of the Spinal Cord; and there are certain injuries of these parts, to be afterwards specified, which never fail to put a stop to all indications of the most important mental phenomena.

4. There is no other texture, upon which the mental phenomena show any dependence,—any alterations which they undergo, in consequence of injury of other textures, being always referable to an injurious influence transmitted, directly or indirectly, from these other textures to the nervous system.

5. The changes produced in different organs of the body, by the different acts or affections of the mind, cor-

respond very nearly to the changes which are observed in these organs (*e. g.* muscles, voluntary or involuntary, glands, &c.), from the physical injuries of the Nervous System already considered.

We can have no doubt that the Nervous System is fitted for the purposes which it serves in regard to the mind, by the peculiar Vital Properties with which we have found that it is endowed; and which are so far exemplified by the effects of physical irritation or injury above noticed. But these vital properties are known to us only by their effects; either on the mind, on the one hand, or on the other bodily organs, on the other.

III. Certain general conditions may be stated, as essential to the existence of these vital properties in all parts of the nervous system.

1. The most important is, the circulation of Arterial Blood through the nervous matter,—a condition necessary for all functions, but the interruption of which is more speedily injurious to this than to any other: and the necessity of which condition will appear distinctly when we treat of Respiration.

2. Various facts show, that any sudden alteration of the Pressure to which the nervous matter is subjected, is frequently followed by diminution or suspension of all the animal functions; as, *e. g.* in the case of insensibility, produced by bleeding in the erect posture; or by tapping, without bandaging the abdomen, &c.; and again, in the case of any such mechanical compression of the brain as shall specially affect the medulla oblongata. It seems probable, that to the sudden alteration of pressure on the nervous substance, we should refer the fact, that drawing off the small quantity of fluid that exists, in living animals, beneath the arachnoid and in the ventricles, enfeebles or suspends the animal functions *.

3. Various facts pretty clearly indicate, that the Nervous System is not passive during the performance of any of the

* Magendie, Journal de Physiologie, t. vii. et viii.

animal functions connected with it, but undergoes changes in which some (although imperceptible) Movement of its particles is probably concerned. Of this kind are the following:

An impression from an internal physical cause, made on a part of the Nervous System, will sometimes excite the same kind of sensation as an external impression on certain organs of sense. Again, the sensation produced by an impression on an organ of sense, lasts longer than the application of the external cause, as is particularly obvious in regard to the sensation of Light; and sensations which have forcibly engrossed the attention, are often irresistibly obtruded in a less degree of intensity, especially during darkness and silence, long after their causes have been removed.

Farther, it may be observed, that excessive exertion of any of the animal functions induces morbid phenomena, which indicate derangement of the circulation in the parts of the nervous system most connected with them;—that both Sensations and Volitions, as connected with the Nervous System, present many striking analogies to the phenomena of muscular contractions;—that they undergo changes from repetition and habit, similar to those formerly noticed in contractile parts;—and, in particular, that the nutrition of the nerves of sense at least, is increased by their habitual employment, and diminished by their inactivity;—that these functions require, equally as most muscular contractions do, intervals of relaxation or suspension, which they enjoy during sleep;—that they are gradually altered, nearly in the same way as muscular contractions are, in the progress of life;—and that various poisonous or medicinal substances taken into the circulation, affect the animal functions in a way analogous to that in which they affect involuntary muscular contractions.

IV. It is now well ascertained, not only that the Vital Properties, which show themselves on physical irritation of nervous matter, vary in different parts of the system, but that the Mental Phenomena, which are connected with different parts, are quite distinct; and considerable progress has been made in the *appropriation* of the parts of the Nervous System to the different mental phenomena. The parts which are appropriated to Sensation, and to Instinctive or Voluntary Motion, are nearly ascertained; and the statements to be made on that subject may be introduced here. Those appropriated to other mental acts are less clearly distinguished, and what is known as to them will appear in the account to be given of the functions in which these acts are concerned.

1. As to the office of *Nerves* in Sensation and Voluntary Motion,—it is known that they are essentially concerned in these functions (see p. 123.) But it is also ascertained that there are *no sensations*,—not even such as are common to all parts of the body,—which are *felt in all nerves ; i. e.* in consequence of impressions made on all nerves; but that there are, in all parts of the body, certain nervous fibres or filaments destined to sensation, and others incapable of exciting sensation.

It has appeared, from the numerous experiments, first of Mr Bell, and since of Magendie, Beclard, Mayo, and many others,—confirmed in a great measure by observations of cases of disease in the human body,—that it is by irritation of the posterior roots of the spinal nerves, almost exclusively, that indications of pain (*i. e.* of common sensation) are excited; and that it is by section of these roots that insensibility of the parts supplied by these nerves is produced. And on the other hand, as it is by irritation of the anterior roots of the spinal nerves that muscular contractions are chiefly or almost solely excited, so it is by section of these roots that muscles are palsied, *i. e.* that voluntary efforts are rendered ineffectual for their excitation. Hence it appears, that it is only in consequence of different filaments of nerves, with different endowments, being bound up in the same sheath after they leave the spinal canal, that these spinal nerves generally appear to minister both to sense and to voluntary motion.

Again, similar experiments and observations show still more clearly, that those of the cerebral nerves which were mentioned as capable of exciting muscular contractions when themselves irritated, (the 3d, probably the 4th, the anterior branch of the 5th, the 6th, Portio Dura, and 9th), are the motor nerves, by which the muscles of the eye-ball, lower jaw, face, and tongue, are moved in obedience to the will; and that the ganglionic portion of the 5th is the sensitive nerve, which gives, exclusively, common sensation to the face, eye-ball, mucous membrane of the nose, mouth and tongue.

This great sentient nerve is easily shewn to be in communication with the posterior columns of the spinal cord; and the motor nerves, above mentioned, would seem to communicate with its anterior columns. There is an exception, however, in the case of the 4th, any connexion of which with the anterior columns of the spinal cord is very doubtful. And it is farther to be observed, that all the larger portions of the 8th nerve, which seems to be more connected with the posterior than the anterior columns, appear from experiment to be nerves both of Sensation and of Motion *; and the statements of BELLINGERI and others show, that the appropriation of the nervous filaments, arising from the different surfaces of the spinal cord to motion, and to sensation, is not yet ascertained to be absolutely exclusive; perhaps because the separate offices of the different columns of the spinal cord have not been distinguished with sufficient minuteness. According to the recent observations of MULLER †, in the case of reptiles, the appropriation of the roots of the spinal nerves to sensation and to voluntary action, appears to be complete and exclusive.

While it thus appears that the sensations common to all parts of the body are felt only through certain of the nerves, it is also certain that the peculiar sensations which have

* MAYO's Anatomical and Physiological Commentaries, No. 2.

† Annales des Sciences Naturelles, t. xxiii.

special organs appropriated to them, Smell, Sight, and Hearing, are felt only through their peculiar nerves, the 1st, 2d, and portio mollis of the 7th (or a part thereof); and even, from the experiments of MAGENDIE, that these nerves are incapable of exciting common sensation; their sensibility being confined to the qualities of external things to which they are appropriated, and the common sensations of the organs in which they are found depending on the 5th pair *.

The peculiar sensations of these special organs have been found to be impaired by injury of the branches of the 5th nerve entering them; but this does not prove, that the injuries of that nerve have more than an indirect influence on these sensations, perhaps dependent on the alteration which its injury produces on the nutrition of these parts (see p. 115). It has been thought, that in some animals the organs of some of the peculiar senses are supplied from the 5th pair exclusively, and the peculiar sensations felt only through them; but this observation is probably erroneous †.

No observations have yet shewn, whether or not the ganglia, found very generally throughout the animal kingdom, on the roots of the nerves of common sensation, have any necessary connexion with their sensitive power. But no such arrangement is found in the nerves of the special senses; and the sympathetic nerves, and its ganglia, give but obscure indications of sensibility on irritation. It is obvious, from what we see of some of the cerebral nerves, that the union of motor nerves in plexuses is by no means necessary to the power of the will over them.

2. There is some difficulty as to the necessity of the intervention of the Spinal Cord in Sensation and Voluntary Motion. It has generally been observed, in experiments on animals, and in cases of injury in the human body, that

* Journal de Physiologie, 1824 and 1825.

† See SERRES, Anat. Comparée du Cerveau, Art. Nerf Trijumeau; and GEOFFROY ST HILAIRE, sur la Vision de la Taupe; Revue Médicale, tom. iv. p. 138.

destruction of the spinal cord, above the origin of a nerve, equally destroys sensation and voluntary motion in the parts supplied by that nerve, as section of the nerve itself; and hence it has been concluded, that some change is necessarily propagated *upwards*, along the nerve and spinal cord, to the brain, in the case of Sensation, and *downwards* along the spinal cord and nerve, from the brain, in the case of Voluntary Motion.

But it has been observed by different physiologists, HALLER, WHYTT, LEGALLOIS, MAYO, &c., that even in warm-blooded animals, after the spinal cord has been divided, certain movements of the inferior extremities have been made on irritation of the skin of these parts, which appear to indicate some remains both of sensation and of voluntary power in the parts thus severed from the brain; and in the cold-blooded animals, it is known that the Nerves and Spinal Cord generally suffice for giving some indications, both of sense and voluntary motion, when separated from the Brain and Cerebellum. In the human body one case of division of the spinal cord by wound, and several of more or less complete interruption of its continuity by disease, have been recorded, in which absolute loss of sense, and of voluntary power, were not observed, and were thought not to have occurred before death *.

Such cases have led some physiologists, at different times, to think, that the changes essential both to sensation and voluntary motion, may be truly *confined to the nerves*, and only *liable to a noxious influence*, transmitted downwards, from injury or disease of the Spinal Cord or Brain; which noxious influence, although it very generally follows, may not necessarily follow, such injury or disease.

But the following considerations, long ago urged on this point by HALLER †, seem sufficient to show that the common opinion of the *transmission of some change*, through the

* See DESAULT, Journal de Chirurgie, t. iv.; OLLIVIER sur la Moelle Epiniere; VELPEAU in Archives des Medecine, 1825.

† Elem. Physiol. t. iv. p. 295, *et seq.*

spinal cord, *upwards* to the brain in sensation, and *downwards* from the brain in voluntary motion, is well founded.

First, In the common case of loss of Sensation and voluntary power after section of the spinal cord, the lower segment of the cord, and nerves arising from it, are still perfectly capable of exciting contraction of the muscles of the lower limbs, when themselves physically irritated; which implies, that the loss of voluntary power, after the section, is not because the nerves of the lower limbs cannot act on the muscles, but because the brain, or upper part of the spinal cord, cannot act on the nerves; and therefore, that when the communication is entire, the brain, or something within the cranium, does act on the nerves.

Secondly, After division of the spinal cord, as after amputation of a limb, pains are often felt, distinctly referred to the parts below the section; which implies, that the usual sensations of these parts had been dependent on changes extending at least as high as the section. Farther, at the will of the person, in such cases, the usual effort to move the limb is made,—seems to the person to be effective on it,—and is truly effective on such muscles, supplied from above the section, as used to be associated with those now palsied; which implies, that the effort which was wont to be effectual on the whole of these muscles, had been attended by a change in the parts of the nervous system higher than the section, which had been transmitted downwards.

As these statements apply to sections in *any part* of the Spinal Cord, it can hardly be doubted that the propagation or transmission of a change along the nervous matter, to and from the brain, in the ordinary case of Sensation and Voluntary Motion, does take place; but it does not follow from this, that no degree of sensation, or of voluntary action consequent on sensation, can possibly take place when the nervous communication with the brain is in any manner interrupted. In some of the lower animals (chiefly cold-blooded), there can be no reasonable doubt of the possibility of sensation being felt, and a certain degree of voluntary motion being performed, in parts cut off from communication with the brain. In most of the cases of the kind recorded as having occurred in the human species, inaccuracy of observation, before or after death, may be suspected; but it is also possible that a less degree of the mental acts may be connected with the inferior portions of the spinal cord; or that absolute continuity of nervous substance is not essential to the transmission of nervous agency; particularly as we have reason to believe that that agency can affect blood within vessels, and as the effects of section of a nerve, when the cut ends are laid in contact, have, in various instances, appeared less injurious than the effects of section, with loss of substance *.

3. It is now satisfactorily ascertained, that no part of the Brain, higher than the Corpora Quadrigemina, nor of the Cerebellum, is essentially concerned in Sensation. All the parts superior to this have been frequently injured, by many physiologists, in warm-blooded animals; and have been wholly removed, even in warm-blooded animals, by Du Verney, Chirac †, Lorry ‡ Legallois, Flourens, Fodera, and Magendie; and, if the remaining nervous matter was kept free from compression, all the usual indications of sensation remained. Farther, in these cases, such Instinctive or Voluntary efforts as were made, were still effectual in exciting muscular contractions of all parts of the body.

It appears from these experiments, that if we regard the spinal cord as reaching to the Corpora Quadrigemina, and giving origin to all the nerves (see p. 104.), we are to attribute to it, and to the nerves arising from it,—but especially to its highest portion, the medulla oblongata, and fibres extending thence to the crura cerebri,—all the physical conditions that are necessary, in order that Sensation may be felt, and that Voluntary efforts may excite muscular contraction; the mental stimulus of Volition being just

* Wilson Philip, Philosophical Transactions, 1822.

† Phil. Trans. 1697.

‡ Mem. presentées à l'Acad. des Sciences, t. iii.

on the same footing, in regard to muscular contraction, as a physical stimulus applied to the medulla oblongata. (See p. 111.)

Accordingly, instances have been recorded by Mr LAWRENCE *, and others, of infants of the human species, born alive, obviously capable of sensation, and of certain instinctive actions, in whom the nervous system terminated at the Tuber Annulare.

It has also been distinctly proved by experiments by LEGALLOIS and FLOURENS, that two of the sensations which may be called peculiar and special, those of the eye and of the lungs, are necessarily connected only with those portions of the contents of the cranium which lie close at the origins of their nerves.

It will appear afterwards, with what intentions, as regards sensation and voluntary motion, the brain and cerebellum are superimposed on the spinal cord. It will appear that they are useful, not in order that Sensations may be felt, but that they may be remembered, and availed of for useful purposes; not in order that Volitions may act as stimuli on muscles, but that they may act on them at the right times, and in the requisite variety of combinations and successions.

The facts now stated enable us to understand, without difficulty, so far as mere sensation and the power over the muscles are concerned, how it should happen that some injuries or diseases of the brain proper, or cerebellum, should affect these functions materially, and others not at all; because all injure these functions only in so far as they affect the medulla oblongata; and it is easy to understand, that the effect of some such diseases or injuries may extend downwards to the medulla oblongata, and that of others not. And this is well illustrated by FODERA's experiments on the comparative effects of *lateral* and of *vertical* compression of the brain or cerebellum †, the former seldom

* Medico-Chirurgical Trans. vol. v.

† Journal de Physiologie, t. iii.

affecting the functions of sense and voluntary motion, and the latter always producing either convulsion or coma.

V. It is necessary, before proceeding to the functions of Respiration and Digestion, to distinguish more accurately the different kinds of mental acts, which operating through the spinal cord and nerves, excite muscular contraction.

1. Voluntary motions are those which are not only preceded by a mental act, and attended by a sensation that informs us of their performance, but accompanied besides by a conviction, that we may perform them or not as we please. This conviction is the characteristic of that mental act which we call Volition. How this motion is formed, and whether or not it may be deceptive, we do not now inquire; its existence is all that concerns us at present.

2. There are likewise in the healthy state, motions of voluntary muscles which are quite involuntary, of the performance of which we are conscious, but which we have no direct power of controlling, and often strive in vain to counteract or conceal. These, on examination, appear always to be preceded, and we have every reason to think that they are caused, either by Sensations, as in the case of Sneezing, Coughing, Vomiting, &c., or by those mental acts or affections which we call Emotions, as in the case of Laughter and Weeping.

3. The former class of actions are divided into those which are more strictly Voluntary, and those which are properly called Instinctive. The distinction of these lies in this circumstance, that in the former case, we have a distinct object in view; our actions are not only prompted by an act of which we are conscious, but directed to an end which we desire; but in the latter case our actions are consequent indeed on a sensation, but prompted by a blind impulse, the consequences that are to follow from the action being either unknown or disregarded;—as in gratifying the appetites, guarding the eyes from danger by closing the eyelids, or the body from falling by throwing forward the hands.

The instinctive actions are closely connected with the motions that proceed directly from sensations on the one hand, and with the strictly voluntary motions on the other. In the adult human being it is hardly possible to distinguish them from movements that have been prompted by reason, and become habitual; but in the infant, and in the lower animals, they are easily distinguished, chiefly by two marks, 1*st*, That they are performed always in the same way; whereas actions that are strictly voluntary and prompted by reason, although directed to the same ends, vary considerably in different individuals. 2*dly*, That, however complicated the movements, the truly instinctive actions are performed equally well the first time as the last; whereas even the simplest of the strictly voluntary movements require Education.

The phenomena and effects of Instinctive and Voluntary motions will require a separate consideration afterwards; but it was necessary here, as a preliminary to the subjects of Respiration and Digestion, to specify the different modes in which, through the intervention of mental acts, muscular contractions may be excited in the living body.

These two functions are common to the whole animal kingdom, and their purpose is to maintain the requisite quantity and purity of the nutritious fluid, which is essential, as was already stated, to the vital powers of the moving solids, and to the vital action of all other parts, and especially of the Nervous System.

These purposes are fully accomplished in vegetables, and in the fœtus *in utero*, before there are any indications of sensation; and even in the adult animal a great part of the changes, which come under the heads of Respiration and Digestion, belong strictly to the Organic Life. But in all animals the reception of food into the digestive organs, and in all vertebrated animals, and many of the inferior orders, in the adult, the reception of air into the respiratory organs is accomplished, by movements which are excited through the intervention of Sensations and of Instincts or Volitions; and therefore the commencement of the processes of Respiration and Digestion in them belongs to the province of Animal Life, and may be shewn to be dependent on the Nervous System.

CHAPTER IX.

OF RESPIRATION.

The arterialization of the blood by exposure to air is of such importance in the animal economy, that in man, and the animals the most analogous to man, its interruption for a few minutes is fatal. In comparing the different classes of animals, especially the great divisions of Warm-blooded and Cold-blooded, and still more remarkably, in comparing the different states of those animals which hybernate, or are subject to periodical torpor, it is observed that the strength and rapidity of vital contractions, the energy of the functions of the Nervous System, the elevation of the animal heat, and, in general, the intensity of all the vital functions, are nearly in proportion to the degree of action that takes place between their blood and the air.

But it is not yet fully ascertained, whether this action is merely of the nature of excretion from the blood, of something which would be noxious if retained, as is the case with the discharges of bile and of urine; or whether any thing is necessarily added to the blood from the air, which assists in qualifying it for its office in the system: and therefore it is still doubtful whether the intensity of the vital functions, that goes along with the high degree of this action of the atmosphere on the blood, is to be regarded as its cause or its effect.

One chemical change on the air is seen from the action of the fluids of all living beings, viz. the disappearance of more or less of the oxygen, which forms about 20 per cent. of its constitution, and the increase of its carbonic acid, which forms less than 1 per cent. of it; and the volume of the carbonic acid added has always appeared to approach, and in many cases to equal, the volume of oxygen lost.

But in vegetables, when living and exposed to light, another chemical change is effected on the surrounding air, viz. the removal of part of its carbonic acid, and the substitution of oxygen, or what is usually called purification of the atmosphere.

It has not yet been ascertained, whether this purifying influence of vegetables does or does not exceed the vitiating influence of the exhalation or formation of carbonic acid, which is likewise seen in them; but it is certain that the whole effect of animal life on the atmosphere is vitiating, *i. e.* to cause addition of carbonic acid to it; and other processes, always going on at the earth's surface, have a similar effect; and yet the whole quantity of carbonic acid in the atmosphere is not found to increase. There must, therefore, be some purifying cause continually in operation to compensate for the continual vitiation; and we know of none acting on a large scale, except the influence of living vegetables.

Farther, it appears certain that vegetables may grow, and the quantity of carbon in them gradually increase, when they are supplied with air and water only, and can derive no supply of carbon from the earth *.

These circumstances render it highly probable that living vegetables, on the whole, decompose more of the carbonic acid of the atmosphere than they form; and therefore both purify the atmosphere, and derive part of their nourishment from it.

The facts which favour this opinion have been ingeniously and judiciously connected by M. Adolphe Brongniart †, with observations made on the remains of organized substances on the crust of the earth, which show that an extensive vegetation must have existed, at a time when there were few or no animals, and that subsequently many

* Saussure, Recherches Chimiques, p. 50, *et seq.*

† Annales des Sciences Naturelles, tom. xv.

cold-blooded animals inhabited the earth and sea, before there were any warm-blooded animals. If we suppose the atmosphere to have contained originally a much larger proportion of carbonic acid than now, it may be inferred from what has been said, that it would enable vegetables to grow before any carbonaceous soil existed, and would be gradually purified by their growth; and the degree of vitiation which would result from the respiration of the cold-blooded animals, might probably be more than compensated by the purifying influence of the vegetables. After the purification had been carried to a certain length, the atmosphere would become fitted for the respiration of warm-blooded animals, which require a fuller supply of oxygen, and exhale carbonic acid more abundantly; and, from the time of their creation, it would appear that the processes which purify, and those which vitiate, the atmosphere, are pretty nearly balanced.

But whatever the provisions may be, by which the average purity of the atmosphere is maintained, notwithstanding the continual additions of carbonic acid which it receives from the respiration of animals, the importance of the process to animal life is illustrated by the adaptation of the respiratory organs, in different animals, to the degree, and the mode of action, of the air on their fluids. This adaptation is determined chiefly by the following conditions.

1. By the degree of density or solidity, and complication of the textures composing the animal. When the structure is simple, or the materials light and porous, air is admitted freely into all parts of the animal, and no part of the body is appropriated to the reception of air. This is the case in Zoophyta and Insects. But where the structure is complex, and some of the textures dense and impervious to air, a separate respiratory organ, and along with it, as before observed, a circulating system, are required.

2. Where these organs exist, their nature is determined by two conditions,—*first*, by the amount of vital energy which the animal is to possess, and proportional amount of

action of the air on the blood, for which provision is to be made; *secondly*, by the medium in which it is to exist. When it inhabits air, and is warm-blooded, it breathes by lungs, and has a double circulation, *i. e.* all its blood, after completing the circulation through the body, is sent to the lungs. This is the arrangement in the Mammalia and Birds. When it inhabits air, and is cold-blooded, it breathes by lungs, but has a single circulation, *i. e.* sends only part of its blood to the lungs, and that part is mixed with what returns from the rest of the body. This is the mode of respiration of Reptiles. When the animal is to inhabit water, it acts on the air contained in that water, by gills or analogous organs. But as this action is necessarily slight in comparison with that which takes place in lungs, the whole blood is sent to the gills, and the animal nevertheless is cold-blooded. This is the mode of Respiration in Fishes and most of the Mollusca, the Crustacea, &c.

The smaller number and larger size, of the particles of blood in cold-blooded animals, are likewise adapted to the less degree of action which is to take place between it and the air; and various additional provisions, adapted to the circumstances of different classes of animals, farther illustrate the same principle. Thus birds, in which there is occasion for great muscular energy, and therefore for a full supply of air, have not only lungs, but likewise tubes which admit the air into contact with their blood, in almost all parts of their bodies. Reptiles, which breathe by lungs, but are frequently under water, or in very impure air, have lungs provided with vesicles of such size as to serve as reservoirs of air for these occasions. On the other hand, certain fishes and crustaceous animals, which breathe by gills, but are often for some time in air, have reservoirs of water for their gills to act on during the time of their abode in air *. Warm-blooded animals which habitually dive in water, seem to be enabled to dispense with the inspiration

* Cuvier and Dumeril, Rapport sur le Memoire de Audouin et Milne Edwards, Annales des Sciences Naturelles, tom. xv.

of air, at these times, by the great quantity of their blood, and by the great size of their large veins, permitting it to accumulate there, when, in consequence of suspended respiration, it cannot freely penetrate the lungs *.

In the human body, the mechanism by which the regular application of the air to the blood in the lungs is secured, is well understood; but there is still some difficulty as to the precise nature of the chemical change; and as to the mode in which the cessation of that change at the lungs affects the rest of the system.

I. The first step in the process is a Sensation in the breast, felt when the chest is at rest, especially after expiration, caused by venous blood moving through the lungs, amounting quickly to extreme anxiety if not relieved, and uniformly prompting the complicated action of inspiration, by which it is immediately appeased. The influence of the sensation, in exciting the acts of respiration, even during sleep, and during coma, is proved by the increased energy and frequency of these acts, which may be produced by any means of obstructing the free access of air to the lungs, and so augmenting the intensity of the sensation †. And other Sensations, particularly those caused by certain irritations of the nostrils, or by cold suddenly applied to the face or breast, equally excite the act of inspiration.

This action being, in the natural state, caused by a sensation at the lungs, is necessarily dependent, in the first instance, on the sensitive nerves of the lungs, and especially on those which most directly communicate between the lungs and the medulla oblongata, viz. the eighth pair. Accordingly, after section of these nerves, the actions of Respiration, although not stopped (probably on account of the other communications, through the sympathetics and spinal cord, which the lungs have with the brain), are yet in general performed slowly, and always imperfectly ‡. And the ex-

* Edmonstone, in Phil. Magazine, August 1827.

† See Whytt on Vital Motions, sect. 8.

‡ See particularly Brodie, Phil. Trans. 1812.

periments of LEGALLOIS and FLOURENS have shewn unequivocally, that by injury of the part of the medulla oblongata, from which these nerves originate (and of that alone, of all the contents of the cranium), all attempts at inspiration are finally arrested; no doubt because a final stop is put to the sensation which prompts them.

The objects of the movements which the sensation excites are, to enlarge the cavity of the chest in all directions, and at the same time to hold open the passages by which the air is to enter it.

The cavity of the chest is capable of change of dimension in all directions, in consequence of the diaphragm, which forms its lower boundary, being itself a moveable and contractile part, and in consequence of the ribs, which enclose the greater part of it, being so articulated with the spine, as to be susceptible of motion upwards and downwards.

The chest is lengthened in the act of inspiration, chiefly by the contraction and descent of the diaphragm, especially of its fleshy lateral portions, which, from being convex towards the chest, are flattened, and slightly depress its central tendinous part. It cannot pull down the ribs, because they are fixed, at the moment, by the contraction of the intercostal muscles. But the elongation of the chest is partly also effected by the action of those muscles of the front and sides of the neck, which pull the highest ribs towards the neck and head.

The chest is rendered broader and deeper in the act of inspiration, by the elevation of the ribs; because these are both curved outwards, and sloped a little downwards; and therefore, when raised nearer to a right angle with the spine, enclose a larger space within the arches they form transversely, and also project, and push the sternum slightly forwards.

The elevation of the ribs is caused partly by the action of the two strata of intercostal muscles, because the lower ribs are more moveable than the higher, and therefore must be drawn towards the higher, when the whole of these muscular fibres contract; but the motion of the ribs, in inspiration, especially when forcible, is assisted by the action of the diaphragm forcing upwards the lower margin of the chest, at least when the abdominal viscera oppose much resistance to its descent *; and also by the combined action of those muscles which draw the scapulæ towards the cervical vertebræ and head, and of those which draw the ribs towards the scapulæ.

The glottis is held open, during inspiration, by the action of the muscles connecting the arytenoid to the thyroid and cricoid cartilages. The nostrils are slightly expanded, in forcible inspiration, by the muscles attached to the alæ of the nose. The Velum Pendulum Palati is raised and stretched by its own muscles, when inspiration is made chiefly through the mouth; and the lower jaw is often slightly depressed by the contraction of the muscles between it and the os hyoides.

Of these muscular actions, those of the diaphragm and intercostals are probably all that are employed in healthy and easy respiration; and in various circumstances, when there is an obstacle to the action of one of these, that of the other is found to suffice; but when the sensation prompting inspiration is intense and long-continued, all the other movements take place simultaneously, and with perfect precision, independently of all experience. The force, rapidity, and frequency with which they are performed, are all under the command of the will, and they may even be performed in conjunction or separately, except when the sensation that prompts them is unusually intense, in which case it supersedes all efforts of the will.

The movement of Inspiration is immediately succeeded by that of Expiration, partly no doubt because of the natural tendency of muscular contraction to alternate with

* See MAGENDIE, Precis Elementaire. The protrusion of the lower margin of the chest, apparently by the action of the diaphragm, is very obvious in the deformed chests of rickety children, when affected with dyspnœa, and seems to be the cause of the great depression of the ribs at the sides of the chest in such children.

relaxation, but partly also because somewhat of the uneasy sensation in the chest is felt when we rest on an inspiration, and is relieved by expiration; probably in consequence of the motion thereby given to the air along the surface of the membrane, where the capillaries carrying the venous blood ramify.

The act of ordinary expiration hardly requires any muscular effort, but is the natural effect of cessation of the contractions by which inspiration was effected. The state of the thorax, after an ordinary expiration, is that which is determined by the physical structure and properties of the parts, and the pressure of the atmosphere, and has therefore been called the natural state of the thorax; and the return to that state, after the effort of inspiration is over, is produced by the elasticity of the parts concerned,—of the lungs themselves, of the parietes of the abdomen, of the cartilages of the ribs, and more especially of the ligaments that connect the ribs to the spine.

But when the sensation caused by venous blood in the lungs is intense,—when certain other sensations in the trachea or bronchiæ, or certain emotions, are felt,—or when a certain voluntary effort is made,—the diaphragm and ribs are brought back to their position, after inspiration, with force and rapidity; and, by a continuance of the same action, the thorax is contracted within its usual limits. This is done by a simultaneous contraction of all the abdominal muscles, which both pull down the ribs and force up the abdominal viscera against the diaphragm; and the descent of the ribs is farther aided by the contraction of those muscles which arise from the sacrum and vertebræ of the loins, and are partly inserted into the lower ribs.

The movements of inspiration and expiration take place, in the healthy state, about once for every four pulsations of the heart, and therefore, on an average, about eighteen times in the minute. They are variously modified, both at the command of the will, and in obedience to certain sensations and emotions, in the performance of different complex movements to be mentioned afterwards.

As the chief agents in ordinary inspiration are the diaphragm and intercostal muscles, so the Nerves chiefly employed in conveying the stimulus given by the sensation in the lungs, must be expected to be the phrenic (which arise chiefly from the third and fourth cervical nerves, and descend along the fore part of the chest) and the dorsal nerves. As the sterno-mastoid muscle assists in elevating the whole chest, the trapezius in fixing the shoulders, and the serratus magnus in drawing the ribs towards the scapulæ, it must be expected that nerves supplying these muscles will be concerned. As the glottis is held open by the crico-arytenoid and thyro-arytenoid muscle, it must be expected that the recurrent nerves of the eighth pair, which supply these muscles, will be concerned; and, as the levatores labii superioris dilate the nostrils, it must be expected that some of the fibres of the portio dura, which supplies these, will be concerned. Accordingly, it has appeared in many experiments and observations by GALEN *, by CRUICKSHANKS †, by LEGALLOIS, by BELL, by MAGENDIE, and others, 1. That section of the phrenic nerve stops the actions of the diaphragm in inspiration; 2. That section of the spinal cord in the lower part of the neck stops the actions of the intercostal muscles; 3. That section of the spinal accessory nerve stops those of the sterno-mastoid and trapezius; 4. That integrity of the nerve called external respiratory, which has similar origins to the phrenic, and supplies the serratus magnus, enables the actions of that muscle to go on, after the spinal cord has been divided in the neck; 5. That section of the recurrent nerves, or of the par vagum above their origin, prevents the free opening of the glottis; and, 6. That section of the portio dura prevents the dilatation of the nostrils. The necessary agency of certain nerves supplying the other muscles concerned, *e. g.* the scaleni, lesser pectoral, levator and circumflexus palati, digastric, and genio-hyoid, &c. may be safely inferred.

Experiments on animals, and cases of injury or disease

* See HALLER, Elem. t. iii. p. 240.

† Phil. Trans. 1795.

in the human body, have also very frequently shown, that division of the dorsal portion of the spinal cord renders the movement of expiration feeble and ineffectual for many purposes to which it is commonly applied.

Both by experiments on animals, of the class Mammalia, and by cases of injury of the human body, it has been ascertained, that division of the spinal cord above the origin of the phrenic nerves, palsies all the respiratory movements of the chest, and so causes sudden death. In birds, where the muscles corresponding to the diaphragm are of little avail, and respiration is entirely dependent on motion of the ribs, destruction of the dorsal portion of the spinal cord is fatal as quickly, and in the same way. In fishes, on the other hand, where the organs moving the gills have all their nerves from the medulla oblongata, the injury which palsies their respiratory movements must be as high as that part of the nervous system *. But there is no injury, except that of the origin of the eighth pair, which instantly, and in all animals, palsies the whole combination of respiratory motions; no doubt because there is no other, which puts an end to the sensation which is the common cause of them all.

It is supposed by Mr Bell, that the nervous fibres, which excite the different respiratory muscles in obedience to the sensations of the lungs, are distinct from those which move the muscles in obedience to the will; and that they excite and combine the respiratory movements, because they originate exclusively in the lateral columns of the spinal cord, from which the great sentient nerve of the lungs (viz. the eighth pair) also arises. But the proof of these points is essentially defective; and it will afterwards appear, that the circumstances of two nerves having any such peculiar bond of connexion at their root, if it were proved, would furnish no adequate explanation of their acting in contact with, or in obedience to, one another.

We do not, therefore, pretend to explain why the sensation caused by the venous blood in the lungs, should always

* Flourens, in Annales d'Histoire Naturelle, t. xiii.

excite that extensive combination of muscular movements only, by which it can be appeased; but it is obvious, as Mr Bell observes, that in Man, as in other animals, where the provisions for the reception of air are partly dependent on the nervous system, the nerves and muscles employed for this purpose are "put under the guidance of a Sensibility, more certain and more powerful in its effects than the Will."

The lungs in the living and adult state, having air in contact with their inner surface only, are always distended somewhat beyond the dimensions which they assume when the pressure of the atmosphere is allowed to act on their outer surface also, as by puncturing the chest. When the chest is enlarged, the air which they contain is rarefied, fresh air enters by the trachea, by reason of its own gravity and elasticity, and the lungs are farther expanded. This expansion, when the motion of the diaphragm is free, is chiefly in the longitudinal direction; so that the lungs slide on the pleura costalis.

When the access of air to the interior of the lungs, or of part of the lungs, is prevented either by closure of the glottis, obstruction of one of the bronchiæ, or occlusion of part of the air-cells, although the usual effort be made, the movement of inspiration is wholly or partially prevented; not because the air within the chest is a cause of that movement, but because the pressure of the air without the chest is an effectual obstacle to the movement, when no air is admitted into the interior to counterbalance it.

The passage of the air through the bronchiæ, and into the cells of the lungs, causes a gentle murmur, perceptible on applying the ear to any part of the chest where it is going on, but which is not perceived when the subjacent portion of lungs is impervious to air; and is easily altered by disease either of the substance of the lungs, or of the bronchiæ of the part, especially by morbid effusions.

The reasons which have led several physiologists to think that the lungs are not merely passive in the acts of Respiration, are—1*st*, That after the chest has been fully opened, and all motion of the lungs on the principle of suction necessarily prevented, movements in them corresponding to the respiratory efforts have still been seen in living animals *. 2*dly*, That the respiratory murmur is in some individuals observed to be subject to sudden changes, for which no causes appear so probable as partial vital contractions of the cells of the lungs, or smallest bronchiæ †. But if any action of this kind in the lungs themselves does accompany the respiratory movements of the parietes of the chest, it must be to a very small extent only, because exposure of the surface of the lungs to the atmosphere very speedily causes death by suffocation, *i. e.* by stopping the admission of air to the lungs.

From the experiments of Jurine, Menzies, Thomson, Gordon, and others, it appears that the average bulk of air entering the lungs at each ordinary inspiration of a healthy man, is about 40 cubic inches; and if there be 20 such inspirations in a minute, this gives 1,152,000 cubic inches of air, or about 666½ cubic feet, drawn into the lungs in a day. It appears also, that not more than one-eighth part of the air contained in the lungs is changed by each respiratory act, not less than 280 cubic inches probably remaining in the lungs at the end of each ordinary expiration.

Although little of the inspired air can pass, at each inspiration, into the minute bronchiæ, or cells of the lungs, yet as it is now ascertained, that gases placed in contact mutually penetrate each other according to a fixed law ‡, a rapid communication will necessarily take place between the contents of the larger bronchiæ and the minutest air-cells; and as it appears, likewise, that gases readily enter fluids, when brought in contact with them, and pass out of fluids

* Williams in Edin. Med. and Surg. Journal, vol. xix. p. 353.

† Laennec, Traité d'Auscultation, &c. tom. i. p. 188.

‡ See Dr Mitchell on the Penetrativeness of Fluids, in American Journal of Medical Sciences, vol. vii.; Graham on the Law of the Diffusion of Gases in Edin. Phil. Trans. vol. xii.; and Stevens on the Blood, p. 72.

when exposed to other gases, it is certain that, on simply physical principles, much interchange of the component parts of the blood and the air must be expected at the lungs.

II. The results of very numerous experiments on the changes effected on the Air by Respiration may be stated thus:

1. It appears from the experiments of Edwards and others, that a slight and variable diminution of the whole bulk of the air in which an animal breathes, even in ordinary circumstances, generally takes place. When the air becomes vitiated, and the breathing difficult, this diminution is greater, probably because the lungs, in these circumstances, are not completely emptied. The proportion of oxygen in air that has been breathed is ascertained, and compared with the ordinary proportion, by different eudiometers; and the proportion of carbonic acid by exposing the air over mercury, in a graduated tube, to aqua potassæ, which absorbs the acid.

2. The proportion of azote, in air that has been breathed, has appeared in many experiments to be the same as in the atmosphere in general, and therefore it has been supposed that this gas is neither absorbed nor exhaled at the lungs; but Dr Edwards' experiments coinciding with those of several other physiologists, have shewn, that, on some occasions, there is a small increase, and on others, a small diminution, of the azote of the air breathed *; and experiments made by Allen and Pepys have shewn, that when oxygen, or a mixture of oxygen and hydrogen, is breathed, azote appears in the expired air; and these points being established, it becomes highly probable that there is always a certain degree both of exhalation and absorption of azote. In experiments made recently by Despretz and by Collard de Martigny, a pretty uniform exhalation of azote was observed †. In the respiration of fishes, it ap-

* De l'Influence des Agens Physiques sur la Vie, p. 420, *et seq.*

† Journal de Physiologie, tom. iv. et x.

pears, from the experiments of Humboldt and Provençal, that there is, more generally, a considerable absorption of azote *.

3. The proportion of carbonic acid in air that has been once breathed, has been found to vary from 3 per cent. to nearly 10 per cent.; but in ordinary respiration does not appear to exceed 3.5 per cent. The whole average quantity of carbonic acid given off in 24 hours, by the respiration of an ordinary sized man, appears to be about 40,000 cubic inches, which weigh nearly 3 lb., and contain about 11 ounces of carbon. The quantity of water exhaled from the lungs in 24 hours, has been estimated by Dr Thomson at 19 ounces, and by Mr Dalton at 24 †. If these estimates be correct, as they greatly exceed the whole daily loss of weight attributed to this function (see p. 97.), they indicate a considerable and habitual amount of absorption at the lungs.

4. It appears from the experiments of Dr Prout, Dr Fyfe, and Dr Edwards, that the quantity of carbonic acid thrown off from the lungs varies considerably from various causes, that it is greatest about mid-day, least about midnight, greater in middle age than in youth; that it is diminished by fatigue, by various weakening causes, and, at least in animals that do not hybernate, by external warmth.

5. Before the inquiries of Mr Ellis, and of Allen and Pepys, the most general result of experiments shewed, that the volume of carbonic acid that appears in air that has been breathed, is in general one-fifth or one-sixth less than the volume of oxygen that is found to have disappeared from it in the process ‡. The experiments of these last authors (chiefly confined to the human species) were thought sufficient to prove that the carbonic acid of expired air exactly equals in volume the oxygen that disap-

* Mem. d'Arcueil, tom. ii.

† See Bostock's Physiology, vol ii. p. 111.

‡ Ellis, Inquiry into the Changes induced on Atmospheric Air, &c, § 122.

pears; but the numerous and more diversified experiments of Dr Edwards and of Dulong have again led to the belief, that in the ordinary respiration of all animals, the volume of oxygen consumed is greater than the volume of carbonic acid that appears, although the amount of the difference is very variable and often slight *.

It is known that the volume of any given quantity of carbonic acid, is just the same as that of the oxygen which it contains; and therefore, when it was generally believed, that the carbonic acid of the expired air exactly equalled in volume the oxygen that disappeared, it appeared highly probable that the carbonic acid is formed by the union of its parts in the cells of the lungs, and that the chief office of the lungs is simply to excrete carbon, in a state admitting of its solution in the oxygen of the air. But now that it seems well ascertained, that more oxygen disappears than the carbonic acid that shews itself can account for, it becomes more probable that the carbonic acid is exhaled, as well as the water, ready formed, and that the oxygen that disappears is absorbed into the blood.

It is no sufficient objection to this opinion that a membrane intervenes between the air and the blood at the lungs, because, in various other instances, absorption of gases certainly occurs in the living body; and besides, the reddening of blood, and evolution of carbonic acid from it, take place from the action of air on it out of the body, and through a bladder; and although it is true that part of the carbonic acid appearing in that case may come from the bladder, yet it has been proved, that the quantity of carbon that escapes in that experiment is greater than the loss of weight of the bladder †.

The opinion, that the carbonic acid of expired air comes directly from the blood, and that the oxygen that disappears directly enters the blood, is strongly supported, not only by the inequality of volume between the oxygen that

* Edwards, p. 410, *et seq.* and Journal de Physiologie, t. iv.

† C. Williams in Edinburgh Medico-Chirurgical Transactions, vol. ii.

vanishes, and the carbonic acid that is evolved, but also by the following facts.

1. Experiments and observations by Dr DAVY * and others show, that when mixed gases are confined over different membranes in the living body, oxygen disappears more rapidly than the others, and in greater quantity than the carbonic acid subsequently found can explain.

2. In experiments by COUTANCEAU and NYSTEN † it appeared, that carbonic acid, in fully the usual quantity, may be exhaled from the human lungs, when the air taken into the lungs is, as nearly as possible, pure azote.

3. In many experiments by Dr EDWARDS, confirming more partial experiments of SPALLANZANI, it appeared that different animals which can exist for various periods of time in pure hydrogen, throw off from their lungs, when confined in such an atmosphere, nearly as much carbonic acid as when breathing in atmospheric air, and more than can possibly have existed in a gaseous form, in their lungs at the commencement of the experiments ‡. And a similar result was obtained by COLLARD DE MARTIGNY, from experiments on animals confined in azote §.

These statements are nearly decisive; yet there is one possible source of fallacy attending them, viz. that the carbonic acid which appeared in them, instead of being exhaled from the blood, may have been previously condensed in the cells in the lungs, in the manner in which various gases are known to become condensed in the pores of charcoal ¶. And if carbonic acid exist at all times in venous blood, it is difficult to understand why it should not be at any time extricated from it by the air-pump, and why the soda of the serum should not appear saturated with it.

We cannot therefore decide with absolute certainty whe-

* Philosophical Transactions, 1823.

† COUTANCEAU, Revision des Doctrines Physiologiques, &c.

‡ De l'Influence, &c. p. 442, *et seq.*

§ Journal de Physiologie, t. x.

¶ ELLIS, Farther Inquiries, sect. 611.

ther the carbonic acid of expired air comes directly from the blood, or is formed in the cells of the lungs; but it appears well ascertained that a part at least of the oxygen that disappears from the inspired air is directly absorbed into the blood.

The venous blood, and chyle, which enter the lungs by the pulmonary artery, thus appear uniformly, and in all animals, to throw off these *binary* compounds of oxygen with carbon and hydrogen. The remaining constituent of this compound fluid, azote, must of course exist in the arterial blood which leaves the lungs by the pulmonary veins in an increased proportion, and the elements are probably better adapted for entering into these *quaternary* combinations which exist in different textures. Accordingly the crassamentum of the blood, and especially the fibrin of the crassamentum, are in greater proportion in the arterial blood. These are the most animalized of the constituents of the blood, and probably the seat of its vital properties.

III. In order to have a precise knowledge as to the purpose served by respiration in the animal economy, it is necessary to attend to the successive steps of the process by which life is extinguished,—not when an animal is confined in a limited quantity of air, and therefore soon breathes an atmosphere loaded with carbonic acid, which is a poison, but when the access of air to the lungs is in any way simply prevented; *i. e.* the process of death by Asphyxia, or beginning at the lungs.

The experiments of BICHAT, BRODIE, and others, have satisfactorily shewn, that a quantity of the blood sent from the right side of the heart to the lungs, although not arterialized there, passes on to the left side of the heart, and is propelled into the arteries; and that *as soon as this venous blood reaches the brain, the animal becomes insensible*, and generally convulsed *. But the circulation of venous

* BICHAT, Recherches Physiologiques, Art. 7.

blood becomes gradually weaker, and, in warm-blooded animals, ceases after a very few minutes; not, however, as BICHAT supposed, because the venous blood has penetrated the muscular substance of the heart, and destroyed its vital power, but because the *venous blood has failed to penetrate the substance of the lungs*, and is no longer delivered to the left side of the heart in sufficient quantity to maintain the circulation *.

Accordingly, immediately after death from this cause, the blood is found accumulated in large quantity, not in the left side of the heart and aorta, but in the lungs, right side of the heart and great veins, indicating that the stop to the circulation had been in the lungs. And for some minutes after the circulation has ceased in a warm-blooded animal, it is still possible to restore it by blowing air into the lungs, which would not have been the case if the cause of the failure of circulation had lain at the heart †.

Venous blood, penetrating the substance of muscles, appears from the experiments of Dr KAY, and from some of those of Dr EDWARDS ‡, to support their irritability in some degree, although less effectually than arterial blood.

It appears from these facts, that in death by asphyxia, the deleterious influence of venous blood is exerted first on the nervous system; next, and most fatally, on the circulation in the capillaries of the lungs (as was already remarked, p. 36), and, in a less degree only, on the heart, or other muscular parts. Both the animal and organic life are thus dependent on the arterialization of the blood, which penetrates the textures concerned in them; but the dependence of animal life on this process is more immediate, perhaps simply because the nervous system is a more delicate texture, and the changes which take place in it more easily arrested by any noxious influence. The lungs

* See KAY's Experiments on Asphyxia, Edinburgh Medical and Surgical Journal, vol. xxix, pp. 42, 46.

† See ROESLER, in Edinburgh Medical and Surgical Journal, vol. xxiii., and GOODWYN's Answer to BICHAT, ditto, vol. xxxiv.

‡ De l'Influence, &c. Part. i. Chap. i., and Part. iv. Chap. iv.

suffer more than the heart, perhaps merely because every part of their structure is more completely penetrated by, and exposed to the influence of, the venous blood.

In these ways, venous blood admitted into the arterial system is more injurious than the simple failure of the circulation, as appears from what is observed in the human body in some cases of very profound syncope, but in a much greater degree in hybernating animals;—where an almost total suspension both of circulation and respiration can be borne with impunity, much longer than the privation of air can, when the circulation is vigorous.

The experiments of CRUICKSHANKS *, BICHAT, BRODIE, and others, show farther, that in what is properly called death by Coma, or beginning at the brain, where the primary change is gradually increasing insensibility, the circulation survives the respiration, and comes to a stand in the same way as now described, and from the same noxious influence of venous blood. This is indeed sufficiently proved by the effect of artificial respiration,—often practised on animals since the time of FONTANA,—in maintaining the circulation, long after it would otherwise have ceased, when the functions of the brain have been suspended, or when the head has been cut off. But the blood becomes venous in the case of death by coma, not because the air cannot enter the lungs, but because the sensation which prompts to the act of respiration is extinguished, and the lungs are not expanded to receive it. In the one case, the sensibility fails because the blood has become venous; in the other, the blood becomes venous because the sensibility has failed. The Organic Life is extinguished in the same way in both cases, viz. by the circulation of venous blood; but the extinction of Animal Life is, in the one case the consequence, and in the other the cause, of the failure of respiration †.

In the case of approaching death by coma, from an in-

* Philosophical Transactions, 1795.

† See BICHAT, Recherches, &c. Art. 10.

jurious influence acting primarily on the nervous system, the blood may therefore be arterialized, and kept in motion for a time, by artificial respiration, after the natural respiration has ceased; and, if the cause which has extinguished sensibility has been only temporary, the organic life may in this way be maintained, until the effect of that cause on the nervous system, and on the animal life, has gone off, and the natural mode of breathing been resumed;—as has been shewn by the recovery, thus effected, of animals under the influence of narcotic poisons, by Mr BRODIE *, and in one case of apparent death by opium, in the human body, by Mr WHATELY †.

It appears from the experiments of Mr BROUGHTON ‡, that when pure oxygen is breathed so long that the blood is arterial even in the veins, the nervous system is affected as by a narcotic poison, and death takes place by coma in the way now described; so that the effect of an excess of oxygen absorbed into the blood, upon the brain, is very similar to that of carbonic acid; and a certain dilution of oxygen by azote is necessary to qualify it for producing that change on the blood, which enables it to maintain the vital action of the nervous system. A standard degree of purity is therefore as necessary a condition to vitality, as a standard temperature, of the atmosphere.

CHAPTER X.

OF ANIMAL HEAT.

IT is evident that one of the changes continually in operation, in living animals, is an evolution or disengagement of caloric, whereby their temperature is generally kept above that of the surrounding media, and the effect of

* Philosophical Transactions, 1812.

† London Medical Observations and Inquiries, vol. vi.

‡ Quarterly Journal of Science, April 1830.

which is much aided, in many animals, by the nature of their coverings, and by the thickness of the adipose texture beneath them.

As the formation of carbonic acid, by union of its constituents, is a process which is attended with evolution of heat in all other circumstances where it occurs, and as the ordinary temperature of different classes of animals appears strictly proportioned to the amount of oxygen which they consume, and of carbonic acid which they exhale, it has generally been supposed, since the time of Dr BLACK, that the union of carbon and oxygen to form the carbonic acid of the expired air, is at least a great source of the heat of animals.

This is strongly supported by the fact, that animals in a state of winter torpor, or in a state resembling that, when their respiration and circulation are slow and feeble, and their temperature very low, may be roused by exciting sensations,—even by the sudden application of intense cold,—and in proportion as their respiration becomes more frequent and fuller, and their circulation stronger, their temperature rises, often by many degrees, while that of the surrounding air is unchanged or even lowered *.

Farther, some of the observations made on the temperature of animals, in which the circulation has been maintained, after apparent death, by artificial respiration, seem to leave no room for doubt as to the influence of this cause on animal heat; because they show that when the insufflation of cold air into the lungs is not too frequently repeated, and is successful in maintaining the circulation, it may materially retard, instead of accelerating, the cooling of the animal †.

But there is a difficulty in understanding how a cause which appears limited to one organ, should produce the

* See EDWARDS, De l'Influence, &c. Part iv. Chap. 10.

† See particularly Experiments by Dr HASTINGS, in Dr WILSON PHILIP's Experimental Enquiry, p. 223; by Dr HALES, in London Medical and Surgical Journal, 1814; and by Dr C. WILLIAMS, in Edinburgh Medico-Chirurgical Trans. vol. ii.

elevation of temperature which is general over the body. For, although it appears from the observations of Dr DAVY, and others, that the temperature of arterial blood in the chest, is about 1° higher than that of venous; and that the temperature of the chest is generally several degrees higher than that of the extremities; yet this difference is certainly not so great as would be found, if the only calorific change were at the lungs, and the rest of the body were only warmed by the superior temperature of the arterial blood flowing thence.

But it is to be observed here,

1. That if, as appears most probable from the facts already stated, the carbonic acid that is exhaled from the lungs is not formed there, but chiefly at least, throughout the capillaries of the system, the evolution of heat from this source must be expected to take place generally over the body, wherever the arterial blood becomes venous.

2. That even although the whole calorific change be at the lungs, if, as Dr CRAWFORD endeavoured to show, arterial blood has a greater specific caloric than venous, the blood which becomes arterial at the lungs will necessarily absorb the greater part of the caloric evolved by the change on the air there, and only set free this caloric in the capillaries of the system, where it becomes venous again. And although Dr DAVY's estimate of the difference of specific caloric in arterial and venous blood, is much less than Dr CRAWFORD's, yet even he has assigned a higher specific caloric to arterial blood; and no great reliance can be placed on any estimate of the exact difference.

But although there appear sufficient grounds for believing, that the formation of the carbonic acid which is exhaled at the lungs, is one essential element in the process by which the heat of animals is maintained, yet it is very doubtful whether this is a sufficient cause for the whole caloric which is evolved in their bodies. The experiments of DULONG and of DESPRETZ, made by enclosing a small animal in a box placed in water, measuring and analyzing the air which it inspired and that which it expired, observing the elevation of the temperature of the water which corresponded to the evolution of a given quantity of carbonic acid from its lungs, and comparing this with the estimate, obtained in a nearly similar way by LAVOISIER, of the quantity of caloric evolved by the combustion of a given quantity of carbon,—lead to this result, that the quantity of carbonic acid thrown off in a given time from an animal, is sufficient to account for nearly three-fourths of the caloric which the animal evolves (from 74 to 75 per cent.), but not for the whole of that caloric *.

It is highly probable, that *several* of the chemical changes which are wrought on the blood, during the greater circulation, are attended with an evolution of caloric †; and that the application of oxygen to the blood, in respiration, is essential to the animal heat, not simply by combining with carbon, and so generating heat, but by adapting the blood for the maintenance of the *various processes* (partly chemical and partly vital), by which it is to be changed in the living body; and of which one of the results is, the formation of the carbonic acid which appears in the expired air.

The temperature of the body is not raised by voluntarily increasing or quickening the act of respiration; but it is raised by voluntary exertions of other muscles, which accelerate the circulation, and so necessitate an increased frequency of respiration; and this appears to indicate, that it is dependent, not simply on the application of oxygen to the blood, but on the changes which take place during circulation, and to the maintenance of which, the oxygenation of the blood is one essential condition.

The evolution of heat in the animal body has been found in the experiments of Mr BRODIE and others, as well as in numerous cases of disease in the human body, recorded by Mr EARLE and others, to be much influenced by injuries of the nervous system, being generally diminished in those animals, or in those parts of the human body, in which the chief functions of the nervous system have been lowered or suspended; but in a few cases, being increased in consequence of such

* Journal de Physiologie, t. iii. & iv.

† See C. WILLIAMS, Edin. Medico-Chirurg. Trans. vol. ii.

injuries. But as we know that the circulation, and especially the circulation in the capillaries, and that secretion and nutrition, are easily and variously affected by injuries of the nervous system, we can readily understand this farther influence of such injuries; without being obliged to suppose that any influence derived from the brain or nerves is essential to animal heat, or that chemical principles are inadequate to explain it. Accordingly, in numerous experiments by CHOSSAT, it appeared, as a general result, that the injuries of the nervous system, which lower the temperature of animals, are the same which manifestly diminish the processes of secretion and nutrition *.

In Mr BRODIE'S experiments, after the head of an animal was cut off, and the circulation maintained by artificial respiration, repeated at least as frequently as the natural breathing of the animal, the cooling of the animal was accelerated, although the usual quantity of carbonic was thrown off for some time. But, according to the most probable opinion, already stated, as to the source of the carbonic acid of expired air, what was thus thrown off had been formed previously, and the changes leading to the formation of fresh carbonic acid were suppressed by the injury.

It is necessary to distinguish carefully between the power of generating heat in the animal body, and the power of bearing cold. The former appears to be a chemical effect of the changes which take place on the blood in the living body, and is directly proportioned, so far as observations have gone, to the vigour with which the Circulation and Respiration, or the analogous functions in lower animals, are performed. It is greatest and most enduring at the age of greatest strength, and during winter, in those animals which preserve their strength and activity in that season, —the velocity of their circulation and their consumption of air being at the same time augmented. The latter appears to be an original endowment of the living solids, varying in different kinds of animals, and in different states of the

* Memoire sur l'Influence du Systeme Nerveux sur la Chaleur Animale.

same; and is greatest in cold-blooded animals,—in animals that hybernate during their state of torpor,—and in the young of warm-blooded animals; *i. e.* in cases where the circulation is languid, or easily depressed: it varies therefore nearly in the inverse ratio of the power of generating heat *.

Animals possess the power of maintaining their own temperature, not only when that of the surrounding air is lower, but also when it is higher than themselves; and in the experiments of Sir C. Blagden, De la Roche, and others, a temperature approaching to, or even exceeding, that of boiling water, has been borne by the human body, for many minutes, without more elevation of the temperature of the skin than 4° of Fahrenheit. The experiments of De la Roche and Berger † have shewn that a lower temperature than that of the air is in like manner maintained by moist and very porous substances, although not endowed with life; and again, that when hot air is saturated with humidity, so as to allow of no evaporation, the temperature of animals confined in it is raised, and they are soon killed. This power of resisting the influence of high temperatures seems therefore to be owing entirely to the increase of evaporation from the surface, and the cooling effect of that process.

CHAPTER XI.

OF DIGESTION.

The processes of Nutrition and of Excretion, already considered, manifestly require, in the human body as in all living beings, that the nourishing fluid should not only be regularly purified by exposure to air, but also receive fre-

* See Edwards, De l'Influence, &c. Part i. Chap. ii.; Part iii. Chap. i, ii, iii, iv; and Part iv. Chap. vii.

* Journal de Physique, tom. lxiii, lxxi, lxxvii.

quent supplies both of solid and fluid materials, to compensate for the continual losses which it undergoes.

For the nourishment, probably of all animals, certainly of all of the higher classes, and even for the greater part of the nourishment of vegetables, at least under the present constitution of the atmosphere *, it is necessary that much of the materials taken into the system should have been previously organized. As the life of animals springs only from the life of others of their own species, so it is maintained only by the life of other organized beings.

It is further necessary, probably in all living beings, that the nourishment, received from without, should be acted on by the fluids of the body into which it has been taken, should be reduced, by their means, and by water from without, to a fluid form, and so far assimilated to them, before it is applied to the purposes to which it is destined.

All these objects are accomplished in vegetables, and perhaps in the lowest order of animals, without the appropriation of any particular organs to the reception of unassimilated nourishment, and without the aid of any appetites or other mental acts. The circumstance, in the life of animals, which appears especially to require a separate apparatus for the occasional reception and gradual assimilation of food, is their faculty of Locomotion, which precludes the possibility of their continual adaptation to the reception of solids and fluids from without, and makes it necessary that they should carry about with them, and gradually avail themselves of, the materials by which they are to be nourished. This condition in the economy of animals, therefore, imposes the necessity of the function of Digestion, as subsidiary to that of Nutrition †.

In all animals, the first part of the vital actions by which these objects are accomplished, is put under the guidance of Sensations; but as the solids and fluids, which are the subjects of digestion, are not always within the reach of animals, the muscular actions, by which these sensations are to be appeased, are not made directly consequent on

* See p. 136.

† See CUVIER, Leçon 16.

their being felt (as is the case with the movements of respiration), but are linked with the sensations by the more complex mental processes to which we give the names of Appetites and Instinctive propensities. And as it is dependent on these different mental acts, so this function differs from all those which we have yet particularly considered, in this important circumstance, that wherever it exists it is fitted and intended to be a *source of enjoyment*.

As the materials on which this function is to be performed are numerous and diversified, and the circumstances of the animals that perform it very different, so we observe great varieties, both in the mental and physical part of the process, in the different orders of animals. Without altering the general plan of the function, or even the essential parts of the organs concerned in it, Nature makes such additional provisions, in the instincts by which the reception of food is guided, and in the organs by which it is assimilated, as are suited to the circumstances in which each animal is placed, to the food on which it is to subsist, and to the ulterior purposes which it is to serve in the world.

For example, the agility, ferocity, and predatory instincts, and the canine teeth, high zygomatic arches, and strong temporal muscles of the carnivorous quadrupeds, with their short and simple alimentary canals, fit them for subsisting on prey which it is difficult to procure and to prepare for introduction into the stomach, but which requires no great chemical change to be wrought on it there, that it may be assimilated to the animal textures; while the quiet habits, the comparatively feeble limbs, and large bodies, the ruminating instinct, the deficiency of canine and incisor teeth, the complex stomachs, and long intestines of the ruminating animals, fit them for obtaining the greatest quantity of nourishment from vegetable matters, which they can easily procure, and easily reduce to the proper consistence for entering the stomach and bowels; but which must necessarily undergo much change there, before they can be applied to the nutrition of animals. Again, the camel and lama, which traverse the deserts, are instinctively led to swallow large quantities of water beyond what the purposes of their digestion and nutrition immediately require; and their first and second stomachs are provided with numerous cells, with muscular orifices, in which it is securely stored, until it is required to assuage thirst, or to assist the assimilation of food. And graminivorous birds, instead of having heavy jaws and teeth, for the requisite comminution of their food, are prompted by instinct to swallow gravel, and furnished with stomachs of extraordinary muscular strength, the action of which, aided by the attrition of the gravel, is effectual for the purpose.

The mental powers and inclinations, which lead the whole human race to practise the art of cookery, are equally a part of the plan of Nature, for the management of this function in our species, as any of the instincts of animals; and enable us to dispense with additional provisions, in the structure of the digestive organs, which would otherwise be necessary to secure the digestion of many articles of our diet.

The different actions, however, which immediately precede the reception of food and drink into the stomach, even in our species, are truly *instinctive;* that is, they are excited by mental determinations, which are linked to certain complex sensations,—to a combination of the simple feelings of hunger and thirst, with those which result from the sensible qualities, especially the taste and smell, of the objects by which hunger and thirst are to be allayed; and although very complex, they require no experience or education.

Hunger and Thirst, in the natural state, are sensations probably dependent on the nerves of the stomach almost exclusively; for although thirst is naturally referred to the mouth and fauces, it has been found, in cases where a preternatural opening has been made into the œsophagus from the neck, not to be relieved by any applications to the upper portion of the divided œsophagus, although quickly relieved in the usual way by drink taken into the stomach. They are not destroyed, but manifestly perverted, by section of the eighth pair of nerves. Thirst would seem to depend simply on want of the usual moisture on the mucous membrane, and is relieved by whatever is effectual in restoring the natural condition as to moisture. Hunger is certainly not dependent on the action of the solvent liquor of the stomach, already effused on the mucous membrane, because it is instantly destroyed by mental emotions, which cannot remove such a liquor; and besides, we shall see reason to think, that the solvent liquor does not usually exist in the stomach, at the time when hunger is most felt. It is probably connected with a particular state of the contraction of the muscular fibres of the stomach; but, according to the observations of MAGENDIE, at the time when it is most felt, the stomach is not strongly contracted on itself.

Whatever be the conditions under which the nerves of the stomach become the seat of these sensations, it is certain that, in the healthy state, they are a true index, not only to the state of the stomach, but to the immediate wants of the system at large.

The sensations excited by the smell, taste, or touch in the mouth, of alimentary substances, are naturally either agreeable or disagreeable, especially when hunger or thirst co-exist with them; but these feelings are susceptible of much alteration by custom and habit. These complex sensations, and accompanying mental emotions, produce two effects,—an increased flow of the secretions of the mouth and salivary glands,—and certain definite instinctive muscular contractions; and the different varieties of these sensations prompt to corresponding variations of the muscular actions that succeed them. It is because they give occasion to these instinctive muscular contractions, that these sensations are called Appetites. These actions, however, are always distinguished from those which depend on sensation simply, by this circumstance, that they are felt in ourselves, and inferred from observation in other animals, to be completely under the control of the will, even when the sensations, which prompt to them, are felt the most keenly. There is a propensity leading directly to the performance of a certain definite action, on each of these complex sensations being felt; but the particular mental act, called a Volition, always intervenes between the sensation felt, and the muscular action excited.

In this way, the contact of liquids with the lips excites, and the reception of liquids into the mouth is much promoted by, the instinctive but complex act of Suction, in which, by partially closing the lips, and either moving the tongue backwards and forwards after the manner of a piston, or by acts of inspiration, or by these two movements together,—we cause the pressure of the atmosphere to urge fluids into the mouth.

The contact, especially of solid food, with the interior of the mouth, excites also the act of Mastication, performed by alternating contractions of the muscles, which pull the lower jaw upwards towards the bones of the head and face, and downwards towards the os hyoides and sternum,—the jaw moving on its condyles as a lever of the third order, and subjecting the food to the pressure of the teeth.

The increased flow of the saliva and mucus by the mouth is unconnected with any act of instinct or volition, which never affects any secreting organs; but results directly from the complex mental feeling above described, and may be reproduced by the emotion, which forms a part of that feeling, even when that is excited by recollection, independently of any physical impression on the parts.

The experiments of Sir Charles Bell and Mr Mayo are quite satisfactory as to the dependence of the sensations of the lips and mouth on the ganglionic portion of the fifth nerve; —as to the dependence of the contractions of the temporal, masseter and pterygoid muscles, which elevate and close the lower jaw, on the anterior portion of the fifth, which does not pass through the Gasserian ganglion,—and as to the dependence of the motion of the lips and tongue on the portio dura and ninth nerve. The particular nerves concerned in the depression of the lower jaw by the digastric, genio-hyoid, and mylo-hyoid muscles, &c. have not been so clearly demonstrated.

We can have no doubt, that the increased flow of the saliva and mucus, consequent on the sensations and emotions described, is effected through the nerves of the salivary glands and mucous glands and membrane; and these are chiefly the ganglionic portion of the fifth, and branches of the eighth pair and sympathetics; but the influence of these nerves on the secretions has nŏt been distinctly elucidated by experiment.

The food, comminuted and moistened in the mouth by the means now mentioned, is prepared for the act of Deglutition, the first and most complicated part of which is also guided by an instinctive impulse. The food is first pushed back by the tongue, till it arrives within the sphere of action of the constrictor muscles of the pharynx; but at the same time that it is moved downwards by the successive contractions of their fibres, several other movements take place. 1. The passage of the fauces is narrowed by the contraction of the Constrictores Isthmi Faucium, in the anterior arches of the palate. 2. The Velum Pendulum Palati is raised and stretched by the Levator and Circumflexus Palati, so as to direct the food past the opening of the posterior nares. 3. The glottis is closed, partly by depression of the epiglottis, but chiefly by apposition of the arytenoid cartilages. 4. The larynx, and lower portions of the pharynx, attached to it, are drawn *upwards*, partly by the muscles connecting the larynx to the os hyoides and lower jaw, but more especially by the lowest of the constrictors, and by the Stylo-pharyngeus and Palato-pharyngeus; the moveable origin of the latter muscle in the velum pendulum being fixed at the time. By this combination of movements, the food or drink is rapidly and safely carried past the openings to the nares and lungs, and lodged on the lower part of the pharynx, after which its descent is slow.

Great part of this movement is distinctly voluntary, though prompted by instinct only; but the actions of the constrictor muscles of the pharynx in it appear to be strictly dependent on the sensation caused by the matter to be swallowed, when it touches the mucous membrane of the pharynx, because they cannot be correctly imitated by any voluntary effort, when there is no substance to be swallowed. The ninth and glosso-pharyngeus nerves are no doubt much concerned in this action, but the precise office of each nerve in these parts has not been ascertained.

In passing from the Pharynx to the Œsophagus, the food comes within the field of Organic Life, and its subsequent movements are neither excited by the will, nor attended by the consciousness of the individual. The essential parts of the whole canal through which it now passes, are the mucous membrane on which it moves, and the muscular coat, provided both with longitudinal and circular fibres, by which it is propelled, but which is much thicker and stronger in the œsophagus than in the stomach or intestines; and to these, in the abdomen, the serous coat is added.

The muscular action propelling the food is of the same general description in all parts of the canal,—each portion of the canal contracting as the food distends it, and continuing contracted until the portion next in advance has contracted also; but the rapidity of the motion is very various in different parts, and at different times. The lower part of the œsophagus exhibits, when exposed, continued gentle movements of contraction and relaxation, (perhaps the effects of sensation), dependent on the eighth pair of nerves, which form a plexus about the part, and ceasing on the division of these nerves *; on which account, after that operation, part of the food taken ascends to the pharynx. In a slighter degree, a similar movement in the stomach appears also to be determined by these nerves †. But no

* Magendie, Precis, &c.

† Breschet and Edwards in Arch. de Méd. 1825, and Tiedemann and Gmelin, Recherches sur la Digestion, sect. iii. p. 374.

such effect results from division of any nerves on the peristaltic movements of the intestines.

When the stomach receives the food, its great left sac is chiefly distended, its surfaces rounded, and its great arch thrown forward; and in this position it retains the food for a time, which is very various in different cases, letting successive portions escape by the pylorus, after they have undergone certain changes; which do not begin immediately after it is taken, and are not completed until several hours after an ordinary meal. The chief obstacle to the passage of undigested materials from the stomach, is the contraction of the circular fibres at the pylorus; and for this we can assign no cause but a peculiarity of the irritability of these fibres.

The sensations which prompted the reception of food and drink abate after they are received into the stomach, but not simply in consequence of its distention; probably rather in consequence of the increase and alteration of the secretion of the stomach thereby effected. They are more easily appeased by a small quantity of nutritious food, or of slightly stimulating drink, than by larger quantities of other matters. Different and more grateful sensations succeed them, which are certainly dependent on the eighth pair of nerves; because, when these are cut in the neck, the animal is not aware of the condition of his stomach, and continues to eat after that is distended with undigested food. The sensations which accompany and succeed the reception of food into the stomach, prompt to no muscular action, but are probably of importance in exciting the secretion of the stomach.

The materials on which the function of Digestion, in the human stomach, may be performed, are the chief proximate principles of animal and vegetable substances,—Fibrin, Albumen, Gelatin, Osmazome, &c., the vegetable Gluten, Starch, Gum, Extractive matter, Sugar, and animal or vegetable Oil. In regard to these the following facts demand attention.

1. They answer for the purpose of Digestion best, when

in a medium state of aggregation and density; hardened or dried food, solid albumen in any form, vegetables not softened by boiling, are acted on with difficulty in the stomach; and, on the other hand, very soft or liquid aliments seem to give but little stimulus to the digestive process. Of the different proximate principles, Oil is perhaps, in any form in which it can be taken, the most difficult of digestion.

2. It has been fully ascertained by MAGENDIE, LEURET and LASSAIGNE, and others, that a certain *variety* of articles, whether of vegetable or animal food, is necessary in various animals, on which experiments were made, in order that the due action of the stomach on them may take place, and that they may be effectual for the nourishment of the body; the animals that were fed on single chemical principles only becoming almost uniformly, after a time, unable to digest sufficient quantities of these for the support of life. The importance of the art of Cookery to the human species, no doubt, consists in its fulfilling these necessary conditions as to the consistence and the mixture of aliments.

3. According to Dr PROUT, all the articles of food which are used by the human species may be arranged, according to their chemical relations, under three heads, the Saccharine, the Albuminous, and the Oily; the first of which consists of carbon in different proportions (from 30 to 50 per cent.) chemically combined with water; the two last of compound bases also united with water; the carbon in some of the oils is nearly 80 per cent., and its proportion therefore varies, in the different aliments, from 30 to 80 per cent. The prototypes of these three classes of aliment exist in the milk; and of these three he thinks that a mixture of two at least must be taken, either together or soon after one another, to answer the purposes of Digestion and Nutrition.

4. There is much variety in individuals as to the kind of food that is found easy or difficult of digestion; and by repetition and habit, those kinds which are at first unsuit-

able, are very often found ultimately to become easy of digestion and nutritious. This is perhaps sufficiently explained by the connexion of the process with the sensations of the stomach, and by the general principle of the influence of habit on sensation.

When such food as is suitable for digestion has been received into the stomach of a warm-blooded animal, and is retained there in the usual way, the mucous membrane becomes more vascular than before, its villi prominent, and its cryptæ or minute cells appear full of their secreted fluid; and this increased flow of the secretion of the stomach is manifestly promoted in the first instance by rest.

When the stomach is examined two or three hours after food has been freely taken, the portion of the alimentary mass which lies outermost, or next the mucous membrane, is found most altered, and the central part least altered; but towards the pylorus the alteration of the whole contents is more uniform; apparently because the portions of food that have been acted on by the fluid at the surface of the mucous membrane, all round the stomach, pass gradually on to the pylorus, while fresh portions from the interior of the mass take their place on its exterior; and after being subjected to the same change, are pushed forwards in their turn *.

The change that is wrought on the food during this process is its conversion, more or less complete, into the homogeneous, greyish, pultaceous matter called Chyme.

It is satisfactorily ascertained by numerous experiments, of Montegre, Prout, Magendie, Tiedemann and Gmelin, Leuret and Lassaigne, and others, made on a variety of animals, using very different kinds of food, that this chyme, in the healthy state, is uniformly, though slightly, *acid.*

Farther, the following facts leave no room for doubt, that the acidity, found in the healthy state, does not depend on fermentation of the alimentary matters; and make it at

* Wilson Philip, Experimental Inquiry, ch. vii. sect. i.

least highly probable, that it depends on the nature of the secretion of the stomach itself.

1. The chyme is acid from the commencement of its formation, *i. e.* long before the same substances, kept at the same temperature, can have run into acetous fermentation.

2. The secretions of the living stomach, so far from promoting, at least the putrefactive fermentation, are decidedly antiseptic.

3. The acid found in the chyme is, for the most part indeed, the lactic, *i. e.* a modification of the acetous; but in part also it is the muriatic, which of course cannot be generated by fermentation *.

4. The presence of the same acids in the stomach is determined, not only by the reception of food, but by the excitation given by grains of pepper, or even by particles of sand †.

In fasting animals, it appears that this acid liquor is seldom found in the stomach, but its formation appears always to be excited, in the healthy state, by the presence of food in the stomach; and even its quantity to be greater, in proportion as that food is more difficult of digestion, if within the limits of the natural food of the animal ‡.

This enables us to understand, that the fluid taken from the stomach of fasting animals should often have been found, as in the experiments of Montegre, ineffectual in producing an *artificial digestion*, i. e. solution of the food, and formation of chyme, when mixed with alimentary matters at the temperature of the body; and yet that in many experiments of Reaumur, Spallanzani, Stevens, Leuret and Lassaigne, &c., alimentary matters introduced into the stomach in perforated balls or tubes, should

* Prout, Philosophical Transactions, 1824, and Annals of Philosophy, vol. xii.; Tiedemann and Gmelin, Recherches sur la Digestion.

† Tiedemann and Gmelin, Recherches, &c. sect. ii. p. 161.

‡ Ibid. sect. iii. p. 335.

have undergone digestion, evidently from the action of a fluid in the stomach; and that in those of TIEDEMANN and GMELIN, the acid chyme itself, beginning to form in the stomachs of animals recently fed, should have been found effectual for the artificial digestion, out of the body, of fresh aliments *.

The solvent power of the acid liquor formed in the stomach after the reception of food, is most clearly demonstrated by its having dissolved portions of the stomach itself after death, in various cases, both in the human species and in animals, where death has taken place suddenly during the act of digestion. But it is seldom, and perhaps never without disease of the secretion at the stomach, that any such solvent power is found to have been exerted where death has taken place during fasting †.

Some part of the aliment always passes the pylorus along with the chyme, unchanged; and according to the observations of LONDE ‡, made on the human body, in cases of artificial anus, animal food is longest retained and most altered in the stomach, and vegetable food passes out of the stomach more rapidly, and less changed, and probably undergoes more change in the intestines.

The chyme in the stomach appears to contain little or no matter having exactly the chemical properties of albumen, (unless albumen has formed part of the food taken), and therefore shews little approximation to the chemical nature of the blood ¶. But, according to the microscopical observations of LEURET and LASSAIGNE, it would seem to contain a number of globules, resembling those of the blood, and having the same tendency to arrange themselves

* Recherches, &c. sect. iii. Exp. 30 and 31.

† See CARSWELL on the Digestion of the Coats of the Stomach after Death, in Edinburgh Medical and Surgical Journal, October 1830; and GAIRDNER on Perforation of the Stomach, in Edinburgh Medico-Chirurgical Transactions, vol. i.

‡ Archives de Medecine, tom. x.

¶ See PROUT, in Annals of Philosophy, 1819; and TIEDEMANN and GMELIN, Recherches, &c. sect. iii. p. 344 and 388.

into fibres. And in the stomachs and intestines of the cold-blooded animals, these and other authors have described a number of globular bodies, which were thought to have a power of spontaneous motion, resembling animalcules *.

The passage of the chyme out of the stomach does not take place uninterruptedly, but by successive series of peristaltic movements along the stomach and duodenum, each of which is preceded by a series of slighter movements in the opposite direction †.

After passing the pylorus, and mixing with the Bile and Pancreatic Juice, which slowly distil into the duodenum, and with the Mucus of the Intestines, the Chyme and undissolved aliments gradually separate into the Chyle, which is absorbed into the lacteals, and the Feculent matter, which passes on to the large intestines; and the more watery portions of the chyme seem to be absorbed away from the rest chiefly by the veins, both of the stomach and intestines.

The peculiar matter of the bile appears manifestly to connect itself with such substances as have passed unchanged from the stomach, and to become part of the feces ‡; and is no doubt useful, by stimulating both the mucous secretion and the peristaltic movements of the intestines. The free alkali of the bile and perhaps of the mucus unites with the acids of the chyme, and also with any oil which the chyme may contain; and it is probably in part from this cause that the acidity of the contents of the canal gradually disappears in the small intestines §. The white colour often seen in part of the contents of the intestines, as well as in the lacteals, appears to rise chiefly from oily articles of food uniting themselves with the alkali ||.

It appears, on comparing the experiments of Mr Brodie, Mr Mayo, Magendie, Leuret and Lassaigne, and Tiede-

* Recherches pour servir à l'Histoire de la Digestion.

† Magendie, Precis. ‡ See p. 89.

§ Prout, Tiedemann and Gmelin.

|| Tiedemann and Gmelin, Magendie.

MANN and GMELIN, that after the biliary ducts are tied in animals, a matter, possessing the chief properties, though not the usual white colour, of chyle, may be formed, and digestion go on to a certain degree; but cases of jaundice, without organic disease, in the human body, seem sufficiently to indicate, that digestion in these circumstances is imperfect.

As the Pancreatic Juice contains much albumen, and as it is found most abundantly in herbivorous animals, which have no albumen in their food, it is thought probable that a greater portion of it, than of the bile, goes to the formation of the chyle. It is certain, from the experiments of Dr PROUT, that albumen is found in larger proportion, and more distinctly formed, in the fluid of the small intestines, during digestion, than in the stomach; that it is found still more distinctly, and in larger proportion, in the lacteals and thoracic duct; and that it is not found at all in the larger intestines. The organic globules described by LEURET and LASSAIGNE, and which are probably composed chiefly of albumen, or animal matter closely resembling it, were also seen much more abundantly in the contents of the small intestines than of the stomach.

The chyle, which is found in the lacteal vessels, certainly contains very numerous globules, similar to those in the blood, but of a white or grey colour; and the formation of these globules is probably the main object of the whole process of digestion. After passing through the mesenteric glands, and in the thoracic duct, *i. e.* when it must have been mixed with the contents of lymphatic vessels, and probably with some of the contents of arteries *, the albuminous contents of the chyle are more distinct; it contains a little fibrin, and coagulates on exposure to air, after the manner of blood, although less firmly; and is now slightly alkaline †. Its composition, in the thoracic duct of a dog, fed on animal food, is thus stated by Dr PROUT:

* See p. 61. † TIEDEMANN and GMELIN, sect. iii. p. 385.

Water,	89.2
Fibrin,	.8
Incipient Albumen,	4.7
Perfect Albumen,	4.6
Salts,	.7
	100.

The proportion of animal matter in the chyle from vegetable food is less.

According to TIEDEMANN and GMELIN, the acidity of the mixed fluids of the intestines, which disappears in the course of the Ileum, re-appears in the Cæcum; and as there is necessarily a considerable delay in the passage of the contents of the bowels at this point, particularly in herbivorous animals, in which the cæcum is in general more developed than in man, it is probable that some fresh chyme is formed here, and partly converted into chyle as it passes along, and is absorbed from, the great intestines.

From the experiments of MAGENDIE and CHEVREUL, it appears that oxygen and azote exist in the stomach during digestion; but that, in the lower intestines, the oxygen is found to have wholly, and the azote partly, disappeared,—and that they are replaced by carbonic acid, hydrogen, and carburetted hydrogen, with sometimes a little sulphuretted hydrogen.

It is still doubtful whether these gases have been in part secreted by the intestines; but it seems beyond doubt, that part of those which exist in the stomach must be absorbed in the bowels.

As the Chyle is mixed with the blood just before its entrance into the lungs, and is never recognised in blood that has passed through the lungs, it appears highly probable that a change takes place on it there, which completes its assimilation; and as nourishment of animal textures, of which azote is a constituent, may be effected without the use of any food known to contain azote, and as we have seen the possibility both of absorption and exhalation of azote at the lungs, and that fishes, which have less access to air than terrestrial animals, habitually absorb a quantity of the azote of the air they breathe,—it has been naturally conjectured, that the addition of azote from the atmosphere to the blood at the lungs, is a part of the process of assimilation there; but no satisfactory evidence of such an action at the lungs has been obtained.

The examination of the course of the lacteals, in all the vertebrated animals, and the experiments of Dupuytren and others, in which ligature of the thoracic duct (where that was single), was followed by rapid emaciation and death, leave no room for doubt that the main course of the chyle absorbed from the intestines, is through the Thoracic Duct to the Subclavian Vein. But on the other hand, that some admixture of the contents of the lacteals with those of the bloodvessels takes place in the mesenteric glands, appears probable,—from the structure of these glands, formerly described,—from the change observed in the chyle by Tiedemann and Gmelin, after it has passed through these glands,—from streaks of white matter, resembling chyle, having been observed, particularly by the same physiologists, in the larger mesenteric veins,—and from the result of two experiments of Leuret and Lassaigne, in one of which a dog recovered after ligature of the thoracic duct, and no auxiliary duct could be discovered; and in the other, after ligature of the vena portæ, blood was found in the Receptaculum Chyli, and lower part of the thoracic duct.

It is at all events nearly certain that, during digestion, there must be a great increase in the quantity of fluid passing from the mesenteric veins into the vena portæ and liver, for two reasons, 1. Because, in the distended and excited state of the stomach and intestines, the quantity of blood entering these veins from the arteries is much increased. 2. Because much, of the thinner fluids at least, received into the stomach, is absorbed by these veins.

But the branches of the vena portæ, within the substance of the liver, cannot be much distended; and therefore it is to be expected that, during digestion, either the contents of the gastric and mesenteric veins, leading to the liver, will stagnate and distend these veins, or else, if their blood makes its way readily through the vena portæ and liver, that other branches of the vena portæ must suffer distention in their stead.

Now, there is no evidence of any great distention of the gastric and mesenteric veins themselves during digestion; but it appears from the observations of BICHAT, Sir E. HOME, LEURET and LASSAIGNE, and others, that the *spleen* becomes obviously engorged with blood during that process, or even after copious draughts of liquids.

These considerations have induced LEURET and LASSAIGNE to think, that the chief use of the Spleen (which is known not to be of essential importance in the animal economy, as animals bear its extirpation without much inconvenience, but which is obviously an appendage to the stomach, intestines, and liver), is to suffer venous congestion, instead of the bowels themselves, during digestion, and thereby to allow the venous circulation through the liver to be equable and uniform, notwithstanding that the source whence the venous blood comes thicker is liable to so great variation. And the very vascular and distensible structure of the spleen, the great size of the vein leading from it to the liver, and the correspondence of its diseases to those of the liver, may be stated as farther evidence in favour of this hypothesis.

It is important to be aware, that the time in which the process of Digestion is completed, and probably the amount of nourishment procured by it from a given quantity of food, vary considerably in individuals in perfect health.

We must not suppose that we understand the whole change which is wrought on the food taken into the stomach, when we have stated its chemical changes, and its course, up to the time when it is finally mixed with, and assimilated to, the blood. As we found that the blood possesses truly Vital properties, so we can have no doubt that, during the process of digestion, these properties are communicated to a part of the nourishment taken, probably to that part of it which takes the form of *globules*.

The process of Digestion is much influenced by mental

Emotions and Sensations; but no part of it is influenced by any Voluntary efforts of mind, from the time that the food enters the œsophagus, until its residue, unfit for assimilation, along with the biliary matter, and some part of the other secretions of the alimentary canal, arrives at the rectum.

The rectum is closed by the permanent tonic contraction of the sphincter ani, which is strictly a voluntary muscle, and the relaxation of the usual contracted state of which is within the power of the mind.

When the sphincter is voluntarily relaxed, the peristaltic movements of the rectum, excited by its distention, suffice, in general, for the expulsion of the fæces.

The sensations which the feculent matter here excite, are more distinct than those excited by it in the higher parts of the canal. When felt more distinctly than usual, they give occasion, in the first instance, to an effort which is truly instinctive, by which the sphincter ani is forcibly closed, and their escape prevented; but when these sensations become intense, they excite, more directly, a contraction which is quite involuntary, of different and distant voluntary muscles,—viz. of the diaphragm, which descends as in inspiration,—of the arytenoid muscles, which close the glottis and keep the chest distended,—and of the abdominal muscles, which, acting against the contracted diaphragm and distended chest, forcibly compress the viscera, and aid the peristaltic movements of the rectum in expelling the fæces.

The influence of the sensation of the rectum in producing this movement is well seen in the tenesmus which results from the increased sensibility of the mucous membrane of this part when inflamed, although little or nothing be passing along it.

The discharge of urine from the bladder is in like manner prevented, in general, by the tonic contraction of the levatores-ani muscles, and of those called acceleratores urinæ, and muscle of Wilson, (probably much more than of any of the fibres of its own muscular coat, which is strictly involuntary), and at times more forcibly restrained by voluntary contractions of these muscles, which compress the origin and first part of the urethra. The bladder is emptied, in ordinary circumstances, simply by voluntary relaxation of these, giving effect to the contraction of its own muscular coat, which is caused by the distention and irritation of its mucous membrane; but when the sensation resulting from distention of the bladder is intense, or when the sensibility of its mucous membrane is much increased, or the discharge of the urine difficult, the same simultaneous action of distant muscles is excited, as in the case of the rectum, to secure the forcible evacuation of the bladder.

When the function of Digestion is suspended by the denial of aliment, but thirst is allayed by drinking water, the consequences are, gradually increasing emaciation and debility; a sense of faintness takes the place of hunger; all the functions are performed slowly and imperfectly; the tunica conjunctiva of the eyes becomes inflamed (probably from the deficiency of secretion, and consequent action of the air on the membrane), and death takes place very gradually, at very different times after the last food was taken; but, in the human species, sometimes not until after forty days or more. Much longer fasting has no doubt been borne in some cases, chiefly by persons in whom the vital functions had been previously languid; but the moral evidence of many reported cases of the kind is doubtful. After death the most remarkable appearances, besides the mere wasting and deficiency of blood in the vessels, are, the distention of the gall-bladder by bile (the flow of which is neither solicited, as in the natural state, by irritation of the mouth of the ductus communis choledochus, nor promoted by the distention of the stomach); the contracted state of the stomach and bowels; and frequently marks of inflammation in their mucous membrane; probably the effect of deficient secretion on that membrane, and consequent irritation by their contents.

The effect of total abstinence both from food and drink is to produce febrile excitement, perhaps a more active inflammation of mucous membranes, and subsequently a more rapid depression of strength, and death in less than half the time above stated.

CHAPTER XII.

OF THE EXTERNAL SENSES.

Having completed the view of those functions which are concerned in the preservation of the organized frame, we proceed to a more detailed account of the strictly Animal Functions, which are connected with the Nervous System in the living body, and are manifestly the object of Nature in the construction of the animal machine.

The general conditions requisite for all the Sensations, viz. the circulation of arterial blood in the parts concerned, the presence of certain nervous filaments, and integrity of these up to the base of the brain, have been already stated. Some farther condition in the state of the Nervous System is certainly necessary, although it has not been detected; for cases frequently occur where, notwithstanding the presence of all those mentioned, the nerves of sense are unfit for their office.

The word Sensation is properly restricted to that kind of change in the state of the mind which immediately follows, and informs us of, an impression on any of the organs of sense. A little attention to what passes rapidly in the mind on these occasions, enables us to recognise the important distinction drawn by Dr Reid and others, between this change, in which the mind is truly *passive*, and the judgment we are immediately led to form of the external existence, and the notion we are often led to form of the nature of the cause of the feeling which we experience; *i. e.* of the quality of some external object which it immediately suggests to us, and of which, through it, we have the *Perception*.

Various other mental acts, such as the Consciousness of our own existence, the recollection of past sensations, and belief in our own identity, the general notion of Time, connect themselves, even with some of the simplest acts of sensation. And as almost all sensations are either pleasant or painful, and many very fruitful sources of pleasure, they constitute a very important source of enjoyment, and motive to action. But at present we leave out of view all these ulterior consequences of sensations, and confine ourselves to the enumeration of the different sensations themselves ;—to a statement of the particular conditions under which the Nervous System is impressed in the case of each ;—and to a short analysis of the inferences immediately drawn by the mind, touching the properties of external things, which are thus made known to it, or perceived by it. Some of these inferences are *natural* or intuitive, and others *acquired ;* but the line of distinction between these classes of perceptions is not easily drawn.

In the lower animals, the mental acts excited by Sensation are much less numerous and diversified than in man; but the sensations themselves are often more acute; the pleasure immediately attending them probably equally intense; and certain immediate inferences from them, or Perceptions of the qualities of objects, more rapidly formed, so that the exercise of their senses requires less *education*.

A distinction was drawn by Dr GORDON * between Simple Sensations and Sensations of Emotion; the latter term being applied to certain feelings, exactly resembling those which may be produced by external agents, distinctly referred to individual parts of the body, and often attended with obvious physical changes there; which cannot be traced to the influence of any external agents, but distinctly follow the excitation of certain mental emotions. This distinction is important, but the term Sensations of Emotion is not sufficiently comprehensive to include all those

* Heads of Lectures on Physiology.

Mental Feelings, exactly similar to Sensations, which may proceed from internal causes only, independently of any impression from without on the organs of sense.

Simple Sensations are not so easily arranged into classes and genera as has been represented. Among the Higher or Special Sensations, felt only in consequence of impressions on individual organs, we should reckon not only those of Sight, Hearing, Taste and Smell, but also Hunger, Thirst, and the peculiar sensations of Anxiety at the lungs, already considered, and perhaps Nausea and Faintness; and the term Common Sensation should include not only what is commonly called Touch, but likewise the feelings of Heat and Cold, Pain, Itching; and another important class, which have been called Muscular Sensations, by which we are informed of the situation and extent of any muscular contractions which we voluntarily excite.

The individual sensations, referred to some of these genera, differ only in *degree;* but those referred to others have a manifest and original difference in *kind*—as Colours, Visible and Tangible Figures, Smells, &c. The individual sensations referred to the heads of Common Sensation, Sight, and Hearing, have differences according to the *position* of the objects causing them; those belonging to Taste and Smell hardly differ in that respect. Those only which belong to Common Sensation and to Sight differ according to the magnitude or *size* of the objects that excite them.

It is a general and important fact in regard to all sensations, that their intensity is very much influenced by Habit; they are felt strongly at first; and by continuance or repetition, at short intervals, the degree in which they are felt, and the portion of attention which they occupy, gradually diminish; and the emotions of pleasure or aversion which they occasion are not only blunted, but sometimes actually exchanged for one another. Impressions on the organs of Taste and Smell, which are at first unpleasant to most persons (*e. g.* those caused by tobacco or spirits), become gradually tolerable—then agreeable,—the want of them is felt as a painful privation,—and their cause must be applied in a gradually increasing degree, in order to produce the wonted effect. On the other hand, those causes which at first excite the most pleasing sensations, are successively followed by feelings of indifference, of satiety, and ultimately of disgust or aversion, if merely kept constantly before the organs of sense. In this respect there is a striking analogy between sensations and muscular contractions. A similar law, as we shall afterwards find, applies to the action of poisonous or medicinal substances, which likewise affect strongly the nervous system, but without distinctly exciting sensation.

In considering in detail the different sensations, and the information they communicate, we treat first,

Of Common Sensation.

The physical conditions requisite for the sensations of this class, are merely those general conditions relative to the nervous system, which have been already stated, and the healthy state of the organization of the textures in which it resides.

The simplest form of common sensation is that to which the name of Touch is commonly given, which results from the mere apposition of any external substance on most parts of the body. These parts, from their susceptibility of sensation from that cause, are said to be endowed with Common Sensibility; and, from mechanical irritation carried to a certain length, they are affected with Pain. It appears from the elaborate experimental inquiries of Haller, that there are many textures in which this sensibility in the natural state is slight. Most of these are textures which have slight vascularity, particularly bones, cartilages, tendons, ligaments, fibrous membranes, even cellular and serous membrane. All these textures are, however, the seat of acute sensation in certain circumstances, *e. g.* the tendons and ligaments, when forcibly stretched, and the fibrous and serous membranes, when their vascularity is increased, particularly by inflammation.

The internal parts of the solid viscera appear to have less sensibility than their membranous coverings; and the greater part of the brain, and the nerves of the special senses, seem nearly destitute of common sensation *.

The parts which are absolutely insensible (*i. e.* all sensations commonly referred to which are really seated in the adjoining textures), are those which are not vascular, the cuticle, nails, hairs, and bony substance of the teeth.

The parts in which common sensibility is the best marked, and employed for the most useful purposes, are the skin and the mucous membranes; and especially the very vascular and nervous papillæ on the fingers and on the tongue. The sensibility of the skin is blunted, as its other vital functions are restrained, by the intervention of the cuticle; that of all these membranes is manifestly increased by any increase in the flow of blood, and diminished by such causes as check the afflux of blood to them, *e. g.* by cold; that of the mucous membranes has the peculiarity of being apparently much less exalted by the state of inflammation than that of other membranes; perhaps because the capillary vessels of the mucous membranes, when distended by inflammation, are less compressed by adjoining firm textures than those of other membranes.

The sensation of Pain varies considerably, according to the different textures and parts of the body where it is excited. In many cases, its excitation may be referred, both in the healthy and diseased state, to the principle of mechanical pressure or irritation acting on sensitive nerves in one way or another: but there are other cases where the mode of its excitation is quite unknown. As residing in some parts, it is blended with the feelings of nausea and faintness, as from violent injury or disease of the abdominal viscera; and the effects which may be traced to this combination are of great importance in pathology.

The sensations of Heat and Cold are felt chiefly in the skin, distinctly in the mucous membrane of the alimentary canal, but hardly at all in that of the air-passages, in the

* Haller, Bichat, Wilson Philip, Flourens, Magendie, &c.

lungs, or other viscera. Whether they are dependent on peculiar nervous filaments is still doubtful.

These sensations are remarkably dependent on the state of the capillary circulation on the surface, and more rapidly altered by changes in that respect than the actual temperature is. In consequence of the operation of causes which excite or strengthen the cutaneous circulation, cold is often little felt, when the temperature of the air in contact with the body is very low; and in consequence of the operation of causes weakening that circulation, it is often much felt when the temperature is moderate. These sensations are likewise peculiarly influenced by habit, and therefore dependent on the state of the temperature applied previously to the change which excites them; and farther, they are sometimes felt in consequence, not only of internal causes altering the state of the circulation on the surface, but of internal causes acting probably on the nervous system only, and unattended with any such perceptible effects. It is of great importance to keep in mind these different causes, independent of the actual state of the temperature, which influence the production of the sensations of heat and cold, when we speculate on the efficacy of these agents either in producing or counteracting disease.

The different sensations which we refer more strictly to the head of Touch, using that term as applied to feelings in which the mind is merely a passive recipient of impressions from without, belong only to two heads, Extension and Resistance; and by these we are informed, in some degree, of the magnitude, and of the hardness or softness, roughness or smoothness, &c. of objects.

There are differences, also, in the sensations of Touch, corresponding to the figure, and more especially to the position, on the sensitive surface of the body, of the objects perceived by this sense; but it seems to be only by experience that we learn to connect certain differences in our sensations, either with the particular figures of objects, or with the particular parts of our bodies on which impressions are made. These may be called, therefore, Acquired Perceptions of Touch, although founded on original differences of sensation.

The sense of Touch, without any active or voluntary effort, would probably suffice to convey to us the notions of extension or space, and of hardness or solidity, which are the essential elements in the idea we form of matter, and have therefore been called the Primary Qualities of Matter. But the information obtained in this way, particularly the knowledge thus acquired of Forms, would be very vague and imperfect. Our knowledge of these is acquired with much greater rapidity and precision, by the combination of the mere feelings of Touch, with the *muscular sensations*, already noticed, which inform us of the contractions of voluntary muscles, that are employed in moving the organs of Touch,—and of the degree and extent of resistance, opposed to these movements of the organs of Touch, by the solidity, the figure, and the position, of tangible objects. It is by the number and variety of these muscular sensations which it can combine with distinct feelings of Touch, that the human hand is so admirably fitted for procuring information as to the size, form, weight, and character of the surface of external objects.

These muscular sensations are likewise an important source of enjoyment, particularly in early life; their absence is a serious privation, and the effect of their excess is the uneasy sensation of Fatigue.

The distinction of the mere passive sense of Touch, from the combination of this with voluntary movements of the organs employed, made known by the muscular sensations that accompany them, is well stated by MAGENDIE, in distinguishing the words Tact and Toucher; but the importance of the latter complex sensations to the acquisition of knowledge by the senses, is more fully illustrated by Dr BROWN *, than by any other author.

It is by this process that we acquire precise and accurate knowledge of the figures and other primary qualities of external things, and the process is necessary to correct the

* Lectures on the Philosophy of the Human Mind, Lect. 22-3-4.

more vague and fallacious notions of those matters which we derive from Sight; but the information acquired, whether by the active or passive exercise of the sense of Touch, is infinitely extended by means of Sight.

On comparing the feelings of Heat and Cold, with those sensations of Touch that communicate to us the notions of Extension and Resistance, and the mental processes consequent on these different sensations, we perceive the distinction between what are called the Secondary Qualities of matter, which are *known to us only as the causes of certain sensations* (and of other effects in the inanimate world); and what are called the Primary Qualities of matter, of which *our minds form clear and definite notions, perfectly distinct from the sensations by which they are suggested;* and which notions are the essential ingredients in the general idea that we have of the external world.

Both the primary and secondary qualities of objects are apprehended by us, in the adult state, and after long experience, as depending on causes external to ourselves, (see p. 119). But it is more difficult to determine in what circumstances it is, that the notion of external and independent existence is first formed in the mind, or what conditions are essential to its formation. Perhaps the most reasonable supposition is, that the mere repetition of any sensation,—and the conviction of want of power on our part to cause, or prevent, or in any way affect, that repetition, as long as the circumstances in which it was felt continue unchanged,—are enough to suggest that notion to the mind. Some think that it is only on apprehending the existence of the primary qualities of matter, that we form that general notion; and Dr Brown endeavoured to shew, that the notion could not be formed, but for the muscular sensations, which accompany the active exercise of the sense of touch, and the interruptions which these experience from the resistance of external things.

But these are in reality only questions of curiosity. The important fact is, that by the exercise of the senses, and especially of this sense of Touch, which informs us of what we call the primary qualities of matter, we are naturally led, not only to form that general notion of external and independent existence, but also to form more particular notions of Extension, Form, Hardness, Motion, &c. as qualities of external things, which *bear no resemblance whatever to the sensations*, through the medium of which we apprehend them. And one decisive proof of this being the true representation of this part of our mental constitution, is obtained by attending to the idea of extension or Space; which is undoubtedly formed during the exercise (whether active or passive, is immaterial at present) of the sense of touch; and is no sooner formed than it "swells in the human mind to Infinity;"—to which, certainly, no human sensation can bear any resemblance *.

Of Smell and Taste.

The Sensations of the Nose and Mouth may be considered together, on account of the intimate connexion which will appear to exist between them.

In order that the sensation of smell may be felt, the only special conditions necessary are, *first*, the passage along the internal nares, of air impregnated with certain effluvia which are believed to arise from many substances, but which manifest their existence in no other way than by the sensations they thus excite; and *secondly*, the healthy condition of the mucous membrane which lines the ossa spongiosa and other parts of the internal surface of the nostrils, especially, as it would appear, of the upper and middle meatus, where the 1st nerve is chiefly distributed. That some particular condition of the membrane is necessary to the sensation appears from the fact, that, unlike common sensation, it is diminished or lost in consequence

* See Reid's Inquiry into the Human Mind, chap. v. sect. 3–7; and Stewart's Elements of the Philosophy of the Human Mind, chap. i. sect. 3. and 4.

of inflammation of the part; but the nature of this particular condition is unknown.

It is necessary to distinguish between the special sensations, which odoriferous substances only can produce, and the sense of irritation in the nostrils, which any acrid or stimulating vapour or powder will occasion. The latter is the immediate cause of sneezing; and it has been proved by the experiments of MAGENDIE *, confirmed by observations in some paralytic cases in the human body, that the sensibility to such irritation depends on the 5th nerve, and continues after the 1st nerve, usually called the Olfactory, is destroyed by injury or disease. It appears also, that by section of the 5th nerve, the sense of smell, as well as others of the special senses, is blunted or perverted. But the distribution of the 1st nerve to the parts concerned in this sense, and to no other;—its greater development in proportion to the size and complexity of the organ of smell, in animals in which this sense is more exquisite †;—some cases on record, in which the sense of smell was lost in consequence of disease of the origin of the 1st nerve, while the 5th was healthy ‡;—and the appropriation of the 5th nerve to common sensation in other parts;—seem sufficient to shew that the 1st nerve is that most essentially concerned in the sense of Smell, properly so called.

This sense informs us only of the different varieties of a single secondary quality of matter, to which the term Odour is properly applied, existing only in certain bodies, and which extends itself, by an unknown medium, to some distance from them.

The sensation of Taste is commonly described as that which results from the contact of certain bodies, called Sapid, with the upper surface and tip of the tongue, inside of the gums, and palate, especially when rubbed forcibly between these; and which is aided by the action of the fluids of the mouth.

* Journal de Physiologie, tom. iv.

† See SERRES, Anat. Comp. du Cerveau, pp. 281 and 286.

‡ SERRES, p. 294.

In the case of this sense likewise, we should distinguish the component parts of the complex sensation felt on such occasions. The sensation which informs us of what is strictly called the Flavour of any substance, is at once distinguished as bearing a strong resemblance to smell; and the following facts seem sufficient to prove that it is in fact the sensation of smell, produced by effluvia from the substance held in the mouth passing through the nostrils during expiration.

1. When the mucous membrane of the nostrils is inflamed, the flavour even of sweet, bitter, or acid substances is not perceived, although there be no symptoms of disease in the mouth, and all the other sensations felt there are natural.

2. By carefully inspiring, during the whole time when a sapid substance is held in the mouth, or by carefully expiring through the mouth only, its flavour may be rendered imperceptible, even though it be rubbed repeatedly between the tongue and palate; a sense of what is usually called irritation or pungency, more or less acute, according to the nature of the substance in the mouth, only remaining; but, on the slightest expiration through the nostrils, the true flavour becomes immediately distinct.

When the various sensations which appear from these facts to belong strictly to the sense of smell, are carefully distinguished from the others, which are felt in the mouth, although these last may appear both acute and peculiar, it seems very doubtful whether they amount to more than very fine sensations of touch; produced chiefly by fluid substances penetrating the papillæ of the tongue. They hardly appear to merit the title of a special sense, any more than those feelings in the nostrils which prompt to sneezing, or those in the larynx which prompt to coughing. And accordingly, it will be observed, that there is no special nerve for the sensations in the mouth, the papillæ of the tongue having their nervous branches from the third part of the fifth.

The mixt sensations, probably referable to the heads of

Smell and of very delicate Touch, which have their seat in the nostrils and mouth, are not only the occasion of much enjoyment, but have evidently two important uses, in reference to the function of digestion: 1. To excite the flow of the mucus and saliva, which are to aid in preparing the food for the action of the stomach: 2. To inform us of qualities in the objects that excite them, which bear a certain, though not a uniform, relation to their fitness for digestion.

Of Sight.

It is here necessary to recall to recollection the structure of the principal parts constituting the organ of sight; first, the protection given to the eyeball by the eyebrows and eyelids, and the lubrication of its surface by the tears descending from the lachrymal gland, and also by the thin mucous fluid that exudes from the tunica conjunctiva: next, the different coats of the eyeball; the conjunctiva covering its fore part; the firm and strong sclerotic coat, which bounds and encloses the essential parts of the organ, and connects itself, in front, with the prominent and transparent cornea; the vascular and opaque choroid coat, terminating in front in the annulus albus at the root of the iris, and in the ciliary processes behind the iris; and within it, the nervous expansion called the Retina, the concave surface of which is spread over the thin membranous capsule that contains the Vitreous Humour; in front of which humour, the coats of the eyeball enclose the dense transparent Crystalline Lens, and the thin aqueous humour, divided into two compartments by the opaque and coloured iris: lastly, the entrance of the optic nerve, and its expansion to form the retina, on the inner side of the axis of the eye,—its passage through the sphenoid bone, and within the cranium, to the place of its union with its fellow on the opposite side,—and its winding course across the crus cerebri and along the lower and outer edge of the thalamus, till it reaches the corpus quadrigeminum.

The aqueous and vitreous humours of the eye contain about 2 per cent. of animal and saline matter, and the crystalline lens, which is solid, and denser towards its centre than on its exterior, contains 42 per cent. of animal matter and salts.

In order that the Sensations enabling us to perceive light and colour should be felt, the only special condition probably is, that light, by which we mean the external cause of these sensations (generally believed to be an imponderable substance), should impinge on the retina. But in order that this light should give any distinct information as to the form or other qualities of the objects whence it comes, it is necessary that it should be so affected by the coats and humours of the eye, as to form a distinct image of these objects on the retina at the bottom of the eye.

That such images of external things are really formed on the Retina, has been shown, by fixing the eye of an animal just killed in a small aperture of a darkened room, stripping off carefully the opaque sclerotic and choroid coats at its back part, (or, in the case of albino animals, without that preparation), and inspecting the posterior surface of the retina. Magendie was even able to show, in such experiments, by drawing off successively the different humours, the importance of each of these in the formation of the images.

In order to understand how this is effected by the eye, it is necessary to attend to the following optical propositions, the truth of which is known, partly by experiments, and partly by mathematical deduction from principles which experiments had established.

1. When light passes through any single transparent medium, it moves always in straight lines.

2. When it passes from one transparent medium to another, unless it falls perpendicularly on the surface where

they join, it undergoes a change of direction, or is *refracted;* and we judge of the mode and degree of its refraction by supposing a perpendicular drawn to the surface of junction of the two media, at the point where the ray quits the one and enters the other, and observing whether, in its course through the second medium, its change of direction is towards, or from, that perpendicular. If it be refracted towards the perpendicular, the medium which it enters has the *greater refractive power* of the two; but if from the perpendicular, it has the *less refractive power.* The angle which the incident ray makes with the perpendicular is called the Angle of Incidence, and that which the refracted ray makes with it the Angle of Refraction; and the greater the difference between these two, the greater the difference of refractive power of the media.

3. On comparing the course of rays which fall with *different degrees of obliquity* on the surface of junction of the *same media,* it is found that the refractions they respectively suffer bear a certain proportion to the degree of their obliquity; the sine of the angle of incidence having to the sine of the angle of refraction always the same ratio.

4. Denser bodies have, in general, a greater refractive power than rarer; and accordingly, water, glass, and the transparent parts of the eye, have a greater refractive power than air.

5. When a ray of light passing through air falls obliquely on a convex lens of glass (*i. e.* a piece of glass bounded on each side by a segment of a sphere), or of any other transparent matter of greater refractive power than air, it necessarily undergoes one refraction where it enters, and another where it leaves the lens, and each of these brings it nearer to the axis of the lens;—*i. e.* to the straight line which joins the centres of the two spheres, segments of which bound the lens.

6. When different rays, coming from the same point, and traversing air, fall on such a lens, and each, after the two refractions it undergoes, is brought towards the axis of the

lens, the point of that axis towards which they tend is determined by three conditions,—by the distance of the point from which they come,—by the degree of convexity of the surface of the lens,—and by the degree of its refractive power, that is, by the proportion of the sine of the angle of incidence, to the sine of the angle of refraction, of all rays that enter it from air. Now, these three conditions are the same in regard to all the rays that issue from any one point; and therefore, if the refractive power be such as to bring any one ray from that point to intersect the axis of the lens, it will bring all the rays from that point to intersect the axis at the same place; *i. e.* it will concentrate all the rays from that point into a *focus* beyond the lens.

7. Every double convex lens in this manner draws together into a focus all parallel rays, *i. e.* rays coming from a point at an infinite distance; and the fixed point to which these tend is called the principal focus of the lens: And farther, every such lens draws together into a focus all the rays coming from any point more distant from itself than its own principal focus; but the rays from a point at the distance of that focus become parallel after passing through the lens; and those from a point nearer than that, diverge after passing through the lens, although in a less degree than before entering it.

8. As a convex lens concentrates all the rays from a distant *point* into a *focus*, so it concentrates all the rays from a distant *object* into an *image*, which will be nearer the lens, and smaller, as the object is the more distant, and the refractive power greater; and which will be *inverted*, because the rays from any point of a luminous object, which lies on either side of the line that is a production of the axis of the lens, must necessarily cross that line, after the two refractions they suffer, before they can be concentrated.

Now, in the eye, although the apparatus is more complex, yet the effect on light from a point, or from an object placed before the eye, is necessarily the same as would be produced by a double convex lens. The ray which falls from any luminous point perpendicularly on the centre of the cornea, and passes through the axis of the eye, undergoes no refraction. All other rays coming from the same point, and forming a long narrow cone of light between it and the pupil, are refracted, first where they enter the cornea and aqueous humour,—then where they enter the crystalline lens, which has the greatest density and refractive power,—and lastly, where they pass from the crystalline into the vitreous humour. All these refractions are towards the axis of the eye, and these rays meet the one that passes along the axis in a focus. And as the humours of the eye draw together all the rays entering the pupil, from a luminous point placed before it, into a focus, so they draw together the rays from an object, or set of objects, into an image, which is necessarily placed *somewhere behind the crystalline lens*, and is *inverted.*

In the usual and natural state of the eye, its transparent parts are fitted, by their refractive power, for concentrating parallel rays (or rays from a point at an infinite distance) just at the Retina, *i. e.* the *principal Focus of the eye lies at the Retina,* and therefore clear and definite images of very distinct objects, the rays from any single point of which are almost exactly parallel, are formed on the retina, and the eye is fitted for the vision of these distant objects. And as the divergence of the rays which come from a single point, even a few feet distant from the eye, and fall on so small an area as the pupil of the eye, is very trifling, the eye is equally fitted, in its natural state, for all practical purposes, for the distinct vision of all objects situated more than a few feet from it.

But in the natural state of the eye, after it has been employed in distant vision, when an object is brought within a few feet of it, the rays from that object converging to form an image beyond the retina, it is at first seen indistinctly, and an effort is voluntarily or instinctively made, by which the eye adjusts itself to the distinct vision of this object; and if it be brought still nearer, the eye may be made to continue this effort of adjustment, till it come within about five inches of the eye; after which, the refractive power of most eyes is insufficient for bringing together the rays on the retina, and the object is again seen indistinctly.

The effort by which the eye increases its refracting power, and adjusts itself to the distinct vision of an object thus approaching it, may be observed to be attended with a contraction of the pupil; and Dr Brewster found, that the application of bright light to the eye, whereby a sudden contraction of the pupil is effected, causes the eye to adjust itself to vision at a shorter distance than previously *; and Dr Wells shewed, that when the iris is palsied, as by belladonna applied to the eye, the power of adjustment to distances is lost †. But the mere elongation or shortening of the iris, although it alters the size of the cone of light passing from any luminous point to the pupil, and therefore alters the illumination of the image formed at the back part of the eye, does not alter the refractive power of the eye. The adjustment of the eye must therefore be produced by some other change, contemporaneous with the contraction of the pupil.

The manner in which this is done is still uncertain; but the most probable supposition is, that it is by a vital contraction of the annulus albus, or ciliary ligament at the root of the iris, simultaneous with the contraction of the sphincter iridis, and which will have the effect, either of increasing somewhat the convexity of the cornea, or of bringing the crystalline lens somewhat forwards, and of course bringing forwards also the image, previously formed behind the retina ‡.

The usual movements of the iris (probably of its sphincter muscle, though that is not easily demonstrated) are caused by the impression of light on the retina, and no

* Edinburgh Journal of Science, vol. i. p. 77, 1824.

† Philosophical Transactions, 1811.

‡ See Knox, in Transactions of Edinburgh Royal Society, vol. x., and Brewster, in Edinburgh Journal of Science, vol. i. 1824.

doubt, in the natural state, by the sensation of light felt in consequence of that impression. When the light is diminished the pupil expands, the cone of light coming from any one point to it is enlarged, and the focus of that point (or the image of an object of which it makes a part) is rendered more luminous than previously; and the reverse change happens when the light becomes more intense; so that this is a moveable curtain, placed before the eye to regulate the quantity of light admitted into it, and which is moved by the very sensations which call for its intervention *.

Accordingly, Mr MAYO found that the iris could be made to contract, either by irritation of the optic nerve, within the cranium of a bird, or by irritation of the third nerve, which is perhaps the only motor nerve that sends filaments to the ophthalmic ganglion, whence the ciliary nerves, passing to the iris, are derived †.

The orbicularis oculi muscle, which closes the eyelids, and has been shewn by Sir CHARLES BELL to be moved by filaments of the portio dura, is also obedient to the sensation of light, when that sensation is so intense as to require the complete removal of its cause to prevent acute suffering, and subsequent loss of the powers of the retina and optic nerve.

The aperture of the pupil obviously admits rays of light only to a part of the concave expanded surface of the retina, and this illuminated part is farther diminished when the pupil is contracted. Accordingly, the *field of vision*, when the eye is kept at rest, is very limited. According to the observations of Dr YOUNG, it extends upwards to objects situated in a line forming an angle about 50° with the optic axis, downwards to 70°, inwards to 60°, and outwards to 90°.

But it is farther obvious, on attending to what is seen when the eye is fixed on a single object, that the field of *distinct* vision is much more limited than this; any object

* See WHYTT on the Vital and Involuntary Motions, sect. vii.

† Anatomical and Physiological Commentaries, No. II.

situated in a line which makes an angle of 5° with the optic axis, is seen very indistinctly.

From this we learn, *first*, the importance of the muscles of the Eyeball, by which the eye is easily moved, voluntarily or instinctively, so as to bring its axis to bear on any object that is to be examined, and secure distinct vision of it; *secondly*, the peculiar sensibility of that portion of the organ which lies in the axis of the eye, exactly opposite to the pupil.

Just at this point there is found, in the human eye, and in certain animals, whose vision is very acute*, the central foramen, or opening in the retina; the dimensions of which, after death, are such, that it would seem that the images which give the most distinct vision must be formed within it.

How the change in the optic nerve, necessary to the sensation of sight, should be produced by an impression, thus apparently made on a point, which the nervous filaments do not themselves reach, it is at present impossible to explain; but the observation should perhaps be connected with another, viz. that in many birds, reptiles, and fishes, which are endowed with a more penetrating sense of sight than ours, an empty space is in like manner found at the other extremity of the filaments composing the optic nerve, viz. in the Corpora Quadrigemina †.

Another peculiarity in regard to the sensibility of the retina is, that those rays of light which are concentrated on the part, on the inner side of the optic axis, where the optic nerve enters, are found to cause no sensation; as is easily proved by fixing the right eye on two small objects placed together on a plain surface, then moving the one of these objects gradually to the left, and keeping the axis of the eye directed towards it, while the attention is fixed on the sensation communicated by the other object; the existence of the insensible spot on the retina is then quickly

* See Knox, in Edinburgh Phil. Trans. vol. x.

‡ Serres, Anat. Comp. du Cerveau, pp. 197 and 304.

discovered. It has been conjectured that this depends on the entrance, not of the optic nerve, but of the central artery of the retina which it encloses.

The experiments of FLOURENS have unequivocally shown that, in many of the lower animals, the Corpora Quadrigemina, where the optic nerves originate, are the only parts of the larger masses of the Nervous System concerned in the mere sensations of the eye *.

What has been said of the conditions in the eye, necessary to vision, sufficiently explains most cases of blindness; and likewise enables us to understand the nature of the imperfections of this sense called Presbyopia and Myopia. In the former, the eye has generally become somewhat flattened, and has lost somewhat of its refractive power, so that the images of near objects, seen by diverging rays, are formed a little beyond the retina; and a convex lens is useful, to diminish the divergence of such rays before they enter the eye,—cause them to converge sooner in passing through it,—and thereby render the images they form on the retina definite and distinct. In the latter, the eye has generally a more convex form,—has an excessive refracting power, so that it is naturally adjusted to the distinct vision of near objects;—and its focus of parallel rays, by which distant objects are seen, being a little in front of the retina, these are seen indistinctly; unless a concave lens is employed, to give a little divergence to the rays coming from them.

These are the most important principles that have been ascertained relative to the conditions, in each eye, necessary to distinct vision. But in general, both eyes are employed; and the condition which is necessary, in order that an object, at any distance, may appear single, although an image of it is formed in each eye, appears to be merely this, that the axes of the two eyes shall be fixed on the same point of the object; for which purpose, the motor nerves and muscles of the eyeball, instinctively act together, even from the time of birth. The necessary effect

* Recherches Experimentales, &c. p. 150.

of this is, that the rays coming from all the points of the object in question, are concentrated upon *corresponding points* of the retinæ of the two eyes; that is, upon points similarly situated in regard to the centres of the retinæ of the two eyes; and experience shows that, in these circumstances, objects are seen single, but that, when their images are not formed on corresponding points of the retinæ, they are seen double. Of this there are several simple proofs. 1. When the axes of the eyes are fixed on a near object, and the attention at the same time directed to a distant one; this last, the image of which cannot be formed on corresponding parts in the two eyes, is seen double, and *vice versa.* 2. When pressure is made on the ball of one eye, so as to prevent its axis from being directed to the same point as the axis of the other, any object that may be looked at is seen double; and the same occurs in Squinting, or distortion of the eyes, although as, in most of these cases, the sensibility of one eye is much feebler than that of the other, one image only is usually made an object of attention. 3. When two distinct objects are placed carefully in the lines of the axes of the two eyes of a person who squints, or whose eyes are distorted, as their images are necessarily formed on corresponding points of the retinæ, they are seen to coincide. 4. When two objects are held close to the two eyes, and exactly in their axes, as the optic axes cannot be directed to the same point in either of them, and as their images, although necessarily very faint from their proximity to the eye, must fall on corresponding points of the retinæ, so they are seen, although indistinctly, yet evidently as coinciding *.

We can go no farther, with confidence, in determining the conditions requisite for single vision, than to illustrate the general proposition above stated. It was conjectured by NEWTON, that single vision may depend on a semi-de-

* See REID's Inquiry into the Human Mind, ch. vi. sect. 13. The objections stated to REID's principles on this subject by Dr WELLS (Essay on Single Vision), seem to be founded on misconception.

cussation of the optic nerves at their commissure, whereby the right half of each retina might be in communication with the right hemisphere of the brain, and the left half of each with the left hemisphere; the consequence of which may be easily conceived to be, that the *corresponding points* in the retinæ of the two eyes may be connected with, and their sensibility depend upon, *the same points* in the brain. Different anatomists have agreed as to the semi-decussation of the human optic nerves; and Dr WOLLASTON has supported the theory, by reference to the known fact, that, in a transient diseased state of vision (the suffusio dimidians), one half of each retina is occasionally insensible to the light at the same time *. But the anatomical evidence of this theory, as applied to the human species, is defective. In many other animals, it appears certain that the decussation of the optic nerves is complete; but as most quadrupeds and birds have their eyes placed more laterally than the human eyes, and are accustomed often to regard objects with one eye only, the analogy of their structure is probably not to be trusted.

In order that any object of sight may appear *above* the optic axis, it is necessary that the image formed by it on the retina be *below* that axis; or, more generally, every visible point appears to be in the direction of a perpendicular erected on the retina at the point where the rays issuing from it are concentrated. This appears from our seeing objects erect, although the images they form are inverted; and is farther illustrated by the following fact. If a small object, brightly illuminated, be held within an inch of the eye, and inspected through two very minute holes, set close to one another in a card, two faint images are formed of it, (by rays already converging before they reach the eye, and which do not cross the axis before reaching the retina), on different points of the retina; and it is seen double, although by a single eye; and, by closing one or other of the holes in the card, it is found that the image which appears

* Phil. Trans. 1824.

uppermost is formed by rays which pass through the lower hole, and therefore is formed on the lower part of the retina, and *vice versa**. But this principle must likewise, at present, be held to be an ultimate fact on this subject.

The images formed on the retina certainly differ as to colour, as to illumination, as to size, form, and position; and it is obvious that, in the adult state, the different sensations they excite not only inform us as to light and colours, but also as to the size, forms, position, and distance of objects. But it is difficult to judge how far the notions on these last points, which we connect with them, in the adult state, are simply dependent on them, or how far they are acquired by the sense of touch, and only suggested by the sensations of the eye, in consequence of experience, and association with those of touch.

The notions we have of the brightness, and of the colours of objects, are necessarily and entirely dependent on the sensations of sight. The colour depends on the part of the compound ray of light which each object reflects or transmits; and the perception of it depends on a peculiar sensibility of the optic nerve, which is not enjoyed, in an equal degree, by all men, of perfectly distinct vision in other respects †.

The forms of the images of external things, which exist in the eye, differ so widely from their real forms, that we should probably not be able to acquire the notion

* See Reid's Inquiry, &c. chap. vi. sect. 12.

† It has been long known, that there are many persons who cannot distinguish accurately a colour from its complementary colour; *i. e.* from that which the other colours in the spectrum united together will produce. Thus the distinction of red from green is hardly perceptible to many. Sir David Brewster has given a satisfactory explanation of this fact, by discovering, that in all parts of the coloured spectrum, there are rays which have escaped decomposition. To a person, to whom one of the prismatic colours is imperceptible, all colourless objects being seen by means of rays of the other colours only, will necessarily appear of the colour complementary to that, which is invisible to him; and objects of that unperceived colour, being seen by the undecomposed or colourless light, will of course have to him that complementary colour also.—See Edin. Phil. Journal, 1831.

of any complex form by this sense, unassisted by the sense of touch. Neither is it possible that the differences of sensation, that correspond to the differences of the magnitude and position of objects, can suffice to inform us of their real size or real position. And the distance of any object from the eye, being measured by a straight line drawn from it, which, to the eye, must appear as a point, cannot of course be a direct object of sense. Nor can any reasoning, on the mere sensations of sight, furnish just conclusions as to these points. All these are, therefore, usually considered as Acquired Perceptions of Sight; *i. e.* it is supposed to be by experience, and by comparison with the information acquired by the sense of touch, that we learn to associate the differences, in these respects, of the sensations we feel, with the actual circumstances of the external objects from which they proceed; and some have supposed that it is only in the same way that we learn that objects, seen by inverted images, are really erect, and even that we learn to distinguish the numbers of visible objects.

The instances of persons blind from infancy, who were restored to sight by Mr CHESELDEN *, Sir E. HOME †, and Mr WARDROP ‡, are sufficient to shew that the notions of position, form, distance, and size of objects, suggested by the newly acquired sense of sight, were very imperfect and erroneous. We can observe, even in the adult state, that our ideas of form and position are much aided and corrected, if not acquired, by touch; and our ideas of the latter by the muscular sensations which accompany the actions necessary to fix the optic axes on any object of sight; that the judgment, as to size, from sight, is dependent on a previous judgment of distance; and that our estimates of distance are very liable to error, and are assisted, if not acquired, by help of different kinds of experience,—by the effort made to adjust the eye to distinct vision, when the object is very near,—by the degree of inclination of the

* Philosophical Transactions, vol. xxxv.

† Philosophical Transactions, 1807. ‡ Ibid. 1826.

optic axes requisite to fix both eyes on it, when it is rather more remote,—by the degree of vivacity of its colours,—by the distinctness of its minute parts,—and more especially by the number, and the known size, of intervening objects.

But although it is certain that a *great part* of our judgments on these points, connected with the sensations of sight, is really acquired by experience and education, we should not hastily conclude, that the differences in our sensations, corresponding to these circumstances of external objects, may not suggest to us, even prior to experience, *some part* of the conclusions which we habitually draw from them. For we know that many of the lower animals form, and act on, correct judgments of the position, size, and distance of objects, immediately on coming into the world; and that we ourselves, in various other instances, both act instinctively, we know not why; and acquire knowledge intuitively, we know not how *.

Of Hearing.

In examining the organ of this sense, we see indications of much contrivance, the uses of which are not understood, because the laws of the transmission of sound are not so

* Dr Brown makes the following observation on objects being seen single and erect, by means of two inverted images on the retina. "If the light reflected by a single object, touched by us, had produced not two only, but two thousand separate images, erect or inverted, the visual feeling thus excited, however complex, would still have *accompanied the touch of a single object*; and if only it had accompanied it *uniformly*, *the single object would have been suggested by it*, precisely in the same manner as it is now suggested." But is it not a sufficient answer to this doctrine, at least as far as regards single vision, to observe, that to a man who has a permanent squint, or distortion of the optic axes, the visual feeling always suggests double objects, although he knows, by touch, that they are single? This fact proves, that there are conditions in the eyes themselves, as stated above, essential to single vision; and consequently, that it is *not merely* by means of *the sense of touch* that we are led to a correct judgment on that point.

well known as those of the transmission of light; and therefore it is to no purpose to enlarge on them.

The condition necessary to the sensation appears to be the communication of certain vibrations, of which many substances, in different degrees, are susceptible, to the branches of the auditory nerve which are spread over the different parts of the labyrinth; these vibrations may be transmitted by the bones of the head, as when a sounding body is placed between the teeth; but in order that impressions may be received by this sense from a distance, through the medium of air, the contrivance employed is complex; the vibrations of the air, derived from the sounding body, are first communicated through the meatus externus, which is lubricated by its oily secretion, the cerumen, to the outer chamber, or tympanum,—which is closed by a membrane where the impression is made on it, but filled with air from the posterior nares,—which is extended, in a very irregular form, into the mastoid process, and traversed by a chain of minute bones (furnished with muscles whereby they are, to a limited extent, moveable), one of which is fitted to the aperture that leads to the inner chamber or vestibule. This cavity is filled with a liquid like the aqueous humour of the eye, and communicates with different small winding canals, situated in the interior of the hardest bone in the body, and the membrane lining which is supplied, by many minute holes in the bone, with very numerous small branches of the portio mollis of the 7th pair of nerves. The whole of these cavities and canals, containing the fluid, have been generally thought to be the seat of this sense; but the experiments of Flourens, shewing that injury or destruction of the semicircular canals injures other functions indeed, but apparently not the sense of hearing *, render it probable that those parts of the 7th nerve only which supply the cochlea and vestibule, are essentially concerned in this sense.

Comparative Anatomy shews, that a shut sac, containing a fluid, and lodging the extremities of the 7th pair of nerves,

* Ann. des Sciences Naturelles, tom. xv.

is all that is essential to constitute an organ of hearing throughout the animal creation *.

The importance, in our species, of the different parts of the organ of hearing is shewn by deafness resulting,—1. From hardened wax in the air-passages: 2. From closing of the eustachian tube, which conveys air to the tympanum: 3. From separation and discharge of the small bones, and consequent discharge of the liquor from the labyrinth: 4. From disease of the 7th nerve, or of the adjoining parts injuring that nerve. And in the case of this sense, as well as of sight, there are also examples of its total deficiency even when all parts of the organ appear naturally formed, believed to be owing to some imperceptible defect in the 7th nerve, or its origin in the floor of the 4th ventricle.

The individual sensations of sound differ from one another, not only in intensity or loudness, which depends on the length of the vibrations of the body whence the sound proceeds, but also in two other particulars, which are peculiar to them, viz. Tone and Timbre.

The tone, or pitch, of a sound, depends on the number of vibrations performed by the sounding body in a given time, being lower as these are less numerous, and higher as they are more. According to the observations of Dr WOLLASTON †, there are some persons who are totally insensible to certain very acute sounds, although they have the usual sensibility as to lower sounds.

The timbre of sound depends on the nature of the sounding body, and varies in every different musical instruments, although the note struck is the same. There are other differences in sounds, which cannot be so easily reduced to classes or genera.

Sensations of sound differ according to the direction of the sounding body, although it is difficult to understand how differences in this respect should reach the auditory nerves so as to affect them. The same sound coming from points, the directions of which from the ear make an angle

* CUVIER, Leçon 13. † Philosophical Transactions, 1820.

of 10° or 12°, is felt to differ; but it is probably from experience only that we learn to connect these differences with the true directions of objects.

Our judgment of the distance of objects by means of this sense, is founded only on the intensity of the sound; and the intensity that corresponds to each distance is known by experience only, which renders the judgment liable to error. We know, for example, by experience, the ordinary tone and loudness of conversation at ordinary distances. When, by reflection of sounds from concave surfaces, the same tones are heard louder than usual, we judge the distance of the speaker to be less than the reality; and in the state of syncope, when the same tones are heard fainter than usual, we judge the distance to be greater than the reality.

Those persons who can articulate distinctly during inspiration, produce sounds which have nearly the same tones as are heard in ordinary conversation, but are much more faint, and therefore deceive us as to distance; and this is an essential part of the art of the ventriloquist. But he has no such means of imitating those differences of sensation by which we judge of the direction of sounds; and can only attempt that by misleading the imagination.

What is properly called a Musical Ear differs from the mere perception of minute differences of sounds, and recollection of their successions; and is characterized by the pleasure those possessing it derive from certain successions of sounds only; and by immediate observation of any deviation from the successions fitted to give this pleasure. The circumstances of organization on which it depends are quite unknown. By the habit of minute attention to the differences of sounds, it is susceptible of much improvement; but the pleasure derived from it being complex and much connected with associations, is probably by no means strictly proportioned to the degree of accuracy in which it is possessed.

Before leaving the subject of the external senses, it is right to mention the cases, in which causes internal to the body produce sensations, exactly similar to those generally produced by impressions from without.

Hunger, Thirst, Anxiety from the want of air in the chest, most cases of Pain, and other internal sensations, depend on causes internal to the body, but external to the nervous system; but there are some cases of pain in which there is no evidence of any cause, external to the nervous system itself. And there are two sets of well-known phenomena, important in pathology and practice, which must be regarded as affections of sentient nerves, from causes acting in the Nervous System, but in parts of it distinct from those to which they are naturally referred. These are independent of the feelings which are strictly called Sensations of Emotion, which will be mentioned along with the other effects of emotions on the body.

I. The phenomena which are strictly called Sympathetic Sensations, are of this kind. These are cases where a sensation, distinctly referred to one part of the body, is known to be produced by an impression made on another part. Of these we may make two divisions.

1. The first is where a cause acts somewhere in the course of sentient nerves, or at their origin at the base of the brain or in the spinal cord, and the sensation produced by it is referred to the extremities of a nerve; because the part where it is excited is the same, where the nervous action, necessary to sensation, had formerly been produced by impressions made on those extremities. Such sympathetic sensations are illustrated by the sensations felt in the stump of an amputated limb, and referred to individual parts of the limb that has been removed. Of this kind, are the sensations of a flash of light from an injury of the eyeball or brain; the sensations of suffusions, of tinnitus aurium, of nausea, of aura epileptica, referred to the eyes, ears, stomach, or limbs in consequence of peculiar diseases of the brain, no doubt affecting the origins of the nerves; the sensation of pain often referred to a paralytic limb, after an attack of palsy from diseased brain; the sensation of

pain or tightness stretching round the chest or abdomen, from disease or irritation of the spinal cord, as in paraplegia; pains of various parts of the lower limbs from the pressure of aneurisms of the aorta on the spinal cord or lumbar nerves; and the slighter sensations of the same kind seen in hysterical cases, and stated to have been best relieved by remedies applied over the origin of the intercostal or lumbar nerves; the sensation of pain, often referred distinctly to the neck, back, or different limbs, in the course of hydrocephalus.

2. There are many instances of pains distinctly referred to one part of the body, but which are known, from experience, to proceed from irritation or disease of another part. These sympathetic sensations may, in several cases, be ascribed to connexions of the sentient nerves of the parts (especially when the part really injured is internal, and that to which the feeling is referred is external, and both have their sentient nerves from the same larger branches), and may so be brought under the same head as the last; but we cannot, as yet, refer all such cases to this principle.

Of this kind are, the pain of the shoulder from disease of the liver or diaphragm; pain of the urethra and glans from disease or irritation of the bladder; pain of the testis and thigh from irritation of the kidney; pain of the side of the neck and head, and of the left arm, from disease of the heart; pain of the back from disease or irritation of the uterus; pain (and spasms) of the legs from irritation of the intestines, as in cholera; pain of the knee from disease of the hip-joint in the morbus coxarius; pain of the forehead from irritation at the stomach; pain of the cheek or temple from irritation of a tooth; itching of the nostrils from irritations in the bowels; the uneasy feeling referred to the teeth from harsh grating sounds; and various other less frequent sensations, in constitutions of unusual delicacy as to sensibility, which are distinctly referred to one part of the body, but traced to irritation of other parts.

In both these cases it is often observed, that there is not only the mistaken judgment, as to the seat of the cause exciting the sensation, but some physical effect (*e. g.* inflam-

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mation in a greater or less degree), follows in the part to which the sensation is referred, which implies that some change is really propagated downwards, along the sentient nerves of these parts to their extremities, which excites their sensations, and may also influence the capillary circulation in their neighbourhood.

II. Another set of facts which must be referred to the head of sensations proceeding from internal causes, but exactly resembling those excited by impressions from without, consists of cases of Spectral appearances, or sounds, differing from the sympathetic sensations now considered, in being exact representations of certain definite and complex impressions on the higher senses; and differing from mere recollections, or fancied scenes, in being equally vivid and distinct, and equally beyond the control of any voluntary mental effort, as the sensations excited by real impressions from without.

The most common case of such spectral appearances, is in persons under the influence, or recently recovered from the influence, of opium or of strong liquors; but they occur occasionally in persons of what is usually called Nervous temperament, independently of any such cause *.

Cases recorded by Dr Bostock, (System of Physiology, vol. iii. p. 204), and others prove, that these spectral appearances are not merely the repetition of past sensations, but, in some instances, differ from any thing that has ever been presented to the senses; in which case, their excitation implies the exercise of that mental power which is strictly called Imagination.

It was formerly stated, that the sensations, and other mental feelings, so easily reproduced during darkness and silence, after unusual muscular exertions, or unusually strong impressions on the senses, as well as other facts, pretty clearly indicate, that the nervous system is not pas-

* See the works of Alderson, Ferriar, and Hibbert, on Apparitions, and Abercrombie on the Intellectual Powers.

sive during the performance of its different functions, but undergoes various, although imperceptible, changes corresponding to them all. It is probable that a slight degree of the same changes, in the sensitive nerves, which accompanied the original excitation of all sensations, may accompany every act of recollection of these; and that similar changes may attend acts of imagination, by which imitations of objects of sense are created in the mind (in which operations we shall find that the mind acts for the most part involuntarily); and if, on particular occasions, these physical changes are in any way rendered stronger and more enduring than usual, it is only in conformity with principles already stated, and to be afterwards more fully explained, that they should impress the mind, for the time, with the idea of the external and independent existence of the causes exciting them.

Various cases have been recorded, at different times, in which it was thought that, during a singular excited state of the nervous system (called Somnambulism or Reverie), slight impressions, on the sense of touch only, were followed by sensations in the organs of the special senses, which gave correct information of kinds coming within the province of these special senses. We cannot conceive that the conditions which appear to be essential to the exercise of these senses, can be imitated in this way; and the moral evidence, attending such alleged cases of transference of the sensual powers from one part to another, is very liable to suspicion; yet there is a striking similarity in the different cases of this kind, recorded by different observers, unknown to each other, which demands farther inquiries, before we can think ourselves entitled finally to reject such observations as mere fallacies *.

* See ROSTAN, Art. Magnetisme Animal, in the Dictionnaire de Medecine, and especially BERTRAND " Du Magnetisme Animal en France."

CHAPTER XIII.

OF THE MENTAL FACULTIES.

The sensations which we feel in consequence of external impressions, are manifestly instrumental in exciting, and are continually mingled with, certain other internal changes, of which we are conscious, and to which we give the general names of Trains or Successions of Thoughts.

The method of inquiry which it is necessary to pursue, in order to acquire satisfactory information as to these operations of our minds, is just the same as that which is followed in the physical sciences; consisting first in the careful observation, and then in the comparison and classification, of individual facts, whereby we acquire the knowledge of general principles, or laws of this department of nature; by reference to which other individual facts may be explained, when they have taken place, and be anticipated when they are about to take place. But as attention to the changes which take place in our own minds requires a peculiar and often painful effort, to which few men have carefully accustomed themselves, and as the words employed to denote the transitory thoughts or states of mind of which we are conscious, are necessarily analogical, and very easily misapprehended, there has been a want of precision in the conduct of most inquiries on this subject, as compared with those made into the laws of the material world; and the results have been less satisfactory.

In particular, two important errors may be pointed out in the conduct of different inquirers on this subject. Some have assimilated them too much to physical researches, and have refused to acknowledge, or not appreciated the importance of, those distinctions among mental phenomena, which do not correspond to physical changes, either immediately preceding or immediately following them. This is the most common error of physiologists who speculate on these subjects.

Others again, estranging themselves too much from the simple observation of facts, have engaged in much visionary speculation, and in many verbal controversies regarding the mental phenomena, which not only lead to no practical result, but often appear to be directed to no definite object.

In order to avoid both those kinds of error, all that seems necessary is, *first*, To recognise the necessity of patient attention to, and *reflection* upon, the different thoughts that pass through our own minds, as the only foundation of accurate knowledge in this department of science; *secondly*, To define strictly, and observe carefully, the meaning of all the words employed to denote the changes of which we are conscious; *thirdly*, To understand distinctly the objects of inquiry into the operations of the mind, and the limits which nature has imposed on the gratification of curiosity on this subject, and which are just similar to those that circumscribe our researches in all other departments of science.

The first observation that may be made on the thoughts of which we are conscious, is, that they are all *transient*, or in a continual state of change, one act or state of mind passing away, and another succeeding. Hence two inquiries naturally present themselves, which have not perhaps been so carefully distinguished as they might have been; 1. Into the nature or characteristics of the different acts or affections of mind that succeed one another; and 2. Into the laws which regulate their succession.

I. The exercise of our senses naturally and immediately leads us to form certain general ideas or notions, the tendency to the formation of which has been called by some metaphysicians, the Power or Faculty of Simple Apprehension; and in connexion with these, we have a natural disposition to put faith in certain propositions or principles, which have been called by Dr Reid, Principles of Common Sense, and by Mr Stewart, perhaps more correctly, Fundamental Laws of Human Belief; of which no proof can be given; which we know, not from Reasoning, nor from Experience, but by Intuition; and our confidence in which must be stated as an *ultimate fact* in the constitution of our minds. A little attention to the existence, and to the authority, of these laws of belief, will enable us to set aside a great deal of useless controversy, and simplify our account of the mental part of our constitution.

Acquiescence in these principles is, in fact, equally necessary in the prosecution of physical, or even of mathematical science, as of metaphysics; but in the former sciences, they have been always *tacitly admitted*; and only brought into question in the latter, because it is only in the latter that the instruments by which truth is sought, are themselves made subjects of discussion. But as we have no instruments to apply to inquiries into the mind itself, different from those which we employ in the other sciences, we must be content to use them in the same manner, and trust them equally; otherwise we must abandon the labour.

"All reasoning," says Dr Reid, "must be from first principles, and for first principles no other reason can be given than this, that, by the constitution of our nature, we are under the necessity of assenting to them. Such principles are parts of our constitution, no less than the power of thinking. Reason can neither make them nor destroy them, nor can it do any thing without them. We cannot prove the existence of our minds, nor even of our thoughts and sensations. A historian or a witness can prove nothing, unless it be taken for granted that the memory and the senses may be trusted. A natural philosopher can prove nothing, unless it be taken for granted, that the course of nature is uniform, or her laws permanent. That my thoughts and sensations must have a subject which I call myself, is not an opinion got by reasoning, but a natural principle. The belief of it, and the very conception of it, are equally parts of our constitution. If we are deceived in it, we are deceived by Him that made us, and there is no remedy."

"Deny the evidence of memory as a ground of certain knowledge," says Mr STEWART, "and you destroy the foundations of mathematical science, as completely as if you were to deny the truth of the axioms of EUCLID:" but no man can give a reason for believing in what he remembers, any more than in what he feels.

Those who do not put faith in *any* such fundamental laws of belief as are here mentioned, are thereby disqualified for scientific inquiries of all kinds, equally as they would be by the loss of the faculty of memory; because it is manifestly absurd for any one, who has determined that he will believe nothing, to engage in the pursuit of knowledge.

But those who admit that there are *some* principles which must be believed, for no other reason than that we cannot help believing them, may reasonably inquire, in regard to any individual principle, which commands the general assent of mankind, whether it is really of this kind, or whether the belief reposed in it can be founded on any fallacy.

It is only by careful reflection, on the circumstances in which these articles of belief take possession of our minds, that we can judge on this point; but the following have been stated as the most distinctive marks of those principles, which we are entitled to regard as fundamental laws of human thought.

1. These principles are formed, and in the first instance believed, uniformly by all men, and in all circumstances, and do not appear to be influenced by any accidents, of situation, habits, or previous associations of individuals.

2. They are of such a nature, that they can neither be

attacked nor defended, in any other way than by reference to principles, which are not more universal, and have no other foundation than themselves.

3. Their practical influence is found to extend, even to those who affect to question their authority *.

Judging by these marks, and by carefully attending to the natural, uniform, and irresistible tendency of our own minds, we believe that the following principles, so formed, may be regarded as belonging to the class of fundamental laws of belief.

1. The belief in the existence of the sensations and thoughts which pass through our minds, and in our own existence, as sentient and thinking beings,—or the faith we repose in the Evidence of Consciousness.

2. The belief in what we remember to have felt or thought, or in the Evidence of Memory, and in our own Identity during the whole time to which our memory extends, which implies the formation of the general idea of Time.

3. The belief, already mentioned, in the external and independent existence of the causes of our sensations, or in the Evidence of Sense, which involves the formation of the general idea of Space †.

* See STEWART'S Elements of the Philosophy of the Human Mind vol. ii. ch. i. art. 2. & 3.

† The sceptical argument against this universal belief, when reduced to its simplest terms, appears to be this, That we know nothing of any existences external to our own minds, except by means of those feelings which we call Sensations, and therefore that "the material world, if such there be, must be the express image of our sensations;" but that a sensation is a mental change only, and it is absurd to suppose that any thing can resemble a sensation, except another sensation in the same, or another mind.

The answer given by Dr REID and others to this argument is, That although it is by means of sensations that we acquire our knowledge of external things and their properties, yet, in point of fact, the notions which our minds are so constituted as uniformly and necessarily to form of these (at least in the case of the primary and most essential qualities of bodies already noticed, p. 241), have *no resemblance whatever* to the sensations, through the intervention of which they are formed; that the material world, as made known to us through our senses, is *not the express*

4. The belief in the existence of an Efficient Cause, for the changes that we see take place around us, which implies the formation of the general idea of Power.

Here it is to be observed, that our senses never inform us of any events in nature as being causes of other events, in any other way than by showing that they are immediate and invariable antecedents of these. It is only by experience of the consequences which follow any change, that we learn what consequences to anticipate, when we see the same change again.

But although this be the case, most philosophers have thought, that the mere observation of changes in the world around us naturally suggests to the mind, not only the facts of antecedence and consequence, but farther, a general notion or idea, which we express by the term Power; and the notion thus expressed, being truly an attribute of Mind, is considered as the first step in Natural Theology *.

image of our sensations, nor does it resemble them in any particular; and therefore, that although our notions of its nature, and belief in its external existence, cannot be explained, and may be said to involve a *mystery*, as every ultimate fact, whether in physics or metaphysics, does, yet they involve no *absurdity*. The essential point of this answer is not correctly stated by Dr Brown in his criticism on it.

* That this is a fact in the natural history of the mind is denied by others, and especially by Dr Brown, who argues that no farther idea is annexed to the term Power, than merely "invariable antecedence," and that the mere observation of the changes of physical events would never suggest the notion of any attribute of mind, that being only suggested, according to him, by the observation of *contrivance*, or adaptation of means to ends. (Lecture 7.)

But that a general notion, distinct from mere uniformity of sequence, and most correctly expressed by the term Power, does suggest itself to the mind, on the mere observation of physical changes, appears not only to be sufficiently proved by considerations stated by Mr Stewart (Outlines of Moral Philosophy, § 257), but to be distinctly admitted by Dr Brown himself, in other parts of his Lectures. Thus, in speculating on what would have been the effect "if the generations of mankind could have existed in a world of darkness, and then the sun had arisen suddenly on the earth," he says it would have been sufficient to show, "that there

5. The belief in the stability of the Order of Nature, which is necessary to enable us to apply the experience of the past to the conduct of our lives, or the knowledge of natural phenomena acquired by one person, to the instruction of others. This belief is judged not to be the result of experience, because it may be observed to operate the most strongly in those whose experience is most scanty, and in relation to subjects which are perfectly new to them *. Indeed several philosophers teach, that our belief in the independent existence of external things, being founded on a *repetition* of sensations, is resolvable into this principle of our nature.

6. Our belief in our own Free Will, involving the general idea of Voluntary Power, in like manner attends a part of those mental changes, which the exercise of sensation excites.

In regard to this, just as in regard to the other principles now stated, it is a fair question, whether there is any reason for thinking that the feeling of voluntary power, which undoubtedly attends certain acts of the mind, can be fallacious. But if no irresistible reason be stated *against* the belief, it is unreasonable and unphilosophical for us to ask, because it is impossible for us to obtain, any other reason *for* the belief, than the fact, that in performing certain of the mental acts, of which we are conscious, we are naturally and uniformly impressed with the conviction, that we may do so or not as we please. If no clear proof be given, that this conviction is erroneous, and that the general notion of free will which it involves is a fallacy, all

is a Power *which can create*." "The sudden appearance of the sun would have indicated Power of some sort;" and again, "After a few successions of days and nights, its regularity would *add* to the previous conception of Power some conception of corresponding *order;* (Lecture 92). This passage, and others to the same purpose, sufficiently demonstrate that the conception of *sudden and striking change* was sufficient to introduce the idea of Power, exactly as commonly understood, even to a mind that had denied the possibility of its introduction in that way.

* See STEWART's Elements, vol. ii. chap. i. sect. 3.

that we have to do is to state, in the course of our account of the different mental phenomena, what the circumstances are, in which it uniformly and spontaneously arises in our minds.

What has already been said of Sensation, and of these different acts of Thought, which naturally and inevitably succeed sensation in every individual of sound mind, is sufficient to show that the only *foundation of much of our belief*, and the only *source of much of our knowledge*, is to be found in the *constitution of our own minds* Not only are the notions that we form of the qualities of external things, which affect our senses, totally different from our sensations themselves, but certain general ideas, which inevitably arise in our minds, in consequence of the exercise of our senses, are at once perceived, when the attention is fairly fixed on them, to have an extent of application far beyond what the senses themselves can ever reach. The simple notion of our own existence, which is sufficiently suggested to our minds by the occurrence of any single sensation, instantly extends to the whole period of which our memory gives us any information. The notion of Power, or Causation, which may be suggested by the observation of a single striking change in the world around us, is immediately judged to be applicable to all changes without exception. The notion of Time is no sooner formed, than it swells in the human mind to Eternity, as surely as the notions of Space and of Number to Infinity.

Even from these simple instances, it appears, how necessary an addition was made to the scholastic maxim, "Nihil in intellectu quod non fuerit prius in sensu," by the words "Nisi intellectus ipse *;" and how extended a meaning we must annex to the word Reflection, if we assent to the doctrine of LOCKE, that all our knowledge is derived from Sensation and Reflection. Although "sensible objects may be the destined medium to awaken the dormant energies of the understanding, yet are these energies them-

* LEIBNITZ.

selves no more contained in sense, than the explosion of a cannon in the spark that gave it fire."

It is next to be observed, that many of the mental acts, which are felt as constituting our trains of thought, consist in a certain renewal, or what we call Recollection of past Sensations. The act or state of mind which constitutes such a recollection is felt as much slighter, and much more transient, than that which followed the impression formerly made on some one of the senses, but is precisely similar to it. To this act of mind the term Conception is properly restricted.

Farther, this act of mind, transient as it is, always carries along with it a conviction, that a precisely similar state formerly existed in consequence of an impression on the senses; and to this *conviction of past existence*, attending the consciousness of the present existence, of this or any other mental act, we properly refer when we use the term Recollection, or Memory.

The act of mind, distinguished by these last terms, is so very frequent and important, that it accompanies or immediately succeeds almost all others, and appears, on consideration, to be essential to the formation of our simplest notions of the qualities of objects, and to the other mental acts which immediately result from sensation.

The Conceptions, or renewed images of past sensations, present themselves to the mind in succession, and mingled with other thoughts, but independently of any effort of the will; the degree of indirect power which the will has over them will be considered afterwards, but it may easily be observed, that no such effort is necessary, in order that conceptions may present themselves in various number and order. And on reflection on such involuntary successions of images in the mind,—particularly on such as from any cause impress themselves more strongly, and remain longer, than usual,—it is thought by several metaphysicians, that there is a natural tendency of the mind to conceive them as representing external and independent existences, in like manner as sensations do. This tendency is instantly checked, and prevented from leading to a false judgment of the mind, by two circumstances:—1. Although each conception is involuntarily presented to the mind, yet we are conscious of a voluntary power either of retaining it, and fixing our attention on it, or of letting it pass off, which naturally leads us to believe, that it has no existence independent of the mind that is conscious of it:—2. The conceptions are continually intermingled with real sensations, dependent on impressions from without, which convey to us a notion, known to be correct, of external and independent existence; and which we feel to be widely different from the conceptions, and often to be incompatible with the external existence of any causes corresponding to these.

That there is a natural tendency to believe in the present external and independent existence of the causes of our conceptions, as well as of our sensations, appears probable from the state of our minds, when many vivid recollections of past sensations, or fancied images closely resembling such recollections, with little interruption either from present sensations or voluntary efforts, are called up by an interesting narrative read or heard; and still more by the state of mind during Sleep, when both the checks, stated above, to the belief reposed in them, are withdrawn (sensations being little felt, and voluntary efforts suspended); and when the same belief attends conceptions, as attends sensations and perceptions in our waking hours *.

These statements are important as illustrating the formation of delusions in Delirium and Mania, when, in consequence of conceptions (and other acts of thought to be afterwards mentioned) being more vivid, and more lasting than usual, and absorbing the attention more completely, their causes are believed to have a separate and independent existence, just as those of sensations are in the healthy state.

The power or disposition of the mind to form, at any

* See STEWART's Elements, vol. i. chap. iii.

future period, the conception of, *i. e.* to remember, any sensation, or indeed any former act of thought, depends very much on the circumstances in which the original impression is made, and especially on the state of the nervous system at the time: For sensations felt in youth are longer remembered than those which are first felt in advanced life; and impressions made on the senses during intoxication, during sleep (provided they do not interrupt sleep), or during certain diseased states of the nervous system, although they cause sensation, and even some of the usual effects of sensation, both mental and bodily, are yet very imperfectly, or not at all remembered.

Next, a very important part of the trains of thought, which the exercise of the senses excites in the mind (and which implies indeed an exercise of the different faculties already considered), consists of acts of *Abstraction*, by which we separate from the complex sensation or conception, corresponding to any individual object, certain of the qualities which that object possesses, and make them distinct objects of attention; thereby both forming to ourselves general or abstract ideas or notions, and likewise enabling ourselves to form classes or genera of objects. Thus when we compare any two bodies, and observe them to be both black or both white,—compare two animals, and observe them to be both quadrupeds,—two flowers, and observe them to be both fragrant,—we begin to exercise this faculty of abstraction, which enables us to occupy ourselves with the *general relations of things*, and to classify and methodize our knowledge. The nature of this mental operation is perhaps best expressed by the term used by Dr Brown, the Suggestion of Relations.

It is obvious (on a little reflection), that the general qualities of objects, expressed by such terms as white, black, tall, short, round, square, &c. and that the general classes of objects, as plant, animal, horse, dog, formed by attention to their respective qualities, and relations to each other,—have no real external existence, but belong only to the individuals referred to these classes, or invested with these qualities; and it has even been disputed whether any definite notions of these abstract qualities, or of the classes distinguished by means of them, are ever formed in the mind,—some philosophers thinking that it is only by means of the *words* employed to denote such abstract ideas, that we are enabled to make them objects of thought. This is the substance of the metaphysical dispute between Realists, Nominalists, and Conceptualists. But it appears beyond doubt, that the operation of the mind, by which the relations of things are perceived, and by help of which the objects of our knowledge are arranged into classes, is not only independent of language, but is a necessary preliminary to the use of all abstract or general terms *.

It is important to observe how generally, by means of this faculty of mind, and of the general notions already mentioned as immediately succeeding sensation, our thoughts are elevated above individual objects of sense, and occupied about what are called abstract ideas, or classes of objects; and this is well illustrated by the nature of language;—for there is only one class of words (substantive nouns), and only a part of these, which express what is individual; all others denoting either classes of objects, comprising many individuals; or qualities, or events, common to, or contingent upon, many. This, accordingly, is the

* See Brown's Lectures; Lecture 46 and 47. The following sentences contain a summary of his doctrine on this subject, which is substantially the same as that of various other authors, and appears satisfactory:—"We perceive two or more objects. This is one state of the mind. We are struck with the feeling of their resemblance in certain respects. This is a second state of the mind. We then, thirdly, give a name to these circumstances of felt resemblance,—a name which is of course applied afterwards only where this relation of similarity is felt. It is unquestionably not the name that produces the feeling of resemblance, but the feeling of resemblance which leads to the invention or application of the name; for it would be equally just and philosophical to say, that it is the name of the individual John or William which gives existence to the individual John or William, and that he was nobody, or nothing, till the name was given,—as to say that the name Man, which includes both John and William, is that which includes our notion of their resemblance; and that but for the name, we could not have conceived them to have any common properties."

faculty, the more perfect possession of which appears to furnish the most essential and fundamental distinction between the human intellect and that of the lower animals.

Again, in reflecting on such acts of thought, a farther distinction presents itself; the mind not only forms general notions of the qualities or relations of objects, but likewise perceives and decides on the relations of different objects to one another, or to these abstract ideas of its own formation; as when the separate conceptions of two quadrupeds not only suggest to us the general idea of resemblance, and the general class of quadrupeds, but likewise fix the relation which each of these individuals bears to those general notions; and this is what is strictly meant by the mental faculty or power of Judgment. A succession of individual acts of this kind takes place when we apply our experience of individual sensations to the formation of classes of objects, and to the determination of laws of nature; and again, when we deduce certain conclusions, either from ascertained laws of nature, as in physics, or from arbitrary definitions of our own, as in mathematics.

In exercising this faculty of Judgment, we are guided, or our judgments are determined, partly by the knowledge we have acquired, or the definitions we have laid down, of the subjects on which our thoughts are occupied, and partly by the intuitive principles or laws of belief already mentioned.

All the acts of mind hitherto mentioned are said to be simply Intellectual; they cannot be strictly called either pleasant or painful; and they prompt to no acts of volition: but other feelings form part, even of our simplest trains of thought, which are at once felt to belong to a different class. Emotions of Pleasure, Pain, Surprise, Fear, Resentment, Curiosity, &c.—feelings which neither admit of nor require definition,—immediately succeed both the excitation of present, and the recollection of past sensations; constitute a great source of enjoyment, and form a part of what are called the Active and Moral Powers or Dispositions of our nature.

The different acts of mind now considered,—the Apprehension or formation in the mind of certain general notions, the Conception and Remembrance of past sensations, the Abstraction of certain of the qualites of objects from others, so as to form additional general notions, and, by them, classes of individuals; the Judgments of the relations of objects to one another, and to these general notions; and the simple Emotions, pleasing or painful, which several of these operations excite;—are the simplest elements that compose those varied trains of thought, which the exercise of our senses excites.

And before going farther, we can pronounce, with confidence, on the inaccuracy of the theory of several French philosophers and physiologists, who resolve all acts of Thought into Sensation,—a theory which, in fact, amounts to nothing more than an extension of the term Sensation to what, in our language, is expressed by the more general term Consciousness. If we were to adopt that extension, we should not only involve ourselves in misapprehensions, but should be obliged afterwards to subdivide the sensations, so as to make them correspond to what we now call the different mental faculties *.

But when our minds are employed for their destined use,

* "I perceive a hare," says Dr Brown, "and I perceive a sheep: each of these separate states of my mind is a sensation. I cannot attend to them long without comparing them, and perceiving those circumstances of agreement, which lead me to apply to both the term Quadruped. The one state of mind is a consequence of the other state of mind. But this is far from proving the comparison itself, as a subsequent state or phenomenon of mind, to be the *same mental state* as the mere perception of the two animals which preceded it. If the evidence of our consciousness is to be trusted, it is very different; and on what other evidence can the assertion of their sameness be founded?"—"It is not as being susceptible of mere sensation, but as being susceptible of *more than mere sensation*, that the mind is able to compare its sensations with one another. We may see, and certainly do see, objects together, without forming the same comparison; which could not be the case if the mere co-existence of the two perceptions constituted or involved the comparison itself."—(Lect. 33.) See also Stewart's Philosophical Essays, Essay i. ch. 3 and 4, and Essay iii.

either for the acquisition of knowledge, the pursuit of pleasure, or the attainment of any practical purposes, it is plain, not only that these different mental acts must take place, but that they must succeed one another in a determinate order, and tend to a definite object; and accordingly, before we can consider the two noblest and most characteristic, but also most complex, of the mental powers, those of Imagination and of Reasoning, by which the conduct of our lives is chiefly directed, we must take notice of the laws which appear to regulate the successions of thoughts in our minds.

II. In this respect there is observed a much greater difference among individuals, or in the same individuals at different times, than in regard to the nature of the mental acts. There are first, certain laws as to the succession of thoughts, which are imposed by nature on the minds of all; and secondly, there is a certain power which we feel that we can exert voluntarily on our own minds.

1. The rapidity with which all the component parts of the train of thought pass through the mind, is very various in different persons; different in youth and age; perhaps generally different in women and men. And there is a still more striking difference between individuals, as to the length of time, during which certain peculiar objects of thought dwell on their minds, and the degree of attention they excite. Thus some persons are strongly impressed by differences of colour, some of forms, some of countenances; the minds of some dwell habitually on certain abstractions, such as numbers, or mathematical figures; those of others on certain of the properties of external objects; those of others on the words by which thoughts are expressed, &c. The memory of all subjects of thought depends very much on the length of time that they have occupied the mind; and therefore the subsequent recollections, and the usual reflections, of different minds, will necessarily depend very much on the peculiarities of this disposition of Involuntary

Attention. The striking differences of individuals, in this respect, are well illustrated in the writings of GALL and SPURZHEIM, and their followers.

2. In the same person, at different times, there is also great variety as to the rapidity with which different thoughts succeed one another, and as to the intensity of mental attention which is fixed upon them; sometimes from physical and sometimes from moral causes. The effect of any cause accelerating the circulation in the brain, in a degree consistent with health, is to increase, for a time, the rapidity and the energy of the mental acts; and the same is often remarkably seen in the stage of greatest vascular excitement, in febrile and inflammatory diseases. The effect of every emotion or moral feeling, which blends itself with any mental act, is to modify the rapidity of the train of thought at the time; sometimes to quicken it, as in the case of joy; sometimes more remarkably to retard it, and keep the same image or idea long before the mind, as in sorrow; but always to give additional intensity to the involuntary disposition of the mind, to attend to any such act; as is often shown, both by the long and vivid subsequent recollection of such thoughts, and by the slight degree of attention which any object of sense presented during the continuance of the emotion receives, and the very short period to which the power of recollecting it extends.

3. It would appear that the mind is truly "incapable of attending at one and the same instant to objects to which it can attend separately;" although the length of time during which a single object of thought remains before the mind is often so inconceivably short, as to deceive us into the belief of its actual coexistence with others *. At least, when any mental faculty is strongly excited, or the attention strongly fixed on one mental act, any other mental act is imperfectly performed, is hardly an object of attention, and fails of its usual effects. Mental occupations of intense interest, or violent muscular exertion, greatly diminish the inten-

* See STEWART's Elements, vol. i. ch. 2.

sity and the effect of sensations excited by impressions on the senses. On the other hand, any very intense and uneasy sensation so engrosses the mind, as to disqualify it for carrying on any continuous train of thought, or exciting any definite succession of muscular efforts. And when two distinct impressions are made about the same time on the senses, the stronger sensation overpowers or obscures the weaker.

This principle is of great importance in the pathology and treatment of disordered states of the mind. But in the healthy state, and when none of the mental acts take place with unusual force, there is frequently a *virtual* co-existence of feelings or thoughts, which, when strictly analyzed, appear widely different from each other.

4. Much attention has been paid to the different bonds of union that exist among our thoughts, or the laws of association according to which they succeed each other. When we reflect on the very various thoughts which pass through the mind within a short time, we are sometimes quite at a loss to detect any principle to which we can ascribe their succession; nor is it certain that any such connecting principle does always exist; but in general we may observe, that one suggests another, either by reason of *previous Association* in the mind, of *Resemblance*, or of *Contrast* in the objects themselves*.

When two events which immediately succeeded one another,—when a cause and its effect,—when the different parts of a complex scene, or the different countenances of an assembly of persons,—when the successive steps of a de-

* On this subject Dr Brown makes a just and acute observation. "All suggestions, I conceive, if our analysis be sufficiently minute, may be found to depend on *prior coexistence*, or immediate proximity. For this very nice reduction, however, we must take in the influence of *emotions* and other feelings; as when an object suggests an analogous object, by *the influence of an emotion or sentiment*, which each separately may have produced before, and which is therefore common to both. But it is very convenient, in illustration of the principle, to avail ourselves of the more striking subdivisions, in which the particular instances of proximity may be arranged." —Lect. 35.

monstration, or heads of an argument, already gone through,—present themselves to the mind in succession, it is obvious that they have been suggested by the principle of previous association. And, in proportion as that previous association has been more recent, as it has been more frequent, as it has been less disturbed by other concurrent circumstances, as the thoughts constituting it have been longer and more strongly impressed on the attention of the individual, either from his natural disposition, or from emotions formerly attending it,—the same succession of thoughts will be more certainly and more perfectly reproduced.

The associating principle of Resemblance, again, often brings together in the mind, not only objects of sense, which have obvious and striking similarities, or many qualities in common, but thoughts and feelings which have less tangible analogies, or which resemble each other chiefly in giving rise to the same emotions; as when warmth and sunshine awaken emotions of joy, when slow deep-toned music excites solemn reflections; or in general, when any object of interest suggests those slighter and more fanciful analogies, which may be traced among the component parts of the trains of thought to which the epithets of Sublime and Beautiful are appropriated.

Again, in other cases, the resemblances which serve to associate thoughts with each other are in the words which denote them, not in the objects of thought themselves, as is shewn by the fantastic assemblages of thoughts often brought together by rhymes, puns, or alliterations.

Some of the greatest intellectual differences that exist among individuals, turn on the natural tendency of the mind to these associations or successions of thoughts. In some minds the chief associating principle is merely previous association; and if it be strong, such men are well fitted for practical exertions, varying according as their involuntary attention has been more frequently and longer bestowed on one class of thoughts or another; but they are not fitted for works of genius. In other minds the chief associating principle is resemblance; and according to the kind of resemblance or analogy, which they are most apt to observe, they are fitted for various works of art or of fancy. In all men, when under the influence of strong emotion or passion, as the whole train of thought is more rapid, so the associating principle of analogy becomes (apparently at least) more than usually powerful, and the language used is more metaphorical.

It is according to the strength and endurance of more or fewer of these principles of association, that individuals differ in what is commonly called the fidelity and retentiveness of Memory; and it is by the failure of more or fewer of them, that those diseased states called general or partial loss of memory are chiefly characterized *.

5. All this applies to the causes which influence, or laws which regulate, the train of thought in the mind, independently of any influence of the Will. The Voluntary power which we may fairly affirm that we are conscious of possessing over the succession of our thoughts, is in all cases *indirect;* because it is plain that to make the effort to call up any particular thought, necessarily implies that it already exists in the mind; but it is not the less real or important. "It consists in singling out any one thought that has pre-

* It may seem a needless multiplication of scientific terms to speak of the images of past sensations being retained by Memory, suggested by the Association of Ideas, and called up by Conception; and Dr Brown thought he had simplified the subject considerably by ranking all these powers under one head as Simple Suggestion. But perhaps this generalization is rather verbal than real. When the sight of any scene in nature recalls another which it resembles, it is true that the mind does no more than pass from one state, which the impression made on the eye has excited, into another state which is the conception of the scene formerly before the senses; but it is equally true, that in this mental change, three distinct principles are illustrated; *first,* the power of the mind to represent again to itself an impression formerly made on it through the senses; *secondly,* its power to retain that impression latent, for a great length of time, and recognise it, when again presented, as having been formerly an object of its attention; and *thirdly,* the efficacy of the law of association by resemblance, to which the recollection, at that moment, is to be ascribed. These are all general facts, as to our mental constitution, which connect themselves with others, and demand separate consideration, and hence the propriety of using three different words to denote them.

sented itself, detaining it at pleasure, and making it a particular object of attention; whereby we not only stop the succession which would otherwise take place, but frequently, by bringing into view less obvious relations among our ideas, direct the current of our thoughts into a new channel." And if this be done repeatedly, and habitually, in regard to the exercise of our minds on any particular subjects,—so as to strengthen and rivet particular successions of these by the principle of previous association,—we ultimately acquire, indirectly, so great a voluntary power over our thoughts, that it requires a considerable exertion of attention to observe, that the laws of association which enable us to recall any piece of knowledge for which we have occasion, are in reality fixed beyond our own direct control by the constitution of our nature.

Our indirect voluntary power over our thoughts is often aided by our more direct voluntary power over various muscles, whereby we may either command, or prevent, the excitation of sensations, calculated either to confirm, or to break through, those lines of association which we may wish to preserve.

When the various thoughts which pass through the mind are habitually intermingled with Sensations, which occupy a certain degree of attention, and which are themselves either pleasing, or painful, or calculated to excite any peculiar emotions, both the rapidity of the train of thought, and the kind of mental feelings or operations on which the mind habitually dwells, are very apt to be materially modified; as we observe when we attend to the peculiarities of character of persons who are habitually asthmatic; still more of those habitually dyspeptic; and to the striking differences of the character of the inhabitants of warm and cold climates; of mountaineers and the inhabitants of plains; or of persons habituated to solitude and to society.

When the train of thoughts in the mind is either accelerated or retarded, and particular acts of thought rendered more vivid and engrossing, by strong emotions accompanying them, the indirect voluntary power is proportionally diminished; and this is still more the case when certain of the thoughts acquire an unnatural energy from disease.

The principal varieties of character in individuals, the changes which the mind undergoes in the progress of life, and those to which it is liable in disease, are most easily understood, when they are considered as chiefly depending on alterations of the laws which regulate the duration of thoughts before the mind, and their succession in the mind; rather than of the faculties or powers, of which the individual acts of thought, when analyzed, appear to be composed.

III. It was already said, that the highest and most characteristic faculties of the mind are those of Imagination and of Reasoning; by the first of which we understand the power whereby the mind voluntarily combines various of its conceptions and abstractions, and forms a visionary creation of its own, differing from any thing that has been presented to the senses; and by the second that whereby the mind voluntarily connects together successive acts of Judgment on the relations of things; and so adapts premises to conclusions in matters of speculation, and adapts means to ends in practice.

It is obvious that the exercise of both these faculties implies (or that they consist in) not only the performance of the simpler acts of understanding already considered, but likewise a certain determinate succession of such acts, regulated in the manner above stated by the will; and that these complex mental acts may be altered or suspended by any alteration of the laws, by which the succession of thoughts in the mind is determined; and it is in this way, accordingly, that they are chiefly altered or perverted in disease.

In the conduct of life, it is most generally by an exercise, more or less complex, and partly voluntary, of the Faculty of Imagination, that we propose to ourselves objects of pursuit; and then, by an exertion more or less sustained, of the Faculty of Reasoning, that we adapt means to the attainment of these ends.

As the more elementary acts of Thought,—Sensations, Conceptions, and the perception of the simpler relations of things,—are attended with emotions, pleasing and painful, and sometimes with instinctive propensities, so the more complex acts now in question are attended with what are more strictly called *Desires*; which are, in general, anticipations of enjoyment, of one kind or another, consequent on the prospects, more or less fanciful, of effects to be obtained by our exertions, and accompanying the complex mental acts, by which these prospects are to be realized. Thus, the Desire of Pleasure, the Desire of Power, the Desire of Knowledge, the Desire of Esteem, the Desire of Praise, the Desire of Social Intercourse,—attend the acts of Imagination and of Reasoning on the common affairs of life, and bear the same relation to them as the Instinctive propensities do to the Sensations by which they are excited, *i. e.* they constitute the chief Motives to our actions.

Farther, in like manner as the perception of the qualities of material things, and the simpler relations of objects of thought, naturally excite in our minds certain simple ideas, and compel our assent to certain intuitive truths, so the observation or anticipation of certain actions and their effects, naturally excite in our minds the notions of Right or Wrong, Justice and Injustice, which may in like manner be held to be ultimate facts in our constitution; and which, when combined with the consciousness of a certain degree of voluntary power, impose on us the sense of Moral Obligation.

As almost all human actions tend to procure some kind of enjoyment or advantage for the agents, some authors have thought that the simplest and most satisfactory view of this subject is, to suppose that all motives to action resolve themselves into the desire of pleasure; and much has been said to prove, that as the highest and most enduring pleasure is derived from the exercise of virtue, there is nothing adverse to morality in this view of human motives and conduct. But the considerations urged on this point by Mr STEWART, seem quite sufficient to prove that this is an excessive simplification; that we have a sense of Duty, not resolvable into a regard for our own happiness, and which ought to be, and often is, a rule of human conduct *.

We must consider, therefore, the general notions of Right and Wrong, which present themselves on a view of the effects, or probable effects, of human actions, as an ultimate fact in our mental constitution, or a primary element of human reason, equally as the notions of Power, of Intuitive Truth, &c.; and which imposes on all persons of sound mind a sense of moral obligation, although many circumstances constantly tend, either to weaken its influence on our conduct, or to mislead us in its application.

This slight sketch of the strictly mental phenomena will at least serve to illustrate the different sets of facts which

* These considerations are,

"1. There are in all languages, words equivalent to Duty and Interest, which men have constantly distinguished in their signification. They often coincide in their application, but convey very different ideas.

"2. The Emotions excited by the contemplation of what is right or wrong in conduct, are different, both in kind and degree, from those which are produced by a calm regard to, or careless disregard of, our own happiness. This is particularly remarkable in the emotions excited by the conduct of others, for few men are perfectly fair judges of their own actions.

"3. Although philosophers have shown that a sense of duty, and an *enlightened* regard for our own happiness, do, in most instances, give the same direction to our conduct, yet this is a truth by no means obvious to the common sense of mankind, but deduced from a very extensive view of human affairs, and of the remote consequences of human actions. Consequently, the great lessons of morality, which are obvious to the capacity of all mankind, cannot have been suggested to them merely by a regard to their own interests.

"4. The same conclusion is very strongly confirmed by the very early period of life at which judgments on the moral character of actions make their appearance,—long before children can form such a general notion of happiness as can demonstrate the coincidence of duty with self-love, and indeed in the very infancy of reason."—Outlines of Moral Philosophy, § 172.

require consideration under this head,—first, the formation of certain general notions and principles consequent on the exercise of our senses,—next, the recollection of past sensations,—then the perceptions of the relations of things and formation of farther general or abstract notions: these thoughts are continually mingled, not only with our sensations, and with the recollections of similar states of the mind in time past, but also with emotions, pleasing or painful; they succeed each other according to certain tolerably definite laws, but are, to a certain degree, regulated by our own will; and under this guidance, they are so combined and directed as to excite desires, and call up moral feelings, and so furnish motives for action; and, at the same time, to determine the kinds of actions, by which the objects thus set before us may be attained.

As we formerly stated the manner in which certain sensations, excited in the mind, throw into action directly, or through the intervention of instinctive propensities, certain nerves, muscles, and other moving parts, essential to respiration and digestion (functions of such importance to the animal economy, that they are not left to the guidance of reason, but provided for by the surer process of instinct); so we have now taken a general view of the slower and more circuitous process, by which the acts of thought that are excited by sensations, and left to the control of the will of the individual, become occasions of voluntary efforts, and thereby of nervous actions, muscular contractions, and motions of other organs of the body,—to be presently more particularly considered.

We can only go a certain length in determining the parts of the larger masses of the Nervous System contained within the cranium, which furnish the essential conditions to the mental operations now considered; but the following facts on this subject appear to be well ascertained.

1. The parts of the nervous system which attain their highest development in the human species, and may, from that circumstance, be supposed to be especially connected

with those mental operations in which the pre-eminence of the human species consists, are, the Convolutions of the Brain and Cerebellum, the Corpus Callosum, Corpora Striata, Thalami, and Tuber Annulare. Those which are least developed in the human species, but are proportioned to each other in the different classes of vertebrated animals, and may therefore be presumed to be chiefly connected with sensations and voluntary motion, and to have less connexion with any strictly intellectual acts, are the Spinal Cord, Corpora Quadrigemina, (called Optic Lobes in many of the lower animals), and Vermiform Processes of the Cerebellum. The Fornix and Pes Hippocampi attain their highest development in some of the mammalia, but not in man *.

2. Although we commonly give the name of Instinct to all the mental operations of which we see indications in the lower animals, yet it is obvious that many of their actions are guided, not merely by the instinctive propensities which are connected with appetites, but by mental operations similar, in some respects, to those of human intellect. In particular, it is obvious, that sensations are distinctly recollected; that emotions (as those of fear and joy) attend them, both when first excited, and when afterwards reproduced; that these mental acts are associated, and called up in successive trains; and even that some of the simpler relations of things are perceived; so that a certain degree of contrivance (implying some exertion of a faculty of reasoning), may be practised; although it is plain that their intellect is very little adapted for forming, or dwelling upon, most general or abstract notions.

Now it has been shown, by the experiments of FLOURENS, MAGENDIE, and others, that the indications of such mental operations are not diminished by cutting off the cerebellum, in the animals that survive the operation; but that they are almost entirely suppressed, particularly in birds, by cutting off the cerebral lobes; which appear to correspond to the great mass of the hemispheres and convolutions of

* See SERRES, Anat. Comparée du Cerveau.

the brain, especially in the leading circumstance of the medullary fibres from the spinal cord expanding and terminating in them. An animal thus mutilated may live long, and is capable of sensation, and of the instinctive actions most directly linked with sensations; swallows what is put in its mouth; moves its legs when irritated, and its wings when thrown into air; but when not excited by any impression on the senses, appears in a state of stupor; gives no signs of recollection, even of sensations just felt, nor of such emotions as sensations were wont to excite; and cannot seek its food, nor even avoid obstacles thrown in its way.

Hence it would appear, that such of the strictly mental faculties above described, as these animals possess, and particularly that Memory, or the Association of thoughts, are dependent chiefly or entirely on this portion of the contents of the cranium; which, accordingly, is the most material part of what is found peculiarly developed in man *.

3. Injuries confined to the hemispheres of the brain have also appeared very generally, in the experiments of Flourens, Bouillaud †, and others, to impair the indications of the strictly mental phenomena; but no distinct evidence has been adduced from experiments, of any one class of these phenomena being more affected by injury of one part of the hemispheres of the brain than of another.

Many persons who have given attention to this subject since the first publications of Gall and Spurzheim, have agreed with these authors in thinking, that sufficient evidence of the appropriation of different parts of the contents of the cranium, to different mental acts, may be obtained by comparing the heads of individual persons, whose characters and dispositions are known; and observing such relative proportions of the different parts of the skull to one another, and such prominences or depressions on the skull,

* See particularly Cuvier's Report to the Institute on the Experiments of Flourens, in the Recherches Physiologiques of this author, and in the Journal de Physiologie, t. ii.

† Journal de Physiologie, t. x.

as they consider to be sufficient to indicate the comparative size of different portions of the brain and cerebellum in these persons.

The object of this inquiry appears to be quite philosophical, and was accordingly long ago recommended by Lord BACON *. There is nothing improbable, nor in the smallest degree at variance with the principles formerly stated (p. 119, &c.), as to the essential distinction between Mind and Matter, in the supposition, that as (by the admission of all) the whole Nervous System furnishes the conditions necessary to the manifestation of the whole mental phenomena, in this state of our existence,—so any one portion of the nervous system may furnish the conditions necessary to the manifestation of any one part of these phenomena. And it is also possible, that the different portions of the brain may be appropriated, as the phrenologists in most instances suppose, to the exercise of the faculties on particular subjects, or particular classes of objects, rather than to such differences among the acts of thought themselves, as have chiefly attracted the attention of metaphysicians.

But when it is considered, *first*, That there must necessarily be great want of precision, both in the physical and metaphysical part of many of the observations made in this way; *secondly*, That sources of fallacy exist in the inference as to the form or size of the brain, from inspection of the skull, particularly in the neighbourhood of the frontal sinuses, and of the cerebellum, which seem sufficient to vitiate some of the conclusions which these authors have regarded as the best established; and *thirdly*, That observations made in this way, by different competent observers, have given, in different instances, very discordant results;—it may safely be inferred, that very little reliance can be placed on conclusions drawn from such comparisons, unless these are confirmed from other sources. And it does not appear, on examination of the results, either of experiments on the

* De Augmentis Scientiarum, Lib. 4. C. 1.

brains of animals, or of pathological observations on the human body, that any conclusions favourable to the phrenological division of the functions of the different parts of the brain, can be deduced from them.

On the whole, the only point ascertained is, the general appropriation of the great mass of the hemispheres of the brain proper, to the acts of thought; which is by no means peculiar to, and does not derive its chief support from, the writings of phrenologists. The very same kinds of alteration of the mental faculties have been often observed, from disease or injury of very different portions of the brain; and again, large and various portions of the hemispheres of the brain have been found, in other cases, manifestly injured, or even destroyed by disease, without perceptible alteration of the mental faculties, almost to the moment of death *. Experiments and pathological observations would seem to indicate, therefore, that the manifestation of these mental phenomena depends, not so much on the mere presence of any particular quantities of the nervous matter of the hemispheres, or the forms which it presents, as on some other conditions in that nervous matter †; and whether these are, in any respect, different from the general conditions, formerly stated as necessary to the nervous actions in all parts of the system, is still uncertain.

* See, for example, a case recorded by Dr Abercrombie, (Pathology of the Brain and Spinal Cord, Case 89,) where the patient appeared in full possession of her faculties, mental and bodily, a few hours before death; and on dissection, nearly the whole of one of the hemispheres was found in a state of complete softening.

† Flourens' conclusions are, " Qu'une portion assez restreinte mais determinée de ces organes (lobes cerebraux) suffit au plein et entier exercice de leurs fonctions;" and again, " Les perceptions, les volitions, toutes les facultés intellectuelles et sensitives, occupent concurrement et conjointment le meme siege dans ces organes."—(Recherches, &c. p. 161 & 212): and the researches, pathological and experimental, of Bouillaud and others, do not enable us to modify this conclusion farther than had been previously done by Cuvier, *i. e.* by showing that it does not apply to the mere susceptibility of sensation, and of the instincts most closely linked to sensations.

CHAPTER XIV.

OF VOLUNTARY AND INSTINCTIVE MOTION.

We have stated what is known of the conditions, under which the human mind is connected with the body, and is informed of, and affected by, impressions made on the body by any foreign substance. We have now to consider more particularly the laws, according to which the body is subjected to the control of the mind; is made to change with the changes, express the feelings, and minister to the wants, of its immaterial inhabitant.

All the mental acts which can be observed to produce, through the intervention of the Nervous System, any decided effect on other organs of the body, may be referred to the heads of Voluntary and Instinctive Efforts (or Volitions and Instincts), Sensations and Emotions; and partial illustrations of the effects of all these mental acts on the body have already been stated. The effect of the volitions and instincts is much more striking than that of any other mental acts, but is also much more limited; being confined to the direct excitation of certain of the muscles of the body, viz. the voluntary muscles,—through certain of their nerves, viz. those formerly described as the motor nerves; while sensations and emotions produce well marked effects, not only on these muscles, but also on the involuntary muscles, and the secretions.

All the movements which we call either voluntary or instinctive, are essentially characterized by being immediately preceded by the consciousness of a voluntary effort, and likewise attended by a sensation, which gives information of the position and degree of the muscular contraction that is excited. These mental feelings, accompanying such movements, are easily distinguished. In a case of paralysis, or temporary loss of power in a motor nerve, we have the consciousness of effort without the muscular sensation; and in the case of sneezing, or vomiting, from urgent uneasy feelings, we have the latter with hardly any thing of the former.

The contractions which are excited in the voluntary muscles by these mental efforts, acting through the nerves, are much stronger than any that can be produced by direct irritation of the fibres of these muscles, probably because the nervous fibrils penetrate the whole interior of the muscles, and therefore any irritation acting on them reaches the whole of the fibres more completely than one merely applied to their exterior. But the involuntary, or spasmodic contractions of such muscles, which may be excited by physical irritations of the nerves, spinal cord, or medulla oblongata, are stronger than any voluntary contractions.

Many instances illustrating the great strength of voluntary muscular contraction, under certain circumstances, have been recorded. In the dead body the tendon of a muscle has generally more tenacity than its fibres; but there are many cases of tendons ruptured, and even some of bones broken (as the patella, or even the humerus), by the vital contraction of muscles attached to them. The muscles of the lower jaw of a man have been known to raise a weight of 300 lb., and the extensors of the back of a delicate girl, in opisthotonos, to counterbalance a weight of 800 lb *. The disproportion between the size of the muscles, and the force which they can exert, is still greater in some of the lower animals, especially insects.

It was formerly observed, that the involuntary muscles require intervals of relaxation equally as the voluntary do; but the increasing difficulty of exciting repeated contractions by efforts of which we are conscious, and the uneasy feeling consequent on frequent repetition of muscular sensations, are peculiar to the muscles employed in the function now under our view; mental efforts being wholly ineffec-

* See HALLER, Elem. Physiol. tom. iv. p. 481.

tual, and muscular sensations being hardly felt, in the involuntary muscles.

The actions of the voluntary muscles are habitually more irregular, and their contractions are often continued longer, than those of the involuntary are; and it is evident, from the variety of positions which the limbs may retain during sleep, that all these muscles can rest in various states of contraction; which is of great importance, as enabling them to combine in the performance of complex motions. But the amount of contraction of which these muscles are susceptible, is not so great as that which some of the involuntary muscles, such as the bowels, or the bladder, occasionally undergo.

The rapidity with which separate contractions of voluntary muscles may follow each other, both in the human body and the lower animals, is inconceivable. It has been ascertained that some men can pronounce articulately 1500 letters in a minute, which implies 1500 successive contractions of muscular fibres. If we suppose, with HALLER, a relaxation, of equal duration as the contraction, to be necessary to make the sounds distinct from one another, each of these contractions must have taken place in the 50th part of a second; but even if this condition be not necessary, each contraction must have been willed and accomplished in the 25th part of a second; and during this time, or in the intervals of these volitions, the mind must have been carrying on other trains of thought. According to the calculations of HALLER, a dog, in running, will sometimes exert distinct volitions for the movement of his legs, 200 times in a second.

It was already observed (p. 134) that the strictly Instinctive motions of the voluntary muscles, caused by volitions which instantly and inevitably succeed certain sensations, however complicated they may be, are performed correctly from the first. But when we attend to the manner in which the strictly Voluntary motions, prompted by more complex mental processes, are at first performed in the human species and in some other animals, we observe, that it is only by repeated trials, and after frequent failures, that we learn how to move the voluntary muscles, so as to accomplish the objects desired. This process of education evidently depends on two principles, *first*, on the Muscular Sensations, which accompany all the contractions that the will excites, and which are remembered, and are the guide to the repetition of the same action; *secondly*, on the mental law of the Suggestion of Thoughts by previous Association, whereby each of these muscular sensations suggests the volition, which had formerly succeeded it, in the performance of any complex action; so that, after some experience, the different volitions necessary to its performance, become associated in trains, which follow one another without fixing the attention, and cannot afterwards be broken without an energetic effort of the will.

In attending to the acts of our own minds in performing any voluntary action which has, by frequent repetition, become *habitual*, we become sensible of the power and the importance of this mental law of Association.

Farther, by such habitual repetition of movements, the muscular organs concerned in them are gradually augmented and strengthened (see p. 14); and thus a gradual increase is effected in the strength, facility, and precision, with which habitual movements are performed.

These habitual movements are ultimately performed with so little effort, interfere so little with other trains of thought, and the volitions prompting them are so quickly forgotten, that many writers have considered them as becoming, after a time, truly involuntary. But that this doctrine is quite incorrect appears distinctly from two considerations.

1. That the inconceivably short space of time, in which the different volitions necessary for such habitual movements must take place, and the total want of subsequent recollection of them, furnish no evidence against their existence, is proved by the case adduced by Mr Stewart on this point, of the equilibrist who balances himself on a cord, and, at the same time, two or three rods on different

parts of his body *. The frequent, rapid, varied, and nicely regulated movements, by which this must be done, cannot possibly have been associated in any one train, as those in any habitual mechanical operation are,—because they must be regulated by accidents which will vary on each repetition of the experiment; yet they are performed in as short a time, and leave as little traces on the recollection, as those concerned in any such habitual movement.

2. Although " in playing a musical instrument, or in many mechanical operations in the arts, the motions are so rapid, that we find it difficult to say that there could have been a distinct voluntary effort for each, yet these motions cease as soon as the will to move is discontinued, and begin again when it is renewed. This case is most obviously distinct from the motion of the heart or other truly involuntary muscles, in which not only the closest observation can detect no sensation, but the most resolute exertion of the will cannot modify the motion †."

We must be careful, therefore, never to confound those motions which are truly voluntary, however easily they may be performed, and however closely they may have "clung together by association," from those which, by reason of the peculiar endowment of the nerves supplying the muscles employed in them, are truly beyond the control of the will. " Eterna lege separatur Voluntatis imperium ab Irritabilitatis provincia ‡.'

Inattention to this distinction led Stahl, Darwin, and other physiologists, to think, that the same law of Association, which explains the formation of habitual trains of successive voluntary motions, would likewise explain the constant successive movements of the auricles and ventricles of the heart, and the peristaltic movements of the bowels §, and was generally applicable to all muscular contractions without exception; whereas it is in reality a law of mental phenomena only, applicable to those muscular

* Elements, &c., vol. i. chap. ii.

† Rees' Cyclopædia.

‡ Haller.

§ Darwin's *Zoonomia*, vol. i. p. 38, 267, &c.

contractions which are excited by mental acts, but not to other muscular contractions.

The distinction of the Instinctive from the strictly Voluntary motions stated at p. 170, is sufficiently illustrated by the complex acts of sucking and deglutition, correctly performed by the new-born infant; and by a comparison of these movements with the corresponding actions of other young animals, destined to procure their nourishment in other ways; but it is difficult to determine what other movements, as seen in the human species, are truly instinctive. Probably, however, not only those movements by which the immediate gratification of the appetites is procured, but those likewise by which we avoid certain injuries immediately threatening us, as in winking, withdrawing the hand from the fire, or throwing forward the arms when we fall,—those by which we move the eyeballs so as to turn the axes of both eyes to an object which arrests our attention,—those by which we close the sphincters, on irritation of the rectum or bladder,—are truly instinctive; by which we mean that these movements are prompted by volitions originally and directly consequent on certain sensations; and are not prompted, like the strictly voluntary motions, by the more circuitous process above described, in which reasoning, imagination, desire, and experience or association, are successively concerned.

At the same time it is to be observed, that these instinctive motions are always preceded by distinct efforts of the will, and are not therefore the direct effects of mere sensation; and in many instances, in the lower animals, they procure no enjoyment, but inconvenience and even suffering, to the animals themselves, although necessary to the preservation of the species *.

The phenomena of these instinctive motions are peculiarly important as evidences of Design in the Universe, because they are precisely analogous to the phenomena, from

* See PALEY's Natural Theology.

which we all uniformly and habitually infer the existence of intelligent minds in other men ; they lead directly to the same inference as to Intelligence; and yet we see clearly, and even feel in our own persons, that the intelligence which they imply is not in the individual beings that are endowed with them, but must be ascribed to the higher Power, from which they derive both their mental constitution and their muscular organs.

The following general facts or principles demand attention in regard to the movements, whether instinctive or strictly voluntary, performed by the voluntary muscles of the human body.

1. They appear to be all the effects of muscular *contractions*. Voluntary relaxations are within the power of the mind, and are necessary to various movements, but do not appear, in the human body, to be in any case the cause of voluntary motions, although it is suspected that they are in some other animals *.

2. As the voluntary muscles are intended to move bones, and other solid parts, which are so articulated or connected with one another as to be susceptible of motion only in certain directions, and require considerable force to move them at all, so they have regular forms, and the direction and effect of their contractions are determined by these forms, by their position in the body, and by the other textures, especially the fibrous textures, with which they are connected. But every muscle can contract either partially or completely, with various degrees of force, and to various extent, and can combine variously with the contractions of other muscles; and therefore it is impossible, by merely studying the forms of muscles, and their origins and insertions on the skeleton, to understand the whole extent and variety of motions, which these muscles may communicate to the bones, and to the soft parts which the bones support.

3. The word Origin is generally applied to the less

* See BECLARD, Anat. Gen. p. 564.

moveable extremity of a muscle, and the word Insertion to the more moveable, which is brought towards the other when the muscle contracts; but in some cases, the less moveable extremity of a muscle is fixed by other muscles, and it then acts on its origin, as when the abdominal muscles assist in depressing the trunk of the body, or when the genio-hyoideus and mylo-hyoideus depress the lower jaw.

4. Muscular fibres are generally placed obliquely to the line of direction in which the motion they communicate is to take place, being seldom rectilineal, often radiated, penniform, or compound penniform. From this two consequences necessarily follow, *first*, That they must exert a *greater* force to communicate a given extent of motion; *secondly*, That they will undergo a *less* amount of contraction in communicating that extent of motion, than they would have done if their direction had coincided with their line of action.

Farther, the oblique disposition of the fibres of muscles allows of their tapering form, and of their power being concentrated in narrow tendons, or on small points, and is therefore frequently important, both to symmetry and to convenience.

5. In studying the action of muscles on bones, and on the parts which these support or inclose, we consider the bone as a lever; the joint at which it is to be moved as the fulcrum; the muscle, acting at its point of insertion, as the power; and the weight of the parts supported by the bone, acting at their centre of gravity, as the weight or resistance, which the lever, moved by the power, has to overcome. And in this view we observe, *first*, that the kind of lever employed in the animal system is generally of the third order, *i. e.* where the power is applied between the fulcrum and weight; *secondly*, that the point where the power acts is generally very near the fulcrum; and *thirdly*, that the line of direction by which the power acts, generally makes, in the beginning of the motion at least, a very acute angle with the lever. All these points are illustrated by attend-

ing to the insertions of the flexor and extensor muscles of the arm, fore-arm, thigh, and leg. In all these respects, the power of the muscles acts at great disadvantage in regard to the motion to be communicated; and the more so, as the muscles of the limbs are generally bound down by fasciæ, so as not to change their direction so much, and so advantageously, as they otherwise would do, after the motions they cause have commenced.

In these respects, as well as in the direction of the individual fibres of muscles, the arrangements are such as to economize the *length*, much more than the *strength* or power of muscular contractions; and are, besides, evidently adapted to prevent interference of one part of the body with another, to preserve symmetry of form, and permit elegance of movement.

6. In some instances, however, where the weight or resistance is very great, the lever employed in the animal economy is of the first order; as when the trunk of the body is either bent or extended on the articulations of the spine, by the abdominal muscles or extensors of the back, —or of the second order, as when the whole weight of the body is thrown on the toes by the elevation of the heel by the Tendo Achillis; and, in some instances, as in this last movement, and in the flexion of the body by the abdominal muscles, both the length of the arm of the lever, by which the muscles act, and the angle at which they act, are much more advantageous than usual. The extension of the body by the muscles of the back, placed longitudinally along the spine, being an action in which the power acts by a very short lever, and often in opposition to gravity, requires a much greater strength of muscle than the flexion of the body does.

7. In performing many even of the most common movements of the human body, a definite combination and succession of contractions, not only of neighbouring muscles, but of distant muscles, associated into groups by their concurrence in these actions only, and by no anatomical relations, is often required. Thus the projection of the body

at each step in running or walking quickly, requires a combined action of the extensors of the thigh, of the leg, and of the foot, in order that the metatarsal bones may be pressed with due force against the ground; this must be succeeded by an action of the flexors of all these parts, by which the limb may be raised and brought forward; and farther, in order that the equilibrium and erect posture may be maintained during these movements, a certain action of the extensors of the back, and certain motions of the arms, are necessary. By much attention, and frequently repeated trials, especially in youth, a great variety of combinations of muscular actions may be formed and associated, exactly in the same manner as those concerned in these common motions.

8. For the performance of most complex actions, not only various muscles, and associated combinations of the actions of these, but a certain adaptation of the form of the skeleton to the movements thus effected, are essential conditions; and the circumstances, in the form and disposition of the bones, which are most important for these purposes, are often not obvious on first consideration of the subject. For example, for maintaining the erect attitude of man in all his movements, and at the same time rendering these movements easy and graceful, the following provisions, in the bony fabric, different from what are seen in others of the mammalia, are truly essential; *first*, That the lower limbs should bear a very unusual proportion to the whole body in length, and their articulating surfaces in breadth; *secondly*, That the pelvis should be unusually broad, and so hollowed internally as to give room for certain viscera, and through them support to others; and that the basis of support which it gives to the trunk of the body in the erect posture, should be farther enlarged by the length of the cervix femoris, which disengages the shaft of the thigh-bone from the hip-joint, and allows the limbs to be widely separated; while the head of the bone, within the acetabulum, being the centre of movement, the angular motion of the pelvis at each successive projection of the lower extremi-

ties is small;—*thirdly*, That the shaft of the femur be oblique and its inner condyle long, as well as its general direction vertical, so that its articulating surface at the knee may be perpendicularly under the pelvis in the erect posture;—*fourthly*, That the whole lower surface of the tarsus, metatarsus and toes, be at right angles to the leg, and rest on the ground in standing, so as to give a broad and firm support to the body;—*fifthly*, That the breadth of the bony fabric of the chest be greater than its depth from the sternum to the spine, whereby the arms are widely separated, and the centre of gravity of the trunk is thrown back;—*sixthly*, That the lumbar vertebræ and sacrum be large and strong, and the vertebral column disposed in a waving line, so that the viscera may be duly lodged and supported, and the centre of gravity be prevented from coming too much forward in the erect posture;—and *lastly*, That the foramen magnum, and condyles of the occipital bone, be situated about the middle of the head, and the eyes and mouth be directed forwards, so that the form of the head and face may be adapted to the erect posture. The peculiarities of the forms of the muscles, attached to these parts in the human species, correspond strictly with those now stated in regard to the bones*.

The particular combinations of contractions of voluntary muscles, and movements effected by them in the other parts of the body, cannot be studied with advantage without the aid of preparations or drawings; but are well explained in the writings of BARCLAY†, MAGENDIE, ARNOTT‡, and ROULIN §.

One curious department of this subject relates to the manner in which the different modulations of the voice, and different articulate sounds, are effected by voluntary movements of the respiratory muscles, and of the muscles of the Larynx, Velum Pendulum, and Arches of the Pa-

* See LAWRENCE'S Lectures on the Physiology and Natural History of Man.

† On Muscular Motion. ‡ Elements of Physics.

§ Journal de Physiologie, t. i. and ii.

late, Tongue, and Lips, producing and varying sonorous vibrations in the expired air. It is ascertained that the posterior part of the tongue, the velum pendulum, and arches of the palate, as well as the muscles of the larynx (especially of the thyroarytenoid muscles, moved by the recurrent nerves, and which stretch the ligaments of the glottis), are necessarily concerned in the modulation of the voice *. The chief agents in articulation are the lips and anterior part of the tongue.

The general effects of repeated and habitual exercise of voluntary muscles, on other parts of the animal economy, are of great importance, particularly in the prevention of disease. The following effects undoubtedly result from exercise, habitually taken, but within limits consistent with health.

1. The motion of the blood is habitually accelerated, and the heart excited to increased action, whereby it acquires an increase of strength, and probably even of bulk †.

2. The circulation on the surface of the body is habitually excited, and the excretion there, and probably at the lungs also, increased.

3. The circulation in the muscles that are exerted is particularly excited, and their bulk, as well as strength, gradually increased; and both in consequence of this effect, and of that last mentioned, a considerable derivation of blood from the capillaries of other parts, especially internal parts, is no doubt effected.

4. The mental efforts requisite for continued and vigorous voluntary exertions, and the different sensations neces-

* See Report by Cuvier, to the French Institute, on a Memoir by M. Bennati, 10th May 1830; and a case by Renauld, in Journal Hebdom. t. i. p. 66.

† Some experiments of Magendie distinctly prove, that strong muscular exertion, particularly when attended with violent efforts of expiration, implying compression of the great arteries in the thorax and abdomen, forces forward the blood into the great veins rapidly and powerfully, at the same time that the flow along these veins is somewhat retarded by the disordered state of the respiration.

sarily resulting from them, are incompatible with any continued exercise of the mental faculties on other subjects, and therefore often interrupt, or prevent, such trains of thought as might otherwise have occupied the mind.

It appeared from facts already stated (p. 131 and 236), that such voluntary efforts as continue to be made by an animal, in which the medulla oblongata only remains in the cranium, are still effectual in exciting muscular contraction; but that all indications of those more complex acts of thought,—which precede and cause most of the voluntary efforts by which the muscles are moved,—disappear, at least in the higher animals, after the removal of the higher parts of the nervous system, and especially of the hemispheres of the brain. Hence it may naturally be inferred, that in most cases of voluntary actions, where the volitions exciting them are consequent on recollections and trains of thought (however short), some physical change is transmitted downwards, from the higher portions of the brain or cerebellum, to the medulla oblongata, and determines the peculiar action there, by which the voluntary muscles are excited; and it is reasonable to suppose that any such physical change, which these higher portions of the brain or cerebellum thus transmit downwards to the medulla oblongata, may be imitated by a mechanical injury.

These considerations enable us to understand how it should happen, as many experiments by Magendie and others have shown, that in consequence of sections of different parts of the nervous system within the head, superior to the medulla oblongata, certain definite and combined actions of voluntary muscles are excited; such as apparently indicate, not that the muscles are moved involuntarily, as by irritation of their own nerves,—but that the will of the animal is constrained so to act, as to excite certain movements only. Phenomena exactly similar are occasionally observed in the course of various diseases of the nervous system.

The most uniform effects of this kind, observed in experiments on animals, have been a movement forwards, when the bands of medullary matter passing forwards through the Corpora Striata, from the crura cerebri into the hemispheres, have been cut through; a movement backwards, when the Cerebellum has been wounded or cut off; and a movement of rotation, to either side, when the bands of medullary matter passing through the Crura Cerebelli, to form great part of the Tuber Annulare, have been divided on that side. And these facts seem to lead to the conclusion, that those acts of thought which prompt the volition to move in these different ways, act on the Medulla Oblongata for that purpose, through these different parts respectively. It is a fact ascertained by Flourens, and which must at present be regarded as anomalous, that section of the branches of the seventh nerve contained in the semicircular canals, in birds, produces movements of the head, horizontal or vertical, according to the parts injured, similar to those now mentioned in the trunk and limbs; which abate when the animal is at rest, but constantly recur when it attempts any motion *.

The loss of the Cerebellum in animals, particularly warm-blooded animals, appears from the experiments of Rolando, Flourens, and others, to be generally attended by a peculiar effect on voluntary motion. The animals, after this mutilation, provided that compression of the parts of the nervous system which are left is avoided, not only appear capable of sensation, but give all the usual indications of intelligence, and evidently exert volitions which throw many voluntary muscles into action; but they are unable so to regulate the contractions of their muscles, as to perform any definite voluntary action, excepting only those which are the most strictly instinctive, and the most closely linked with some of their sensations, such as biting and deglutition. All the voluntary movements of the body and limbs are performed in this state, in so irregular a manner, that they are generally ineffective for the purposes which are evidently intended; and most of the usual complex movements cannot be performed.

* See Ann. des Sciences Naturelles, t. xv.

This may be supposed to be, either because the injury produces certain permanent uneasy feelings, such as vertigo, which interfere with and confuse the sensations, by which the voluntary movements are regulated; or because the recollection of muscular sensations, which are the guide to all definite voluntary movements, depends upon the cerebellum, and is lost when it is destroyed, in like manner as the recollection of other sensations and mental acts appears to be lost when the hemispheres of the brain are destroyed *.

This last opinion may be thought to be supported by the fact, that in Man, where a greater number and variety of complex voluntary movements are learned by experience, and are associated in trains by means of the muscular sensations accompanying them, than in any other animals, the lobes of the cerebellum are more developed than in any other; and again, that in those animals which have, immediately after birth, the power of regulating their voluntary movements for definite objects, with the most precision, according to observations recently made by Sir W. Hamilton, the cerebellum is very generally found, at the time of birth, the most developed.

This is all that can be stated, at present, as to the parts of the nervous system which furnish the conditions necessary for the excitation, *first*, of the volitions by which the actions of the voluntary muscles are caused; and *secondly*, of the muscular sensations, by which they are guided. When the volitions take place, it appears from facts already stated, that it is by changes which they effect in the medulla oblongata, spinal cord, and nerves, that they produce the contractions of muscles.

* See Girou de Buzareingues, in Annales des Sciences Naturelles, t. xv. p. 52.

CHAPTER XV.

OF THE INVOLUNTARY ACTION OF THE MIND ON THE BODY.

There is reason to think, not only that all mental acts are attended by some physical changes in the nervous matter itself, but that different mental acts, and particularly any strong efforts of voluntary attention, produce effects on the state of the circulation through the nervous system. But all the decided effects upon other organs, which can be ascribed to mental causes, may be referred to the heads of Volitions and Instinctive propensities (already considered), of Emotions, and Sensations. The effects of these last involuntary acts of mind, on the body, deserve more attention than they have received from most physiologists. They constitute one important element, which must be taken into account in considering various questions in pathology and therapeutics; and they may serve to give precision to our inquiries, into the physiological uses of those parts of the nervous system, which we have reason to suppose to be concerned in producing them.

The effects which can be distinctly ascribed to mental *Emotions*, are the following.

I. When acting *in full force*, they excite *strictly involuntary* motions of the voluntary muscles; of which we are conscious, because no contraction of voluntary muscles takes place, in the natural state, without a muscular sensation informing us of its occurrence; but which we do not excite by any effort of our own, and can only control indirectly, either by fixing the attention on some other object,—and thereby superseding the emotion itself,—or else, by voluntarily exciting other muscular contractions, which antagonize those that we wish to conceal.

Of this kind are the complex actions of Laughter and Weeping, from the feeling of the Ridiculous, or from the emotion of Grief, however excited; whether by what is seen, heard, remembered, or imagined; and the slight contractions of the muscles of the face, and often of the body and limbs, by which mental emotions are expressed, and the interpretation of which has the name of Physiognomy. The movements of Sighing from sorrow, and of Yawning from listlessness, although traced to mental emotions, are more directly dependent on certain uneasy sensations.

These movements, as usually performed in the body, may be said to belong to the same class as the instinctive acts, already considered, by which appetites are gratified; and this class of muscular movements, therefore, passes, by insensible degrees, into that last mentioned; but when the emotions prompting to them are of a certain intensity and duration, no voluntary efforts can be felt to intervene between them and the actions; and the most energetic efforts of volition are even ineffectual in exciting motions by which the action may be concealed.

The essential condition to the action both of laughter and weeping is a long, often interrupted, inspiration, succeeded by several short expirations; the relaxation or ascent of the diaphragm being repeatedly stopped by short contractions of its own fibres, alternating with those of the abdominal muscles: with these movements are combined certain contractions of the muscles of the glottis and fauces, regulating both the escape of the air, and the sonorous vibrations of the air that escapes, from the windpipe; and likewise certain definite contractions of the muscles of the countenance, and of those moving the lower jaw, which give *expression* to the action.

Besides these definite movements, which are nearly confined to the muscles of the face, neck, and chest, there are other contractions of voluntary muscles from mental emotions, which take place either generally over the whole body, or indiscriminately and irregularly in various parts, as in tremors from fear, or in the writhing of the body from the emotion of horror, or in the course of violent fits of laughter or weeping.

Farther, mental emotions of some strength and endurance, have a manifest influence on the energy of the strictly voluntary contractions, all over the body; some, such as Anger, Hope, Joy, increasing the muscular vigour: while others, such as Grief, Fear, or more correctly Despair, diminish it. There are examples of persons long paralytic, who have recovered the power over their limbs suddenly, when under the influence of violent emotions *; and there are many instances of great, although temporary, increase of muscular strength, from the influence of military ardour, and still more of religious enthusiasm or fanaticism.

These effects on the strength of contraction of voluntary muscles, cannot be referred simply to the increased or diminished strength of the circulation, which results from the same mental emotions, and will be considered immediately; because they sometimes take place almost instantaneously, and because other agents which affect the heart's action more powerfully, do not add equally to the vigour of the voluntary muscles. Nay, the emotion of fear often quickens and strengthens the heart's action, while it weakens the limbs.

The effect of emotion on voluntary muscular contractions may be supposed to take place chiefly in that part of the process necessary to such contractions, which is confined to the nervous system; but as a similar effect is produced on the actions of the heart, which are not excited through its nerves, we must suppose that at least a part of the effect is produced on the property of irritability, resident in the muscular fibres themselves.

It is to be observed, that this kind of effect of emotions on voluntary muscles is not produced on individual parts only, but *generally over the body.*

II. The different mental emotions produce decided ef-

* See ABERCROMBIE, Pathology of the Brain and Spinal Cord, p. 308.

fects on the Organic Functions of the body, and especially on the involuntary motions concerned in circulation, by which they are divided into exciting, such as Joy, Hope, &c. and depressing, such as Grief, Fear, &c.; and although these phenomena are too various and complex to be always reducible to distinct heads, yet this distinction may be recognised in most cases.

1. The effects of the Exciting Emotions or passions are widely different, according as they are of such a kind or degree as to act gently and uniformly for a length of time; or as they act suddenly and violently, and soon subside.

Such emotions as act permanently, and without violent agitation, *e. g.* the emotion of pleasure that attends any occupation which interests and occupies the mind,—the emotion of hope, from the prospect of lasting and rational enjoyments, or of returning health,—the emotion of benevolence, or kindly feeling, which attends the conferring, or that of gratitude, which follows the receiving, of benefits,—even the excitement produced by a certain degree of the feeling of indignation,—when they are of sufficient intensity and duration, and especially when they are strongly contrasted with the previous state of the mind,—have a decided effect on the circulation; which is chiefly observed throughout the capillary system. They cause a slight but permanent glow on the countenance, which contrasts with the paleness of grief; they quicken the flow of fluids through, or the secretion on, the conjunctiva and cornea, and give brilliancy to the eye; they perhaps elevate slightly the temperature of the surface, and certainly cause it to be less easily depressed by cold. According to the observations of SANCTORIUS and of BRYAN ROBINSON, they increase the insensible perspiration by the skin; and according to Dr PROUT, they increase the quantity of carbonic acid thrown off at the lungs; they promote the secretions, as is obvious from their influence in increasing the power of digestion, and securing the regular evacuation of the bowels; and favour nutrition, as appears from their being generally found in connexion with increasing bulk of the body; they have a well ascertained effect in protecting the body against the influence, not only of cold, but of malaria and contagion,—therefore against all the most powerful causes of acute disease; they manifestly accelerate the convalescence from acute diseases, and are found very beneficial in various chronic diseases, in which debility is a prominent symptom. In these last instances, the effect of these emotions is to counteract causes which evidently weaken, and to assist other means, particularly the use of nourishing food, and agreeable sensations of warmth, or moderate alternations of temperature, which strengthen the body. On the whole, therefore, it appears that the effect of these emotions is gently and permanently, and often most beneficially, exciting or tonic, on the circulation; and that it is most distinctly observed in the vital actions that take place in the capillary system of vessels;—the heart's action being little affected in most of these cases,—while, in many other instances, both from mental and physical causes, the heart is manifestly excited without any of these good effects.

When any of the exciting emotions or passions act more suddenly and violently, their influence is chiefly observed in the heart, and larger arteries, where the blood is moved solely by the impulse of the heart; they cause increased pulsation, heat, and flushing, and a state like temporary fever, followed often by more or less of depression; but not attended by any of the beneficial effects on the secretions and excretions, and nutrition of the body, above remarked. The exciting emotion of anger, by its stimulating effect on the circulation, has often become the cause of dangerous or fatal disease. This effect on the heart's action, implying an increase of its irritability, according to what was formerly stated (p. 12), is more correctly expressed by the term *Stimulant* than *Stimulus*.

The effects of the more sudden and more violent passions are also more *local* than those of the gentler and more continued emotions. Thus the emotion of surprise, especially when attended with fear, excites the heart's action strongly, and thereby causes irregularities in the flow of blood in the larger vessels, and sometimes internal hæmorrhages; while it causes paleness and constriction, instead of flushing, on the surface of the body; and the emotion of shame has a powerful exciting effect on the circulation in the face and neck, without any such effect on other parts, even of the surface. The well known exciting effects of certain emotions on the secretion of the lachrymal gland; of others on that of the mammæ; and of others on that of the testes, are still more partial.

2. The feeling of listlessness or ennui, from want of mental occupation, and the feeling of permanent depression from continued sorrow, disappointment, or hope deferred, produce effects on the circulation, especially in the capillaries, and on the secretions, just the reverse of those ascribed to a permanent feeling of hope or joy; they make the face pale, the eye dull, the skin cold or easily chilled; they diminish the amount of perspiration, and the excretion at the lungs, injure the digestion, and generally bind the bowels, and cause the body to decline in flesh and strength; they favour the effect of cold, contagion, and malaria, in producing acute diseases; and facilitate the attacks, and often frustrate the cure, of various chronic diseases, of which debility is an essential constituent.

Again, more sudden and violent Emotions of grief, fear, or despondency, or more mixed feelings, as those commonly expressed by the terms Horror, Disgust, Vexation, &c. often produce syncope, sometimes fatal syncope; they have often a peculiar irritating, if not stimulating, effect on other involuntary muscles, the bowels, and bladder. Fear acts peculiarly on the vessels, and perhaps on the fibrous texture, of the skin; and different passions affect variously and rapidly the secretions of the lachrymal gland, of the mouth, of the kidneys, sometimes of the liver, and more remarkably of the mucous membrane of the bowels, and probably of the stomach,—and so dispose peculiarly to diseases of the primæ viæ.

Farther, various emotions, at the same time that they affect, in these different ways, the organic functions of the body, excite distinct *Sensations*, sometimes pretty general over the body, sometimes confined to the parts principally affected, and which have been distinguished by the name of Sensations of Emotion. Thus a peculiar feeling of chilliness attends the constriction of the surface from fear or other mental feelings; and the sensation of nausea, sometimes leading to vomiting, attends, in many persons, those emotions to which we give the name of horror or disgust. Those persons in whom strong mental emotions, and effects consequent on them, in the circulation, and in other vital actions, have been excited by such means as tractors (real or fictitious), or the manipulations of animal magnetism, have generally felt acute sensations in the parts to which their attention has been forcibly directed. These sensations of emotion so uniformly attend the excitation of physical changes in this way, that it may be conjectured that it is through their intervention that emotions effect those physical changes; on which supposition, the agency ascribed to this class of mental acts would resolve itself into that of sensations, next to be considered.

This outline of the effects of Emotions on the different functions of the body, animal and organic, shews that they differ very materially from the effects of any voluntary acts, in the *extent of their operation* over the body, as well as in the variety of parts which they can affect. At the same time, it shews that, extensive as is the operation of these emotions, there are individual organs which each has a special power of affecting; a fact which is probably as little susceptible of explanation, as the special effects of the causes of our different sensations on the appropriate organs of sense.

It is also important to observe, that the effects of these involuntary acts of mind are much more various in different individuals, than those of instinctive and voluntary efforts,—some persons being more easily affected by one kind of emotion, and others by another,—and some parts or organs of the body being more apt to suffer in one person than in another. In general, women and children are more under the influence of mental emotions than men are; and all persons are most under their influence at the times when their voluntary muscular powers are the weakest.

III. The effects, in the living body, which may be reasonably ascribed to Sensations, are very similar to, and in some instances identical with, those which we have ascribed to mental emotions,

1. As to their action on the Voluntary muscles,—the effect of the sensation caused by venous blood slowly pervading the lungs, in exciting the complex actions of inspiration and expiration, was fully considered already. The modifications of these movements in Laughter and Weeping, are produced not only by emotions, but also, in those in whom the nervous and muscular organs are much under the influence of involuntary mental acts, by the sensation of pain, and by the sensation of tickling, excited in any part of the body.

The long inspiration of Sighing seems to be merely the effect of the sensation in the chest being felt more strongly than usual, in consequence of respiration having been previously performed slowly and imperfectly for some time together, generally on account of some mental emotion, or intense occupation of the mind, having prevented the sensation, which prompts to inspiration, from attracting the usual attention, or producing its usual effect *. Accordingly, it results from various mental acts or affections, besides the feeling of grief. The action of Yawning seems also to result from a bodily sensation of lassitude or general uneasiness, which either succeeds fatigue, or results from inactivity of the body and mind; this last motion differs from the former chiefly in being followed by a longer and more forcible expiration, and in being attended by a definite movement of the muscles depressing the lower jaw,

* See DARWIN's *Zoonomia*, vol. i.

and by a less definite contraction of various other muscles of the trunk and limbs.

The actions of Coughing and Sneezing are among the best examples of complex motions of voluntary muscles, strictly referable to sensations in the mucous membrane of different parts of the air-passages, and over which, when these sensations are in full force, the Will has no direct power. In both there is a long inspiration, followed by a sudden and forcible expiration, in which all the muscles that pull down the ribs and force up the abdominal viscera are called into action; but in sneezing both these movements are fuller and more sudden than in coughing, or in any voluntary motion of the same muscles. To both it is essential that the glottis be closed by an action of the superior laryngeal nerves, and arytenoid muscles, after the effort of expiration has commenced, and then, that effort continuing, that it be suddenly opened, so as to give a sudden impetus to the current of air driven through the air-passages, sufficient for the expulsion of irritating matters; but in the act of sneezing, it is farther necessary that the current be directed through the nostrils, by the tongue being pressed against the palate, so as to prevent its escape through the mouth.

It is obvious, and it is important to remember, that neither of these movements can be correctly performed after an artificial opening has been made into the Trachea, or lower part of the Larynx, because such an aperture cannot be voluntarily closed and opened at pleasure, so as to give the requisite impetus to the current of air.

The spasmodic movement of the diaphragm, called Hiccup, and the actions of Eructation, Regurgitation or Rumination, and Vomiting, by which different matters, and with different force, are rejected from the stomach, are likewise preceded, and may fairly be said to be caused, by certain sensations. In eructation, all that seems necessary is a relaxation, longer than usual, of the muscular fibres of the œsophagus, allowing what lies at the cardia to arise to the mouth; but in the others, and especially in Vomiting, it is obvious that repeated and sudden simultaneous contractions of the diaphragm and abdominal muscles take place at the same time with the relaxation of the œsophagus, by which the stomach is strongly compressed, and its contents forcibly expelled. These contractions, in the case of Vomiting, are always preceded by the peculiar sensation of Nausea, which is often attended with more or less of faintness, or of vertigo; and as it becomes more intense, they are gradually and repeatedly excited. This sensation is followed also by a sudden and rapid flow of saliva, and generally of sweat; at the moment of vomiting the glottis is shut, and the velum pendulum palati raised and stretched as in deglutition; and the œsophagus assumes an inverted action *.

The experiments of MAGENDIE have distinctly shewn, that in the act of vomiting, any contraction of the stomach itself which occurs, is hardly perceptible either to the sight or touch; that the simultaneous action of the diaphragm and abdominal muscles is sufficient to expel, in the same way, fluids contained in an inanimate sac, placed in the same situation as the stomach; and even that the expulsion of the contents of the stomach can be produced by a strong contraction, either of the diaphragm or of the abdominal muscles, excited by an emetic, when the other of these agents is palsied. At the same time, it is to be observed, that the appearance of bile, after a time, in matters rejected by vomiting, is enough to show that a degree of inverted action of the stomach and duodenum must attend the movement. And it is pretty certain that there is an increased flow of the fluids of the stomach, as well as of the mouth, during vomiting.

It is important to remember, that the sensation of nausea may be excited in very various ways,—by certain substances introduced in any way into the blood,—by certain irritations of the stomach,—by certain impressions on, or diseases of, the brain,—by certain impressions on the nos-

* BECLARD,—See Dict. de Medecine, Art. Vomissement.

trils, or the fauces,—by certain diseased states of the heart, bowels, kidneys, uterus, &c.:—but in all these cases, when it attains a certain intensity and duration, the complex actions of vomiting follow.

The actions of voluntary muscles, by which the evacuation of the Rectum and Bladder is partly effected, were also stated as examples of the effects of peculiar sensations on this class of muscles. And in other instances, less definite contractions of these muscles are excited by sensations, as in the writhing of the body from pain, or from tickling the soles of the feet, the general tremors succeeding the sensations in the bladder and urethra which follow the discharge of urine, &c.

2. Various sensations evidently modify, nearly in the same way as emotions do, the action of different Involuntary muscles, which they cannot be said directly to excite. Thus the action of the heart is depressed or weakened by the sensation of nausea,—in some persons by certain smells,—and in all persons by the sensation of cold, when of a certain intensity and duration,—and by intense pain of a peculiar character, or resulting from affections of certain parts, as from a blow on the epigastrium or testis, from inflammation of the bowels or kidneys, &c.; and it is augmented by a grateful sense of heat after chilling of the surface,—by a different kind or slighter degree of pain,—by certain smells,—by grateful impressions on the palate and stomach, &c. The sensation of cold applied to one part of the surface, often causes constriction of the capillaries, and perhaps of the skin over the whole body; and sometimes acts rapidly on the involuntary motions both of the intestines and bladder.

3. Sensations act equally as emotions, and variously, on different Secretions of the body,—on those of the lachrymal gland,—of the salivary glands,—of the stomach,—of the liver and kidneys,—and more remarkably of the testes.

Those sensations which are pleasing and lasting, and not violent, especially if agreeably varied, appear to have a permanent beneficial effect on the capillary circulation and secretions, similar to that of the gentler exciting emotions; and those which are more keenly felt, like the more violent emotions, affect individual parts peculiarly, but all of them show a much more extended operation over the system than any individual voluntary acts can exert.

Many of the muscular contractions, and other changes, now described as the effects of Sensations, have been regarded by most physiologists as results and illustrations of what has been called Sympathy, or Consent of Parts in the animal system, whereby it is supposed that a change in the vital actions of one part of the body becomes the immediate cause of a change in those of another, although the actions of these parts have no immediate dependence on one another.

Thus, when cold water dashed on the face, or stimulating vapours applied to the nostrils, cause a sudden act of inspiration, it is said that there is a sympathy between the skin of the face and membrane of the nose, and the diaphragm and intercostal muscles; when nausea and vomiting are produced by various changes in, or impressions on, the brain, nose, fauces, bowels, kidneys, uterus, &c., many physiologists have been satisfied with saying, that there is evidence of sympathies between these parts and the stomach; and again, when nausea and vomiting have abated on certain changes being induced on the skin (as by the breaking out of a sweat, or appearance of an eruption), it has been said that this is an indication of a sympathy between the stomach and skin. So also when grateful food, or stimulating liquors taken into the stomach suddenly, excite the action of the heart, it is said that the heart sympathizes with the stomach.

It is of great importance to possess accurate information as to the nature of the connexion between different parts of the body, to which this name has been given; because, when we attend to the manner in which various diseases are excited by their external causes,—to the manner in which different morbid changes succeed one another in the course of diseases,—and to the manner in which different remedies appear to influence the body,—we find that these changes are often more analogous to the phenomena usually called sympathetic, than to any others which the healthy body presents; and frequent reference is accordingly made to the principle of Sympathy in medical writings.

The subject of Sympathetic *Sensations* has been already sufficiently discussed (p. 207, *et seq.*); and it is with those *actions* only, of certain parts of the body, which are produced, as is usually said, sympathetically, or by reason of a sympathy with other parts, that we are here concerned.

Now, the following considerations seem sufficient to prove that the doctrine maintained as to this description of facts by WHYTT and MONRO *, and acquiesced in by HALLER, is correct,—that the immediate cause of such changes as those above mentioned (p. 261, *et seq.* and 265), is truly, as we have stated, a mental Sensation, which always intervenes between the impression produced in the one part, and the change which follows in the other (or perhaps more correctly, is some action in the nervous system which is attended with, and makes itself known by, a sensation); and that the two parts sympathize with one another *only in so far* as the sensation which affects the one, is excitable by an impression on the other.

1. That the cause assigned, in this explanation of what are called Sympathetic Actions, is adequate to the effect ascribed to it, is sufficiently obvious from the fact, that the changes in voluntary muscles, in involuntary muscles, and in secretions, thus ascribed to Sensations, are not only closely analogous to, but in several instances identical with, those which are allowed on all hands to be excited by emotions; which are mental acts bearing a close resemblance to sensations, and very generally attended or followed by sensations. Thus weeping and laughter may be excited in the irritable constitution of a child, as surely by a blow on the face, or by tickling the sole of the foot, as by any men-

* See WHYTT's Observations on the Sympathy of the Nerves, and MONRO's Treatise on the Nervous System.

tal emotion; and when so excited, furnish as good evidence of sympathy between these parts and the respiratory muscles, as exists to prove a sympathy between the nose and diaphragm.

2. All such phenomena as we here ascribe to Sensation, coexist in the animal system only with indications of sensation. Movements may be excited in muscles, by irritation of their own fibres, or the nerves entering these, for some time after animal life is extinct; but after the indications of sensation have ceased, no movements of the diaphragm result from irritation of the nose, fauces, trachea, &c. similar to those which were so readily excited by irritation of these parts while sensibility remained; and the different changes usually called sympathetic, are slowly and imperfectly effected whenever sensibility is much diminished, as in the different comatose diseases.

3. In various instances, the Sensations, which we here regard as the causes of changes usually called sympathetic, may be excited by impressions made on *different* and distant parts of the body; and the actions which succeed them, in these different cases, are *the same;* which proves that these actions follow, not the irritation of any particular organ, but the excitation of a particular sensation. This is illustrated by the very various modes, in which the sensation of nausea, and the complex effects succeeding it, may be excited; by the excitation of laughter, by tickling very distant parts of the surface; by the influence of a sudden and intense sensation of cold,—in whatever part of the surface it may have been excited,—on the respiratory muscles, on the heart, and on the capillaries of the skin.

4. Conversely, when different impressions, made on *the same* part of the body, excite *different* Sensations, even although it may be certain that they are felt through the medium of the same nerve, they are *not* followed by the same action. Thus of many sensations felt through the first nerve, very few only are followed by any diminution of the heart's action, or by retching; tickling the fauces with a feather excites retching, but no such effect results from firm pressure

against the fauces, nor from their painful inflammation. Certain sensations in the nostrils and face, felt through the fifth nerve, are followed by full inspiration; but no such effect results from cutting, burning, or bruising these parts; certain sensations in the abdomen, as those excited by a blow on the epigastrium, or inflammation of the ileum, are followed by uniform depression of the heart's action; but many other sensations are strongly felt in the same parts, without any such effect resulting.

5. It has been already stated (p. 226), that when the mind is much engrossed, either by previous sensations, or by interesting trains of thought, any impressions on the organs of sense are transiently and imperfectly felt; and in these circumstances it is observed, that the effects in distant parts usually following such impressions, and ascribed to sympathy, are either suspended or imperfectly produced; which is farther proof that the intervention of the Sensation is essential to their production. Thus the actions of hiccupping, coughing, sneezing, even vomiting, or laughter from tickling,—when the sensations preceding them have not been very intense,—have often been observed to be arrested or prevented by sudden and lively impressions on other sensual organs, or by the excitement of intense mental interest on other subjects; and the same is true of the effects of cold applied to the surface, on the heart, or on the capillary circulation.

6. The remedies which have been found most effectual in stopping or preventing the actions usually called sympathetic, when in excess, are either such as make strong and new impressions on the organs of sense, and thereby, on the principle just stated, diminish the effect of sensations already existing; or else, such as blunt the sensibility in general, and therefore must be expected to diminish all effects of Sensation.

7. Another peculiarity of such actions, denoting their origin in affections of mind, is, that they are remarkably obedient to the law of Habit, being more easily excited where they have repeatedly and recently taken place; as is

seen particularly in coughing, sneezing, and vomiting ;—the short train of mental acts, consisting chiefly of sensations, but often including slight voluntary or instinctive efforts, which precedes any one of these motions, is easily reproduced by association, after a few repetitions.

Thus it appears that when any vital action, or alteration of action, in one part of the body, is said to be the result of Sympathy with another part, the fact is in general more correctly expressed by saying, either that the two parts are affected by some Sensation which acts on both alike, or that some Sensation, which is the natural cause of the action at the one part, is the natural effect of an impression made on the other. And we cannot go farther than this in explaining such connexions of the living actions of different parts.

Many physiologists have indeed supposed, that what have been called sympathetic actions, may be explained by peculiar connexions among the nerves of the sympathizing parts; and it seems to be the opinion of Sir CHARLES BELL, in regard to the movements of the respiratory muscles (which are so generally and so variously excited in this way) *,—and is also stated more generally, although in a more qualified manner, by Mr MAYO †,—that the circumstance of nerves being connected, not in their course, but at their origin, gives a peculiar tendency in the parts supplied by these nerves to sympathize; or affords an explanation of the fact, that a sensation, felt through one of these nerves, excites a muscular movement, or some other change, through the other.

But various considerations, several of which were stated on this subject by WHYTT and MONRO, seem equally conclusive against the supposition of such connexions in the vital actions of different parts, depending on connexions of nerves, in their course, or at their roots.

1. We have already seen, and must regard it as a leading fact in regard to actions of this class, that it is *not every impression* made on the sensitive organ concerned in any

* Exposition of the Nervous System, pp. 54, 76, 88.

† Outlines of Physiology, 2d edition, p. 343.

such case, which is followed by the change in a distant part, but only *those impressions* which excite a particular Sensation;—that other impressions, although felt through the same nerve, if they excite different sensations, have no such effect;—and again, that impressions on other parts, felt through other nerves, if they excite the same sensation, have the effect. Now, no effect, which is thus variable and occasional, can be ascribed to a cause which is uniform and permanent, such as a connexion of nerves, whether in their course or at their roots.

2. Although there are various cases (enumerated by Mr Mayo), where a nerve, certain of the sensations of which are followed by a change in a distant part, arises very close to the nerve of that other part, yet this is by no means a general law. For example, some of the most striking sympathetic actions in the body are those excited in the diaphragm, intercostal muscles, and abdominal muscles, by impressions on the sentient extremities of the fifth and eighth nerves, as in the varied actions of breathing, coughing, sneezing, vomiting. But the phrenic, dorsal, and lumbar nerves, by which these actions are known to be excited, are not so closely connected at their root with the fifth and eighth nerves, as several other motor nerves are, which are not affected, or only very slightly affected, in these movements. Again, several motor nerves arise nearer to the origin of the olfactory, than the phrenic and dorsal nerves; but it is by these last that vomiting, when produced by smells, must be excited; and the third, fourth, and motor part of the fifth, arise nearer to the origin of the optic nerve than the seventh does; but a portion of this last nerve, moving the orbicularis oculi, is much more surely excited by bright light impressing the retina, than any of those other nerves are.

3. Conversely, there are many instances of nerves closely connected at their origin, the parts supplied by which show no tendency to sympathize. No particular effect is ever seen on the motor part of the fifth nerve, supplying the elevators of the lower jaw, from impressions made on

the branches of the sensitive part of the fifth, which supply the nostrils, eyeball, and forehead, though other and more distant nerves are very easily excited by impressions on these parts. The whole of the spinal nerves are associated at their origin, by arising from the same columns of medullary matter; but when an impression is made, and sensation excited, in one of the sensitive cerebral nerves, that sensation extends its influence along the spinal cord, selecting some of the spinal nerves, which it excites, simultaneously or alternately, in the movement to be produced, and *passing over* others, which have just the same connexion with the part where the impression was made. The lower cervical, and first dorsal nerves, which supply the axillary plexus, and the arm, are very generally passed over in this way, when sensations excited through the sentient nerves of the brain throw into action the phrenic nerve above them, and the intercostal nerves beneath them; but the anatomical connexion of all these spinal nerves with the sentient cerebral nerves is the same.

We conclude, therefore, on the whole, that the actions or changes usually called Sympathetic, whether in voluntary muscles, involuntary muscles, or secretions, are, in general, effects of Sensations; and that sensations have a much more extended influence along the spinal cord and nerves, in exciting such changes, than any single voluntary efforts have; but that no anatomical reason can be given for the fact, that each of these sensations acts upon certain nerves only*.

The peculiar effect of certain sensations on individual muscles, or individnal organs, is often very troublesome, or even dangerous, and tends to no beneficial effect, in disease; *e. g.* in the case of coughing from incipient inflammation of the bronchiæ, tenesmus from inflammation of the rectum, faintness from inflammation of the stomach or small intestines; but a final cause for the peculiar sympathetic effect of each sensation, in the healthy state, may in general

* For farther illustration of this subject, see a paper on the Physiological Principle of Sympathy, by the Author, in Edinburgh Medico-Chirurgical Transactions, vol. ii.

be easily traced; and we should suffer much more from the want of the connexions, thus established among the actions of our different organs, than we do from their occasionally inconvenient operation.

Some general observations remain to be made on the involuntary agency of mind on body, in the animal frame.

I. It is a curious fact, that the changes thus produced in one individual, are *instinctively interpreted* by others. It is plain, that the effects of Sensation and of Emotion, on the countenance, on the respiratory muscles, on the attitudes and gestures, are no sooner seen than they convey to the spectator a notion of the mental state of the person experiencing them; and several reasons may be given for thinking that this interpretation is not the result of experience.

1. These signs of mental affections are evidently very early understood by young children; sooner than any fixed associations can be supposed to have been formed, by experience, of their connexion with any particular modes of conduct.

2. These *natural signs* of strongly felt emotions or sensations affect us both more quickly and more powerfully, than the expression of them by words, or other *artificial signs* does; which would not have been the case if both modes of expression had owed their significance only to experience, and therefore been on the same footing.

3. To one who attends to them minutely, the varying expressions of countenance, manner, and voice, in a person under the influence of strong unaffected feelings, convey *more meaning*, and denote nicer varieties of these feelings, than we have words to express; or than experience can have taught.

The rapidity and precision with which the natural signs of the passions are interpreted, are most strikingly illustrated in observing the effect of theatrical representations, and especially of pantomimes; where it is obvious, that although few individuals acquire the power of correctly imitating the effects of strong emotion or feeling, yet no man has any difficulty in interpreting and appreciating its correct imitation *.

The final cause, or use, of many of the effects of Sensation and Emotion on the body, particularly of such as show themselves externally, is to be found in this interpretation of them by other men. The provisions of nature, in the constitution of each individual of the human species, are not confined to his own immediate wants; they extend to his adaptation for social intercourse; to the relief of his sufferings by the sympathy, and the increase of his enjoyments by the participation, of others; and to the cordial union and co-operation of numbers, in prosecuting objects, and surmounting difficulties, for which the exertions of individuals would be inadequate.

II. This becomes still more obvious when we consider, that along with the instinctive, or at least very rapid, interpretation of the natural signs of Sensation or Emotion, there is more or less of a natural or *instinctive disposition to imitate* these, in the person who interprets and is affected by them.

What has been called the Principle or Desire of Imitation is exemplified strongly, and has been considered by some as exemplified only, in the strictly voluntary actions; as in the case of children, who "copy the voices of their companions, their tones, accents, and modes of pronunciation; and learn, insensibly, to model their habits, on the appearance and manners of those with whom they are habitually conversant." But it is even more strongly marked, at least in constitutions very susceptible of changes of this kind, in regard to many phenomena which come under the head of Involuntary Agency of mind on body; as in the case of yawning, laughing, weeping, even nausea and vomiting, fainting, involuntary motions of the face and eyes, and involuntary contractions of the body and limbs in

* See STEWART'S Elements, vol. iii.

different spasmodic diseases. The spectator, in these cases, first interprets these movements as an expression of some emotion or feeling in the actor, and then assumes somewhat of the same feeling himself; and then this assumed feeling produces somewhat of its natural effect on his own system. In some cases, the emotions arising from the sight of the expression, or even the sure anticipation, of suffering in another, produce likewise slight but distinct *sensations* in the spectator.

The degree in which the mind of the spectator, in such cases, participates in the feelings of the actor or sufferer, depends on various circumstances, the influence of which is easily understood, and is of real importance in the conduct of life. It depends on the nature of the emotion or feeling expressed; the gentle and more amiable emotions being in general most easily communicated from one person to another, while the rougher and more boisterous passions excite less sympathy when suddenly presented; but if gradually infused into the mind of the spectator, rouse him to stronger emotions, and often to a more permanent and cordial imitation and aid of the person whose words or actions excite them. It depends on the circumstances in which the expression of emotion or feeling is observed, which are sometimes such as, by suggesting a short and simple process of reasoning, to interest the mind of the spectator strongly, and at other times not. It depends on the susceptibility of impression and of change in the Nervous System,—remarkably different in the two sexes,—and on the character and state of mind of the spectator, especially on the degree in which his mind is open to new impressions, and unembarrassed by previously prevailing thoughts, as in early youth,—or accustomed to various impressions, and preoccupied by habitual attention to other objects, as in more advanced life. And it depends also, very remarkably, on the number of spectators. For when the emotion which agitates an individual is reflected from the countenances, and expressed by the voices, of many around him, its intensity, and the tendency it gives to imitation of those by whom it is expressed, are naturally multiplied by the extended operation of this principle *.

Hence the most striking examples of the natural interpretation, and instinctive imitation, of the effects of violent emotion or passion, are always seen in large assemblies of men; and the excitement of courage, or the diffusion of panic, among soldiers, the extremes of party violence, the absurdities of religious fanaticism, the propagation of various disorders of the nervous system in schools, prisons, or hospitals,—are all illustrations of the principles now stated.

When we compare the evils with the benefits which we derive from the disposition, existing more or less in every individual of our species, to sympathize with, and participate in, the feelings of those around him, we can have no doubt that the benefits infinitely outweigh the evils. But it is important to be aware of, and prepared for both.

III. We cannot give an opinion with confidence as to the *parts of the Nervous System* that are chiefly concerned in the Involuntary agency of Mind on the human body; but the following general facts, in connexion with that subject, seem to be tolerably well ascertained, and to demand attention.

1. Several organs belonging to the department of *organic* life, which are much influenced by mental emotions and sensations—the heart, the bowels, the capillary arteries, the secreting organs—are chiefly supplied with nerves from the ganglia and plexuses of the sympathetic nerve. And it is remarkable that the veins, in which no influence of these mental acts is discernible, have in general no such nerves †.

2, Those *voluntary* muscles, which are peculiarly influen-

* See SMITH's Theory of Moral Sentiments.

† See BECLARD, Anat. Gen. p. 688. In what follows, the term Ganglionic nerves is applied only to those which have much connexion with the ganglia of the sympathetic nerve. There has been no probable conjecture as to the use of the ganglia on the posterior roots of the symmetrical spinal nerves.

ced by Sensations and Emotions of mind, may be stated to have in general either more ganglionic nerves, or more nerves of the irregular system of Mr BELL (see p. 130), which " connect the divisions of the frame,"—than those voluntary muscles have, which are little under the influence of such involuntary mental acts. This appears on comparing generally the nerves supplying those muscles of the face and neck which are most under this influence, and almost all those of the trunk of the body—with other nerves of the head, and with the nerves of the extremities.

3. Those muscles, or other organs, which have many of their nerves from the ganglia of the sympathetic, and plexuses connected with them, are thereby (in consequence of the intimate union of very numerous nervous fibrils in these ganglia and plexuses), connected pretty uniformly with the *whole extent* of the cerebro-spinal axis.

4. In several instances, individual nerves which supply muscles notoriously much under the influence of sensations and emotions, are strikingly contrasted with those that supply muscles simply voluntary,—in having a *more extensive* connexion with other nerves, and thereby with an extended surface of the spinal cord; as is obvious on comparing the ciliary nerves coming from the ophthalmic ganglion, and moving the iris, with other nerves of the muscles of the eyeball; the portio dura of the seventh nerve, moving the muscles of the face, with the smaller portion of the fifth, moving the elevators of the jaw; and this again with the nerves supplying the muscles of the fauces, and the depressors of the jaw; and the spinal accessory nerve, (which, according to experiments by Sir CHARLES BELL, appears to be the one that moves the sterno-mastoid and trapezius muscles in the respiratory acts,) with other nerves supplying muscles in the neck.

5. In some instances voluntary muscles, having nerves which, through the plexuses and ganglia, connect them extensively with the spinal cord, have been observed to move *under the influence of sensations*, when, in consequence of

partial disease of the brain, they were *palsied to voluntary efforts* *.

6. It has been already observed, that from the experiments of LE GALLOIS, WILSON PHILIP, and FLOURENS, it appears that the heart and the capillary vessels, and perhaps other parts concerned in organic life, are influenced by physical impressions made on any *large portions* of the brain and spinal cord, but not directly by injuries, however violent, confined to any very small portions of these organs.

7. It appears from facts already stated (see p. 255 and 261 *et seq.*), that Sensations and Emotions must operate *more extensively* over the nervous system than volitions do, because they throw into action simultaneously very distant muscles, or affect simultaneously distant secreting organs; and some of them affect simultaneously the whole of the voluntary muscles, and the whole of the small capillaries on the surface of the body.

The general conclusion to which these facts appear manifestly to point is, that when sensations or emotions are strongly felt, the changes which accompany them extend throughout the whole of the cerebro-spinal axis; and that those parts which are intended to be peculiarly influenced by these mental affections, are connected, by ganglionic or irregular nerves, with the whole extent of the spinal cord, in order that they may be brought fully under the influence of these changes.

It has been already said, that no reason can be given for the fact, that each sensation or emotion acts especially on certain organs, and therefore through certain nerves; but if it be true that each of these mental acts extends its influence through the whole spinal cord, there is an obvious reason why every nerve intended to be especially affected by any one of them, should gather roots from every part of

* See BELL's Exposition of the Nervous System, p. 212, and Case by Dr ABERCROMBIE, in BELL's Appendix to Papers on the Nerves, p. 120. Several examples of the same kind, in different parts of the body, have occured to myself.

the spinal cord; for which the arrangement of the ganglionic nerves provides.

It is commonly said, that the ganglionic nerves are intended to *preside over* the involuntary motions, and organic functions in general; but this language is very vague, because no distinct intimation is given of the precise meaning annexed to the term *preside.* But if we suppose, that the object of these nerves is to bring these functions, and the actions of certain voluntary muscles, *under the dominion of involuntary acts of mind,* we shall propose a definite theory, and one which the facts now stated appear strongly to support.

It must be admitted, however, that this speculation is attended with difficulties, and can only be stated at present as a probable approximation to the truth.

CHAPTER XVI.

OF SLEEP.

It was formerly observed, that the necessary alternations of repose and activity in the functions of the Nervous System, to which we give the names of Sleep and Waking, bear so great an analogy to the alternations of rest and motion in living muscles, as to favour the supposition of some active changes, and probably movements, continually taking place in the nervous matter, in the state of waking, which either cease or undergo a change in sleep; and we cannot doubt that some physical change in the nervous system attends the transition from the one of these states to the other. But these, like all other changes in the nervous system, corresponding to the healthy changes of the Animal Functions, are known to us only by their effects or accompaniments; so that all we can do, in treating of this subject, is to state what has been observed of the conditions which essentially characterize sleep, of the circumstances in which it naturally occurs, and of those which favour or impede its occurrence. The following are the most important facts that have been observed on this subject.

1. Natural sleep is essentially characterized by the change that takes place in the Animal Functions during it, and especially by the Suspension of all Voluntary Power, not only of that habitually exerted over the voluntary muscles, but also of that exercised over the trains of thought in the mind (see p. 229). The power of sensation is not suspended; respiration, dependent on sensation, continues; instinctive movements of the limbs, consequent on a constrained posture, take place; any unusual impressions on the senses are felt, and even subsequently remembered; and any strong, sudden impressions are so effectual as to interrupt sleep. But all sensations are blunted; respiration consequently becomes slower and fuller; slight impressions on the senses fail of their wonted effect; no effort of voluntary attention to any of these impressions is observed; and if we attend as carefully as possible to the state of our minds when sleep is approaching, we observe that we are gradually losing the power of fixing our attention on, and detaining before our minds, any particular object of thought; and that, in proportion as we do so, the images of external things, which pass before our minds, assume the character of reality *.

2. The organic functions go on during sleep, but are differently affected in different parts of the body. The actions of digestion and assimilation are apparently promoted by it; perhaps chiefly because the exercise of the limbs, and of the senses, which continually promote, during waking, the circulation towards the surface of the body, and so retard these internal actions, is suspended. In hot climates, where the effect of exertion to promote the circulation on the surface is greater than in cold, sleep, after the principal meal, especially if of animal food, seems essential to easy digestion. On the other hand, the action

* See STEWART's Elements, chap. iii. & v.

of the heart becomes somewhat slower, and perhaps somewhat weaker, during sleep, probably merely from the want of the stimulating influence of sensations and voluntary exertions. The power of the voluntary muscles, as appears from their condition after wakening, is somewhat enfeebled by their inactivity. The perspiration and excretion of the lungs, and the evolution of animal heat, are somewhat diminished. The surface of the body is more easily chilled; and the body becomes more liable than previously to the influence of various causes of disease, the first effect of which is to depress the capillary circulation, especially on the surface.

3. The state of relaxation, or suspension of the animal functions, which constitutes sleep, is, in the healthy state, merely the consequence of the activity of the changes going on in the nervous system during waking; the disposition to it is stronger as these, within certain limits, have been more numerous and greater; and it is promoted by whatever withdraws the causes that habitually excite the voluntary activity of the mind;—therefore, by withdrawing all causes of lively sensation, by darkness, by silence or gentle and uniform sounds, by the absence of all pain, or of any strong impressions on the senses of Touch, Taste or Smell, by an agreeable temperature, and by mental tranquillity.

4. The tendency to sleep is evidently promoted, in different cases, by causes which increase the flow of blood towards the head and its impetus on the brain; especially if they be not such as to excite at the same time the activity of the mind; but according to the observations of Blumenbach, the turgescence of the vessels of the brain, when that is exposed to view, appears to be diminished during sleep.

5. After sleep the senses are more lively, the train of thought probably more rapid, and all voluntary mental exertions are easier and pleasanter than before; but the strength of the circulation, especially on the surface of the

body, and the full power of the voluntary muscles, appear not to be completely restored until food is taken.

6. In the most profound sleep, the mental acts (excepting only slight sensations, such as those prompting inspiration) are either at a stand, or leave no trace on the memory; but the state of the mind called Dreaming, which is remembered more or less distinctly after wakening, is very common during perfectly natural sleep: and is sufficiently characterized by the two circumstances already noticed, that the succession of thought, though often modified by any sensations that may occur, is not regulated by the will, and that the images which pass before the mind are considered as realities.

7. From 6 to 8 hours in the 24 are occupied by sleep, in most adult persons; but the length of time thus spent, requisite for refreshing the body, is not strictly proportioned to the amount of exertion made during waking; and may often be gradually and beneficially abridged by habit, as well as by any desire, strongly impressed on the mind before sleep commences.

The state of imperfect sleep called Somnambulism, seems to be characterized by a partial restoration of the power of the will over the voluntary muscles, and over the mental operations, while some part of the mental delusion attending sleep continues; and especially, by a suspension of some of the principal associations, which were wont to regulate the succession of thoughts; so that the person does not recall the past thoughts or images which objects presented to him would naturally suggest, and neither talks nor acts as he had been accustomed to do; although his mind acts with great energy, and sometimes with unusual power, on certain subjects. When he awakens from this state, which he does in general as suddenly as from natural sleep, the usual associations of thoughts in his mind being restored, he retains little or no recollection of what had passed during it. This state has sometimes lasted long, or recurred repeatedly, and in precisely the same form. A similar state of partial and temporary hallucination, with suspension of some of the usual associating principles, sometimes occurs from disease, generally in the course of some of the less violent diseases of the nervous system;—is sometimes brought on by drinking strong liquors;—and has often been produced, in certain constitutions, by strong mental emotion, especially when heightened by numbers, as in the ceremonies of some sects of religious enthusiasts, or by the practices of those who profess Animal Magnetism. Whether in this last case any influence, really emanating from the body of one person, can contribute to the effect upon another, independently of the excitation of a strong mental emotion, is very doubtful *.

There is every reason to believe, that this state of somnambulism, reverie, or extase, depends on some peculiar physical change in the condition of the Nervous System, just as the natural state of sleep, and the more usual forms of delirium do; but none of these states can be ascribed solely, to alterations, either of the circulation in the brain, or of the pressure on it, or of its own texture; and as all other changes in the condition of the Nervous System, whether healthy or morbid, are known to us only by their effects, it is in vain to attempt more in regard to this anomalous state of the functions of the brain, than to determine the circumstances in which it occurs, and the phenomena by which it is essentially characterized.

* See the works already mentioned on Animal Magnetism—Darwin's Zoonomia, Art. Reverie; and Abercrombie on the Intellectual Powers, &c. sect. 3. chap. iv.

CHAPTER XVII.

OF GENERATION.

This function is the most complex, and has been called the most mysterious, in the animal economy; because the formation in an animal, of another being, similar to itself, and capable of maintaining a separate existence, is an effect of its vital action, which nothing that we see on examining its structure, or any of its other functions, would have enabled us to anticipate that it would produce. But in every other department, not only of physiology, but of science in general, when we have ascertained the conditions under which a phenomenon takes place, we must admit that its appearance, after all these conditions are fulfilled, is equally inexplicable.

This function is very variously managed in the different orders of living beings. The only condition essential to all cases of generation that have been fully investigated, is the separation of a small portion of the organized frame of a living being previously existing, which portion is capable of subsequently maintaining a separate existence.

But in Man, and in all the higher animals, several distinct subordinate conditions are essential to this purpose, the number of which increases as we ascend in the scale of beings. These are,

1. The formation, in a particular organ, of a germ, or small organized body—to be afterwards developed into a separate animal.

2. The fecundation of this germ, which seems to be always effected by the application to it of a seminal fluid; and implies a distinction of sexes, whether on the same or on distinct individuals.

3. Copulation, which is an essential condition only where it is required that the fecundation should take place,

before the germ is detached from the body of the female; *i. e.* in all the mammalia and birds,—in most reptiles,—in some fishes,—and many of the lower tribes of animals.

4. Utero-Gestation, which is essential only where it is necessary, not only that the germ should be impregnated within the body of the female, but that it should draw its nourishment, during a part of its development, from the fluids of the female; *i. e.* in the mammalia, the only true viviparous animals *.

The organs destined for the two first of these purposes,—for the formation and fecundation of the embryo,—although existing from birth, are fitted for their function later than any others (the usual age of puberty in this climate being at from 14 to 16 years); and they become unfit for it again in women at from 45 to 50 years of age, in men at a considerably later and less definite age.

The circumstances in regard to the anatomy of the testes in the adult, which chiefly demand attention here, are their position within the scrotum, and isolation from the surrounding textures by two serous membranes, the tunica albuginea and vaginalis,—their connexion with the rest of the body by the spermatic cord, consisting chiefly of vessels and nerves which descend from high in the abdomen, and by the cremaster muscle surrounding the other parts of the cord, by which the testes may be drawn upwards, and the flow of their secretion along the vasa deferentia probably promoted; their vascular texture, and the very numerous convolutions of their excretory tubes, in the body of the testes and epididymis; and the long and circuitous course of the vasa deferentia arising from them, and passing up the spermatic cords, through the abdominal rings, and by the sides of the bladder and vesiculæ seminales, till they penetrate the prostate gland, and terminate at the origin of the urethra.

The vesicula seminalis appears to consist of a single canal, much convoluted, and which secretes a mucous fluid;

* See Cuvier, Leçons, &c. t. v.

and it seems certain that both this fluid, and that of the prostate gland, must be forced out chiefly at the time of the passage of the semen, and be discharged along with it; but although it appears probable, that a reservoir may be provided for the seminal fluid, similar to the gall-bladder for the bile, it has not yet been ascertained whether the vesiculæ seminales, in those animals where they exist, answer this purpose.

When the testes enlarge at puberty, and their secretion is fully formed, the sexual appetite is first felt; and at all subsequent times, the presence of a quantity of that secretion in the long and convoluted course of the seminal ducts, and perhaps in the vesiculæ, is one condition essential to its being felt, and that, on the amount of which the degree of its intensity is mainly dependent.

At the same time, the other changes characteristic of puberty take place,—the growth of hair on the organs of generation, in the axillæ, and on the lower part of the face, the enlargement of the larynx, and alteration of the voice, an increased development of the chest and shoulders, as compared with the pelvis, an increased energy of mental disposition, and manifestation of the peculiarities of the male character,—probably connected with an increased development of some portion of the nervous system within the cranium.

These changes are not merely simultaneous with the secretion of semen, but dependent upon it; for they are all prevented from taking place by castration; but whether the sensations and emotions, consequent on the establishment of the secretion, or whether the secreted fluid itself, absorbed into the blood, may be regarded as the stimulus to nutrition in these different parts, is uncertain *.

Although the presence of the secretion of the testes is es

* The case of the young man born blind and deaf, recorded by Mr Stewart (Transactions of Royal Society of Edinburgh, vol. vii.), appears to favour this last supposition, for all the usual marks of puberty had taken place in him, when he had never shown any marks of sexual desire.

sential to the existence of the sexual appetite, yet that mental feeling is not immediately excited by any changes in the testes, or seminiferous ducts, and the sensations by which it is accompanied and characterized, are referred to, and are connected with physical changes in, the corpora cavernosa and glans penis. They are on a footing with the sensations of emotion, formerly mentioned;—as the change in the circulation of these parts is on a footing with the other changes in the circulation, which we formerly referred to mental emotion. But when this feeling has been excited, it has likewise a manifest action on the testes themselves, and greatly promotes the secretion there.

The mental feeling, or Emotion of Desire, which has these effects, is probably connected with some portion of the cerebellum; because it has been often observed to exist in an unnatural degree, in cases of disease or injury of that part; but we have already seen evidence that the cerebellum is also concerned in very different functions; and it is very improbable, that the whole of that organ should be devoted to the excitation of this single feeling. It would appear, that the change in the state of the Nervous System, within the head, which attends this feeling, is imitated by the compression of the brain, which results from stagnation of the blood in the jugular veins, because erection, and even emission, very frequently accompany death by strangulation.

The duration and intensity of this mental feeling are remarkably influenced by the mental law formerly noticed, according to which no two mental acts of importance can coexist; and it is accordingly often rendered ineffectual for its purpose by the concurrence of other feelings; for example, of hypochondriacal apprehensions.

The manner in which the distention of the corpora cavernosa, corpus spongiosum urethræ, and glans penis, is effected, under the influence of this feeling, is still somewhat doubtful. The blood is evidently received into large cells in this texture, but anatomists are not agreed as to whether these cells are truly exterior to the circulation, or merely dilatations of the small vessels. Neither are they agreed as to how the stagnation of blood in the penis is effected; but it has been found, that in large animals, such as the elephant, the nerves of the penis (which are always large, and originate from several of the sacral nerves, and from the sympathetics) form plexuses in an unusual way about the large veins on its dorsum; and MAGENDIE found that ligatures of some of these veins produced a partial distention of the corpora cavernosa; these facts render it probable that a vital constriction of these veins, determined by an action of the nerves, is its main cause; and Dr HOUSTON has lately demonstrated small muscles and tendons, situated behind the arch of the pelvis, distinct in some of the lower animals, and visible, although more rudimentary in man, by which the great vein leading from the penis is encompassed, and may easily be compressed *.

The effects of this distention of these parts are,—that the canal of the urethra is straitened and narrowed; that the general direction of the urethra forms a less angle than before with the extreme part of the vasa deferentia, by which the semen enters it, and a greater angle than before with the direction of the orifice of the bladder, by which the urine enters it; and that the form of the whole organ, and the sensibility of the glans in particular, are adapted to their office in the generative function.

The mental feeling which prompts the whole of these changes, heightened by the sensation of these parts in their distended state, ultimately excites both the flow of the semen along the vasa deferentia, and likewise the spasmodic action of the levatores ani and acceleratores urinæ, by which the emission is effected, and which has been vaguely ascribed to a sympathy between these muscles and the urethra.

It is well ascertained by the microscopical observations of LEUWENHOEK, HALLER, SPALLANZANI, PREVOST and

* See Dublin Hospital Reports, vol. iv.

DUMAS, MAGENDIE, and many others, that a number of vermiform animalculæ, capable of apparently spontaneous motion, are contained in the seminal fluid of all animals, when these are in a state fit for procreation.

Although the whole of the female organs of generation,—the uterus, and its broad and round ligaments, the Fallopian tubes, vagina, and external parts, as well as the ovaria, are formed from the time of birth, they are more fully developed at the age of puberty, not only simultaneously with, but in consequence of, the development of the ovaria at that time; and the other changes which then take place, and especially the enlargement of the pelvis, growth of the mammæ, establishment of the menstrual discharge, and manifestations of the female character, are also believed to be dependent on the change in the ovaria; none of these having taken place in some cases where these organs were found to be only rudimentary. Whether these changes may be dependent on the absorption of something from the ovaries, or whether the sensations and mental feelings connected with the active state of the ovaries are concerned in producing them, is unknown.

The menstrual discharge takes place from the inner surface of the uterus, in the healthy state every four weeks, lasts about three days, amounts to six or eight ounces, and consists, so far as has been yet ascertained, of blood in a great measure deprived of its fibrin. It is generally preceded and attended, especially about the time of its first establishment, by some degree of pain of the back and abdomen, often of the head, and frequently by dyspeptic, nervous, or febrile symptoms; which abate as it goes on, and gradually subsides; but are aggravated if it is suddenly checked.

As the continuance of this periodical discharge coincides very generally with the time during which women are adapted for childbearing, it seems evidently to be a consequence of the active state of the organs of generation. As it very generally ceases during pregnancy and nursing, it has been often thought to be a succedaneum for the discharges from the system, which take place during these states; and as it has not been ascertained to consist of any thing beyond the usual constituents of the blood, and is manifestly increased, as morbid hæmorrhages are, by causes of general and local plethora, and diminished by means which obviate these, it has been supposed that it is to be regarded merely as a natural hæmorrhage.

But on the other hand, as the effects resulting from the suppression, especially the sudden suppression, of this discharge, are generally more serious than those which follow the stopping of any simple hæmorrhage, or other evacuation, of the same amount; and as such suppression has often been followed by hæmorrhages from parts very little disposed, in general, to such a form of disease,—or by various inflammatory or nervous disorders,—there is some reason for suspecting that this evacuation is intended, not merely to keep down the quantity of blood in the system, but to secure the evacuation of something formed in the system during the active state of the genital organs, and which would be hurtful if retained.

The visible change upon the ovaria, which takes place at puberty, consists partly in the formation or development, in them, of the small bodies called Graafian Vesicles, which contain a serous fluid, and are dispersed through their substance.

The changes which take place in these organs, at the time of sexual intercourse, and particularly the great congestion of blood in them all, must no doubt be ascribed to the influence of sensations and mental feelings; but the precise extent of the effect of these is uncertain.

Observations on animals, and in some instances on the human body, distinctly prove, that at the time of such sexual intercourse as is followed by conception, the fimbriated extremities of the Fallopian tube embrace the ovarium, so as to make a single, though very winding and irregular passage from it to the external parts; and that thereafter one of the Graafian vesicles, extending itself to the surface of the ovary, bursts and discharges a smaller vesicle or ovum, which descends along the Fallopian tube, into the uterus; and part of which is there developed to form the embryo. The smaller vesicle seems to have been detected by BAER, even in the ovarium; and to consist of an outer and inner portion, containing a liquid, and the embryo ultimately forms on a part of the sac of the inner portion *. But there is more doubt and difference of opinion as to the following points:

1. Physiologists are not yet fully agreed whether the rupture of a vesicle in the ovary, and escape of an ovum, can take place in the human body, or in others of the mammalia, without impregnation. The numerous observations of HALLER, and of PREVOST and DUMAS, would seem to show that this can seldom happen in the lower animals of this class; but on the other hand, the observations of VALISNERI, SANTORINI, and BERTRANDI in Italy †, and of Sir E. HOME and Dr BLUNDELL ‡, in this country, seem sufficient to prove, that in the human body, and probably in some of the lower animals also, vesicles are occasionally detached from the ovaries, and their marks subsequently found, where there had been no sexual intercourse.

When a vesicle has been ruptured, and ovum detached from the ovary, it leaves at first a ragged cavity, containing a little blood; but this gradually assumes the appearance of a yellowish substance, called a corpus luteum, with a corresponding cicatrix on the surface of the ovary, which afterwards becomes gradually less distinct. But

* BAER, in BRESCHET'S Repertoire d'Anat. et de Physiol. 1829; and ALLEN THOMSON, in Edin. Phil. Journ. Oct. 1830.

† See BLUMENBACH, in Comment. Soc. Reg. Scient. Gotting. vol. ix.

‡ Phil. Trans. 1817, and Physiological Researches.

according to the observations of Sir E. Home, of Magendie *, and of Baer †, a yellowish substance appears to be formed around one of the Graafian vesicles, before it bursts, and continues, after the escape of its contents, gradually encroaching on, and ultimately obliterating, the cavity left.

It would appear, therefore, that the total absence of any corpus luteum may be regarded as a proof that no recent conception had taken place; but that the presence of a distinct yellow body in the ovarium, may depend on one of two causes, perhaps independently of conception, certainly independently of the growth of an embryo in the uterus; viz. either on the escape of an ovum, without sexual intercourse, or on the development of a vesicle containing an ovum which has not yet escaped.

2. It is not fully ascertained how far, in the winding canal, closed by the adhesion of the fimbriæ to the ovary, it is essential that the male semen should penetrate, and whether its contact with the ovum, or vesicle detached from the ovarium, is necessary in order that it may impregnate the ovum.

That its contact with the ovary itself is not necessary to the discharge of the ovum, appears not merely from the facts already stated, but also from many experiments by Dr Haighton and Dr Blundell, made on rabbits, in which animals there are two uteri corresponding to the two ovaries. In these experiments, different portions of the canals leading from the external parts to the two ovaries, were obliterated by adhesive inflammation, and sexual intercourse afterwards permitted, and the escape of vesicles from the ovaries was clearly ascertained to have followed that intercourse ‡.

* Precis Elementaire.

† Breschet's Repertoire d'Anat. et Physiol. 1829.

‡ See Blundell's Physiological Researches.

On the other hand, that the seminal fluid must necessarily reach the ovum in the uterus, in order to vivify it, seems to be rendered highly probable, *first,* By the farther result of the experiments of Drs HAIGHTON and BLUNDELL, in all of which it appeared, that although ova were detached from ovaries, the communication of which with the external parts had been interrupted, yet such ova never were developed into embryos; while those from the opposite ovaria, received into the opposite uteri of the same animals, were so developed; *secondly,* From the observations of GALEN, RUYSCH, CHESELDEN, HALLER, HUNTER, and many others, who found the male semen in the uteri of different animals killed soon after copulation; and especially from the microscopical examinations of PREVOST and DUMAS *, who satisfied themselves of its always existing, in these circumstances, about the horns of the uterus, but could never detect it in the Fallopian tube: and *lastly,* From the analogy of many animals of the classes of Reptiles and Fishes, in which it is certain that the actual deposition of the male semen on the ova, at the time of, or after their discharge from the body of the female, is the essential condition of their development.

If this be so, the rare cases of extra-uterine conception, where the ovum is developed either in the Fallopian tube, or beyond its extremity, must be cases where a portion of the seminal fluid has penetrated farther than usual along the canal leading to the ovary †. And that this may happen, we can understand from the observation of Dr BLUNDELL and others, that at the time of intercourse, the whole of that canal is in a state of spontaneous movement.

* Annales des Sciences Naturelles, t. i, ii, iii. & xvi.

† Cases of extra-uterine conception were published by Mr LANGSTAFF and Dr ELLIOTSON (Medico-Chirurgical Trans. vol. vii. and xiii.), in which the Fallopian tube was obstructed; but the facts now stated render it most probable that the obstruction had been subsequent to conception.

This last fact likewise enables us to understand, consistently with this doctrine, how impregnation should have taken place in several cases on record *, where the vagina was preternaturally narrow, or the hymen nearly entire.

On the other hand, in the case of birds, a single intercourse is known to be sufficient to impregnate many eggs, which are laid successively after it; and it is difficult to understand how the semen should have been conveyed to the ovary for that purpose. And we have accounts of experiments, in which artificial impregnation of female animals, by semen taken from male animals, is said to have been effected (by what has been called the Seminal Aura), where the male fluid did not come into actual contact with the uterus of the female †.

3. The time when the ovum leaves the ovarium, and descends along the Fallopian tube, is not certainly known, and probably not uniform; but the observations of PREVOST and DUMAS, MAGENDIE, and others, show that, in various animals, it is not for some days, and that in the human species it may probably be eight or ten days, after the sexual intercourse with which it is connected.

Thus it appears, that the changes in all viviparous animals, at the time of the intercourse which is to be fruitful, are confined to the deposition of the seminal fluid in the uterus, and the adhesion of the fimbriæ to the ovary; and that the growth, detachment, and passage of the ovum or vesicle into the uterus, takes place within some days after; during which time, PREVOST and DUMAS found the seminal animalcules to be distinctly visible in the uterus; and it is a probable conjecture, that the implantation of one or more

* *Ex. gr.* in Memoires de l'Acad. des Sciences, 1712; Edin. Med. and Surg. Journ. vol. i.; Medico-Chirurg. Trans. vol. ii.; FODERE', Medecine Legale, § 252 and 986.

† Edin. Med. and Surg. Journal, vol. xix. p. 485.

of the animalcula on the ovum may be the necessary condition to its development.

After such an intercourse, the inner membrane of the uterus is found to be lined all over with an effusion of flocculent lymph, part of which stretches across the cervix uteri, and closes its mouth, and the formation of which is not dependent on the passage of the ovum, nor even on the admission of semen into the uterus; for it has been found, both in cases where the conception was extra-uterine, and in experiments where the vagina was obstructed *.

In this flocculent lymph, the ovum, when first seen, is loose and detached; it is much smaller than the vesicle which disappeared from the ovary †; and, according to almost all observers, it appears as a sac containing a limpid fluid, on one side of which the embryo becomes visible, not sooner, according to MAGENDIE, than three weeks after conception.

The sac containing the embryo, when the parts become more distinct, appears to consist of two membranes, the outer of which, called the Chorion, is of loose texture, and its exterior flocculent surface has the name of Spongy or Shaggy Chorion; while the inner, called the Amnion, is smooth and uniform. The lymph lining the uterus, and continuous with the shaggy chorion, also appears separable into two parts, the outer of which is called Decidua Vera, and the inner, supposed to be turned back by the entrance of the ovum, is called Decidua Reflexa. In the course of the second month, the shoots of the shaggy chorion, on one part of the ovum, implant themselves firmly in the corresponding portion of the decidua, generally towards the fundus of the uterus, and form the Placenta, and the rest of the flocculi of the chorion then disappear. The embryo

* BLUNDELL, loc. cit.

† PREVOST and DUMAS, loc. cit.; and CRUICKSHANKS, Phil. Trans. 1797; BAER, loc. cit.

slowly detaches itself from the side of the ovum, and floats in the liquor amnii, the proportion of which to the whole ovum is afterwards gradually diminished; and the only attachment of the embryo to the membranes is then found to be the umbilical cord, by which it is connected with the placenta.

But for a time, before these changes are completed, there is a small sac containing a whitish fluid, called Vesicula Alba, between the amnion and chorion, which, according to the observations of BAER and of ALLEN THOMSON, would seem to be the inner portion of the ovum, above noticed.

The Placenta, formed at first of adventitious membranes thrown out on the inner surface of the uterus, and in which no bloodvessels are discernible, is found, when fully developed, to be a spongy mass composed chiefly of vessels, infinitely subdivided and convoluted. It has been generally stated that a part of this vascular structure is continuous with, and may be injected from, the arteries of the uterus, and this has been called the Maternal Portion; but that another portion, towards the inner surface of the placenta, can be injected only from the vessels of the umbilical cord of the fœtus, and this has been called the Fœtal Portion. But according to the recent observations of Dr LEE * it would appear, that the whole vessels of the Placenta may be injected from the Fœtus, and that whatever passes into them from the uterine vessels, must transude through the very thin membrana decidua, from the uterine sinuses, or large veins, many of which appear to terminate in open mouths on the inner surface of the uterus, at the part where the placenta is attached.

The existence of cells in the placenta, into which blood is effused from the uterine vessels, is certainly not clearly demonstrated. It is probably, therefore, by transudation

* Phil. Trans. 1832.

only, that the contents of the uterine vessels pass into the minute branches of the umbilical vessels; and it seems certain that no entire globules of blood are transmitted from the one set of vessels to the other, because the globules of the fœtal blood appear, from the observations of PREVOST and DUMAS, to be differently shaped from, and larger than, those of the adult.

In experiments by MAGENDIE and by Dr WILLIAMS *, it appeared that camphor, and that oil, injected into the blood of pregnant animals, were soon detected in the blood of the fœtus; but poison injected into the umbilical arteries, although mixing with the blood on its way from the fœtus to the placenta, did not affect the mother. Neither does fatal hæmorrhage in the mother apparently diminish the fulness of the vessels of the fœtus:—so that it would seem that the transmission of fluids in the placenta is almost entirely from the mother to the fœtus.

The placenta must answer, in some measure, the purpose of arterializing, as well as supplying, the blood of the fœtus; but the difference between the blood in the umbilical arteries, coming from the fœtus, and that in the umbilical vein passing into it, is never nearly so great as that between venous and arterial blood in the adult; and to this it is partly owing, that all the functions of the Nervous System are nearly at a stand in the fœtus, but are excited into action immediately after birth.

The gradual formation of the different organs during the life of the fœtus, has been lately much studied both in the lower animals and in the human body, and the growth of various parts minutely described. Some general observations only on this subject can be made here †.

1. It is certain that the different parts of the fœtus do not result merely from *evolution* of organs already existing

* Edinburgh Medical and Surgical Journal, vol. xxv.

† See PAGET. Edinburgh Medical and Surgical Journal, Oct. 1831.

in the ovum; but from movement of the fluids, and agglomeration of their particles at particular points, to form different solid textures; under the influence, no doubt, of the same vital properties to which we give the name of Vital Affinities, on which the nourishment of these textures at all subsequent times depends. Many well known parts of the different organs, such as the heart and brain, are distinctly seen to be added after other parts have attained a considerable size. It would appear that the ovum, when it first descends into the uterus, has two coverings, the outer of which becomes the chorion, and the inner becomes what has been called the Umbilical Vesicle. This last membrane is first thickened at one part, then separates into distinct layers; these are thrown into folds, which gradually inclose the remains of the vesicle, from which they are at first nourished, and then retain a vascular connexion with the chorion or outer membrane of the ovum, and with the uterus, by the umbilical vessels only; and these folded layers of membrane gradually undergo conversion into the amnion covering, and the different textures composing the animal body *.

2. The commencement of the formation of organs in this way is anterior to the first formation of the heart, and to the development of vessels on the umbilical vesicle; and the part of which the rudiments are first seen is the vertebral column.

3. The growth of the embryo is slow in the earlier months. The form of the trunk is always considerably curved, but the extremities, when first seen, stand out from the body, and are afterwards folded in. The distinction of textures is very gradually effected, so that the bone is not distinctly formed before the end of the second month,—muscles and fat not until the end of the third; and several organs can-

* See the papers of BAER, of ALLEN THOMSON, and of PREVOST and DUMAS.

not be perceived sooner than the fourth, at which time the weight of the embryo is hardly above two ounces; after this time it is called the Fœtus. The head of the fœtus, in a great majority of cases, lies ultimately in the lower part of the uterus. The distinction of the grey and white matter of the brain is never distinct in the fœtus; but the parts of the nervous System which are first formed are those that consist ultimately of white matter *.

4. After the heart is distinctly formed, and the vessels contain red blood, and when the nourishment mustbe chiefly drawn from the placenta, it appears beyond doubt that the heart, for a time, consists of one auricle and one ventricle only, from which one artery arises, and that the septum is afterwards gradually formed, the aorta separated from the pulmonary artery †, and the peculiarities of the fœtal circulation established, about the end of the second month.

5. This circulation takes place in the following manner: From the placenta the blood ascends by the single contorted umbilical vein to the umbilicus, and thence by the edge of the broad ligament to the liver, where it joins the left branch of the Vena Portæ, and is distributed for the most part through the left lobe of the liver,—part, however, passing forward by the ductus venosus, directly to the vena cava ascendens, which the rest likewise enters after being distributed through the liver.

When the blood of the vena cava ascendens reaches the heart, the greater part of it is directed at once to the left auricle; the Eustachian valve, in front of it, preventing much admixture with the blood of the right auricle, at least until the later months, when this valve is shortened. From the left auricle it is projected into the left ventricle, and thence into the aorta; and nearly the whole contents

* See TIEDEMANN's Anatomy of the Fœtal Brain, translated by BENNETT.

† ALLEN THOMSON, loco cit.

of the left ventricle appear to pass into the carotid and subclavian arteries, to supply the upper parts of the body, and upper extremities *. Returning from these by the vena cava descendens, the blood passes through the right side of the heart, and is projected by the right ventricle and pulmonary artery, partly into the lungs, but chiefly through the canalis arteriosus into the commencement of the descending aorta, which it appears completely to fill, at least during great part of the fœtal life. From the internal iliac arteries a great part of this blood ascends by the two umbilical arteries at the sides of the bladder, and passing out by the umbilicus, is carried by the cord to the placenta;—while the rest is circulated through the lower parts of the fœtus, and rejoins it in the vena cava.

The use of the distribution of so much of the blood from the placenta to the liver is still doubtful; but the other arrangements now described are evidently calculated, not only to expose the blood of the fœtus to the salutary changes which it undergoes at the placenta, but likewise to send most of this blood to the upper parts of the body of the fœtus before it visits the lower parts; to allow a small portion only of this blood to have access to the lungs of the fœtus; and farther, to secure the co-operation of both ventricles of the fœtal heart in the circulation through its body.

6. After this circulation is established, it seems to be a general law, that the growth of organs is proportioned to the development of, and flow of blood through, the blood-vessels supplying them. The deficiency of parts of the body in monsters may generally be traced more or less directly to this cause; and the development of the Nervous System, in particular, appears strictly proportioned to, and dependent on, the development of the vessels supplying it,—the

* See a translation of Kilian's work on the Fœtal Circulation, in Archives de Medecine, 1828.

nerves being first formed in most parts of the body, the spinal cord before the brain, and the brain before the cerebellum, and the growth of both these organs taking place in the direction in which the branches of the carotid and vertebral arteries extend themselves *.

7. There are certain parts fully developed in the fœtus, which shrink and become apparently useless in the adult, and the use of which is still unknown, particularly the Thymus Gland, situated between the layers of the anterior Mediastinum, and the Supra Renal Capsules. The liver and thyroid gland are likewise, for reasons not known, of larger size in proportion to other parts than in the adult; and the urachus connecting the bladder with the umbilicus, has no known use in the human fœtus. Another curious fact is, the development of parts of organs, which afterwards shrink and become rudimentary, even during the fœtal life; of which the most striking is the caudal prolongation of the vertebral column and spinal cord during the first three months; the membrana pupillaris, which lies across the pupil in the earlier months, and the prolongation of the cæcum, which afterwards becomes the Processus Vermiformis, belong to the same class. And a still more curious process is the descent of the testes, from their position on the Psoæ muscles, through the abdominal rings to the scrotum, and the change connected with that movement, in the adjoining portions of peritoneum.

8. The circulation in the fœtus is very rapid, the pulsations of the heart above 120. The secretions, and more particularly the excretions, must necessarily be much restrained during the fœtal life; but a whitish unctuous substance is formed on the surface in the later months; and there is a copious secretion into the intestines (which are longer in proportion to the size of the body than in the

* See particularly SERRES, Anat. Comp. du Cerveau.

adult), both of mucus and of bile, from which the greenish liquid matter called Meconium is formed, which exists in the lower intestines during the later months, and is discharged soon after birth. In some instances this has taken the exact form of hardened fæces; and from this circumstance, and more especially from the contents of the lower intestines showing little or no albumen, while those of the higher intestines contain albumen in abundance, it appears probable, that there is a process of Digestion of the contents of the intestines during fœtal life, on which the nutrition is partly dependent *. The power of generating animal heat is feeble in the fœtus, its temperature being 92° or 93°,—which is to be expected from its venous blood being less different from its arterial than in the adult,—from its small supply of oxygen, and deficient secretions. In these circumstances, and in the greater size of the particles of its blood, its vitality approaches to that of cold-blooded animals.

The weight of the lungs of the infant is in general nearly doubled after respiration is established, but the proportion of their weight, either before or after that change, to the whole weight, is exceedingly various; being, according to the observations of Chaussier, from $\frac{1}{27}$ to $\frac{1}{130}$ in children still born, and from $\frac{1}{10}$ to $\frac{1}{48}$ in those dying very soon after birth. The whole weight, at birth, is, on an average, about 7 lb., and the length about 20 inches.

The changes on the uterus, which attend the development of the ovum within it, likewise demand attention. These are, not only very great enlargement of size, but softening of texture, and alteration of form, which take

* See Geoffroy de St Hilaire, Philosophie Anatomique, p. 288; and more particularly Drs Lee and Prout, in Philosophical Transactions, 1829. Dr Lee having found the albumen also in the hepatic ducts, suspects that the liver is its chief source, and therefore, that the office of the liver is specifically distinct in the fœtus and adult.

place gradually, and somewhat variously. For the first three months the uterus remains in the pelvis, and its absolute increase is slow; but in the next three it increases more rapidly, and rises nearly, or quite, to the umbilicus, and by the end of pregnancy, nearly to the sternum. Its shape is gradually altered, first by the increase of its transverse diameter at its central and lower part, by which it becomes more oval, and afterwards by the expansion of its cervix, which in general takes place almost entirely in the three last months, and furnishes the surest sign of the visible enlargement of the abdomen depending on the development of the uterus.

The constitutional effects which attend pregnancy are, *first*, suppression of the menses, which is nearly invariable; being in fact the natural result of the formation of the membranes which line the inside of the uterus closely, and cover its mouth, and never separate from it in the healthy state of pregnancy;—*secondly*, the enlargement of the mammæ during the last half of the time, and more particularly the formation of the brown areola around the nipple;—*thirdly*, various dyspeptic symptoms, particularly the morning sickness;—and *fourthly*, various nervous symptoms, particularly mental languor or irritability. But these, although often very obvious, are not exclusively characteristic; and the dyspeptic and nervous symptoms are in some cases slight, and in many abate considerably after the third month. The movements of the child may be felt occasionally, but of very various strength, during the last four or even five months.

The usual duration of pregnancy is just about 280 days. Many children are born before this time, but very few after it; and the law which allows a child to be legitimate if born six kalendar months after the marriage of the mother, or ten months after the death of the reputed father, is generally thought to embrace all possible cases. Yet cases have occurred, in which there was good evidence of children having lived that were born before the sixth month, and of parturition having been delayed beyond the tenth *.

The contraction of the uterus, on which parturition depends, is not the effect of its distention by its contents, but of a change in the vital actions going on in itself; for it is observed, in a certain degree, at the usual time, even in cases of extra-uterine conception. It appears from experiments by Magendie, that there are likewise changes in the placenta, towards the end of pregnancy, tending to the gradual dissolution of part of the vascular union between it and the placenta, whereby the hæmorrhage attending the ultimate separation is no doubt lessened.

The principal changes during parturition are these,

1. The contractions of the uterus cause pains, recurring at intervals, which gradually diminish, for some hours, referred to the back, abdomen, pelvis, and thighs; and, along with these, gradual dilatation of the os uteri.

2. When this is accomplished, the membranes are more or less protruded, and then burst, and the liquor amnii escapes.

3. There is after this an increase and change of the painful contractions of the uterus, aided by sympathetic actions of the diaphragm and abdominal muscles, by which the head of the child (in natural labour), is forced down,—the vagina and external parts being stretched and unfolded to make room for it; and the head changing its direction as it descends, so that the occiput, from being directed towards one of the acetabula, comes to be behind the arch of the pubes, and the face in the hollow of the sacrum. After the head has passed the external parts, the pain becomes less urgent, and the rest of the body passes more easily.

5. There is subsequently a slighter renewal of the painful contractions, ending in the discharge of the placenta, and membranes; then a bloody discharge for some days, with occasional pains, by which coagula are thrown off;

* See, for example, Edinburgh Medical and Surgical Journal, vols. xi. and xxv.

a whitish discharge for some time longer; and the uterus gradually returns to its original form and situation in from twenty to thirty days after delivery.

According to the observations of Dr GRANVILLE, the uterus, at the time of delivery, attains a temperature ten or twelve degrees higher than has been observed in any other part of the body*.

The singular circumstance of the sudden rupture of so many large vessels as those which ramify on the inner surface of the uterus, at the parts carved by the placenta, without dangerous hæmorrhage, depends chiefly on gradual and uninterrupted contraction of the uterus, constringing the mouths of the vessels; and most cases of dangerous hæmorrhage depend on imperfection or interruption of this tonic contraction.

It may be remarked here, generally, that uterine hæmorrhage, leading to separation of the placenta and abortion or premature labour, may very frequently be referred to one or more of the following causes: General weakness, and especially unusual susceptibility of those impressions in the nervous system, which are apt to influence the circulation; general, and more particularly local, plethora; any sudden excitation of the system, whether from physical or mental causes; febrile disease, especially such as proceeds from a contagious poison; local injury, whether from external or internal causes, in the neighbourhod of the uterus. There are also many cases in which abortion depends on original malformation or fatal disease of the fœtus. There are cases which we cannot refer distinctly to any of these causes; and it has been observed, that such cases are remarkably prevalent in certain times or seasons.

The most important change, in the mother, consequent on parturition, is that which takes place in the mammæ, which are already much enlarged, and already, in general, secrete and discharge a small quantity of serous fluid. With-

* Phil. Trans. 1825.

in two days after parturition, this fluid assumes the character of milk, which it retains (the proportion of curd however increasing) for many months afterwards. Its discharge is effected, in consequence of the arrangement of the ducts of the gland, by a certain erection of the nipple, as well as by the suction of the child. The flow of blood to the mammæ, during the whole time of nursing, is very much increased, as is obvious from their increased tendency to inflammation. That *sympathetic* change on the secretion of these glands, according to what was formerly stated, is probably dependent, at first, on sensations which result from the action going on at the uterus. Certainly in this, as in other cases to which the term Sympathy is applied, it is by no means a general law, that every change at the uterus is followed by a change on the mammæ. And after parturition, it is certain that the continuance of the secretion depends very much on the emotions excited in the mother by the sight of the infant; and this not only in the human race, but even, according to the observation of HUNTER and of ROULIN, in the lower animals *.

The important changes on the fœtus, consequent on parturition, are the effects of the interruption of the flow of blood along the umbilical cord; and of the powers of *Sensation*, which are unnecessary for any of the purposes of fœtal life, being excited by the new circumstances in which it is placed. Its first respiration may be ascribed, partly to the cessation of the small supply of imperfectly arterialized blood, which its lungs had received from the placenta, but chiefly to the novel impression of cold air on the surface of the body. The changes in the circulation within the chest, the gradual closure of the foramen ovale, and the more rapid obliteration of the canalis arteriosus, for which provision had already been made in the altering form of the parts, may be ascribed partly to the expansion of the

* See Journal of the Royal Institution, No. II., and Annales des Sciences Naturelles, t. xvi. p. 24.

lungs, and the vital and chemical actions established there, which *solicit* the flow of blood into the lungs, and therefore fill the left side of the heart from them. The changes in the lungs themselves, their great increase of absolute weight, and great diminution of specific gravity, which are likewise effected gradually, are the natural result of the admission of much additional blood into their vessels, and of air into their cells. The continuance of the acts of respiration, the instinctive movements of the limbs, eyes, &c. and the instinctive acts of sucking and deglutition,—being all the natural effects of sensation in the living body, and especially of the establishment of the feeling of anxiety from want of air, and of the appetites of hunger and thirst,—are all to be ascribed to the increased Sensibility, which results from the action of perfectly arterialized blood on the nervous system. Thus it is that Life, which during the fœtal state is Organic only (and may therefore be maintained without brain or spinal cord), now becomes truly Animal, and is placed in dependence on Sensation.

Another subject of importance in this department of physiology is the influence of the constitution and habits of parents on their offspring.

That the stature, complexion, forms of features and limbs, &c., as well as the mental peculiarities of the offspring, frequently bear a strong resemblance to those of the parents, is matter of familiar observation ;—it is certain also, that resemblances in these respects are observed nearly indiscriminately to both parents ;—and it has often been noticed, that such peculiarities have passed over one generation, and appeared in the next. Peculiarities of formation, such as supernumerary fingers or toes, have in like manner often been hereditary in families,—sometimes descending by the females and sometimes by the males,—and yet been found only in a certain number of the members of these families *. In like manner longevity is very often observed to be here-

* See CARLYLE in Philosophical Transactions, 1814 ; and HALLER, Elem. Physiol. tom. viii. p. 96.

ditary *; and it is therefore quite in conformity with other ascertained facts, that we find the tendency to certain diseases, particularly to Asthma, Gout, Mania, and the various forms of disease which are ranked together under the term Scrofula, to be much greater in some families than in others; although in many cases it is only by the action of well-marked exciting causes, that such diseases, even in persons so predisposed to them by hereditary constitution, are produced.

Various observations appear to indicate, that the sex of the offspring is in some measure dependent on the relative energy of the parents; being most frequently male, when the male parent has been of the stronger habit of body, and *vice versa* †. Whatever be the causes acting on parents, which influence the sex of their offspring, these causes must operate, on the whole, very uniformly over the world, and so as to cause a slight preponderance of the number of males, the male births exceeding the female very generally in all countries, and nearly in the proportion of 21 to 20.

The age of parents must also, no doubt, influence the constitution of their offspring;—those who are in the vigour of life being best fitted for the procreation of children of strong constitution; but statistical statements from different countries show, that the average productiveness of marriages is very different in different stages of advancement and civilization—evidently because marriages are usually contracted much later in some of these countries than in others,—without any corresponding difference in the average health of the community; from which it may be inferred, with more confidence than from any individual observations, that both men and women are equally capable

* See a collection of cases of this kind in Sir J. Sinclair's Code of Health and Longevity, vol. i. p. 27.

† See Girou de Buzareingues in Ann. des Sciences Naturelles, tom. xv.

of the procreation of healthy offspring during a considerable part of their lives.

We have no means of judging in what manner peculiarities, either of the male or female parents, are impressed on their offspring; but it is an important fact, that the influence of the male, in the case of some animals, is not confined to the ovum which he actually impregnates; the peculiarities of a male animal, that has once had intercourse with a female, having been distinctly recognised in the offspring of subsequent connexions of that female with other males *.

The acquired habits, and mode of life of parents, have likewise a very important influence, which is well ascertained on a large scale, but cannot be easily demonstrated by individual instances, on the character of the vital actions which their offspring will exhibit. In so far as the mode of life of parents is permanently debilitating, and disposes them to scrofulous disease, it is certain that it will generally give a similar tendency to their progeny; as is evident on comparing the amount of scrofulous disease in the young children of a great town, with its amount in the previous generations of the same families, if engaged in agricultural employments. The effect of habits of parents on the vital actions of their offspring is well illustrated by the great variety of appearances assumed by animals when domesticated, and their return, in the course of a few generations, in a state of nature, to a single and uniform type †.

But a more singular fact, which appears well ascertained in regard to certain animals (dogs and horses), and probable in regard to the human species also, is the transmis-

* As in the instance of an Arabian mare that had been once covered by a quagga. Philosophical Transactions, 1821.

† See Isidore St Hilaire, "Considerations sur les Mammiferes;" and "Recherches sur quelques Changemens observés dans les Animaux Domestiques," &c. by Roulin, in Ann. des Sciences Naturelles, t. xvi.

sion, to the second and third generation, of habits not natural to the animal, but acquired by education and training *.

Again, it is certain that various accidental circumstances affecting the mother during gestation, may influence the nutrition and subsequent vital actions of her offspring. It appears, from the observations of GEOFFROY ST HILAIRE †, that preternatural adhesions of parts of the fœtus to the membranes and the placenta occur occasionally, and so confine and derange the circulation in, and development of, the fœtus, as to produce various kinds of monstrosities; and both from his observations and those of many others, it seems well ascertained, that such derangements of the vital actions within the uterus, may be produced either by injuries, or by sudden and violent mental emotions, when these are not so powerful as to cause abortion. If the observations of Sir E. HOME ‡ shall be confirmed, that nerves may be distinguished in the placenta and umbilical cord, the efficacy of mental emotions, on the growth of the fœtus, may be more easily understood. It is much more doubtful, whether the precise nature of the alteration effected in any case on the growth of the fœtus, can be determined, as is vulgarly supposed, by the images in the mind of the mother; but as we know, from such facts as that noticed in last page, that the peculiarities of a male animal may influence the products of conceptions in which he is not himself concerned, we are hardly entitled to deny the possibility of such an agency of mental affections.

* See ROULIN's paper, above quoted; and the report on it by GEOFFROY ST HILAIRE.

† Philosophie Anatomique, p. 208 and 527.

‡ Philosophical Transactions, 1825.

CHAPTER XVIII.

OF PECULIARITIES OF AGE, SEX, AND TEMPERAMENT.

THE vital actions of all warm-blooded animals, immediately after birth, approach in several respects to those of cold-blooded animals. Their circulation, although very rapid, is easily repressed, particularly by cold *; their power of generating heat is feeble, and in the human species and many others, would be insufficient, of itself, to preserve life; their sensibility, and mental powers, are imperfectly established; and their lives are chiefly spent in sleep;—but on the other hand, they have more endurance of life, in different circumstances; the same degree of reduction of their own temperature †, the same length of suspension of the function of respiration ‡, and the same amount of destruction to the Nervous System §,—is not fatal to the vitality of their organs of circulation, as in adult animals.

The following appear to be the most important peculiarities which appertain to the periods of childhood and early youth, gradually diminishing as life advances:

1. The capillary vessels, and particularly the capillary arteries, are much more numerous in all the textures, and bear a much greater proportion to the larger vessels, as is obvious on comparing the red lines in an aged countenance, with the diffused bloom of youth, and as is more distinctly

* See EDWARDS, De l'Influence des Agens Physiques, &c. Part iii. ch. i.

† Ibid. Part iv. ch. ii.

‡ Ibid. Part iii. ch. iv. and Part iv. ch. vi.

§ LEGALLOIS.

shown, by injections of subjects at different ages; so that the blood must diverge much more into the interior of the textures, than in adults.

2. During the whole period of youth, the irritability of the organs of circulation is evidently greater than in adults; the number of pulsations of the heart, at first double that in the adult, is only gradually reduced, and is easily raised by various kinds of excitement; hence a febrile state, with increased heat of skin, is much more easily produced than in advanced life, and if excited by inflammation, is of greater intensity and duration, than that which the same extent of inflammation, in advanced life, would occasion.

3. The vital action of the vascular system, although more easily excited and increased, has not (according to the general observation of physicians) so much strength or endurance, as in adults. It is more easily depressed, not only by cold, as already stated, but by evacuations, particularly of blood.

4. The organic functions going on in the capillary vessels take place with greater rapidity; as appears, not only from the growth of the body, but from digestion being more rapid, and more frequent reception of food being required; from the bowels being more open; and again, from the body wasting more rapidly under the influence of any disease which impairs digestion.

5. The peculiarities of the functions of the Nervous System during youth are analogous to those of the organs of circulation. The Nervous System appears more susceptible of change of all sorts, or to possess more *mobility*, than in more advanced life. All objects of sensation impress themselves more strongly on the attention, and thereby on the recollection, and knowledge of all sorts is more easily acquired. All the natural desires are more lively, and the flow of thought more rapid; but the power of continued voluntary attention, either to objects of sense, or to mental

abstractions, is less. Muscular motion is more grateful; continued inactivity is felt as a greater restraint; and variations of any combined voluntary movements are more easily performed, so that the physical education is easier; but the strength and endurance of the power of voluntary muscular contraction are inferior to what they afterwards become. Mental emotions are more easily excited, and their influence on the body is more obvious; but they are also more transient and capricious.

The body does not attain its full height till some years after the time of puberty; the growth in other directions continues, although slowly, for a time after the full height is attained; and it is not until the growth in all directions is completed, that the bodily strength is greatest.

The brain is probably the first part of the body which attains its full size, being, in general, as large about seven years of age, as subsequently. The growth at the extremities of the body appears manifestly to be accelerated by a sedentary life (when the health continues good), and to be somewhat retarded by habits of muscular exertion, which solicit the flow of blood into muscular parts. The growth is perhaps accelerated, and certainly invigorated, by frequent alternations of temperature within certain limits; but is permanently checked by habitual exposure to extreme cold, as in the Arctic Regions.

Growth, in all parts of the body, after birth, appears to take place, not as in the earlier periods of fœtal life, by deposition from the fluids to form new organs, but by the extension of parts previously organized. And the vessels of every organized texture possess the power (although in very various degrees), of throwing out, under certain circumstances of injury or disease, lymph which shall gradually assume the properties of that texture. But the deposition of bone, whether between membranes, as in the cranium, or in cartilages, as in the extremities, takes place in parts already formed; it is always preceded by increased vascularity; and the deposition of the new bone appears to be chiefly at the extremities of the bony fibres already formed. The cartilaginous rings which unite the epiphyses with the shafts of the long bones, and the sutures of the bones of the head, allow of growth of bones taking place in this way, without any extension of fibres already formed; and some experiments of Mr Hunter * have been thought to indicate that bones never do grow in this last way. But the changes which take place in the lower jaw, long after birth, are enough to show, that bony fibres may grow by extension of their parts, as well as by deposition at their extremities.

Most of the second set of teeth are formed within, as well as protruded from, the maxillary bones, at different periods after birth.

The changes which take place on the body in old age (but which begin at very different periods of life in different persons), cause peculiarities nearly the reverse of what were remarked in youth. The circulation in the capillary arteries becomes gradually more confined to the larger of those that communicate with veins, while many of the smaller are obliterated; and the power of generating heat is again diminished. The circulation is somewhat retarded, and gradually enfeebled, notwithstanding that the pulse often feels strong, by reason of the diminished elasticity and vital power of the arteries. The same amount of inflammation, or of other diseased states of the body, excites less febrile reaction than formerly; and any diseased action established in the vascular system shows less tendency to spontaneous abatement. The cells of the lungs are remarkably enlarged, so that the action of the blood and the air in the lungs must be diminished. Nutrition of all the textures takes place more slowly; the *decrementum corporis* is established; the textures become generally more

* See Transactions of a Society for the Improvement of Medical and Surgical Knowledge, vol. ii.

rigid; the proportion of fluids is diminished; the cornea is flattened; many of the cartilages, and sometimes certain of the membranes (independently of any decided disease), become bony. The senses become somewhat blunted; muscular exertion, especially any new combination of muscular actions, becomes irksome; as the vital power of the muscles diminishes, the desires become less keen; the disposition to fix the mind on any new object of thought is lessened; and the associations connected with these become few and feeble; so that the recollection of them is soon lost. Mental emotions are less easily excited, and their influence on the body is less obvious. But in different individual cases, there is very great variety in these respects.

The peculiarities of the female constitution, in the functions common to both sexes, are seen chiefly between the time of puberty and the cessation of the menses. According to the observations of Le Canu, the blood in women contains more water, and less of the solid matter of the crassamentum than in men; the proportions on an average of 10 cases being as follows, in 1000 parts :

	In Men.	In Women.
Water,	789.3	804.3
Solids of Crassamentum,	132.5	115.9
Solids of Serum,	78.2	79.8

The branches of the descending aorta, supplying the abdomen and pelvis, are not only larger in women, but are more habitually liable to variation in the quantity of their contents; and hence probably it happens that inflammations, and other diseases of the parts supplied by these vessels, are more easily induced. The nourishment of the organs concerned in locomotion is less active, and that of the cellular and adipose textures generally more active than in man. But the chief difference is in the functions of the nervous system. The sensations in women are probably more acute, or their minute differences more easily discerned; the mind is more easily impressed by any new object of thought; the disposition to active and sustained exertion, whether mental or bodily, is less, and the mental emotions are stronger, and arrest the attention more forcibly, than in man; so that women are more habitually under their influence. They are less guided in their conduct, by simply intellectual acts, directed to the attainment of definite objects, and are more apt to be biassed in their judgments, by preconceived feelings; but these feelings are very generally disinterested, and true to the purposes for which they are destined by nature. The great influence, on all the functions of women, of sensations and emotions, and of changes in the nervous system, which affect the other organs nearly in like manner as these mental feelings do, is very important in reference to many of their diseases.

The influence of habits and external circumstances on the human constitution is obviously great, but not easily referable to distinct principles. It is illustrated by the difference between the vigorous circulation, muscular strength, strong mental determination, but deficient sensibility, or versatility of mind, which often characterize men habituated to the labours of the country; and the feebler circulation, inferior muscular power, and less tenacity of purpose, but greater acuteness of sensibility, and greater activity of mind, generally observed in the inhabitants of great towns; and such differences modify very materially both the kinds of disease to which these persons are liable, and the action of remedies upon them. A difference in some respects similar is seen on comparing the usual temperaments of the inhabitants of the North and South of Europe.

An enumeration of the peculiarities of the different races of mankind would require a long discussion; and ample information may be found in the works of Lawrence, Prichard, Mayo, Desmoulins, Edwards, &c. In Europe, it would appear that two races, in some respects considerably different, have existed almost from the earliest periods of history,—the one characterized by black hair and eyes, and a dark complexion; and the other by light coloured or red hair, generally blue eyes, and a fair or florid complexion. Individuals of the first race belong generally to the nations originally Celtic; they constitute the bulk of the population of France, Italy, and Spain, and have been divided by medical authors into those of the choleric and those of the melancholic temperaments. Those of the second race are generally of Gothic origin; they predominate greatly in Germany, Denmark, and Sweden, and have been divided into those of the sanguine and those of the phlegmatic temperament *. In the British Islands, and in Switzerland, there appears to be a greater mixture of these races than in most other countries.

The differences between the great divisions of black and white men, and some of the subordinate divisions of nations, in different quarters of the globe, are much more striking. The secretion on the cutis vera, which gives the black colour to the skin, appears to assist in fitting men for residence in hot climates; because although such skin, by absorbing more caloric, rises to a higher temperature under the sun's rays, than white skin does, yet it does not inflame so readily from a rise of temperature †; and as the radiation of caloric from it, when its temperature is higher than that of surrounding objects, is greater than that from white skin, those who have it must enjoy greater alternations of heat and cold.

But it appears evidently from what has been observed of the comparative liability of whites and blacks to different diseases, (especially of remittent fever, inflammations of different parts, and the Indian cholera), and of the difference of the course of these diseases in them, that the vari-

* See GREGORY's Conspectus, cap. xxiii.

† Sir E. HOME, in Phil. Trans. 1821.

ous races of blacks and whites differ from one another in circumstances not to be explained by the colour or texture of their skin, and which have not yet been satisfactorily investigated.

The study of such varieties, consistent with health, in the human species, forms the proper connecting link between the subjects of Physiology and Pathology. These subjects have been generally treated together; but it is impossible to give a satisfactory account of the changes that take place in any disease, or even in consequence of an injury, without reference to the Physiology of different parts of the system; and therefore all such discussions are better postponed, until the healthy condition of all the functions has been examined.

OUTLINES OF PATHOLOGY.

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CHAPTER I.

PRELIMINARY OBSERVATIONS.

As the object of Physiology is to deliver the history and explanation of all the phenomena by which the living body is distinguished from the dead, so the object of Pathology is to describe and explain all the phenomena by which the diseased states of the living body differ from the healthy; and we call all states of the living body diseased, in which there are such deviations from its natural condition, as cause suffering or inconvenience, or endanger life.

A slight attention to this subject is sufficient to show, that there are many facts in regard to the operation of external causes on the human body, and the modes of diseased action assumed by its different organs, which could not possibly have been inferred from our knowledge of the structure and healthy action of parts; which are made known to us only by observation of the diseased conditions of the body themselves; and can only be properly generalized by an induction strictly confined to this department of knowledge.

The first step in this induction is the classification of individual cases of disease into Genera and Orders, according to the resemblances which their symptoms, observed during life, bear to each other. Those cases which appear the most closely analogous are carefully observed, and their usual history and terminations ascertained; a selection is made from these histories, of the symptoms which appear the most characteristic, and are observed the most uniformly, to form the definitions, (*i. e.* abridged descriptions) of genera of disease; and from a number of such definitions, a farther selection is made of certain sets of symptoms, which are stated as characterizing a class or order of genera.

This process, of the description and nosological arrangement of diseases, was necessarily begun, and carried to a high degree of perfection, for practical purposes, before any considerable progress was made in the investigation of the intimate nature of the changes which take place in the living body, whether in health or disease.

When the characteristic symptoms and usual history of a disease are accurately fixed, the principles of Physiology, enabling us to understand what functions of the body are disordered, in what manner they are altered, and how their alteration affects other functions, suffice for the explanation of many of the phenomena of that disease. The nosological characters, and observed symptoms of diseases, enable us, therefore, to go so far in their Pathology. And there are some diseases, which do not necessarily cause any change in the structure of the body, and the explanation of which can hardly be sought in any other way than this.

But that the explanation of the phenomena of disease thus obtained is necessarily very limited and imperfect, appears from the following considerations.

1. The variety of individual cases of disease being in fact infinite, and the rules by which they are classed into orders and genera being for the most part arbitrary and artificial, it very often happens, that a case which, in some of its symptoms, resembles one set of other cases, (and is therefore necessarily classed along with them under the same title), in others of its symptoms bears an equally important resemblance to others, in different parts of the Nosology.

There are, therefore, many combinations and successions of symptoms, which it is important to study (both for theoretical and practical purposes) besides those on which the arrangements of classes and genera are founded;—such are those which we express by the terms, Tendency to Syncope, to Coma, or to Asphyxia,—typhoid tendency,—inflammatory tendency,—nervous irritability,—gastric derangement,—putrescent diathesis, &c. which are often observed in the course of many different diseases. When we attempt the explanation of deviations from the healthy state of the body, these morbid states, often common to many cases which are otherwise very dissimilar, claim attention equally as the histories of diseases distinguished by the nosologist, and it becomes obvious, that the science of Pathology cannot be limited by these arbitrary distinctions.

2. When the changes in the structure of the body that take place in the course of diseases, are examined during life, and more especially after death, it appears that different combinations of symptoms are often apparently excited by the same fundamental diseased action, and consequently found in connexion with the same alteration of organic structure; and again, that very different alterations of structure may be attended, in different individuals, by symptoms the greater number of which are very nearly the same.

These last facts have led many inquirers into this department of Nature, to look on organic changes of structure, apparent in the dead body after disease (and which are subject to less variety, and more easily described and arranged than the symptoms of diseases) as the only sure basis of all pathological discussions; and the accurate description and arrangement of these has been regarded too exclusively by some as the main object of Pathology, which is thus rendered nearly a synonymous term with Morbid Anatomy.

But the following considerations seem sufficient to shew, on the other hand, that the study of organic lesions, although an essential, can form but a small part of a rational and useful system of Pathology.

1. There are very numerous cases, arranged into different genera of disease, some of them important, and even

rapidly fatal, *e.g.* different forms of fever, certain cases of apoplexy, and of syncope, tetanus, &c. which do not uniformly or necessarily leave behind them, so far as is yet known, any alteration of textures, or other change, perceptible to the anatomist; the Pathology of which diseases, therefore, although it may derive assistance from, cannot possibly be founded on, the knowledge of morbid appearances.

2. In many cases of disease, where decided alterations of structure are found after death, these cannot be connected with the fatal event, and do not furnish a rational explanation of it, without reference to general facts or principles, known to us simply by the previous observation of disease, and by generalization of facts which that study presents. It is only by such observation that we learn, that a certain amount of inflammation on the peritoneum furnishes an adequate explanation of fatal depression of the heart's action; or even, that a certain extent of ulceration of the lungs is sufficient to explain a wasting hectic fever*. In such cases it is obvious, that the laws, according to which such lesions become injurious or fatal, as they cannot be deduced from the study of the lesions themselves, demand a separate investigation.

* Jouent-elles un role important dans l'economie animale, les membranes sereuses qui tapissent quelques visceres ? Leur lesion traumatique est-elle immediatement mortelle, comme l'est par example celle de quelques parties de l'encephale ? Certainement non ; et pourtant voyez les suites qu'entraine leur inflammation. Serait ce l'injection de leurs capillaires qui aurait donné la mort ? Serait ce la couche de lymphe coagulable qui tapisse la surface lisse de ces membranes ? Qui le croira ? Il y a donc encore autre chose dans ces cas que ce qui tombe sous les yeux. Il y a, independamment des elemens materiels, un agent vital à signaler et etudier. Et neanmoins que trouve t'on dans les ouvrages d'anatomie pathologiques d'ailleurs si justement estimés ? Les recherches les plus precieuses sur l'etat des tissus, l'examen le plus scrupuleux de leurs proprietés physiques et chimiques, le rapprochement le plus exact des phenomenes de la maladie avec les alterations organiques ; mais peu de considerations physiologiques sur la pathogenie de ces derniers. Or, il est tres essentiel de s'occuper de ces considerations, à fin de donner à tons ces travaux le complement qui leur manque.—LOBSTEIN, Traité d'Anatomie Pathologique, liv. i. §. 299.

3. Even in those cases where the morbid structures that are ascertained to exist before death or found after death, easily and satisfactorily explain the symptoms in the latter stages of the disease and the death of the patient, it is obvious that these alterations of structure must themselves have resulted from *previous diseased actions*, *i. e.* that every disease must necessarily have been one of *function*, before it could become one of *structure*. The main object of inquiry is into the essential conditions and intimate nature of these diseased actions; and although all the information we can acquire in regard to them is necessarily limited, and liable to various sources of fallacy, yet the study of the diseased structures, which are their effect and indication, has little value, either with a view to Pathology or to Practice, except in so far as it tends to give some insight into the nature of the diseased actions themselves.

These considerations are sufficient to shew that Pathology, or the study of diseases, cannot be made to assume the form of a science, without careful investigation, and reference to general laws, 1. Of those morbid actions which produce no lesions of structure; 2. Of those which precede, and cause such lesions; and, 3. Of those which are produced by, and succeed such lesions, or attend their formation.

It thus appears, that neither the study of Physiology, the study of symptoms as they appear during life, nor the study of organic lesions discoverable after death, is sufficient in itself to enable us to deliver the history and explanation of the phenomena of disease; but that information from all these sources must be collected and combined for this purpose.

There is, farther, a very important subject of inquiry, which forms part of Pathology, but requires a separate induction of facts, and a different kind of evidence, viz. that which relates to the remote Causes of Diseases, or the external conditions necessary to their production; and which are ascertained chiefly by comparative observations, on large numbers of individuals, becoming affected with particular diseases under certain circumstances or conditions, and escaping them under others.

When all the information obtained by these different inquiries is collected and generalized, it naturally leads to the determination of certain ultimate facts, or laws in this department of Nature; according to which, under the influence of certain external causes, the different textures and organs of the living body undergo particular alterations of their vital action, and thereby derange the other vital actions of the system. The fewer, and the more comprehensive, these ultimate facts, the more successful must the induction be regarded.

Some of these laws have been already so far ascertained as to enable us to treat the subject in some measure *synthetically*.

The simplest exemplification of these ultimate facts in Pathology is to be found in cases of sudden death, and in the action of violent injuries; and we therefore premise a short account of different fatal injuries, to discussions on the Pathology of any diseases.

CHAPTER II.

OF THE ACTION OF CAUSES OF SUDDEN DEATH.

THESE have been already in some degree under consideration, as illustrating the importance, and dependence on one another, of the different functions; but the effects produced by the most powerful external agents on the functions which they especially affect, could not have been inferred from our knowledge of the natural actions of the body, and must be regarded as ultimate facts,—to which reference may be afterwards made in attempting the explanation of the more complex phenomena of disease.

The action of all causes of violent or sudden death may be referred ultimately to two modes of injury, which are in some cases perfectly distinct, although in others they are evidently blended. We cannot, indeed, arrange the causes of violent death strictly according to these differences in the mode of their action, because the same causes appear to act, under different circumstances, sometimes chiefly in the one way, and at other times in the other; but we can point out that their fatal effects are always produced, either by their *directly depressing or suspending the vital action of the organs of circulation*,—or else, by their *obstructing the arterialization of the blood*, and therefore, according to principles formerly stated, *arresting the circulation at the lungs*.

We know farther, that the first effect, or what may be called in general *death by syncope*, or beginning at the Heart, may be produced in two ways: 1. By a cause acting on the system after the manner of a Concussion or shock, depressing the vital powers by which the blood is moved; 2. By abstraction, sudden or gradual, of the vital stimulus;—and that the second effect may be produced also in two ways, 1. By injury of the Nervous System, arresting respiration through the intervention of insensibility, *i. e.* producing *death by Coma*, or beginning at the Brain; and, 2. By direct impediment to the access of air to the lungs, producing what is strictly called *death by Asphyxia*, or beginning at the Lungs.

To these principles we can ascribe the known effects of the following kinds of injury; and having illustrated these, we may afterwards refer to them with advantage, as the facts most analogous to the changes that constitute disease, and especially to those circumstances of disease which are immediately dangerous to life.

I. It is to be expected, from what we know of the functions of the Nervous System, that Injuries affecting it should impair, more or less completely, the sensations, the mental powers, and the voluntary motions; but they become dangerous to life only in the ways already specified, inasmuch as they affect the fundamental function of Circulation, either directly, or through the intervention of the Respiration.

1. The most violent injuries, affecting the Nervous System, suddenly arrest, or greatly impair, the motion of the blood in all parts of the body, *i. e.* they produce a state of Syncope or faintness; the heart's action either suddenly ceasing, or becoming very feeble; the pulse small, or imperceptible, and the surface cold; at the same time that sensation and voluntary motion are suspended immediately after them. This direct effect on the circulation of violent injuries of the brain was overlooked by Bichat, but is well illustrated by Dr Wilson Philip; and has long been known to practical men, as constituting the most characteristic part of the first symptoms of general concussion of the brain, as distinguished from more partial compression of it.

The experiments of Legallois and Dr Wilson Philip farther shew, that this effect on the heart's actions, and on the motion of the blood in the capillaries, may result from injury of any part of the brain or spinal cord, if it extend to large portions of the nervous matter; and many examples inform us, that when concussion is general over the whole system, it is frequently fatal, in this way, without any visible disorganization being produced.

After death from affection of the nervous system, thus directly influencing circulation, the heart is sometimes found, especially in the most sudden cases, quite empty of blood (the cause of which appearance is doubtful), in other cases distended; but with no decided difference as to the quantity of blood in its right and left sides.

In cases of this kind it is not quite certain, that the fatal depression of the vis vitæ in the circulating system is the effect of an impression made on the nervous system; and some have supposed, that such injuries are fatal by a direct effect on the smaller arteries, checking the circulation in them so completely, as to throw a burden on the heart which it is unable to overcome. But the effects of violent injuries confined to the brain or spinal cord, as in the experiments of Wilson Philip and Legallois, are just similar to those of a general concussion; mental causes, of powerful operation, which certainly act through the nervous system, have just the same effect; partial although violent injury of other textures has no such effect; nor does such an effect result from suddenly stopping the flow of blood in several large arteries by ligatures, or by amputation of a large limb; and therefore it is highly probable, that general concussion of the body does act, as is generally thought, on the vascular system through the intervention of the nervous; and this is one of the facts included under the general statement formerly made, that the nervous system, although not necessarily concerned in the functions of organic life, is yet so connected with them, that by certain changes in it, any of these functions may be variously altered, or even totally suspended.

There is great variety as to the amount of injury which will produce, in different individuals of the human species, the sedative effect on the circulation now in question; and as to the duration and termination of that sedative effect, which sometimes abates quickly, and sometimes gradually increases till it is fatal, some hours after the injury.

There appears to be a variety also, in the part of the circulation chiefly affected by such injuries. In some instances the circulation on the surface appears to fail, and the heat of the surface is reduced much more than in others, where the heart's action is equally depressed. In experiments by Chossat, the heart's action was for some time little affected by certain injuries of the brain, which checked the circulation in the capillaries so completely, as to suspend the secretions and the evolution of heat. When the spinal cord has been severely injured in the human body, below the neck, the circulation in the capillaries has generally appeared, for some time, more affected than the heart's action, although it is by gradual failure of the circulation that such cases are ultimately fatal.

There is also great variety in the alterations of the functions of the Nervous System itself, which result from such injuries, and accompany or succeed the sedative effect on the circulation. In some cases the coma is long continued and profound, in others transient; in some cases it is attended by much convulsion, in others by little or none; in some cases it is succeeded by much headach, or by general or partial amentia or delirium, or by incessant nausea and vomiting; and in others by none of these. And it is certain that all these varieties in the symptoms, in such cases, may be independent of any perceptible alteration of the structure of the nervous system *.

It is an important fact, that when injuries that have affected the Nervous System, and through it the circulation, in the manner now stated, are not quickly fatal, but are followed by the slower processes, to be afterwards described, of inflammation and fever, the progress of these is frequently observed to be modified by the preceding or accompanying state of the system, likewise consequent on the injuries; and that in these circumstances fever is apt to assume the form to be afterwards described as *typhoid*, and inflammation to terminate rapidly in gangrene †.

2. A slighter, and especially a more partial injury of the Brain, or upper part of the Spinal Cord, if its action be of sufficient intensity and duration, is adequate to produce death in a totally different way, viz. by Coma or stupor,—"superstite actione cordis et arteriarum." The essential peculiarity of this kind of fatal effect of an injury of the Nervous System is, that Respiration takes place imperfectly, and ultimately is suspended, by reason of the defect of sensation; and in the cases which are characteristic examples of this mode of death, the circulation, and sometimes the animal heat, not only continue entire up to the moment when the last breath is drawn, but even survive the respiration for a short time; during which time, of course, venous blood moves along the arteries; but the venous blood soon ceases to make its way through the capillaries of the lungs, and the circulation is therefore brought to a stand. (See Outlines of Physiology, p. 152.)

* See Brodie, Medico-Chirurgical Transactions, vol. xiv.

† See particularly Travers on Constitutional Irritation.

The experiments of many physiologists shew, that it is in this way only that death is produced when the spinal cord is cut in the upper part of the neck, or the head cut off, without violent hæmorrhage, and without any large portion of the brain or spinal cord being crushed.

The most common injuries of the nervous system which cause death, thus preceded by Coma, are those in which there is partial compression of the nervous matter, as by depressed bone, or effused blood, pus, or serum; but it is in the same way that death is often produced by disorganizations of the brain, which do not necessarily imply compression of its substance; and also by certain poisons, the effect of which on its functions does not appear to depend on alteration of the pressure on it; and it is therefore incorrect to speak generally of such symptoms as indications of pressure on the brain.

We know from Physiology, that the part of the Nervous System which must be especially affected in these cases, where the failure of respiration is the immediate cause of death, must be at the sides of the medulla oblongata; but the part visibly injured is often considerably distant from this.

There is very great variety as to the duration and degree of the insensibility, which precedes the failure of respiration in such cases of injury of the Nervous System; and as to the other affections, either of the brain and nerves, or of other organs, which may attend that insensibility, such as headach, delirium, somnolency, spasms, palsy, dilated or contracted pupil, preternaturally slow, or frequent, or irregular pulse, &c. Even the function of respiration itself is variously affected in different cases of the kind, being sometimes hurried and imperfect, and in other cases unnaturally slow and deep, for some time before it is finally suppressed. After the death thus produced by injuries of the Nervous System, just as after death by asphyxia, the blood is found accumulated chiefly in the lungs, pulmonary artery, right side of the heart, and great veins.

These two modes in which injuries of the Nervous System may cause death, though perfectly distinct in some cases, are evidently combined in others; the same cause both instantly weakening the heart's action, and likewise deadening the sensibility, so as gradually to suppress the action of respiration. And there are many cases of injury of the head, where insensibility and faintness from the concussion immediately succeed the accident, but quickly abate, and are succeeded after an interval by insensibility with full pulse, and death in the way of coma; which may then be confidently ascribed to compression of the brain by effused blood or serum.

There are various causes, physical and mental, which affect the Nervous System, nearly in the manner of a Concussion, and are apt to produce a similar depressing, and sometimes dangerous, effect on the circulation, and the operation of which is illustrated by the facts now stated, as to the effects of mechanical injuries. One of these is, a sudden diminution of the pressure, to which the brain and spinal cord had been previously subjected. Thus, when a depressed piece of bone, or a coagulum of blood, or a quantity of serum, which had long rested on a portion of the brain, has been removed, insensibility, and along with it sudden feebleness of circulation, have often ensued. When a large bloodvessel has given way in the head, and poured blood into the ventricles (implying, in the first instance, a sudden diminution of the pressure on a part of the nervous matter), a similar result has often been observed; and been followed in both cases by a partial recovery of sense, and of pulse, and then by gradual accession of fatal coma, as the effused blood has increased in quantity and compressed the brain around it *. The sudden attack of insensibility, and sudden depression of the heart's action, which may often be determined by the erect posture during bloodletting, or by rapidly removing the fluid of ascites without substituting artificial compression, must likewise be ascribed to sudden diminution of the pressure on the brain, acting after the manner of a concussion; and are illustrated by the

* See ABERCROMBIE on Diseases of Brain and Spinal Cord, p. 228. *et seq.*

attacks of syncope, with suspension, or great diminution, of the motion of the heart, which are often produced by rising suddenly after long stooping.

Another cause, which many persons have thought adequate to produce such an effect on the Nervous System as shall act as a concussion, is the impression made by a cannon ball, or other large substance passing with immense velocity close to the head.

A cause certainly adequate to produce fatal depression of the heart's action, and which no doubt acts through the Nervous System in like manner as a concussion of the brain, is a violent blow on the abdomen, especially on the epigastrium, which has been supposed to act immediately on the great semilunar ganglion. A draught of cold water taken when the body is heated and exhausted by fatigue, has in some cases been instantaneously fatal in the same manner; and the concussion from a violent and extensive wound of any part of the abdomen is usually fatal in the same rapid way, independently of hæmorrhage, and before there is time for inflammation to be established. These facts are important, as illustrating the more gradual, but very dangerous depression of the power of the heart, which is seen even in the earlier stages of inflammation of the abdominal viscera.

Violent injuries of various other parts of the body, especially if inflicted on a person of weakly habit, and in whom the nervous system is in a state of unnatural excitability, (as from the habitual use of opium or spirits) may equally act on the footing of a concussion, either causing sudden death, or so depressing the actions of the vascular system, as to give the typhoid form to the fever, and the gangrenous tendency to the inflammation, which are to result. This has been observed from severe surgical operations, and from extensive lacerated wounds, and bad compound fractures of various parts, even although there had been no general concussion of the body, nor insensibility immediately after the injury *.

* See TRAVERS on Constitutional Irritation.

In the cases last mentioned, it can hardly be doubted that the violence, or peculiar nature of the Sensation, which attends the injury, is the intervening link through which the vital action of the heart is sympathetically affected; and accordingly, we have many facts to prove, that various violent and overpowering Sensations, or those corresponding Emotions of mind, as Joy, Grief, Anger, Fear, when acting in the utmost intensity, affect the circulating system just as a concussion does, and sometimes with fatal effect,—especially when they take place in persons in a state of unusual weakness or exhaustion.

II. The effect of very intense Heat, applied to a pretty large surface of the body, as in an extensive burn, or to the whole body, as in the case of a *coup de soleil*, is also quite similar to that of concussion; there is often insensibility, and always, when the case threatens the most immediate danger, there is the characteristic depression of the heart's action; and when recoveries take place from the state of collapse (as it has been called) immediately succeeding such injury in its extreme degree, it is often under the use of stimulating remedies *.

But intense heat of the sun, in other circumstances, especially, as it would seem, if acting on a stronger habit of body, and when there is less exhaustion by muscular exercise, has often produced a state of insensibility, in which the pulse has been fuller than natural, and the vessels of the head unnaturally turgid, and which has either been fatal in the way of coma, as above explained, or been relieved by copious evacuations, and cold applications; and the same cause has often produced other diseased conditions connected with a derangement of the action of vessels of the head †. In this case, the most injurious effect of the heat is evidently on the vascular system, exciting the action of the heart, and probably expanding the blood in the vessels; and the brain suffers probably from increased

* See TRAVERS, l. c.

† See MITCHELL in Edinburgh Medical and Surgical Journal, 1828.

compression by the blood; whereas in the former case, the first and chief effect of the heat appears to be on the nervous system, and the heart suffers from the violent impression made there.

III. It appears from experiments on animals, by Fontana, Hunter, and Brodie, and also from cases observed in the human body *, that the effect of Lightning or Electricity, when acting with the utmost intensity, is likewise similar to concussion, depressing or even extinguishing the vital action in the vascular system, at the same time that it causes insensibility; but that when acting in a less intense degree, it produces insensibility without any such immediate sedative effect on the circulation,—that this appears often to be connected with turgescence of the vessels of the head, and probably expansion of their contents; —and that it may terminate in death by coma, or be followed by partial and more permanent injury of some of the functions of the brain and nerves.

IV. The effects of Cold on the body are remarkably various, according to circumstances formerly briefly noticed. They depend, not so much on the degree of cold that is applied to the body, nor even on the degree to which the body is actually cooled,—as on the rapidity of the change, and probably on the intensity of the sensation thus excited. Thus it was found by Chossat, that the temperature to which the bodies of animals killed by cold had been reduced before they died, was considerably various, and always higher, as the reduction of temperature had been more rapid, and therefore more injurious. And the degree of effect of any cold applied to the living body has always been observed to be greater, as the sensation it excites is the more intense and the more lasting; and therefore to be increased by all circumstances, either of the body which undergoes the ex-

* See, *e.g.* Parkinson in Memoirs of Medical Society in London, vol. ii; and Macaulay in Edinburgh Medico-Chirurgical Transactions, vol. ii.

posure, or of the degree and mode of the application of the cold, by which the intensity and duration of the sensation are increased.

When cold is applied in such circumstances as to take full effect on the body, it has been commonly stated that it becomes dangerous by inducing stupor, and ultimately death in the way of coma. This effect of cold has often been observed, and has sometimes been preceded by delirium, has sometimes been attended by hæmorrhage from the nostrils or ears, and has been found, on dissection, connected with considerable serous effusion in the head. It is therefore probably in a great measure dependent on the greatly diminished flow of blood to the surface and extremities, and proportionally increased flow to the brain. Persons recovering, by assiduous application of heat, from this state of stupor, produced by cold, have continued comatose for hours after the circulation in their extremities has been well restored *.

But in those who become comatose from cold, the heart's action is at the same time enfeebled; and it appears distinctly, from experiments on animals, and observations on the human body, that the most intense cold may be fatal in the same way as a concussion, by a direct depressing effect on the circulation; in which case, of course, respiration continues up to the moment when the heart's action ceases, —the heart is found motionless, and with arterial blood in its left cavities immediately after death,—and the artificial respiration is quite ineffectual in prolonging life †.

In all cases, cold acts as a sedative power on the capillary circulation on the surface ‡, and Dr EDWARDS found that its repeated or long continued application has a peculiar effect in depressing the power of subsequently generating heat. In some instances of frost-bite this effect is so

* See, *e. g.* KELLIE in Edinburgh Medical Journal, vol. i. p. 304.

† See CHOSSAT, Mem. sur l'influence du Systeme nerveux sur la Chaleur Animale, p. 8.

‡ BEAUPRE', on the Effects of Cold,—translated by CLENDINNING, p. 131.

powerful on the parts to which it is chiefly applied, as to put a final stop to all vital action in them, even when the system at large does not materially suffer; and in many cases, the sedative effect on the vital actions of frost-bitten parts is such, that the inflammation, (which is always excited in a greater or less degree by the return of heat to such limbs) shews evident marks of deficient reaction, and tends rapidly to gangrene.

But such effects of intense cold on the vital actions of *individual parts*, must be carefully distinguished from the case of cold acting as a powerful sedative on the *whole system;* because in the first of these cases, when the general circulation is strong, the chief danger is from the inflammation, which is the direct consequence of the restoration of the circulation and natural heat of the part; and this is chiefly to be moderated by causing that restoration to take place very gradually, therefore chiefly by cold applications tending to retard it; whereas when the vital power of the whole system has been depressed, there is no such risk of local injury from the restoration of temperature, and external heat and other stimuli may be much more freely applied.

V. In regard to the action of Poisons on the animal economy, there are several questions of much importance, to which it is the more necessary to advert, as these phenomena are more analogous to the changes which take place in some of the most malignant diseases, than any others to which we can refer for illustration of these diseases.

1. It has been long a subject of inquiry, whether it is essential to the action of poisons, that they should be absorbed into the circulation, and carried with the blood over different parts of the system, or whether their action may be on the nerves of the parts to which they are directly applied, and the affection of the organs more necessary to life be produced sympathetically.

That the peculiar agency, and even the fatal effect of some poisons, may be produced in this last way, appears distinctly,—

a. From the very great rapidity of the action, *e. g.* of the oil of bitter almonds, and still more, of the hydrocyanic acid, the application of which to the tongue of an animal, has been followed by death within eight, five, or even three seconds, certainly before it can have reached in the way of absorption and transmission along the vessels, the heart, on which organ its fatal effect is mainly exerted.

b. From the suddenly fatal effect of concentrated acids and alkalies taken into the stomach, which disorganize the mucous membrane there so completely that they cannot be absorbed from it; but when in that concentrated state produce death much more rapidly than they do, when so far diluted that their absorption is easy *.

c. From the effect of many poisons, such as Opium, Belladonna, Aconite, Hydrocyanic Acid, having often been observed to take place, chiefly in parts in the neighbourhood of that to which they are applied, and not merely in the course of the blood passing thence to the heart.

d. Perhaps also, from the effect of a poison lodged in the stomach, having often been observed very rapidly to abate, as soon as it was discharged by vomiting.

But there is abundant evidence, that in a great majority of cases of poisoning, the effect produced is subsequent to the absorption of the poison into the blood, and to its transport, in the blood, from the point where it is applied, to other parts of the system.

The numerous experiments of Fontana, Monro, Brodie, Magendie, Fodera, Christison, Coindet, and Barry, leave no room for doubt, that poisons inserted into wounds, or laid in contact with internal membranes, are quickly absorbed into the blood; that the passage of the venous blood, from that point towards the heart, is in most cases the only condition essential to their action; and that

* Christison on Poisons, p. 6.

such a diminution of atmospheric pressure on the surface where they are placed, as shall prevent their absorption, will also prevent, or even suspend, their action.

But it is not so clear, to what distance from the point of its application a poison must be transported by the blood, in order to produce its full effect. The experiments of Dr Addison and Mr Morgan have shewn, that a poison introduced into a large vein will act, notwithstanding that its direct access to the heart is obstructed,—that a poison introduced into the femoral artery will act as rapidly as one introduced into the jugular vein, or carotid artery;—and again, that when the blood from the carotid artery of one dog is sent to the brain of another, a poison may be applied to a wound in the first dog, and take full effect on him, without affecting the second. But these results do not seem sufficient to authorise the conclusion which they have been thought to support,—that the sole direct action of poisons is on the nerves of the vessels, and their action on the brain or heart only sympathetic *. It still appears much more probable, that the greater part of the effect of poisons, which have been absorbed into the blood, is consequent on their direct application to the more important vital organs.

Some poisons taken into the blood have been detected there, and the action of some has been observed to be attended by a change of the sensible qualities of the blood; and especially by a diminution or loss of its coagulating property; but many act fully without altering its sensible qualities; when these are altered, it is doubtful how far the alteration is connected with the action of the poisons on the living solids; and the loss of coagulating power is so often seen in cases of sudden death, that of itself it gives no information as to the immediate cause of death. It is very important to keep these cautions in mind when

* The last experiment gives no information as to the mode in which poisons circulating in the blood affect the body. Experiments by Verniere (Journal des Progrès des Sciences Medicales, t. iii.) shew, that blood *strongly* impregnated with a poison, may be transfused from one animal to another, and produce its usual deleterious effects.

we apply the analogy of poisons to the elucidation of malignant diseases. They shew that although the blood be changed by the agency of the causes of these diseases, it does not necessarily follow that that change is concerned in producing the most essential symptoms, or the fatal event.

2. Another question which has been started on this subject is, whether the action of a poison, that has been absorbed into the blood, on the circulation itself, is to be ascribed to its direct contact with the heart and vessels, or in a great measure to an influence transmitted to them from the nervous system, which it must necessarily also pervade. On this point all that can be stated is, that we have clear evidence of the noxious effect of many poisons on moving solids to which they are directly applied, (*e. g.* on those of the fibres of the heart or intestines with which they are laid in contact), or even on vegetables; but nevertheless, as we have seen that the action of all parts of the circulating system in animals is subjected to an influence or control, from changes taking place in their nervous system, it is quite possible, that the agency of poisons, circulating in the blood, on muscular organs, and especially on the circulation, may be in part consequent on the impression which they make on the brain and nerves. And the *order of the symptoms* in the case of some such poisons, as the oxalic acid, would seem to denote that the primary effect is on the brain and spinal cord, and that the heart suffers secondarily.

3. The action of the different mortal poisons clearly exemplifies two of the modes in which it has been stated, that sudden death may be produced, *i. e.* the death by Coma, and the death by Syncope. Although some poisons appear to act peculiarly on the lungs, none produce sudden death strictly in the way of Asphyxia.

a. Those which are called the Narcotic poisons, affect especially the nervous system; and when acting in full force, produce the state of Coma, and death strictly in the way of coma, already described, the circulation continuing, sometimes even tolerably strong, after the last breath is drawn, and then coming to a stand, because the respiratory movements are suspended, and the blood continuing venous, stagnates in the vessels of the lungs.

This ultimate effect of these poisons is preceded in different cases, just as the ultimate fatal effect of injuries of the brain is, by various affections of the nervous system, Delirium, Convulsions, Vertigo, loss of different of the external senses, &c.; or it may take place gradually, without any of them. After it, the blood is found accumulated in the great veins, and on the right side of the heart, and the left is nearly empty.

That this is the immediate cause of death in such cases, appears most clearly from the experiments of Mr Brodie *, to which reference was formerly made; in which the circulation was maintained by artificial respiration, after the natural respiration had been suspended by the action of such poisons, until the impression which they had made on the nervous system had subsided, and the sensibility, and therefore the natural respiration, were restored; and the animals recovered from apparent, and what would otherwise have been real, death.

It is thus that, according to these experiments, alcohol, the essential oil of almonds, and tobacco, the juices of the aconite, and the woorara poison, produce death; and the same is evidently the full and perfect action of opium, hyoscyamus, camphor, conium, and other medical agents commonly called Narcotics.

But although the chief agency of these poisons is on the sensorium, *i. e.* on the brain, yet it is to be observed, that they all appear more or less to weaken, and often may irretrievably depress, the action of the heart likewise, and not merely by reason of their effect on respiration. And although there is one case, already quoted, on record, where

* Phil. Trans. 1812.

the fatal effect of opium on the human body was arrested by the artificial respiration, after the natural had failed; yet, in general, the pulse becomes so feeble, the skin so cold, and the vital actions in the capillary vessels are evidently so much impaired, under the influence of large doses of opium, before the respiration comes to a stand, that there is little ground for expecting that their fatal effect can often be arrested, even by this means, at so late a period.

b. There are other poisons, the fatal effect of which is evidently exerted on the heart only, and which cause death merely by Syncope,—preceded by feebleness and often irregularity of pulse, by coldness, tremors, and failure of muscular power, and often by rigors, nausea, and vomiting, or by convulsions, as happens in many other cases of syncope. The unequivocal indications of this kind of death are, that the respiration continues as long as the action of the heart; and that the heart is therefore found, immediately after death, motionless, unexcitable by stimuli, and filled with venous blood on the right side, and arterial on the left, as in a living animal. It was thus that in the experiments of Mr Brodie, death was produced by the upas antiar, and by the infusion of tobacco; and the fatal effect of full doses of hydrocyanic acid, digitalis, strychnia, oxalic acid, arsenic, preparations of antimony, and of baryta, various animal poisons, &c., appears to be of the same kind, although these poisons have a more complex operation, and affect a greater variety of organs.

c. There are some vegetable, and many mineral poisons, which excite Inflammation, chiefly in the mucous membrane of the primæ viæ, but in some instances in other parts; and the symptoms of these inflammations (although rarely the sole effect of the poisons) blend themselves with those which proceed from the direct agency of the poisons on the nervous or vascular system, and in some instances the inflammation excited causes death, in modes to be afterwards considered. It is thus that many metallic, and some saline and earthy substances, and the different vegetable and animal earths, are dangerous or fatal.

d. In some cases, the effects of poisons introduced into the system take place slowly, and last much longer, and are usually regarded simply as diseases, sometimes not to be distinguished from diseases which may be excited by other means, and implying a similar danger; as when arsenic produces epilepsy, lead colic and palsy, when the ergot of rye causes a peculiar kind of inflammation of the limbs, ending in dry gangrene, or different kinds of vegetables or fish, urticaria.

The Gases which act as poisons illustrate sufficiently these different modes of action; chlorine, or nitric or muriatic acid gases, producing bronchial inflammation; carbonic acid, or pure oxygen, acting as a narcotic; and air itself, if introduced into the blood in any quantity, suspending the circulation, by the very peculiar manner in which it affects, and quickly stops, the actions of the heart.

But although these different kinds of injurious or fatal action of poisons may be clearly distinguished, yet it is impossible to classify poisons strictly by their mode of action, because it is certain that the agency of almost all poisons is complex; and that according to varieties of the dose, or mode of preparation, the same poison, on different occasions, may cause death in different ways, oxalic acid, *e. g.* in full doses, acting directly on the heart, but in smaller doses chiefly on the nervous system; the essential oil of tobacco acting strictly as a narcotic, while the infusion of the leaves affects the system chiefly by its powerful sedative effect on the heart; and arsenic, when taken in large quantity, producing its fatal effect on the heart, before there is time for the inflammation to be established, which constitutes the chief danger to be apprehended from smaller doses of the same poison.

These statements are sufficient to illustrate the various intentions with which our scientific knowledge of the action of poisons demands that remedies should be applied to that action.

VI. In regard to the effects of dangerous or fatal *Hæmorrhage* in the living body, the following seem the most important facts.

1. When the hæmorrhage is very gradual, all the indications of failure of the circulation may come on,—the feebleness of muscular action,—the paleness and collapse of the countenance,—the coldness beginning at the extremities, —the cold sweat beginning on the face,—and the pulse may become imperceptible; without the senses, or the intellect, being impaired, and a slightly laborious or heaving respiration may be almost the only indication of injury of the nervous system up to the moment of death. Such perfect endurance of the functions of the nervous system, attending irretrievable depression of the powers of the circulation, is still more remarkably seen in some fatal diseases, where the heart's powers are depressed sympathetically in consequence of disease of other parts, than in cases of hæmorrhage where the vital stimulus is gradually withdrawn.

2. A more sudden and violent hæmorrhage affects the nervous system much more speedily, just as we have already seen, than any other means of suddenly diminishing the pressure, to which the brain had been subjected, does; —and the impression thus made in the brain *reacts on the heart after the manner of a concussion*, and causes its action to fail much sooner than it would have done, merely by reason of the loss of blood. It is only in this way that we can explain the fact, that in bleeding from a large orifice, and in the erect posture, not only sensation, and the other functions of the brain are sooner suspended, but *the heart's own actions fail*, with much less loss of blood than when the orifice is smaller, and the patient lies horizontally, so that the diminution of the pressure on the brain is less, and more gradual.

In this manner death may be produced, certainly in much less time, and probably with less loss of blood, than by a more gradual hæmorrhage; and in such a case, the greater affection of the nervous system is shewn, sometimes by transient delirium, often by nausea and vomiting, and very generally by insensibility, and by more or less of spasms or convulsion, often repeatedly occurring before death. These two distinct varieties of the violent death by syncope, are important to be remembered in speculations on the fatal tendency of several diseases.

3. The loss of blood, especially if frequently repeated, has, on many constitutions, especially in women and children, a subsequent effect, which could not have been anticipated *a priori*, of increasing the excitability of the vascular system (whether by reason of the impression made on the nervous system or not is doubtful), and so leading to a state of the system described as Reaction after the loss of blood, or as Prostration with Excitement; in which, especially if any cause of febrile excitement at the same time exist, there is a fallacious degree of strength and frequency of the heart's action, when the other vital actions are feebly performed, and farther evacuation is dangerous *.

The transfusion of healthy blood, of the same species of animal, into the bloodvessels, may be effectual in arresting the fatal effect of hæmorrhage, not only when the power of the heart is rapidly sinking, but even after the heart's actions have come to a stand from this cause, but probably only within a few seconds after that time †.

VII. It was already stated, that in the case of death by *Fasting*, more or less of inflammation of mucous membranes is excited, apparently by reason of the deficiency of the natural protecting mucus; and probably in connexion with this inflammation a febrile action is established, which renders the case more complex than it would have been, if all the symptoms had depended simply on the gradually diminishing quantity of blood. Nevertheless, gradually increasing debility of the circulation, and of all functions dependent thereon, and consequent extreme emaciation, characterize this mode of death. Ultimately even the function of absorp-

* See BURN's Principles of Midwifery, p 243. ARMSTRONG on Typhus, &c. p. 548. PARRY on the Arterial Pulse, Exp. 27. MARSHALL HALL on the Effects of Loss of Blood, p. 28. TRAVERS on Constitutional Irritation, p. 591.

† See BLUNDELL, Researches, &c.

tion is nearly suspended. The appearances after death formerly noticed *, observed in a body free from other marks of disease, are nearly characteristic of this cause of death.

The duration of life in such cases is very various, as might naturally be expected, when it is remembered, 1. That a degree of febrile action is excited, the intensity of which will necessarily be very different in different constitutions; and, 2. That different living bodies are habitually dependent in very different degrees on the alternate vital actions of nutrition and absorption: Accordingly, in general, fasting is best borne by those in whom these vital actions have been long languid; and in some such cases it has certainly been borne for a period many times as long as that which has been fatal in others.

VIII. After what was formerly stated, it is unnecessary to enlarge on the phenomena of death by asphyxia, or beginning at the lungs, whether by strangulation, suffocation, drowning, confinement in a gas that is not poisonous, but contains no oxygen, exposure of the surface of the lungs to the atmosphere, pressure on their surface, occlusion of their cells, or any other mode of obstructing the access of air to the blood of the pulmonary artery, while the other organs essential to life are uninjured. In all these cases there is a hurried and laborious action of the muscles of respiration, and more or less of lividity; then insensibility with spasms, believed to depend on the contact of venous blood, which has passed unchanged through the lungs, with the brain and nerves; the respiratory efforts become irregular and then cease; and on examination immediately after this, the heart is found still contractile, but its left side nearly empty, and the blood accumulated on its right side and in the lungs; implying, that although some blood is transmitted unchanged to the left side of the heart, and thence sent over the body, yet it makes its way slowly and imperfectly through the capillaries of the lungs, and at length stagnates there, when it is not arterialized.

* Physiology, p. 178.

This accumulation on the right side of the heart is especially observed, when death is produced most slowly in this way, because then there is time for much of the blood from the body at large to reach the heart, before the final stop to its passage through the lungs.

It is important to remember the occurrence of insensibility, and often of spasms, before the circulation comes to a stand, or is even very much weakened, as illustrating what happens in many diseases affecting the functions of the lungs.

It is important to remember also, that the circulation comes to a stand before the heart has lost its power, as this is the foundation for the practice by which resuscitation from apparent death of this kind has often been accomplished, even some minutes after pulsation has ceased. Of that practice, notwithstanding some difficulties that have been started on the subject, it may still be maintained that the artificial respiration is the most essential part.

It may easily be believed, from what has been stated, that after such resuscitation, distress, and even danger, may result from the congested state of the lungs, and therefore that bloodletting may be useful in such cases, even before the circulation and animal heat are effectually restored in the extremities.

The tendency to a fatal termination in different diseases, and in different stages or circumstances of the same, is very different, and often complex; but is always susceptible of illustration by reference to the simpler cases of violent death now considered. And it is of especial importance to keep in mind these different modes of fatal termination in those diseases (such as fever) which admit of the greatest variety, in which different dangers threaten on different occasions, and in which various kinds of treatment are recommended; because it is only by anticipating the kind of fatal termination which is most probable in each case, that we can expect to be guided to a rational and scientific selection of remedies.

CHAPTER III.

OF THE REMOTE CAUSES OF DISEASE IN GENERAL.

The living body assumes, in many cases, different kinds of diseased action,—varying remarkably in different periods of life,—without any apparent or known cause; but in the greater number of cases, certain circumstances in the situation or condition of patients, before diseases appear, can be assigned with confidence as their causes. The efficacy of these, however, is seldom established in any other way than simply by the observation, that persons known to be exposed to their influence, become afflicted with certain diseases in a proportion very much greater than those who are not known to be so exposed.

This kind of evidence is in many cases very liable to fallacy, in consequence of the great variety of the circumstances, capable of affecting health, in which individuals are placed, and of the difficulty of varying these, so as to obtain such observations, in the way of induction, or exclusion, as shall be decisive as to the efficacy of each. Hence the importance of the observations, intended to illustrate this matter, being as extensively multiplied as possible; and hence also the peculiar value, with a view to the investigation of the causes of diseases, of observations made on large and organized bodies of men, as in the experience of military and naval practitioners. All the circumstances of the whole number of men, whose diseases are there observed, are in many respects exactly alike; they are accurately known to the observer, and are indeed often to a certain degree at his disposal; they are often suddenly changed, and when changed as to one portion of the individuals under observation, they are often unchanged as to another; and therefore, the conditions necessary to obtaining an *experimentum crucis* as to the efficacy of an alleged cause of disease, are more frequently in the power of such an observer, than of one who is conversant only with civil life.

But when the necessary precautions, as to the multiplication of facts, and the exclusion of circumstances foreign to the desired result, are observed, the efficacy of the remote causes of disease may often be determined with absolute certainty; and the knowledge thus acquired, as leading directly to the prevention of disease, is often of the greatest importance, especially with a view to regulations of Medical Police. And if the human race be destined, in future ages, to possess greater wisdom and happiness in this state of existence than at present, the value of this knowledge may be expected to increase in the progress of time; because there are many diseases which the experience of all ages has shown to be nearly beyond the power of medicine, but the causes of which are known, and under certain circumstances may be avoided; and the conditions necessary for avoiding them are in a great measure in the power of communities, though beyond the power of many of the individuals composing these.

Under the head of Remote Causes of Disease, we include not only causes acting externally to the body, but also circumstances in the condition of the body itself, previous to the attack of disease in question, which are believed to assist in exciting it; and of the mode of operation of these last, we have often more satisfactory information than of external causes. Some general observations on this subject will put it in a clearer point of view, than more detached and incidental statements in delivering the history of diseases would do, and will save repetition in future.

The Remote causes of disease are commonly divided into Predisponent and Exciting, the former of which have been long in operation before the disease appears, the latter immediately precede its appearance; it is impossible to distinguish them accurately in all cases; but nevertheless, this distinction, and especially the very frequent concurrence of causes of both kinds in producing disease, must be carefully kept in mind.

In illustration of this, it may be stated, that the hereditary nature of certain diseases (*i. e.* the peculiar tendency to them given by hereditary descent) is well ascertained; but some occasional external cause very generally excites the disease, to which there is this predisposition; and those who attend only to the obvious operation of the exciting cause, are apt in this and other instances to overlook the evidence by which the efficacy of the predisponent is established.

Again, unless we attend to the very frequent concurrence of different causes in producing disease, we may readily misapprehend the evidence of the efficacy of a powerful exciting cause, as cold, contagion, or malaria, if we shall see it repeatedly applied to persons not predisposed to suffer from its effects, and taking effect only on those in whom its operation is aided by some latent predisposition, or some concurrent and accessary cause. Both these errors have very often occurred in medical inquiries as to the remote causes of disease.

I. The following may be stated as the chief predisponent causes of disease, that is, the circumstances to which we can in general refer the tendency observed in certain individuals, more than in others, to fall into disease on the application of the exciting causes, to be afterwards enumerated.

1. The transmission of the tendency to certain diseases from parents to children, has been already remarked as part of the general fact of the influence of the constitutional peculiarities of parents on their offspring *. But it is only to certain kinds of diseased action that this *predisposition from hereditary constitution* has been observed; these are, certain well-marked varieties of inflammation, termed the Scrofulous and the Gouty,—certain kinds of morbid formations, especially the scrofulous tubercles,—and certain forms

* Physiology, p. 307.

of diseases of the Nervous System, Asthma, Epilepsy, and Mania. Of these, the scrofulous affections only are in a few instances *congenital*, as well as hereditary; and the appearance of the others is frequently determined more by the application, and often the concurrence, of other causes, than by the circumstance of hereditary predisposition in those who possess it.

2. There are many causes very often observed to predispose to disease, which may be ranked together, as their obvious effect on the system is very much alike. They tend, whether acting singly or several in conjunction, to *enfeeble the vascular action in the body*, and perhaps especially that in the extreme capillaries; and at the same time, they *render the nervous system more susceptible* of impressions from without. They thus dispose the body to suffer, and especially the vascular action to become disordered, from the application of exciting causes, either of acute or chronic disease, which might be otherwise innoxious. But it does not appear that any of these predisposing causes of themselves determine either the kind or the seat of the diseased action which is to ensue:—they are often observed to precede, and believed to assist in producing, very different kinds of diseased action, which may be seated in different textures or organs, according to the original or acquired peculiarities of individual constitutions.

Of this kind are,

(*a.*) Imperfect nourishment.

(*b.*) Deficiency of the natural stimuli of pure air, and of muscular exercise.

(*c.*) Excessive exertion, mental or bodily, and deficiency of the natural relaxation of sleep.

(*d.*) Long-continued heat, with little of the refreshing and invigorating influence of occasional reduction of temperature.

(*e.*) Long-continued cold, not sufficiently counteracted by artificial warmth, and by muscular exertion.

(*f.*) Intemperance, *i. e.* the frequent use of strong liquors, in such quantity, that their first or exciting effect on vital action, is more than counterbalanced by their more permanent depressing effect.

(*g.*) Excessive and repeated evacuations, either of blood, or of the serous part of the blood.

(*h.*) Depressing passions of mind, especially those which are of the longest continuance.

(*i.*) Previous debilitating disease, whether acute or chronic.

Ample experience, not only of what occurs within the observation of individuals, but more especially that which is afforded by statistical returns of the amount of disease and mortality in great towns, and chiefly in the worst aired parts of towns, as compared with agricultural districts;—in seasons of scarcity as compared with seasons of plenty;—among the most indigent classes of society, as compared with those in comfortable circumstances;—among the poorest inhabitants of hot or very cold climates, in circumstances where persons who have been more habitually protected from the extremes of temperature retain their health;—among the intemperate as compared with the sober;—in beaten armies, or among depressed and disheartened individuals, as compared with victorious armies, or more fortunate and flourishing members of society,—establishes beyond all doubt the efficacy of these various debilitating causes in augmenting the amount and fatality of disease.

Some of the causes above enumerated peculiarly affect particular organs,—as heat the liver, and mucous membrane of the bowels, excessive mental exertion the brain, violent mental emotion the heart, &c.—and dispose them perhaps more than other parts to suffer from the application of exciting causes of disease. Others of the causes in question have a peculiar tendency to produce certain kinds of inflammation, as the air of low, damp, and crowded habitations, to determine the scrofulous form of inflammation.

But there is no one organ or texture which is uniformly affected, nor any one kind of diseased action which is uniformly excited, by any of these causes. Their general effect is, to dispose the body to suffer from the application of the exciting causes of inflammation, or of other acute diseases; and farther, especially when they are long applied, to dispose the body to those kinds of chronic disease which consist essentially in the deposition from the bloodvessels, in different parts of the system, of morbid matters, which bear more or less resemblance to the products of inflammation.

3. Again, there are certain diseases to which a tendency seems evidently to be given by a state of general Plethora, depending on full living and deficiency of regular exercise. This is perhaps more strictly true of Gout than of any other inflammatory disease, and of Apoplexy, than of any other disease unconnected with inflammation. There are others which, if not necessarily connected with general plethora, are evidently in a great measure dependent on partial plethora, *i. e.* increased flow of blood to, or retarded return from, individual parts of the body; either occurring before they first shew themselves, or manifestly facilitating their recurrence. Thus all secreting parts, at a time when their secretions are peculiarly abundant, are unusually apt to have disease excited in them. Indeed it is by producing a state of partial plethora that several causes already mentioned, and others to be mentioned immediately, as predisposing to diseases of individual organs, seem evidently to produce that effect.

A state of partial plethora, although it may be combined with a weak state of vascular action over the body, can seldom be effectually obviated without such evacuations and low diet as may reduce and keep down the whole quantity of blood in the system.

Those whose knowledge of diseases is chiefly taken from examinations after death, as they generally find sufficient lesions of individual organs to explain the symptoms and event, see little of the evidence which establishes the importance of general and local plethora as a cause of disease; but those who are accustomed to trace the whole progress of individual cases, and observe the effects of remedies and regimen on them, have ample grounds for the belief that plethora, general and partial, is one of the most frequent, and often the most remediable, of the causes to which attacks, and still more frequently recurrences, of various local diseases, whether inflammatory, hæmorrhagic, or more chronic, may be traced.

4. A frequent predisposing cause of local disease, which may be said to act by causing or facilitating partial plethora, is Previous Disease, and especially previous inflammation of the same organ, even although it may have been at some distance of time, and may have left no organic lesion. There is a similar tendency in diseases primarily seated in the nervous system, to facilitate their own recurrence. This is one of the circumstances by which the seat of the diseased action, that may be caused by any accidental excitement, is most frequently determined.

5. Organic disease already existing in the body, although in an inert state, and causing little uneasiness, very often acts as an important predisposing cause of other diseases, which might otherwise have been avoided; and that in three distinct ways.

First, The existence of organic disease, probably by reason of the quantity of blood directed upon it, and the consequent deficiency of the supply of blood to other parts of the body, appears frequently to dispose the whole system, in like manner as other debilitating causes, to suffer from the application of cold, contagion, or other causes of acute disease, more readily than it otherwise might have done. It is probably on the same principle that pregnancy and lactation render the body peculiarly liable to the acute diseases resulting from such causes. But it does not appear that this is true of all organic diseases; and especially those which are attended with a continual febrile or excited state of the circulation (*i. e.* Phthisis), appear rather to fortify the body against the attacks, at least of contagious diseases, than to predispose to them.

Secondly, Organic diseases already existing in the body, by confining the circulation in the parts that are still healthy, and often by obstructing the circulation, first in their own neighbourhood, and afterwards in more distant parts, naturally and materially favour local congestions of blood; thereby disordering the functions of parts not themselves organically diseased, and frequently leading either to inflammations, serous effusions, or fresh solid deposits from the blood, according to the texture and vital properties of the organs where this local plethora is established; in the production or renewal of all which affections, however, external exciting causes may very often be observed to operate.

Thirdly, Certain kinds of organic disease (such, *e. g.* as scrofulous tubercles), already existing in the body, give a peculiar tendency to the reproduction of the same kind of morbid texture in any part of the body, where disease may be excited; the cause of which tendency will be afterwards discussed.

II. It is especially on those who are predisposed to disease, either generally or more partially, in some of the ways now mentioned, that the different Exciting Causes of disease act with full effect.

There are many cases, however, in which diseases are gradually formed in the human body, under the influence of the predisposing causes above stated, without any exciting cause being observed to operate. And there is hardly any exciting cause of disease that acts with uniformity or absolute certainty, even on constitutions apparently predisposed.

There is obviously an essential distinction between those exciting causes of disease which consist in the application, under peculiar circumstances, to the human body, of agents to which it is often and necessarily exposed, in all parts of the world, and those which result from the application of peculiar poisons, of local and temporary existence only. And it is of the more importance to attend to this, because there is an equally important distinction as to the kinds of diseased action which are found to be excited in the body by causes of these different kinds.

1. The following are the chief agents referable to the *first*

of these heads, which are found to act as exciting causes of disease.

a. Mechanical Injury, or chemical irritation, which, in a certain degree of intensity, infallibly excite inflammation, and when acting in co-operation with some of the predisposing causes above stated, excite either inflammation of a peculiar character, such as the gouty or the scrofulous; or else, if their application be long continued, some kind of chronic organic disease.

b. Muscular Exertion, hurrying the movement of the blood, and often more particularly disordering it, by reason of such efforts of straining, affecting the respiratory motions, as impede the return of the venous blood, especially from the head, and so favour local plethora.

c. Mental Emotion, or acute Sensation, sometimes suddenly affecting the actions of the heart, sometimes augmenting the flow of blood to the head, and sometimes more gradually modifying secretions, especially those of the alimentary canal.

d. Such Excess, or intemperance in eating or drinking, as may either injure the secretions of the stomach and bowels, or so stimulate the circulation, as to determine local congestions of blood in any part that may be predisposed to that state.

e. The sudden Suppression of accustomed evacuations, tending to a state of plethora, which will especially affect any organ that may be predisposed.

f. Such an amount of Evacuation from the body, as may suddenly depress the heart's action, or materially influence the functions of the Nervous System.

g. External Heat, in such a degree, as either to irritate the part to which it is directly applied, or to impress the nervous system violently, or to stimulate the general circulation and favour local congestions.

h. External Cold, applied in such circumstances as powerfully to affect the Nervous System, or to disorder the circulation.

In regard to this last, which is the most frequent and powerful of this kind of exciting causes, it is to be observed, that Cold seldom acts as more than a predisposing cause of disease on the *external parts* directly exposed to it; any diseased action which these parts assume being in general directly excited by the subsequent restoration of temperature. It is in *internal parts*, the temperature of which is probably hardly affected, that cold is most apt directly to excite disease.

The Sensation of cold which is excited appears, according to principles formerly laid down, to be the connecting link between the cause applied externally, and the morbid action excited in the interior of the body; and the more acute, and more lasting, that this sensation is, the more powerful will be the effects resulting from it.

To this simple principle we can refer many facts, which are important to be known, as to the agency of Cold in exciting disease.

It has been already observed, that the degree of effect produced on Sensation, or on other vital actions, in the healthy state, either by heat or cold, is obviously proportioned, not so much to the actual temperature that is applied, as to the amount and rapidity of change of temperature, effected by its application; and the same holds of the morbific effects of these agents. Thus the natural temperature of the body, applied suddenly to a part previously long chilled by frost, produces just the same local effects, as the temperature of 212°, on a part not previously cooled.

In like manner, the effect of cold in producing internal disease is increased by previously heating the body, and still more remarkably by all the other circumstances stated above (p. 351) as weakening the circulation; because, when the body is under the influence of these causes, the lost heat is slowly and imperfectly restored, and the sensation heightened and prolonged. It is greater, for the same reason, when the cold is applied by a draft or current of air, or by wet clothes, which rapidly carry off the heat of the body; and it is greater when the cold is applied to the extremities, as the parts where the circulation is most languid.

It is probably owing chiefly to a languid state of the circulation during Sleep, and consequent deficient power of generating heat on the surface of the body, increasing and prolonging the sensation of cold applied at that time, that the system is then peculiarly apt to suffer from the application of cold.

On the other hand, the injurious effect of cold is lessened or prevented by such a vigorous state of the circulation as counteracts its effect on the temperature of the surface, or quickly restores the temperature that is lost,—therefore, by exercise, taken after the cold is applied, and by febrile excitement of the circulation, at least by such febrile heat as is attended with full strong pulse and dry skin; it is lessened remarkably by such intense occupation of mind, as limits the intensity and duration of the sensation resulting from it; and it is lessened by such habitual exposure to variations of temperature, as blunts somewhat the sensibility of the surface, and excites and strengthens the capillary circulation there, according to principles that have been already explained.

2. Of those exciting causes of disease, which act, often with extreme virulence, and on great numbers of the human race, but only at certain times and at certain places, we may first notice those which are ascertained to consist in the introduction, by the *primæ viæ*, of substances acting as poisons on the system, although so slowly, that their effects are usually ranked among diseases, not as examples of poisoning.

Thus, the symptoms of Scurvy, depending in a peculiar alteration of the blood, are ascertained to proceed from the long-continued use of innutritious, and especially of salted aliments; a peculiar form of external inflammation, tending rapidly to Gangrene, has been distinctly traced to the use of wheat or rye infected with the parasitical plant called the Ergot; a peculiar variety of Colic, and such an alteration of the nutrition of muscles as produces a certain form of Palsy, are the well known effects of the poison of lead slowly introduced into the body; certain varieties of inflammation of the skin are produced by some vegetables, and by some species of fish, acting as poisons; and it has lately been ascertained, that peculiar affections, which have been endemic in some parts of Germany, depend on some of the ingredients used in making cheese and sausages, which are there common articles of diet.

It is important to observe, that in all these cases, the efficacy of the alleged exciting causes is ascertained, not by the affection of all who are exposed to them (for none of them act with unerring certainty), but by the affection of a certain number only of those persons, and by the immunity of all who are certainly known to avoid them.

There are more topical diseases known to be *endemic* in certain localities (*i. e.* to prevail pretty uniformly and exclusively in these), which are also generally believed to depend on certain substances taken into the body, and operating injuriously on certain organs or textures, although their nature, and the mode of their introduction, have not yet been clearly detected, *e.g.* the Bronchocele, in some hilly countries, or on the banks of certain rivers, the Cretinism of the Alps, the Guinea-worm of some parts of Africa and India, the Elephantiasis of Egypt, the Pellagra of Lombardy, &c.

Again, there are other diseases of much greater importance, because, at certain times, much more generally and fatally prevalent, which we ascribe with equal confidence to the operation of certain specific poisons; although these are imperceptible to our senses, and known to us only by their effects on the human body; and although the mode of their introduction into the body (by the absorbent surface of the lungs) is only matter of presumption, not of actual observation.

These are the diseases which prevail *epidemically*, *i. e.* in certain districts or countries, and at certain times only, while other countries, and the same at other times, are quite free from them.

The mere fact of a disease (clearly distinguished from all others) being absolutely unknown for a length of time, in any large community, and prevailing extensively in another in a similar climate, or in the same community at another time, is enough to show that it has a local and temporary cause; and that all reference of its origin to such exciting causes only as were treated under the last head (and which must inevitably be applied to many persons in a very large community, even within a limited period of time), must be totally unavailing.

Such a disease may always be suspected to proceed from a Poison somehow introduced into the body, and experience teaches us, that the origin of that poison is generally to be looked for, either in certain effluvia arising from the earth, or in exhalations from the bodies of persons previously affected with the same diseases, *i. e.* that these diseases usually arise either from a *Malaria* or a *Contagion*.

At the same time, it must be allowed, that there are diseases which occasionally prevail much more extensively than usual, and take nearly the form of epidemics, but do not appear, from the mode of their extension, either to be confined to limited districts, or to be propagated solely or chiefly by contagion. Of this we have examples, in certain seasons, in Erysipelas and in Dysentery, and according to the opinion of many, in epidemic Cholera. It appears well ascertained that all these shew a certain degree of contagious property, but their extension does not appear to be exclusively owing to this property. It is commonly referred to the rather vague principle of peculiar constitutions of the atmosphere; but it is doubtful whether this term be correctly applied.

The following are the facts observed as to the extension of an epidemic disease, which lead us to believe that it arises from a Malaria, or emanation from certain portions of the earth's surface.

1. Such a disease is found to prevail within certain limits only, all persons who avoid these localities escaping the disease, although in all other respects similarly circumstanced to those who become affected.

2. The districts infected with such a disease are, in some

respects at least, similar to one another, in the different parts of the world where they are found.

3. No precautions for the separation of the sick from the healthy, within these districts, appear to have any effect in limiting the extension of the disease; but the removal of the inhabitants, both sick and healthy, to other districts, appears obviously to arrest, in a great measure, the extension of the disease among them; and is unattended with any injury to the health of those with whom they are associatéd after their removal.

It is by facts of this kind that we are assured, that some kind of subtile matter arising from certain parts of the earth's surface, especially from parts of it on which water has stagnated, and from which it has gradually evaporated, is the cause of Intermitting and Remitting Fevers; which vary remarkably in different seasons and climates, and at different elevations above the level of the sea, but still retain the same general characters.

Whether the putrefaction of animal and vegetable matter is a condition essential to the generation of this Malaria, is much more doubtful; but it is certain that the conditions which are essential, belong to the localities which are thus affected, not to their inhabitants; and it will afterwards appear that the laws of its development and diffusion are to a certain degree ascertained.

Again, the following facts, when carefully observed, as to the mode of extension of other epidemic diseases, especially if observed about the time of their commencement, when they are not yet generally diffused, leave no room for doubt, that they propagate themselves by Contagion, or in consequence of exhalations or secretions from the bodies of persons already affected with them, being somehow introduced into the bodies of those who become affected in their turn.

1. Successions of cases, of the diseases in question, are observed within narrow limits, both of space and time; first in one situation, and afterwards in others; while other districts, similarly circumstanced, and fully inhabited, are wholly unaffected.

2. On inquiring into the circumstances of these successions of cases, we find them in various situations, not confined to one description of locality, and in situations which vary quite irregularly with the different returns of the disease, instead of remaining nearly fixed, as is the case in regard to malarious districts.

3. There is very frequently, in such cases, evidence of importation into the affected districts, *i. e.* the first patient in the succession is found to have had intercourse with persons who have had the same disease, or recently recovered from the same disease elsewhere;—either directly, or through the intervention of substances, to which exhalations from sick persons may easily attach themselves.

4. Within the district where the disease exists, those persons who have earliest and closest intercourse with the sick, are observed to be first and chiefly affected.

5. Absolute seclusion from all intercourse with the persons or houses affected, produces complete immunity to whole families, to the inmates of barracks, schools, workhouses or hospitals, even in the midst of the infected districts.

6. When the sick are carefully separated from the healthy in the beginning of the disease, and all substances, to which exhalations arriving from them can have attached themselves, are purified, the extension of the disease, even within the infected districts, is obviously diminished, or even entirely stopped.

Observations of these different classes are so many different ways of establishing the general propositions,— 1. That those who have intercourse with the sick, are affected with one of these diseases in a proportion very much greater than those who cannot be ascertained to have had such intercourse; and, 2. That no other common circumstance, but that of intercourse with the sick, can be ascertained to exist in the case of most of the persons who are affected, and not to exist in the case of the much greater number who escape. And when these propositions are established, especially in the case of a disease which has recently invaded a large community, and affected only a small portion thereof, a calculation of chances puts beyond all doubt the efficacy of the circumstance of intercourse with the sick, in determining the attacks of the disease.

All other considerations are perfectly irrelevant as to the question of the contagious nature of a disease, but those which bear on the evidence of the propositions stated above. For example, the escape of great numbers of those who have intercourse with the sick, is no evidence of the disease not being contagious, if it be ascertained,—1. That the disease is one of local and temporary existence only; and, 2. That of those known to have had intercourse with the sick, the proportion who take the disease is very much greater than that of those in whose cases such intercourse cannot be traced.

It is on evidence of this kind that we ascribe more or less of a contagious property to various febrile diseases,—the Continued Fever of this climate, and probably a continued fever occasionally prevailing in hot climates,—Small-pox, Chicken-pox, Measles, Scarlatina, Plague, Erysipelas, Dysentery, Influenza; and the same evidence will be found to extend to the epidemic Cholera; although there are certainly anomalies as to the propagation, as well as the symptoms, of that singular disease.

It is by similar evidence that we are assured of the contagious property of scabies, syphilis, gonorrhœa, and purulent ophthalmia. The accuracy of the conclusion is confirmed in the case of several of the febrile diseases, as well as of those chronic diseases, by the effect of inoculation. The very peculiar contagious poison by which hydrophobia is excited, has never been observed to be communicated otherwise than by inoculation.

But in ascribing a contagious property to a disease, we must be careful not to consider it as ascertained, that contagion is its only exciting cause. There is good reason to believe, that several of the diseases now mentioned originate occasionally, at the present day, from unknown causes, and perhaps extend themselves in an unknown way, besides being propagated by contagion.

Some special laws, that have been ascertained in regard to malaria and contagion, will be more properly stated as part of the history of the diseases which they excite; but it is important to state here some general facts in regard to the whole of this class of the exciting causes of disease.

1. The well-ascertained fact, that the morbific effect of these poisons is remarkably increased by debility and inanition, and diminished by fulness and excitement, of the vascular system, gives good reason to believe that their action is consequent on their absorption into the blood; because it appeared formerly, that by these circumstances absorption is remarkably increased and diminished *.

2. None of them act with uniformity, epidemic fevers of all kinds, and all contagious diseases, varying extremely in character, in prevalence, and in malignity, at different times, and for reasons which are very imperfectly known.

This difference is evidently in part owing to the concurrence, or absence, of some of the predisposing causes of disease above stated, especially of impure air, imperfect nourishment, and mental depression, long-continued heat or cold; but there are many cases of such difference which we can ascribe only to variations in the nature and virulence of the morbific poisons themselves.

3. None of them act with unerring certainty; some persons escaping, even when such diseases are most prevalent and malignant, and in the circumstances in which the greatest number suffer.

4. Both malaria and contagion are very often aided in their effect, not only by predisposing causes, preparing the body for their reception, but by exciting causes, concurring with them, and determining attacks of disease, which might probably otherwise have been avoided. Thus during an epidemic fever, so many attacks immediately succeed exposure to cold, that many pathologists have thought this a sufficient exciting cause of that disease; and in the malarious countries, so many agues are contracted apparently by exposure to cold, or intemperance, that some have represented

* See Physiology, p. 67.

the malaria as the predisponent, and cold or disordered stomach as the common exciting cause of ague. In like manner, scurvy, although the specific effect of salted aliments, is very generally observed to be essentially aided and promoted by cold, by intemperance, and by mental depression.

It is probably to the frequent concurrence of other exciting causes with malaria or contagion, in producing epidemic fevers, that we should ascribe the remarkable fact, that when such epidemics are most prevalent, most other diseases nearly disappear; the poison already imbibed into the human system, determining the excitation of its own peculiar effect, on the application of any one of the common exciting causes of disease, rather than of the other diseases, which at other times might result from that application.

It appears, therefore, that the agency of those causes of disease, which we call specific poisons, differs from the agency of what are more commonly called poisons, in being much more dependent on contingencies, subsequent to their introduction into the body; and this fact, which could not have been anticipated *a priori*, but seems well ascertained, enables us to understand that in certain cases, even after the diseases resulting from these agents have shewn themselves, they may be not only conducted to a favourable termination, but successfully *arrested* in their course.

5. In all the febrile diseases which are of local and temporary existence, and result from the operation of these poisons, there may be observed, at least when they appear in their violent form, a peculiarity of symptoms, and a kind of danger, hardly to be dreaded in diseases excited only by such causes as are of more general and permanent existence. This peculiarity may be said to consist in a general depression of vital action, and an alteration of the vital properties of the blood, and is denoted by the appearance of more or less of the symptoms, which have the name of *typhoid*.

CHAPTER IV.

OF DISORDERED ACTION OF THE HEART.

Arranging the subject of Pathology as nearly as possible in the same order as the Physiology, we examine first those diseased actions in which the organs of circulation are chiefly concerned. We do not affirm, that the affection of the circulation is the primary change in these diseased actions; but it is certainly the most obvious, and is that by which the application of remedies is chiefly guided. Of these, a few appear to consist essentially in alterations of the heart's action; the greater number manifestly originate in the capillary vessels; as may naturally be expected when it is remembered, that these are the scene of the continual vital changes which it is the object of the circulation to maintain.

Three morbid states of the action of the Heart may be frequently observed, and easily distinguished,—Deficient action, Inordinate or Irregular action, and Painful action.

I. The deficient action of the heart demands particular attention, both theoretically, as illustrating the important subject of the connexion between the nervous and vascular system in the living body, and also practically, not because it is frequently met with as the sole cause of danger, but because it takes place in a greater or less degree, and constitutes a part of the danger, in many complex diseases; and because we are necessarily very much guided in the use of remedies in these, by the degree in which the danger may or may not appear to consist in this part of the morbid changes.

The defective action of the heart, and threatening of Syncope, or of death beginning at the heart, is of course most essentially characterized by feebleness of pulse, by paleness and coldness of the surface, often attended with cold sweating, and by muscular debility; but in many cases, more striking symptoms are presented by the change in the condition of the Nervous System which is connected with the enfeebled state of the heart; and there has been some misapprehension as to the characteristic symptoms of this state, from the great variety that exists as to the degree in which the Nervous System participates in the depressed state of the Vascular System.

The circumstance on which this variety appears mainly to depend is the degree of suddenness with which the depression of the heart's action is effected.

When it takes place *slowly*, the impetus of the blood on the brain and nerves being very gradually diminished, the Nervous System suffers in the first instance very little, and the pulse may become imperceptible, and the skin quite cold, before the senses are obscured, or the intellect sensibly impaired. The senses of sight and hearing are generally the first that are blunted in such cases; but the mind is clear,—voluntary motions, though enfeebled, may often be performed with precision,—and the sensation which prompts to acts of respiration is so entire, that a heaving and laborious breathing is gradually produced, evidently depending, not on any impediment to the access of air to the lungs, but simply on the increasing difficulty, with which the enfeebled heart propels the blood through the lungs. This is the state of the symptoms in many cases of disease, when there is imminent danger of death by syncope. In such cases, the pulsations of the heart become usually more frequent as they become feebler.

But when the heart's action is *rapidly* depressed, as by hæmorrhage, or violent mental emotion, the sudden diminution of the pressure on the brain and nerves, like other sudden changes in the condition of these parts, powerfully affects the functions of the Nervous System; and there is first vertigo, tinnitus aurium, confusion of thought, and then often an instantaneous loss of sense, intellect and voluntary power, constituting what is called a complete fit of syncope, even when the pulse is still quite perceptible, and before the surface has become cold. In such cases the diminution of sensation is often such, that the action of respiration, as well as all perceptible action of the heart, may be nearly or entirely suspended for a time, without any bad consequence. A sensation of anxiety and of nausea, prompting to acts of vomiting, is a common accompaniment of the impression made on the Nervous System in such sudden syncope. The pulsations of the heart, in this state, especially if the patient has previously been of strong habit, are generally slow as well as feeble.

There are some cases, usually called cases of syncope, where the sudden loss of sense and voluntary power takes place almost without alteration of the heart's action, and which in their pathology are more closely allied to Epilepsy.

It has been already stated, that a sudden diminution of the pressure on the brain and nerves is itself a cause, not only of insensibility, but of weakened action of the heart; and the impression made on the heart's action, especially in a feeble and irritable habit, by bleeding in the erect posture, as compared with bleeding in the horizontal,—or by rapidly assuming the erect posture after stooping down,—is enough to establish this principle.

When, therefore, we see fits of syncope, or a tendency to it, brought on either by loss of blood, or by purging, or sweating, or by alteration in the distribution of the blood, as by drawing off the fluid of ascites, we may reasonably infer, that the immediate cause of the complete failure of the heart's action is not the mere diminution of the stimulus acting on the heart, but a change in the condition of the Nervous System; just as it certainly is, when syncope is produced by strong mental emotions, by certain long continued and unpleasant sensations, such as particular odours or by intense pain, or the sudden transition from pain to ease, which are likewise frequent exciting causes of this affection. The secondary action or reaction on the heart, of diminished pressure on the brain, (originally consequent in some cases on deficient action of the heart itself) is very important to be kept in mind in all speculations as to Syncope; and explains the well known effect of the horizontal posture, not only on the nervous symptoms in syncope, but on the affection of the heart itself.

But all this does not establish, as CULLEN and others have conjectured, a necessary *dependence* of the heart's actions on the brain (a supposition which is inconsistent with facts formerly stated); it is only one of the considerations which prove, that in the living body the actions of the heart are subjected to an *influence and control*, from certain changes which take place in the nervous system; and which probably extend, as was formerly illustrated, over the whole of that system, and act at a peculiar advantage on the heart, as an organ connected through the ganglionic nerves, with all parts of the cerebro-spinal axis*.

The agency of all exciting causes of Syncope is greatly increased by certain circumstances of predisposition, sometimes by peculiarity of constitution of which no account can be given; but often by deficiency of the vital fluid, or general weakness of vascular action, as in convalescents from other diseases, or in persons exhausted by muscular exertion, or under the influence of sedative causes, as certain poisons or contagions; or else, by such a state of excitability or *mobility* of the body, that impressions from without peculiarly affect the nervous system, and again, that affections of the nervous system are transferred with peculiar facility to other living parts, and especially to the heart. It is thus that in women, especially of feeble and irritable habit,—about the menstrual period more than at other times,—in women affected with the slighter uterine diseases, and in persons labouring under long-continued mental depression or anxiety,—all the exciting causes of syncope act with peculiar effect.

II. There are several varieties of Inordinate Action of the

* See Physiology, p. 275.

heart, unconnected with organic disease, which it is to no purpose to consider separately, because we know little of the causes of their difference. Such are permanently increased frequency, and sometimes apparent strength, of the heart's pulsations, with perfect regularity, and nothing unusual in the mode of contraction; or occasional violent fits of palpitation from exercise, mental emotion, or other slight causes, (*i. e.* such causes as produce palpitation in the healthy state, but in a much less degree, and of much shorter duration); or paroxysms of irregular action, the irregularity being sometimes in the succession of the pulsations, and sometimes rather in the mode in which each contraction is effected. In all these cases there is more increase of the sound, than of the impulse of the heart's action, experienced by the ear laid on the chest; and the last of these, the irregular contraction of the fibres, is denoted chiefly by unnatural sounds attending the pulsations.

In regard to all these cases of morbidly irregular or excessive action of the heart, it is to be observed, that if unconnected with increased bulk of its muscular substance, they seldom or never indicate any real increase of strength. But they are sometimes evidently dependent on fulness of blood, and increased stimulation of the heart; and farther it seems a general law, that when the heart is feebler than usual, it becomes more irritable, its contractions are more easily excited, and more easily deranged. Hence both habitual frequency of pulse, and likewise fits of palpitation, or irregularity of pulse, are often observed under the same circumstances, or in the same persons, as the tendency to syncope; and are, equally as that tendency, often to be ascribed rather to alterations in the state of the nervous system, than of the heart itself.

The unusual irritability of heart, indicated by the modifications of its action above stated, is remarkably observed in persons previously healthy and full-blooded, when taking little exercise, when enjoying less sleep than usual, and when under the influence of mental anxiety. It is often observed also in persons previously healthy, but much weakened, as during convalescence from acute diseases; and farther, in certain chronic diseases, particularly those which are attended with habitual uneasy sensations at the stomach. In cases of this last kind, inordinate pulsation is often observed almost exclusively along the abdominal aorta, the immediate cause of which is still uncertain.

Although advantage may often be derived, in the earlier stages of these cases of increased and irregular action of the heart, without change of structure, from loss of blood, as may naturally be expected when they occur in pretty full habits, yet it may be stated in general, that ultimate and permanent relief to them is obtained chiefly by remedies and regimen of the tonic kind, *i. e.* by which vascular action is invigorated, and the nervous system rendered less liable to sudden and injurious impressions.

III. Painful action of the heart is that affection which, in its extreme degree, is described under the name of Angina Pectoris, and is marked by acute pain, not only in the situation of the heart, but in general extending sympathetically * to the left shoulder, and down to the left arm, generally brought on, and always remarkably aggravated, by any such exertion as may quicken the heart's action. This pain occurs, however, in different cases with very various degrees of intensity; and is attended with various affections of the movement of the heart, generally with increased action at the time when it begins, but in severe cases, with greatly diminished action during its continuance, whence it has had the name of Syncope Anginosa. It obviously depends immediately on an impression made on the sensitive nerves of the heart: but what circumstances are essential to this impression is still uncertain. It is not necessarily connected with any kind of organic disease at the heart, but is seldom well marked when no such organic disease exists. It is certainly more immediately connected with fulness of blood than mere palpitations are, and is

* See Physiology, p. 208.

hardly ever permanently relieved otherwise than by evacuations and low diet.

As both palpitations and painful action of the heart must naturally be readily excited, when the tendency to them exists, by any cause increasing the quantity of blood brought to the heart by the veins in a given time, it is easy to understand, that at the moment of transition from the state of waking to that of sleep, when the circulation on the surface of the body is repressed *, these affections of the heart should especially occur; and also, that their occurrence at that time should very frequently, though often only temporarily, be relieved by loss of blood.

It is obvious, that both palpitation and irregular painful action of the heart, will more easily be excited when there is any obstruction to the free transmission of the blood through the heart, than when the motion of the blood is free; and therefore, that habitually increased strength and fulness of pulse, palpitations, irregular pulse, and fits of angina pectoris, must be much more frequent and dangerous when any disease of the valves of the heart, or of the aorta, impeding the transmission, or allowing the reflux of blood, exists, than in any other cases. And although it is perhaps not so easy to explain the fact, it is equally certain, that in those circumstances fits of syncope are frequent and dangerous.

The existence of such organic obstructions to the course of the blood, is very generally demonstrated, soon after they have commenced, and in many instances their nature is more specifically indicated, *first*, By the enlargement of the heart, and often of the aorta, consequent on them, and which is easily ascertained after a time both by the ear and the hand applied to the chest; *secondly*, By the increased *impulse* which the heart communicates to the parietes of the chest, when, as commonly happens in consequence of such obstructions, it has got into the state, not only of dilatation, but of hypertrophy; and *thirdly*, By alterations of the na-

* See Physiology, p. 280.

tural sounds, that attend the heart's actions,—consequent on the obstructions which the current of blood encounters, and especially on the modifications of the muscular contractions, which are required to overcome these obstructions.

The nature of the diseases which produce these obstructions, and the ulterior consequences to be apprehended from them, besides the mere disorder of the action of the heart, will come under consideration afterwards.

CHAPTER V.

OF LOCAL DETERMINATIONS AND CONGESTIONS OF BLOOD, AND THEIR IMMEDIATE EFFECTS.

Of diseased states of the body, originating or chiefly existing in the organs of circulation, the next in point of simplicity to the affections of the heart itself, are the occasional determinations or congestions of blood, affecting individual organs or textures, which are known frequently to occur, and the effects of which are very various. They often lead to, or are combined with, not only great increase of exhalations, or of secretions, but likewise with increase of the nutrition of healthy textures, or with such perversions of nutrition, as constitute morbid or adventitious structures; and we shall find that they often pass into true inflammation, acute or chronic; but without altering the chemical phenomena, or the products from the blood in any part of the body,—they may be injurious, or even dangerous in two ways, *first*, By disturbance of the functions of the parts where they take place, independently of any lesion of their structure; and, *secondly*, By leading to extravasations of blood, and either to hæmorrhages, or to such lesions of the structure, and consequent derangement of the functions of parts, as result from the simple effusion of blood into them.

The study of these disorders of the circulation, and of their causes, is therefore important, both with a view to their immediate effects, and also to the pathology of the most important acute and chronic diseases, to be afterwards considered.

There is probably no kind of diseased action of which any part of the living body is susceptible, which is not connected sooner or later with increased afflux of blood towards that part, either as its cause or its effect, and the immediate object of all our most powerful remedies is to act on these irregularities of the circulation; but it is important to distinguish accurately in the first instance, the causes that may be assigned for, and the effects which may be ascribed to, mere increased flow of blood to a part, independently of any *alteration* in the vital actions that go on there.

That the quantity of blood circulating in the small vessels of any part of the body may be occasionally and greatly increased, is obvious from what is known of the structure and distensibility of the vessels, and from what has been often observed of the capillary circulation in those parts of animals, where it can be best examined with the microscope. And the phenomena formerly mentioned, of temporarily increased sensations, of periodic nutrition of parts, and of the effects on the circulation, in various organs, of sensations and emotions of mind, clearly shew that in the perfectly natural and healthy state of the body, occasional and great congestions of blood are a part of the intentions of nature.

Much stress has been laid by some pathologists on the difference between *active* congestions of blood, brought about by evidently increased action of the heart, and at least probably increased action of arteries; and *passive* congestion, in which there is evidence of languor, and deficient rather than increased action in any part of the vascular system. But it is only in a few cases, that this distinction can be accurately observed. In by far the greater number of cases, there is evidence of what may be called active congestion in the first, and of passive congestion in the last stage, of the same affection.

It is farther known, that certain textures and organs of the body are much more liable to such congestions of blood than others, by reason of the quantity of blood which they receive in the healthy state, and especially, perhaps, of the variations to which that quantity is habitually liable. The mucous membranes, and the parenchymatous viscera, the lungs, liver, spleen, and kidneys, are frequent seats of morbid determinations or congestions of blood. And notwithstanding what was formerly said of the peculiarity of the circulation in the brain, and the impossibility of much variety ever taking place in the quantity of blood within the cranium; yet, as the impetus with which the blood enters the brain, the quantity passing through it in a given time, and even the quantity existing at any given time, in one part of it, as compared with another, are all liable to change, there is no sound theoretical objection to the belief, of occasional determinations and congestions of blood taking place there also; and the evidence of these actually and frequently occurring, and leading to some of the principal diseases of the brain, to be afterwards stated, is in many cases quite conclusive.

It is certain also, that there is a difference at the different periods of life, as to the parts in which congestions of blood and hæmorrhages are most apt to occur, and for this probable reasons have been assigned. In all parts of the body, as growth ceases, the capillary circulation becomes more confined than before, and a morbid fulness of the vessels is more easily produced. About the period of puberty,—the head having acquired its full size more nearly than other parts, and the blood sent thither having a less capacious capillary system to receive it, than in parts still growing,—on occasion of any unusual fulness of blood, or hurry of the circulation, a morbid fulness is apt to take place in the head, and hæmorrhage from the nose is common. When the growth of the whole body is over, it may be supposed that the blood, diverging less than before, and not detained so long in the capillaries of the greater circulation, will return quicker to the heart, and congestion and hæmorrhage in the lungs be more easily produced than previously. In women, during the continuance of the periodical menstrual discharge, the uterus may be expected to be more liable to morbid congestion of blood than other parts. And in all persons in the decline of life, when the vessels lose somewhat of their propelling power, and the capillary circulation is much limited, venous plethora may be supposed to become more common, and, according to circumstances to be afterwards mentioned, may be produced especially, either in the vessels of the head, or in those of the abdomen, disposing most generally to apoplectic attacks in the former case, and to hæmorrhoids in the latter. Several of the general causes of disease, already mentioned, may be said to act chiefly by promoting or exciting such irregularities in the distribution of the blood as we now consider, whether these are their sole effects, or whether, through the medium of these, they lead unto other and more permanent consequences.

In a large proportion of cases, even of congestion that does not go on to inflammation, it appears distinctly, that the cause of the affection is some local irritating cause, by which the vital actions of the part are first altered and increased, and on the local effect of which, the determination of blood to the part subsequently supervenes; just as it was formerly stated, that in the healthy state the flow of blood to any part of the system is very much determined by causes acting on the extremities of the arteries there, and the effect of which is more properly expressed by the term *Attraction*, than either by Propulsion or Retardation, of the circulating fluids.

Thus when excessive mental exertion or emotion affects the brain, when mercury affects the salivary glands, heat the liver, irritating vapours the bronchiæ, or various ingesta the stomach or bowels, so as morbidly to excite the actions which take place in the capillaries of these parts, without causing inflammation, a determination of blood to them is effected by an influence which is *retrograde along their arteries.*

But the effect of these local irritations will naturally be very much increased by the action of causes which operate more generally on the circulation, and on the distribution of the blood; and in many cases it is obvious, that causes of this kind are adequate of themselves to the production of local congestion. The following are the chief causes, independent of local irritation of any particular set of capillary vessels, by which irregular determinations of blood appear evidently to be promoted or excited.

1. It is obvious that the tendency to any morbid congestions of blood will in general be greatest when the whole quantity of blood in the body is excessive, and, therefore, that full living, and indolent or sedentary habits, which, in a healthy constitution, naturally favour Plethora (and therefore promote the formation of the fat, which seems to serve as a depository for superfluous nourishment in the animal body), will often predispose to this class of diseases.

Persons in the prime of life, who are vigorous and plethoric, are certainly less liable to *inflammatory* diseases than others are, these diseases usually beginning with a state of depression and debility in the circulation on the surface of the body, which is not easily produced in such persons. But they have no such immunity from simple *congestions* of blood; and those especially in whom (as appears often to be the case) the state of plethora is attended with a feeble rather than vigorous condition of the moving powers of the circulation, are naturally predisposed to congestions and hæmorrhages.

2. It is also reasonable to expect, that the Suppression of accustomed Evacuations, by increasing the state of plethora, sometimes probably by the irritation consequent on the retention within the body of matters destined to excretion, may have a peculiar tendency to produce such disorders of the circulation. It is in this way, accordingly, that this cause of disease appears manifestly to operate; and there are many cases, *e. g.* of Apoplexy or Epilepsy, consequent on suppression of the discharge from hæmorrhoids, or of Hæmorrhage from the nose, lungs, or stomach, consequent on

suppression of the menses, where very serious consequences result from the local congestion of blood, although unattended with any other diseased action.

3. The tendency to local congestions of blood is very much dependent, in many cases, on previous diseases, especially on such previous Organic Lesions, even of distant parts, as obstruct some portion of the circulation; whence it happens that these local congestions are not only the cause of many diseases, but often the consequence, and the most dangerous part of the effect, of others. Of this the following are the most remarkable examples.

a. The congestion of blood in the Lungs,—leading to various alterations of these, and frequently to effusion of blood into the air-cells, with or without hæmoptysis,—very often consequent on such disease of the heart or aorta as obstructs the flow of blood through the left side of the heart.

b. The stagnation of blood in the vena cava descendens, and appearance of various symptoms indicating compression of the Brain, or sometimes bloody effusion on the brain, consequent on obstruction to the flow of blood through the heart, and therefore frequently succeeding to violent palpitations, however caused.

c. A similar stagnation in the jugular veins and congestion in the head, leading to various diseases of the Brain, in cases of disease where there is obstruction to the free flow of blood through the lungs, although the heart be sound, especially if there be frequent exertions of coughing (implying an additional cause of disturbance of the circulation, to be considered immediately), as in Bronchitis, Hooping-cough, or Asthma.

d. A congestion of blood in, and consequent enlargement of, the Liver and Spleen, and congestion in, and sometimes hæmorrhage from, the Stomach and Intestines (especially their mucous membrane), very often consequent on such disease, either of the heart or lungs, as habitually retards the flow of venous blood on the right side of the heart, and occasions stagnation in the vena cava ascendens;

—the nature of which is well illustrated by the condition of those parts in persons suffocated or strangled.

e. A congestion of blood in the Stomach and Intestines, especially in their mucous membrane, and frequently hæmorrhage from that membrane, producing Hæmatemesis, or Melæna, or both, consequent on any such organic disease of the liver as obstructs the flow of blood through the vena portæ.

It is easy to understand that such obstructions to the circulation as thus favour congestions and hæmorrhages, should also very frequently lead to increased serous effusion from the parts where that exhalation is always going on; and that a slight change of circumstances may often determine whether such effusion from the serous membrane, or hæmorrhage from the mucous membrane in the thorax or abdomen, should result from obstruction at the Heart or at the Liver.

It will appear afterwards, that very many cases, both of acute inflammation, and of chronic lesions of texture, in the organs now mentioned, are referable in part to the obstructed state of the circulation and consequent congestion of blood now in question.

Even independently of such manifest obstructions to the course of blood in the larger vessels, as result from the kind of organic disease now mentioned, it is obvious, that any tumour or adventitious structure existing in an organ, must obstruct and disorder more or less the circulation through the healthy parts of that organ, and may therefore give occasion to congestion, and to hæmorrhage or other consequences of congestion there, as is occasionally seen in the course of chronic diseases in the lungs, and more frequently in the brain.

4. It is known, by ample experience, that the tendency to any local determination or congestion of blood is very much increased by its having once occurred, so that all diseases dependent on this cause may be said to facilitate their own recurrence; although our knowledge of the causes of the movement of the blood in the capillaries does not en-

able us to say with confidence, what is the nature of that vital action which appears thus to be strengthened by repeated exertion. In consequence of this increase of the tendency to them from repetition, diseases which proceed from this cause become gradually less and less dependent on general plethora, or on excitement of the circulation, for their reproduction; and hence, when they have become habitual, the remedies which were useful in their commencement become quite inefficient.

5. There is in some persons at times a peculiar State of the Blood, by which the tendency to hæmorrhage, and perhaps to congestions of blood preceding hæmorrhage, is greatly facilitated, viz. the state in which it is preternaturally fluid, and its coagulation imperfect, as in Scurvy, and in Purpura from unknown causes.

6. There is in many persons, especially in those somewhat advanced in life, a condition of the Bloodvessels, which greatly facilitates their rupture; viz. a rigid, inelastic, and brittle state of their coats (consequent on local disease of them to be afterwards considered), and often a partial thinning or even ulceration of these. Where such disease exists, especially within the cranium, the action of any of the general causes of congestion of blood is of course peculiarly dangerous.

7. Many of the more strictly Exciting Causes of disease, formerly enumerated, have a peculiar effect in determining local congestions of blood, and their immediate consequences, especially the following.

a. External Heat acting as a general stimulus to the circulation, and " urging to excess inequalities in the distribution of the blood, otherwise innocent," as is often seen in the effect of this agent on determinations of blood to the brain, and their consequences, and still more remarkably in its effect on the abdominal viscera, which it disposes to diseases that necessarily imply a great increase in the quantity of their blood.

b. External Cold, partially obstructing the flow of blood through certain parts of the body, and proportionally augmenting the flow through others; on which account, the very same diseases of the brain have often been found to result from incautious exposure to cold as from intense heat; and statistical tables prove, that Apoplexy and Palsy are rendered more frequent, either by unusually cold, or unusually hot weather *; and nearly the same may be said of other diseases, connected with irregular determinations of blood.

c. Muscular Exertion acting in like manner as external heat, to hurry the circulation, and urge to excess any local determinations that are already established, and especially such as are already attended with an excited state of the circulation, or such as exist in parts (*e. g.* the lungs or the brain) which must necessarily suffer from any strongly excited action of the heart. Those muscular efforts which are attended with *straining*, *i. e.* when the play of the lungs is forcibly restrained, at the same time that the blood is urged towards the heart, are necessarily peculiarly injurious, in producing congestion in the lungs, and in the great [redacted], and thereby in the brain.

d. The partial Exercise of individual organs, particular postures of the body, and ligatures impeding the flow of blood in parts of the body, are all occasional causes of local congestions of blood, as is seen in many cases of hæmoptysis in those predisposed to it, excited by unusual exercise of the organs of respiration,—of menorrhagia excited or aggravated by the erect posture,—or by tight-lacing,—of apoplectic seizures or threatenings, from stooping, or wearing tight neckcloths, &c.

e. Mental Emotion or anxiety is frequently a cause of general hurry of the circulation; and must necessarily aggravate determinations to any individual organs which may

* Thus the deaths from apoplexy in the severe winter of 1795, were to those in the milder winter of 1796, as 52 to 31, (Heberden); and again, the deaths from apoplexy at New York in July, on an average of 11 years, were to those in any one other month, as 109 to 59, (Rush).

at the time be peculiarly liable to disease. Thus many Apoplectic attacks and many cases of Menorrhagia in those predisposed to them, may be ascribed, in part, to this cause.

Impressions on the Nervous System at large, whether from mental or other causes, appear to act peculiarly on the circulation in the bowels, and in the uterine system. These parts (especially the intestines) are less affected than the contents of the head or thorax, by any sudden excitement of the heart's action; but the history of many diseases shews that, in women particularly, the circulation in them is very easily deranged by causes acting in the Nervous System, and such occasional increase of their natural secretions easily effected there, as implies increased determination of blood thither *. Indeed, diarrhœa is so apt to occur in cases of great debility, as to favour the supposition, that the mucous membrane of the bowels is a part in which the blood is always apt to accumulate or be congested, when it has difficulty in making its way through other textures.

When the blood is congested from these causes, or from unknown causes, in individual parts of the body, the symptoms resulting must of course vary according to the part affected, and the degree of the affection. And it is often difficult to distinguish those symptoms which depend on the ulterior consequences of the congestion of blood, from those which may be stated as the natural attendants of the circumstance of congestion itself, unconnected with any change in the products formed from the blood at the affected part.

In many instances the irregular determinations of blood

* See, *e. g.* LATHAM'S History of the Epidemic in the Penitentiary in 1823, where there were many examples of violent disorder of the Nervous System, succeeded immediately either by hæmorrhage from the stomach or bowels, or by such mucous and watery discharges from these, as plainly denoted great increase in the flow of blood thither.

are attended with febrile symptoms, either preceding or following them. But true febrile action, such as will be described as accompanying inflammation, is not only no essential concomitant of local congestions of blood, but may most generally be distinctly traced to other causes; either to a degree of inflammation attending the congestion,—or in some instances to inflammation supervening on hæmorrhage, to which the congestion has led,—or to some other cause of febrile action affecting the body at the same time. In some instances, however, attacks of disease which appear to depend on such determinations of blood, (*e. g.* fits of Epilepsy in young and plethoric subjects) are attended with general symptoms closely resembling inflammatory fever, although we have no reason to think that inflammation exists, and no other cause for fever appears.

Two classes of local effects which result from these determinations and congestions of blood, may be shortly considered here, viz. those which may be produced by derangement of the functions of the parts affected, without hæmorrhage or inflammation, or any kind of disorganization of these parts; and those which may be produced by hæmorrhage independently of any ulterior consequences. The effects of inflammatory action, and of adventitious growths or alterations of structure, consequent on the congestions, will come under consideration afterwards.

I. 1. Very various derangements of the functions of the Nervous System, headachs, giddiness, transient imperfections of sense, or of memory, fits of epilepsy, of hysteria or other spasms, even of mania, in those predisposed to these diseases, some cases of transient paralytic affections, and many of apoplexy, appear to result from simply increased afflux of blood to the brain, without rupture of its vessels, disorganization of its texture, or even increased effusion of its serous fluid.

2. There are many cases of asthma and of catarrh, which may probably depend on merely increased determination of blood to the mucous membrane of the air-passages; but

such cases are hardly to be distinguished from those either of inflammation or of spasm affecting these parts.

3. An increased determination of blood to the mucous membrane of the stomach, although not followed by inflammation there, is probably a frequent cause of severe dyspeptic symptoms *.

4. An increased flow of blood to secreting organs is certainly one condition, and in many cases probably the only condition, essential to the production of those diseases which consist in simple increase of their secretions, such as cholera, or many cases of diarrhœa and of leucorrhœa.

5. Even independently of attacks of hæmorrhage, there is evidence of increased flow of blood to the uterus, in many cases of uterine pains; and of a similarly increased flow to various other parts in connexion with nervous pains, *i. e.* pains which are unconnected with indications of inflammation.

6. An increased flow of blood to, or stagnation of blood in, the serous membranes, or the cellular membrane of the body in general, or of the lungs,—whether it be dependent on obstruction to the circulation in the great veins, as in cases of diseased heart or liver, or on suppression of excretion by the skin and kidneys, as in cases of dropsy after scarlatina, or connected with disease of the kidneys,—is the main condition essential to the occurrence of dropsical effusion in those parts; and is therefore a cause of diseases of such importance as to demand future consideration.

As true inflammation of cellular, serous, or mucous membrane is always attended with increase of the quantity of fluids thrown out there, it is obvious that effusions dependent on simple congestion of blood, and those dependent on inflammation, must often closely approximate; and the only essential distinction between them lies in the peculiar *alterations* of the products effused in these parts, which are effected by inflammation, and which will be afterwards described.

* See PARRY's Elements of Pathology and Therapeutics, sect. 484.

Increased secretions or exhalations upon all these different membranes, although dependent, in most cases, and in the first instance, on congestions of blood there, are often attended with less general disturbance of the circulation, than the other effects of local congestion which have been mentioned. And there is this difference among the different membranes, that those determinations of blood which take place to serous membranes, and lead to dropsical effusions, are seldom effected without some kind of obstruction to the natural course of the circulation existing at the time; whereas the mucous membranes are often congested, and their secretions much increased, when no kind of organic disease or obstruction exists.

That these different diseased states depend essentially on morbid determinations or congestions of blood, even when these do not make themselves obvious either by hæmorrhage, or by any disorganizations perceptible on dissection, we conclude from various facts, most of which may be ranked under the following heads:

1. In many of these instances the symptoms are the same, and the whole history of the disease, up to a certain period, is the same, as in other cases, where the increased determination of blood is afterwards unequivocally shewn, either by hæmorrhage, or by such disorganization of parts as equally denotes congestion of blood there; *e. g.* a fit of apoplexy, in a plethoric person, after a full meal, and either mental agitation or intoxication, although preceded and attended with flushing of face, and heat of the head, may be fatal without any effusion being discoverable in the head; but after many cases of fatal apoplexy, of which the history was similar, we find effusions of blood or serum; and we cannot doubt that these latter cases illustrate the essential nature of the diseased action which took place in the former.

So also, urgent dyspeptic symptoms, following suppression of the menses, have often been succeeded, and immediately relieved by vomiting of blood; and this fact evidently illustrates the nature of the severe affections of the stomach which often succeed the suppression of that discharge when there is no hæmorrhage. And the nature of many cases of diarrhœa is illustrated by what is seen in a few unusually violent cases of that kind, which are attended by severe hæmorrhage, even when there is no inflammation or ulceration, and no obstruction to the flow of the venous blood through the liver.

2. The nature of the diseases which have been represented as often depending on determinations of blood, is very often illustrated by their ready transition, in the same patient, into hæmorrhagic or inflammatory diseases. Thus we know that various combinations or successions of the symptoms and affection of the nervous system, above enumerated, and the cause of which may be thought doubtful if they stand alone, are often followed by regular apoplectic or paralytic attacks dependent on hæmorrhage in the brain; and that cases of simple diarrhœa are easily convertible, by errors of régimen, which in other circumstances would be innocent, into strictly inflammatory diseases.

3. The dependence of many cases of the diseases above enumerated, on the cause here assigned, is farther confirmed by a very sufficient experience of the *juvantia* and *lædentia* in at least a large proportion of cases of the kind, especially in their earlier stages; although experience also teaches that morbid actions which commence with increased local determinations of blood, and even with general excitement of the circulation, often subsequently go on for a long time, without any indications of increased vascular action, and when remedies are chiefly demanded by the general weakness of the circulation which subsequently ensues.

When diseases of the kind we have now considered prove dangerous or fatal, the immediate cause of danger may be very various, even although no farther morbid action be established than these natural effects of congestion.

Increase of the natural secretions from the serous or mucous membranes, when very copious, may be fatal in ways to be afterwards considered. There are, perhaps, cases of affection of the lungs, and certainly cases of affection of the brain, where the fatal event is produced by the obstruction of the functions of these parts consequent on mere congestion of blood without farther change; and there are many cases of very various diseases, in which congestions of blood in these organs are part of the cause of the fatal event. It is therefore of great importance to study the indications of mere Congestion of Blood, as well as the effects of Hæmorrhages, as they appear on dissection.

It may, however, be stated generally, that the indications of local congestions of blood, observed after death, when no farther consequence has occurred, are very liable to fallacies, and are not much to be trusted as proofs of the nature of the preceding disease, unless the nature of the symptoms, or other circumstances in the condition of the patient, confirm the conclusion which they suggest.

These fallacies result chiefly from what is known of the unequal and irregular distributions of blood that may take place at the moment of death, or within a very short time before it, even in cases where there had previously been little or no unusual determination of blood.

At the moment of death, or within a very short time after it, congestions of blood in various parts and textures (at least in the skin, most of the vascular parts, mucous membranes, and the parenchyma of some of the viscera), frequently occur; which are not referable to any known cause, but may be followed by transudation of serum after death, and present appearances very similar to those of inflammation in its first stage.

A congestion of blood, with some serous effusion, is certainly often determined also by gravitation, acting before death, but at the time when the circulation is very much enfeebled, in those parts of the body which then lie lowest *. This takes place especially, if any additional cause for slow motion of the blood at the same time exists in these parts; as in the lungs, when there is any impediment to the free

* Hence the Peripneumonie des agonisans of Laennec, and the Engouement de Position of Andral.

arterialization of the blood, or in the abdominal viscera, when the flow of venous blood is obstructed either in the liver or at the lungs or heart. A similar state of congestion and serous effusion sometimes occurs in the lower extremities from old age or extreme debility; and in any part of the body, if the veins leading from it are narrowed or compressed by tumors *.

Such congestions and effusions are of course most apt to take place in cases when the blood is in full quantity, and has less tendency to coagulation than usual, and therefore such fallacious appearances are seen most frequently after different kinds of violent death, or after contagious febrile diseases of short duration.

But when the same appearances are found in parts of the body where gravitation would not determine them,—when they are found under the circumstances stated above, as favouring local congestions of blood,—and when they correspond to symptoms observed during life, of embarrassment of the functions of the parts where they are formed, there can be no difficulty about regarding them as the effects and indications of morbid determinations of blood.

II. Hæmorrhage frequently takes place from the mucous membranes of the nose, fauces, bronchiæ, stomach or bowels, and still more frequently of the uterus; in some cases in such quantity as to be dangerous or fatal, by reason of the debility produced by the loss of blood, or, in the case of its occurring in any of the air-passages, by reason of the obstruction to respiration thence produced. When taking place from the inner surface of the uterus, at the moment of the separation of the placenta, it has often been fatal in persons previously quite healthy; but in the other parts mentioned it is seldom immediately dangerous, unless connected either with the morbid state of the blood, or with some of the obstructions to the free course of the blood, already mentioned. In all these parts, it often appears, on minute

* See Andral Precis. d'Anat. Pathol. t. i.

investigation, that no rupture of vessels on the surface whence the blood came can be detected.

More rarely hæmorrhage takes place in like manner independently of injury or of perceptible rupture of vessels in the cellular substance, or on the surface of the serous membranes, even when uninflamed, and if this happen within the head or the chest, it may of course produce fatal coma or asphyxia. But the greater number of fatal hæmorrhages in any of the shut cavities of the body are the result of a diseased state of the bloodvessels.

Hæmorrhage within the substance of the brain is more frequently dangerous, and the effects it produces, and the disorganizations to which it tends, have been more carefully studied, than in other viscera.

It takes place most generally in persons advanced in life, and is preceded very frequently, though by no means uniformly, by the circumstances already mentioned, which favour,—by the causes which excite, and by the symptoms which indicate,—an increased determination to the head, and consequent obvious, although very various, derangement of the functions of the brain.

It takes place most commonly in the parts immediately adjacent to, or at least on a level with, the ventricles, the corpora striata, thalami, or adjoining parts; and in a large proportion of cases it appears obviously to have been facilitated by a diseased state of the vessels there situated. But in other cases, no disease of vessels is detected, and, in a few, the effusion of blood is in too many minute points to be ascribed to rupture of any but the smallest of the vessels.

It hardly ever occurs without sudden disturbance of the functions of the brain; but the amount of this disturbance is exceedingly various,—from transient loss of speech, or memory, or spasm or palsy of some voluntary muscles, up to perfect coma, fatal within a few hours. When the hæmorrhage has taken place into, and filled the ventricles, the amount of injury being more extensive than usual, the symptoms are more uniform; there is first, temporary loss of sense and voluntary power, and depression of the heart's action,—a recovery from this state,—and then a gradual accession of profound, and uniformly fatal, coma. The most common permanent effect of effusion of blood into the substance of the brain is loss of sense, or of voluntary power, or both, in the opposite * side of the body.

That there should be much variety as to the affections of sense and voluntary power, in such cases, is not surprising, when we remember that the small portion of the contents of the cranium, which appear to be really essential to these functions, are seldom *directly* injured †; but the degree of variety that is observed in the affection, both of these and of the strictly mental powers, and in the permanence of that affection—even when the parts actually injured are the same, is certainly greater than could have been expected.

The sudden attack of symptoms indicating effusion of blood in the brain, is often preceded or followed by fever and other symptoms, which may excite suspicion of inflammation of the brain; and when death takes place within a short time after the hæmorrhage, marks of inflammatory action are often found combined with it, especially effusion of serum into the ventricles, and softening, and other inflammatory appearances (afterwards to be considered) around the effused blood. In some such cases, the clot of blood has probably excited the inflammation, of which the effects appear around it; but in others, there is good reason to believe that the inflammation, and even the softening, took place first, and that the hæmorrhage was consequent on the injury done by the inflammation and its effects, to the coats of the vessels of the part.

When no such amount of disorganization attends the effusion of blood, and when the immediate effects of it on the functions of the brain abate, the changes consequent on it are, that a thin layer of coagulable lymph is thrown out around it, and becomes gradually organized (by the inflammatory action which it excites, and which will be afterwards explained); and that the colouring matter of the blood, and afterwards the rest of the coagulum, are

* See Physiology, p. 112. † Ibid. p. 131.

gradually absorbed from the interior of the preternatural cyst thus formed, which is then left, containing only a yellowish fluid, and afterwards shrinks farther, but never entirely disappears. It is certain that the absorption of the coagulum may be effected in this way within three months after its effusion *. This process is attended with a gradual, but variable, and very seldom complete, recovery of those functions of the brain and nerves which had been impaired.

Effusion of blood into the substance of the lungs is not so common as into the brain; the effusion, in most cases of hæmoptysis, being either into the bronchiæ, or into ulcerated cavities; but it takes place occasionally, and has been accurately described under the title of Apoplexy of the Lungs; and the history of the organic lesion thus effected is important.

It takes place very seldom when there is no other organic disease within the chest; occasionally when there is other disease of the lungs, limiting and obstructing the circulation; but much more frequently when there is disease of the valves on the left side of the heart, and consequent impediment to the movement of the blood there. It is most generally attended with hæmorrhage into the bronchiæ and hæmoptysis, but the amount of that discharge bears no proportion to the extent of the effusion, and sometimes, even in fatal cases, it is altogether awanting.

Besides the hæmoptysis, the effusion of blood into the air-cells must naturally produce sudden dyspnœa, and disorder of the heart's action; and when it is in any considerable quantity at one spot, it must obscure or suppress the natural respiratory murmur, and even make that part of the chest dull on percussion; but these last indications are equally given by various other lesions, to be afterwards mentioned. When, however, they take place rapidly, with sudden dyspnœa, with hæmoptysis, however slight, and especially in a case where there are indications of diseased heart, it may be suspected that they proceed from this cause; and in such cases, the affection is sometimes rapidly fatal.

The appearance in the dead body of the lesion of the

* See ABERCROMBIE's Pathology of the Brain and Spinal Cord, p. 271.

substance of the lung, thus caused, is just that of a coagulum of venous blood filling up a part of the cellular texture. The colour is darker and more uniform, the texture is firmer, and the edge more circumscribed, than in the case of effusions from inflammation.

Blood thus effused into the substance of the lung, does not appear so rapidly to excite inflammation around it, as in the brain; and it is not, therefore, found afterwards to be surrounded with any cyst; but in the lungs, as in the brain, and as in the cellular substance after bruises, such simple effusions of blood, in the perfectly healthy state, appear to be easily absorbed; and judging both from the gradual improvement of the general symptoms after many cases of hæmoptysis, with much dyspnœa (unconnected with phthisis), and from the gradual abatement of the indications of effusion given in such cases by auscultation and percussion *, we may presume, that large coagula of blood may be absorbed from the cellular texture of the lungs, and the functions of the part gradually restored; although the complex and necessarily dangerous nature of most of the cases, where this accident happens, prevents our having many examples of this kind.

Blood is sometimes effused into the substance of the liver, and presents there the same appearance as in the lungs. This happens chiefly when there is congestion of blood in the liver, consequent on disease within the chest. In some instances, also, it is found surrounded by adventitious substance, or softened portions of the glandular substance, as so often happens in the brain; and there are similar reasons, in some such cases, for believing the latter to have been the primary change †. But it is beyond our power to discriminate this change in the substance of the liver before death, from mere turgescence of the bloodvessels, and its other effects, to be afterwards mentioned.

There are some cases, in which coagula of blood, apparently unchanged, are effused from disease into, and gra-

* See Laennec, t. i. p. 383.

† See Andral, Precis. d'Anat Pathol. t. ii. p. 604.

dually distend, the Graafian vesicles in the ovaries; but on what this depends, or whether it can be suspected from any particular symptoms, is uncertain.

In all these situations, as well as in others, where effusions of blood from disease are less common, we have reason to believe, that the blood effused in a few cases becomes an organized mass, and then is gradually converted into different kinds of tumor. This we gather from careful examination of some instances of the kind, where successive effusions have taken place, and are found at the time of death in different stages of their progress *. But as many facts inform us, that blood effused in the perfectly healthy state is readily absorbed, it is obvious that there must be some constitutional peculiarity in the cases, where such transformation of effused blood takes place.

In a much greater number of cases, we have good reason to believe, that congestions of blood lead to the formation of adventitious textures (very little liable to absorption) without any hæmorrhage. But the consideration of all these is more properly delayed, until after we shall have examined the process of inflammation; which is probably the most frequent, and certainly the simplest case of the formation of new products in the animal economy in consequence of disease.

CHAPTER VI.

OF INFLAMMATION.

Inflammation is, on many accounts, the kind of diseased action in the living body, which must occupy the largest share in all pathological discussions. It is that which is the most easily excited by external causes, and is indeed the only one, not necessarily fatal, which we have the means of exciting at pleasure;—its effects, varying exceedingly in different organs, and in different circumstances,

* See *e.g.* ANDRAL, Precis, &c. t. ii. p. 589, & 764.

bear a close resemblance to, and therefore illustrate, and very often combine themselves with, all other modes of diseased action, of which the body is susceptible; under favourable circumstances, it is more completely under the control of remedies than any other; and nevertheless, it is more or less concerned in producing a very large share of the mortality in every part of the world.

SECTION I.

OF THE SYMPTOMS OF INFLAMMATION IN ITS FIRST STAGE.

THE name given to this, as to many other diseased states of the body, expresses nothing as to its essential nature; but the condition to which this name is applied, is in general held to be characterized in any part of the body, by the concurrence of four symptoms, Pain, Swelling, Heat and Redness; symptoms which in external parts at least are easily recognized, without requiring such minute examination as is requisite when we investigate the intimate nature of the disease. Of these the first, although often the most urgent, is in fact the least constant symptom. It is much felt in external inflammations, and in those which affect the outer coverings of the different viscera, but is little felt in some cases of inflammation of the internal membranes, and of the substance of viscera, (perhaps because the parts affected in those cases have fewer nerves of common sensation); and is often excited only by occasional impressions made on the affected parts. The increased temperature, in all probability, exists in every case of inflammation; but it seldom amounts to more than a few degrees; it is of course often concealed from the observer; and as the sensibility to heat is less general over the body than the susceptibility of common sensation, the heat of inflammation is less generally felt by the patient than the pain.

The swelling and redness, although very various in degree, in form, shade of colour, &c. in different cases, and often concealed from view, likewise exist, more or less, in every case of inflammation; and depend, in the first instance, not on any extravasations, but on the distension of the small vessels of the part, and on the passage of the colouring matter of the blood into vessels which had before hardly, if at all, admitted it.

But in order that Inflammation may be clearly distinguished from all other states of any living texture, it is necessary to add to these four characters two other distinctive marks, 1*st*, That the affection should remain fixed in the part for at least some hours;—and, 2*dly*, That unless the affection be speedily and artificially arrested in its course, more or less of *extravasation* should shew itself from the vessels of the part, first, of the serous part of the blood only, but afterwards of a more glutinous fluid, or even of solid matters,—constituting the different inflammatory effusions to be presently considered. This last character, drawn from the local effects rather than the symptoms of Inflammation, is the only sure mark of distinction between this state and mere Congestion of blood, already considered.

These are the characters which appear, on careful consideration of the phenomena of Inflammation in all parts of the body, and after exclusion of all individual and local peculiarities, to be the most uniformly present, and therefore the most essential parts of its history, in its earliest stages. But in many individual cases, these are in a great measure concealed from view; and, in order both to secure the recognition of this condition of individual parts, and also to understand the manner in which it gradually deranges the living actions of other parts, and endangers life, it is necessary to observe minutely and generalize the *effects* which are found by experience to result from it,—*first*, in the condition of the system at large; *secondly*, in the *functions* of individual organs,—either those that take on the diseased action themselves, or those most closely connected with them.

Afterwards we shall consider the effects of inflammation on the structure and properties of the parts that are actually inflamed; which last effects, although often the most important of all, are generally the latest in point of time.

I. The effects of local inflammation on the system at large, may be ranked under two heads, 1. The inflammatory fever, and, 2. The inflammatory state of the blood; both of which very generally attend inflammation of any considerable extent and intensity, and in many cases bear a tolerably uniform proportion to its amount.

Of the combination and succession of symptoms which constitute the state called Fever, it is generally allowed that the most uniform and characteristic are (as stated in CULLEN's definition of Pyrexiæ) a sense of coldness and debility, succeeded by increased heat of skin, and increased frequency of pulse, and by a general derangement of the other functions, of which continued debility of the voluntary muscles is an important part.

The general derangement of functions, during the febrile state, may be thus arranged.

1. During the first, or cold stage (which is almost always observed, and always very important to be marked, as fixing the date of the febrile attack), there is very generally, for a short time, besides the increased frequency of pulse, more or less of depression or debility of the heart's action, and afterwards an increase of the force, and sharpness or quickness of its pulsations, as well as of their frequency, to which change, and the concomitant rise of temperature, the term *Febrile Reaction* is properly applied. In the decline (whether temporary or permanent) of the febrile state, the usual change is in the pulsations becoming softer, or taking place more slowly, as well as becoming less frequent; but there may be many variations in the pulse in the course of fever, before that improvement takes place.

2. The functions of Secretion, Exhalation, and Nutrition, in all parts of the body, are more or less diminished during the febrile state; as appears from the surface being more

parched, or any sweat being temporary, and ineffectual in cooling the surface; from the mouth and tongue being clammy, or dry, with the feeling of thirst; from the appetite being deficient, and digestion imperfect; from the bowels being costive (unless there be a special affection of their mucous membrane); from the urine, sometimes limpid and abundant in the cold stage, soon becoming high coloured, and often turbid and acrid; from the morbid secretion of ulcers, and the morbid exudation of eruptions on the surface, usually abating or disappearing; and from the general wasting of the body.

3. The Respiration is often somewhat irregular, and attended with a sense of anxiety in the cold stage of fever, and becomes always somewhat more frequent than natural, when the febrile reaction is established; and the Heat of the surface becomes greater than natural at the same time, although by no means in exact proportion to the strength and frequency of the pulse.

4. The functions of the Nervous System are very often and variously affected during the febrile state. 1. The *sensations* are generally somewhat blunted in the first stage, when the febrile depression is most strongly marked, and often morbidly increased, at least partially, when the reaction is established. Pains of the back and limbs, and more especially of the head, are also natural accompaniments of the earlier stages of fever, independently of any inflammation in the parts pained. 2. There is in general disinclination to voluntary muscular exertion, and *debility* on attempting it, so important as to be introduced into the general definition of Fever; but there is occasionally, during the febrile state, especially when the more active kind of delirium is present, an excitement and transient morbid energy of voluntary action, even when the circulation has become feeble; and there is more frequently, during some part of the febrile state, irregular and involuntary action of the voluntary muscles, tremors, subsultus tendinum, or even convulsions. 3. There is always, during fever, more or less affection of the *mental faculties;* at first a degree

of torpor, which is often succeeded, when the reaction is established, by a morbid rapidity, and more generally by a morbid energy, of the different mental acts composing the train of thought, with a peculiar difficulty of exerting the power of voluntary attention, from which there naturally results some confusion of thought, and often such hallucination as characterizes delirium *; and this febrile condition of the mental faculties often blends itself with, or passes gradually into coma.

It is chiefly by greater or less predominance of different parts of the combination of symptoms now sketched, that the species of varieties of Fever are distinguished from each other; and that called *Inflammatory Fever*, which most commonly attends inflammation, is especially denoted by the following circumstances. 1. That the febrile reaction of the vascular system is stronger, and more enduring; 2. That there is less derangement of the secretions; and 3. That there is less disorder of the nervous system,—than in those fevers which cannot be so distinctly ascribed to local inflammation as their cause. On the other hand, when the vascular reaction is feebler, or less permanent, the derangement of the secretions more obvious, and the nervous system earlier and more decidedly affected, and especially if that affection shews itself by depression, and tendency to stupor, rather than by more active delirium, the form of fever is said to be *typhoid.*

Several other circumstances, in regard to the Fever which accompanies Inflammation, demand notice.

1. Although the febrile symptoms are generally regarded as the effects of the local inflammation, and accordingly, are generally posterior to some part of the local symptoms in date, yet there are instances,—not only in the case of specific inflammations attending febrile exanthemata (of which the whole pathology is different),—but of simply inflammatory diseases, pneumonia, cynanche tonsillaris, mastodynia, &c. where the febrile attack precedes any local symptoms; and perhaps may contribute to excite them. And there are

* See Physiology, p. 220.

other cases, particularly in irritable constitutions, where the febrile symptoms last for a time (*e. g.* a few days), after the local symptoms of inflammation have subsided, and where these do not recur.

2. Although intense and extensive inflammation is usually attended with high fever, and *vice versa*, yet the proportion is by no means uniform. The degree of febrile symptoms, attending a given extent of inflammation, is generally increased by youth, plethoric habit, and sanguine temperaments, and lessened by the reverse of these. In some, even vigorous constitutions, the degree of fever excited by active inflammation is slight; and there are some organs, as the tonsils, the inflammation of which is frequently attended with a degree of fever quite disproportioned to their size, or importance in the system.

3. Although the febrile symptoms attending the earlier stage of inflammation have generally the character of inflammatory fever, as above distinguished, yet deviations from this type of fever are frequently seen, and may be referred to two heads, as they depend either, *first*, on the peculiarity of the part affected, or *secondly*, on the action of some other cause influencing the system simultaneously with the inflammation itself.

Of the modification of the fever of inflammation by the part affected, the most important instance is in the case of inflammation of the Stomach and Intestines; where the fever is characterized by an early and often very rapid depression of the heart's action, strongly resembling, and evidently illustrated by, the effect on the heart's action of violent injuries of the abdomen, which was already considered. An effect somewhat similar results from active inflammation of the kidneys, uterus, bladder, and larger joints.

The modification of the fever of inflammation by the action of a concurrent cause affecting the system, is remarkably seen, 1. In the case of inflammation from an injury which has given a violent shock or Concussion; 2. In the case of inflammation occurring in a constitution in which the nervous system has been habitually influenced by peculiar Stimuli, such as alkohol taken in excess; 3. In the case of inflammation attended with the introduction of peculiar animal Poisons into the system.

In all these cases, the fever attending inflammation shews a less forcible and less enduring reaction, and is attended with more derangement, both of the secretions and of the functions of the nervous system, than is usual; and therefore assumes, more or less exactly, the form to which the term *typhoid* is applied.

The state of the Blood which usually attends inflammation, of considerable intensity, is that in which it shews the Buffy Coat, *i. e.* in which a separation, more or less complete, of the fibrin from the colouring matter of the crassamentum takes place spontaneously during coagulation.

It was formerly stated, that this separation does not depend on the circumstance of slow coagulation of the blood, and consequent subsidence of the colouring matter, but that there appears to be in this state a repulsion between the particles of the fibrin and the red matter; causing them to separate from each other before the fibrin has become solid, or in films so thin, that they separate laterally instead of vertically. This repulsion may or may not coexist with a strong aggregation of the particles of the fibrin among themselves; but in most cases of violent inflammation there is both the complete separation and the strong aggregation; the effect of which is a buffy coat, both thick and strong, *i. e.* contracted.

A thin buffy coat, implying imperfect separation of the fibrin from the colouring matter, usually attends cases of slight or very partial inflammation only. A thick, but loose, flabby buffy coat, implying more separation from the colouring matter, but weak aggregation of the particles of fibrin among themselves, is generally observed where another cause of general disease of the system (*e. g.* contagious fever) coexists with local inflammation. It appears from the observations of GENDRIN, that the proportion of albumen in the serum of sizy blood, and especially in that part of the serum which is entangled in the buffy coat itself, is much greater than in the serum of healthy blood.

The buffy coat is seen on the blood in some persons, chiefly of a plethoric habit, without inflammatory disease existing in them, and is often found in the blood of pregnant women, but in these cases it is seldom thick or very firm. The formation of the buffy coat, though not dependent on slow coagulation, is of course facilitated by that circumstance; and when coagulation is much hastened, a complete separation of the parts of the crassamentum cannot take place. Hence blood which is drawn in a small stream, or spread over a flat surface, as its coagulation takes place quickly, is not apt to shew the buffy coat; and this is probably also the reason why blood drawn from weakened or fainting persons, which is more serous, and coagulates more quickly than most venous blood, seldom shews the buffy coat; and why the last drawn blood in a bleeding on account of inflammation, is usually the least sizy.

In a few cases the last drawn blood is the most sizy, and that especially when the pulse, previously depressed, becomes fuller and stronger by reason of the bleeding; probably because the capillary circulation becoming more free, and more serum being admitted there, the blood in the large veins then becomes less serous, and the coagulation takes place more slowly *.

Inflammation, even when violent, generally lasts for a day or two, before it causes the blood to shew the buffy coat. It is not yet ascertained whether the blood in the veins leading from an inflamed part, becomes sizy sooner than that in other veins of the body; but microscopical observations on the changes which take place in the blood in the capillary vessels of an inflamed part render this supposition probable.

II. The concurrence of the symptoms already considered is generally sufficient to indicate the existence of inflammation, even when seated in internal parts; but there are al-

* See Physiology, p. 46.

most always more local symptoms, indicating a peculiar derangement of the function of some particular organ, which enables us more decidedly to fix on the seat of the inflammation. These local symptoms are such as denote *alteration of the function*, either of the part that is inflamed, or of an adjoining part, or of a part connected with it in function, or by known sympathies, although not adjacent.

1. When any internal part is inflamed, its own functions are in general perceptibly, though somewhat variously altered. Thus inflammation of the heart and large arteries causes generally preternatural, and sometimes irregular impulse of the heart, inflammation of the lungs causes dyspnœa, and soon alters the sound produced by the air entering the lungs; inflammation of the serous or synovial membranes causes increase and alteration of the serum naturally effused into these cavities, which often becomes obvious to the observer; inflammation of the mucous membrane of the air-passages or bowels, leads to increased and altered secretions there, and consequent *profluvia;* inflammation of the serous, or perhaps more especially of the muscular coat of the bowels causes costiveness; inflammation of the kidneys alters the composition of the urine, that of the bladder renders its excretion difficult and painful; inflammation of the brain leads generally to derangement of some part of its functions, to palsy, spasm, delirium, or coma; inflammation of the eye or ear augments the sensibility to light or sound, while inflammation of the lining membrane of the nose blunts the sensibility to smells; inflammation of muscles or their coverings, or of motor nerves, greatly impedes or wholly prevents the motion of the parts they are destined to move.

But there are many cases of important, at least apparent exception to this rule, especially in the case of those internal viscera, the whole of which is not required for the outward manifestation of their functions. Thus a portion of the liver may be inflamed, without the flow of bile being perceptibly altered; and experience shews, that portions of the lungs, and of the brain, may be inflamed, without the usual alteration of the functions of these parts being observed.

2. Alteration of the functions of parts adjoining those that are actually inflamed, is seen in the painful and difficult deglutition caused by inflamed parotids, tonsils, or larynx, in the painful and difficult descent of the diaphragm, when the peritoneum or liver is inflamed, &c.

3. When inflammation of the liver causes pain of the right shoulder, inflammation of the bladder pain at the point of the urethra, inflammation of the spinal cord pain stretching round the abdomen, or inflammation of the hip-joint pain at the knee, we have examples of the phenomenon considered formerly under the name of Sympathetic Sensation: And when inflammation of the brain, liver, stomach, bowels (especially their serous coat), kidneys or bladder, causes vomiting, the diaphragm and abdominal muscles take on a Sympathetic Action; the sensations which excite them to the act of vomiting being excitable by irritation of all these parts. Again, when inflammation of the mucous membrane of the trachea or bronchiæ causes violent and painful cough, when that of the colon or rectum causes painful and ineffectual tenesmus, or that of the mucous coat of the bladder causes strangury, the actions excited are only an excessive degree of those Sympathetic Actions of various and sometimes distant muscles, which the natural sensations of these parts excite, for useful and important purposes. And in all these cases, the sympathetic phenomena, when coexistent with other symptoms of inflammation, are an important indication of its seat.

In concluding this sketch of the symptoms by which inflammation is distinguished in its earliest, and, in a practical view, its most important stage, it is right to notice the circumstances in which it is most common to observe symptoms nearly resembling those of inflammation, although it does not exist; and again, those in which it has been often found that internal inflammations may exist, without their usual indications being distinctly perceived.

Pains in the most sentient parts of the body, equally intense as those of inflammation, occur pretty frequently, especially in persons of nervous temperament, and in those liable to hysteria and hypochondriasis, without being connected either with inflammation or with any perceptible change of structure. In women, in whom the sanguiferous system is in general easily excited, a part at least of the symptoms of general fever will often accompany such nervous pains. In young persons especially, congestions of blood often leading to hæmorrhages, and which will be afterwards mentioned as specifically distinct from inflammations, will often, for a time, excite very similar symptoms, both general and local. And in children, fever is easily excited, both by inflammation and other kinds of local diseased action, and bears no fixed proportion to the degree of local disease from which it may originate.

On the other hand, the cases in which inflammation is attended with least of its usual symptoms, either local or general, are chiefly those in which it affects internal parts, during a state of great debility and emaciation, *e. g.* in convalescents from acute diseases, especially if advanced in life*. And when occurring in the course of a disease in which the sensibility is greatly impaired, as in continued fevers, some of the symptoms of inflammation are much concealed. It is in these circumstances that the most striking examples of *latent inflammations*, requiring peculiar attention in order that they may be recognised, have been observed.

SECTION II.

OF THE LOCAL EFFECTS AND TERMINATIONS OF INFLAMMATION, AND THE SYMPTOMS THENCE RESULTING.

In strict language, there are only two *terminations* of the inflamed state of the vessels of any part, viz. that by Resolution, or return of these vessels to their previous condition, and that by Mortification or sloughing, *i. e* death of

* Les pleurisies les plus graves sont ces des sujets les plus debiles, des cachectiques, des hommes affaiblis par des exces quelconques, par la syphilis, la goutte, le scorbut, le cancer, et surtout par l'age."—Laennec.

the part. But it has been already stated, that different effusions from the inflamed vessels take place in almost every case of inflammation; these effusions very often continue, and sometimes become the seat of farther morbid changes, after the inflammation has subsided or been resolved; and hence, these effects of inflammation have often been called terminations of it; although most generally the resolution of the inflammation does not take place till some time after these effects have appeared.

I. In regard to the termination of inflammation by resolution, (which term is applied whenever the effusions from inflammation are so slight and transient as to cause little or no inconvenience and demand no treatment), several facts demand attention.

1. In all parts of the body, the spontaneous tendency to this termination of inflammation is strongly marked, (whether other consequences result from the inflammation or not) although the time within which this tendency begins to shew itself, may vary from a few hours to many days or weeks, according to the intensity of the inflammation, and according to various circumstances which will be stated under the head of Varieties of Inflammation.

2. When inflammation is established at any part of the body, it very generally extends itself more or less to the neighbouring parts, before subsiding; and frequently the decline of the inflammation, in the part first affected, is followed by an extension of it in the surrounding parts. This extension is more obvious in some varieties of inflammation, to be afterwards described, than in others. The extension of inflammation takes place more rapidly along any one texture, than from one texture to another immediately adjoining; *e. g.* more readily along the peritonæum, or mucous membrane of the bowels, than from either of these to the other; more readily along the membrane lining the bronchiæ, or along the pleuræ, than from the bronchiæ to the substance of the lungs, or from the pleura costalis outwards; although intense inflammation may spread rapidly through various textures.

It is very remarkable, that in spreading over a single texture, such as the peritoneum covering folds of intestine, inflammation evidently extends itself, not only along continuous surfaces, but to surfaces adjoining to, or in contact with, that first affected, although not continuous with it, or united with it by any material bond of union.

3. In some inflammatory diseases there is a peculiar tendency of distant parts (generally, however, consisting of the same or similar textures) to become inflamed, and run the usual course of inflammation successively, as in gout, rheumatism, cynanche tonsillaris, or inflammation of the testes.

4. In a few cases we observe a sudden and unusual resolution of inflammation in a part first affected, followed immediately by its appearance in a distant part, to which the term *metastasis* is properly applied. This occurs chiefly, perhaps exclusively, in the case of those inflammations which we shall afterwards describe as *specific*, *i. e.* as presenting decided marks of distinction, from the inflammations seen in other instances in the same parts or textures, *e. g.* in Gout, Rheumatism, Erysipelas, Gonorrhœa, Cynanche parotidæa.

II. The first effect of inflammation in any texture, often perceptible in the living body, and more generally in the dead body, is Congestion of blood in the small vessels, with some Effusion of the serous part of the blood. Where the symptoms of inflammation, during life, have been well marked, these appearances may in some cases be all that may be found after death. But if no farther effects of inflammation are observed, these are not sufficient of themselves to entitle us to affirm that the part has been inflamed; as is sufficiently proved by what has been formerly said of the difficulty of judging even of the congestions of blood having taken place at any distance of time before death, from such appearances only.

There is probably a distinction between any appearances resulting from mere congestion of blood, and those of genuine inflammation in its early stage, in the colour of the affected parts, which in the latter case is more florid; but this difference is to be depended on only if the parts are examined within a very short time after death.

The very early effusion of serum from inflammation is most distinctly seen in certain cases of inflammation affecting the skin, and in the inflammation of serous and synovial membranes, and of the substance of the lungs, where it takes place almost from the very commencement. The effusion of serum on the pleura causes in a very short time the dull sound on percussion, and the absence of respiratory murmur, at that part of the chest, and in some such cases, while the quantity effused is still small, the modification of the voice, heard when the ear is applied to that spot, and termed Œgophony, may be distinctly perceived. The effusion of serum into the cells of the lungs causes the modification of the respiratory murmur called Râle crepitant, which, however, is a symptom of short duration, and is followed by total suppression of the murmur. The same effusion takes place behind the mucous membrane of the air passages, in cases of œdema of the glottis, consequent on inflammation there, and often rapidly fatal; and to the same cause we must ascribe the increased quantity, diminished consistency, and altered qualities, of the secretion of the mucous membranes soon after the commencement of inflammation in them; and the diminished cohesion, or softening, from incipient inflammation in these membranes, and in most of the parenchymatous viscera,—the brain, liver or kidneys. Part of the swelling in inflammation of the cellular texture is owing to the same effusion, and there are some cases in which œdema, extending to some distance from the inflamed part, is consequent on inflammation of the cellular texture. But the serous effusions of the first stage of true inflammation are *more limited in extent* than dropsical effusions, and are quickly followed by other exudations. No great extent of dropsical effusion is ever the effect of local inflammation only; although we shall afterwards find that different inflammatory diseases, by the obstructions to the free movement of the blood which they ultimately produce or aggravate, frequently assist in the production of dropsy.

III. As inflammation advances, it would appear that the fluid effused from the vessels becomes of a thicker or more gelatinous consistence, and there is soon a distinct effusion of the coagulable lymph of the blood, characterizing the *Adhesive stage* of the inflammation.

This effect of inflammation is most distinctly seen in the formation of adventitious membranes, which are frequently found on the free surface of the serous membranes when inflamed, and by which the opposing parts of that surface, in the thorax or abdomen, are often united. But a similar deposit is often seen on the surface of the skin, from intense inflammation and vesication, and often likewise succeeds inflammation of the mucous membranes in some parts of the body, as in the larynx and trachea in croup, or in parts of the great intestines in dysentery. It is by a similar exudation of coagulable lymph on the surface, or into the interstices of textures, that either the membranes already mentioned, or the fibrous or synovial membranes, become thickened and corrugated; that the cornea becomes white and opaque, or the iris partially loaded, discoloured and irregular; that the cellular substance in any part becomes dense and hard, in common phlegmonous inflammation, and in many cases of erysipelas also; that the spongy texture of the lungs becomes mottled with reddish or whitish granulations, in what is usually called hepatisation from peripneumony; and that enlargement and condensation of other of the parenchymatous vicera result from their inflammation, and precede the other consequences of that process. Where the bloodvessels or valves connected with them are themselves inflamed, a similar exudation thickens these coats, and often lines part of their inner surface, and obstructs the flow of blood along them. And in all textures, when ruptured or lacerated, this kind of effusion, consequent on the inflammation excited, is the most essential step towards the reparation of the injury.

The lymph thrown out is probably always at first semi-fluid, and is soft and flocculent for some time, but the serous part of the effusion is soon absorbed, and, if the inflammation proceeds no farther than this stage, the fibrin effu-sed becomes gradually of firmer consistence, and soon shrinks remarkably in bulk. From this cause, there is frequently much hardening of various parts of the body, as of the skin and other membranes, and of different viscera, consequent on their inflammation, after it has lasted some time, and especially when it has not been very intense.

In some cases, much of the colouring matter of the blood is thrown out with the coagulable lymph on inflamed surfaces. This takes place especially in the cells of the lungs in peripneumony, on the serous membranes of the chest in certain pleurisies, and on the mucous membrane of the great intestines in dysentery. And in most cases, when the effusion of lymph has been considerable, reddish striæ are seen in it after a time; and these subsequently assume the appearance of small vessels, stretching across the effused lymph, generally in a pretty straight direction, containing fluid blood, and communicating freely with the vessels of the textures originally inflamed. The power of forming these vessels in the lymph effused, is the vital property to which the term *plasticity* has been applied. When this is the case, the matter effused has the appearance and properties of condensed cellular substance, so that the ultimate result of this *adhesive inflammation* is to make this addition to the organized textures of the body.

There is very great variety in the length of time requisite for these effects of inflammation to take place. There are many instances of intense inflammation, in which much solid lymph is thrown out, within thirty-six hours from the commencement of inflammation; aud cases have been quoted, in which it was thought that the vascular organization of such lymph has been effected within that time, but in general it would seem that several days are necessary for this last process.

It is by this inflammatory exudation, and subsequent organization of lymph, that the permanent adhesion of surfaces which have been inflamed is effected,—that parts, recently removed from the living body, may be reunited to any surface, which is in the requisite stage of inflammation,—that permanent additions are often made, by attacks of inflammation, to the thickness or bulk of membranes and other textures, and that wounds are healed, and ulcers filled up, and all breaches of texture permanently repaired; a part of the matter which is effused in these last cases gradually assuming the appearance and properties of the texture which has been removed. The conditions most favourable to this effect of inflammation, are a moderate degree of the inflammation, a certain vigour of vascular action, seclusion from air, and the absence of all other irritations.

Coagula of entire blood, effused on living parts, have appeared in some cases to become vascular and organized, but certainly are in general easily absorbed again, and do not undergo that change nearly so readily as the effusions of lymph from inflammation.

Various facts prove, not only in the case of injury of bone, but likewise of some of the soft textures, (as the skin and mucous membranes), that the matter which thus assumes the properties, and repairs the losses of the texture that has been injured, is thrown out not only by the vessels of that texture itself, but likewise in part by those of adjoining textures, which have taken on this form of inflammation. In cases of disease it probably often happens, that the matter thus thrown out by inflammation, instead of assimilating itself to the texture which has been injured, either acquires the properties of other textures, or degenerates into structures which differ from any found in the healthy body.

IV. The next effect of inflammation is Suppuration or the effusion of Pus, which is at once distinguished by its opacity, fluidity, and yellowish-white colour, and appears, on minute examination, to contain great numbers of globules, somewhat larger than those of the blood, and shewing as little tendency to cohere together as those of the blood in the living body do.

In some instances, pus gradually mixes itself with the effusion of serum in inflamed parts, without other change; but most generally, the formation of pus is preceded both by effusion of serum and of coagulable lymph; and the purulent effusion is bounded more or less definitely by the lymph thrown out around it, so that if the abscess forming be near the surface, fluctuation becomes perceptible in it; as in the case of common abscesses in the cellular membrane, where the pus is formed in the centre of the part previously hardened by effused lymph; or in the case of pustular eruptions (such as smallpox) on the skin, which are set on a hardened base, formed chiefly by effused lymph.

In the advanced stages of inflammation of the skin, cellular membrane, fibrous and synovial membranes, serous membranes of the head, chest or abdomen, parenchymatous viscera, and bloodvessels, effusions of pus are very generally found mixed with the adhesive lymph that has been thrown out, but in very various modes and proportions in different cases, and in inflammation of different textures. On the skin and serous membranes it is often thrown out for a length of time, and in much larger quantity than the lymph; in the substance of the viscera it is formed more sparingly, and when formed, seems to distend and narrow the cysts of lymph by which it is surrounded more gradually. In the cellular texture of the lungs it is seldom formed, in consequence of active inflammation, into circumscribed abscesses, but is gradually infiltrated or diffused through the whole inflamed part. On the mucous membranes of the air-passages (including the tunica conjunctiva of the eye), and urinary passages only, it is frequently effused and mixed with the other secretions of the parts, even from simple or healthy inflammation, without any previous distinct exudation of plastic lymph. In all other textures, when the effusion from inflammation is puriform only, it may probably be concluded that the inflammation is of a peculiar or specific character.

The length of time requisite for inflammation to last before pus is distinctly formed, varies from a few hours (in the case of the urethra) to several weeks. The length of time that suppuration, once established, may continue in a part, is still more various; and the intensity of the inflammatory symptoms that may precede or accompany the suppuration, bears no fixed proportion to its amount or duration.

When the formation of pus ceases, in a circumscribed abscess, the cavity is gradually filled up, partly by the surrounding parts that had been compressed regaining their previous form and bulk, and partly by the organization and subsequent contraction of portions of the lymph thrown out along with or after the pus, and which take the form of granulations.

The effusions of adhesive plastic lymph, and of fluid pus, from inflammation, are very distinct in their progress and effects, but in their origin it is obvious that they are very closely allied. In cases of pleurisy or peritonitis, detached flakes of lymph, mingling with the serous effusion, appear to constitute the first step to the formation of pus; and in rapidly fatal cases of various inflammatory diseases, the glutinous exudation that is found often appears to be intermediate betwixt lymph and pus. On the surface of the body, it has been observed that the character of the inflammatory exudation is much determined by the circumstance of exposure to the air, the same surface which throws out pus when exposed, forming plastic lymph when protected from the air. And the same influence of exposure to air, in promoting the formation of pus, may be observed in comparing the effect of inflammation of the free surface of the mucous membrane of the urethra, in gonorrhœa, with that of the attached surface of the same membrane, which causes exudation of lymph, and so leads to stricture. So also that inflammation of the pleura, which is consequent on admission of air into the cavity of the chest, leads, more surely than any other, to copious purulent effusion, or empyema; and in the later stages of pneumonia, if the patient live so long, much of the lymph thrown out into the air-cells appears to be converted into pus, constituting the purulent infiltration which has been described as the *third* effect of inflammation there.

In those instances, and in those parts in which the effusion of pus is not distinctly bounded and circumscribed by effused lymph, its effect is naturally to soften the textures in which it occurs, as is seen especially in the purulent infiltration of the lungs, and in the yellow softening of the brain; sometimes, also, in purulent infiltration into the subcutaneous cellular membrane, or into that which unites the coats of the intestines. Such changes are generally the effect of a longer continuance of inflammation, than the softening or serous infiltration only; but they denote a shorter and more violent inflammatory action than the chronic induration of textures by effused lymph, already mentioned. That both the softening, with infiltration of reddish or brownish serum, and the softening with infiltration of yellowish or greenish pus, in nervous matter, are effects of inflammation, appears most clearly from this, that they may clearly and speedily result from mechanical injury.

V. The inflammatory effusions, and especially that of pus, are always attended with more or less of *Absorption*, first of the serum originally effused, and afterwards of the lymph which surrounds and limits the suppuration, and of part of the purulent matter itself. The maturation of a pustule of small-pox, or other cutaneous suppuration, and the enlargement of the cavity of an abscess, and its progress towards the surface of the body (the intervening textures, and ultimately the skin, disappearing to make way for it), sufficiently illustrate the amount of absorption which necessarily attends this effect of inflammation. But very frequently the absorption, both of the lymph effused, and of the surrounding textures, that coexists with the advanced stages of inflammation, takes place in a greater degree, and more irregularly, than is requisite for any useful purpose, and the process is then said to be attended by Ulceration.

The destruction of the solids of the body by ulceration takes place with very different rapidity in different textures, and in different circumstances; and it is always obvious, that the intensity of the preceding inflammation, and the extent of the other effects resulting from it, are by no means the only conditions which determine the degree of the ulceration. It is common on the surface of the body, both in the skin and cellular membrane, and common in the mucous membrane of the alimentary canal,—including the fauces. It is common also in bones, and in cartilages that have had osseous matter morbidly deposited in them by an inflammatory action; in the lungs, and in the inner membrane of arteries; but it is not so clearly the effect of mere inflammation and suppuration in these cases. It takes place, in all parts of the body, more readily in solids recently formed by inflammatory exudation, than in any of the original textures. There are some textures, again, which seldom ulcerate, and often resist and limit the extension of that process; particularly the fibrous texture in all its forms, the serous membranes, and the outer coat of arteries. These peculiarities are often observed, and have important consequences in disease.

The occurrence of ulceration in consequence of inflammation, is very often determined by causes which are sufficiently understood, especially by such as stimulate and irritate parts already inflamed (as is done by the continued contact of any foreign body); and such as enfeeble the circulation, either generally or locally, before and during the excitement of inflammation. There are certain specific kinds of inflammation, to be mentioned afterwards, in which the tendency to ulceration is greater, and more uniform, than in simple inflammation.

As ulceration, consequent on inflammation, is very generally preceded by effusion of plastic lymph, so it is attended by more or less of that effusion which forms the little vascular and organized eminences, called Granulations. When, therefore, inflammation has advanced to this stage, it has established three vital processes, which go on simultaneously, and all of which are new to the part that has become inflamed,—the exudation of plastic lymph, the effusion of pus, and the ulcerative absorption. By the irregular growth of the granulations, and the irregular or varying extent of the ulcerative absorption, the surface of an ulcer is necessarily rendered uneven; and ultimately the healing of the ulcer is effected by the process of exudation and organization of lymph prevailing over the contrary process of destruction of solids.

The degree in which these opposite processes shew themselves, either over the surface or in any part of the ulcer, admits of great variety. When the wasting by ulcerative absorption is most rapid, and there is little or no renovation of solid matter, the ulcer is said to be *phagedenic;* when the ulceration is attended with partial mortification, portions of the solid textures separating entire from the rest, the case is one of *sloughing* ulcer; when the process goes on slowly, the lymph thrown out at the base and around the edge of the ulcer becomes hardened, and the granulations on its surface are deficient, and the ulcer is said to be *callous*, or indolent; and again, when the granulations are larger and softer than usual, and require to be repressed, in order that the healing of the sore may be effected, we have the variety called the *fungous* ulcer. All these varieties may occur in ulceration following the usual and simple form of inflammation.

There is a very important difference between the morbid actions of Suppuration and Ulceration, once fairly established, and the morbid action of Inflammation not yet advanced beyond the earlier effusions of serum and lymph, as to the degree in which these actions depend on the quantity of blood that visits the parts affected;—the process of inflammation, in its earlier stages, being very certainly restrained or arrested by diminution in that quantity; whereas the loss of blood, although it often prevents the extension of suppuration and ulceration to parts not yet affected, is generally found ineffectual in checking the formation of pus, where that has been already established; and is often, as may be judged from what has been said as to granulations, unfavourable to the healing of ulcers.

There are a few cases where inflammation, (*e. g.* of the testis, or of muscular fibres), after it has caused some effusion of lymph, is followed, not by the ulcerative absorption now considered, but by a simple increase of the natural absorption of the part, producing mere wasting.

VI. The termination of inflammation in Gangrene, and then in complete Sphacelus, or in Mortification, is denoted by the part inflamed becoming gradually cold and insensible, and the circulation in it ceasing. This change generally takes place in the parts that had been most inflamed, while the surrounding parts are still in a state of active inflammation. It is usually attended with softness and flaccidity of the affected parts, with a gradual change of colour to purple and then to black, and ultimately with putrescence and a cadaverous smell. But in some cases, chiefly of slow progress, as in the gangrene from the use of diseased grain, the parts affected are hard and dry, and hardly become putrid; and in many cases mortification, especially when partial, is unattended with blackness. Gangrene on the surface of the body often takes place in connexion with serous effusion, and the vesicles formed are then coloured purple or black.

Mortification is observed in consequence of inflammation frequently in the different textures on the surface of the body, and in the mucous membrane of the alimentary canal, occasionally in the serous membrane of the abdomen, and in the substance of the lungs; rarely in other internal organs, excepting in cases of inflammation from injury. Mortification of the bones, either in the partial form termed Exfoliation, or in the more general form called Necrosis, is a common effect of inflammation, especially about the central parts of the long bones; but the whole process is very slow in that texture.

This effect of inflammation is much less uniform, in any texture, than the others, occurring in very various degrees, and at very various periods, from the commencement of the disease, in different cases; and hence there is a manifest presumption that its occurrence is determined by other conditions in the state of the patient, besides the existence or the intensity of the inflammation. Accordingly, various causes have been observed to increase remarkably the disposition to this effect,—the general tendency of all which may be said to be, to weaken the circulation in the affected part.

Thus inflammation, *e. g.* that from the irritation of a blister, at a distance from the heart, is more apt to run to gangrene in a feeble habit, than on the chest. The depending position of a part, impeding the action of blood from it; a ligature compressing the veins leading from it, or a fibrous membrane firmly enveloping it, may give the tendency to gangrene from its inflammation; and the same tendency is often observed, if the arteries leading to a part are so injured by disease as to become rigid, and unable to maintain a vigorous circulation through it.

The inflammation excited by a violent stroke or injury, by heat, by cold, by electricity, and by certain poisons (particularly animal poisons), is very apt to go to gangrene, if these causes, at the same time that they excited the inflammation, have had the effect of manifestly weakening the circulation; as in what has been called traumatic gangrene succeeding violent concussions, in severe burns, or frost-bite, in the bites of venomous serpents, and in the effects of some poisoned wounds received in dissection. In like manner, any inflammation, external or internal, which may attend or immediately succeed a contagious febrile disease, where the circulation is much weakened,—typhoid fever, small-pox, scarlatina, or measles, the worst forms of erysipelas or dysentery, the yellow-fever, or the plague,—is more apt than other inflammations to run to gangrene. The same is true of inflammation on the surface of the body co-existing with dropsy or with palsy, when the circulation there is feeble.

Inflammation affecting the stomach and intestines has more tendency to gangrene than in any other internal part; and this co-exists with the peculiar depression of the circulation, which characterizes the fever attending inflammation of these parts.

In some instances, the tendency to this termination of inflammation would seem to depend on no other cause than unusual intensity of the inflammation, as in the case of the Egyptian or gonorrhœal ophthalmia, tending to sloughing of the cornea, or of unusually violent syphilitic inflammation of the genitals; but it is seldom that extensive gangrene can be referred to this cause only.

When Gangrene has commenced in any part, it must be expected to extend somewhat, and sometimes it spreads very rapidly, especially when the body is under the influence of a powerful cause of weakness or depression. But in more favourable cases, a line is gradually formed along or around the parts in the state of gangrene, which feels hard, and is in a state of adhesive inflammation. At this line there is an effusion, first of serum, then of pus, and ulceration is established, by which a fissure is formed between the living and dead parts, and the latter are loosened and detached. Thus the adhesive inflammation, followed by suppuration and ulceration, sets bounds to the extension of gangrene. The adhesive inflammation extends to the vessels of the part, which are closed by lymph effused from their coats at the point of separation of the living matter from the dead; and it is to this circumstance, rather than to the coagulation of the blood which stagnates in the vessels, that we must ascribe the frequent separation of large sloughs, without hæmorrhage from the divided arteries.

When Inflammation affects the internal parts of the body, and the changes consequent on it are concealed from view, it is of great importance to ascertain the time, when the different effects now considered have already resulted from it, and become so important as to demand the chief attention of the practitioner. This period, of course, cannot be accurately defined, because some of the effects of inflammation commence almost from the beginning of the diseased action; and the activity of the inflammation is by no means necessarily at an end after its effects have become obvious and considerable; but it is always possible and important to mark the transition from that stage of any inflammatory disease, where the symptoms of the inflammatory action itself are the most prominent, to that stage where the most urgent symptoms depend on effects already produced by the inflammation, and, for the time at least, irremediable.

If there has been a well-marked attack of inflammatory disease, and it has proceeded, unchecked by any adequate treatment, for a few days, it may always be presumed, that its effects have already become of such amount, as to embarrass materially the functions of the parts affected, even if the inflammation were itself at an end. And the most general indication that can be observed in inflammatory diseases, of their having advanced to this stage, is the continuance or increase of those symptoms which denote derangement of the functions of the parts, after the febrile action of the circulating system has become enfeebled, or undergone a material change.

Thus, in the case of inflammation within the Cranium, if the delirium, or tendency to coma, continue and increase after the pulse has become slow or irregular, and the skin cool, there is much probability of effusion of serum having already taken place, whether with or without other disorganization.

In the case of inflammation of the Air-passages, or the substance or covering of the Lungs, if the affection of the breathing thence resulting continues or increases, while the pulse becomes somewhat feebler, and the heat of skin is somewhat lowered, then it may be a general presumption, that the state of the breathing depends more on the effects of inflammation already produced, than on inflammatory action itself. But more precise information may in this case be very often obtained.

When there is any considerable inflammatory effusion between the Pleura pulmonalis and costalis, on one side of the chest, the most characteristic effects are, that the expansion of all that side of the chest in inspiration becomes imperfect, and there is in general difficulty of lying on the other side,—that the sound produced by percussion of it becomes dull,—and the respiratory murmur in it becomes faint or inaudible. When a large portion of the substance of one Lung becomes condensed by inflammation, the same changes are observed, but take place more gradually, and the two last less completely; and besides, in this case the expectoration is more copious, and becomes viscid, generally stained with blood, and ultimately often puriform. When inflammation within the chest is confined to the mucous membrane of the Bronchiæ, the expectoration is often still more copious, but its changes take place more slowly, and it is hardly ever stained so completely with blood; the natural respiratory murmur is obscured by the râles produced by the thickening of the membrane, and increased effusion of mucus upon it; and the indications above stated of effusion exterior to the lungs, or condensation of their substance, are wanting.

When either the external covering, or internal lining, of the Heart has been inflamed, if the general febrile symptoms either decline, or undergo a manifest change, by increase of debility, while the action of the heart continues preternaturally strong, and is felt farther over the chest than natural, or its sounds altered from the natural condition,—the presumption is, that there is already either inflammatory effusion on the surface of the heart, or that change on some of the valves, or lining membrane of the aorta, of which the essential characters are, increased thickness, rigidity, and corrugation. And in either case the alteration of structure effected in the heart, and consequent impediment to its functions, soon becomes obvious, by the perceptible enlargement of its size, produced by its preternatural distention and irritation.

Again, when either the external or internal coat of the Intestines has been inflamed, in the different forms of enteritis and dysentery,—the recurrence of vomiting, especially if its character change, and approach to ileus,—the continuance of constipation, especially if attended with increased flatulent distention of the abdomen,—or the conversion of dysenteric symptoms into intractable diarrhœa, —while the strength of the heart's action, and the heat of the surface, undergo a manifest abatement,—generally indicate that inflammatory effusion on the serous coat, or ulceration on the mucous coat, has already taken place, and will necessarily continue for a time to derange the functions of the bowels; although in this case the degree of danger that may exist is not strictly dependent on that derangement of function.

There are some instances, where more sudden and striking alterations of the local symptoms consequent on inflammation take place, and indicate with almost absolute certainty certain consequences of ulceration.

Of this the following are the most striking examples.

1. A sudden attack of Pleurisy, succeeding the symptoms of ulceration of the Lung, and followed by indications, both of fluid effusion, and of air, collecting in the side of the chest,—*i. e.* by the sound of fluctuation heard on agitation of the body, the modification of stethoscopic sounds called the tintement metallique, and the dull sound on percussion in part of the side of the chest, the clear sound in another part, and the absence of respiratory murmur in both. This denotes, that an ulcer in the lungs has perforated the pleura, allowed the escape of air into the cavity of the chest, and excited pleurisy with pneumo-thorax.

2. A similar state of the symptoms in one side of the chest, and a sudden expectoration of pus, succeeding to the symptoms, not of ulcerated lung, but of Pleurisy and pleuritic effusion, in that side; and implying that ulceration has begun on the surface of the lung, where there has been previously inflammation and effused lymph, and penetrated inwards to the bronchiæ.

3. The discharge of purulent matter by expectoration, by vomiting, or by stool, after the symptoms exciting suspicion of inflammation and suppuration of the Liver,—implying, that suppuration of the liver, and adhesion to neighbouring parts, have been followed by ulceration, and escape of the effused pus, through the parts that have adhered.

4. The symptoms of violent and acute Peritonitis suddenly supervening on the indications (often obscure) of more chronic inflammation and its effects in the mucous membrane of the stomach or intestines; which implies, that the coats of the alimentary canal have been somewhere perforated by ulceration, and its contents effused into the cavity of the abdomen.

Farther, the alteration which takes place after a time on the symptoms of the general Fever, accompanying internal inflammation in its advanced stages, is often to a certain degree characteristic of the kind of effect that has resulted from the inflammation.

In particular, the commencement of Suppuration is often marked by rigors, and irregular febrile attacks, which soon pass into the state of Hectic Fever, more or less distinctly defined; and when this is established, it continues during the processes of suppuration and ulceration, and is marked by the evening exacerbations (sometimes two exacerbations daily) and morning sweats, followed by abatement, without solution of the fever,—by a slight degree only of the thirst, anorexia, or other affections of the organic functions, usual in fevers,—by the absence of delirium, or other derangement of the functions of the nervous system, until the very last stage,—by the long continuance of the disease, and progressive emaciation and debility,—and generally towards the end of fatal cases by diarrhœa, with florid and often aphthous tongue and throat, which is usually found on dissection to have been connected with ulceration in the mucous membrane, chiefly of the small intestines.

This state of hectic fever is by no means distinctly marked in every case where extensive suppuration and ulceration succeed to inflammation; but in young persons, of irritable constitutions, it may generally be observed. It is often established in such constitutions, by long continued diseased actions, which, although generally combined with or succeeding to inflammation, are not to be considered as simply its effects, particularly the growth and progress of tubercles, afterwards to be considered. In a few cases it is produced by causes acting on the system for a length of time, but not exciting inflammation in it, as by diabetes, or long-continued nursing. But it attends long-continued suppuration and ulceration so frequently, as to be an important indication of their existence.

There is no form or modification of the constitutional fever, which necessarily attends, or can be regarded as the effect, of the termination in Gangrene. In some instances this effect of inflammation is seen, while the fever retains the strictly inflammatory character. More generally the pulse has become feeble, the surface cold, generally damp, and the countenance collapsed, before gangrene takes place; —or else, the form of fever preceding this effect of inflammation is, in all respects, that described as typhoid. But these peculiarities of the febrile symptoms are not to be regarded as the effects of the gangrene, but the effects of other causes (generally debilitating causes) acting on the body, which at once modify the general fever, and give this tendency to the local inflammation.

It is always to be remembered, that after the consequences of inflammation, now considered, have taken place, there are still provisions of nature, by which their injurious effects are very often averted, and many recoveries effected. The serum thrown out by inflammation is in general readily reabsorbed; much of the lymph that exudes on membranes, or into cellular texture in a healthy constitution, is gradually absorbed also. Either in this way, or else by being converted into pus and expelled by the bronchiæ, it seems certain that much of the solid matter deposited in the cells of the lungs by inflammation may be removed. After suppuration has taken place in any part, absorption of the fluid effused, though a slower and more difficult process, is still occasionally effected, both in external and internal parts; more generally, when pus has been formed in any part of the body, and is confined in the usual way by lymph, it swells outwards where there is least resistance, and makes its way either towards the surface of the body, or towards some adjoining cavity, where it may be discharged; its pressure, in the direction where there is least resistance, causing progressive absorption of the intervening textures, while the less degree of pressure on the surrounding parts determines adhesive inflammation only, and effusion of lymph, which prevents its being diffused laterally with injurious effect; as is well exemplified in the progress of abscesses in the liver towards the surface of the body, or towards the interior of the lungs, stomach, or bowels.

After ulceration has taken place, and after part of the inflamed textures has mortified, the processes of sloughing, granulation, and cicatrization, are still adequate, in many instances, to the restoration of the healthy condition, especially of external parts. And there is no reason to doubt, that every texture of the body which is susceptible of inflammation, is susceptible also of these healing processes, by which the injurious effects of inflammation are obviated; although in many individual cases the injury done by the inflammation may be fatal, before the provisions for recovery have time to take effect.

An abatement of the violence of the inflammatory action (as denoted by the chief local symptoms), seems always essential to these healing processes; most generally this abatement of the local inflammation is attended by a corresponding decline of the general fever; but in young and irritable constitutions, the febrile symptoms once excited may continue for a short time, after the local inflammation has almost entirely subsided.

It is very important to bear in mind, in concluding this view of the effects of inflammation, how great a variety of diseased actions, disturbance of functions, alterations of the forms and qualities of parts, destruction of parts, and again, præternatural growth of parts, may be distinctly traced to this first and most important alteration of vital action, which is excitable at pleasure by physical irritation; because this information may be applied, in a certain degree, to the explanation of the still more varied and more obscure forms of morbid action, to be afterwards considered.

SECTION III.

OF THE REMOTE CAUSES OF INFLAMMATION.

After what has been already said of the causes of disease in general, it is unnecessary to enlarge at any length on this part of the subject, but it is necessary to state which of the causes formerly enumerated have a peculiar or specific effect in producing inflammation.

Inflammation is hardly ever directly excited merely by muscular exertion, by external heat (unless in such intensity as to be a local irritant), by mental emotion, by such intemperance in eating or drinking as hurries the movement of the blood, or by such evacuations, or such suppression of previous evacuations, as alter the quantity, or even the composition of the blood, although it is often aggravated or renewed by such causes. But it is excited by mechanical or chemical irritation (including Heat) applied to the part itself which inflames; and it is excited by Cold, applied generally, or to parts distant from those that inflame, by certain poisons, and by certain contagions, which are believed to be taken into the blood, and to visit all parts of the system, but affect in this manner only certain textures, chiefly the skin, the mucous membranes, and certain glands. And there is always ground for inferring the action of some peculiar or special cause, if any other but an inflammatory disease is produced by these means.

In the natural actions of the intestinal canal, especially when excited, and in its relations to the containing parts, there are special causes for certain accidents, often acting as causes of fatal inflammation there, viz. Hernia and Intussusception.

There is a class of causes which may be said to act on the footing of local irritants in exciting inflammation, but which are applied, not to the parts that become actually inflamed, but to others in their immediate neighbourhood, or peculiarly connected with them. Thus various local chronic diseases, a carious tooth, a diseased vertebra, or joint, a strictured urethra, very generally excite repeated attacks of inflammation and suppuration in the adjoining soft textures. And injuries of certain nerves excite inflammation in the parts which they supply. Of this the best examples are in the effects and section of the 5th and 8th nerve, on the eye and lungs; and a conjectural explanation of this fact was already offered *.

It is always to be remembered, however, that there are many cases of inflammation for which no adequate exciting cause can be detected.

The tendency to inflammation is not in general given by Plethora (although the gouty inflammation occurs almost solely in plethoric habits), nor by habitual excitement of the vascular system. On the contrary, there are none who resist the influence of the exciting causes of inflammation so well, as those in whom the blood is abundant and the vascular system vigorous. But the tendency to inflammation is remarkably given by all permanent causes of Debility,—by imperfect nourishment, impure air, long continued heat, or cold, excessive exertions, excessive evacuations, intemperance, and mental depression. Of the numbers who fall into disease under the influence of these causes, a very large proportion are always found to have contracted different forms of inflammation.

The *seat* of the inflammation, which may be produced by the concurrence of any causes which do not act as local irritants, is determined in many cases by some assignable circumstances of predisposition, affecting particular organs, which were formerly mentioned,—by various causes of local plethora or increased action,—by heat acting on the liver and bowels, or cold acting on the air-passages; by any causes exciting the secretions of individual secreting organs more than of others, as of the stomach and bowels during digestion, or of the breasts during lactation; by

* See Physiology, p. 115.

organic diseases confining or obstructing the circulation in particular organs or textures; by previous inflammation facilitating local congestion or inflammation in the same parts as had formerly suffered.

Lastly, the *kind* of inflammation excited on any occasion in the body is very often determined, either by predisposing causes previously acting on the body, or by a specific property in the exciting cause. Thus there is a hereditary tendency, often much increased by full living, which disposes to Gout, in circumstances where otherwise a different inflammatory disease might have been excited; there is also a hereditary tendency, often aggravated by imperfect nourishment, by inadequate protection from cold, and by residence in vitiated air, which disposes to Scrofulous affections, rather than to other forms of inflammation; there is a peculiarity of habit, often resulting from habitual intemperance, which seems to predispose remarkably to chronic inflammation, and to slow effusion of solid lymph and induration of textures. The influence of these causes on the character of the inflammation which may be excited after their application, is of great practical importance, and the evidence of it will therefore be stated afterwards.

Again, the kind of inflammation which is excited by heat acting on the surface of the body is specifically different from that which is excited there by bruises or wounds. And the inflammation excited by each of the contagious poisons, by gonorrhœa or syphilis, by smallpox, measles, or scarlatina, erysipelas, plague, &c., has always something peculiar and *specific* in its own course, and in the nature and progress of the accompanying fever.

SECTION IV.

OF THE PROXIMATE CAUSE OF INFLAMMATION, AND OF ITS LOCAL CONSEQUENCES.

UNDER this head are usually included in medical writings, all observations and speculations in regard to the intimate nature of the changes on which the phenomena of inflammation depend, and the explanation thus afforded of these phenomena.

As all explanations of any physical phenomena consist in reference to general laws, which are exemplified in other and more familiar cases, and as the alterations of vital action, excited by the action of external causes, are a set of phenomena quite peculiar, and hardly to be compared with any others in nature, we cannot expect to go far in the explanation of the facts, of which the history of inflammation consists; it must be expected that all such inquiries will terminate in the determination of ultimate facts, peculiar to this department of nature; and these can be no long series of causes and effects connecting these ultimate facts with the phenomena, of which the explanation is sought. Nevertheless, the rationale of this diseased action, so far as it can be traced, is a perfectly legitimate subject of scientific inquiry, and the results will ultimately be so far satisfactory, and may probably be useful.

There is, in the first place, a preliminary question, which we cannot answer with confidence, as to the share which the Nervous System has in exciting Inflammation;—whether all the remote causes act on the vessels, and their contents, through the nerves of the part, or whether they act directly on the moving fibres and fluids.

It has been supposed by many, that all external causes, which affect the movements of the living body, act through the intervention of nerves; and the causes of inflammation among others. But the question cannot be satisfactorily disposed of in this summary way; we formerly found, that the supposition of stimuli acting on all moving parts exclusively through nerves, is gratuitous and even improbable; and farther, it is by no means ascertained, that the first and most essential of the changes in inflamed parts, consist in, or bear any close relation to, contractions of moving parts.

Nevertheless, several considerations prove, that in some instances at least, the nerves of parts are the instruments through which inflammation in these parts is excited.

If it were certain that the inflammations of certain organs, especially of the eye, the lungs, and the stomach, formerly stated to be consequent on cutting their nerves, were the direct effects of that section only, these inflammations might be properly adduced in proof of what is now said. But it has been already remarked, that the impaired sensibility of the parts in question, and the consequently deficient secretion of the mucus, by which they are naturally protected from the irritation of foreign matters, are probably sufficient to explain these inflammations; as well as the inflammations of the same parts observed in cases of extreme inanition, or of disease where there is long-continued debility and deficient sensibility.

Those causes, however, which excite inflammation in parts distant from the points to which they are applied, such as external Cold exciting internal inflammation, may be reasonably supposed to affect these parts by effecting changes in their nerves; because we know, that sensations and other mental acts, produced by causes acting on distant parts, powerfully affect the vital actions in the small capillary vessels of many organs of the body, and cause great variations in the quantity of blood which they contain, and in the quantity of secretions which they furnish; and we have good reason to believe, that these effects (bearing a close analogy to inflammation) are produced through the intervention of nerves, and especially of the nerves that accompany the small arteries, and which have generally passed through ganglia.

In a case (not unfrequently observed) of sympathetic sensations of nerves, becoming attended with inflammation of the parts sympathetically affected, as in the shoulder from liver disease, or in the integuments at the knee from disease of the hip, we have still clearer evidence of the possible excitation of inflammation in this way. Nor is it any objection to this doctrine, that the parts which take on inflammation are in some instances neither provided with visible nerves, nor distinctly sensible in the healthy state; because it is hardly possible to be certain of the non-existence of nervous matter in any texture; and also, because we have already seen reason to believe, that an influence derived from nerves may extend to some distance from nerves themselves, and especially may affect the blood which is moving in the bloodvessels.

If it be allowed, that some inflammations may be excited through nerves, a presumption may thence be thought to arise, that even those causes of inflammation which are applied directly to the parts that inflame, affect the vessels through the medium of the nervous filaments; but there is certainly no positive evidence of this. And the fact of all the changes which constitute and succeed inflammation, taking place in an organ of which the sensitive nerves have been cut, and the sensibility extinguished, almost unequivocally shews, that if an influence of nerves be necessary for the commencement, it is not necessary for the subsequent progress of inflammation.

Before proceeding farther, it is necessary to state the general results of microscopical observations, made chiefly on the changes that take place in the vessels of the translucent parts of animals, where inflammation has been artificially excited. It appears, from these observations, that the following changes are observed.

1. An acceleration of the movement of the blood in the vessels of the part, sometimes attended with a distinct

though slight constriction of these vessels; but more generally, at least soon after its commencement, attended with dilatation of the vessels, gradually extending itself from the part first affected. In this accelerated state of the circulation, the blood passes into the small veins less changed than usual from its arterial state.

2. Within a short time, this state of the circulation, in the part chiefly affected, gives way to retarded movement in the dilated vessels, and ultimately to complete stagnation in some of these.

3. The blood, in all the neighbouring capillaries, appears to incline, sometimes even backwards, towards the part chiefly affected; these neighbouring capillaries are distended, and many new vessels shew themselves, whether brought into view by the red globules traversing them, or actually formed in the process, is not fairly ascertained. In the capillaries somewhat farther removed from the point most affected, the motion of the blood is generally observed to be accelerated, while there is slow motion, or even stagnation at that point.

4. As the blood stagnates in the vessels of the most inflamed part, it gradually concretes into irregular masses, in which the distinction of the globules is no longer perceptible. These changes are seen to go on, in animals dying while inflammation exists, even after all movement of blood in other capillaries has ceased *.

5. The serous effusion, and afterwards the effusions of lymph and pus from the inflamed vessels, take place chiefly while the movement of the blood is slower than usual. The texture surrounding the inflamed vessels is enlarged. When there is complete stagnation, the part is much softened, and approaches to the state of gangrene.

6. If the inflammation subsides without sloughing, the blood in the part most affected is gradually set in motion again, its globules reappear, and the capillaries containing it gradually contract to their former dimensions.

* Kalkbrunner in Magendie's Journal, 1828.

7. After the first serous effusion from the inflamed vessels, the fluid that escapes from them becomes partially solid, or at least of gelatinous consistence, immediately on its escape, and is partially tinged of a reddish colour; and several observers agree, that in this slightly coloured gelatinous effusion, it is possible to recognise globules of the blood, more or less divested of their colouring matter, or adhering to one another *.

8. Another very important observation is, that much of the blood which stagnates within the vessels of the inflamed part appears to undergo the same changes †, as that which escapes from them, the colouring matter separating from the bodies of the globules as these are aggregated together; and even in those capillaries at some distance from the most inflamed spot, which are distended, and where the blood is only slightly retarded in its course, the separation of the colouring from the colourless part of the globules may be observed; and this change takes place on the globules passing through the capillaries of an inflamed part, even till the latest period of the inflammation.

9. When the inflammation does not pass beyond the adhesive stage, canals are gradually formed in the lymph effused, which have generally an external covering of red matter, and an interior covering of colourless lymph, (LAENNEC), and into which some of the capillaries of the inflamed textures soon effuse blood. These cavities in the effused lymph are of larger calibre than the vessels which supply them, but gradually contract and assume the usual appearance of vessels. In a few cases it would appear, that such new vessels have been formed in the interior of coagula of blood formed during life in obstructed blood-vessels ‡.

10. In the more advanced stages of inflammation, the actual conversion of some of the decolorized globules of

* GENDRIN, Hist. Anat. des Inflammations, § 1441.

† GENDRIN, § 1457. KALKBRUNNER in BRESCHET's Repertoire, t. 4.

‡ See LOBSTEIN, Anat. Pathol. § 334.

blood, which adhere closely together, into the larger and yellower globules of pus, which have a free motion on one another, may be traced; and according to GENDRIN, this may be seen to take place in three different situations. 1. In the decolorized lymph that has been already thrown out by inflamed vessels. 2. In the blood itself, if confined by ligatures, in the interior of a vessel, the inner coat of which is irritated and excited to inflammation; the globules of blood next the inflamed part of the vessel first losing their colour, and then gradually passing into the state of pus. 3. Within the capillary vessels of a part where inflammation has already advanced to suppuration; some of the globules not only losing their red colour, but acquiring the size and form of particles of pus, while still confined to these capillaries*.

Two other observations, on a larger scale, are of great importance in reference to the question of the proximate cause of inflammation. 1. That the arteries leading to an inflamed part pulsate with more apparent force, and if divided project blood farther than in the sound state †; and, 2. That a vein leading from an inflamed part discharges in a given time a much greater quantity of blood, than a corresponding vein leading from a sound part ‡. It is not certain, however, during how much of the progress of inmation these observations hold good.

It is unnecessary to make any statements to prove, that the phenomena of inflammation cannot be explained by any alterations that can be supposed to take place in the mechanical or chemical qualities of the blood, and that they are independent of changes in the action of the heart.

The most general opinion, of late years, has been, that they depend on an alteration in the vital action of the arteries of the inflamed parts. But there is much difficul-

* GENDRIN, Hist. des Inflammations, sect. 1443, *et seq.*

† THOMSON on Inflammation, p. 67.

‡ LAWRENCE's Lectures in Medical Gazette.

ty in forming a precise notion of the kind of alteration in that vital action, which will explain the changes observed in the motion of the blood, and the effusions from the vessels.

The following facts appear strongly to indicate, that there is an actual increase of vital action in the vessels of an inflamed part.

1. The causes which, applied directly to any living part, excite inflammation there, are causes which excite in other instances muscular contraction and vital action in general.

2. In inflamed parts it is undeniable that the vital action of nerves is increased, as indicated by the increased sensibility; and also, that the vital affinities, whereby products are formed from the blood, are both altered and increased, the natural result of the process being either the formation of a new deposit and organized texture, or the establishment of a new secretion from the blood at the part. It seems highly probable, that whatever vital power of contraction resides in the coats of the vessels of an inflamed part, will also be excited to increased action under the influence of known stimuli, and simultaneously with this decided increase in the other vital actions of the part.

3. The immediate effects of inflammation on the contents of the vessels of the part, the exudation first of serum and afterwards of coagulable lymph, are effects which may naturally be expected from increased constriction of the coats of these vessels.

4. Although it may be doubted whether the increased force of the movement of the blood in the vessels leading to an inflamed part, implies actual increase in the contractile power of these vessels, yet it is certain that when the heart comes to participate in the altered condition of living parts, consequent on inflammation, the effect on its action is decided increase.

5. As the causes which excite, or aggravate inflammation, are those which excite vital action in general, and muscular contraction in particular, so the causes which diminish or remove inflammation, are means by which mus-

cular contractions are enfeebled, and other vital actions repressed.

But on the other hand, the following are very strong objections to the opinion, that an increase of the vital contraction of arteries can produce all the changes which are observed in inflammation.

1. No such contraction can be perceived on microscopical examination of the small arteries of an inflamed part, as seems adequate to account, either for the increased quantity of blood sent through these vessels, or for their distention, and the effusions from them. The chief and sometimes the only phenomenon observed in the coats of the vessels of inflamed parts is dilatation, insomuch that the condition of these vessels, essential to inflammation, has been thought by many observers, (as Wilson Philip and Thomson) to be Relaxation; and is called by Hunter active Dilatation; and by one of the most recent and careful observers, Kalkbrunner, Inflammatory Erection.

2. It is difficult to understand, how an increase of the only vital power which we have seen reason to ascribe to arteries, viz. Tonicity or Tonic Power of Contraction, can lead to distention of the vessels, and at the same time to an increased flow of blood through them.

This difficulty is in some degree obviated by observing, that the smallest branches into which an artery divides itself probably exert, on the whole, a greater action on the blood, than the trunk of that artery*; and therefore, that if the tonic power of contraction is increased along the whole extent of the artery and its branches, that increased contraction must act as a spasm on the extreme vessels, or obstruction to the flow of blood forward into the veins. But although this enables us to understand how an increase of the vital power of arteries should lead to *congestion* of blood in these arteries, and to their *distention*, yet it does not explain how that increased action should cause the increased *transmission* of blood through them; such as takes place, both during much of the inflamed state, and during

* See Outlines of Physiology, p. 24.

the time of any occasional increase of the nutrition or secretion of any part of the body.

The real condition, as to the vital property of Tonicity, of the arteries leading to an inflamed part, has not yet been determined by experiment. The microscopical observations seem to indicate, what seems *a priori* probable, that in the small capillaries, there is at first an increased exercise of tonic power, and afterwards a diminution of power from distention, going on, in cases of mortification, to absolute loss of power. But at all events, the explanation of the congestion and distention of vessels, and of the increased transmission of blood, by any conceivable alteration of the only vital power of contraction which arteries are known to possess *, is not only difficult and unsatisfactory, but, in the case of inflammation, is necessarily incomplete; because there is here a change in the *Vital Affinities* of the part, and in the nature of the products formed from the blood in it,—such as no change in the mechanical powers moving the blood can explain. The ordinary vital affinities of the part, as shewn by the products usually formed from the blood in it, are lessened or suspended; the blood in the part undergoes a decided change, the particles of its fibrin aggregating together more closely than usual, while its colouring matter separates from these †; more solid matter escapes from the vessels than either in health or in other cases of disease. This solid matter is possessed of peculiar vital properties, enabling it to become organized; and, after a time, a new secretion is established at the part. All these changes vary in the different kinds of inflammation, and in the inflammation of different textures; and it is by these circumstances that we distinguish inflammation from cases of occasional increased determination of blood to a part,

* See Physiology, p. 28.

† The strong aggregation of the particles of lymph thrown out by inflammation is well shewn, as Mr Hunter observes, in the case of inflammation of the inner coat of a bloodvessel, where the lymph that exudes, instead of mixing with the blood, concretes on, and "furs over the lining membrane of the vessel."

where there is no change of its vital affinities, and therefore no new product formed from the blood.

Now, it appeared from facts formerly stated, that the natural vital affinities of all parts and textures, are a part of the cause of the movement of the blood through them; and if so, it is natural to infer, that so great changes in the vital affinities, and consequent chemical actions taking place in a living texture,—involving a greatly increased vital attraction of some particles to others,—must be an adequate cause for much of the alteration of the movement of the blood, seen in inflammation.

It appears highly probable, therefore, that the primary and fundamental change in inflammation is not in the vital contractions of vessels, but in the vital affinities subsisting between the component parts of the blood, and between them and the surrounding textures; and that any alterations that take place in the capacity or vital action of the arteries are consequent on that fundamental change at their extremities, just as the excitement of the action of the heart is consequent on the altered condition of the vessels.

According to this view of the subject, the primary change is not, strictly speaking, in the fluids of the body, as distinguished from the solids, but it is in the *vital affinities*, common to the solids and fluids, and acting chiefly in that part of the system where the solids and fluids are most intimately mixed, and are continually interchanging particles; —rather than in the *vital contractions*, which are peculiar to the solids, and which are most distinctly seen in parts of the system where the solids and fluids are most distinct from each other.

Two striking and important facts in the history of inflammation may be stated here in confirmation of this opinion.

1. The effect of inflammation, at least on the heart and large arteries, and probably on the greater part of the vessels leading to the part affected, bears no fixed proportion to the amount of the change which is there effected; being often slight, as in the cases called latent inflammation, when the

inflammatory exudation is very extensive, and *vice versa;* which is not what might have been expected on the supposition, that all consequences of inflammation result simply from altered contractions of vessels.

2. Inflammation is more apt to extend from one portion of a membrane to another portion of the same lying contiguous to it, but having no vascular connexion with it, than to parts supplied from the same vessels as itself, but possessing a different structure. Now, the influence of vital affinities certainly extends to some distance from the particles in which they reside; and we can understand, therefore, that any changes in the vital condition of the blood in a set of capillary vessels, may be communicated to the blood in adjoining vessels, equally as it certainly is, to that in the neighbouring capillaries on the same surface; but it is difficult to conceive how either increase or diminution of the contraction of vessels should be communicated to other vessels not continuous with, nor arising from the same trunk as, those first affected.

The nature of the change in the vital affinities of an inflamed part, cannot at present be farther characterized than by the increased aggregation of the particles of the fibrin, and separation from them of the colouring matter; the increased attraction between the serum and fibrin of the blood, and the surrounding textures, into which they exude; the increased vitality of the fibrin that exudes, shewn by its readily becoming organized; and the gradual transformation of part of it, under certain circumstances, into globules of pus.

The first effect of inflammation, effusion of Serum, is perhaps sufficiently explained by the known increased propulsion of the blood along the arteries of the part, (to whatever cause or causes that may be owing), at the same time that there is stagnation in some of the capillaries to which these lead. That, in certain constitutions, effusion of entire Blood, in these circumstances, should ensue, is also easily understood. But it is plain that this merely mechanical explanation will not suffice in the very frequent cases where solid Lymph is thrown out rapidly, in much more than the usual proportion to the serum, and without colouring matter; and that this effect of inflammation, therefore, must be referred to the head of alteration of vital affinities, and increase of the efficacy of certain of these.

It would appear from what has been already stated, that it is by a subsequent alteration, or transformation, of globules of the blood which have stagnated, and been partially decolorized, that the globules of Pus are formed; and that this transformation may go on either in the interior of vessels, or in the exudations that have taken place from them. But on what conditions this farther alteration of the blood depends, or how it comes to pass that, in some cases, it begins almost from the beginning of the inflammation, and in other cases hardly takes place in any stage of it, however protracted, we have no satisfactory information.

The knowledge of the formation of pus taking place within the vessels of inflamed parts is, however, important, as it enables us to give at least a probable explanation of several known and important facts.

Thus, it is stated by Andral, that he had in one case found purulent matter mixed with the blood at the heart, where no suppurating surface existed in the body; and many pathologists have found pus in pretty large quantity in the veins leading from a part where extensive suppuration was going on. In some cases, after suppuration there has been a purulent discharge by urine. It has been likewise often observed, that after amputation of a limb, where there had been long-continued and extensive suppuration, inflammation and very rapid deposition of pus have taken place in internal parts; and the connexion of these with the previous suppuration, is illustrated by precisely similar internal affections following inflammation and suppuration of the inner membrane of veins *.

These facts are easily understood, if we suppose that pus is not only thrown out of the vessels of suppurating surfaces, but also formed within these vessels, and therefore

* See Arnott in Medico-Chirurgical Transactions, vol. xv.

gradually mixed with the circulating blood; and when so mixed, is determined to certain parts of the system, nearly as we now know that urea, circulating in the blood, is determined to the kidneys; and either finds an outlet at the suppurating surface itself, or, if obstructed there, escapes by some of the excretories, or is apt to be deposited in some of the most vascular of the internal viscera.

The purulent matter so circulating with the blood is probably an aggravation at least, if not a chief cause, of hectic fever; and one effect, which very often follows long continued suppuration, may perhaps be ascribed to its action, and tend to its discharge, viz. the ulceration of part of the mucous membrane of the bowels, and colliquative diarrhœa.

The formation of pus within the vessels of inflamed parts, and its gradual admixture with the blood, are principles of much importance likewise, as illustrating the frequent extension, or re-appearance, of various kinds of organic disease, such as Tubercles, Melanosis, or Fungus hæmatodes.

The dependence of the process of Ulceration on absorption, co-existent almost always with the effusion of pus, and the fallacy of the old opinion, which ascribed the loss of substance in ulceration to solution of the solids of the body in the pus formed at the time, were fully and satisfactorily illustrated by Mr Hunter; partly by comparing the process with other cases, where from pressure, from inflammation, or in the natural growth of parts, absorption to an equal extent goes on in the body,—and partly by pointing out the numerous instances of disease, in which great effusion of pus takes place without any diminution, or even with increase, of the solid texture yielding it.

That this effect of inflammation should frequently be determined by pressure on inflamed parts, we can easily understand from what we know of the effect of pressure in increasing absorption; which may perhaps be ascribed simply to its impeding the efflux from the small arteries, and favouring the ingress into the small veins of the part.

In like manner, the increased tendency to ulceration which is given by a languid state of the circulation, general or local, may easily be understood; but there are other cases of inflammation, as that from specific poisons, or that of certain textures as compared with others, which tend peculiarly to ulceration,—but where the reason of this tendency is quite obscure.

The putrefaction of parts affected with Gangrene from inflammation, implies both cessation of circulation and loss of vitality in the blood. The mere circumstance of over-distention of the small vessels, may be thought sufficient to explain their loss of power, just as the bladder or the bowels become powerless from distention; but many vessels in a gangrenous part probably lose their power without being more distended than in other cases where they retain it; and the vital contraction of the capillaries does not appear to be an agent of much efficacy. The principle to which this termination of inflammation is commonly referred, is that of increased action being necessarily followed by diminution or exhaustion of vital power; but it is still doubtful how far this principle, deduced chiefly from the observation of voluntary muscular motions, can be ascribed to the involuntary motions, or to those changes which we refer to the head of Vital Affinities.

It is certain, however, that the tendency to this termination of inflammation is given in most cases, by circumstances in the part affected, or in the condition of the patient, which are known to depress all vital action, as may be shewn by referring to the enumeration, formerly given *, of the cases in which this termination is the most frequent.

* P. 416.

SECTION V.

OF THE PROXIMATE CAUSE OF INFLAMMATORY FEVER.

The same general remarks, on the limits which the nature of the subject imposes, apply to all inquiries into the nature of Fever (of which that symptomatic of inflammation may be regarded as the simplest case) as to those which relate to Inflammation.

Although the febrile symptoms, accompanying even simple inflammation, in some cases appear earlier than the local symptoms, yet the general case is, that they succeed these; and it is so general a fact, that fever succeeds any extensive inflammation, by whatever cause excited, in a healthy constitution, that we cannot hesitate about regarding general fever as the natural effect of inflammation.

Now, it may be conjectured that inflammation may excite general fever in different ways,—either by tainting the Blood, which is afterwards to be diffused over the body; or by causing such change of the vital contractile powers (perhaps such a constricted state) of the vessels, as may extend itself over the whole Vascular System; or else, by making an impression on the Nervous System, whereby the other parts of the circulation may be sympathetically affected.

That the change on the blood, which accompanies inflammation, is not of itself sufficient to explain the fever, appears sufficiently obvious from the fact, that sizy blood exists in some persons, as in pregnancy, without exciting fever; and, again, that, in some cases, inflammation excites fever, without the blood becoming distinctly sizy.

That it is through the intervention of the nervous system, and not by mere extension of an altered mode of action along the vessels, that inflammation excites fever, appears highly probable from the following considerations.

1. This *general* affection of the system, consequent on local disease, which is seated in the capillary vessels, appears to be peculiar to animals, although actions similar to those which take place in the capillary vessels of animals are observed in vegetables, and are there also liable to *local* morbid changes.

2. Fever follows local inflammation, the more quickly and surely in different individuals, as the functions of the nervous system are more easily excited.

3. The febrile affection of the system consequent on inflammation, takes place suddenly, and is general and uniform over the body from the first, as the effects of mental emotions and sensations, and other causes acting through the nervous system are; which is different from what might have been expected, if the febrile action of the system were the effect of a change gradually extending over the vessels from the part inflamed.

4. Symptoms very much akin to those which usher in fever consequent on inflammation, may be excited by causes certainly acting on the nervous system, such as a concussion, or violent and overpowering sensation or emotion.

5. The degree and kind of fever, consequent on inflammation of different parts of the body, are observed to vary, according as the rest of the system is more or less apt to sympathize with these parts; *i. e.* (agreeably to the account of sympathies formerly given) according as the sensations, excitable by impressions made on these parts, are apt to influence other parts of the body *. Now, the sensations of these parts undoubtedly act only through the intervention of the nervous system, and hence arises a strong presumption, that it is through the nervous system also that inflammations in different parts excite general fever.

We shall afterwards see that there are other reasons for thinking that fever, when unconnected with inflammation, commences by a change in the nervous system; and if so, we have another ground for the presumption, that inflammatory fever also is excited in this way. We judge the

* See James on Inflammation.

immediate cause of the alteration of vascular action in inflammatory fever to be, therefore, an impression on the Nervous System, consequent on the local inflammation, and acting on the organs of circulation in a manner somewhat analogous to a concussion, or a violent sensation or emotion.

Next, as to the nature of the change, produced in the vascular system at large, which constitutes the first step in the febrile action, the most essential part of that change was designated, by Dr CULLEN, by the phrase Spasm of the Extreme Vessels, because there is clear evidence, that during the febrile state the natural secretions from the capillary vessels take place more sparingly and imperfectly than during health. Although the circulation is as much accelerated as by violent exercise, the skin is dry, or any sweats that take place are transient, and ineffectual in reducing the temperature; the clammy tongue, thirst, impaired appetite and digestion, and usually costive bowels, denote deficiency of the various secretions of the *primæ viæ*; the quantity of urine is less than the usual proportion to the liquid ingesta would make it, and its colour and saline impregnation proportionally greater than usual; any morbid secretions, such as ulcers, are diminished or suspended, and nutrition appears at a stand, while absorption goes on.

These phenomena, succeeding to a state of constriction and coldness of the surface of the body, and attending an increased frequency, and often strength, of the heart's action, evidently indicate that the natural and healthy relation between the strength of the heart's action, and the amount of vital actions in the capillaries over the body, is materially altered; and if we supposed, as CULLEN did, that contraction of the heart, and of the different orders of vessels, are the only causes by which the amount of secretions and excretions is determined,—we should admit, that the supposition of spasm in the extreme vessels, confining the circulation to the larger of the vessels that terminate in veins, is at least highly probable. But we have seen reason to believe, that the amount of secretions and excretions is very much influenced by other causes, besides the contractions of any living solids; and therefore, instead of speaking of *spasm of the extreme vessels*, we use the expression *deficient vital action in the extreme vessels*, as more accurately indicating what we know to be the fact, as to the state of the functions that go on there, as compared with the excited condition of the heart, in fever. And it seems probable, that the chief cause of this deficiency of vital action is a *torpor of the vital affinities*, rather than any alteration of the vital power of the vessels.

We have seen, that there are powers acting in the extreme vessels, which *dilate* and *expand* the arteries leading to the parts where they are exerted,—such powers as act in the uterus during pregnancy, and in the breasts during lactation, and which appear to consist in increase of the affinities by which the solids or fluids of the body attract their appropriate pabulum from the blood. When these powers are diminished, (as they certainly may be by causes acting through the Nervous System) the effect must be the same as if the tonicity, or contractile tendency, of the smallest capillaries were increased; the flow of blood through them will be diminished, and proportionally more of the blood will be returned by the largest of the branches that communicate with the veins.

It is to be observed, that an excited condition of the heart's action is always followed by some diminution of secretions, as we see in the effect of exercise; but this diminution of secretions is more partial than in fever, and is unattended with the diminution of voluntary muscular power; and besides, the indications of deficient vital action in the capillaries in fever, evidently *precedes* any decided increase of the frequency and strength of the pulse, and therefore appears to be the cause, not the effect, of the Febrile Reaction.

Now, in whatever way it may happen that the vital actions in the capillaries are impaired in fever,—the mere circumstance of their being impaired, implies that the motion of the blood through them will be limited and imperfect; the flow of blood in the capillary vessels of the greater circulation will be obstructed, somewhat in like manner as the flow in the capillaries of the lesser circulation is obstructed, when the exposure of the blood to the air at the lungs is in any way impeded; and the quantity of blood that returns to the heart by the largest of the vessels that open into the veins, will be proportionally increased; and this state of things at the extremities of the circulation is certainly, as HOFFMAN and CULLEN taught, an adequate cause for the affection of the heart in fever.

The effect of *temporary* torpor of the vital actions in the capillaries, obstructing the free motion of the blood there, and thereby leading to temporary excitement of the heart, is illustrated by the fact, that *permanent* obstruction to the free flow of blood from the heart, in cases where the large arteries are rigid and inert from disease, leads to permanent excitement, and thereby to increased bulk and strength, or hypertrophy of the heart.

That the obstructed flow of blood in the capillaries, and accelerated return by the veins, is the cause of the excited condition of the heart in fever, appears farther from the effect of bloodletting in the cold stage, (especially of Intermittent Fever, where the successive stages are the best marked) which has been repeatedly observed to arrest the progress of the existing paroxysm.

The increased energy given to the heart's actions by muscular exercise, accelerating the motion of venous blood towards it, appears to be analogous to that which is given to it in the beginning of fever, when the blood, not diverging so readily as before into the smallest capillaries, is returned more rapidly to the heart.

There is no difficulty in understanding, how an increased action of the heart, thus produced by, and co-existing with, deficient vital action in the capillaries, should produce the chief symptoms of the hot stage of fever, such as heat of skin, flushing, headach, thirst, &c.

In thus attempting to trace the mode in which local inflammation appears to excite general fever, there is no occasion to refer to what has been called the Vis Naturæ

Medicatrix, and indeed all reference to that supposed agent amounts to nothing more than a statement of the final cause, or ultimate result, of the changes ascribed to it,—which, however important as evidence of design, and of the moral government of the world,—is of no avail in simply tracing the sequence of physical causes and effects.

Neither is there any ground for thinking, as CULLEN did, that the increased action of the heart has ultimately the effect of resolving the diseased condition of the capillary arteries, and is thus the chief agent in removing the disease; for the abatement of the mordid condition of the capillaries generally takes place at a time when the action of the heart has already become weaker, and is often remarkably promoted by the use of means which rapidly and decidedly enfeeble that action.

In fact, the fever that is symptomatic of inflammation, although it changes its character materially, does not altogether subside, until the morbid actions consequent on the inflammation have ceased; and for the cessation of these, in a case left to Nature, we can assign no other reason than the essentially temporary nature of the diseased state in which they originate.

There is no difficulty in understanding how it should happen, that in some cases already mentioned, especially the case of inflammation of the abdomen, and of inflammation preceded by a violent injury and concussion, the reaction in the inflammatory fever should be deficient; and the whole febrile symptoms remarkably modified by that circumstance; because these are cases, in which the effect of the inflammation is combined with the agency of a cause which evidently depresses, and when it acts in the highest degree extinguishes, the vital power of the heart,—as has been sufficiently illustrated when we treated of the depressing or even fatal effect of various injuries, or rapid diseases, of the abdomen, and of the effect of those injuries of the whole body which are fatal by concussion.

A somewhat similar form of inflammatory fever, with feeble or deficient reaction, may be observed in the case of inflammation excited by the introduction of a poison into any part of the system, and also in the case of inflammation affecting a vein, and leading to the formation of pus, which mixes with the blood, and may probably act as a poison; and in these cases likewise it is obvious that the heart's actions are affected by another cause besides the existence of a local inflammation.

SECTION VI.

OF THE MODES OF FATAL TERMINATION OF INFLAMMATORY DISEASES.

In order that the Pathology of this or any other diseased state may be satisfactory, and susceptible of practical application, it is evidently necessary that we should understand, not only the changes that take place in the organs affected, and the way in which they are effected, but also, the manner in which these influence the actions of the system at large, and ultimately extinguish life. It is by the knowledge and anticipation, in individual cases, of the particular kinds of fatal termination to be apprehended from them, that rational and scientific practice in inflammatory diseases must necessarily be regulated; and fortunately we have more accurate information on this subject, by reference to the simpler cases of violent death, already considered, than we have as to the nature of the inflammatory action itself.

It is to be observed, however, that none of the fatal terminations of inflammation are inevitable; when the effects which lead to them have already commenced, there are still provisions of nature by which all of them may be arrested; it is by the degree, not by the mere existence of these effects, that the fatal event is always determined.

I. Inflammation is sometimes quickly fatal, independently of any alteration in the texture of the inflamed part, simply by the gradual depression of the powers of the circulation which attends it, and which may be called a strictly sympathetic effect. The case of inflammation of the Peritoneum is the best example of this danger. This inflammation is sometimes fatal (especially if it has occurred in consequence of a perforating ulcer of the intestine and effusion of feculent matter) without even effusion of lymph on the inflamed surface. When effects of this inflammation, perceptible on dissection, are found, they bear no fixed proportion to the intensity or rapidity of the symptoms; and in all cases of this kind, the disorganization which is found, effusion of serum, of lymph, or of pus, thickening of the membrane, even gangrene of the membrane (which is more rarely found), although they may explain torpor of the intestines, afford no explanation of the gradual but rapid depression and ultimate extinction of the heart's action, and consequent coldness of the surface; otherwise than by reference to the principle already explained *, that any violent injury of the abdomen, by virtue probably of the intense and peculiar sensation it excites, acts as a powerful sedative on the heart.

There is very great variety as to the length of time, after inflammation of this texture has commenced, before this sympathetic influence on the heart becomes manifest,—as to the rapidity with which it advances,—as to the extent and degree of inflammatory effusions that go along with it,—and as to the period within which it may be fatal. Even when the consequences of inflammation, found on dissection, are the same,—effusion of pus and of soft lymph,—the duration of the disease may have varied from thirty-six hours to several weeks, and for this variety we cannot assign with confidence any cause but peculiarity of constitution. But it is in this manner almost exclusively that inflammation of this part produces death, and it affords the best example of death beginning at the heart, and uncomplicated with simultaneous affection of the brain, which occurs in any disease.

Inflammation of the Mucous Membrane of the bowels,

* See p. 333.

producing the symptoms of dysentery, is sometimes, though rarely, fatal in its first stage, when the only effect visible on dissection is effusion of lymph, taking somewhat of a tuberculated form, on this membrane. In such cases, death is produced just in the same way as in the cases of peritonitis now mentioned. More generally, inflammation of the mucous membrane of the bowels goes to ulceration long before it is fatal, but it is almost always attended with more or less of the sedative effect on the circulation, which is so strikingly exemplified in these rapid cases; and this is apparently the reason of dysentery having been ranked with putrid, rather than inflammatory diseases, by the older pathologists.

Inflammations of the kidneys, bladder, uterus, and larger joints, may be fatal on the same principle, without any such visible effect resulting from them, as can impair the functions of the organs essential to life, and before there is time for any exhausting process of suppuration or ulceration to be established. And although inflammation of the liver generally leads to decided disorganization before it is fatal, yet the change effected on that organ is often inadequate to explain the cause of the symptoms, and the fatal event, otherwise than on the same principle.

II. Inflammation is sometimes fatal by reason of the Serous Effusions consequent on it, impeding and obstructing the functions of parts essential to life. This may happen especially in three situations. 1. When inflammation of the brain, marked by the symptoms of phrenitis or acute hydrocephalus, leads to such effusion into the ventricles of the brain as causes fatal Coma. 2. When inflammation of the mucous membrane of the larynx produces œdema of the glottis, and consequent Strangulation. 3. In the rare case, where inflammation, attacking both lungs at once, is fatal in its earliest stage, before any other consequence than serous effusion into the cells of the lungs has taken place, but that so generally as to disqualify the lungs for their function, and cause death by Asphyxia.

In all these cases there is a difficulty in assigning inflammation as the cause of death where nothing but serous effusion is found on dissection; nor are we justified in doing so, merely from the appearances in the dead body. In merely chronic cases, great effusion into these parts may take place independently of inflammation; and in the case of effusion within the cranium, not only when the sutures yield and the head is gradually enlarged, but when there is no such enlargement, we know, that the greatest accumulations of serum, and distention of the ventricles, are exceedingly slow in their progress; and are unattended, at least during most of their progress, with inflammatory symptoms during life, or any decisive indications of inflammation after death.

It is therefore always by a comparison of the serous effusion, found in the parts above mentioned after death, with the causes, duration, and progress of the symptoms before death, that we judge such effusions to be inflammatory. When we find, *e. g.* such effusion into the ventricles of the brain, as, if taking place within a few days, must necessarily imply much pressure on the brain, and explain a fatal coma equally as effused blood or depressed bone does,—preceded by violent symptoms of a few days duration,—and these symptoms just the same as are seen in other cases, where, on dissection, not only serum, but pus and lymph are found effused on the brain,—we cannot hesitate about regarding the serous effusion also as a result of inflammatory action. And in fact, in many of the cases to be mentioned under the next head, where lymph or pus are effused into the brain, air-passages, or lungs, the fatal coma or asphyxia cannot be ascribed to them alone, but must be held to be in part the effect of the concomitant effusion of serum.

III. In many cases, inflammation within the Head or Chest, has such distinct and unequivocal effects as satisfactorily explain death by Coma or by Asphyxia.

1. The formation of circumscribed abscesses containing pus within the substance of the brain,—the "ramollissement

rouge," or softening with serous and bloody infiltration, the "ramollissement jaune," or softening with purulent infiltration of that substance, and the effusion of an extensive layer of soft lymph or of pus, on either surface of the pia mater, whether attended with serous effusion into the ventricles or not, are held to be sufficient to explain not only convulsions, delirium or palsy, but stupor and death. For although it be true, as formerly stated, that these and other injuries of the nervous matter, superior to the medulla oblongata, do not necessarily imply any such consequences; and although the inflammatory action which produces these effects may take place with very various degrees of rapidity, and be attended with a considerable variety of symptoms; yet it is evident that when it does take place rapidly, it must naturally make such an impression on the substance of the brain, and such a change on the circulation there, to some distance from its own seat, as may effectually disqualify it for its function. And it is known by sufficient experience, that when the general symptoms of inflammation, and the particular symptoms of derangement of the functions of the brain, have occurred with violence, and advanced rapidly to coma and death, these appearances, and these only, have often been found on dissection.

In some cases of partial softening of the substance of the brain; the condition to which the affected part is reduced approaches to sphacelus; and in some instances of this kind effusion of blood into these disorganized portions takes place, which will naturally account for rapid acceleration of the fatal coma *.

In other instances, where effused blood and surrounding softening of the brain are found, the progress of the symptoms gives us reason to believe, that the effusion of blood by rupture of vessels is the first change.

Induration of portions of the brain from inflammation is sometimes likewise the chief cause, which appears on dissection for fatal coma; but the progress of such cases is generally so slow, that they are to be regarded rather as on the footing of organic diseases connected with alteration

* See ANDRAL, Precis. &c. t. ii. p. 764.

of the nutrition of these parts, than as the results of inflam mation simply.

2. When the Pericardium is inflamed, there often results such an effusion of serum loaded with flakes of lymph, or of soft but concrete lymph almost without serum, or subsequently of purulent matter, as necessarily impedes and alters, and, within a time admitting of great variety (from forty-eight hours to several weeks), finally suppresses the action of the heart. But as, in such cases, the functions of other parts, and especially of the lungs, naturally suffer likewise, the death from this cause seldom takes place so distinctly and simply in the way of Syncope, as in other cases of inflammatory diseases already noticed, where the affection of the heart is truly sympathetic.

3. When the mucous membrane of the Larynx and Trachea is severely inflamed, there is always reason to apprehend rapidly fatal Asphyxia, either from an effusion of lymph forming a preternatural membrane, obstructing the glottis, and sometimes stretching down to the bronchiæ (which occurs chiefly, though not exclusively, in young children), or from effusion of pus behind the membrane about the glottis, or even from mere inflammatory thickening of the membrane (with or without the serous infiltration already noticed) at that, which is the narrowest part of the air-passages.

It is important to be aware, that death may occur with similar indications, by strangulation rather than suffocation, in consequence of effusion of pus into the cellular substance surrounding the pharynx, causing pressure on the rima glottidis.

4. When the lining membrane of the Bronchiæ is inflamed, an increased secretion of mucus, often changing gradually to the puriform appearance, necessarily results; and although this may go to a great extent and last very long without danger, yet it becomes certainly dangerous, and may even cause rapidly fatal asphyxia, by the obstruction it gives to the access of the air to the blood, in two cases,—*first*, when it occurs in a feeble habit,—as in the very old

or the very young, or in the course of weakening diseases, when expectoration is difficult and imperfect; and *secondly*, when it occurs (as seldom happens in idiopathic cases) generally in both lungs, and extends every where to the minute branches of the bronchiæ *.

5. When the substance of the Lungs is extensively inflamed, the effusion into the air-cells of lymph, more or less coloured by the red matter of the blood, and tending more or less rapidly to conversion into purulent matter, must be expected to cause such impediment to the arterialization of the blood, as to threaten death by asphyxia within a few days.

6. When the Pleura is inflamed pretty generally on one side of the chest, it often happens that the fluid effused into its sac, and which gradually assumes the character of pus, becomes so abundant as to compress the lung of that side to such a degree (although with very various rapidity), as to disqualify it for its function, and threaten death by asphyxia.

In both these last cases there is a difficulty as to the reference of death to the inflammatory effusion compressing or obliterating the cellular structure of the lungs, from the observation of the great variety in the amount of effusion found after death in different individual cases; the portion of the lungs left fit for their functions being in some cases much smaller than in others,—whereas the danger from this cause might, on first consideration of the subject, seem to be just in proportion to the amount of obstruction of the air-cells.

But this difficulty is removed if we attend to the following considerations, *first*, that in cases where the whole quantity of blood in the body is less than usual, there is less occasion for a large amount of healthy lung to arterialize this blood, than when the full quantity of blood circulates in the vessels; *secondly*, that when a portion of lung is *gradually* rendered unfit for its office, the blood of the pulmonary artery, as injections demonstrate, is gradually diverted from the dis-

* See Laennec, Traité de l'Auscultation, &c. t. i. p. 203.

eased portion, and directed to the healthy parts *; *thirdly*, that in many cases the effects of peripneumony and pleurisy, now in question, are combined, either with each other, or with the other causes of asphyxia already mentioned.

Indeed, several of the different causes of the fatal termination of inflammatory disease of which we now treat, are often and very variously combined in different individual cases.

IV. There are cases in which inflammation is fatal, apparently by reason of some part of the effusions to which it gives rise, being mixed with the blood, and acting on the footing of a poison. Thus, when inflammation is excited in a spot on the surface, by the application of a specific Poison, as by a wound in dissection, it is speedily attended by the formation, probably of a similar poison, which is evidently absorbed, and excites fresh inflammation in the line of its passage into the mass of the blood; but this inflammation is attended by a peculiar *typhoid* fever, in which the heart's action is rapidly depressed, which bears no fixed proportion to the extent or intensity of the inflammation itself, and by which death takes place without visible injury of any vital organ; sometimes before the inflammation has advanced beyond its first stage †, and generally long before it has gone so far as in the more usual inflammations of the same parts.

Again, in the case of inflammation of the lining membrane of a Vein, the accompanying fever soon takes a similar typhoid form, often with vomiting and purging, always with a feeble or depressed state of the heart's action, as well as with derangement of the nervous system. In many such cases, this typhoid form of the fever, rather than any effect which we can ascribe to the inflammation itself, appears to lead to the fatal termination; in like manner, as a similar combination of typhoid symptoms does, when occurring idiopathically, or as a part of a malignant contagious febrile

* See Schræder Van der Kolk, Observations Anat. Pathol. p. 66.

† See Travers on Constitutional Irritation.

disease; and this peculiarity of inflammation of this part has been ascribed to the necessary admixture of much of the inflammatory effusion with the circulating blood, with more probability than to any other cause.

V. In many cases, the fatal termination of inflammatory diseases cannot be ascribed to any mechanical or even vital agency of products of the local disease, but is effected by gradual exhaustion of the vital powers during the processes of Suppuration, and of Ulceration or Sloughing. In such cases, death takes place rather by syncope than by coma or asphyxia; but often after so slow a process as to resemble more the death by fasting than that by concussion, or by any injury directly depressing the heart's action. The febrile symptoms attending suppuration and ulceration have usually the form of hectic; those which attend gangrene are more rapid in their progress, and more typhoid in their character; but it has been already observed, that these last are very generally to be ascribed, in part, to some other cause, acting simultaneously with the inflammation, and depressing the vital powers.

It is by the gradual exhaustion consequent on the concomitant fever, rather than by local changes, that inflammation of the surface of the body, of the extremities, and organs of locomotion, is dangerous or fatal; and the danger attending inflammation and suppuration of some internal viscera, as the liver, spleen, kidneys, and mucous membranes of the intestines, is generally of the same slow gradual kind.

VI. Inflammation often leads, more indirectly, to a fatal termination, by gradually passing into, or blending itself with, other modes of diseased action, which demand future consideration, and aggravating the danger to which they may respectively give rise. Local inflammations of certain parts, and of a peculiar character, very often attend both idiopathic fever and febrile exanthemata, and constitute great part of the danger of these diseases; and it is generally allowed that inflammatory action sometimes gives origin to, and often combines itself with, almost all the chronic diseases to which the living body is subject at various periods of their progress, and especially with those which imply the greatest danger, viz. those which consist in perversion of the nutrition, and increase of the exhalations of various textures, or what are usually called Organic Diseases, and Dropsies; and the combination is frequently fatal, where either affection existing separately might subside, or pass into a more inert or less dangerous form. This kind of danger is, of course, to be apprehended chiefly when the causes of inflammation are applied, either simultaneously with those of other diseases, or to persons in whom chronic diseases, or a strong predisposition to them, already exist.

As we know that the products of unequivocal inflammation admit of considerable variety, and that lymph, effused by inflammation, may subsequently undergo conversion into various kinds of substance, it is evident that any kind of adventitious texture that may be formed in the body may originate in inflammatory action, and that it is possible for inflammation to give rise to every kind of organic disease. But on the other hand, as we know that the lymph which is thrown out by simple and healthy inflammation remains for an indefinite time quite inert, and undergoes gradual absorption, after that inflammation has subsided, it is clear that some additional morbific cause acts, whenever inflammatory effusions change their form, and especially when they increase in bulk, after that period; and many observations shew that, where such morbific cause exists, very little inflammatory action is required to give origin or continuance to the growth of adventitious textures, and the phenomena of organic disease.

SECTION VII.

OF THE VARIETIES OF INFLAMMATION.

Although there are many variations in the progress of inflammation, in different instances, which cannot be reduced to any general heads; yet it is also ascertained that there are varieties which admit of being classified and generalized, and the causes of which can be assigned; and these are of such importance as to demand a separate consideration.

I. After the statements already made, it is unnecessary to dwell on differences among inflammations which are dependent on the *texture affected; i. e.* differences in inflammations proceeding from the same cause, especially from cold, and affecting different textures.

It is sufficient to observe, that inflammation in cellular substance, and in the parenchymatous viscera, is generally attended with less intense fever, and with less pain (unless the inflamed parts are so situated that their distention is prevented), than that in serous membranes, and that it is generally more limited in extent, and tends more surely to the formation of circumscribed abscesses;—that the inflammation of the true skin is rapid in its progress, and tends especially to effusion of serum betwixt it and the cuticle, *i. e.* to vesication, as is seen in blistering, and in the effect of burns, or of mechanical pressure, affecting this texture only;—that the acute inflammation of serous membranes is that which spreads the most rapidly, and excites the most pain and fever, tending first to the effusion of serum and lymph, and less certainly to that of pus, and in all parts of the body, inflammation of these membranes possesses these general characters;—that inflammation of the mucous membranes varies more in different parts of the body, but, in general, is attended with less pain or fever, spreads less rapidly and extensively, and tends first and chiefly to increase and alteration of their own secretions; in some parts also, especially in the stomach and intestines, to ulceration.

Again, inflammation of the investing membrane of bones, and other fibrous membranes and cartilages, has, in general, less tendency to effusion of pus than in many other parts; it is slower in its progress, and tends especially to effusion of solid lymph, often afterwards undergoing conversion into bone, and to various alterations of the nutrition of the bones, to which many of these membranes are attached. Inflammation of bones themselves, and of cartilages, has also peculiar characters, particularly in the tendency to the formation of fresh bone, on the one hand, and to ulceration or sloughing (*i. e.* caries and necrosis), on the other.

When rheumatic inflammation (which has certain specific peculiarities not at present in our view), attacks different textures, it is obvious that the results to which it leads are determined by the nature of these textures,—the synovial membranes pouring out fluid effusion only, the sheaths of the tendons, and the pericardium, if it be affected, often acquiring a lining of solid lymph, the bones acquiring an increase of solid matter, by which they are enlarged and distorted, and the muscular fibres undergoing no decided change but that of loss of substance and of power; this last is indeed a texture, from the nutrient vessels of which inflammatory effusions perhaps never take place.

II. There are varieties in the degree of intensity and rapidity of progress of inflammations in all parts of the body, which cannot be strictly defined, but are expressed by the terms Acute, Subacute, and Chronic. It is right to distinguish the second as well as the third of these varieties from active and intense inflammation, because there are cases which are rapid in their progress, sometimes even pretty extensive, but never attain any great intensity, nor require very powerful remedies to control them. Many such occur in various parts of the body, sometimes idiopathically, sometimes in combination, either with acute febrile disease (idiopathic Fever or Exanthemata), or with chronic disease, functional or organic; and have had the epithet Subacute applied to them with more propriety than Chronic.

The term Chronic is properly applied to those inflammations which tend to the same consequences, and, in many instances, infer the same danger as the acute, but run their course much more slowly, and generally with less urgent symptoms. It seems necessary to make a deduction from cases which have been described as of this kind, because many such had not been seen by the describers at the commencement of the inflammatory symptoms, and may therefore have been cases of effects, or sequelæ of acute inflammation inadequately treated, rather than examples of chronic inflammation. It is proper also to exclude, at present, from chronic inflammations, cases where adventitious textures are found, distinct from the ordinary products of inflammation, although there be much difficulty in distinguishing these forms of disease by their symptoms. But setting aside all such ambiguous cases, there remain a large number, where the usual results of inflammation, especially effusion of grey or yellowish lymph, and consequent induration of textures, or effusion of pus (*e. g.* into the sac of the pleura) has certainly taken place slowly and gradually, and often with symptoms, obvious indeed and decided, but chronic rather than acute,—the local affection being for a long time more obvious than the constitutional, and the latter consisting more in debility and emaciation than in febrile action.

Such Chronic Inflammations are chiefly seen in debilitated habits, but it were a fatal error to suppose that such subjects are not likewise very liable to attacks of acute inflammation. It may perhaps be stated as a general fact, that on membranes chronic inflammation leads more to effusion of pus, and in the interior of viscera more to thickening and induration.

III. There is a well marked and important difference between the form of inflammation called Phlegmonous and that called Erythematic, in external parts. The Erythematic Inflammation is characterized, 1. By its tendency to spread along the surface of the body, often subsiding at one part as it extends to another; 2. By its colour, which is of a less vivid red than other external inflammations, and by its producing vesication of the surface, but little or no effusion of solid lymph; 3. By the form of the accompanying fever,—which in different cases bears no proportion to, and does not appear to be dependent on, the extent or intensity of the inflammation,—generally commencing in severe cases, to which the name Erysipelas is given, one, two, or even three days, before the inflammation shews itself,—being sometimes dangerous or fatal when the inflammation is slight,—and very often shewing, throughout its course, more prostration of strength, more tendency to delirium or stupor, more dryness of tongue, and evidence of diminished secretion over the body, *i. e.* a more typhoid form, than the fever that is simply symptomatic of inflammation does.

In all these respects, this form of inflammation may be said to be *specific*. It differs from that which may be excited, at pleasure, by mechanical or chemical irritation of the surface of the body, although it often supervenes in injuries so excited. The body here appears to be under the influence of a cause, which produces both a peculiar inflammation, and a peculiar kind of febrile action; and the case is therefore justly held to bear as much analogy to the febrile exanthematous diseases, to be afterwards considered, as to the inflammations.

Accordingly, although the danger in this form of inflammation sometimes depends merely on the extent of the local changes, and is to be obviated by moderating or repressing these, yet it sometimes depends obviously on the typhoid form, and especially on the depressing influence of the constitutional fever, and cannot be inferred from observation of the local inflammation, nor be averted by remedies applied to that part of the disease.

So decided a deviation from the more usual form of inflammation of the surface of the body, may be suspected to depend on a local and temporary cause, rather than on causes of general operation; but the conditions necessary to the existence or effect of this cause have not been fully ascertained. The Erysipelas has been observed to prevail most in confined and ill-aired situations, and to occur most commonly in persons in whom the digestive organs are disordered, or the general health otherwise impaired, but it certainly cannot be referred simply to any of these circumstances as its cause. At certain times and places it prevails much more extensively than at others; and at these it is well ascertained that it is sometimes propagated by contagion, or in a few instances by inoculation.

The term Phlegmonous is applied chiefly to that inflammation of external parts which ends in the formation of circumscribed abscesses formed by dense lymph; but it may be applied to any external inflammation which does not produce vesication, nor spread rapidly along the surface.

The Erythematic Inflammation is certainly not peculiar to the skin. In many cases it is seen to affect the mucous membrane of the nose, mouth, fauces and larynx, simultaneously with the skin of the face and neck, and to preserve its appropriate characters in these situations. In some instances it affects the fibrous membranes, especially the pericranium. It very often affects the cellular texture, immediately beneath the portions of skin which it occupies, and produces effects similar to what it does on the surface, effusion first of bloody serum, and then of pus which is in general imperfectly, or not at all bounded by effused lymph. And it is well ascertained, particularly by the inquiries of the late Dr Duncan, that this diffuse inflammation of the cellular membrane not only extends in many cases beneath the skin, and among the muscles, to a distance from the affected parts of the skin, but likewise occurs independently of any affection of the skin,—that it may arise from many causes, but especially from the introduction of a poison into the system,—that it sometimes prevails almost epidemically along with the Erysipelas;—

and that it is attended, like it, with fever of extremely various intensity, and often of strictly typhoid character.

Again, there is good evidence, that at least in one of the internal serous membranes, viz. the peritoneum, inflammation occasionally presents very nearly the same characters as Erysipelas on the skin, tending to effusion of bloody serum, of a whitish milky fluid, or of more perfect pus, with little or no exudation of plastic lymph; that such cases are in general remarkably rapid in their progress, and that the depression of the circulation attending them takes place early, and is hardly to be counteracted by antiphlogistic remedies *.

When Peritonitis succeeding parturition prevails epidemically, and evidently spreads by contagion, under the name of Puerperal Fever, the inflammation is in like manner attended, in most cases, with little exudation of plastic lymph; and the danger of the disease, in the worst epidemics of that kind, is so little dependent on the extent or intensity of the inflammation, that the most rapidly fatal cases are those in which the least inflammatory appearance is found on dissection. Such epidemic Peritonitis has also been observed to be connected with unusual frequency of Erysipelas.

IV. Besides the Erythematic, there are various other forms of inflammation affecting the skin, which are easily distinguished from the inflammation that is excitable at pleasure by irritation, from the erythematic above described, and from each other.

Although the different orders of cutaneous diseases which are distinguished from one another according to the nature of the products, which appear in the skin, in consequence of an inflammatory action there, are combined, or hardly to be distinguished, in many individual cases: yet there are other examples, where these distinctions are easily observed, throughout the whole of the affections. Even setting aside, at present, the contagious Ex-

* See ABERCROMBIE's Pathological Researches on Diseases of the Stomach, Intestinal Canal, &c. 2d edition, p. 197.

anthemata, there are many cases, *e. g.* of pretty intense inflammation of the skin, which lead to no effusion whatever, and are merely followed by desquamation (Exanthemata of WILLAN), yet are easily distinguished from the simple Erythema. There are many distinct examples of inflammation leading merely to effusion of serum between the cutis vera and cuticle (*vesicles* when they are small, *bullæ* when large),—of inflammation leading to purulent effusion there (*pustules*),—of inflammation leading to little elevations of the cuticle, without fluid (*papulæ*),—or to larger elevations, with partial suppuration only (*tubercles*), —and of inflammation leading to the formation of dry scales only (*squamæ*). All these run a peculiar course, with various rapidity, undergoing various changes, and often admitting of very little abbreviation by art. In many of them the sensations are also peculiar, smarting heat or itching, rather than pain; and they may all be called Specific Inflammations.

Again, when inflammation is seated chiefly in the subcutaneous cellular membrane, it often shows those peculiarities to which the term Carbuncle, instead of simple Phlegmon, has been applied; in which the effusion of pus takes place into many small cavities lined by lymph, instead of one larger cavity,—there is afterwards sloughing of much of the affected part of the membrane,—the progress of the changes is slow, and the constitutional symptoms often typhoid.

There is no reason to think that inflammations of internal parts take place in equally numerous and definite varieties; but the Aphthæ, or whitish crusts often occurring in children idiopathically, and in adults in the course of different weakening diseases, on the mucous membrane of the mouth and fauces, are an example, similar to most of the cutaneous diseases, of slight inflammation followed by peculiar and long-continued effects; and there is one form of inflammation of the mucous membrane of the fauces, almost equally well defined as any of the cutaneous affections above mentioned, and sometimes prevailing almost epidemically, —that to which the term "Diphtherite" has been applied by BRETONNEAU and others, of which the chief characters are, the rapid formation of flocculent aphthous crusts, often extending into the larynx, and sometimes down the œsophagus, with little intensity of previous inflammation, and with fever, slight in the commencement, and afterwards generally typhoid.

Whether there is any thing equally peculiar or specific, in the exudation, and subsequent ulceration, on the mucous membrane of the intestines, which often takes place in the course of continued fever (and has been called Dothin enterite), or in that which characterizes Dysentery, is not so clearly ascertained.

V. There are three distinct varieties of Inflammation, strictly called Specific, each of which affects a variety of textures,—the Rheumatic, the Gouty, and the Syphilitic.

The distinctive characters of the Rheumatic Inflammation may be stated to be, 1. That it affects different parts, and, in general, even different textures, within a short time, viz. certain fibrous membranes, probably muscular fibres, synovial membranes, often portions of the bones, and sometimes certain internal membranes, especially the pericardium, and membrane lining the interior of the heart. 2. That it shifts from one to another of these more rapidly, and more frequently, than any other inflammation does, insomuch that its rapid recession at one part of the body is rather a reason for expecting its appearance in another, than any security against its farther progress. 3. That, when existing alone, it never leads to suppuration nor ulceration, but to serous effusion into the articular cavities, to thickening and induration of fibrous membranes, and remarkably to effusion of solid lymph on the surface of the pericardium, or on the internal membrane of the heart, when these are affected. From these peculiarities, it may be suspected that there is something peculiar in the state of the blood in Rheumatic Inflammation; and it has been generally observed, that the fibrin of the blood, in violent cases of Acute Rheumatism, is very abundant, and its separation from the colouring matter very complete.

The Gouty Inflammation, which affects the same textures as the Articular Rheumatism, differs from it chiefly, 1. In affecting a much smaller number of joints in one paroxysm, and these generally the smaller joints of the extremities. 2. In being very generally preceded by disorders of the stomach, and when it recedes suddenly, being as generally followed by violent affection of the stomach, sometimes inflammatory, often apparently neuralgic. 3. In being one of the diseases to which a portion of mankind only is in any circumstances liable, and in its occurrence being very often traced to hereditary predisposition, and very much dependent on a state of plethora, and especially on the use of fermented liquors. 4. When it lasts long, in leading to the effusion of the peculiar matter called Chalkstones, which consists chiefly of uric acid.

From this last fact, and from the frequent connexion of gout with gravelly deposits in the urine, it is pretty obvious that one condition necessary to the establishment of this kind of inflammation is, a morbid matter circulating in the blood; but the origin of this matter is much more doubtful.

All that need be stated here as to the Syphilitic Inflammation, a variety undoubtedly depending on a peculiar morbid matter applied to the surface, and then circulating in the blood, is what follows.

1. It affects peculiarly the skin of the genital organs, the lymphatic glands in their neighbourhood, the mucous membrane of the fauces, the skin generally, the iris of the eye, and the periosteum and bones, at the parts where these are densest.

2. It is every where of a chronic character, and tends to peculiar consequences—in the lymphatic glands, to suppuration and then ulceration; in the skin, to various, but perhaps most frequently to scaly exudations, and often subsequently to ulceration; in the iris, to simple effusion of lymph; in the skin of the genitals and of the fauces,

very certainly to ulceration (which ulceration, in the best marked and most severe cases, is characterized by the deep excavation and hardened base); in the bones, to irregular deposition, and concomitant absorption, constituting Caries.

It may be added, that the Syphilitic Inflammation and Ulceration are peculiarly under the influence, in most cases, of Mercury acting specifically upon them; but it certainly cannot be maintained, as was formerly done, that any form of syphilitic ulceration is absolutely devoid of the disposition to heal, where mercury is not used.

It is very important to bear in mind, that syphilitic inflammation is often combined with, or passes into the form of, simple acute inflammation of the same parts, and often also, it appears to be combined with scrofulous inflammation. Independently of such combinations, there are many varieties in the appearance and progress of the affections resulting from impure sexual intercourse, such as those designated by the names pseudo-syphilis, syphiloid disease, phagedenic, pustular, vesicular, or tubercular venereal disease; but whether these varieties are to be ascribed to different specific poisons acting on the body, or to peculiarities of constitution, is still doubtful.

The poison of Gonorrhœa acts as a cause of specific inflammation in the mucous membrane of the urethra and tunica conjunctiva of the eye, which is characterized by rapid extension along the membrane, by copious effusion, which soon becomes puriform and capable of propagating the disease, and by great thickening of the membrane, but, on the former part at least, by total absence of tendency to ulceration.

The action of Mercury on the body is a specific cause of inflammation in the salivary glands,—of inflammation, aphthous exudation, and superficial ulceration in the mucous membrane of the mouth and fauces,—and in certain persons, of a peculiar vesicular eruption on the skin. It seems also to be a frequent cause of aggravation of inflammation, whether simple, scrofulous, or in some instances even syphilitic, in various parts of the body; but it can hardly be said to act *per se* as a sufficient cause of inflammation in other situations than those mentioned.

VI. The form of Inflammation which is termed Scrofulous demands a somewhat more detailed notice.

"The term Scrofula is used by medical writers in two senses; *first*, to express the existence of a disease which possesses certain distinctive characters in whatever part it may be seated, *secondly*, to indicate a disposition, diathesis, or state, which *predisposes* some part of the body or other to become affected with such disease *."

Scrofulous disease is most generally and distinctly characterized, either by a peculiar variety or modification of inflammation, and of suppuration and ulceration consequent thereon, easily enough recognised when the affection is seated externally; or else, by the formation and subsequent changes of those tumours, or adventitious textures, in various parts of the body, which are called Scrofulous Tubercles. The connexion which exists between the scrofulous inflammation and the deposition and growth of these tubercles, will be considered presently.

There are some kinds of disorganization or organic disease, distinct from either of the kinds of diseased action also mentioned, to which the term Scrofulous is likewise commonly and correctly applied, but which generally coexist with indications either of the scrofulous inflammation, or of the scrofulous tubercles.

The term Scrofulous Diathesis is applied to that peculiarity of general habit, which appears to furnish the great predisposition to these kinds of diseased action, it being well ascertained that it is only a portion of mankind that under ordinary circumstances of exposure to the causes of disease become affected in this way.

The marks by which we distinguish the form of Inflammation denominated Scrofulous, are less peculiar and characteristic, than those which distinguish the erythematic, or other specific inflammations; but where the whole course

* THOMSON on Inflammation.

of the affection is observed, the distinction from simple or healthy inflammation becomes obvious. The common affection of external lymphatic glands is perhaps the best example. The pain and heat are not great, the colour is often nearly unchanged for a long time, and then is somewhat livid or bluish, the progress is remarkably slow, and is little influenced by remedies. But besides these, which may be said to denote only chronic inflammation, there is a more decided peculiarity in the suppuration, which generally follows such inflammation, lasting longer than in ordinary cases, in the discharge being more serous, but usually mixed with fragments of curdy matter,—in ulceration very generally succeeding, and in the ulcers being indolent, shewing little disposition to heal, and often degenerating into fistulæ.

The following may be stated as the distinctive characters, (known from the examination of many different bodies, in which they exist in different stages of progress), of Scrofulous Tubercles; which, however, admit of considerable variety, both as to the mode of their deposition, and the changes they afterwards undergo.

They are at first very minute, soft, or of nearly gelatinous consistence, of a greyish colour, and of a somewhat opaline lustre, have more or less of the rounded form, and are very often set together in clusters on the membranes, or in the textures, where they are formed, (Tubercules miliaires.)

They afterwards enlarge considerably, several of them generally coalesce into one irregular mass, and they become opaque, yellowish, and of the consistence of soft cheese (tubercules crus). These tubercular masses then frequently soften, first in their centres, and degenerate into a purulent fluid, having more or less the character of scrofulous pus above described, some fragments of the solid tubercular matter floating in the fluid without becoming themselves liquid. But although many tubercular masses are thus converted into ulcers, there are others which gradually harden into cartilaginous, and then into earthy concretions, and remain in an inert state for a very long time. The ulcers shew very little disposition to heal, but when they are not very numerous the discharge from them gradually abates, and they may become small fistulous cavities free from all diseased action.

Appearances of simple inflammation are very often found around these tubercles, many of which may be judged from various circumstances to be posterior to them in date, and may be ascribed in part to the irritation resulting from them.

Although they undergo various changes in the interior of their substance, at various periods after their deposition commences, it does not appear from injections, that tubercles are themselves provided with vessels, and hence they have been called morbid secretions, perhaps more properly than adventitious textures. When the tubercular deposition is far advanced, the vessels of the parts affected are much obstructed, by the disease extending to their coats, the quantity of the blood sent through these parts is much diminished, and the whole circulation in the neighbourhood much altered *.

These appearances are found in very different parts of the body,—according to the observations of LAENNEC nearly in the following order of frequency. The lungs, the lymphatic glands, the liver, the prostate gland, the mucous membrane of the bowels, the pleura and peritoneum, the testis and its appendages, the spleen, the heart, the uterus, the brain and cerebellum, the bones, and lastly, adventitious or morbid textures, with the peculiar matter of which they are not unfrequently mixed. Of these parts, the lymphatic glands and the highest portions of the lungs are those in which tubercles most frequently originate; and it is important to observe, that these are parts in which the capillary circulation must necessarily be very slow.

When tubercles exist in any part in considerable numbers, they are very generally attended by much debility and emaciation, and, in young persons especially, by frequency of pulse; but the other symptoms connected with

* See SCHRÆDER VAN DER KOLK, Observationes, &c. p. 75 & 85.

them must be expected to vary extremely, according to the organs in which they are formed, or the functions of which they impede,—according to the presence or absence of concomitant inflammation, and according to the changes which they themselves undergo. When they exist in those parts in which they generally suppurate, as in the lungs, and in the intestines and mesenteric glands, they are generally attended with hectic fever; but this is by no means a general fact. Deposits very similar to incipient tubercles, taking place in the heart, liver, or kidneys, are often fatal, without attaining any great size, or shewing any tendency to suppurate, and without producing any symptoms but what may be distinctly traced to obstruction of the functions of these parts.

The following affections, often seen in connection with scrofulous inflammation, or with tubercles, may be stated as perhaps equally characteristic of the scrofulous habit.

1. The slow phagædenic ulceration of the nares called Lupus.

2. The conversion of the synovial membrane of joints into a brownish pulpy matter, seen in the most distinct cases of White Swelling *.

3. Ulceration of the cartilages of the joints without distinct previous inflammation of the synovial membrane †.

4. The formation of those tumours which have the name of Encephaloid substance, or Fungus Hæmatodes, which may exist in various parts of the body, and which are of softer consistence, are found in larger masses, and grow much more rapidly, than the scrofulous tubercles.

In applying the general term Scrofulous to the different affections now noticed, we do not, of course, mean to assert, that they are essentially of the same nature, although a general resemblance may be traced among them. But we are induced to give this general name to all these affections, in consequence of our knowing by ample experience, 1. That they all occur very frequently in persons in

* See Brodie on Diseases of the Joints. † Id.

whom certain peculiarities of constitution, independent of actual disease, may be observed. 2. That two or more of them very often succeed one another in the same individual. 3. That they all occur remarkably in different individuals of the same families, while other families are exempt. 4. That they are all induced or aggravated, and again may be confidently believed to be averted or mitigated, by the same or similar causes.

No word would convey the same important meaning, which this term Scrofula does, which should be confined to affections precisely of the same kind; because what we wish to do, in using the term, is to mark the connexion that subsists between different diseased actions, which appear, from their history, to depend on the same peculiarity of constitution, and therefore ultimately on the same general causes, and which may often be prevented or alleviated by the same general measures.

Neither is it meant, in referring these different affections to the Scrofulous habit or Diathesis, as their great predisposing cause,—to assert either that every inflammation in such a habit must be of the scrofulous character, or that none but persons previously of that habit, are susceptible of scrofulous disease. We know that healthy inflammation, shewing no unusual or specific character, may exist in a person already suffering under scrofulous disease; as we see in the healing of many wounds in such persons, and in many cases of occasional or *intercurrent* inflammation, occurring in the course of tubercular diseases. And we know, that in certain circumstances (*e. g.* under the influence of long-continued cold, and deficient nourishment, coupled with long-continued local irritation) scrofulous disease may be excited in constitutions previously quite healthy and robust.

Nevertheless, it is important both to mark the indications, and to generalize, as far as possible, what experience has established as to the cause, of that habit of body, in which the different scrofulous affections are most apt to occur, and most to be dreaded.

The chief mark of the scrofulous habit, in persons not yet affected with any disease, is a certain soft, flaccid habit of body, and especially a remarkable softness of skin, observed in persons in whom such a texture of the skin is not to be expected. The complexion is usually pale, with frequently a clear circumscribed redness in the cheek; and this colour is easily changed to purple or livid by cold. The eye has often a peculiar pearly lustre. The senses are usually acute, and the mental powers of observation and apprehension peculiarly active, so that children of this habit shew, in general, a precocity of intellect. The scrofulous tendency is perhaps more frequently and decidedly seen in those who have fair or red hair, and blue eyes, than in others; but is common in dark-complexioned persons also.

In many cases it is more decidedly shown by slight diseases, or the effects of injuries, before any serious disease is contracted;—by the enlarged glands in the neck and groins, the tumid upper lip, the chronic inflammation of the alæ nasi and membrane of the nostrils,—the chronic ophthalmia tarsi, or the strumous inflammation of the tunica conjunctiva of the eye, lasting long, with little heat or redness, but much impatience of light, and a peculiar tendency to the formation of small pustules; and also remarkably by the slow healing of slight wounds, the somewhat livid and chronic inflammation, and often the unhealthy suppuration, that succeed them. Those children that have the softness and consequent distortion of the bones, enlarged joints, and other marks of Rickets, are also very frequently, if not necessarily, prone to scrofulous disease.

The following are the principal facts that have been ascertained, as to the causes by which the Scrofulous Diathesis, or liability to scrofulous disease, is produced.

They may all be ranked together as causes of debility, acting permanently, or habitually for a length of time, although not so powerfully as to produce sudden or violent effects.

1. The tendency is decidedly *hereditary*,—*i. e.* those whose

progenitors have shown marks of scrofulous disease, become affected in this way in much larger proportion than others; although it is very seldom that tubercles, or other scrofulous affections are *congenital*. Feebleness of habit in parents, even independently of actual scrofulous disease in them, appears evidently to dispose to scrofula in their offspring.

2. Although not so exclusively confined to one period of life, as has been stated by some, scrofulous diseases are much more frequent in childhood and youth, *i. e.* between the ages of two or three, and thirty or thirty-five, than at any subsequent period.

3. Although a diet almost entirely vegetable is often found sufficient, when other circumstances are favourable, for the formation of a vigorous habit of body, yet it may be confidently stated, that *a low diet* habitually taken during youth and in health, disposes to scrofulous disease more than a fuller diet does.

4. The scrofulous diathesis is remarkably increased by the influence of *cold and wet*, acting for a length of time in the living body; as is shown by the much greater prevalence of such diseases in the temperate or cold climates, than in those where any applications of cold are comparatively transient,—and also, by the greater frequency of such affections in winter, and especially in spring, than in summer and autumn, in this climate.

It is, however, a mistake to suppose, that the tendency to scrofulous disease cannot be formed in hot climates. The long-continued application of heat, in early life, is weakening, and therefore favourable to the formation of the scrofulous habit; and it is found by experience, that the natives of those climates, both white and black, are peculiarly liable to scrofulous diseases when they come to the colder climates; from which it obviously follows, that the rarity of scrofulous disease in the warmer regions of the globe, is the effect of exemption from its great external cause,—from cold of sufficient intensity, and more especially of sufficient endurance;—but that it is not the effect of absence of the internal predisposition to such disease, in the inhabitants of those regions.

Hence, although it is often of real importance to remove young persons, evidently of scrofulous habit, from a colder to a warmer climate, at the period of life when scrofulous disease is most apt to occur, in order that the excitation of the disease at that period may be avoided; yet it is a mistake to suppose, that this measure furnishes any security against scrofulous disease in future, if they shall return to their native climate, and be there fully exposed to the causes of such disease.

Children brought up in the colder climates, if of healthy constitution, well fed, and duly protected from the excessive or long-continued application of cold, acquire a decidedly stronger habit of body, from the habitual stimulating effect of alternations of temperature formerly considered, than those who are never exposed to such alternations; and therefore resist scrofulous disease (*e. g.* Phthisis) when the latter would fall into it; and the natives of the colder climates, therefore, while they are more frequently exposed to the external cause of scrofula, have also at their command more effectual means, if duly and cautiously employed, for fortifying the constitution against it.

Perhaps it may also be stated, that the exemption of the inhabitants of hot climates, is rather from the scrofulous diseases of particular organs (especially the external parts and the lungs) than from scrofulous disease in general; for the chronic diseases of the Liver and Bowels, so common in hot climates, approach very nearly, in their first origin, to the distinctly scrofulous affections.

5. The formation of the scrofulous habit is probably more influenced by mode of life, especially in early youth, than either by hereditary taint, or by climate.

It is hardly possible to observe separately the effect on the animal economy, of deficiency of exercise and deficiency of fresh air, these two causes being very generally applied together, and often in connexion with imperfect nourishment. But it is perfectly ascertained, on an extensive scale, in regard to the inhabitants of large and crowded cities, as compared with the rural population of the same climate, *first*, that their mortality is very much greater, especially in early life, and the probability of life very much less (the difference being, in some cases, as 45 or 50 to 5, or even to 3); and *secondly*, That of this great early mortality in large towns, a very large proportion, generally a majority of the whole *, is caused by scrofulous disease. And from these two facts, it evidently follows, that deficiency of fresh air and of exercise, are among the most powerful, and the most important, because often the most remediable, of the causes from which the scrofulous diathesis arises.

6. It has also been frequently observed, although the observations have not been on so large a scale, and therefore the conclusion is not so completely established, that the inhabitants of low moist situations are more liable, *cæteris paribus*, to scrofulous disease, than the inhabitants of higher and more airy districts.

7. The tendency to scrofulous disease is remarkably increased by habitual mental languor and depression, as it is counteracted by mental excitement and habitual pleasing emotions †.

8. This tendency is increased by the debility succeeding great evacuations, and especially by that which succeeds acute diseases, as fevers, or the exanthemata, or the febrile state excited by mercury.

9. It is increased by any such causes as habitually impair the digestion, and counteracted by such means as are effectual in restoring the more natural state of the digestive organs, and thereby the general strength.

The effect of all the causes now enumerated is, to give a tendency to inflammation, however excited, to assume the peculiar chronic form above described, and likewise to predispose to the deposition, in various parts of the body, of

* See a paper on Scrofulous Diseases by the author, in Edinburgh Medico-Chirurgical Transactions, vol. i.

† See a striking example in the inhabitants of a nunnery, living under unusual restraints, stated by Laennec, Ausc. Mediat. t. i. p. 647.

the substances described as Scrofulous Tubercles, and which are the origin and foundation of the most formidable scrofulous diseases.

Now, it is obviously of the utmost importance, to ascertain whether, or how far, the deposition of tubercles is itself an effect of inflammatory action. If these deposits can be assimilated to the lymph effused by inflammation, their pathology will be greatly elucidated, and the means of restraining their formation be clearly indicated. And, on the other hand, in so far as we can ascertain that their formation differs from the simple effects of inflammation, we must regard the remedies for inflammation as inadequate or improper in the view of checking that formation.

That the deposition of tubercles may be, and often is, the result of an action, to which it would be absurd to give any other name than Inflammation, appears to be sufficiently demonstrated by the following facts.

1. Their formation may be determined in various instances by the application of the same causes which excite inflammation. This is most unequivocally shewn by experiments on animals, *e. g.* those of FLOURENS on ducklings and chickens *, which, by being kept in a temperature somewhat less cold and more varied than that which excited acute pneumonic inflammation, were subjected to a disease of the lungs, having the essential characters of scrofulous phthisis; and those of MOULIN, SAUNDERS, CRUVEILHIER, KAY, and others†, in which substances not to be distinguished from scrofulous tubercles, and in some instances running nearly the usual course of these, were formed, in consequence of particular modes of mechanical irritation, as by mercury dropt into the trachea, and acting in small quantities, but permanently, on the minute vessels of the lungs.

When we compare the results of such experiments with the well ascertained facts, that masons, miners, needle-

* Annales des Sciences Naturelles, 1828.

† See CULLEN's First Lines, with Appendix by GREGORY, vol. i. p. 590.

grinders, and other artificers, who are necessarily in the habit of very frequently inhaling irritating particles, are peculiarly liable to scrofulous phthisis, we cannot doubt that this peculiarity is to be ascribed to the habitual mechanical irritation; and it is surely reasonable to infer, that what is so easily excited by mechanical irritation of a living part, in a previously healthy animal, must be a product of inflammation.

Again, there are many instances of strictly scrofulous local disease excited manifestly by more serious local injuries, and in which it appears ultimately that the deposition of tubercles had been the origin of the mischief.

2. Cases occasionally occur, where although the deposition of tubercles does not result from mechanical injury, we are very certain that the symptoms attending their first formation are observed,—especially the cases where this deposition is much more general than usual, and fatal much more quickly, and where they are found in great numbers, and all about the same size, implying simultaneous deposition; and in such cases, the remote causes, symptoms and progress of the disease are very generally found to be just those of inflammation of the same parts, of somewhat slower progress than is usual *.

3. The examination of the morbid parts in cases where we see tubercles in their early stages, often shows scrofulous tubercles not only coexisting with, but graduating by insensible degrees into, usual and acknowledged effects of inflammation,—such as flakes of lymph on membranes, or granulations formed by lymph and effused into cellular texture; and the substance which has the form of incipient tubercles, so precisely similar to that which is thus irregularly diffused, that we cannot ascribe to them a different mode or period of formation. This intimate blending of tubercular deposits with inflammatory effusion, and distinct transition by insensible degrees, of the one into the other, is often seen on the serous membranes of the head,

* See the papers in Edinburgh Medico-Chirurgical Transactions already quoted, vols. i. and iii.

chest, or abdomen, on the mucous membrane of the bowels, and in the interior of the lungs or liver. The tubercular matter in the lungs is often, as LAENNEC states, *infiltrated* into the cellular texture, and when so, it is impossible to draw a distinct line of demarcation between it and the grey hepatization of the lungs.

4. Although the changes which tubercles undergo after they have been deposited, are generally much slower than, and sometimes materially different from, those which take place in decidedly inflammatory effusions, yet in many cases they resemble those changes in their essential characters; and in the case of children, in particular (where their course is always more rapid than in adults), they are sometimes hardly to be distinguished from small abscesses, resulting from the usual causes of inflammation, gradually enlarging, then softening, and ultimately discharging purulent matter.

From these facts, it seems quite reasonable to infer, that in certain constitutions, tubercles and all their consequences are direct effects of inflammatory action, and may be prevented if that action be arrested or subdued.

But on the other hand, it is plain, that there must be an essential peculiarity in the nature of the morbid action by which tubercles are formed, from these two leading facts in their history, which distinguish them from the ordinary effects of inflammation; 1*st*, That they are originally deposited in very minute but separate globules; and, 2*dly*, That when deposited, instead of being very liable to absorption (as the lymph effused by healthy inflammation is), they continue to grow, when there is no indication of inflammation around them, and even when the whole quantity of blood supplying the parts where they exist is much diminished. And the history of many cases informs us, that when the constitutional peculiarity leading to such consequences is very strong, little or no inflammatory action is necessary to determine the deposition of tubercles; but that they will be formed wherever there is any congestion of blood, and sometimes where there is no vestige of previous disturbance of the circulation.

This tubercular diathesis may be reasonably supposed to depend, in part at least, on some peculiarity in the condition of the blood; and it is very important to observe, that it appears to be manifestly increased by tubercular disease already existing in any part of the body; fresh deposits taking place, often in various parts, more frequently, and with much less evidence of previous disease, in cases where tubercles already exist in numbers in one organ (*e. g.* in the lungs), than in any other cases.

The most leading fact that has been observed, as to the essential nature of tubercular deposits, and their difference from the diffused organizable lymph thrown out by healthy inflammation, is that stated by GENDRIN *, but requiring farther confirmation, that when examined by the microscope in their earliest stages, and in their distinct form, they never shew any of the decolorized globules of the blood, which can be detected in the fibrinous effusions from healthy inflammation. Hence probably it is, that they do not form layers or flakes, as the latter substance does, in consequence of the peculiar mode of aggregation of the globules into fibres; but that they gather into little spherical masses, under the influence of gravitation, as any other viscid fluid does, when slowly poured out in thin films, or narrow lines. Hence, also, in all probability, their incapacity of acquiring vascular organization.

All that is known of the conditions under which scrofulous tubercles usually originate, may perhaps be comprised in the proposition, That when the blood is unusually serous, and its motion languid, in numerous small capillaries, partial exudations of its albuminous portion are apt to take place, and cohere together into minute spherical masses, which are destitute of the power of acquiring an organized structure themselves, but grow by attracting to themselves fresh matter from the vessels; and that this exudation, although not absolutely dependent on, is much promoted by, congestion of blood, or inflammation, in the parts where it takes place.

* Hist. Anat. des Inflammations, t. ii. p. 595.

CHAPTER VII.

OF IDIOPATHIC FEVER.

THE combination and succession of symptoms, which we regard as characteristic of Fever, or febrile action, have been already described; and it has also been stated, that these symptoms, even as occurring in connexion with, and apparently in consequence of, inflammation, are liable to considerable variety, and particularly to two varieties, already designated as *inflammatory* and *typhoid;* of which the latter has this important peculiarity, that it may very generally be ascribed to the influence of some other cause affecting the constitution, besides the inflammation itself. We have now to treat of Fever (almost always more or less of this last character), as it frequently occurs, either without marks of local inflammation, or with so slight or so variable marks of that kind, that we judge it proper to consider it as independent of inflammation.

It is true, that there are eminent pathologists who doubt of the existence of such Idiopathic Fever; believing all febrile action to be dependent on local irritation and inflammation; but we set aside that doctrine in the mean time, simply on the ground, that physicians have generally described fevers, of the kind now in question, as distinguishable by their symptoms and history, independently of all theory, from any of the certain and acknowledged effects of inflammation; and this being so, it is right to treat of the diseased states thus distinguished, in the first instance, separately; and afterwards to consider the *Theory* which would resolve the one into the other. And although the term Idiopathic Fever may appear too theoretical to be used in the first instance, yet it is hardly possible to substitute another; and if it be understood that it is at first used to designate peculiarities of symptoms, independently of all theory, it can hardly tend to mislead.

We set aside also, without hesitation, the objection that has been urged against the doctrine of Idiopathic Fever, that the term expresses only an abstraction, and therefore a nonentity; because what we mean to express by the term is not an *abstract* existence, as distinguished from individual *facts*, but a *general* change, or succession of changes, common to all the organs, and to almost all the textures of the body, as distinguished from such changes as are *partial*, *i. e.* confined to particular situations in the body,—and from the direct consequences of such partial changes.

SECTION I.

OF THE DIAGNOSTIC SYMPTOMS AND VARIETIES OF IDIOPATHIC FEVER.

The peculiarities by which Idiopathic Fevers, according to this acceptation of the term, seem to be best distinguished, are the following.

I. There is the *negative* fact, that in many of the cases, to which this name is given, the general febrile symptoms, —the chilliness and lassitude, the subsequent reaction, and often long-continued acceleration of pulse and heat of skin, the thirst, anorexia, various uneasy sensations, and derangement of all the functions of the body (whether functions of the vascular or nervous system),—are often unattended during great part or the whole of their progress, by any such local symptoms,—such fixed and permanent local uneasy feeling,—or such peculiar derangement of the functions of any one part of the body, as justifies the belief that any individual organ is inflamed. And if these observations be thought ambiguous, on account of the occasional occurrence of cases of latent inflammation, formerly mentioned, the absence of local inflammation, in many such cases, is farther attested by the fact, to be afterwards stated, that they sometimes terminate fatally, without any satisfactory evidence appearing, on dissection, of inflammation of any part of the body; and very generally with so slight appearances of that kind, as are inadequate to the explanation of the fatal event.

II. Besides this negative observation, which applies only to a part of the cases thus named, there is the *positive* observation, applicable probably to all cases of idiopathic fever, although much more obvious in regard to some than others, that the *typhoid* symptoms, formerly shortly described, (and which may always be held to imply the action on the system of some cause distinct from mere local inflammation) are distinctly to be perceived. These typhoid symptoms shew themselves in one or other, but generally in several, of the following ways.

1. In the state of the Circulation, the pulse having very generally, from the commencement, or early in the disease, less strength, or resistance to compression, than in the fever which usually accompanies simple and decided inflammation, at the same period after the attack.

2. In the state of the Secretions, which are more deranged, and generally more diminished, than in inflammatory fever; as is sufficiently obvious in the fur on the tongue, and the secretions of the mouth, becoming viscid, dry, and dark-coloured; in the more complete failure of appetite; and generally, after a short time, in the greater dryness of the surface of the body, attended in most cases by a more pungent, though less enduring, heat of the surface.

3. In the state of the Nervous System, the greater tendency to stupor or confusion of thought, generally to be detected even in the commencement, and very obvious in most cases throughout most of the disease, often shewing itself unequivocally in the later stages by the involuntary voiding of the excretions which are naturally under the restraint of the will; the greater weakness, vertigo, and faint-

ness on attempting exertion, in the early part of the disease, attended generally with much tenderness of surface and general soreness; the frequent tremors and subsultus tendinum, even when no exertion is made; the greater derangement of the external senses, particularly of that of Hearing; the greater tendency to delirium, as the disease advances, and the usually peculiar character of that delirium, which extends to all the trains of thought in the mind, is unattended with propensity to violence, and is more or less blended with, or graduates into, stupor, and hence is generally designated by the epithets low, muttering.

4. In the state of the Blood, which is probably always so far altered in its vital properties, in idiopathic fever, as to coagulate less firmly than usual, and in some cases loses the power of coagulation altogether; in connexion with which state we frequently observe more or less of the symptoms formerly called those of putrescency in fever, petechiæ or vibices, passive hæmorrhages, and gangrene from slight irritation.

These symptoms, and especially the indications of nervous affection, and of putrescent tendency, are very generally sufficient to distinguish idiopathic from any form of inflammatory fever; but in many cases, there is a farther positive distinction in the appearance of peculiar or *specific inflammations of the skin*, subsequent to the attack of the fever, which take different forms,—essentially characterising the fevers that are designated as eruptive or exanthematous,—often appearing also in the simple continued fever,—but never forming any part of the constitutional symptoms that result from local inflammation exclusively.

III. A most important part of the history of what we call idiopathic fever, distinguishing it from the acknowledged effects of inflammation, is its much greater tendency to a *spontaneous favourable termination*. This is shown in different ways. In many cases the febrile symptoms return at regular intervals, of 24, 48, or 72 hours; and subside completely after a cold and hot fit of some hours' duration, by a spontaneous sweating,—constituting the *Intermitting* form of fever. In others there are equally distinct, but less perfect and less regular remissions of the symptoms, and the term applied is *Remittent* fever. And in the remaining, or *Continued* form of Idiopathic Fever, although we can observe only slight and partial abatement of the symptoms at different hours of the day, we very often observe complete recovery from the most urgent and distressing symptoms, taking place spontaneously at various periods of the disease,—sometimes, in the fever of this country, as early as the 7th or even the 5th day; sometimes not until the 30th, or even 40th day, most generally between the 10th and 20th; sometimes very rapidly, and with evacuations (whether at regular or irregular times) evidently resembling the sweating stage of intermittents; sometimes gradually, and without any such critical evacuations; but under very various treatment,—often without the use of remedies,—and always with less assistance from remedies, and with much less risk of subsequent organic disease, than where recovery takes place from an equally disordered state of the system, consequent on decided internal inflammation.

IV. There is this farther leading peculiarity in the cases of febrile disease, to which we give the name of Idiopathic Fevers, that they are often absent for a length of time, even from large communities, and again at other times, or in other districts, are extremely prevalent; and therefore evidently do not proceed merely from causes which are of general operation, as the exciting causes of inflammation are, but must necessarily result from causes of more local and temporary agency; and accordingly, we have good evidence, that all these idiopathic fevers either originate from a Malaria, or propagate themselves in part at least, and in certain circumstances, by Contagion.

By attention to these particulars in the history of many febrile disorders, even independently of attention to the results of practice, we are authorised to conclude, that they may be distinguished from the effects of simple inflammation, and belong to the class which we call, for the present, Idiopathic Fevers; and that the *onus probandi* rests with those who would attempt to assimilate them to, or resolve them into, the acknowledged effects of inflammation.

But these Idiopathic Fevers are liable to very considerable varieties; and, setting aside for the present the Eruptive Fevers, we may enumerate two distinct heads of these varieties; in the first of which the distinctions lie in the essential symptoms of the febrile action itself; in the second, in the indications of local and general inflammatory disease, which attend it frequently, although not uniformly, and therefore not necessarily.

I. 1. There is a form of fever, of rare occurrence, but of great pathological importance, which has been lately described under the title of *Congestive;* and although that term expresses what is probably a concomitant, rather than the cause of the peculiarity of the symptoms, yet it is perhaps better to endeavour to fix its meaning, than to substitute another.

In this variety of fever, the symptoms of the earliest, or cold stage, assume their highest degree of intensity; and feebleness of pulse, coldness of surface, muscular debility, and depression of all the functions of the nervous system, approaching, and sometimes amounting, to complete coma, are the leading symptoms. Spasms attend some cases of this kind, and vomiting attends others. Such cases occur now and then in epidemics of common continued fever, but are more frequent in the most malignant epidemic diseases, Plague, Yellow Fever, Cynanche maligna; and many cases of Epidemic Cholera are closely analogous to them. In all these cases, if this first and very dangerous effect of the remote cause of the disease is recovered from, it is usually succeeded by a distinct, but generally feeble, febrile reaction.

2. What is called the *Inflammatory* form of Idiopathic Fever, is the most widely different from the congestive form. In this case, the depression in the first or cold stage

is the least, and the febrile reaction is the strongest, the pulse full, firm and frequent, the skin hot and retentive of its increased temperature; the thirst intense, the urine generally high coloured, the face often flushed, and the febrile pains of head and other parts intense; the senses often preternaturally acute, and the delirium, if present, attended with increased rapidity of thought, and sometimes with violence.

In all cases of idiopathic fever, these symptoms, sooner or later, undergo a change, and pass into the typhoid form more or less completely; but the cases in which the symptoms now mentioned are the best marked, and last longest, and where the subsequent typhoid stage is the least obvious, have the general name of Inflammatory Fever.

3. On the other hand, the name of *Typhoid* Fever is given to those cases in which, after the febrile reaction has been established, the typhoid symptoms already enumerated *,—in the state of the circulation, of the secretions, of the nervous system, and of the blood, are earliest observed, and are most urgent;—the distinction between this and the inflammatory form of fever being therefore a difference in degree rather than in kind.

The term Malignant, as applied to fevers, may be said to include the rare congestive, and the frequent typhoid fever; as applied to epidemics, to denote those in which cases of these two descriptions are the most frequent.

Under the general name of Typhoid Fevers, we may describe three subordinate varieties, which it is in some cases easy and important to distinguish; but which in most instances are blended together, or graduate into one another.

a. When the most obvious and urgent of the typhoid symptoms are those of mere debility of the vital actions,—soft compressible pulse, dry foul tongue and lips, deficient or easily depressed heat of the surface, and extreme muscular debility, shewn in the voice and attitude as well as in the muscular movements,—the name of "Fievre Adynamique" is given by recent French authors, and the term Low Fever is the most appropriate in our language.

* See p. 483.

b. When the most obvious and urgent of the typhoid symptoms are those indicating derangement of the functions of the Nervous System,—pervigilium, restlessness, tremors or spasms, deafness, contracted pupil, and other affections of the external senses, delirium, especially of the more active kind, and this afterwards subsiding into stupor, —the case has been styled "Fievre Ataxique" by the French, and is generally called Nervous or Brain Fever in this country. This form of fever is most remarkably seen in persons in whom the nervous system has been previously and habitually excited, either by voluntary mental exertion, or strong and lasting emotion,—or by the inordinate use of stimuli, such as alcohol.

c. When the most obvious of the typhoid symptoms are those denoting a dissolved state of the blood, petechiæ, passive hæmorrhages, gangrene from slight irritations, &c. the case has still among many the name of Putrid Fever.

All these varieties may be observed in cases where neither the symptoms before death, nor the appearances after death, give any clear indication of inflammation in any individual organ; and may be said therefore to be different forms of *Simple Fever*.

II. The more complex and most generally dangerous forms of fever, are those where the symptoms, especially of the typhoid fever, are combined, either from the first or during their progress, with such symptoms as indicate, with more or less certainty, local Inflammatory Action in some part of the body; and these are most simply divided into Fevers with affection of the head, chest, or abdomen.

It may be stated generally, that inflammations of certain organs in the body are very apt to combine themselves with general fever; but that the course of these inflammations is evidently modified; the fixed pains attending them are generally less acute; their other symptoms often become protracted, and remain nearly stationary for a longer time than in other cases; and they tend, as will afterwards appear, to terminations which are in some respects peculiar.

The *modifying* effect of fever on local inflammation, is seen where fever attacks a person in whom any cutaneous inflammation and effusion are going on; the appearance of which is usually much altered, and the discharge often suppressed during the febrile state.

1. It is obvious that many of the symptoms of affection of the brain which occur in fever, are the same as attend cases of unequivocal inflammation of the brain, *e. g.* the headach, often violent; the impatience of light and sound; frequent nausea and vomiting; the indications of determination of blood to the head; the delirium, of various character, spasms of various muscles; and ultimately Coma. Such symptoms are perhaps chiefly seen in the fevers of the hottest weather of this climate, and in those of warmer climates. It is also certain, as will be stated afterwards, that unequivocal effects of inflammation have been occasionally found on dissection, after fatal fevers; that more or less effusion of serum within the cranium, which was described as the first effect of inflammation there, is common in such cases; and that the remedies for inflammation, early and prudently applied, have often appeared to relieve very considerably the symptoms of affection of the Nervous System occurring in fever; and therefore, although we shall afterwards see reason to believe that the affection of the brain in fever is by no means simply inflammatory, but partly dependent on another cause, yet we may consider it as ascertained, that a degree of inflammation within the cranium (generally best designated by the title of Subacute), does often accompany idiopathic fever; and is most to be apprehended when the symptoms above mentioned are the most urgent, and when there appears to be danger of death strictly in the way of coma, rather than by reason of the circulation being enfeebled.

2. There are many cases of fever, especially in winter and spring, in which an inflammatory affection of the organs of respiration, marked by cough, hurried or laborious, and sometimes stridulous breathing, and more or less of pain of chest, either accompanies the disease from the com-

mencement, or supervenes during its progress; and in a number of these, it is obvious that death takes place, or is strongly threatened, by Asphyxia, from the embarrassed state of the respiration, rather than by Asthenia, from the weakened action of the organs of circulation.

This affection of the chest, besides being attended with more or less of the typhoid symptoms, formerly mentioned, which make no part of the symptoms in ordinary cases of idiopathic bronchitis or pneumonia, has a course considerably different from those diseases. It is often of long duration, is apparently less under the influence of active remedies; and although it may be moderated or restrained, is seldom observed to subside completely, until the period of spontaneous abatement of the fever, which, in such cases, is often long protracted. The cough and dyspnœa are generally much more urgent symptoms in this combination of pectoral affection with fever, than the pain of chest; and the symptoms observed by auscultation and percussion, and the appearances on dissection, clearly indicate that the mucous membrane of the bronchiæ, and parts of the substance of the lungs, are very liable to inflammation, of a somewhat peculiar character, in the course of fever, but that inflammation of the serous membranes within the chest is very rare.

3. The affections of the abdominal viscera, frequently attending idiopathic fever, are somewhat various. An attack of jaundice, at least of yellowness of the skin, in the course of the disease, is frequent and very dangerous in the fevers of hot climates, and occurs occasionally in this. It is often attended with pain and tenderness in the situation of the liver, and such affection of the breathing, such nausea and vomiting, as usually attend inflammation of the liver; but in some cases, it is unattended with such symptoms. In some cases, it is unattended with the usual indications of jaundice in the stools and urine; and in general, it has appeared, on dissection, unconnected with any visible obstruction of the gall-ducts.

In other cases of fever, without jaundice, there is so much pain and tenderness in the situation of the stomach, and nausea and vomiting, increased by all ingesta, as to justify the belief of inflammation (generally subacute) in the stomach itself. These affections, both of the liver and stomach, in fever, if not early checked, are frequently followed by sudden increase of the symptoms of affection of the brain, and by rapidly advancing coma.

But the most common abdominal affection in fever, is that in which the intestines are chiefly concerned, which comes on at different times, but chiefly, and with most danger, in the later stages; and this is marked sometimes by severe pain and tenderness, but in general chiefly by diarrhœa, seldom violent, but often obstinate; it is attended with occasional griping (often aggravated by ingesta), sometimes with scanty mucous and bloody stools and tenesmus, as in dysentery, but more frequently without such symptoms. It is often accompanied with gradually increasing tympanitic distention, and often occasions long protraction of the typhoid febrile symptoms, in the course of which great emaciation, extreme debility, and often a peculiar dryness of the skin are observed; and in a few cases it is followed, either by sudden exhausting hæmorrhage, or by a sudden attack of acute pain and tenderness of abdomen, with vomiting and rapid sinking.

It is well ascertained that such abdominal symptoms in fever depend very generally on inflammation of the mucous membrane, and especially of the mucous glands of the intestines; that this inflammation tends rapidly to ulceration; and that the attacks of sudden hæmorrhage or of acute pain and tenderness in the advanced stages of such cases, usually depend on erosion of bloodvessels, or perforation of the whole coats, and escape of the contents of the intestines into the cavity of the abdomen, in the course of that ulceration; but that inflammation commencing in, or confined to, the peritoneum, is equally rare in fever, as that of the serous membranes within the chest.

Besides these inflammatory appearances in internal parts, often found after fatal fevers, there are many cases of external inflammation going on to ulceration, and often to gangrene, which attend the later stages of fevers. These may often be ascribed to accidental irritation, such as pressure, or the dribbling of urine. They sometimes occur, especially in the extremities, without any assignable cause; but from the time and mode of their occurrence, are always regarded as effects or accompaniments of the fever.

The different local affections now described frequently succeed each other, or are combined together in the course of fever, in the same patient; and observation of the symptoms of the later stages of most fatal fevers, at least in this climate, sufficiently indicates that the danger most generally results from a *combination of one or more of these local affections* with the typhoid form of the fever, and especially with the enfeebled state of the circulation.

Whenever the symptoms of any local inflammation have combined themselves with those of general fever, it is to be apprehended that the fever will be much protracted; and in fact, it is frequently by the protraction of the case, rather than by the intensity of any local symptoms, that we are led to suspect the local diseases, of which the evidence may afterwards appear on dissection. There are also great varieties, not only in different individual cases, but in different epidemics, as to the average duration of the disease, and as to the intensity of the typhoid symptoms, the frequency of eruptions, or the indications of a diseased state of the blood,—which cannot be ascribed to the influence of any external causes, and must be held to denote varieties in the nature and virulence of the remote cause of the disease.

But although we consider it of real importance to mark these distinctions, both in the essential symptoms of Fever itself, and also in the concomitant local affections which distinguish individual cases, and sometimes epidemics, from each other, yet it appears equally certain, from consideration of the nature of these distinctions, of the manner in which the varieties, thus marked, graduate into one another, or are blended together in the same cases, and by the many varieties which present themselves in the same epidemic, and in immediate connexion with each other, that all the continued fevers of this climate must be regarded as fundamentally the same disease.

The Intermitting and Remitting Fevers have obviously, from what was already said of their characteristic symptoms, as well as from their remote causes, peculiar characters, and may be regarded as varieties of a disease different from Continued Fever, although so closely allied to it, as to be properly included in the same genus. In the warmer climates, and especially in the lower grounds in these climates, the external cause of this disease acts with the greatest virulence; and in these, it is doubtful whether the continued fever of this climate really exists. But it is certain that the remittent fevers, in their highest degree of intensity, have nearly the continued form; and they are then attended with great danger, and shew the following peculiarities: 1. That their whole progress is much more rapid than that of the fevers in this climate; 2. That the symptoms denoting inflammation or an approach to inflammation of the brain are often more urgent, in the first instance, than here; and 3. That the symptoms of inflammation, or a state nearly resembling inflammation, of the liver and stomach, with or without the occurrence of jaundice, are more urgent, and much oftener appear concerned in the fatal event.

In different cases, and in different epidemics, of the fevers of hot climates, there is a variety as to these concomitant local symptoms; but it appears clearly that there is also a variety, in different seasons and situations in these climates, as to the intensity or malignity of the proper febrile symptoms; the depression of the vital power of the circulating system, and the symptoms of dissolved state of the blood, shewing themselves much earlier, more extensively, and more intensely in some seasons than in others. When this is the case, the remissions are the least obvious, and it is on such occasions that a doubt still exists, whether the remittent fever does not acquire that most important property of the continued, the power of spreading by contagion.

It may be stated, in concluding this account of the symptoms and varieties of Fever, that after the febrile action has subsided, and the patient begun to become convalescent, he is left in a state of weakness and perhaps irritability, in which he is peculiarly liable to inflammatory attacks; the symptoms of which are often obscure, or nearly latent, and very easily confounded with those of the preceding fever, insomuch that it is often difficult to judge, whether death is to be ascribed to fever, or to some of these, its immediate consequences.

Scrofulous affections are likewise very apt to be excited by their usual causes, after the cessation of idiopathic fever; and various other organic diseases often take their origin at that time. In the case of intermitting fevers, and especially of those which are of long duration, and in which the cold stage is long and violent, enlargements of the liver and spleen are peculiarly apt to take place towards the close of, or subsequently to, the disease.

SECTION II.

OF THE APPEARANCES ON DISSECTION AFTER IDIOPATHIC FEVERS.

The first fact to be borne in mind in this part of the subject is the occasional entire absence, after fatal fever, of any appearances, which can be strictly called morbid; *i. e.* of any which are not frequently observed, in cases either of sudden and violent death, or of death from causes allowed to be unconnected, either with general febrile action, or with any symptoms of disease of the parts, where they are found. It may be allowed, that this is a rare case; but it is not on that account the less pathologically important, and it is admitted by the most accurate morbid anatomists as an unequivocal result of their inquiries.

Next, it is to be observed, that the morbid appearances, found after fatal fevers, are often observed to be remarkably various, even in cases, the leading symptoms of which are nearly the same; and that they are far from bearing any fixed proportion to the intensity of the symptoms of affection of the parts where they are found.

This may be ascribed in a great measure to the enfeebled state of the circulation at the time when these local affections take place, rendering them, as has been already stated, frequently *latent*.

In regard to the nature of the morbid appearances which are found after death by fever, it is to be observed, that they are almost uniformly indications of inflammation; but this inflammation is distinguished by two peculiarities, *first*, that it is seated very generally in certain textures only; and, *secondly*, that its effects are apparently more limited than in other cases, and in particular the effusions of coagulable lymph and of pus are found to a very small extent, in comparison with what is seen in idiopathic inflammation of the same parts. Indeed there are so many fatal cases of fever, attended with evident local affections, and shewing on dissectionmarks of local inflammation, in which no effusion of lymph or pus appears on dissection, that it may be suspected, in the comparatively few cases where such effusions to any considerable extent have been described, that they had resulted from simple inflammation immediately succeeding (as often happens) to the fever, rather than that they had taken place during the fever itself.

I. Within the cranium, the morbid appearances found after death from fever, are in by far the greater number of cases, confined to increase of the natural serous exhalation on the different surfaces, particularly in the ventricles, and beneath the arachnoid coat;—in which situations in the case of fever, (although not in strictly inflammatory cases) the increased exhalations are very generally found simultaneously. This effusion may be held to be morbid, whenever it is of such extent as obviously to distend the ventricles, to elevate the arachnoid coat, or to widen the depressions between the convolutions of the brain *.

Such morbid effusion is probably the most frequent of any morbid appearances after continued fever in Scotland; but it is to be observed, that it is frequently found likewise after inflammatory diseases, in which abundant cause of death appears on dissection in other parts of the body. It is also found after many cases of chronic disease of different parts of the body; and this circumstance renders it somewhat difficult to judge, how far it can really be regarded in the cases now in question, as an effect of fever; but when it is found in a person who was in perfect health ten or fourteen days before his death, and in whom febrile symptoms and affections of the head resembling the usual effects of inflammation there have intervened, we cannot hesitate about regarding this, which is an acknowledged result of inflammatory action, as a morbid appearance strictly connected with the fatal fever. It is important, however, to observe, that the whole amount of this effusion within the cranium, in cases of fever, seldom amounts to an ounce; and is very generally much less than in fatal cases of idiopathic inflammation within the cranium, whether acute or chronic.

An injected or unusually turgid state of the bloodvessels within the head, especially of the pia mater and substance of the brain, is often observed after fatal fevers, and is probably often an effect of the same condition of the vessels, from which the effusion results; but agreeably to what was formerly said, we are not entitled to deduce from that appearance alone, any inference as to inflammation, or even morbid congestion of blood in the part before death.

In a few instances, after fatal fever, a little extravasation of blood has been found within the cranium; and in a greater number, where paralytic strokes have taken place in the course of fever, we are pretty certain, that such extravasation has occurred. In a few cases also, effu-

* See Andral, Clin. Med. t. i. p. 418.

sions of lymph on the cerebral membranes, and even deposits of purulent matter, either circumscribed or diffused, have been found; but in some of these, at least, it may be doubted, whether these decidedly inflammatory effusions had taken place during the true febrile state.

The appearances now mentioned may be supposed to have connexion with the comatose tendency, and the death in the way of coma in Fever; but they are sometimes altogether absent in cases of that kind, and their amount cannot by any means be anticipated from observing the duration or intensity of that tendency. It is certain, that neither unusual hardness, nor unusual softness, of the substance of the brain, is uniformly, or even very frequently, connected with the symptoms of fever, and that any indications of disease of the dura mater during fever are very rare.

In the Spinal Cord, appearances similar to those now described in the brain, have been occasionally observed, but do not appear to be very common, nor can any uniform connexion be traced between the appearances there, and spasms or other affections of the voluntary muscles in fever.

II. The morbid appearances found in the air-passages and within the chest after fatal Fever, and which are often evidently connected with the death by Asphyxia in fever, are the following.

1. There is, in a few cases of fever, an inflammation, generally a peculiar aphthous inflammation, of the mucous membrane of the fauces and larynx, and the thickening and exudation in the latter part may be to such extent as to embarrass the respiration very materially, and conduce to the fatal event. But it is very seldom that the mechanical impediment to the access of air to the lungs, produced by inflammation of this part during the progress of the true febrile symptoms, is very great.

2. In a great proportion of fatal cases of fever, more or less of the usual indications of inflammation of the mucous

membrane of the bronchiæ, vascularity and thickening, and effusion of viscid or frothy mucus, are found on dissection; and in some cases these effects of Bronchitis are so general, in both sides of the chest, as to afford a satisfactory explanation of much dyspnœa, and of death by asphyxia.

3. In a considerable number of cases there is found a decidedly morbid amount of serous effusion into the pulmonary cellular substance itself, which is discharged on cutting and pressing that substance.

4. In many cases there is found after fatal fever, condensation of part of the substance of the lungs, known by its not crepitating under the knife, and often likewise by its sinking in water, and attended with softening. But this condensation very generally differs from the hepatisation formerly described, in having a darker and more uniform colour, and not shewing the characteristic appearance of granular lymph *.

In regard to these appearances in the substance of the lungs it is to be observed, that they frequently coexist with the indications of Bronchitis, already mentioned; and that in such cases, if they are found only in the posterior or depending portions of the lungs, and nearly alike in both sides of the chest, although not strictly *post-mortem* appearances, yet they indicate only congestion of blood, and consequent extravasation taking place within the last few hours of life; when the blood, in consequence of its defective arterialization, and of the enfeebled action of the heart, is making its way so slowly through the capillaries of the lungs, that it is liable to the influence of gravitation, and stagnates so much in the lowest of the vessels of the lungs, as to distend these vessels permanently, and to transude from them more or less completely into the adjacent cellular substance.

That these results should follow from the languid movement of the blood through the lungs, in this and other acute diseases, when the blood is in full quantity, its vitality probably impaired, its arterialization impeded, and the powers propelling it much depressed, is what may readily be anti-

* See p. 408.

cipated; and that this is the real explanation of the appearances now described, in many cases of fever, seems sufficiently demonstrated by their occupying so strictly, in many such, the depending portions of the lungs,—by their being often found in that situation where no pneumonic symptoms had occurred,—and by two observations of LAENNEC, 1. That he had repeatedly satisfied himself, by auscultation, of the commencement of this "Peripneumonie des Agonisans," only at the time when the powers of life were prostrate; and 2. That in one case, where in consequence of sores on the back, the patient was constrained to lie on his face, for some time before death, the very same appearances were found in the *anterior* (but still the depending) portions of the lungs.

When the effusion of serum, or extravasation of entire blood, into the cells of the lungs, are found in parts that do not lie lowest, or variously disposed throughout the lungs, it may confidently be inferred that they are the effects of an inflammatory action; but somewhat modified by the presence of the typhoid fever, so as to give results in some measure different from what are seen after other cases of inflammation there.

5. There are some cases, in which real gangrene of the lungs, known by perfect flaccidity and putrid smell, and generally denoted before death by the peculiar fœtor of the breath, is found as a consequence of inflammation of the lungs, accompanying Fever; as in other cases where pneumonic inflammation is attended with great weakness of the circulation.

Evidence of inflammation of the pleura or pericardium is very rarely seen after idiopathic fever, except in cases where the progress of the symptoms gives reason to believe that a simply inflammatory attack had supervened on fever already on the decline.

III. The alterations of the Liver found after fever, and which can be regarded as consequent on it, even where there has been yellowness of the skin, very seldom amount to more than partial enlargement and softening, and injection of minute vessels. In the spleen morbid softening is more common; and much but various alteration of the appearance of the bile, after fatal fevers, has been remarked by ANDRAL and others; and is important to be noticed, as it may possibly be concerned in producing the affections of the intestines now to be mentioned.

The morbid appearances in the mucous membrane of the Stomach and Bowels often seen after fever, demand careful attention. They are seen frequently in cases where there has been much affection of these parts during life, but bear no fixed proportion to the intensity of the symptoms denoting such affection; and in cases that are long protracted, they are often observed to an unexpected extent, when the functions of the bowels had appeared to be very little deranged.

It may be said in general, that these appearances differ from those commonly seen after idiopathic inflammation of the same parts (*e. g.* in dysentery), in the inflammation being here more limited to spots on the membrane, and the effusion of lymph consequent on it, being to a much less extent.

The marks of inflammation of this membrane found after death by fever, are generally the following.

1. Brownish-red patches, generally with a reddish coloured mucus lying on them. But this appearance, if confined to parts that lie lowest in the position of the body in the last hours of life, and after death, is by no means to be trusted as an indication of previous inflammatory action. 2. Softening and thickening of the membrane at the parts so discoloured, which, if accurately and carefully described, are much better signs of real disease than any variations of mere colour *. 3. Effusions of lymph, in

* In the fevers of hot climates, which are so rapidly fatal, the morbid appearances found in the abdomen, and connected with the incessant retching, and ultimately with the black vomit, are generally confined to the appearances now described, existing often in an intense degree in the mucous membrane of the stomach, but without exudation of lymph or ulceration.

spots dispersed over the surface, which adhere for a time to the mucous membrane itself, and sometimes take much the form of exanthematous diseases. 4. Ulcers of various size and form, generally rather thinly scattered, excepting at the lower end of the ileum, where they are often set in clusters; very generally preceded by some effusion of lymph, and formed sometimes by the ulcerative absorption only, in other cases in part by sloughing of the membrane.

All these appearances are observed sometimes in spots of the mucous membrane itself, but more generally in the portions of that membrane already occupied by the small mucous glands, named Glands of PEYER and BRUNNER. They are most common in the ileum, especially its lower extremity, next in the cæcum and colon, and next in the stomach, and are rarest in the duodenum. They are very often attended with vascularity of the corresponding parts of the mesentery, and enlargement and injection of the corresponding mesenteric glands.

Such unequivocal disease of the mucous membrane of the alimentary canal is found, either alone, or in combination with the other diseased appearances above mentioned, in a majority of fatal cases of continued fever, which occur in Paris, and in a large proportion of those that occur in London; but in a much smaller proportion of fatal cases in Scotland. They are decidedly more frequent, at least in this country, after the fevers of children and young persons than in advanced life; and in fevers that are fatal at an advanced period than in those that are rapidly fatal.

We have good evidence that the ulcers thus formed may be afterwards cicatrized; but there are also a certain number of cases, in which dissection shews that the ulceration has extended to vessels of such size as to give a copious discharge of blood; and others in which it has led to perforation of the whole coats of the intestines, escape of their contents, and consequent rapid and fatal inflammation of the peritoneum. These effects of the ulceration are almost always made known by the sudden attacks of hæmorrhage, or of violent pain and sinking, formerly mentioned; and these symptoms sometimes commence at so late a period, after the febrile action has subsided, as to indicate that the fever is by no means necessarily coexistent with the formation or even the extension of these ulcers.

It is important to observe that the external inflammations which often attend the later stages of fever, both those caused by irritation, such as pressure, and those which occur spontaneously, *e. g.* in the parotid glands, or in the feet and toes, are found to exhibit characters, during life, and after death, which distinguish them from the more usual inflammations of the same parts; they often tend to ulceration, and often to gangrene, but seldom to effusion of healthy pus, and hardly ever to the formation of granulations, while the general febrile action continues.

When pains are taken to distinguish the truly morbid appearances left by fever, from appearances (such as staining of the inner membrane of arteries, or of the mucous membrane of depending portions of bowels) which may be fairly ascribed to changes taking place after death, in a body where the coagulation of the blood is imperfect;—and likewise from the effects of inflammations often rapidly supervening during the convalescence from fever;—we shall not be authorized to consider more phenomena than those now described, as certainly belonging to the former class. When the more chronic sequelæ of fever prove fatal, they leave a much greater variety of appearances behind them. In particular, when the enlargements of the liver and spleen, so often consequent on Intermittent Fever, end in a fatal chronic disease, the appearances usually found are just the same as are common, when there has been long-continued obstruction to the course of the venous blood in the thorax, and consequent congestion in these viscera;—viz. enlargement, hardening, increase of the whitish cellular substance in the parenchyma, and ultimately the development of tubercles there. And the circumstances preceding the formation of such organic disease, in the case of long-continued intermittents, (especially Quartans, where there have been frequent long cold stages, implying congestion of blood in the great internal veins, and at the same time feeble circulation),—and again, in cases of mechanical obstruction of the venous circulation,—mutually illustrate one another.

SECTION III.

OF THE REMOTE CAUSES OF IDIOPATHIC FEVERS.

Referring, first, in this part of the subject, to what has been already said *, of the marks by which we can confidently distinguish a disease that results from some local and temporary cause, from one the causes of which are generally diffused, and pretty uniformly recurring,—we observe, that all Idiopathic Fevers, Intermittent, Continued, and Eruptive, appear evidently to belong chiefly, if not exclusively, to the former class; because they are all observed to prevail generally, and affect many persons in quick succession, in certain places, and at certain seasons; and are almost or entirely absent, for long periods, from other large communities, or from the same at other times.

It is to be remarked, however, that continued Fever is on a footing somewhat different, in this respect, from Intermittent Fever, and from most of the Eruptive Fevers, or Exanthemata; because although sometimes nearly absent, and not spreading epidemically, it cannot be ascertained to be ever completely absent, from any large community in this climate, for any considerable length of time; whereas the other diseases now mentioned, have been often known to be absent from whole kingdoms, and for centuries. This is a *prima facie* ground for suspecting, that the occurrence of this disease may be determined, on some occasions, by causes of more uniform and permanent existence than that from which it more generally proceeds; and accordingly, it will afterwards appear, that we have good evidence of its occurring in certain circumstances, independently of the application of contagion.

* P. 359.

Referring, again, to what was said before *, of the marks by which an epidemic disease, depending on a cause which arises from the soil, or is generated in the atmosphere in particular situations, may be distinguished from one that is propagated by the intercourse of the sick with the healthy,—we assert with equal confidence, that Intermittent and Remittent fevers are in the former predicament, and Continued fever, and the Eruptive fevers in the latter. The experience of very numerous observers since the time of LANCISI has shewn, that fevers of the former class prevail only in certain localities,—that these localities resemble one another in certain respects,—and that at a distance from these localities, all manner of intercourse of the sick with the healthy may take place, without a fresh case of the disease shewing itself. On the other hand, we are equally assured by very extensive experience, that all the facts formerly referred to †, as evidence, that the occurrence of fresh cases of a disease, is determined by the circumstance of intercourse with the sick, and is therefore referable to effluvia arising from the bodies of the sick,—are facts constantly observed as to the diffusion of continued fever, or of the eruptive fevers, through any community in which they become epidemic.

It remains for us to state here, what has been ascertained as to the conditions under which these agents, known to us only by their effects, but so powerful in their action on the human body, are developed; and as to the circumstances by which their activity is increased, and their effect on the living body variously modified.

I. The whole conditions necessary to the development of the Malaria which excites Intermittent and Remittent Fevers in many parts of the earth's surface, (and to so great an extent, that no other single cause of mortality perhaps acts with equal effect), are certainly not known; because the disease is found in some districts, where, judging from the analogy of others, it would not have been expected,

* P. 360. † P. 361.

and is absent from others, where all the conditions that are yet ascertained for its development appear to exist; but what is usually observed is, that the districts infested by it are those where water has stagnated for some time, often months, on the earth's surface, and afterwards slowly evaporated under the heat of the sun; it is only after the evaporation is somewhat advanced, that the disease shews itself; and it often continues long, and with great virulence, after the surface is perfectly dried. The putrefaction of animal or vegetable matter is, naturally, a very frequent concomitant of the process, by which the Poison is thus developed; but the facts stated by CHISHOLM *, and FERGUSSON †, seem sufficient to shew that it is not an essential part of the process.

The following general facts appear so well established by observation, as to be correctly designated as laws regulating the agency of this poison; and the knowledge of these, as well as of the conditions of its development now stated, may often be effectual in preventing its ravages.

1. Its virulence appears to be nearly in proportion to the intensity of the heat, by which the surface emitting it has been dried. The Intermitting Fever of northern Europe, the Remitting Fever of the Mediterranean, and the Yellow Fever of the West Indies, are produced in circumstances in all respects similar, except as to the intensity of the heat; the worst fevers of the tropical climates are nearly confined to a moderate elevation above the level of the sea; and at the same time when they are prevailing in the low grounds, the common remittent fevers are often prevalent in the neighbourhood of marshes a few hundred feet higher. The greater heat of certain seasons, and the more complete evaporation of stagnant water, seem to be powerful causes of the greater prevalence and malignity of fevers of this class; but it must be allowed, that unusually virulent epidemics occasionally occur, for which no such known cause can be assigned.

* See Edin. Med. & Surg. Journal. vol. vi.

† On Marsh Poison. Edin. Phil. Trans. vol. ix.

2. The poison does not appear to diffuse itself readily through the air, nor to rise high above the surface emitting it; the inhabitants even of the ground-floor of a house in a malarious district being often affected in a much larger proportion than those of the upper stories.

3. Although the heat of the sun appears to be one of the conditions of the development of the poison, yet its immediate effect on the poison that has been already evolved, seems to be to dissipate and dilute it, for it is much more dangerous to visit the most malarious spots at night than at noon-day.

4. The poison appears evidently to be wafted along the earth's surface by winds; for the disease prevails much more, where the trade-winds blow, to the leeward than to the windward of marshes.

5. It appears to be absorbed or neutralized by passing over water,—ships having been observed to remain quite healthy within 1000 yards of shores, even to windward of them, where the disease was very prevalent.

6. It appears to attach itself particularly to spreading trees; on which account woods and groves are particularly dangerous in malarious countries; and again, when these intervene between a marsh and a town or village, they often appear to afford it protection.

7. Its development, or its virulence, appears to be much diminished by the cultivation and habitation of waste lands, even although they be occasionally flooded; and it has often been found to increase suddenly and greatly, when fertile lands have been laid waste.

8. It affects very differently the permanent inhabitants and the occasional visitors of the districts where it exists; the former being very generally weakly, imperfectly nourished, and short lived, but much less liable to the fever itself than the latter.

9. In the hot climates there is an equally striking difference between the white and black varieties of the human race as to their liability to the effect of the malaria;

the blacks, even when healthy and robust, suffering from it comparatively little.

10. In all climates, this, like other causes of acute disease, acts with peculiar force on those whose bodily strength is at the time unusually depressed, whether by fatigue, intemperance, fasting, evacuations, or mental emotions; and whatever measures are effectual in permanently strengthening the system, are found the most useful in enabling it to resist this noxious influence.

11. In those who have certainly imbibed the poison producing these fevers, it appears very generally to *lie latent* for a considerable length of time before the effect results. In some cases, in this climate, it is quite certain that this latent period may not be less than four months.

12. What was formerly said of the frequent *concurrence* of the more general causes of disease, such as cold, intemperance, or any cause disordering the stomach, with the special cause of certain diseases, is strictly applicable, as many observations prove, to the action of malaria in producing intermittent or remittent fevers; and by the application of such causes, intermitting fevers are often reproduced, more or less perfectly, in persons who have previously suffered from them, but have not lately been exposed to the malaria.

In regard to the disputed question, Whether all the worst epidemic fevers of hot climates can be referred to the agency of this cause, or whether there exist, occasionally, in these climates, fevers of peculiar malignity, which are propagated by Contagion,—it may be held to be established, that the cause of intermittent and remittent fevers does sometimes act with such intensity as to produce both a very unusual extension of disease, and all the worst symptoms, and the rapid and great mortality, of the most malignant form of fever; and farther, that in by far the greater number of cases *, where malignant epidemics, in the hot climates, have been supposed to be imported from a dis-

* See Chervin, Examen des Principes de l'Administration en Matiere Sanitaire. Paris, 1827.

tance, their origin has really been proved to be indigenous; and must be ascribed, therefore, to the unusual efficiency of the causes of fever previously existing in the districts. There is good reason to believe also, that even the worst epidemic fevers of hot climates, are always subjected to the same law as the common remittent fevers, of existing only within certain limits.

But from all this it does not necessarily follow, that the extension of these epidemic fevers, or even that their origin, in certain spots, may not be the effect of contagion: For although it may seem improbable, *a priori*, that a disease should spread in two distinct ways, and although we may not expect, that one which results from a cause existing in the atmosphere, should also be propagated, in part, by communication between individuals,—yet no such speculative opinions can be allowed to invalidate the direct and obvious conclusion from facts (of which several have been recorded), which indicate that, in some of the places where these epidemic fevers have prevailed, those who have had close intercourse with the sick, have become themselves affected in a much larger proportion than others who, in all other respects, were similarly circumstanced.

II. In regard to Contagion as a cause of continued fever, we shall first state what has been ascertained of the laws according to which the propagation of fever, by contagion, takes place (and which are found to apply, in some measure, to the other febrile contagious diseases); and afterwards we shall consider the question, Whether another origin can, in any circumstances, be assigned for these diseases?

1. The extension of continued fever, in any community, is in general proportioned, as may naturally be expected, to the frequency and closeness of intercourse of the healthy with the sick, and therefore to the crowding, and deficient ventilation, of the rooms which they inhabit; but in different seasons, it takes place with very various rapidity, independently of the application of any causes which are known to affect it; and from this varying diffusibility, as

well as from the varying character and malignity of the disease (already noticed), it may be inferred that the contagious poison itself, as developed in the human body, is liable, from time to time, to a certain degree of change.

2. The contagious matter, arising from the bodies of the sick, appears to be readily diffused through the air, and to lose its poisonous quality by dilution; so that, at the distance of twenty or thirty yards, air which has passed over the bodies of persons ill of continued fever, is found to be innocuous. The contagious effluvia from smallpox, and perhaps still more from measles, appear to be more virulent than those from continued fever; and it would appear that the poison of the plague, as arising from the bodies of the sick, is confined within narrower limits than that of any of these diseases.

3. There is good evidence of the contagious poison of continued fever (and of the eruptive fevers also), often attaching itself to fomites (clothes, furniture), &c. and acting on persons to whom it is thus applied at the end of weeks, or perhaps of months.

4. It seems certain, that the Contagious Poison producing any of these diseases, is rendered innocuous by a temperature of 120° of Fahrenheit *. It has been observed, that intense atmospherical heat (though considerably below this point) has repeatedly checked the diffusion of plague, and of small pox; and the continued fever of this climate is very generally observed to abate in frequency in summer weather, and appears nearly incapable of spreading by contagion within the tropics.

5. Diseases proceeding from these contagious poisons differ from the fever excited by malaria in this important particular, that the susceptibility of them is much diminished by their being once excited in the system. This does not confer certain immunity in the case even of the eruptive fevers; and there are many cases of continued fever affecting the same person twice or even thrice; but there

* See HENRY in Philosophical Magazine, 1832.

is certainly a great diminution of susceptibility in all these cases.

6. Young persons are certainly more susceptible of these contagious febrile diseases than persons advanced in life; but the symptoms are very generally worse, and the tendency to spontaneous recovery is much less strong, in advanced than in early life.

7. The susceptibility of the disease (in the case of continued fever in particular) is very much increased by many causes that depress the vis vitæ at the time, by fasting or low diet, by cold long applied, by foul or vitiated air, and by mental depression, timidity, or anxiety, as in the case of besieged cities, communities suffering peculiarly from famine and poverty, beaten armies (especially after the excitement of military operations is quite over); or in that of dispirited bodies of men for military or naval service, or of strangers from the country in their first residence in large towns.

8. After any of these poisons have been imbibed, they very generally lie latent in the constitution for a certain length of time, before producing their specific effects; and in the case of continued fever this time is so various, and the efficacy of concurrent and accessory causes (especially of exposure to cold) in exciting the disease, after the application of the contagion, is so obvious and striking, that it appears quite reasonable to suppose, that where these causes are carefully avoided, many cases of the disease, which would otherwise have occurred, may be averted.

9. Although it must always be remembered, that there are great varieties, both as to individual cases, and as to the general character of epidemics, for which we can assign no cause, yet various facts have been ascertained, as to the effects of concurrent or accessory causes, in not merely favouring the accession, but determining the form or variety, of continued fever in individuals, particularly the following.

a. The Nervous or atactic form of fever (which is perhaps the most generally dangerous to adults in this country) is remarkably more frequent in those in whom the Nervous System has been recently much excited, as by much muscular exertion, by excessive study, by mental agitation or anxiety, by venereal excesses, or by intemperance, especially the use of strong liquors. In many of this last class, the nervous symptoms in fever take very much the form of the delirium tremens of drunkards.

b. The symptoms of fever are often modified by preceding disease, and especially, if there has been recently any local inflammation, the symptoms of that local disease are very often re-excited, although in a somewhat modified form. On the other hand, a chronic disease already existing, at least if it be one which is attended with febrile excitement (such as phthisis) seems to be to a certain degree (although not uniformly) a protection against attacks of fever.

c. The concomitant local affections, if not the proper symptoms of fever, are remarkably modified by the weather and season of the year, *i. e.* by the causes of local disease which are apt to take effect on the body along with, or after the application of, the poison. In winter and spring, the symptoms are stated to be generally more inflammatory, and the complication of fever with bronchitis or pneumonia is certainly more frequent; in autumn the concomitant affections of the stomach, and especially of the intestines, are chiefly observed. Violent affection of the brain, in the more inflammatory form of fever, is remarkably observed in hot climates, and sometimes in the hottest season of this.

d. There is a remarkable difference in the most general form of fever, according as the patients are placed in cool well aired rooms, or confined in a close warm and vitiated temperature. It is very doubtful whether the mortality is so much less in the former case, as has been represented by some; but in that case, the pulse is generally firmer, the fever less typhoid, and the danger more dependent on complication with local affections, and consequent protraction of the disease; and in the latter case the typhoid symptoms are more frequent and more urgent *.

* See BATEMAN on Contagious Fever p. 135.

It has been already stated, that continued fever, although rare in some seasons, and prevailing epidemically in others, is still, to a greater or less extent, so much more uniformly present in every large community, than any of the other diseases, which we ascribe to a local and temporary cause, that we may reasonably suspect it to originate occasionally from some circumstances of more general and permanent existence. And in confirmation of this it may be observed, *first*, that continued fever often breaks out in situations where the application of the contagious poisons, whether by persons or families, not only cannot be traced, but appears improbable; and *secondly*, that circumstances may be stated, in which the appearance of this disease, independently of any perceptible application of contagion, may be reckoned on, with almost absolute certainty; *e. g.* the combination of deficient nourishment, foul air, and mental depression, consequent on the reception of a beaten army into a small town, or on a large town long kept in a state of siege, or on a scarcity befalling an already impoverished country. In these circumstances it appears highly probable, that the circumstances of predisposition above stated are adequate, not only to the extensive diffusion, but even to the generation in a few individuals, of the disease which is afterwards propagated by contagion. But to which of these circumstances of predisposition, the occasional spontaneous origin of the disease may with most probability be ascribed, is still uncertain. The vitiation of the atmosphere by putrescent animal or vegetable substances, or by crowded human beings, has been supposed to be a sufficient cause; but so many instances have been collected by Dr BANCROFT, Dr CHISHOLM, and others, of these causes being fully applied without any such effect, that we must set aside that hypothesis; and perhaps we may assert that long continued mental depression and anxiety, during youth especially, has been assigned with more probability than any other cause, for the spontaneous generation of continued fever *.

* See CHEYNE and MARSH in Dublin Hospital Reports, vol. iv.

SECTION IV.

OF THE PROXIMATE CAUSE OF IDIOPATHIC FEVERS, AND OF THEIR FATAL TERMINATIONS.

Referring to what was formerly said (p. 428.) of the limitations which Nature imposes on all explanations of natural phenomena, we hold it to be unreasonable to expect, that we shall ever go far in explaining the peculiar phenomena of Fever; we look chiefly for the determination of ultimate facts or principles, relative to the action of its remote causes on the living body.

The first question here is, whether the term Idiopathic be in reality correctly applied, or whether we can explain all the phenomena that have been now described by reference to a principle already explained, viz. the effect of local Inflammation in exciting the constitutional fever which was described, and the known varieties of which were considered.

In treating of this question, we may, in the first place, refer to facts already stated, as to the history of fevers.

Taking for granted that what we have called Idiopathic Fevers may be distinguished, in almost all cases where their whole progress is observed, by the marks formerly enumerated,—that the marks of local inflammation attending them, both during life and after death, are often slight and sometimes absent,—that their symptoms have very generally more or less of the character to which we gave the name of Typhoid,—that they have a peculiar tendency to spontaneous favourable changes, even from very unfavourable circumstances,—and when they do so terminate favourably, seldom leave behind them such organic diseases as most frequently follow cases of decided inflammation left to nature,—and that these fevers occur generally in epidemics, are at times nearly absent, for a long time, even from large communities, and appear certainly to depend, for the most part, on causes of local and temporary operation;—we regard all these circumstances in their history as affording very strong presumption, that they are specifically distinct from the strictly inflammatory diseases, and cannot be ascribed to inflammatory action as their cause. And the following considerations may be stated in farther confirmation of this doctrine.

I. The peculiarities of the occasional and local production, and introduction into the system, of the exciting causes of fevers, and of the characteristic depressing agency on vital action, which attends idiopathic fever, evidently assimilate, in some degree, this form of disease to the agency of poisons. Now, it appears from what was stated formerly in regard to all such poisons as act gradually, and must be absorbed into the system before they take effect, that although they may excite local inflammation, yet they have always a *general* effect, and usually a depressing effect, on vital action, whether of the nervous or vascular system, independent of that local agency. From this there arises a manifest presumption that the agency of malaria and of contagion, in producing fever, will in like manner be, in part at least, exerted on the system at large, and independently of local inflammation, or mere alteration of the distribution of the blood.

II. Although it is freely admitted that appearances indicating inflammation are very frequently found after fatal fever, yet the facts already stated as to the morbid anatomy of fever justify our maintaining, *first*, That all such appearances are sometimes absent; *secondly*, That the indications of inflammation, found in the different parts above enumerated after fever, are very generally somewhat different from those which are found after inflammations of the same parts excited simply by cold, and unconnected with the peculiar symptoms of fever; which implies the action, in cases of fever, of a peculiar cause, distinct from inflammation; and, *thirdly*, That the appearances of inflammation, found after fever, are very often quite inadequate to explain the fatal event, on the principles formerly stated as to the fatal terminations of inflammatory diseases.

It is plain that, in order to prove that fever depends essentially on, and is fatal by reason of, the attendant inflammation, it is necessary to shew, not only that such attendant inflammation exists, but that its nature and situation are such as to obstruct some function necessary to life,—or at least such as are found, in other cases, incompatible with life. If therefore, we find after fatal fevers (characterized by typhoid symptoms), marks of inflammation in certain organs, but these in a degree much less than those which we are accustomed to find, where the same parts have been inflamed, but the characteristic typhoid symptoms not shewn themselves, we are not entitled to infer that the inflammation in the former case was the cause of death.

Now, the effects and indications of inflammation, found after fatal fevers, and already described, are generally *much less* than what we are accustomed to observe in those cases of inflammation of the same parts, which are unconnected with malaria or contagion, and unattended with typhoid symptoms; and frequently all that is seen indicates only congestion of blood, which can hardly be held to be a sufficient cause for death, if existing alone, any where but in the brain, or at the origins of the nerves.

Even, therefore, where the evidence of inflammation, or irregular distribution of blood, having existed during fever, is held to be decisive, the proof of these having existed to a degree which can be reasonably considered adequate to the explanation of the fatal event, is very often essentially defective.

III. Not only the fatal event, but the chief peculiarities of the symptoms, of the diseases described under the name of Idiopathic Fevers, are very often inadequately explained by reference to any of the known phenomena and effects of inflammation.

The different authors who ascribe fevers to inflammation as their cause, are not agreed as to the organ in which that inflammation must reside; which circumstance is of itself a presumption against their common doctrine. But there is no locality which can be assigned to the inflammation attending fever, which can explain, by reference to the known effects of inflammation in other cases, many of the typhoid symptoms of fever.

The preternaturally fluid state of the blood, which is very often, although perhaps not uniformly observed, certainly cannot be explained thus. The enfeebled state of the circulation in typhoid fever has been thought by some to be sufficiently explained by the known sedative effect of inflammation of the intestines on the heart's actions; but, besides that there are many cases of truly adynamic fever, where no distinct traces of intestinal inflammation can be detected, the two cases are very different;—the depressed state of the circulation in cases of inflamed intestines being preceded by much more decided local symptoms than we see in fever, and being neither attended with the cutaneous heat of fever, nor with the foul dry tongue and lips of fever, nor with the nervous symptoms of fever, nor with the strong salutary tendency of fever. And although some of the symptoms produced by inflammation of the brain resemble the nervous symptoms of many cases of fever, yet in simply inflammatory cases, there are more sudden and violent attacks of pain,—there are very generally sickness and vomiting,—there is at one period of the disease slowness or irregularity of pulse,—the delirium is of a different character,—there is less stupor in the early stages, and the stupor in the later stages is attended very generally with dilated pupil, squint, blindness, or double vision, and is much more uniformly fatal, than in the fevers described as idiopathic.

Farther, the appearances indicating inflammation, which are found after death by fever, are in many cases observed to correspond, not to any of the symptoms of the earlier periods of the fever, but to symptoms which presented themselves only recently before death; so that the period of accession, as well as the nature and degree of the inflammation, that can be ascertained to exist during the fever, is inconsistent with the supposition of all the symptoms depending upon it.

In farther proof, that the characteristic symptoms of fever are not explained by the inflammations which may accompany it, we should observe, that there are various cases, formerly noticed, besides that now in question, in which inflammation is attended with typhoid fever; *e. g.* the case of inflammation from an injury attended with violent concussion, the case of inflammation and purulent effusion in a vein, the case of inflammation from a poisoned wound, or from epidemic erysipelas, or other exanthematous disease, or puerperal fever; and in every one of these, it is obvious that the system is subjected to the influence, not only of a local inflammation, but also of a cause acting generally on the body, as we suppose the poison of what we call Idiopathic Fever to do.

And if the local inflammation, which can be ascertained to take place during fever, is inadequate to explain the characteristic typhoid symptoms, it is equally in vain to seek an explanation of these symptoms, as some have done, in the mere circumstances of irregular distribution and *congestion* of blood.

Even the peculiarities of that form of fever which has been described under the name of *Congestive* (p. 486.) are not to be explained by the mere circumstance of internal congestion, the existence of which, in the vessels and especially in the veins of internal parts, in these circumstances is admitted. For although congestion or stagnation of blood within the cranium may be held to be a sufficient cause of stupor, yet we are so far from regarding congestion in the great veins leading to the heart, as a sufficient cause for deficient action there, and consequent feeble pulse and cold skin, that we have already stated, (see p. 445.), the accumulation of blood in the great veins to be apparently the chief cause of the *increased* action of the heart, or the *reaction*, in the more usual form of fever. In the cases, therefore, where the congestion in the great veins fails to excite this reaction in the heart, some peculiar cause must have operated, to prevent the heart from being unusually excited by the application of the unusual quantity of its natural stimulus; *i. e.* the circumstance of a congestion in the great veins, greater and more permanent than is usual in the commencement of fever, is in all probability the effect, not the cause, of a peculiar sedative influence affecting the vascular system; which will naturally lead to accumulation of blood in the great veins, for the same reason that determines the accumulation there after death.

That congestion of blood in the great veins is not *per se* adequate to account for the phenomena of any form of fever, appears distinctly from the fact, that no form of fever follows the great congestion there in cases of suspended animation in syncope, or from extreme cold, or submersion in water.

IV. That what we called Idiopathic Fever cannot justly be regarded as the effect of the inflammations often attending it, appears farther from a very sufficient experience of the *juvantia* and *lædentia*, particularly from what is well ascertained of the effect of evacuations on the one hand, and of stimulating remedies on the other, in this disease, as compared with the cases that are acknowledged to be simply inflammatory. For after making allowance for the sources of fallacy necessarily attending such observations, we may assert that experience has fully established the following points.

1. That in the strictly inflammatory diseases, evacuations of blood are of the utmost use in the early stages, all other remedies comparatively inefficient, and stimulant remedies decidedly hurtful in all but the latest stage.

2. That in the cases described as idiopathic fever, even although symptoms of local inflammation be present, the amount of evacuation which it is safe to practise on ac-

count of these is much less than in the former case; that its beneficial effect is less decided,—the local symptoms being seldom so effectually subdued, and the general, especially the typhoid symptoms, being seldom improved, and sometimes evidently aggravated by loss of blood; that the tendency to a spontaneous favourable termination is much stronger; and that even when indications of recent local inflammation exist, decided benefit may often be obtained from the use of stimulants, under which the pulse may improve, and the typhoid symptoms of general fever abate, without the local affection being materially or even perceptibly aggravated.

It is also ascertained by sufficient experience, that the inflammatory symptoms are more urgent, and evacuations in general much better borne in some epidemics of continued fever; and that in others the indications of debility of the vascular system are more permanent, and stimulants more generally useful; while no such differences are observed as to the strictly inflammatory diseases in different seasons.

These statements seem sufficient to shew, that it is a limited and hasty view of the phenomena and history of Fevers, which has suggested the opinion of their being resolvable into the constitutional effects of the Inflammations, or local determinations and congestion of blood, which can be ascertained to attend them; and that we may now safely apply the term Idiopathic as expressing the belief of an essential distinction existing between these fevers, and those that were formerly described as resulting from local inflammation.

At the same time, the strong similarity or coincidence in many respects, of the essential symptoms of the symptomatic and the idiopathic fever, must always be regarded as a leading fact in reference to the pathology of the latter.

But in idiopathic fever, not only is a diseased action excited throughout the system, similar to that which local inflammation can excite, but the system is at the same time under the influence of a cause, which acts on it nearly after the manner of a Poison; which we know, from the history of the disease, to be probably engendered occasionally within the system itself, but to be more frequently absorbed from without; and which takes effect, as poisons do, only for a time, and then loses its power. In regard to this morbific cause, which both excites and gives the peculiar character to, the febrile actions, several questions present themselves.

I. It may be questioned, whether the effect on the Nervous System, essential to fever, is produced directly by the external cause of fever, or whether that cause first works a change on the blood, and through its intervention affects the brain and nerves.

It is plain, that the blood is changed, at least as to its power of coagulation, in most cases, and perhaps it may be so in all cases of idiopathic fever. But a similar change as to that property may be produced in it, by causes acting in the first instance on the Nervous System; and this fact, therefore, does not indicate the part of the system which is primarily affected in fever.

Reasons which appear satisfactory may be given against the supposition of many of the older pathologists, that fever essentially and exclusively *consists* in a certain change in the blood (quæ præsens morbum facit, sublata tollit, mutata mutat); and in particular, two facts already stated seem decisive against that theory, viz. 1. That after the morbific cause has been applied to the blood, it may depend, as we believe, on causes acting on the Nervous System only, whether or not it shall produce its specific effect; and 2. That even after that specific effect has been produced, and the febrile actions begun, they may, in a few instances, be arrested by means (such as the cold affusion) which neither evacuate any part of the blood, nor alter its composition.

But it may still be thought, that the remote cause of fever does not produce its effect by merely once impressing the Nervous System, or other living solids; but that it must necessarily circulate for a time in the fluids of the body, and perhaps multiply itself in them, in order that it may take effect on the solids. And in favour of *this form* of the humoral pathology of fever, the following facts may be stated.

1. In a great majority of the cases in which we see typhoid fever, we are sure that some peculiar matter, generally absorbed from without, must be contained in the blood ; as in the case of fever from malaria, from contagion, (whether of simple fever or the eruptive fevers) from inflamed veins, from animal poisons introduced by wounds, or from suppression of the natural excretion at the kidneys.

2. In all cases of idiopathic fever, as well as of the eruptive fevers, an interval, which is variable and often long, necessarily elapses between the application of the morbific cause, and the development of the fever ; which is easily understood on the supposition that a change is gradually wrought on the blood during that interval, but not on the supposition of the poison acting simply on the living solids.

3. In a great majority of cases of typhoid fever, we know that a matter, similar in its effects on the human system, to that which excited the disease, is ultimately evolved in large quantity from the blood, making the disease contagious ; *i. e.* the morbific poison in one way or another is multiplied in the blood of the living body.

It has been naturally supposed, by pathologists at different times, that the frequent and rapid abatement of fevers, after critical evacuations, is farther proof of the doctrine of their cause residing chiefly in the blood ; and that this morbific cause is really carried off by these evacuations. And in support of this opinion, it has been stated, that when putrid matters, or diseased secretions, have been injected into the veins of animals, and excited febrile symptoms, a peculiarly fetid diarrhœa has preceded the recovery from these.

But when it is considered, 1. That copious or spontaneous evacuations (*e. g.* of sweat) at the critical periods of fevers, often take place without the least good effect, if unattended by other marks of restoration of the natural condition of the capillaries; 2. That many fevers abate spontaneously and perfectly without crisis; 3. That the evacuation of poisons (*e. g.* of narcotic poisons) from the body, is not necessary to the removal of their effects; 4. That in all contagious diseases, morbific effluvia escape for a long time from the body, without any good effect; 5. That there is no evidence of the critical evacuations possessing more contagious property than the effluvia which continually escape without advantage; and *lastly*, that in smallpox in particular, experience has shown, that the morbific matter in the pustules may be evacuated as quickly as it appears, without benefit, and may be reabsorbed into the blood without injury;—we can hardly suppose the critical evacuations to be the *cause* of the solution of the fever that succeeds them; and must rather regard them as the *sign* of the restoration of the natural state of the vital actions in the capillaries of the body; whereby the excited action of the heart is enabled to throw off an unusual quantity of secretions and excretions, and then subsides; because the cause confining the circulation, and therefore stimulating the heart, has ceased to operate.

The doctrine of the existence of a morbific matter in the blood, therefore, is not supported by the facts as to the critical evacuations, but must be rested on the other facts above stated.

II. Whether the morbific cause first alter the fluids or not, it is evident that it affects the actions of all the living solids, whenever it excites fever; and it may be questioned, whether the first effect of the morbific cause is exerted on the Nervous or on the Vascular system. Besides what was formerly said on this point in treating of symptomatic fever, (p. 441.) the following reasons may be given for suspecting that the first action of the cause of idiopathic fever is on the nervous rather than the vascular system.

1. The nervous system is evidently more affected through-

out the whole series of morbid actions, than in the former case, and the first symptoms by which the idiopathic fever can in general be recognised, are strictly affections of the nervous system.

2. We have seen (p. 330.), that when inflammation co-exists, in the living body, with the effect of a violent concussion of the brain and nerves, the fever that it excites has quite the typhoid character.

3. We have good reason to believe, that changes taking place unquestionably in the nervous system, viz. those which attend mental emotions of sufficient duration and intensity, if they have not power (as it may reasonably be conjectured, that in certain circumstances they have) to generate fever, have at least such an influence on its causes, as to determine their efficiency or inefficacy in individual cases; which is of itself a strong presumption in favour of the belief, that the primary action of these causes is on the nervous system.

4. Besides these mental emotions, there are various other agents, formerly noticed as concurrent and accessory causes of fever, and by which we have reason to think, that the development of fever, after the poison has been imbibed, is often determined,—*e. g.* cold, muscular exertion, and intoxicating liquors; and the chief action of all these causes also is on the nervous system.

5. There is at least one remedy, of peculiar efficacy in counteracting the agency of one of the causes of fever, *i. e.* the Cinchona, which produces no visible effect on the vascular system, and the action of which there is reason to believe, from what we see of it in other cases, to be on the nervous system.

But whatever be the mode in which the morbific cause, in Idiopathic Fever, comes to affect the circulation, it is to the direct action of this cause, and not to the influence of any local diseased actions, excited in the body, that we must ascribe the enfeebled state of the circulation,—the altered state of the blood,—the peculiarly vitiated state of the secretions,—and in a great measure also, the deranged state of the nervous system,—which were described as characteristic of Idiopathic, and especially of Typhoid Fever.

And there is nothing absurd, or inconsistent with what is known of the action of poisons, or of other agents on the animal economy, in supposing that the morbific cause, after existing some time, and perhaps multiplying itself, in the fluids, *may act simultaneously* on the constitution of the blood, on the powers of the heart, on the vital affinities in the capillary vessels, and the vital actions of the brain and nerves.

We have good reason to think, that it is especially by its action (whether direct or indirect) on the vital changes in the capillary vessels, that this cause excites the symptoms which were described as characteristic of Fever; and we refer to the account given of fever symptomatic of inflammation, for the explanation of the manner in which the different steps in the series of changes constituting febrile action, consequent on that deficient vital action in the capillaries, are connected together.

But the peculiar depressing action of the morbific cause on all the parts of the system above mentioned, appears from what has been said, to be perceptible throughout idiopathic, as distinguished from symptomatic fever; and it is easy to understand, that its effect on any one of these may become so intense, as to be dangerous. The sedative effect on the heart is often such as to enfeeble, and sometimes such as nearly to suppress, the febrile reaction, as in Congestive Fever; that on the brain may produce fatal coma, as in some cases of Nervous Fever, independently of any effusion or organic lesion in the brain; that on the vital functions of the capillary vessels may be such, and so long continued, as to cause fatal inanition and exhaustion, as in some cases of Fever, fatal merely by reason of the long endurance of the disease, without failure of the functions of any one organ in particular.

In most cases of fever, however, the danger is not produced solely in this way; but appears manifestly owing to a *combination* of the enfeebled state of the circulation, with peculiar derangement of the functions of individual organs, consequent on the attendant inflammations there, the symptoms and post-mortem appearances of which have been already described. In consequence of this combination, we have three distinct modes of fatal termination of fevers, which are often blended together, but in some cases are quite separate and easily distinguished; and which are clearly illustrated by the different kinds of sudden or violent death formerly described,—and by what has been said above of the morbid appearances left by fatal fevers. These are, 1. The death by *Coma*, referable partly to the peculiar action of the cause of fever on the brain, but partly also to increased determination of blood thither, or inflammatory action or effusion there; 2. The death by *Asphyxia*, referable partly to the enfeebled state of the circulation, and want of power in the heart to propel the blood through the lungs, but partly also to Bronchitis or Pneumonia. 3. The death by mere *Asthenia*, referable partly to the deleterious effect of the morbific cause on the circulation, but partly also to various local inflammations, prolonging the febrile state; and especially to the inflammations and ulcerations in the mucous membrane of the intestines, which appear to have in this, as in other cases, a peculiar sedative, and what was formerly designated as a sympathetic, effect on the heart's actions.

It was already stated, that these inflammations during the state of fever, are so far influenced by the altered condition of all vital actions in the capillary vessels at that time, that the local effects which they produce differ materially from those which follow inflammation of the same parts in a system free from general fever;—as is seen, *e. g.* in watching the progress of a parotid, or other external abscess, commencing during the febrile state, but only suppurating fairly when that state has subsided. Nevertheless, the internal inflammations often attending fever are quite sufficient, when their effect is combined with the generally enfeebled state of the circulation, to cause great danger.

The nature of the connexion between these local inflammations and the general fever is often obscure. In many cases they are evidently produced by a different cause, (chiefly cold applied before the onset, or during the course of the disease), and only accidentally combined with the fever; but in other cases they may probably be regarded as effects of the general fever. The determination of blood to the head, and consequent slight inflammation and effusion, seem often to be of this description, and are analogous to what sometimes happens in inflammatory diseases of other organs than the head. The reproduction, in any part of the body, of inflammatory action which has recently subsided there, appears to be an effect, rather than a mere accompaniment of fever. And the peculiar inflammation of the mucous glands and membrane in the intestines, when it takes place late in the disease, may be suspected to depend very much on the bile, and other irritating contents of the intestinal canal, passing over a membrane, which in consequence of the feeble circulation, the blunted sensation, and the deficient secretion, has lost much of its natural protecting mucus; and to be analogous to the inflammation of other mucous membranes, consequent on section of their sensitive nerves, (p. 114), and to that which precedes death by starvation (p. 178).

On this supposition, inflammations of the mucous membrane of the intestines, occurring towards the close of protracted fevers, will stand in nearly the same relation to them as the inflammation, ulceration, and gangrene, from pressure on external parts; which are very common, and often constitute a great part of the danger in such cases.

These relations between idiopathic fever and the concomitant local inflammations are of great practical importance; and the chief difficulty and nicety in the treatment of fever, lies in determining, how far the danger depends on such local affections as demand evacuations, and how far on the effect produced on the system by the morbific cause, which will often spontaneously abate, and often demands remedies of the opposite class.

CHAPTER VIII.

OF CONTAGIOUS EXANTHEMATA.

We here treat of those diseases, caused chiefly if not solely by contagion, and therefore prevailing at times epidemically, in which there are symptoms of general fever, more or less of the typhoid character,—and at the same time an eruption on the skin, (as in many cases of continued fever already described); in which there is very generally likewise inflammation, chiefly of the mucous membranes, in internal parts; and the danger appears to depend, seldom on the extent of inflammation on the surface, but partly on those internal inflammations, and partly on the affection of the general system, and especially of the circulation, which results from the action of the morbific cause. There are these material differences from continued fever, that the duration of the febrile action is shorter, and much more uniform, and that the whole succession of the symptoms, and especially the course of the external inflammation, is much more regular. This description applies chiefly to Smallpox, Measles, and Scarlatina, and probably also to the Plague. It applies also to the slight disease called Varicella; and, in several important particulars, to the Erysipelas.

The Pathology of these diseases, and especially of the combination existing in them all, of local inflammation, always of a peculiar or specific character, with general typhoid fever, is essentially the same as that of continued Fever; but it is important to state shortly, how far the statements made as to the history of continued fever are applicable to each of these exanthematous diseases.

I. As to the cause of these diseases. In the case of smallpox, measles, and plague, we are nearly certain, from facts of the description formerly noticed (p. 361.) not only that these diseases are contagious, but that they never proceed, at the present day, from any other cause than the specific contagion, thrown off probably chiefly in the breath of persons themselves affected with the diseases, but likewise existing in the excretions formed on the surface of their bodies, as appears from the communication of the diseases by inoculation. But it is more doubtful whether the scarlatina and varicella (of which a few cases occur almost every season in this country, and which seldom spread epidemically to any great number of persons), do not occasionally arise from unknown causes, and then spread by contagion; and of the frequent sporadic origin, and only occasional communication by contagion, of the erysipelas, there can be no doubt.

In this last case, it seems nearly a necessary condition to the communication of the disease by contagion, that an inflammation of the skin, or at least an abrasion of the cuticle, whether by wound, bruise, scratch, blister, or some other cause, should exist at the time that the morbific poison is presented. It has also been supposed that some derangement of the digestive organs is an essential condition to attacks of erysipelas, but it does not appear ascertained that such derangement does more in this than in various other cases of exposure to the causes of acute disease, viz. strongly predispose to their development.

The protection against future returns of the disease given by its once taking place, which was mentioned as frequently observed in regard to continued fever, is nearly absolute in the case of smallpox, measles, scarlatina, and probably varicella; though a few exceptions to the rule have been observed in all these cases; but it does not hold so surely of plague, and the reverse appears to hold of erysipelas.

The singular and anomalous facts as to the connexion of smallpox and cowpox may be thus stated, That the contagious matter of smallpox may be so applied as to act on the living system of the horse and the cow *, and excite in them a mild vesicular disease, without any general erup-

* See Edinburgh Medical and Surgical Journal, 1831.

tion, and without constitutional disturbance; and that this local vesicular disease, communicated to the human subject by inoculation, runs its course there in the same innocent manner; with the effect of protecting the system, in a great majority of cases, against all subsequent influence of the contagion of smallpox; and with the effect, in almost all the cases, where the protection given by it is not absolute, of so modifying the disease which that contagion can excite, as to arrest the progress both of the cutaneous inflammation and of the fever, about the end of the first week, and so render it nearly free from danger.

The contagious poison of all these diseases, like that of continued fever, is liable to great variations,—in efficiency, as seen in the diffusion of epidemics,—in virulence, as seen in their mortality; and in specific character, as seen in the most urgent symptoms, and most frequent accompaniments of the diseases, as occurring in different seasons.

II. As to the chief symptoms of these diseases. In all there is so distinct an eruptive fever, although of various duration, before the inflammatory appearances in the skin commence, as unequivocally to demonstrate that the inflammation, although an effect, and the only sure criterion, of the specific poison which excites the fever, is not the cause of the fever; which must therefore be held, like Idiopathic Fever, to consist in the reaction of the system against the depressing influence of the specific poison. The internal inflammations attending these diseases, although often aggravated by the usual causes of inflammation, applied at the time, are yet so uniformly observed, and so frequently severe when there has been no such concurrent cause, that we must regard them as likewise effects of the specific poisons.

The Smallpox is distinguished by the pretty uniform duration, both of the latent period (from seven to twelve days), and of the eruptive fever (from thirty-six to sixty hours); and by the pustular character of the eruption, the suppuration of which is not completed till the seventh or eighth day from the appearance of inflammation, and, when the eruption is numerous, is followed by secondary fever for some days more. In this disease the peculiar action of the contagious poison on the Nervous System is often shewn, in the case of children, by convulsions before the eruption comes out. The fever is seldom attended with so great depression of the circulation, as is seen in the more malignant cases of other epidemic diseases, and the disease is very generally protracted at least until the usual time for the maturation of the pustules; but when their number is very great, the powers of the system are inadequate to the filling of the vesicles that had formed in the skin, or to the conversion of the fluid in them into pus. The mucous membrane of the fauces is very generally inflamed early in the disease, and that of the tráchea and bronchiæ, in a greater or less degree, in the later stages. The substance of the lungs likewise often undergoes changes similar to those described as occurring there in Fever. The mucous membrane of the stomach and bowels is more rarely and more variously affected.

In Measles and Scarlatina, the duration both of the latent period, and of the eruptive fever, is less uniform. These diseases are distinguished by the peculiar appearance of the cutaneous inflammation, which seldom lasts above four days, and leads to no result in either, except desquamation, and in the scarlatina, separation of the cuticle in large patches. The constitutional fever resulting from the specific poison,—very generally of shorter duration than that of smallpox, is remarkably various in character in different cases, and also, on an average of cases, in different epidemics. In many of the worst cases of scarlatina, and in some of those of measles, it has quite the form of the *adynamic,* or even of the *congestive* fever formerly described, (p. 436.), *i. e.* fever with feeble and imperfect reaction. In such cases, the peculiar action of the poison on the nervous system shews itself generally by much nausea and vomiting; and the inflammation on the skin is pale or livid, partial, and of short duration.

The internal inflammations attending these diseases are much more uniform than in smallpox; viz. in Measles, inflammation of the tunica conjunctiva and mucous membrane of the nose in the eruptive stage, soon succeeded by bronchitis, or even by peripneumony (which sometimes become aggravated after the decline of the eruption), and occasionally succeeded by inflammation of the mucous membrane of the bowels;—in Scarlatina, inflammation, often tending to ulceration in the tonsils, attended by swelling of the neighbouring lymphatic glands, and also by inflammation of the mucous membrane of the nostrils, sometimes followed likewise by extension of the inflammation to the trachea and bronchiæ.

In Plague, the fever and external inflammation appear at irregular times after the presumed exposure, but generally within a few hours of each other. The latter consists of spots of inflammation, running rapidly to gangrene, and of buboes or swellings of lymphatic glands, rapidly increasing but rarely suppurating. The fever is very generally of the character to which the name of Congestive has been given, *i. e.* the reaction is very imperfect, or hardly observed, and the chief symptoms may be said to be an aggravated degree of those which take place in the commencement of all the contagious febrile diseases, weakness of pulse and of voluntary muscles, paleness, nausea, and vomiting, stupor or confusion of thought approaching to stupor, and tremors. There is no good evidence of any internal inflammation frequently attending this disease.

In Erysipelas, the eruptive fever is of various duration, but seldom lasts more than three days. The inflammation is extremely various, both in extent and duration;—it is characterized chiefly by its rapid spreading along the surface, and its tending to vesication and to desquamation externally, and often to suppuration (chiefly of the diffuse kind) within the true skin. Symptoms threatening inflammation of the brain often supervene on, or follow the rapid recession of, erysipelas; and inflammation of the fauces and larynx very often attend it. The accompanying fever is very various, sometimes strictly inflammatory, often more or less typhoid, and sometimes of the character called congestive; and in those last cases the inflammation is often apparently slight, its colour livid, and its local effects inconsiderable.

III. As to the mode of fatal termination of these diseases. It is obvious from what has been stated, that the danger in them, as in continued Fever, will generally be complex, and widely different in different individual cases of the same species,—sometimes dependent chiefly on the malignant character of the typhoid fever, *i. e.* on the virulence of the morbific poison,—sometimes on the intensity of the local, and especially the internal inflammations; and that the nicety of practice will consist in so balancing between these dangers, as to apply in each individual case the remedies best adapted to that, which is there the greatest.

In Smallpox, the chief danger is of death by mere exhaustion or asthenia, generally attended with much comatose tendency, to be expected at the period of maturation of a very copious eruption, which is always attended with a somewhat typhoid fever, and suppurates very imperfectly. But there is also, in many cases, a great aggravation of the danger, from the hurried and laborious breathing consequent on the Laryngitis, Bronchitis, or even Peripneumony, which take place in the later stages of the eruption; and in some cases the affection of the air-passages is such as so cause death by asphyxia, even when the eruption is distinct, and its maturation pretty complete. But the inflammation in these parts, while the smallpox lasts, hardly ever goes on to any other termination than thickening of the membrane, and increased mucous or muco-purulent secretion in the bronchiæ; nor is it to be expeeted that it can subside completely, until the period of the decline of the eruption.

In most epidemics of Measles, the danger is merely from the accompanying bronchitis, and from this chiefly about or even after the time of the decline of the eruption. But it is probably always more dangerous as occurring in a system which is under the influence of a weakening febrile disease independent of itself; and there are occasional epidemics of measles, and a few cases in ordinary epidemics, where the malignant typhoid fever is evidently very dangerous, even independently of the complication with bronchitis; but of course much more so if that inflammation is at the same time such as to threaten death by asphyxia.

In Scarlatina the danger is more various than in any of the others. In a few cases it depends on the amount of swelling in the fauces in the early part of the disease, or on the early extension of the inflammation to the larynx, threatening asphyxia. In many cases of the kind called Malignant, it depends simply on the depressed state of the circulation in the typhoid fever; in a number of others, where the eruption has been florid and persistent, and the fever originally not malignant, it depends very much on the inflammation of the lymphatic glands around the fauces, which then supervenes on the ulcerated state of the tonsils; and on the aggravation, and generally the more typhoid tendency, of the fever in that stage. When all these dangers are over, there is more risk of subsequent inflammatory affections after this than after any of the other eruptive fevers.

In Plague, the danger, although probably sometimes aggravated by the local inflammations, is obviously chiefly dependent on the direct depressing influence of the specific poison on the brain, and especially on the heart.

In Erysipelas, the danger sometimes depends on the extent to which the inflammation goes in the skin and cellular membrane, and the exhausting processes of suppuration and sloughing that succeed; sometimes on a simultaneous inflammatory affection of the brain, or a metastasis of the inflammation thither; sometimes on a concomitant inflammation of the fauces and larynx; but often it depends in part, and sometimes entirely, on the enfeebled state of the heart, and general typhoid form of the constitutional fever.

In all the Eruptive Fevers except this last, it is to be observed as an important part of their Pathology, that experience has proved the inutility and danger of attempting to arrest the course of the specific inflammations of the skin, after they have commenced. Whether the body contain in it a morbific poison which should be expelled or not, it certainly labours under the influence of a cause, which is most dangerous when any inflammations, that may coexist with it, are abortive; and the unwonted recession of the inflammation, if not a *cause* of injury, is very generally to be dreaded as a *sign* of intense action of the morbific cause on the circulating system, and impending death by asthenia. But in the case of Erysipelas, no such consequences follow the use of remedies which subdue the external inflammation when urgent; and although there are other dangers, in many cases of the disease, which demand very different remedies, yet in so far as danger appears to threaten from the extent and intensity, and probable consequences, of the inflammation on the surface, experience shews that the antiphlogistic remedies, and especially the local detraction of blood, may be used with safety and great advantage to avert it. In this important respect, as well as in prevailing less epidemically, and following a much less regular course, than the other eruptive fevers, the erysipelas may be said to occupy a middle ground between them and the simply inflammatory diseases.

Immediately after the cessation of the eruptive fevers, as well as of continued fever, the system is peculiarly liable to inflammatory attacks, sometimes hardly to be distinguished from the last symptoms of these diseases themselves. This is peculiarly the case about the time of the desquamation succeeding scarlatina; at which time also, and often in combination with such inflammations, a dropsical affection afterwards to be considered, is very apt to occur.

CHAPTER IX.

OF DISEASED STATES OF THE SECRETIONS.

It has been already said that increase or alteration of the vital changes taking place in the capillary vessels, is often the cause, and often also the effect, of increased determinations, or altered distribution of the blood; that Inflammation is, in several instances, attended with increase and alteration of exhalations and secretions already existing, and always tends to a change of the products formed from the blood at the part which it affects; and that a general diminution and alteration of the products formed from the blood, is an essential, and probably the most fundamental, part of the changes that constitute Fever. It is therefore obvious, that no distinct line of demarcation can be drawn between the diseased actions already considered, and those of which alteration of Secretions, and of Nutrition, are the most essential constituent.

But there are many diseases in which these vital actions in the capillaries are much and primarily altered, and in which there is in general, and especially in the commencement, neither fever excited, nor any of the usual products of inflammation formed, nor even any such congestion of blood effected, as is in itself injurious; which we must ascribe, therefore, to alteration or *perversion* of the functions of Secretion, Exhalation, and Nutrition, and of the concomitant function of Absorption, by which the condition of all extra-vascular parts within the body is determined; and these diseases come next under our view.

It is not to be expected that we can *explain* these alterations of vital actions, which are, in their natural state, so very imperfectly understood; but it is necessary to have some arrangement of them, and to state what is known of their causes, and of their connexions with other diseased states.

In a brief outline of this subject, we set aside the cases already considered, of altered secretions dependent on decided inflammation, and on fever; and also the case, afterwards to be shortly noticed, of diseased secretions depending on morbid alterations of the blood from known causes.

In regard to the whole of the classes of disease now to be considered, it is to be observed that they are gene ally of much longer continuance or more frequent recurrence than inflammatory and febrile diseases, and that their abatement, by a natural process, is less to be expected.

It is important to distinguish, in treating of the diseased states of the secretions, those which have been described as Recrementitious, from those destined to Excretion; but it is to be remembered that the Bile, and perhaps others of the secretions of the primæ viæ, appear to partake of the nature of both classes of secretions.

I. The most important disorders of the first class of Secretions, are the affections of the secretions of the Primæ Viæ concerned in digestion. From a simple increase of these arise Ptyalism, Cholera, perhaps in some cases Bulimia, and Diarrhœa of different kinds (often independent of any inflammatory action, as appears from its whole history, and from the appearances seen on dissection after it)*. And from alteration of them arise the varied forms of Dyspepsia, (the symptoms of which are dependent, partly on deficiency of the natural sensations which attend the healthy state of the secretion at the stomach, and partly on morbid sensations, and sometimes morbid actions, consequent on the delay and the imperfect solution of the food); an occasional diseased state of the mucous membrane of the bowels, in which morbid, viscid, or ropy mucus is thrown off, without inflammatory symptoms, and without diarrhœa; another diseased state of the secretion of the mucous membrane, in which much phosphate of lime is thrown out, forming the basis of intestinal Calculi; different diseased states of the stomach and bowels, consequent on the flow of defective or vitiated Bile; Jaundice, when, from inspissated bile, or from gall-stones (the symptoms of which depend partly on the absence of bile from the intestines, and its presence in the blood and in the urine, partly on the sensations resulting from the immediate action of the cause that obstructs its descent, and partly on the imperfection of the process of digestion when it is absent); and constipation or Colic, commonly dependent on the deficiency of the natural stimulus to the intestines, and consequent accumulations and uneasy sensations there.

These diseases of the organs of digestion are, in a few

* See ANDRAL, Clinique Medicale, t. i. p. 424.

cases, dangerous, in like manner as inflammation of these organs, by reason of the sympathetic effect on the heart (as in the cases of violent Gastrodynia attending indigestion, or of violent Cholera); sometimes they are dangerous, by reason simply of the gradual wasting and exhaustion consequent on them; but more frequently they are dangerous by so weakening the system, as to give a strong predisposition to, and aggravation of, other diseases, whether inflammatory or organic, with which they become complicated.

Again, there are cases of chronic cough and asthma, dependent on increase and alteration of the natural mucous secretion of the bronchiæ, which cannot be said to shew any indications of inflammation,—particularly that variety where much pale ropy mucus is expectorated; and there are many cases of chronic diseases of the skin, even such as Lepra, Impetigo, &c., still more such as Ichthyosis or Molluscum, during the greater part of which there are no marks of inflammation, and which may be considered as consisting in morbid secretions on the true skin; and accordingly, when these are affected by remedies, it is by remedies of the class of alteratives, not by antiphlogistic measures.

Now, in regard to diseases thus depending essentially on altered Secretions, we observe, that although their causes are often obscure, yet the following are often observed to act, and may often be avoided or averted.

1. They depend often on the application of external agents of the same kind, but short in degree of those which can excite inflammation of the parts. Thus mercury excites ptyalism, heat cholera; alcohol, or other stimuli, or any aliments very difficult of digestion, or in excessive quantity, in their secondary operation, lessen and injure the secretion at the stomach; many kinds of food or drink produce diarrhœa; and sometimes exposure to cold excites either dyspepsia or diarrhœa, without any appearance of inflammation.

2. They are often the result of changes taking place in the condition of the Nervous System, the peculiar influence of which on the secretions has formerly been illustrated; as

when long continued mental languor or depression, or more violent mental emotion lessens, and probably vitiates, all the secretions of the primæ viæ, and causes dyspepsia, constipation, diarrhœa, sometimes jaundice, according to the constitution of individuals;—when mental emotions so injure the secretion of milk as to make it poisonous to the infant; —or when the sensation of intense pain in any part of the body causes thirst or dryness of the mouth, and destroys the power of the secretion at the stomach. A still more striking case of this kind, if we can regard it as duly authenticated, is the supposed effect of violent rage, pain, and terror, in so altering the secretions of the mouths of animals, as to make them capable of communicating by inoculation the true Hydrophobia.

3. They are often produced by deficiency of the natural stimuli of fresh air, exercise, and variations of external temperature; which privations may be supposed to act, partly by producing long continued irksome sensations, and partly by repressing the circulation on the surface, and the different excretions from the body, and so favouring plethora in internal parts.

4. They are often *sympathetically* produced by diseases, functional or organic, of other parts of the system; as when various disorders of the stomach ensue in the course of diseases of the brain, liver, bowels, kidneys, uterus or other pelvic viscera. According to what has formerly been stated as to sympathies, this influence of the diseases of distant parts may be believed to take place through the intervention of long continued uneasy sensations resulting from these diseases, and therefore may be resolvable into the second head of the causes of diseased secretions.

5. Although not necessarily dependent on any alteration of the usual state of the circulation, yet in many cases they supervene on, and in others they give rise to, congestions of blood in the parts where they take place; and in both cases they are aggravated by such congestions of blood; as is obvious when we observe the facility with which Dyspepsia or Diarrhœa often supervenes on obstruction to the

flow of venous blood through the liver; or the manner in which dyspepsia or diarrhœa often assumes somewhat of the character, and is relieved by a moderate use of the remedies, of inflammation of the stomach or bowels.

This is remarkably observed in certain forms of dyspepsia in adults, described by Dr Wilson Philip, Dr Parry, and others, in this country, and by Broussais and his followers in France; and again, in many cases of the Febris Infantum Remittens; which does not always imply, but often threatens, or even passes into, inflammation of the mucous membrane of the bowels.

It is farther important to observe, in regard to these alterations of secretions, that they produce, and frequently make themselves known by, not only derangement of the functions in which they are themselves concerned, but likewise derangement of other functions, often of distant parts; and that in two ways,—either when the function secondarily affected is necessarily dependent on that first deranged; —or else in a more precarious and variable way, when the affection of the second is truly a sympathetic change.

Thus a disordered state of the function of digestion, or habitual constipation or diarrhœa, leads naturally to deficient nutrition, and to debility and emaciation; and it also leads much less certainly, but sometimes more obviously, to a distempered state of the external senses, particularly vision,—or of the mental faculties (Hypochondriasis), —or of the respiratory actions (Asthma),—or of the voluntary muscles (Hysteria, or even Convulsion),—or to various indefinite uneasy sensations common in persons of *nervous* temperament, &c.; or modifies the progress of inflammation, especially if scrofulous, or of any other local disease that may be excited in the body, rendering it more obstinate, and less amenable to treatment, as has been well illustrated by Mr Abernethy, Dr Hamilton senior, and others. In children, febrile action is frequently excited by derangements of the secretions of the Primæ Viæ, independently of inflammation; and in certain (chiefly scrofulous) constitutions, this fever is very apt to pass into Hydrocephalus.

The spasms of the legs, which attend violent diarrhœa or cholera, are an example of a more definite and uniform sympathetic effect, resulting from the state of the secretions of the primæ viæ.

II. The Excretions from the body are very liable to increase, diminution, or alteration, from the same kind of causes which act on the other secretions; and are sometimes totally suppressed, with injurious or even fatal effects, but independently either of fever, inflammation, or change of texture of the parts furnishing them.

Thus the Menstrual Flux is often increased and altered (as by the establishment of permanent leucorrhœa) from a luxurious or debilitating mode of life, from mental emotions, or from exertions especially affecting these parts; and again, it is liable to sudden suppression from cold; and in both cases, many sympathetic affections of the stomach, of the heart, and of the nervous system, usually follow. And the Urine is liable to alteration from the nature of the ingesta, from cold or heat, from affections of the nervous system, as in Hysteria, from injuries in the neighbourhood of the kidneys, &c.; and it is occasionally totally suppressed without a known cause.

But from what has been formerly said of the manner in which the peculiar matters of the excretions are probably prepared in the blood before it enters the excretory glands, (p. 52.), and also of the necessity which exists for the evolution of certain matters by these means, from the system, it may naturally be expected, 1. That the excretions may be affected by a disordered state of the functions of different and distant parts; and, 2. That more pernicious effects (consequent on the retention of noxious matters which ought to be expelled), may result from their alteration or suppression than from similar affection of the other secretions. And although the subject is very imperfectly understood, illustrations of both these points may be given.

Thus the Menses are often suppressed, not in consequence of causes acting peculiarly on the uterus, but in consequence of mental emotions, or general sensations, such as cold, or of any cause of general weakness, of long duration.

The two most important alterations of the urine (unconnected with organic disease of the kidneys) are, its tendency to deposit different kinds of earthy deposits in Gravel; (some of them, the uric acid and the phosphates, natural constituents of the urine, others, as the oxalate of lime and the cystic oxide, new combinations of the elements composing it); and its great increase, both in quantity and specific gravity, and the alteration of its animal matters, in Diabetes. The former of these appears, from the other complaints attending it, and from the juvantia and lædentia, to be very dependent, if not on the nature of the ingesta, at least on the condition of primæ viæ, and the nature of the supplies sent from thence to the blood,—rather than on any cause acting directly on the kidneys.

The Diabetes is certainly not a disease confined to the kidneys, nor *chiefly* seated there; because it is often found unconnected with any lesion of the kidneys; and because this remarkable fact is very generally observed in it, that shortly before death the urine becomes quite natural both in quantity and quality. From what we now know, of the appearance of Urea in the blood when its evolution at the kidneys is obstructed, it is reasonable to infer, that the great increase in the quantity of urea, and its conversion into sugar in diabetes (by the change in its constituent elements noticed at p. 90) will be effected at all parts of the body where the formation of urea is begun; and from what was formerly said of the great probability of this substance, destined only to excretion, being a product of absorption, it may be supposed that its formation is begun wherever absorption takes place.

Accordingly it may be observed, that the symptoms seen in Diabetes, (in addition to the increase of the urine), the thirst, the keen appetite, the dryness of the surface, the general wasting, and ultimately extreme debility, notwithstanding the great amount of ingesta, are all indications of unnatural activity of Absorption; from which it seems probable, that first an increased formation of Urea, and then a formation of sugar, (from the same elements, with the exclusion of azote, and an additional proportion of carbon and oxygen), may naturally result.

Again, it was formerly stated, that the different consequences frequently resulting from suppression of the Menses, hæmorrhages often in unwonted situations, inflammations, and various nervous affections, appear to be more serious than what usually result from stopping a slow hæmorrhage of an equal amount. And it is certain that when the excretion of Urine is suppressed, the consequences are such as clearly indicate the action of a poison on the body, viz. Nervous symptoms resembling those of typhoid fever, and ultimately fatal Coma.

It may be observed here, that these consequences follow suppression of the excretion at the kidneys, but do not necessarily follow a great amount of absorption of urine from the bladder or ureters; for cases occur where, in consequence of obstruction at the ureters or bladder, great and long continued distention of the ureters, and great absorption from them, are found to have taken place, without any such consequences having followed.

It would appear that the same principle applies to the secretion of Bile, for although long continued *obstruction* to its descent from the gall-ducts, and consequent absorption of it into the blood, are often borne with impunity, yet in those cases where its secretion at the liver has been *suppressed*, and the ducts have been found on dissection pervious and empty, fatal coma has in general quickly supervened on the jaundice *.

The rapidly fatal effect of suppression of the excretion by the Lungs has already been fully considered. The suppression of excretion at the Skin is seldom effected, and when it is, its bad effects may probably be averted by increased exhalation of the same matters at the lungs. But the peculiar liability to inflammatory affections, and to dropsy,

* See Marsh in Dublin Hospital Reports, vol. iii. Several cases in all material respects exactly similar, have occurred to myself.

while the skin is in an inert state after exanthematous diseases, particularly scarlatina, may be partly owing to the retention of this excretion.

A febrile attack very generally succeeds the sudden suppression of the secretion of Milk; but is of short duration, probably because the conditions necessary to the continuance of that secretion (see p. 304) soon cease to exist.

In regard to all morbid states (at least to diminution and alteration) of secretions in the body, it is to be observed, that they will naturally be more apt to take place in secreting organs which have undergone any organic change of structure than in others; and therefore that when strongly marked and obstinate, these changes in the secretions are often connected with, and may generally excite suspicion of, such organic lesions as are next to be considered.

In connexion with these disordered states of the Secretions, a few words may be said of the pathology of the new and anomalous disease, which is essentially characterised by a very diseased condition of almost all secretions, viz. the Epidemic Cholera.

As occurring in India, this disease was characterised by copious vomiting and purging of a watery fluid, (often loaded with flakes of whitish matter) without bile;—by cramps, not merely of the legs, but often pretty general over the body,—and by rapid sinking of the heart's action,—uncommon shrinking or shrivelling, coldness, and often blueness of the surface,—and frequently laborious breathing in the later stages, as in other cases of death by syncope *. The blood was always observed to lose its power of coagulation, and to be thick and dark-coloured, very soon after the attack of the disease. All the secretions, excepting those by the mucous membranes and the skin, appeared to be nearly suppressed during the violence of the disease, but the whole duration, whether in fatal or favourable cases, was seldom more than two or three days. In this climate, there is this essential difference from the usual form in

* See p. 376.

India, that after the symptoms above mentioned have abated, and the pulse become pretty full and firm, a state of fever, more or less distinctly marked, often with delirium, and always with strong tendency to Coma, very frequently supervenes, and may be fatal strictly in the way of coma, at the end of some days, or even a fortnight or more from the attack. During this febrile or comatose state, although the secretion of bile (of morbid quality) is generally restored, that of urine is still frequently suppressed; or if passed it is generally in small quantity, and of light specific gravity, and often albuminous.

Both in the warmer and colder climates, it has been distinctly perceived, that the spasms of the limbs are not merely the effects of the frequent stools,—not only because they are more general than those of the common cholera, but because they have often been violent before there was any diarrhœa, and continued after that was stopt, even after apparent death;—again, that the depression of the heart's action is not merely the effect of the evacuations, because it is rapid and excessive in some cases where these are slight;—and lastly, that the coldness of the surface is not merely the effect of the depression of the heart's action, because the body has often become warm immediately before, or even after death.

The most important additional facts which have been lately ascertained in regard to the changes in the epidemic Cholera are, that the blood, deprived of much of its watery constituents by the diarrhœa, is found to contain much less water, and less of its usual saline ingredients than in health*; that the watery dejections consist merely of the serosity of the blood, with a small quantity of albumen; and that in the cases of long-continued suppression of urine, the urea has been detected, as in cases of diseased kidneys, in the blood, and also in the serum of the shut cavities of the body.

No morbid structure has been ascertained to be constantly present in the bodies of persons who have died of this disease. A great variety of morbid appearances, found in such bodies, have evidently existed before the attack of cholera; others, such as softness of the mucous membrane

* See O'Shaughnessy, Report on the Cholera, &c.

of the primæ viæ, and unusual development of the mucous glands there, may reasonably be ascribed to the obviously great change in the distribution of the blood. Slight bloody effusions, or ecchymosis, often found on the heart, but more especially on the sympathetic nerves and par vagum, although not essential to the disease, and probably to be regarded as its effects, appear to be important as affording an explanation of a part of the symptoms.

The mode of diffusion of this disease is as anomalous as its symptoms. Although a few cases of violent diarrhœa or cholera (especially such as might be traced to the action of poisonous articles of diet), have shewn symptoms nearly approaching to those of this epidemic disease, yet it is certain that no such disease was frequently seen,—still less did any such prevail epidemically,—in any part of the world before 1817,—or in Europe before 1829, or in Britain before 1831;—and that at this day no such disease has been seen in many towns, villages, or districts of this country, while in others it has been very destructive. It is quite in vain, therefore, to attempt to refer the appearance and extension of this disease to the agency of any of those causes of disease, which are of general and nearly uniform operation in any climate; notwithstanding that such causes may very often have appeared, as in the case of other epidemic diseases, to co-operate in exciting the disease in individuals. As this disease has hitherto existed only within certain assignable limits of space and time, so its main cause must be one of local and temporary agency.

It is equally certain, that this disease does not present the usual indications of one which arises from a Malaria; for instead of being confined to certain districts, and those of similar character in different parts of the world,—and of appearing and disappearing at certain seasons or in certain circumstances only,—it has been found to prevail epidemically in all climates and all seasons, and although perhaps most frequently in low moist situations, yet repeatedly in all descriptions of localities.

It may be stated farther, with confidence, that on different occasions, and particularly on several occasions in Scotland, where the introduction of the disease into a town or district previously unaffected, from a known source (*i. e.* by a person coming from a place where the disease prevailed, and falling ill of it in another, previously untouched by it), has been carefully watched,—it has been observed, that those who had intercourse with the sick took the disease, in the first instance, in a proportion so very much greater than those who avoided such intercourse, as to leave no reasonable ground for doubt, that it possesses a certain degree of Contagious property *.

It is no objection to the supposition of the contagious nature of the disease, that a large proportion of those who have free intercourse with the sick remain unaffected; for, where the disease is epidemic, such persons are necessarily exposed to the local and temporary cause of the disease, whatever it be; and their exemption, although it proves the agency of that local cause to be very irregular (and perhaps contingent on conditions not yet understood), gives no information as to the nature or origin of that cause.

But while a certain degree of contagious property is confidently attributed to the disease, it must at the same time be stated, that when it has become epidemic in towns or districts, many persons have been observed to be attacked, who had certainly no intercourse with the sick; many others, whose intercourse either with the sick or with any thing that could have been in contact with them, must have been very slight and transient; and sometimes it has not appeared, that those who had full and free intercourse with the sick, were affected in larger proportion than either of the two first-mentioned classes of persons.

From these facts it appears to be a perfectly fair inference, that either the disease, besides the degree of contagious property already ascertained to belong to it, has another mode of extending itself, independent of contagion, and not yet understood; or else, that the contagious poison arising from those affected with it, acts according to laws

* See p. 361. *et seq.*

materially different from those, which regulate the diffusion of other contagious diseases. It must have the power of extending itself to a very considerable distance through the atmosphere, so as to affect those who are peculiarly liable to its influence; and again its action, even on those the most fully exposed to it, must be very much dependent on other circumstances in their situation. Its effect must bear no proportion to the quantity of it introduced into the system; and its virulence must be liable to great and unaccountable variations at different times.

Perhaps, when the whole history of the disease,—its recent introduction into the world, and its generally following the great lines of human intercourse,—are taken into account, and the analogy of other contagious diseases considered, it will appear more reasonable to ascribe these singular properties to a specific poison of human origin, than to admit two distinct causes for the extensive diffusion of the disease. But it is impossible at present to decide with confidence on these two opinions, and very difficult to perceive, how observations can be so conducted, as to obtain an *experimentum crucis* on the subject.

Two important facts, in regard to the local and temporary cause of the disease (whatever be its nature), seem well ascertained, viz. 1. That its effect on the persons exposed to it is sometimes very rapid, and sometimes delayed for several weeks; and 2. That the effect of its application is very dependent, not only on previous predisposition, but on subsequent contingencies; avoiding which may probably, in many cases, suffice to avert the disease.

The concurrent and accessory causes which seem most efficient in determining attacks of the disease are, previous organic diseases unconnected with febrile excitement, intemperance, and previous diarrhæa.

As the whole history of the disease shews its dependence on a local and temporary cause, so its essential symptoms, and the mode of its fatal termination, evidently assimilate it to the effect of Poisons on the animal economy, much more than to the phenomena of any diseases which arise from causes of more uniform occurrence.

In particular, the spasms of voluntary muscles, and the very rapid depression of the heart's action,—certainly not referable merely to the amount of evacuation from the primæ viæ,—bear a close resemblance to the action of certain poisons, and to other malignant epidemic diseases proceeding from malaria or from contagion, *e. g.* yellow fever and plague. And the analogy to other effects of specific or morbific poisons appears farther from the remarkable tendency to reaction of the heart, and spontaneous favourable termination, observed in many cases of the disease, and under all possible variety of treatment.

The remarkable effect of injection of large quantities of saline solutions into the veins, in causing temporary excitement of the heart in the stage of collapse or extreme depression in this disease, shews that a part of the cause of the depressed state of the circulation lies in the altered condition of the blood consequent on the evacuations; but the tendency to syncope is seen too early, and recurs too frequently and too rapidly, after the full amount of water and salts have been restored, to be solely referable to this cause.

The stupor in the later stage of the disease may certainly be ascribed in a great measure to the suppression of the excretions, particularly of the urine; but it is still doubtful whether this may not be in part also a direct effect of the morbific poison.

CHAPTER X.

OF DISEASED STATES OF NUTRITION.

We here treat shortly of what are generally called Organic Diseases, *i. e.* both of Preternatural or Morbid Growths in the system, and also of Morbid Changes in the form, size, or texture of organs, which sometimes take place without the formation of any new growth.

These organic diseases become obvious to the senses only when somewhat advanced, and in some parts of the body are necessarily concealed while life lasts; but, in most instances, their existence is pretty clearly indicated in an earlier stage, partly by observation of the diseased conditions and diseased actions from which they may be expected to result, and partly by observation of the altered functions of the parts in which they form, or with which they are connected.

We first enumerate shortly the different morbid changes of structure, or Organic Lesions, to which the different parts of the body are liable, and state what is known of their causes, and afterwards we take a general view of the symptoms that result from them, and the consequences to be expected from them, as occurring in different parts of the system.

SECTION I.

OF MORBID GROWTHS.

One kind of morbid growths, or deposits from the blood in the living body, has been already mentioned, and the mode of their formation explained, viz. that which is the result of distinct inflammation, and consequent exudation of coagulable lymph. The new deposits thus formed in the body are somewhat various (if not in their origin, at least after they have existed some time), according to the texture in which they have taken place; *e. g.* in the substance of the brain or lungs, on bones, on serous, mucous, or fibrous membranes, &c. to the texture of which parts they gradually become more or less assimilated. Some varieties of morbid growths may therefore be traced to simple and healthy inflammation only. But it has been already stated, that when the inflammation causing these has subsided, such deposits, in the perfectly healthy state of the body, are gradually diminished by absorption, and the symptoms resulting from them (although sometimes never disappearing, and often easily renewed), gradually abate.

Many, if not all, the new productions of which we are now to treat, may be traced, in many individual cases, to an inflammatory action, and even to a distinct exudation of lymph, in their commencement, and are often evidently aggravated by fresh attacks of inflammation during their progress; but in other cases no such origin can be detected; and, even when they do originate in inflammation, it is plain that they are often different, in their own texture, from the parts in which they form: and farther, that they are not only much less liable to absorption than the simply inflammatory exudations, but go on increasing after all surrounding inflammation has ceased, and often continue to draw supplies from the blood, notwithstanding any evacuations that may be practised. Whether they originate in inflammation or not, they imply a continued *perversion of nutrition.* The epithet *parasitical* is fairly applied to them; and it is obvious that other conditions besides inflammatory action are concerned in producing and maintaining them.

The same observations apply to the cases, in which there is reason to believe that tumors, of various kinds, and in different parts of the body, originate in coagula of effused blood *.

In connexion with this essential peculiarity of these truly morbid textures, it is to be remarked, that according to the observations of Schræder Van der Kolk, the vessels ramifying in such growths have almost exclusively the appearance of minute arteries; whereas in the false membranes from inflammation, many of them are veins †.

We consider the coagulable lymph, effused by inflammation, as the simplest kind, and often the basis of morbid growths; but from this there are many degenerations; and many different classifications of adventitious textures have therefore been attempted, founded on distinctions which are of real importance, but none of which are found to be uniformly observed.

* See p. 393. † Observat. Anat. Pathol. p. 46.

Thus, there is a distinction between those deposits which are truly new to the system, existing nowhere in the healthy state, and those which are only found in new situations; but many tumors contain matter of both kinds, being, *e. g.* fatty or bony in some parts, and tubercular or scirrhous in others.

There is a distinction between those morbid growths which consist of membranous and vascular coverings, inclosing matter, whether solid or fluid, which is not vascular, and those which are vascular, and organized in their interior, and grow from within outwards *; but a cluster of tubercles, of whatever kind, is first of the former description, and afterwards, when the individuals composing the cluster have coalesced, it may be said to be of the latter.

There is a distinction, often of the greatest importance, between those morbid formations which are, in the language of some pathologists, essentially malignant,—the growth or varied changes of which cannot be prevented from proceeding, and affecting the system at large,—and those which are either inert in themselves, or innocent in regard to the general health; but tumours which assume the former character are often not to be distinguished, during great part of their progress, from those which remain inert for life.

There is a distinction, perhaps the most practically important of any, between those morbid deposits which are merely local, and those which are generally found to take place simultaneously or successively in various parts of the body; but the same kinds which are strictly local in one case, are found very generally extended in others.

This last distinction, however, we shall observe as far as possible.

I. Of morbid growths, which are generally local, the most important may be included under the following heads:

1. The simplest in structure are the Serous Cysts, *i. e.* shut sacs, containing serum, and formed of condensed cellular sub-

* See Schræder Van der Kolk, Observationes, &c. p. 45.

stance resembling the serous membranes; which are formed gradually around a clot of blood, or any foreign substance in the system, and are frequently developed spontaneously in various parts of the body; *e. g.* in the brain (especially when developed in the choroid plexus), in the kidneys, in the liver, in the ovaries. They are frequently attached to the natural serous membranes, but sometimes quite separate from these; sometimes solitary, sometimes set together in clusters; and their size and shape are very various. They must be distinguished from enlargements of natural cavities, such as the calices of the kidneys, or Graafian vesicles in the ovaries. They are often unconnected with disease of the adjacent textures; but in some cases, these textures are found either wasted by absorption, or disorganized by inflammation around them. There is no evidence of their being generally connected, in their commencement, with inflammatory action; and when they are small, their existence is often not denoted by any symptoms whatever.

Now, from this simple type of diseased structure, there are many gradual deviations. When within one of these serous cysts, which is attached to the surrounding textures, we find along with its fluid contents one or more (often a number) of similar cysts nearly or quite unattached, we apply the name of Hydatids. These are often found in the human body, chiefly in the cellular substance, liver, kidneys, and uterus. From the circumstance of these serous cysts being often quite loose, and of various sizes, apparently drawing nourishment from the fluid in which they float, from their shewing a kind of vital contraction when cut, and from the fluid contained in them being often pellucid, while that of the larger cysts surrounding them is turbid or even purulent, they have been thought to possess an independent vitality. And if this point be still doubtful as to the greater number of hydatids found in the human body, and in which no distinction of organs is perceptible, (Acephalocysts of LAENNEC), it is generally allowed that such independent vitality does belong to other nearly similar bodies, found in the same situations, sometimes in the human system, more frequently in other animals, but in which a head, and mouths or suckers, may be perceived (Cysticercus and Polycephalocyst, &c *.)

Again, the simple serous cyst approaches to, and sometimes probably is gradually transformed into, the various kinds of Encysted Tumors, which may form probably in any part of the body that has the cellular structure ; and have received various names according to the nature of their contents, *e. g.* Hygroma, when they contain a nearly serous or seropurulent fluid, or encysted dropsy, if they be of very large size; Hæmatoma, when their contents are bloody; Steatoma, when they approach more nearly to the appearance and consistence of fat ; and Atheroma, and Cold or Chronic Abscess, when they contain purulent matter of more or less consistence, without having been preceded by distinct marks of inflammation. Sometimes substances distinct from any found in the healthy body, or substances which in the natural state exist only in individual parts of the system, (*e. g.* Cholesterine) are found in the interior of these encysted tumors. Those tumors, of this kind, which are of a considerable size, are often formed of a congeries of such cysts, and their contents in the same tumor, are often very various, as is seen remarkably in the most common case of enlargement of the ovary, which appears to consist in gradual distention and alteration of the fluid contents of the Graafian vesicles.

Farther, not only the contents, but the coats or envelopes of these cysts, are subject to a great variety of changes, becoming in some cases fibrous or cartilaginous, or having bony matter deposited irregularly through them.

2. In many cases, though not in all, we can clearly distinguish from these encysted tumors, (where the organized secreting substance is external to the chief bulk of the morbid growth) tumors, the organization of which is so far different, that their substance is penetrated throughout by a vascular cellular or fibrous structure, in which they are

* See Andral, Precis, &c. t. i. p. 512 ; and Kerr in Cyclopædia of Practical Medicine, art. Hydatids.

nourished, and by which they are often divided into lobules. These are generally called Sarcomatous tumors; and the simplest example is the common Vascular Sarcoma, which consists merely of condensed cellular substance, and may be found in any cellular texture, but is often seen in the mammæ and testes. But according to the different situations they may occupy, and the different texture of which they may consist, (sometimes probably from their original formation, and sometimes in consequence of gradual transformation) tumors of the same general structure have received different names, Adipose Sarcoma or Ceroma, when of fatty or waxy consistence; Polypus, when projecting from, and often closely resembling the structure of, mucous membrane; Neuroma, when seated on a nerve, or when growing on its sheath, and splitting up and separating its fibrils; Chondroma, or Fibro-cartilaginous tumor, when traversed by numerous bands or striæ of the consistence of cartilage; and Osteo-Sarcoma, when containing much bony deposition. In many instances, the differences in these morbid textures may be ascribed to their partaking more or less of the nature of the sound texture in which they are developed; but in some, no similarity of the diseased structure to the surrounding healthy parts can be observed. In some cases, as, *e. g.* in the coats of the stomach or intestines, it may be observed that the formation of such morbid growths is preceded by simple thickening and hardening of the sound cellular texture, a part of which only afterwards assumes the strictly morbid appearance.

We have no means of certainly distinguishing by appearance in their early stage, the hard swellings, seen chiefly in the most vascular and sensible parts of the body,—the mammæ, testes, penis, lips, lymphatic glands, cardia, pylorus, cæcum, and above all in the os uteri,—and to which the name of Scirrhus and Cancer are given, from others above enumerated, and especially from those called Fibro-cartilaginous; but the history of the affections is widely different, the latter remaining often inert for many years; while the former continue gradually, although slowly, to increase, are followed after a time by an extension of the diseased appearance to the surrounding textures, are soon attended with much pain, and ultimately with much constitutional disturbance, and pass very generally in the end into partial but irremediable fungoid ulceration.

II. Other kinds of morbid growths frequently occurring in the body, appear distinctly, and from the first, to depend more on constitutional peculiarity; because they are found from their commencement to originate at different points, often in many parts of the same, or even of different organs; and because in many cases their deposition becomes ultimately very general over the body.

1. Perhaps the most frequent and important of this class of adventitious textures, are the Tubercles already considered, as a form of scrofulous disease, and probably often a product of scrofulous inflammation.

But besides the strictly scrofulous tubercles, there is a very numerous class of organic diseases, depending essentially on the deposition in different parts of the body, of numerous small granular bodies, so nearly similar to the scrofulous tubercles, that they often cannot be distinguished from them in their earliest stage, and therefore often called Tubercles, but which are commonly found at a more advanced period of life, and run in general a somewhat different course. They are for the most part also of a more irregular form, and more unequal size, than the most characteristic specimens of the scrofulous tubercles; but some of them are always nearly spherical, and some of the true scrofulous tubercles are of very irregular form; and in their first stage, these granular deposits, as well as the scrofulous tubercles, appear to consist of concrete albumen. These are most commonly found, and most important as occurring, in the Liver, in the Kidneys, and in the coats of the Arteries; but exactly similar deposits are common in other parts, especially in the serous membranes. They not only present in their commencement, the same appearance in these different textures, but very often they are found in two or more of these in the same person, and apparently about the same stage of progress. In the liver and kidneys it may be distinctly perceived, that the first step to their formation is the increase or hypertrophy of the greyish condensed cellular texture, which is interposed among the different portions of the glandular substance *; in the arteries they are found chiefly in the first instance between the middle or fibrous and inner coat, but they frequently occupy a large portion of both coats. They are found very frequently on the inner membrane of the left side of the heart, and its duplications forming the valves,—but rarely in the veins or in the right side of the heart.

It is important to observe, that when these granular deposits are formed on membranes, while they add to the thickness, they are generally attended with shrinking or corrugation of the superficial extent of these membranes. This is very obvious, when such deposits form on the membranous expansions forming the valves of the heart, and on the omentum. When they form in irregular patches, on the peritoneal coat of the liver, from the same cause they occasion partial compression and absorption of its substance; and thereby give it a rough or granulated appearance, even when it is little diseased internally; and when they form on the peritoneal coat of the intestines, they likewise shorten or corrugate that membrane, and so disturb the functions of muscular fibres beneath it, as to lead to habitual increased action and hypertrophy of these fibres.

In all these situations, these granular or tubercular deposits, often so materially impede the functions of the parts in which they are formed, and thereby so influence others, in modes to be afterwards explained, as to cause death before they have themselves undergone much change. But when their formation is not so extensive as to be rapidly fatal, they become liable to changes which vary remarkably in different parts, and in different cases. In the aorta and other arteries, they soon become blended with irregular atheromatous, fatty, cartilaginous, or bony deposits, de-

* Andral, Precis, &c. t. ii. p. 585.

stroying the flexibility and elasticity of these vessels ; and at the same time with partial ulcerations of their inner, and often likewise of their middle coat. In the liver and kidneys they sometimes coalesce in clusters, and pass on pretty rapidly to suppuration, nearly in the same way as tubercles of the lungs ; but much more frequently they merely enlarge more slowly for a time, and harden, and by their pressure on the healthy substance of the gland, cause so much absorption of it, that ultimately the whole organ often shrinks (while its natural structure is nearly obliterated) to less than its original bulk. At the same time, in the liver, these tubercles often acquire a deep yellow colour, and in that state have been described by LAENNEC under the name of Cirrhosis. On the serous membranes such originally tubercular deposits frequently become cartilaginous, and then bony.

2. In almost all parts of the body we occasionally meet with irregular, but encysted deposits, of a very peculiar character, larger, softer, generally of a whiter colour, and growing more rapidly than any kind of tubercles, generally affecting several textures in the same person, and, when they form on the mucous membranes, or come to the surface of the body, often pouring out blood; to which, from their resemblance to the substance of the brain, the names of Encephaloid matter and of Medullary Sarcoma have been given ; and again, from their usual form, and the hæmorrhages connected with them, that of Fungus Hæmatodes.

Tumors of this kind in internal parts frequently soften in their centres, and pass into unhealthy suppuration, after the manner of clusters of tubercles; and in external parts, or on the mucous membranes, they usually pass on to intractable ulceration.

This morbid texture has been often found in all the organs of the body, which are resolvable into cellular texture, chiefly in those that are fully supplied with blood, as the testes, uterus, mammæ, lungs, liver, and serous and mucous membranes,—often also in the bones, or their membranous envelopes.

It is found at all times of life, but always in connexion with a feeble and irritable state of the constitution. Tumors of this description may be said to pass by insensible degrees, on the one hand, in young subjects, into the true tubercles, as in cases of tuberculated accretions on the peritoneum, described by BARON and others; and in the other, in older subjects, into the cirroma or chondroma, or even the true scirrhus, and in the same morbid mass, these different textures are sometimes evidently mixed.

The morbid texture described by LAENNEC under the name of Colloid, and distinguished by its gelatinous consistence and translucency, may probably be considered as a variety of the encephaloid matter.

3. Another morbid formation of rare occurrence, but when occurring, generally observed in different parts of the system at the same time, is that called Melanosis, which is easily distinguished by its black colour (excepting only in the case of the lungs, where other diseased conditions may assume this colour from foreign matters introduced there) and soft consistence. It has been found, and often grows rapidly, in almost all parts which have the cellular texture, sometimes inclosed in cysts, sometimes loosely deposited on the surface of membranes, or through the substance of organs, but seems always to be destitute of organization, and to be liable to no other change than reduction to a fluid consistence.

The matter of this diseased structure appears to be merely blood which has undergone some chemical change, chiefly in its colouring matter; and some cases of the disease appear to approach nearly to cases of Purpura, where blood is extravasated in various parts, and with less change of any of its qualities. The melanosis is observed chiefly in old, and almost always in debilitated persons.

The following observations appear to be of importance in regard to all the organic diseases which are distinctly of constitutional origin, *i. e.* the Tubercular, (especially the scrofulous), the Encephaloid, and the Melanotic.

1. The deposition of these peculiar matters appears often

to be much increased, if not actually determined, by attacks of inflammatory disease,—perhaps especially of those inflammations which often succeed febrile and weakening diseases. In such cases the morbid deposits are not confined to the parts in which symptoms of inflammation appear; but by this circumstance the symptoms of the diseases, which are followed by these morbid formations, are necessarily rendered various, because very frequently complex.

2. While the matter of these morbid textures is concentrated into distinct tumors in certain parts of the body, it is very often irregularly diffused or infiltrated through the cellular texture of other parts, especially of parts adjoining that where the chief deposition has taken place. Thus we have the substance of the lungs very often infiltrated with tubercular matter, at the same time that circumscribed tubercles are disseminated through it, and especially clustered together at its upper part; and similar infiltration of encephaloid, or of melanotic matter takes place, into the texture of various parts, especially if adjoining those in which tumors of these descriptions exist.

3. The matter of all these morbid textures, but especially of the encephaloid and the melanosis, (the formation of which is much more rapid than that of any other morbid growths), is often found, not only in adjoining textures, but especially in the nearest lymphatic glands; and also in the veins leading from the parts in which they are chiefly deposited, and sometimes in other veins of the body.

4. It is an important fact also, in the history of all these diseases, that after the removal of a limb, in which any one of them has existed for some time, it is common to observe fatal disease of some internal organ, which on dissection appears to have resulted from deposition of a similar matter.

The morbid matter of the true Scirrhus and Cancer is often found likewise infiltrated through the organs in the immediate neighbourhood of those most diseased, as in the usual affection of the fundus uteri, where there is cancerous ulceration at the os tincæ; and such matter is found also, often in the lymphatic glands, and sometimes in the blood of the veins, leading from these parts; but this is only in the advanced stage of such diseases, at which time we know, that similar formations are very apt to take place in other parts of the body, or in the same if the most diseased portion be excised;—*i. e.* that the disease which was at first local has become constitutional, or acquired the character to which some authors affix the epithet Malignant.

It seems to be partly in consequence of the great tendency to similar deposition from the arteries in the immediate neighbourhood of any of this class of diseased growths, that the pressure of them on the surrounding parts leads very often to adhesion and agglutination of these to each other, and to that which is most diseased; as we see in the almost uniform close adhesions of the pleuræ in phthisis pulmonalis, and in the very frequent adhesions of the different viscera of the pelvis in scirrhus uteri. By the deposition of morbid matter in the coats of the vessels themselves, they are often much obstructed, and therefore ultimately receive a less supply of blood than in the healthy state, even while the diseased formations are still advancing. In the case of the melanosis, however, perhaps by reason of the peculiar change in the composition of the blood, this tendency to adhesion of the surrounding textures is much less observed.

There is yet another description of morbid growths, the origin of which may be conjectured to be peculiar, viz. the soft fungous excrescences (or vegetations) often seen adhering to the valves of the heart, particularly when these are otherwise diseased, and chiefly in subjects otherwise unhealthy. As these excrescences are often precisely of the same nature as the fibrinous concretions found in the same cavities, and as there is much reason to suppose, from the varying appearances of these concretions, and sometimes from distinct appearances of organization in them, that they must have been forming gradually for some time before death,—it appears highly probable that the fungous excrescences are formed from them.

SECTION II.

OF ALTERATIONS OF TEXTURES WITHOUT THE FORMATION OF NEW GROWTHS.

THE following is an enumeration of the most important of these changes.

1. Although we stated that preternatural softening, and preternatural hardening of textures, were often the direct and unequivocal effects of inflammation, acute or chronic, we must also admit that there are examples of both these alterations of the consistence of various textures, without any evidence of preceding inflammation, to be ascribed only to perversion of nutrition. The brain, spinal cord, the lungs, the liver, the spleen, the kidneys, the muscular substance of the heart and of the uterus, are found in some cases more or less partially softer than natural, in cases that have been perfectly chronic, without change of colour, without any inflammatory effusions around them, with derangement of the functions of the parts, but without any symptoms resembling inflammation before death. The mucous membrane of the stomach is often found remarkably softened, when there is much alteration of the secretions formed in it, and probably chiefly by the action of that secretion, but without clear evidence of any inflammatory action preceding these changes. The inner membrane of arteries is sometimes remarkably softened, and disposed to rupture, with very injurious effects on the circulation, but without any clear indication of the cause of the affection *.

The most general and unequivocal example of softening of textures independent of inflammation, is the great deficiency of earthy matter, and softening of the bones in Rickets; which is attended with a vascular state of the bones, but neither presents the symptoms, nor proceeds from the causes, nor is benefited by the remedies, of inflammation. Some cases of the Mollities Ossium of adults are

* See TURNER, in Edin. Med. Chir. Trans. vol. iii.

probably of the same character; but it would appear that other cases described under that name have really depended on soft tumors growing from the internal membrane, and causing absorption of much of the substance of the bones themselves.

Preternatural hardness, without preceding inflammation, and without morbid deposits, is probably a rarer case; but may occur in the different parts mentioned, perhaps most certainly and unequivocally in the brain.

2. Degeneration of various textures takes place occasionally by more gradual alteration of the elements composing them, without any morbid growth, or alteration of natural forms; as in the rare case of fatty degeneration of the heart, where its muscular fibres gradually assume nearly the appearance of fat; and in the common case of fatty alteration of the liver, where every section of it presents a surface besmeared with an oily matter. There are cases, chiefly in old persons, of conversion of great part of the arterial coats into cartilage and bone, without either inflammatory appearances, or change of the form or size of the tubes. There are many cases of organic alteration of the liver and kidneys, in which these organs become of a paler colour, and firmer and more uniform consistence than natural, but no distinct morbid growths can be observed, and which would seem to be effected merely by gradual change of the mode of nutrition of the natural texture. The voluntary muscles undergo an essential change of texture, as well as great diminution of bulk, under the influence of the poison of lead, in colica pictonum; and there are a few cases in which they are subjected to a complete transformation, into fatty, or nearly cartilaginous substance, independently of the growth of any morbid texture in the intermuscular cellular substance, to cause compression and absorption of their fibres.

3. It is important to understand distinctly the different conditions under which Hypertrophy, or simply increased bulk, of natural textures may be observed.

a. It has been already stated, that increase of the bulk of sound textures sometimes results simply from the gradual organization of the lymph thrown out on them by inflammation. This is seen, *e. g.* in the case of bones, and in that of mucous membranes, and of fibrous membranes or ligaments, after some inflammations of these textures. But in the greater number of cases, where permanent increase of bulk follows inflammation, it is attended with some change of texture.

b. The greater number of cases of hypertrophy of an organ which we meet with, are cases where its function is preternaturally excited, and the flow of blood to, and nourishment of, the organ (always very dependent on the state of the changes going on at the extremities of the capillaries), are thereby augmented. Thus it is, that all the voluntary muscles increase both in bulk and strength from frequent exercise, that the glandular substance of the mammæ swells during lactation, &c.; and just on the same principle, when one of the lungs, or one of the kidneys, is rendered unfit for its function, the blood makes its way in increased quantity, in the direction where the change it is destined to undergo in these organs can be effected, and the opposite lung or kidney gradually acquires a great increase of bulk, without change of texture.

So also, when there is a demand for increased action of the Heart, in consequence of the existence of any disease of the valves on its left side, or of the aorta, impeding the transmission of blood, it is gradually brought into a state of hypertrophy, or what has been called active aneurism, either of its whole substance or of the parietes of the cavity most exposed to the increased stimulus; and this most readily in a constitution otherwise healthy.

When, along with this increased action, and increased bulk of the heart, there is a full quantity of blood in the body, the cavities of the heart are usually found dilated at the same time that their parietes are thickened; but when the quantity of blood in the body is much diminished, the tonic contraction of the thickened fibres of the heart, which is no longer distended, occasions a diminution of the size of its cavities.

Again, when the Bladder is frequently and strongly excited to action, in consequence of stricture of the urethra, or enlarged prostate, or other obstacle to the discharge of the urine, or, without such obstacle, in consequence of an inflamed state of its mucous membrane, its muscular fibres undergo the very same change. In this case, probably by reason of the supply of fluids to the interior of the cavity being so much less than in the case of the heart, the tonic contraction of the enlarging muscular fibres, produces very generally a diminution of the size of the cavity.

The Stomach has been sometimes observed to increase enormously in size, and its muscular fibres to be unusually strong, when there has been some obstruction at the pylorus, without disease of the coats of the stomach, and when probably the reception of ingesta has not been naturally diminished. Again, when there has been chronic inflammation and ulceration of the mucous membrane of the stomach, and consequent excitement of its muscular fibres, it has been found much contracted. And in some cases, the muscular fibres of the intestines have been found in a state of hypertrophy, when there has been chronic impediment to the passage of their contents.

c. There are other cases where hypertrophy of some part of the sound textures is found as the only, or the original disease, and when no cause for that alteration of the nutrition is detected. In a few cases of hypertrophy of the heart, no adequate cause for the affection is perceived in the state of the valves or of the aorta. The brain has been sometimes found in a state of hypertrophy, of which the marks are, unusual dryness of all its surfaces, diminution of the usual interval between the convolutions, and close apposition of the sides of the ventricles, without inflammatory symptoms or appearances, or other indications of disease. The bones (*e. g.* of the head) are sometimes found generally thickened, or affected with partial exostosis, in cases where chronic disease, consequent on the compression of the contents of the cranium by the enlarged bone, is the only precursor of death. Partial thickening of the cellular membrane in various parts, and of the mucous membrane of the intestines, or of their mucous glands, are occasionally found when there have been no inflammatory symptoms, nor any symptoms that can be reasonably ascribed to this change. In the case of the cellular and adipose membrane, such partial hypertrophy of the sound texture is sometimes, though by no means uniformly, a prelude to the formation of morbid growths. The spleen has been often found in a state of hypertrophy, without deposition of any morbid matter into it, and with hardly any change of its consistence, especially perhaps in cases of suppression or retention of the menses. The thyroid gland is often affected with hypertrophy, and sometimes with other changes in the endemic bronchocele, and sometimes in situations where the disease does not prevail, and from causes which are unknown. In the same countries where bronchocele is endemic, cretinism is also frequent; and in that singular affection, there is distinct hypertrophy of the bones, and it has been stated likewise, of the nerves of the face, with deficiency of nourishment of the cranium and brain; and these affections seem to depend on peculiarities either of the air or water of the districts.

4. Atrophy of living textures (besides being in a few cases, as formerly stated, a result of inflammation) is often observed as a consequence of disuse of an organ,—affording another illustration of the dependence of nutrition on causes which act at the extremities of the circulation. Thus the optic nerve has been often found wasted, not only in cases of amaurosis, but in cases of blindness from disease of the coats or humours of the eye-ball. Muscles have been found so much wasted, in consequence of very long inaction, that the greater part of their substance could hardly be distinguished from cellular texture*; and whole limbs kept long at rest, as by disease of the joints, are apt either to waste, or to be so limited in their growth, as to appear shrunk and withered in comparison of the corresponding limbs.

Again, atrophy of any living texture is occasioned by compression, which is known, and may be easily enough

* ANDRAL, Precis, &c. t. i. p. 240.

conceived, to increase the absorption from it, if not absolutely, at least relatively to the amount of deposition. Hence the growth of any of the morbid textures above mentioned, as well as the effusion of any product of inflammation, is very apt to cause atrophy of the surrounding textures, or even of that in which they are themselves developed,—as we see in the case of tubercular deposits in the liver and kidneys already mentioned, in that of tumors growing from the skull or dura mater, or of serum effused within the ventricles compressing the substance of the brain, &c. In some such cases, if the pressure be rapid, inflammation and some of its consequences are produced at the same time.

There are, further, some cases of atrophy of individual organs which cannot be ascribed to any such cause. Whole limbs, during their growth, are sometimes affected in this way. Lameness in old persons from mere interstitial absorption of the neck of the thigh-bone, is another example. And, in some such cases, the absorption is partial and irregular, giving the appearance of ulceration or of caries, where there has been no decided previous inflammation.

5. There are alterations of the structure of organs, effected in the course of certain chronic diseases, apparently, at least in a great measure, by a process more strictly mechanical than any yet mentioned. Of this kind the most remarkable are,

a. The dilatation without hypertrophy, or passive aneurism of the heart, consequent on obstruction to the exit of blood from it, chiefly in a weakly habit of body, when the excitement of the heart, by the unusual amount of its stimulus is feeble,—sometimes apparently produced merely by morbid debility of its fibres, as after some cases of rheumatism affecting them.

b. The dilatation and rupture of the air-cells of the lungs, known by the name of Emphysema of the lungs, consequent in many instances on chronic bronchitis, but especially consequent on it in those spasmodic affections of the air-passages (asthma and bronchitis) where there are violent fits of coughing, implying frequent and forcible expiration, and compression of the texture of the lungs; and at the same time constriction of the passages by which the air is expelled. The characters of this change of structure are, unusual lightness and pale colour, and somewhat enlarged bulk of the pulmonary substance, the air-vesicles seen beneath the pleura larger and more distinct than usual, and sometimes bullæ containing air projecting from the surface of the lungs, and empty cavities in their interior, formed by the rupture of many air-cells, and the effusion of air into, and distention of, the common cellular substance of the lungs. The mode of formation of this organic lesion appears perfectly well illustrated by the occasional occurrence of spontaneous emphysema, even extending to the subcutaneous cellular texture of the body, in cases of violent cough with constriction at the larynx, and in cases of voluntary forcible suppression of cries, as during labour.

c. The great enlargement of the bronchial tubes, leading sometimes to almost complete absorption and obliteration of the proper pulmonary substance, which attends some cases of chronic bronchitis, with very copious secretion of mucus; although the conditions which determine this, rather than the last-mentioned change, are not understood.

d. The great distention of the ureter and pelvis of the kidney, and consequent absorption and obliteration of its proper glandular substance, consequent in many cases on obstruction of the ureter, whether from a calculous concretion, or disease of the bladder, uterus, or other adjoining parts.

e. The gradual unfolding of the convolutions of the brain in cases of chronic hydrocephalus, where there has been very great and gradually increasing distention of the ventricles by serous fluid;—for although the whole change, and particularly the absorption of the medullary substance that intervenes between the ventricles and bottom of the convolutions cannot be explained in this mechanical way, yet the change on the convolutions themselves appears to be simply mechanical.

f. The formation of the small encysted tumors called Meliceris on the surface of the body, by the obstruction of the ducts of the small sebaceous glands.

g. The formation of the encysted tumor called Ranula beneath the tongue, by obstruction of the ducts of the sublingual or submaxillary gland.

h. The partial expansion of certain of the fibres of bones, and formation of those tumors upon them called Spina Ventosa, in consequence of inflammation, and of the formation of morbid growths in their internal medullary membrane *.

There is yet another question, of the greatest importance, in regard to many of the organic changes of structure which we have enumerated, viz. whether after they have once taken place, the adventitious matter which has been deposited, or the alteration of natural size or form which has been effected, maybe reabsorbed, or restored to the natural state?

It may be confidently asserted, that the latter of these changes is much more easily effected than the former; the hypertrophy of the heart, *e. g.* may be ascertained sometimes to diminish so remarkably, when it proceeds from a cause (such as lymph effused on the pericardium) which is capable of diminution, that we may infer that it would wholly disappear, if the cause exciting it could be wholly removed. And from the changes of the symptoms, we are well assured that the emphysema of the lungs (*e. g.* after hooping-cough) may entirely subside, when the affection of the air-passages, in which it originates, has disappeared.

It is probable that adventitious textures, which have fairly acquired their distinctive characters, are hardly if at all liable to absorption; but we can scarcely ever judge with confidence during life, as to the time when they are so fully formed and characterized; and we have good reason to believe, that in their *incipient* stage, some of them at least are susceptible of absorption; from what we see in some instances of tumors on the surface of the body, and from what we can observe in some cases also of the effects of remedies and regimen on persons, in whom there are very strong grounds for believing that internal organic lesions of these kinds have commenced. It may be stated in ge-

* See CRAIGIE's General and Pathological Anatomy, p. 568.

neral, that we have the best illustrations of this remark, in the effect of the antiphlogistic regimen, of the habitual use of antiphlogistic remedies in a moderate extent, and of some of the remedies called Alteratives, in some of the cases where there is threatening of those organic diseases, which are in the first instance strictly local; and again, in the effect of various articles of regimen and remedies, of the class called Tonics, in some of the cases where there is reason to apprehend that tubercular deposits, or others of the class which we have described as constitutional, have already commenced.

SECTION III.

OF THE CAUSES OF THESE ORGANIC LESIONS.

Referring to what has been formerly said of the remote causes of disease in general, a brief statement will suffice here, of the conditions under which these different organic diseases appear to be formed.

1. It has already been stated, (p. 393, and 410) that both the lymph that has been thrown out by inflammation, and the blood that has been extravasated in hæmorrhage, may in certain constitutions be converted into various kinds of tumors; and therefore it may easily be understood, that almost all varieties of organic lesions should often have been observed to originate in external injuries, or other exciting causes of inflammation, or in the circumstances in which it has been stated that hæmorrhages are common.

In particular, it may be observed, that besides the scrofulous tubercles already considered, those very common organic diseases of the heart, the liver, and the kidneys, which consist essentially in minute granular deposits taking place, on the lining membrane of the heart and aorta, or in the coats of the latter, or in the substance of these glands, may very often be traced to the action of the causes of inflammation, (both predisponent and occasional); and especially to the repeated or habitual application of these; and may also be distinctly observed in many cases, to commence with febrile attacks, and with more or less of the usual symptoms of inflammation affecting these parts. And that this should be especially observed of organic diseases of this description is easily understood, when it is remembered, that the first organic change in such cases consists in the augmentation of the dense cellular texture of these parts, *i. e.* of a texture quite similar to that, which is the natural product of inflammatory exudation.

We can have no difficulty, therefore, in admitting inflammation, chiefly chronic, as a frequent origin of this particular class of organic diseases. This may also be concluded, as in the case of scrofulous tubercles, from our often finding on dissection the usual indications of inflammation combined with, and even *passing gradually into*, the organic lesions now in question. But it must at the same time be allowed, that many of the inflammatory appearances found after death in connexion with such organic lesions, are posterior to them in date; and it is further to be remarked, *first*, that acute and well marked inflammation very seldom affects a whole organ, or pair of organs, so generally as this form of organic disease does; *secondly*, that the operation of some other cause than inflammation must be admitted in all those cases, in which distinctly adventitious textures are ultimately developed; *thirdly*, that in some of the cases of organic disease commencing by these granular deposits, neither the application of the external causes of inflammation, nor the symptoms of the first stage of inflammation, can at any time be detected; and *lastly*, that in the cases where such adventitious textures are ultimately found, even if they appear to commence with inflammatory symptoms, and are treated early, the usual remedies for inflammation are found less effectual than in other cases; and in the more advanced stages, when the perversion of nutrition is fairly established, they are often totally inefficient, and contra-indicated by the other circumstances of the disease.

Experience shews, that it is on persons who have been weakened (especially if recently and rapidly weakened) by evacuations, by febrile disease, by impure air and an inactive mode of life, by defective nourishment, by mental depression, or above all, by the debilitating effect of strong liquors, especially distilled spirits, taken to excess,—that cold or other exciting causes of inflammation so take effect, as to excite the diseases in question; and when these predisposing causes have acted with full effect, a very slight application of the exciting causes (especially if repeated) is often effectual for this purpose, where a more powerful exciting cause would probably have determined an attack of acute inflammation. It would appear to be a general fact, that when the circumstances of the living body are such, that the living actions, and the healthy nutrition of the various textures contained in it, are slightly or inadequately excited by the natural stimuli, destined to act upon them, there is always a greater facility of the development of such organic disease, as depends on morbid growths or *perverted nutrition.*

We can frequently assign at least a probable cause for the *seat* of the organic lesion which the concurrence of such causes as have now been mentioned may occasion.

For example, the Heart is peculiarly apt to suffer from such disease in persons who have had its action frequently and strongly excited by general muscular exertion, by exertions of voice in particular,—perhaps also, by mental agitation. The Liver has been observed to be peculiarly disposed to suffer in four distinct cases, *first*, in the inhabitants of hot climates, where it is habitually subjected to a peculiar stimulus; *secondly*, in persons in whom there exists any impediment to the free motion of the venous blood within the chest, and consequent congestion of that blood in the liver; *thirdly*, in persons who have recently suffered, or are occasionally suffering from attacks of intermittent fever, with similarvenous congestion; and *fourthly*, in persons addicted to the use of distilled spirits, where, by reason of the great venous absorption from the primæ viæ, the liver may be supposed to be peculiarly exposed to the action of that stimulus. The case in which the Kidneys have perhaps been most frequently observed to suffer, is that where the exciting cause of the disease has been a copious draught of cold liquid taken when the body was heated, and where it may be supposed, that the effect of the impression produced by the cold was determined to the kidneys by the stimulus always given to their secretion by sudden dilution of the blood.

For the varying *kinds* of adventitious texture, which may be found in different individuals, under the influence apparently of the same external causes, we can in general, in the present state of our knowledge, assign no reason whatever. With the exception of the scrofulous tubercles, and of the medullary sarcoma, the different morbid structures that have been mentioned may be said to be affections of advanced rather than of early life. The true scirrhus and cancer are never seen in early life. This kind of organic disease is nearly confined to the most vascular and sensible parts of the body; and in the case of the uterus and mammæ, is most apt to take place in them about the time when the secretions formerly taking place there are finally suppressed. This and others of the rarer forms of organic diseases have in some instances appeared to be hereditary, but this is not nearly so well ascertained of any of these, as of the scrofulous tubercles.

All that we can state in regard to the rationale of these formations in the animal economy is as follows:

1. As we have seen reason to believe, that the varieties of the vital act of nutrition, in the different parts of the body in the healthy state, cannot be explained by variety in the form or contractile powers of vessels, but must be referred to a variety of those vital powers by which the chemical phenomena of the living body are determined,—so we cannot suppose that the deviations from the healthy state of nutrition now in question can ever be explained in any other way, than by referring them to changes in the *Vital Affinities* of the solids and fluids of the system. We have every reason to be-

lieve, that these changes, as well as the vital affinities in the natural state, are subjected to certain fixed laws. Of this we see probably an illustration in the similarity of the deposits which take place in very different parts of the body, in many of these organic diseases; and again, in the relation which the deposits resulting from simple inflammation in each texture, bear to the chemical nature of the texture itself. Another illustration of the subjection of such morbid changes to certain fixed laws, is the fact observed by LAENNEC and others, that when the lymph thrown out in pleurisy is deeply stained wth blood, the adventitious membrane that results becomes cartilaginous, or even bony *. But until the chemical part of Physiology be more advanced, it is in vain to look for the determination of laws in the chemical Pathology of diseases.

2. In the mean time, it is important to observe the circumstances above stated, in which the natural vital affinities existing in the healthy system appear most apt to undergo changes.

3. It is easy to understand, that the morbid deposits will take place from the blood most readily in those circumstances in which effusions of the fluid, or exudations of the more solid parts of the blood, may be effected in a body previously quite healthy; and therefore, that congestions of blood, and inflammatory action, should so frequently precede and evidently determine the appearance of these organic diseases. Chronic inflammation appears to have more effect in this way than acute, probably both because its duration is longer, and because the blood in the diseased parts is subjected to less pressure, and allowed to stagnate longer, than in acute inflammation.

4. In the case of those organic diseases which are strictly local, it is by no means clear, and often it is improbable, that any deviation from the natural state of the blood, throughout the body, exists; although the vital affinities by which the products formed from it at one spot are determined, have undergone a change. But in the case of those

* Traité de l'Auscultation, &c. t. ii. p. 121.

deposits which take place simultaneously, or in quick succession in many different textures and organs, we have good ground for believing that the blood itself has undergone a change, partly perhaps in its chemical, but more particularly in its vital properties.

5. It is probable, from the examples we occasionally see, of extensive deposits of morbid matter taking place very rapidly, in persons in whom there is no indication (from previous symptoms, or post-mortem appearances) that any such disease had formerly existed,—that the diseased state of the blood concerned in such productions may exist, where no morbid deposits from it have yet occurred. But we have also reason to think, that the blood is gradually deteriorated in consequence of the existence of any local disease, in which certain products are deposited from it; and the observation of morbid matter being found in the veins leading from such diseased parts, and the comparison of this with facts formerly stated as to suppuration *, enable us in a great measure to understand how this deterioration of the blood may be accomplished, and how diseases originally local may become constitutional;—a portion of blood which passes through the vessels of the diseased parts probably undergoes the same degeneration as that which is there extravasated, and the morbid matter thus formed, and circulating in the blood, is afterwards determined, either to that or any other part in which diseased action may be established; nearly in the same manner as Urea, circulating in the blood, is determined to the kidneys, or uric acid to parts affected with gout, where it is deposited in concretions.

But even while our information as to the intimate nature of the processes by which these organic lesions are formed, continues as limited as at present, it is obvious, that our knowledge of the causes from which they originate, of the symptoms by which they may be recognised, and of the dangers to which they may lead, may be extended and corrected, and applied to useful purposes;—sometimes to the preven-

* P. 438 and 9.

tion of such diseases, often to the detection of them in their earlier stages; that it may often enable us to remove causes by which they may be aggravated,—and to counteract those ulterior changes which frequently supervene upon them and increase their danger; and that by it we should regulate our practice in regard to them, even when it has become obvious that the only rational object of that practice is the relief of suffering.

SECTION IV.

OF THE SITUATIONS, SYMPTOMS, AND FATAL EFFECTS OF THESE ORGANIC LESIONS.

We here attempt a very general outline of the kinds of these organic lesions generally found, and the effects they generally produce, in the different organs, or sets of organs, employed in the principal functions of the body.

From what has been said of their frequently originating in, or being repeatedly aggravated by, inflammation, and from what has been formerly said of change of functions, and, among others, of secretions, in internal parts, forming great part of the symptoms of inflammation in these, it will readily be understood, that the symptoms of organic diseases in internal parts should in general very closely resemble, and often be hardly distinguishable from, those of the more chronic inflammations of the same parts, or of the altered secretions of these, already considered. Indeed it is often only by the continuance of the complaint, by the experienced inefficacy of ordinary remedies, and by the increasing weakness and emaciation attending it, that the existence of Organic Disease is made known.

It may be stated in general, that Pain is little to be depended on as a mark of organic disease. It may be felt strongly when there is no such disease, and be intense when such disease is slight, as when the fibres of a nerve are compressed or stretched; it may be absent when the disease is very dangerous; and although the most malignant organic diseases are often attended with acute pain, yet it is usually liable to great and long remissions. It is very often to be regarded, therefore, rather as an accidental concomitant, than as an essential constituent of such diseases. And in general, these diseases are to be recognised much more by alterations of sensible qualities, or derangement of functions, which may be detected by the senses of the practitioner, than by such uneasy sensations as are known only through the complaints of the patient.

I. In the Organs of Circulation, by far the most common kind of organic disease is that which affects chiefly the inner membrane of the heart and larger arteries. In both situations this membrane is very liable to become thickened and corrugated by deposits of lymph in irregular patches, or in the tubercular or granular form mentioned before, which, in the arteries, soon extend to, or even originate in, the middle coat also. That these deposits are frequently the result of inflammation (sometimes pretty acute, more frequently chronic) appears chiefly from three facts, *first*, That the symptoms of disease of the heart, which are ultimately ascertained to depend upon them, often commence suddenly, from the causes, and with the indications of inflammatory disease; *secondly*, That they are often intimately combined with such appearances on the inner membrane,—(thickening and softening, and exudation of layers of soft lymph, or small purulent deposits behind it),—as unequivocally denote inflammation; and *thirdly*, That these changes on the inner membrane of the heart, and aorta, as well as the effusion of lymph in the pericardium, appear, from the history of cases where they are found, frequently to result from the metastasis of Rheumatism.

But in some cases, where these appearances in the lining membrane of the heart and aorta are found, the disease is known to have commenced gradually, and without febrile or inflammatory symptoms; and in all cases the changes in this texture are very apt to continue and extend beyond

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the usual effects of inflammation; the inner surface of the vessel becomes irregularly studded over with patches of dense opaque matter, of the kinds described as atheroma, steatoma, cartilage and bone; the last of which is deposited irregularly, and in the arteries very often simultaneously with irregular ulceration. These changes extend to the fibrous coat of the arteries, their whole texture becomes thickened, rigid, and inelastic, and their calibre is in general irregularly enlarged.

From these changes in the different branches of arteries, various formidable diseases manifestly originate.

1. When the ulceration effected at any one part of an artery is such as to cause the entrance of blood into the cavity thus formed, and its stagnation there, the exterior membrane, which resists the ulceration, is gradually distended, and the Aneurism of SCARPA, or pulsating tumour on an artery, formed by blood which has penetrated the two inner coats, and distended the outer, is established. In other instances, it must be admitted, that aneurismal sacs or pouches are formed on arteries, of the mode of formation of which we have no such accurate knowledge. These aneurisms are found in very various parts of the body, chiefly, as may be readily supposed, at flexures of the arteries; and as they enlarge, they compress and cause absorption of all surrounding textures; their pulsations are in most parts perceptible to the touch, and sometimes, when within the thorax, and not to be reached by the finger, may be detected and distinguished from those of the heart by the stethoscope. Their other symptoms are very various, depending sometimes on the degree of obstruction to the circulation which they present,—sometimes on the disturbance of the functions of the parts in their neighbourhood,—often chiefly on the nerves which they stretch or compress, and in the sentient extremities of which they excite sympathetic pains. These effects of aneurisms are sometimes fatal without any rupture of the sac; but they are more frequently fatal by rupture and discharge of blood, either externally, or into some cavity of the body,—the interior of

the cranium, the larynx or trachea, the stomach or bowels, the cavity of the thorax, or abdomen, or pericardium.

2. From the rigid, inelastic, and brittle state of the smaller arteries of the brain, arises very often their easy rupture on occasion of sudden determination to the head, and either fatal apoplexy or palsy; or, even independently of rupture, such a deranged, probably retarded, state of the circulation in the brain, as may cause various diseases there.

3. From the same state of the arteries of the extremities, disqualifying them for their office in the propulsion of the blood, arises, in many cases, the tendency to gangrene there from slight inflammation.

It is to be observed here, that the peculiar thickened and softened condition already mentioned, as occasionally observed in the inner coat of arteries, leads sometimes to sudden rupture of the diseased coat, which then becomes coiled up, and obstructs the artery, stopping pulsation, and leading often rapidly to gangrene of the limb below.

4. The morbid changes in the lining membrane of the heart and arteries, are the most frequent cause of dilatation or hypertrophy, or the combination of the two, in more or fewer of the cavities of the heart. The rigid inelastic state of the aorta, when pretty general, is sufficient to effect somewhat of this change on the heart, even when all the valves are sound; but in by far the greater number of cases, when diseased aorta attends enlarged heart, it is the participation of the aortic valves in the diseased state of the inner coat of the artery, which chiefly determines the affection of the heart.

All the valves of the heart are liable to two forms of disease, from the morbid concretions forming on them, which disturb the functions, and lead to the enlargement of the heart itself,—viz. to that in which the orifice is narrowed and obstructed by the morbid matter, and that in which the valves are so shortened as to allow of reflux of the blood; these two states often exist separately, but in many cases also, the same valve is affected in both ways at once.

It may be observed, that the diseased state of the aorta, extending to its valves as above described, is hardly ever seen in children, and chiefly in advanced life;—but a morbid state of the valves of the heart only, and especially of the mitral and tricuspid, is not uncommon about or even before the age of puberty.

The general symptoms resulting from such impediments to the free flow of blood through the heart (which exist in a great majority of cases in the left side of it), are Dyspnœa and Palpitation, always produced by exertion, often excited also by mental emotion, and occasionally recurring without obvious cause; disturbed sleep, and particularly sudden starting from sleep, with palpitation; the countenance generally becomes pale; and, in some persons, fits of syncope, and in others fits of angina pectoris supervene. But the most unequivocal sign is such enlargement of the heart, as causes the apex to be felt to strike against the parietes of the chest, lower than the sixth rib, which is very often perceptible within a few weeks after the first indications of these organic diseases commence.

These are the general symptoms, which indicate that there is some difficulty in the transmission of blood through the heart, and consequent enlargement of the heart. This is most frequently dependent on some change of the kinds above described in its valves; but may also depend on lymph thrown out by inflammation on the pericardium, shackling and impeding the movements of the heart; or on an unusual narrowness of some of the openings, or shortness, without morbid structure, of some of the valves; or on a preternatural dilatation, without change of texture, in the ascending aorta; or, in a few cases, may exist without obvious cause.

While these general characters of organic disease at the heart exist, there are many varieties in particular symptoms, of less urgent importance, but which claim attention. The chief of these are the following:

1. In many cases, the pulse at the wrist is preternaturally strong, full and regular, or nearly so; and the pulsations of the carotid, and especially of the subclavian arteries, are felt

distinctly to be fuller and stronger than natural. In such cases, the aorta is very generally enlarged; and if there be, as is most common, disease of the valves, it is of the aortic valves, and of such a kind as to admit of reflux of the blood.

2. In others, the pulse at the wrist is small in comparison with that felt at the breast, often very irregular. There is no strong action in the carotid or subclavian arteries; and sometimes there are pulsations felt at the chest, which do not extend to the wrist. In such cases, the aorta is probably little affected; if there be disease of its valves, it is such disease as obstructs the exit of the blood from the ventricle: disease of the mitral valve may rather be presumed; and, if the last mentioned symptom be present, such a state of that valve is commonly found, as admits of a reflux of blood into the auricle.

3. In some cases, the *impulse* felt on laying the hand or the ear over the heart is very strong, while the sound of the heart's action is less than natural. In such, Hypertrophy of the muscular parietes of the ventricles (chiefly the left), is denoted, without dilatation, perhaps with diminution of the cavity.

4. In others, the impulse is weak, while the sound, and especially the first sound, corresponding to the ventricular contraction, is unusually loud and sharp. This usually denotes Dilatation without hypertrophy. When there is both the loud sound and the strong impulse, both dilatation and hypertrophy are denoted.

5 In some cases, the chief impulse and sound are perceived near the end of the sternum, and the jugular veins appear more turgid, and often pulsate more distinctly than usual. In such, obstruction on the right side of the heart is denoted.

6. In some cases, a preternatural sound, varying considerably in different cases, but generally approaching to the murmur of bellows (bruit de soufflet), is heard to accompany either the first and long, or the second, short sound of the heart's action; and this generally denotes that some rough or irregular obstacle exists, either at the orifice through which the blood, in its natural course, is passing

at the time, when that sound is produced, or in that through which it has an opportunity, in consequence of the disease, of regurgitating *. But no absolute reliance can be placed on this symptom, because it may undoubtedly be correctly imitated by the motion given to the blood by irregular contractions of the fibres of the heart, chiefly in cases of palpitation from affections of the nervous system, where no organic disease exists †.

7. In some cases, the sound on percussion in the situation of the heart, is remarkably dull; which, if taken along with other indications of organic disease, denotes either an effusion into the pericardium, or an unusual degree of enlargement and hypertrophy of the heart.

When such unequivocal indications of organic disease at the heart exist, the progress of different cases is still very various. The case of hypertrophy, without obvious cause, and that of enlargement or hypertrophy from the effects of inflammation of the pericardium, are probably the only cases in which material amendment of the state of the heart may be anticipated, and that chiefly from gradual and spontaneous changes. In some, all the symptoms may remain stationary for a length of time, but in others there is a rapid increase of those depending on the affection of the heart itself; and in all cases, sooner or later, it is to be expected that other complaints, consequent on the disordered state of the circulation, will supervene, and their indications combine themselves with the symptoms already mentioned. These consequences take place more rapidly and more surely in young and full-blooded subjects, than in persons already old and emaciated. It is to be observed that the affection of the heart seldom acts as their sole cause. It is a great and permanent predisposition to them; but, in the majority of cases, some of the exciting causes of disease, and especially of inflammatory disease, most generally cold, intemperance, or muscular exertion, and some inflammatory disease consequent on them, may be observed to act in producing these effects.

* See Hope, Treatise on the Diseases of the Heart, &c. p. 340 and 580.

† Ibid, p. 72, 76.

When these exciting causes are carefully avoided, the fatal effect of the affection of the heart may sometimes be averted for a long time; but the longer the organic disease has lasted, and the more it has disturbed the circulation, the less amount of exciting cause is necessary to produce these injurious effects.

The organic affections of the heart predispose to these consecutive diseases, partly, as is supposed, by the increased impetus of the blood in the arteries, which is given by the heart in the state of hypertrophy; but certainly chiefly by the obstruction to the flow of blood in the great veins, and in the lungs, which is produced in the ways above described, and which leads to the dilatation or hypertrophy of the heart.

Of these ulterior effects of such obstruction, the following are the most important.

1. Attacks of Bronchitis are easily excited, and are unusually obstinate in such cases; and hence cough, expectoration, and habitual dyspnœa, with the sonorous, sibilous, and mucous râles, more or less general over the chest, soon supervene in cases of this kind, and often attend them from the first. In certain constitutions also, occasional paroxysms of spasmodic Asthma (to be afterwards considered), take place in this, as in all other complaints attended with any permanent embarrassment of respiration. In many there are repeated attacks of true Peripneumony.

2. Attacks of Hæmoptysis, and, with or without hæmoptysis, of Apoplexy of the lungs *, are also common, particularly in cases where the chief obstruction is at the mitral valve, evidently because the auricle has much less power than the ventricle, to react against any obstruction, and maintain the average velocity of the circulation.

3. Partly in consequence of the increased impetus from the left ventricle, in the case of hypertrophy, and partly of the obstructed return by the veins of the head, in the frequent congestions of the lungs, there are frequently symptoms of Plethora Capitis, in connexion with organic disease

* See p. 391.

of the heart. In some persons there are repeated attacks of Epistaxis, and in others, or subsequently in the same, there are strokes of Apoplexy or Palsy, or fits of Epilepsy, even when there is no extension of disease of the arteries to the interior of the cranium, to facilitate their rupture.

4. The obstructed state of the circulation, in cases of diseased heart, and the frequent congestion of blood in the lungs, lead very generally to stagnation of blood in the Liver,—sometimes to occasional turgescence of the liver during paroxysms of dyspnœa, and much more frequently to enlargement, morbid induration, and deposition of one kind or another, both in the liver and spleen.

5. The same obstructed state of the circulation, especially if aided by the exciting causes above mentioned, leads generally, sooner or later, to the effusion of serum in some part of the capillary circulation, independently of inflammation there, *i. e.* to Dropsical Effusion ;—in the cells of the Lungs, in the sac of the Pleura or Pericardium, in the subcutaneous Cellular Substance, and, especially after the liver has become affected, in the cavity of the Abdomen,—the symptoms and effects of which effusions will be shortly considered afterwards.

From what has been stated, it will readily be understood in what manner these organic diseases of the heart, besides involving the risk of sudden death by Syncope, naturally lead to such changes as threaten death, frequently by Asphyxia, and occasionally by Coma ; and farther, by the general depressing influence of frequent uneasy sensations, and often by the more special influence of disease of the liver, so impair the actions of digestion and assimilation, as to weaken the whole system, and dispose it to suffer from the application, and to sink under the effects, even of slight exciting causes of disease. There are a few more obscure cases of Palpitation, and of fatal Syncope, dependent on disease of the muscular parietes of the heart only,—on their softened state,—on their fatty degeneration,—or on their rupture, which has been observed almost solely in the left ventricle, and after ulceration of the inner membrane.

II. In the organs of Respiration there are, in the first place, important organic changes of structure, consequent on simple inflammation.

From inflammation (generally chronic) of the Pleura, may arise not only effusion of pus into the side of the chest, rendering it dull on percussion, impeding its movements, and suppressing the natural murmur in it; but distention of the side, displacement of the heart, (causing its apex to strike to the right of the sternum, if the left side of the chest be diseased, and below the sixth rib, if the right be diseased); and total uselessness of that lung; often of long standing, before either death takes place, in consequence of hectic fever and dyspnœa,—or ulceration and escape of the pus, internally or externally, relieves the patient. In such cases the lung, even if not previously itself inflamed, becomes so condensed in texture by the superincumbent pressure, that if an opening or natural ulceration take place into the cavity of the chest, the evacuation or escape of the fluid is only partial; because the lung, unable to expand itself, cannot admit the air, nor fill that cavity. And if the case is to terminate favourably, the secretion of pus abating, and the lung remaining condensed, the natural consequence is, that the parietes of that side of the chest are contracted *, and from being larger, it becomes smaller than the sound side; and either continues so for life, or is gradually and imperfectly restored to its form, as the lung is gradually expanded,—a change which sometimes, but not very frequently, ensues.

Even when there is no fluid effusion left by pleurisy, the thickness and strength of the adhesions left between the pleuræ is sometimes such as to impede the free motion of the lung of that side, and make the sound on percussion permanently duller, the respiratory murmur fainter, and the side of the chest less moveable, and even somewhat smaller, than the other; and this especially if the pleurisy has been attended with effusion of blood, and the adhesive matter thrown out becomes cartilaginous †.

* See Physiology, p. 145. † See p. 573.

2. From partial inflammation of the substance of the Lungs results condensation of these portions, which, although it may in some persons be gradually removed by absorption, or by expectoration, certainly in others remains permanently, causing shortness of breath, absence of the natural respiratory murmur in the affected parts, and sometimes the resonance of the voice, called Bronchophony,—and if the diseased part be considerable, imperfect movement of the side of the chest, and more or less dulness on percussion of the part. In some instances this goes on to pulpy softening, and in a few to suppuration and ulceration, of the affected portion of lung.

3. Still more frequently, in consequence of long-continued and repeated Bronchitis, especially if it be attended with asthmatic paroxysms, the lungs pass more or less generally into the state of Emphysema, above described *, which implies permanent shortness of breath, and is recognized chiefly by remarkable resonance of the chest on percussion, coinciding with absence of the natural respiratory murmur, and generally the presence of catarrhal râles, at the part affected; often indeed over the whole chest.

In all these cases of habitual Dyspnœa consequent on the effects of simple inflammation within the chest, the true Hectic Fever is sometimes formed, especially in young and irritable subjects, and the general symptoms may be just those of phthisis from ulcerated lungs; and in the two last cases the expectoration is often purulent for a length of time. And in many cases, chiefly in older persons, lesions of these kinds within the chest become attended with the same consequences, in other parts of the body, as were described from the obstructions at the heart; especially the depositions in, and induration of, the liver, and the dropsical effusions.

The other frequent and fatal organic disease of the lungs is Phthisis, consequent on the deposition there of scrofulous Tubercles, and on the changes in these, which were formerly

* See p. 566.

described; and in regard to this the following are the leading facts to be kept in mind.

1. When the deposition is very general over both lungs, the disease may be fatal before any of the tubercles have suppurated, and even before many have coalesced. Such rapid and extensive depositions proceed from the usual causes of inflammation, acting on a scrofulous habit. In such cases, the general symptoms are those of pneumonia, of somewhat slower progress and longer duration than usual, the patient may not be emaciated at the time of death, and the respiratory murmur may be heard throughout the lungs, though mixed with the bronchial râles; insomuch that the stethoscope may fail to give any indications of phthisis *.

2. In other cases, likewise of more rapid progress than usual, the cellular substance of one or both lungs may be extensively infiltrated with the *diffuse* form of tubercular matter, especially if some distinct tubercles have already existed in them; and this may cause death by asphyxia, without suppuration, or with very partial suppuration of the tubercular matter. Here, likewise, the general symptoms are very nearly those of pneumonia, and the affected part is indicated as in pneumonia, sometimes by pain of side, more generally by the sound on percussion becoming somewhat dull, and by change of the respiratory murmur there, which becomes faint, or somewhat harsh and abrupt (bronchial), and sometimes disappears.

3. In by far the greater number of cases, tubercles are deposited first in the upper lobe of one or both lungs, enlarge, coalesce, suppurate and ulcerate, and form cavities the contents of which escape by expectoration, and in which, and in the bronchiæ leading to which, puriform matter is copiously secreted; and they are followed by successive depositions in the central and lower part of the lungs, which run the same course; but so slowly that the tubercles in the lowest part of the lungs are seldom advanced beyond their first stage at the time of death.

* LAENNEC, Traité de l'Auscultation, &c. t 1. p. 530.

In such cases the nature of the disease is often indicated, almost with certainty, before the patient is much emaciated, by the sound on percussion in the upper part of one or both sides of the chest becoming dull,—by the respiratory murmur there being altered and diminished, and often by resonance of the voice heard through the condensed lung at that part (bronchophony); and afterwards the excavation of the tubercular masses is denoted at one or more points of the upper part of the chest, by the resonance of the voice combined with the gurgling sound of air passing through a cavity, and raising bullæ in a fluid there, (gargouillement), and by such modifications of the voice, and of the other sounds heard at that part (cavernous râle, cavernous respiration and cough), as, when compared with the natural sounds, convey the impression of a hollow cavity there existing. True Pectoriloquism is then established.

Such changes occur chiefly, though not exclusively, in persons who may be judged, by the circumstances formerly mentioned, to be of scrofulous habit, and often in persons who have indications of other scrofulous diseases. They are attended by long continued cough, and excepting in a very few cases (where the excavation appears to be effected by ulcerative absorption only), by expectoration in the advanced stage of the disease, partly puriform, often at times bloody, and sometimes containing fragments of tubercular matter; they are attended by progressive emaciation and debility; and, in young and irritable constitutions especially, by hectic fever. In all cases they cause the breathing to be somewhat confined, and to be easily hurried by exertion; but as the whole quantity of blood is gradually diminished during their progress, and the blood gradually diverted from the most diseased parts of the lungs, they may go to a great extent, and ultimately disorganize two-thirds, or even three-fourths, of the lungs, without ever causing much suffering by dyspnœa.

4. The rapidity of progress of these changes is exceedingly various in different cases, and there are two ways in which tubercular deposits in the lungs, when to a small extent only, have been observed to pass into an inert condi-

tion, and cease to disturb the general health; viz. 1. By hardening into earthy concretions; and 2. By suppurating completely, and discharging themselves by the bronchiæ, and leaving only fistulous cavities in the parts they have occupied. The very generally fatal result of the disease is to be ascribed therefore simply to the circumstance of the very great tendency to successive depositions of the tubercles.

5. In the course of this disease, several circumstances frequently occur, which render the symptoms more complex, and often hasten the fatal event, especially the following.

a. Attacks of Hæmoptysis consequent on the erosion of bloodvessels by the ulceration.

b. Attacks of Pleurisy or of Empyema with pneumothorax *, consequent on the extension of the ulceration to the surface of the lung at a part not occupied, as the pleura at the most diseased parts usually is, by effused lymph forming firm adhesions.

c. Attacks of occasional or *intercurrent* Inflammations of the substance of the lungs, to which the tubercles may be considered as always affording a predisposition, but which are often excited by external causes, and the indications of which are very often found ultimately combined with those of the tubercular disease.

d. Attacks of Dropsy, more or less general;—which, however, seldom results from the tubercular disease of the lungs, unless already combined with inflammatory condensation.

When none of these complications take place, the fatal event often takes place rather by syncope than by asphyxia,—sometimes pretty suddenly, oftener in a way nearly as gradual as the death by mere inanition.

6. The debility in the later stages is increased not only by the hectic sweats, but by the affections of the abdominal viscera, which very generally take place, and which may be traced, partly to the obstructed state of the lungs and consequent congestion in the vena cava ascendens and vena portæ, and partly to the influence of the *tubercular diathesis*; viz. the enlargement and induration, sometimes the tuber-

* See p. 421.

cular state, and sometimes the fatty degeneration of the Liver (with which various dyspeptic symptoms are often connected); and the inflammation, and ulceration, with tubercular deposition in many cases, in the Mucous Membrane of the Bowels, and frequently also, the tubercular state of the Mesenteric Glands;—which are found when the colliquative diarrhœa has been urgent, but bear no fixed proportion to the other symptoms.

Besides the scrofulous tubercles, other adventitious textures,—the medullary sarcoma, the melanosis, and sometimes more isolated morbid growths, occasionally form in the lungs, and obstruct the breathing; and produce symptoms, and follow a course more or less similar to the common tubercles there.

Other parts within the chest are likewise frequently the seat of tubercular, encephaloid, or other morbid deposits. The bronchial glands are very generally affected, in like manner as the lungs, in phthisis, and occasionally even when the lungs are sound; and when these glands are much enlarged and altered by these diseases, hectic fever may be established in consequence of the diseased action going on in their substance; and the functions of the neighbouring parts, as of the lungs, the trachea, and bronchiæ or the œsophagus, may be variously affected,—or dropsy induced by their pressure on the great veins.

The Air-passages, especially their mucous membrane and the cellular texture immediately behind it, are also the occasional seat, either of morbid deposits, of different kinds that have been enumerated (most frequently of tubercles or medullary sarcoma), or else of ulceration, extending to the cartilages, without distinct previous deposition. This is most common in the cartilages of the larynx, and about the rima glottidis. From these result symptoms resembling those of chronic laryngitis, and sometimes death by asphyxia, or nearly by strangulation.

III. The most common organic disease of the Liver is the tubercular degeneration, sometimes appearing as the result of pretty distinct inflammation, sometimes gradually effected without inflammatory symptoms; beginning as simple increase, or hypertrophy, of the grey cellular texture, and passing ultimately into the state described as Cirrhosis, in which the whole organ is often shrunk, the glandular substance nearly absorbed away, its place occupied by irregular clusters of brownish-yellow tubercles, and the whole circulation in the liver, as injections demonstrate, very much lessened. But in different cases (by reason especially of the complex nature of most such), death takes place in very different stages of this progress; and many modifications of these changes are also observed. In scrofulous cases, the liver is sometimes infiltrated with tubercular matter, in its first stage, of nearly opaline lustre;—in some instances it is enlarged and much hardened, with little change of colour;—in others it undergoes the fatty degeneration, formerly mentioned, or is simply softened without other change of texture;—in some the tubercles become large and distinct in parts of the liver, while others are of natural structure; and there are three kinds of morbid growth, which may be easily distinguished from the more usual changes in the liver,—the effusion of clots of blood, which gradually change into various kinds of tumor *,—the medullary sarcoma (tuber circumscriptum of FARRE), which softens in the centre, and is generally attended by similar deposits in other parts,—and the cysts or sacs containing Hydatids.

The Bile in these different diseased states of the liver is often scanty, and either lighter or darker coloured than natural; but the alterations which it undergoes have not been carefully examined. In most of those cases, where a considerable portion of the substance of the liver remains sound, the bile is of natural appearance and quantity; and in some of those where its whole structure is diseased, the alterations of the secretion are less than might have been expected.

From what has been already said (p. 378 and 571.), it

* See p. 393.

will be understood, that such organic lesions of the liver are chiefly to be expected in persons somewhat advanced in life; and that the tendency to them is remarkably given by chronic diseases of the heart or lungs, by intermittent fever, and by the habitual use of distilled spirits, especially in circumstances otherwise favourable to the formation of organic disease.

The symptoms attending such organic lesions of the Liver, especially when they do not distinctly commence with marks of inflammation, are extremely various. The most certain is perceptible enlargement of the organ, with dull sound on percussion, as far down the abdomen as the diseased organ stretches; but this enlargement may be absent throughout a case of the worst kind, and may disappear in the later stages of cases where it was at first distinct. When it is absent, the difficulty of lying on the opposite side is not to be expected. Sharp pain in the hypochondrium or shoulder, seems to be an accidental, and not a very common, attendant of any kind of these deposits. Jaundice is only to be expected, if there be pressure on some of the gall-ducts; which is neither constant, nor, if present, necessarily permanent. A sallow though not jaundiced complexion is very often observed, but is by no means peculiar to organic disease of the liver. The alterations of the alvine evacuations are various, and, agreeably to what is stated above, are sometimes absent, even when great, although partial, alteration of the substance of the liver exists. And the dry cough, and confined breathing on the one hand, or the sympathetic affections commonly referred to the stomach, anorexia, sense of oppression, flatulence and acidity, nausea, vomiting, &c. on the other, though often obvious and distressing, are neither uniform nor characteristic. The existence of organic disease of the liver is therefore often a matter of probability, rather than of certain knowledge, and gathered from observation of two or more of the symptoms above noted, rather than inferred from any one pathognomonic symptom. The nature of the organic affection is of course still more obscure; but it may be stated, that in a constitution previously healthy, and when such a cause exists for liver disease, as organic obstruction in the chest, and especially if the symptoms have been originally inflammatory, we may generally expect the induration by small granular tubercles only; and that when the health has been otherwise long infirm, and perhaps especially when the stomach is much affected, the medullary sarcoma, or other constitutional morbid structure, may be suspected.

The greater number of such organic alterations of the liver must necessarily obstruct more or less the flowtof blood in the vena portæ, and hence they act very generally as a great predisponent cause, and sometimes as the only perceptible cause, of farther diseases of the abdomen, which frequently contribute to indicate their existence. These are,

1. The effusion of serum into the cavity of the abdomen, constituting Ascites.

2. The increased flow of the mucous secretion of the intestines (more common in the warm climates), constituting mucous Diarrhœa, but easily aggravated into the form of Dysene ry

3. Bloody discharges from the primæ viæ, *i. e.* Hæmatemesis, Melæna, or Hæmorrhois, or a combination of these.

The debility and emaciation consequent on those organic diseases of the liver, which are attended with the greatest sympathetic affection of the stomach, nausea and vomiting, sometimes go on to a fatal termination, without any of these ulterior consequences; but more generally either dropsy, and consequent dyspnœa, or mucous or bloody diarrhœa, has existed for some time before death. In all kinds of severe affection of the liver, it sometimes happens that a sudden attack of coma, not always explained by effusion in the cranium, takes place. It is uncertain whether this can be ascribed, as in the case of disease of the kidneys, to retention of matter destined to excretion.

It has been already explained, that the Spleen is affected with organic disease most generally at the same time, and in the same manner as the liver. In some instances it is the seat of morbid deposits, or of simple Hypertrophy (sometimes going to an enormous extent) when the liver is sound. Such affections of the spleen have been sometimes found, as the chief morbid appearance, when there has been much vomiting, and great and progressive emaciation and debility. Tumors of the spleen produce local symptoms chiefly by reason of their pressure on, and interference with the functions of, neighbouring parts; and they have been often observed, as may easily be understood from the vascular connections of the organ, to be attended with attacks of hæmatemesis, which have been followed by sudden reduction of the swelling.

The Pancreas has been often found affected with different organic diseases, perhaps chiefly in cases where other organs were at the same time similarly affected; but the symptoms have appeared at least as obscure, and the degree of affection of the function of digestion at least as variable, as when the liver has been organically diseased; and many of the symptoms, obvious in some cases, have evidently proceeded from compression of adjoining organs, as jaundice from obstructed gall-ducts, pulsation from compressed aorta, pain probably from stretched or injured nerves, &c.

IV. The Peritoneum is often affected with organic disease, dependent simply on previous inflammation. Adhesions of different portions of intestines to each other, or bands crossing and binding down different portions of the canal, are often left by acute inflammation; and from these, although the general health be good, there will result occasionally more or less derangement of the peristaltic movements,—griping pains, or fits of colic, from any accidental excitement of these movements; and attacks of inflammation, or even independently of much inflammation, such attacks of violent pain and tenderness, with vomiting, and depression of the heart's action, as may be fatal,—on occasion of strangulation, more or less complete, of a fold of intestine beneath any such preternatural adhesions.

It deserves particular notice, that such adhesions are very frequently found uniting the folds of the Ileum, or the Colon and Rectum, within the pelvis, to the ligamenta lata, and other appendages of the Uterus, when these parts have either been the seat of active inflammation, as frequently happens after delivery, or have become affected with organic disease, in which they compress and irritate, and excite the exudation of lymph on, the adjacent peritoneal surfaces.

From chronic Peritonitis, or from the deposition of granular lymph, with or without distinct inflammatory symptoms in the peritoneum, there results a thickened and irregular state of that membrane, sometimes partial, sometimes very general, often with intimate and close adhesions of intestines and omentum, sometimes with little or no adhesion. The state of hypertrophy of the muscular fibres, thus inclosed in an unyielding case, is sometimes a result of this state of the peritoneum. In such cases, the pains, and often likewise the fits of nausea and vomiting, are less urgent, but more constant than in those last mentioned; the bowels often very costive, and this sometimes alternates with diarrhœa, and is generally attended with flatulent distention; the patient wastes, and the hardened intestines may sometimes be felt as a tumour, and dropsical effusion generally takes place before the strength is finally exhausted.

The peritoneum is likewise the frequent seat, especially in young and manifestly scrofulous persons, of tubercular accretions, sometimes apparently originating, or repeatedly aggravated, by inflammatory attacks, at other times, without such precursory symptoms; and indicated generally by symptoms similar to those of the chronic lesion last mentioned, but with the addition that the adventitious texture here attains a much greater size, and the whole abdomen is often greatly distended with solid matter. In some such cases, the effusion is of the encephaloid rather than the truly tubercular matter, and the growth is then much more rapid. But as it is always gradual, the functions of the intestines, though more or less disordered, often continue to be performed after all parts of the canal have undergone much change of form and direction.

The Mucous Membrane of the alimentary canal, and glands connected with it, are often in a state of chronic thickening and of chronic ulceration, consequent on decided inflammation; but frequently also it is found, at different periods of life, affected with various forms of ulceration in cases that have been quite chronic, and where intractable diarrhœa has been the chief symptom; where no peculiar adventitious texture is found, and no distinct indications of inflammation have preceded the ulceration.

The adventitious textures, which are frequently deposited in the stomach and intestines, generally originate in the cellular texture uniting the coats to each other. These vary exceedingly, from simple thickening and induration of that texture, causing more or less of Stricture, to the formation in it of circumscribed tubercles, of Fibro-cartilaginous or Scirrhous tumours, or of Encephaloid or Melanotic masses. They generally lead, sooner or later, to ulceration of the mucous membrane immediately above them, and often to considerable distention of the alimentary canal above them, as compared with the part below them: they sometimes attain such size as to be felt through the integuments of the abdomen; when seated in the pharynx or rectum, they may be felt by the finger or bougie; when in the œsophagus, or at the cardia, they are known by the permanent impediment they occasion to the descent of food into the stomach, and frequent regurgitation of food; and when at the pylorus, by the pain and vomiting recurring regularly two or three hours after food is taken, and by nearly uniform obstinate costiveness. In these ways, some of the most frequent seats of these diseases admit of being ascertained almost with certainty.

When their existence is not thus ascertained, these organic diseases of the alimentary canal can hardly be distinguished from the effects of simple chronic inflammation of the mucous membrane. Their symptoms are of very various intensity, and often subject to remarkable remissions; but the most frequent and important are,—pain and anxiety; nausea and vomiting, increased by all ingesta, when their seat is in the stomach; painful and intractable, though seldom violent, diarrhœa when in the intestines; tenesmus, and frequently mucous and bloody stools, and alteration of the natural form of the feculent evacuations, when confined to the great intestines; obstinate costiveness, and tympanitic distention, with pain, vomiting, and sometimes ileus, when they attain such a size as nearly to close the passage; and progressive emaciation and debility in almost all cases.

They very often excite, or become complicated with, inflammation, acute or chronic, in the parts around them, even repeatedly before they are fatal; and in consequence of the adhesions thus formed, ulceration extending through all the coats of the stomach or bowels has often been found connected with organic diseases, but in which the contents had not escaped, and the usually fatal effects of perforation of these coats had been averted.

These are very generally diseases of advanced life; but one set of organs, necessarily connected with the functions of the bowels, the Mesenteric Glands, are very often organically diseased in children and young persons. The kind of affection is the deposition and growth of the common scrofulous tubercles in these glands—sometimes as a part of a more general deposition,—sometimes almost exclusively,—in some instances, with symptoms, and indications on dissection, of chronic inflammation preceding the formation of the tubercles—in others, without such indications—sometimes apparently depending on the previous formation of ulcers on the mucous membrane of the bowels at the parts corresponding to the affected glands,—sometimes when little or no disease of that kind accompanies it. The tubercles undergo changes almost exactly corresponding to those in the lungs, but few have, in general, passed into suppuration before death takes place. The local symptoms are generally obscure and equivocal; tympanitic distention and mucous diarrhœa are perhaps the most common; but the gradual emaciation, paleness, and weakness, in a scrofulous habit, in early youth, and without adequate apparent cause, are generally sufficient to excite strong suspicion of the disease. The medullary sarcoma also occasionally affects the mesenteric glands, producing similar symptoms, but a more rapid progress. In adults it is not uncommon to find cartilaginous or bony concretions (*i. e.* hardened tubercles), or encysted tumours in these glands, without any symptoms having been observed which can be confidently ascribed to these lesions.

When not fatal by reason of the inflammations that are complicated with them, these organic affections of the digestive organs generally go on until the patient is so much weakened and exhausted that his death takes place nearly in the same manner as that caused by fasting.

In some constitutions, and especially in the case of mans children, it is important to be aware, that chronic affections of the bowels, especially those connected with ulceration, even partial, of the mucous membrane, or with disease of the mesenteric glands, are very apt to give origin to affections of the brain and nervous system; sometimes to sudden and transient disorders there, such as headachs, or fits of convulsion, but frequently also to strictly inflammatory affections there, ending in serous effusion. This is often to be ascribed, in part, to organic disease already existing in the head, or at least to a peculiarity of constitution, generally the scrofulous habit, which predisposes to disease of the brain; and when such predisposition exists, any irritation producing febrile action may have this effect. But many practical observers have thought the diseases of the Primæ Viæ, now in question, peculiarly effectual in exciting such nervous disorders.

The different kinds of Worms, so often found in the alimentary canal, and the origin of which is still obscure, the small worms called Trichuris (usually found in the cœcum), and Ascaris vermicularis (usually found in the rectum);—the long round worm (Ascaris lumbricoides) which usually infests the small intestines; and the jointed tape-worm or Tænia, also found there, but more frequently in adults,—demand attention here, chiefly because of the effect of the irritation which they occasion, to excite symptoms of nervous disorders, and sometimes dangerous diseases of the Nervous System. The symptoms which they excite in the abdomen itself, cannot be distinguished with certainty from those which other irritations acting on the mucous membrane, or slight inflammation and ulceration, may occasion there; but from the action of the lumbrici in particular, epileptic fits, and more anomalous nervous affections have often evidently originated; and in some cases symptoms closely resembling those of hydrocephalus (*i. e.* inflammation in the brain) have been apparently excited in this way, and abated after the expulsion of the worms; while in others, the symptoms apparently originating in this way, have gone on to decided and fatal hydrocephalus.

V. The Kidneys are frequently the seat of organic lesions, some of which, as the serous cysts often found on their surface, or in their substance, or even cysts containing hydatids, seem to interfere very little with their function. But it has been lately ascertained by Dr Bright and others, that the most common organic lesion in these organs, already noticed, *i. e.*—the deposition of granular lymph, sometimes taking the form of tubercles, in their cortical or secreting portion, is always attended by two obvious changes on the urine,—a diminution of its specific gravity,—often to 1010 or less, from the natural standard of 1024, and an addition to it of albumen, which is made obvious by heating it; and these changes necessarily imply considerable diminution of the quantity of urea passing off in this way, even when, as is sometimes the case, the whole quantity of urine passed is somewhat above the average *.

The kidneys affected with such disease are often found somewhat enlarged; but in other cases, especially when the

* See Dr Christison's paper on Diseased Kidneys, in Edinburgh Medical and Surgical Journal, vol. xxxii.; and Dr Gregory's ditto, vol. xxxvi & xxxvii.

affection is of old standing, they are found remarkably shrunk in size, and the glandular texture almost absorbed away, in like manner as that of the liver is from similar disease. In some of these cases, when the urine is light and albuminous, there is much hardening of the substance of the kidneys; but in others, when morbid deposits are found, the kidneys are soft and flabby, and in some there is general infiltration of whitish matter altering the colour of the kidney, without any intermixture of granular or tubercular corpuscles with their natural texture.

The local symptoms of such cases are often obscure, although many of them begin with inflammatory symptoms and pain of loins, and most of them are early attended with dropsical effusions. In some cases, notwithstanding that the altered condition of the urine continues, the patient is restored to tolerable health; but very generally, when the urine is light and albuminous, the health is much, although variously impaired, partly, as we may suppose, by a sympathetic affection of their organs, but chiefly because of the retention within the system of matter destined to excretion. There is a peculiar liability to inflammatory attacks of various parts, vomiting and diarrhœa frequently recur in some such patients, and different affections of the brain in others. Dropsical effusion in different parts often recurs, and in some cases goes to a very great extent; and in some there is ultimately serous effusion in the head, and death in the way of coma; and this perhaps especially when the urine has ultimately become very scanty, as well as of light specific gravity; in which case, it has been already stated that the urea has been found in the blood, and the disease therefore is almost identical with the Ischuria Renalis.

Various other morbid growths or alterations of texture have been seen in the kidneys, but their effects are less known; and some of them (*e. g.* the medullary sarcoma, sometimes found in the kidney, and connected with repeated hæmaturia) are often only a part of a more general disease; and the simultaneous affection of other parts may have been more concerned in the fatal event.

The ureters are sometimes permanently obstructed by morbid deposits (*e. g.* tubercular matter) in their own texture; sometimes by calculi descending from the kidneys, and impacted in them; but more frequently by tumors of some of the neighbouring viscera compressing them; and the effect of their obstruction and distention, in causing absorption of the kidneys, was already noticed. When both ureters are affected in this way, to such a degree as to cause wasting of the glandular substance of the kidneys, the symptoms of ischuria renalis must naturally be expected.

The Bladder of Urine, like the heart, undergoes changes of its structure much more frequently in consequence of disease of its lining membrane, or of the passage leading out of it, than from morbid deposits in its own substance.

The inflammation of its mucous membrane (*e. g.* tha which results from injuries of the spinal cord) leads to thickening of its muscular fibres, and contraction of its cavity, which of course implies frequent irritation, and evacuation of the bladder; and the same results follow from whatever permanently irritates its inner surface, or opposes the exit of the urine; therefore from morbid growths which sometimes originate in its mucous membrane, from calculi lodged in it, from enlargement of the prostate, or stricture of the urethra,—causes of difficult excretion of urine which require to be carefully distinguished by manual examination, but of the diagnostics of which it is not necessary to treat here.

The disease of the prostate gland, which is common in advanced life, consists sometimes of mere enlargement, but often of a gradual change of its substance, similar to that which takes place in the cellular substance connecting the coats of the stomach and bowels, until it has assumed the appearance of a scirrhous tumor. The strictures of the urethra very generally result simply from lymph effused by inflammation immediately behind the mucous membrane; but in some cases this lymph is gradually altered, and becomes ultimately cartilaginous.

In some instances different kinds of morbid growths take place between the coats of the bladder, which impede its action, and lead likewise to thickening and contraction of the fibres not involved in the disease.

These organic affections of the urinary organs cause much and frequently recurring pain, and other uneasy sensations; and thereby become attended with much sympathetic affection of the functions of other parts, often especially of the stomach, and with more or less of the febrile state;—often also with inflammation and its consequences in the parts immediately adjoining those most altered by disease; and they appear to be fatal by reason of the debility and emaciation thus produced, much more than by reason of the absorption of the urine, the evacuation of which is thus impeded.

VI. The Organs of Generation in both sexes are very liable to organic disease, as may be expected from their full supply of blood, and from their habitual excitement by changes in the nervous system. Of this, the frequency of disease of the prostate is one example; and the testes are liable likewise to various morbid changes, particularly to depositions in their substance of the nature of vascular sarcoma, of tubercles, or of medullary sarcoma; and in advanced life to the true scirrhus;—all these affections, in this as in other parts, often beginning from injury or inflammation, sometimes gradually taking place without obvious cause. These last changes, when they are the effects of constitutional disorder, or when they have lasted so long as to affect the constitution at large, are often attended, not only with much pain, but with fever, taking somewhat the form of hectic, great debility, and emaciation; and ultimately may cause death by exhaustion.

The uterus is still more liable to organic changes than any of the male organs of generation, the nature of which may often be ascertained by examination, or known almost with certainty by the state of the symptoms during life. These may be reduced to the following heads.

1. Within the cavity of the uterus, various morbid formations may take place on its mucous membrane, by some of which it may be distended, and even its cervix expanded, as by the development of the fœtus. The simplest in its mode of formation, appears to be the tumor occasionally seen there, which consists of layers of partially decolorized crassamentum of blood, like the contents of an aneurism, formed by a morbid alteration of the menstrual excretion, and apparently, from the increase of uneasy feelings at stated intervals, receiving an increase of bulk at the menstrual periods. The next in point of simplicity are the polypi, often growing within the uterus, and projecting into the vagina; which seem in some cases to originate likewise in coagula of effused blood, and which are usually attended with frequent and profuse hæmorrhage. Again, in some cases a mass of hydatids, and in others a single sac containing a serous or bloody fluid, has been found to occupy the cavity of the uterus, and the contents of such sac have been repeatedly discharged by the vagina. And in unhealthy constitutions masses of the encephaloid matter have also formed here, perhaps in some instances by transformation of effused blood.

2. In some instances the muscular substance of the uterus has been found preternaturally hard, and in others preternaturally soft, without decided previous inflammation; and in many cases ulceration, beginning on the mucous membrane at the os tincæ, gradually pervades the organ, causing purulent and fetid discharge, with very little of inflammatory symptoms, and with no deposition of adventitious textures preceding it.

3. Different adventitious textures are often deposited in the substance, or even originally just beneath the peritoneal coat of the uterus. Of these the most common are the Fibro-cartilaginous tumors, which although often closely resembling the true scirrhus in structure, yet, when growing quite distinct from the natural textures, may be found in considerable numbers, attain a great size, last long perfectly inert, and cause no symptoms, excepting what

may result from their pressure on the adjoining parts;—the medullary sarcoma, and the true scirrhus, both of which are more intimately intermixed with the muscular texture, and sometimes with each other in the same subject. These are first deposited at the os tincæ and cervix uteri, causing enlargement, irregularity, and generally hardness of these parts; and go on to ulceration, beginning at the os tincæ, causing much fetid discharge, and infallibly spreading through the substance of the organ; frequently spreading likewise through the coats of the rectum or bladder, so as to establish unnatural communications; and sometimes through the peritoneal covering of the uterus, so as to allow the escape of the morbid secretion into the cavity of the abdomen, and excite rapidly fatal peritoneal inflammation.

These last diseases sometimes appear to commence with inflammatory symptoms, or at least with increased determination of blood to the uterus, denoted by uterine hæmorrhage after the period of the cessation of the menses, before any puriform discharge begins; but such symptoms are not always observed, and even when they are, it may often be suspected, that an unperceived perversion of the nourishment of the part had preceded their appearance; they are attended generally with severe pain, referred to the back and lower limbs, as well as to the pelvis; but liable to great and long continued remissions; and with rapid sinking of strength, frequently febrile symptoms, and ultimately extreme emaciation.

In regard to all organic diseases of the uterus, it is to be remembered, *first*, that they are very generally attended with various sympathetic sensations, and with sympathetic derangement of the functions of other parts, particularly the stomach; and *secondly*, that many of the symptoms that are very urgent in such cases may depend on the pressure of the diseased and enlarged uterus on the neighbouring parts, and on the chronic inflammation excited, and unnatural adhesions frequently, though not uniformly, formed among these; especially, as was already stated, when the morbid growth is of a malignant kind (p. 560). Thus dysuria from such affection of the bladder, dysenteric symptoms from such affection of the rectum, in some instances disease of the kidneys from distention of the ureter, and in many colic pains, constipation, vomiting, &c. from adhesions of the folds of ileum in the pelvis, combine themselves with those of the diseased uterus. In some instances, symptoms also arise from the enlargement and degeneration of lymphatic glands within the pelvis, consequent on such diseases of the uterus, *e. g.* anasarca of one or both of the lower extremities from pressure on the iliac veins.

In some instances, the Fallopian tubes are distended by serous cysts; or these tubes, and the broad ligaments of the uterus, are beset with different kinds of morbid growths, which may have effects on the adjacent viscera, similar to those just now described.

The most common disease of the Ovaria is the formation of encysted tumors (generally several in one ovary) which appear sometimes to commence as serous cysts, unconnected with the sound texture of the organ, but frequently are formed by the distention of the Graafian vesicles, and which often attain an enormous size. The contents of these are very various even in the same ovary; serous, gelatinous, atheromatous, or purulent; and in other instances, blood, more or less altered from the sound state, encephaloid matter, or melanosis. In other cases sarcomatous, fatty, or fibro-cartilaginous tumors form in and project from the ovaries; and in some, these different morbid growths are found combined. Many of these may subsist long, and cause no symptoms but what depend on their situation and size, and pressure on adjoining parts; but when the encephaloid or melanotic matter is deposited, the general health is always much impaired, and in the former case especially, there are often repeated attacks of inflammatory symptoms, followed by increase of the tumors.

VI. Almost every known variety of organic disease has been repeatedly observed to affect the contents of the Cranium, and almost all have appeared in some cases to originate in an inflammatory attack (*e. g.* from an injury) and in others have seemed merely results of perversion of nutrition, without any such precursor. The bones of the cranium are sometimes found of unusual thickness, and appear to have compressed the contents; exostoses from the inner table, and sometimes tumors, even passing inwards through the bone, from the pericranium, have been found to compress and irritate parts of the brain. The dura mater has been found partially thickened, ossified, or beset with tubercles or other kinds of tumor. Attached to the pia mater on the surface, or to the membrane continuous with it in the ventricles, or detached from any of the membranes in the substance of the brain, we often find scrofulous tubercles, especially in younger subjects, of very various number, and in various stages of progress, sometimes the medullary sarcoma, or other morbid growths of the kinds which affect the general habit; sometimes more isolated tumors, and these either encysted and containing serum (as is frequently seen in the choroid plexus), or blood; or of the class described as sarcomatous, and answering to the description of ceroma, or chondroma, or fibro-cartilaginous, or even bony. We have also examples of injurious effects on the brain, evidently resulting merely from a diseased state of the vessels, enlargement or aneurisms of the arteries, or partial obstructions either of these or of the sinuses from diseases of their lining membrane, without rupture.

Again, besides the hardening and softening of the substance of the brain, which were described as effects of inflammation, either more acute or more chronic, we meet with some examples of both those changes of consistence in portions of the brain, without change of colour, or any clear evidence of inflammation; and in other cases, with the hypertrophy, formerly described, of the whole cerebral substance, or more partial atrophy of the nervous matter. Along with almost all these organic lesions within the cranium, serous effusion into the ventricles is often found, and sometimes also suppuration, or other marks of recent inflammation.

Now, all that can be said with confidence as to the symptoms attending and denoting this great variety of organic lesions within the cranium, may be briefly expressed thus:

1. A great variety of these have certainly existed, and probably for a length of time, in some cases, without causing any such derangement of the functions of the brain, as attracted any attention;—certainly without causing so decided derangement of these functions as has often been observed in cases where, on dissection, no morbid alteration of structure could be detected.

2. In a much greater number of cases these organic lesions, as well as those which result directly from inflammation within the head (*i. e.* effusion of serum and of lymph, abscesses, yellow or red softening of the cerebral substance), have been found connected with derangement of some department of the functions of the Brain,—of Sensation, of Thought, or Voluntary motion; but the seat of the lesion has no ascertained connexion with the function deranged farther than this, that any paralytic symptom is generally in the opposite side from the affected part of the brain, and that a lesion near to the origin of a nerve may be expected to affect the function of that rather than of a distant nerve*.

3. The symptoms found in connexion with these organic lesions of the brain are sometimes quite chronic, and nearly unchanged for a great length of time, *e. g.* constant dull pain of head, or of part of the head, constant vertigo, intractable nausea and vomiting and consequent emaciation, amaurosis, deafness, loss of sensation or of voluntary power, or both, over one side of the body, or in a single limb, continually recurring spasms of particular muscles, loss of memory, general or partial, *e. g.* loss of the meaning of words, or that of substantive nouns), insanity general or partial (*i. e.* characterized by erroneous belief or delusions, either

* Cases have occurred to myself sufficient to shew, that no reliance can be placed on the supposed connexion of disease of the anterior lobes with palsy of the tongue, or with loss of the memory of words, of the corpus striatum with palsy of the lower, or of the thalamus with palsy of the upper, extremity.

on almost all subjects, or on certain subjects only); or even partial or total imbecility or fatuity.

4. In many of these cases, such organic lesions have been found in connexion with violent symptoms recurring only occasionally, and leaving intervals, either of perfect health, or of some of the less violent and more permanent affections of the nervous system; *e. g.* they have often been found connected with fits of epilepsy, *i. e.* of convulsion with insensibility, or with fits of transient insensibility without spasms, or with fits of mania, or melancholia, or with fits of violent headach, or vertigo, or other uneasy sensations affecting the head, with which nausea and vomiting are often combined.

5. In other cases, these organic lesions are found after an attack of fatal coma, preceded by more or less of febrile and inflammatory symptoms, which had either supervened on some of the more chronic diseases above mentioned, or occurred without previous ground for suspicion of cerebral disease; and in many, there is a combination or succession of several of the sets of symptoms, acute or chronic, in the same person.

In order to form some conception how so great variety should exist in the symptoms connected with these organic lesions of the brain, it is necessary to recollect the following principles.

1. Nervous matter may be totally unfit for its functions in the living body, although possessing quite its usual structure and appearance, and duly supplied with arterial blood; as we learn from some cases of amaurosis, or of palsy, unconnected with any perceptible alteration of the nerves or brain; and again, nervous matter may undergo considerable change of form and appearance, if slowly and gradually effected, and nevertheless continue to perform its functions; as we learn particularly from some observations on diseases of the spinal cord. From these facts it evidently follows, that parts of the brain apparently somewhat diseased may still be susceptible of the changes which attend the exercise of sensation or thought, and again, that

portions of nervous matter may be disqualified for their functions by such organic diseases, although situated at some distance (and in a direction which we have no means of ascertaining) from those which are the most obviously diseased. And in fact, it was already stated, that it is only by deranging the functions of nervous fibres at some distance from itself, that any lesion of parts superior to the medulla oblongata can cause either palsy or convulsion *.

2. Any such organic disease must necessarily confine and disturb the circulation within the head, and therefore will necessarily act as a predisponent cause of those diseased states which may be excited, either by sudden determination of blood to the head, or by sudden diminution of the flow of blood thither;—which causes are certainly often concerned in producing the more temporary diseases above mentioned as connected with these organic affections in the brain.

3. Such organic affections must also evidently act as a great predisposing cause of inflammatory action within the cranium, which may be generally supposed to have occurred, not only when decidedly inflammatory effusions are found, but whenever there is reason to believe that a rapid serous effusion has taken place, especially if preceded by violent pain and febrile symptoms.

It will readily be understood, that it is chiefly by the great predisposition given to these more acute diseases, that the organic lesions of the brain produce fatal coma; although in some cases, the more chronic and uniform symptoms which they excite pass insensibly into coma without inflammatory symptoms, and without any effusions that can be ascribed to inflammation appearing on dissection.

The contents of the canal of the vertebræ, and the nerves, are liable to organic lesions corresponding to those described in the contents of the cranium, and with similar effects, often well marked, but likewise variable, in the functions of

* See Physiology, p. 132.

the spinal cord and nerves. When the spinal cord is extensively and seriously injured by disease, the action of the organs of circulation is gradually enfeebled *, and death may ensue apparently from this cause, independently of the accession of coma. Tumours growing within the sheaths of nerves, and separating their fibres, cause intense pain (liable, however, to remarkable remissions), although of no malignant nature.

VII. The muscles of voluntary motion are but little liable to organic changes of structure, excepting to such as they undergo in consequence of disease of neighbouring parts, common with other textures, and where their affection forms no essential part of the danger to be apprehended. But other organs of locomotion, especially the Bones, and the different textures about the Joints, are liable to a great variety of morbid changes, several of them certainly dependent on inflammation in the first instance, but which go on for a length of time after all the effects of mere inflammation are at an end, and admit of no benefit during the greater part of their progress, from the remedies for inflammation. These are sometimes only attendants of other morbid actions in the body (as in many scrofulous cases), which are more immediately dangerous than themselves; but in many cases also, they are dangerous in themselves, either by reason of the constitutional disorder (taking more or less the form of Hectic Fever) which they excite, or by reason of the injury which the alteration affected in the bones necessarily inflicts on the parts adjoining to, or contained within them. Of these organic changes the following are the most important.

1. There is a great and general perversion (as has been already stated), of the nutrition and growth of bones in Rickets,—a state occurring chiefly in scrofulous habits, and produced by the same causes as determine the formation of the scrofulous diathesis; in which the bones are not only deficient in earthy matter, but do not acquire their usual structure; their cellular texture is less compact than na-

* See p. 329.

tural; the contents of the cells gelatinous instead of being medullary; and the medullary canals are not formed in the interior of the long bones, while the extremities of these bones acquire an unnatural size. Such irregular depositions of phosphate of lime sometimes happen *, as shew that the quantity contained in the system is not deficient, and that the fault lies in the vital powers and affinities, by which the nourishment of this texture is appropriated. And accordingly, the disease is often checked, not by the addition of earthy matter to the ingesta, but by a general tonic mode of life. The altered form of the bones in this disease, and particularly the depression of the sides of the chest, compress the viscera, and give necessarily a great predisposition both to inflammation and to organic diseases there, even independently of any simultaneous scrofulous disease; and the change thus effected on the bones of the pelvis often renders parturition difficult or impossible.

2. Besides the simple increase of osseous substance consequent on inflammation, and besides the simple Caries or ulceration, the Exfoliation consequent on the death of the external layers of bone, from inflammation, or from destruction of the periosteum, and the Necrosis consequent on the death of the internal layers from similar changes in the medullary membrane,—there are many more varied local alterations of the nutrition of bones and joints, which may be traced, for the most part, to diseased action in the lining membranes, external or internal, of the bones, or in the synovial membrane of the joints. These are seen chiefly either in cases where there are indications of scrofulous disease, or in syphilitic cases; very often where there are clear indications both of previous syphilis and previous scrofula; and in scrofulous habits, they are certainly often aggravated by the use of mercury, perhaps chiefly by its indirect agency in predisposing to aggravations of scrofulous disease, after its own influence on the system is over. The most important of these are,

1. The different kinds of Exostoses, or hard tumours growing on bone, some simply bony, some cartilaginous,

* See Wilson on the Bones and Joints, p. 164.

some containing bony matter irregularly diffused through them (osteo-sarcoma), and of these some containing an albuminous matter in their interstices, and others the matter of fungus hæmatodes ; some likewise covered by periosteum, and smooth on their surface, while others are denuded by ulceration of the periosteum, and rough on their surface, from irregular attendant absorption or caries.

2. The great enlargement and expansion of the cells of the bones, chiefly of the short bones or extremities of the long ones, which appear to be produced by various morbid growths on the medullary membrane in their interior, distending them, and causing irregular absorption of their substance, generally causing likewise severe pain, as in the Spina Ventosa, or what has been called the Medullary Exostosis; and even, in the opinion of some, in the Mollities Ossium of adults, where the disease appears to consist (at least in the parts most affected), in the substitution of a morbid secretion from the medullary membrane, or of a morbid mass formed from effused blood there, for the bone which is absorbed, rather than in mere alteration of the composition of the bone.

3. The Ulceration and Caries beginning in the cartilages, and extending into the bones of the joints, with or without deposition of tubercular matter into their cancelli, which are most common in the hip-joint, and cause much pain and constitutional disturbance before there is much alteration of the form of the joint.

4. The altered condition of the synovial membrane of joints, causing much swelling and alteration of their form, which seems to be the fundamental change in most cases that are called White Swelling of the Knee; which gradually becomes complicated with disease of the other textures of the joints, but is attended at first with little pain, and which was formerly noticed as equally characteristic of scrofulous disease as the scrofulous tubercles themselves *.

* Both these last changes may supervene on simple inflammation of the synovial membrane of the joints, but often take place independently of any such acute disease in their commencement; and even chronic inflam-

5. The softening and Caries, generally attended with tubercular deposition, in the bodies of one or more of the vertebræ (affecting, and sometimes beginning in, the intervertebral substances), which cause pain, tenderness, and protrusion of their spinous processes, and have the name of Morbus Dorsalis.

The following general facts demand attention in regard to these local diseases of the bones and joints.

1. They become very generally attended, during their progress, with inflammation and suppuration in the neighbouring soft parts, by which their symptoms are rendered more complex, and their danger often increased; and these are not to be ascribed to mechanical pressure from enlarging parts, but are sympathetic effects, similar to the inflammation often excited in the gum or in the cheek, in toothache, by a diseased action originally seated in the pulp of the tooth; and probably depending on irritation of the nerves of the diseased parts affecting other sentient extremities of the same nerves.

2. The portions of bones destroyed by caries, in such diseases, cannot be regenerated in their natural form; but, in cases where the constitution suffers less than usual, and which end favourably, fresh bony matter is thrown out, in an irregular form, as the morbid secretions disappear; which takes the place of the different textures that have been destroyed, and often constitutes the union by Anchylosis, either of the articulating ends of bones or of the bodies of vertebræ.

3. All these processes necessarily impede, or even wholly prevent, the exercise of the functions of the parts affected in locomotion, and several of them, especially such as originate in the interior of bones, are attended with severe pain; and with such constitutional disturbance as may produce death in like manner as internal suppuration and ulceration do. In several of these likewise, symptoms are

mation of the synovial membrane does not necessarily lead to any such changes, its effects being often confined to fluid effusion into the joint, and thickening of the capsular ligament, and consequent stiffness.

often produced, which depend on the compression or irritation of parts of the nervous system; *e. g.* the pain of the knee from disease of the hip-joint, the pain stretching round the abdomen from disease of the vertebræ; but especially the palsy of the lower limbs and lower part of the trunk, and consequent retention of urine, apparently from loss of sensation, and afterwards incontinence of urine from inflammation of the mucous membrane of the bladder, and irritation of its muscular coats *, and frequently also, the gangrene of the nates from pressure,—in cases of extensive caries of the vertebræ. These effects are to be ascribed, not to the mere incurvation of the spinal cord, by the change of form of the canal, but probably in every case to actual injury of the cord, either by the disease extending to its membranous coverings, or by the pressure of displaced or detached bone.

VIII. In more external parts of the body, there are various well known diseases depending on organic changes, which it appears sufficient merely to enumerate.

1. The cornea acquires an increased size, and becomes almost perfectly opaque in the Staphyloma of children, often consequent on, but certainly not a simple effect of ophthalmia; and the crystalline lens of the eye is gradually converted into an opaque mass, sometimes of more, and at other times of less consistence, constituting the different forms of Cataract which obscure or extinguish vision in many persons advanced in life.

2. At various periods of life Polypi form on the mucous membrane of the nostrils, which are somewhat various in texture, seldom become attended either with hæmorrhage or ulceration; but often cause much uneasiness, and impair both the sense of smell, and the passage of air.

3. There are various diseases of the skin (of the class termed Tubercular by Willan) which consists in increased and perverted nutrition of the texture, of which the most striking example is the Elephantiasis, endemic from un-

* See Physiology, p. 113 and 115.

known causes in some countries, and existing occasionally, and as a more local disease in others: attended with, and always aggravated by, repeated attacks of erysipelatous inflammation, but not necessarily originating in such inflammation, and differing widely from its usual products.

4. The subcutaneous cellular membrane, and the portions of the same texture which penetrate among the muscles and external glands, and extend to the bones, are a frequent seat of encysted or sarcomatous tumors of all varieties.

5. The subcutaneous lymphatic glands are very frequently in scrofulous persons, and in cold and moist climates, the seat of tubercles, sometimes apparently originating in inflammation, but often growing slowly without pain, exciting inflammation around them when they have attained a considerable size, and then passing into partial suppuration and slow ulceration. These are sometimes so general over the body as to be attended with hective fever; but much more generally they are dangerous only as indications of the diathesis, from which scrofulous affections of more important organs are to be apprehended.

6. Various parts situated externally, the lips, the tongue, the lymphatic glands, but above all the mammæ, are liable in persons advanced in life, to the formation of tumors, with or without known cause; which either have from the first, or gradually acquire, the character of true Scirrhus, extending to the adjoining parts, causing paroxysms of severe pain, becoming attended with much weakness and emaciation, and passing ultimately into intractable and exhausting ulceration.

CHAPTER XI.

OF DISEASED STATES OF THE EXHALATIONS.

We here treat of Dropsical Effusions, and of certain other cases of disease, where increased and somewhat altered Exhalation into the shut cavities, or cellular membrane (without any of the effusions characteristic of inflammation), is the most essential part of the morbid change, and often the immediate cause of death, by Coma or Asphyxia. These are most generally, however, consecutive on other diseased states, often parts of very complex diseases; and after what has been said of inflammation, and of congestions of blood, as causes of serous effusions, and likewise of obstructions to the free movement of blood, especially in the veins, as a great predisposing cause both of inflammation and congestion, we need not dwell at any length on the pathology of Dropsy.

We mentioned formerly two cases in which serous effusion, consequent on mere inflammatory action, without any obstruction to the return of the venous blood, may be fatal, viz. the common case of rapid effusion of serum into the ventricles of the brain; and the rare case of pneumonia, affecting both lungs at once, and fatal by serous effusion into the cells of the lungs, before any but that first effect of inflammation has taken place.

In the case of Hydrocephalus, and probably in the case of acute Œdema of the lungs also, organic disease of the organ affected very often exists; and, by confining and disturbing the circulation, is no doubt concerned in producing the effusion; but it is not such organic disease as necessarily obstructs the flow of the blood in the veins.

That the cause of the œdema of the lungs in a case of this last kind, is inflammation of the lungs, we infer from the symptoms, local and general, being those of pneumonia, rapidly fatal, and from the appearances (redness, with copious serous effusion), being just the same as we see in ordinary cases of pneumonia, in the portions of lung immediately adjoining that which is most severely inflamed.

That the serous effusion into the ventricles of the brain, in the acute Hydrocephalus, common in children, especially f scrofulous, is to be ascribed to an increased determination of blood, approaching, if not amounting, to inflammatory action, we infer chiefly from these facts,

1. That the combination and succession of symptoms, in cases of that kind, fever, acute pain of head, nausea and vomiting, impatience of light and sound, followed by slow or irregular, and then very quick pulse, by delirium, convulsions, dilated pupil, squint, and double vision, and fatal coma (although admitting, as the symptoms of all diseases do, of some modification in different individual cases), are the same as are met with in many cases where, either from injury or other causes, unequivocal inflammation of the brain or its membranes takes place, and its effects are seen on dissection.

2. That, in cases of this decided inflammation of the brain, besides inflammatory effusions, softening of the brain, &c. serous effusion into the ventricles is almost invariably found; while, on the other hand, in cases usually called Hydrocephalus, where the chief appearance is the serous effusion, strictly inflammatory appearances, to a small extent, very often exist.

3. That when the symptoms of the first stage of hydrocephalus are treated by the active antiphlogistic remedies, particularly by general bloodletting and full purging, the blood often shews the buffy coat, and the progress of the disease is often successfully arrested.

Again there are many cases of fatal Coma in adults, some very rapid, and others slow in their progress,—some preceded by no premonitory symptoms, others by all possible varieties of alteration in sensation, thought, and voluntary power,—where nothing but serous effusion is found, but where no decided febrile or inflammatory symptoms have pre_ ceded the fatal coma, and which have the name of Serous Apoplexy; in such cases likewise, the precise resemblance of the symptoms to those in which hæmorrhage is ascertained to have taken place, and the experience of the juvantia and lædentia, entitle us to say that the effusion is generally to be ascribed to increased determination and congestion of blood, although no obstacle to the return of the venous blood may exist *.

The Hydrocele, or dropsy of the tunica vaginalis testis, is another case, often referable, in the first instance, to an inflammatory action, as when it is excited by a blow, and although naturally favoured by the position of the part, not distinctly referable to obstruction of the venous circulation.

In other cases, dropsical effusions are apt to go on to a greater extent than in these, and perhaps in all others some impediment exists, if not to the flow of blood in the veins, at least to its free movement in some part of the system, which retards the capillary circulation in some considerable surface, and favours the escape of more than usual of the serous part of the blood.

In general, in dropsical cases, the vital actions in the vessels which yield the effusion have not undergone any change in *kind*, as they necessarily have in cases of inflammation; but the natural action of Exhalation from these vessels predominates over that of Absorption; generally on account of some impediment to the return of venous blood from them, situated at some distance from themselves, but causing congestion and retarded flow in them, and facilitating transudation from them.

There are some cases, even of general dropsy, where no such impediment to the circulation can be detected, but such cases are in general slight and easily removed, unless they occur towards the close of a long continued disease,

* It is worth notice, that although, in the natural state, the serum within the ventricles, and that beneath the arachnoid, communicate by the opening at the extremity of the fourth ventricle; yet, when the ventricles are considerably distended, this opening appears to be closed by the apposition of its sides, and the surface of the brain is generally drier than natural.

which is dangerous in itself. The truly important distinction among dropsies is according to the nature and seat of the local disease, obstructing or impeding the circulation, with which they are connected; but it is of course necessary likewise to ascertain, as far as possible, in every case, what cavities are occupied by the effusion.

Anasarcous or œdematous swellings, dependent on effusion into the subcutaneous cellular membrane, are easily known by their soft feel, without discoloration, and by pitting on pressure; and the Ascites, or effusion into the cavity of the abdomen, by the sense of fluctuation felt with our hand when the abdomen is gently struck by the other, particularly if this is most distinct in whatever part of the abdomen is lowest in the position of the patient.

The effusion into the cavity of the Chest is not so easily discriminated, especially as it is very often only a part of the cause of the dyspnœa, and other general symptoms, which are present; and when it occupies both sides of the chest, it may be a cause of considerable dyspnœa, without going to such an extent in either as to be distinctly ascertained by examination. But in many cases, the dull sound on percussion, and obscured, or even suppressed respiratory murmur, in whatever part of the chest is lowest at the time of examination, and the disappearance of these symptoms in that part, when it is made highest, sufficiently denote the disease.

The dropsy of the Pericardium, when unattended with any strictly inflammatory effusion, seldom exists without dropsy in other parts of the chest, and other disease within the chest; its diagnosis is uncertain, but when considerable it causes a dull sound on percussion; makes the heart's action feeble and irregular, with variable and perhaps undulating impulse; and the recumbent and especially the supine position insupportable.

In many cases dropsical effusion, though without inflammatory symptoms, takes place into the cells of the Lungs, more than into any other part within the chest. In such the sound on percussion is hardly sensibly altered; but the respiratory murmur at the part that lies lowest is obscured, and sometimes the râle crepitant or sous-crepitant may be perceived; but as this case is generally complicated, at least with bronchitis, causing the sonorous and mucous râle, the diagnosis is generally difficult.

The increase of dyspnœa on lying down, although often a striking, is neither a uniform nor characteristic, symptom of any serous effusion within the chest; and the starting from sleep is certainly not an effect of this effusion, depending generally, when it is observed, on concomitant disease of the heart. But the presence of anasarca, and of scanty urine, especially if these can be ascertained to have been contemporaneous with the attack of dyspnœa, always give great reason to suspect that effusion exists; there being few cases of any considerable dropsy either of the thorax or abdomen without these symptoms.

The internal parts, with disease of which dropsy is most naturally connected, with the symptoms of which, therefore, its indications are most frequently combined, are, the Heart, the Lungs, the Liver, and the Kidneys. The effect of such organic diseases as have been described, or of inflammatory effusions, at the heart, at the lungs, or at the liver, in retarding the flow of blood in the great veins, either the venæ cavæ, or the vena portæ, requires no illustration. When the kidneys are diseased, although no great veins be affected, the natural outlet of part of the serum of the blood is more or less obstructed. The chronic diseases already mentioned, of the peritoneum and of the mesenteric glands, are likewise frequently attended with dropsy, probably by reason of pressure on some of the mesenteric veins. And in a large proportion, especially of the worst cases, dropsical effusion is connected with simultaneous disease of two or more of the parts above mentioned. The following appear the most important principles to be kept in mind, regarding its connection with the diseases of these parts.

1. It is not a uniform, and therefore not a necessary consequence, of any disease that we can specify in any one of these parts; and the chronic diseases of them, on which

it so frequently supervenes, may be regarded simply as great and permanent *predisponent* causes of it. When that predisposition (dependent on a more or less obstructed state of the circulation) exists from chronic disease of one of these parts, an acute disease, although slight, of another of these, or even a general disturbance of the circulation, is often the exciting cause of the first accession, or of the subsequent returns of dropsical effusion; and the greater the amount of the permanent predisposition, and the more frequently the dropsical effusion has recurred, the less action of any exciting cause is necessary to reproduce it. There are, however, cases of peculiar tendency to dropsical effusion, the cause of which is quite obscure.

2. Inflammation of the heart, of the lungs, or of the kidneys, appears in some cases to excite dropsical effusion, when no other disease of internal organs exists. This we conclude from the dropsy, whether general, or partial, supervening almost immediately on the usual symptoms of inflammation of these parts;—or, in the case of the kidneys, from its being attended with the albuminous urine, of low specific gravity, and taking place suddenly, generally from exposure to cold, and with febrile symptoms; which combination of circumstances, although there be little or no local pain, may be held to be a sure mark of such an inflammatory action at the kidneys, as tends to the disease of their secreting texture formerly described (p. 555). Such cases have the name of Acute or Inflammatory Dropsy. But in most cases of dropsy supervening so rapidly on inflammation of any one of these organs, it will probably appear, on careful examination, that another of them is at least slightly inflamed also; *e. g.* that some degree of pneumonia or bronchitis attends either the acute dropsy with coagulable urine, or that which is apparently owing merely to inflammation at the heart. The acute dropsy after scarlatina is generally attended with coagulable urine, and may therefore be supposed to depend on subacute inflammation of the kidneys, coinciding with the obstructed state of the excretion at the skin. But in severe cases of this kind, in-

flammation within the thorax is very generally present likewise.

3. When the permanent predisposition, resulting from organic disease of any one of these organs, exists, it is important to be aware of the nature of the fresh attacks of disease, from which attacks of dropsy are most to be apprehended.

a. Most of the attacks, in this description of patients, which take place *suddenly*, especially if attacks of general dropsy, appear to depend on an inflammation, often of no great intensity, in the lungs or bronchiæ, (which will necessarily be attended with some acceleration of the pulse, and at the same time with some impediment to the flow of blood through the lungs); supervening either on disease in the left side of the heart,—or on permanent organic disease (*e. g.* partial condensation from previous inflammation) of the lungs themselves, or on an obstructed state of the liver or kidneys.

b. There are other cases in which pretty acute, but more partial, dropsy supervenes on these chronic and organic diseases, and where its immediate cause appears to be a subacute inflammation of the membrane where the effusion takes place, generally the pleura or peritoneum; and in some such cases, on dissection, a few flakes of adhesive lymph are found mixed with the serous effusion; the affection of the serous membrane evidently commences as inflammation, but an unusual amount and duration of serous effusion, consequent on that inflammation, is determined by the existing organic disease which retards the venous circulation.

c. When dropsy supervenes more slowly on organic disease of the heart, it may often be ascribed, in part, to the accession of chronic bronchitis, to which it was formerly stated, that any obstruction on the left side of the heart gives a great predisposition. In this case, the effusion into the cells of the lungs is perhaps fully as common as that into the cavity of the chest.

d. When dropsy, especially if ascites, slowly supervenes on chronic disease of the lungs (*e. g.* on old asthma and emphysema), the reason generally is, that the liver has become hardened and obstructed *.

Here it should be observed, that as hydrothorax, or general dropsy, from disease within the chest, is more frequently, in part, dependent on a temporary remediable cause (*e. g.* bronchitis) than ascites from disease of liver, so it is more frequently seen to abate under remedies.

e. Dropsy with diseased kidney is probably more variable than that dependent on any other cause—often abating entirely, without any improvement of other symptoms. And there is this peculiarity attending it, that the bulk of the urine passed in the day is sometimes fully as great as natural; and in some instances is raised by medicines considerably above what is natural, for some time together, without diminution of the dropsy; whereas in other cases of dropsy, a full flow of urine, though often a temporary, is a certain cause of absorption of the effused fluid.

4. As a certain degree of retardation of the motion of the blood seems essential to dropsical effusion, it is easy to understand, that while on the one hand it is favoured by such a degree of fulness of blood, as increases the effect of any mechanical impediment to the circulation (and is more apt to supervene, therefore, on a given amount of obstruction at the heart in a young and strong, than in an old and feeble subject),—it must also, on the other hand, be favoured by such a state of weakness as hinders the blood in the capillaries from receiving their due impulse from the action of the heart; and therefore should often gradually supervene in the later stages of diseases where any organic obstruction exists, although absent in the earlier stages; and should in some such cases be apparently promoted by evacuations of blood. The effusion into the cells of the lungs, in particular, is apt to occur, in a greater or less degree, in circumstances of extreme debility, from whatever cause that may arise.

Dropsical effusion is always injurious to the vital power of the capillaries in its immediate neighbourhood, the cir-

* See p. 571.

culation in which must necessarily be impeded by the pressure of the effused fluid; as is distinctly shewn by the coldness of dropsical limbs, and still more by their peculiar tendency to gangrene when inflamed. In this way such effusion in the abdomen must necessarily impede the functions going on there, and so co-operate towards the fatal event of cases where it occurs. In the thorax it is frequently the cause, or great part of the cause, of death by Asphyxia. And it is also to be observed, that when much dropsy, especially within the chest, exists, even independently of disease of the heart, sudden death is not uncommon. Lastly, in the course of dropsical diseases, effusion not unfrequently takes place in the ventricles of the brain, and causes fatal Coma; and this sometimes unexpectedly, without increase of the other dropsical effusions.

There are many cases of partial dropsy, as, *e. g.* of the lower limbs, evidently explained by compression, or some mode of obstruction, of the larger veins leading from the part, as by enlarged lymphatic glands. The most remarkable case of the kind is the phlegmasia dolens, or great swelling of the leg and thigh, painful, but without discoloration, occasionally seen in women after delivery, and which has been ascertained by Dr Davis, Dr Lee, and others, to proceed in some cases, and may probably proceed in all, from inflammation in the uterine veins, extending to the iliac veins, and causing effusion of coagulable lymph, by which they are plugged. But in this case the serum effused into the cellular texture of the limb is somewhat albuminous, or nearly of gelatinous consistence, so that the swelling has a degree of elasticity. A somewhat similar condition of the effused fluid is seen in some cases of anasarcous effusion from more common causes.

The effusion of firm matter into the cellular membrane of new-born infants, which is occasionally seen, and even prevails epidemically at times, and has the name of Skin-bound, has been likewise described as a kind of œdema; but appears to be rather a variety of erysipelatous or diffuse inflammation of the cellular membrane.

There are some cases of hæmorrhage on serous membranes, or in cellular texture, which appear to be rather perversion of the natural exhalation there, than the effect either of rupture of vessels or of inflammation ; but in most cases where such hæmorrhage without rupture takes place, it is attended either with some of the symptoms, and with some of the ordinary effusions, of inflammation,—or else with the indications of a general morbid state of the blood, to be presently mentioned.

CHAPTER XII.

OF DISEASED STATES OF THE BLOOD.

It has been already stated, that in those Inflammations which were described as *specific*,—in those Febrile diseases which arise from peculiar poisons, and especially in those which are *contagious*,—and in those Organic diseases which are *constitutional*,—a diseased state of the blood, as to its vital, if not as to its physical or chemical qualities, pretty certainly exists ; and is essential to the production of these diseases, although not constituting their most obvious and distinctive character. In the present state of our knowledge, these states of the blood are hardly known to us otherwise than as the cause, or part of the cause, of the effects in question. In the different contagious febrile diseases the blood coagulates less firmly than usual; in Rheumatism it contracts more strongly, shews a stronger buffy coat, and apparently throws out more fibrine on an inflamed surface (such as the pericardium) than in other cases; in gout the exudations from inflamed vessels contain uric acid ; and in scrofula they often take the form of tubercles. In some of the constitutional organic diseases, such as the Fungus Hæmatodes, as well as in extensive suppurations, the morbid matter has been often found in the veins of the parts chiefly affected, and even in the heart. In cases of Amenorrhœa, and Chlorosis, and in a few cases, where no cause for the symptoms is known, the very pale, sallow, greenish, or yellowish complexion evidently shews, that the blood has undergone a change of composition. But these facts are not sufficient to give us any precise information, either as to the cause or the exact nature, or extent of influence, of the change effected in the blood in these diseases. Besides these, there are a few cases, in which a diseased state of the blood not only evidently exists, but is more obviously concerned in producing the essential symptoms.

I. There are cases in which, from original malformation, of which there are many varieties *, the arterial and venous blood are mixed in various proportions at the heart; so that part of the blood, which is conveyed by the aorta, has not been at the lungs since its last circulation through the body. From this arises a bluish or livid colour of the skin and lips, varying in intensity in different cases,—easily increased by any exertion, and so distinct as to have procured for the affection the name of Morbus cœruleus or Cyanosis,—palpitation and dyspnœa, and even fits of insensibility, on attempting such exertions as hurry the movement of the blood,—coldness, or at least very easy chilling of the surface,—and generally imperfect nutrition, at least as to the breadth or thickness of the bones, muscles, &c. Death sometimes occurs suddenly, in fits of syncope or of convulsion; and the predisposition to various other diseases, as may be judged from what has been repeatedly stated, is so great, and the strength of vascular action so much impaired, that such persons hardly ever attain middle life.

It is remarkable, that in such cases, when the solids of the body have never felt the agency of perfect arterial blood, they can perform their functions, and the sensations and powers of the mind are entire, at a time when, judging from the colour of the surface of the body, we may presume that the blood is as impure as in the last stage of those diseases which are fatal by asphyxia.

* See Hope on Diseases of the Heart, p. 465.

II. The most striking example of a disease clearly referable to a morbid state of the blood, is the Scorbutus or Sea-scurvy, where, in consequence of the long-continued use of salted animal food, the blood becomes preternaturally fluid, ecchymoses, or purple or livid spots (petechiæ and vibices), form on the surface of the body, undergo the same changes of colour as effused blood there, and often pass into ulceration; the gums become swelled and spongy, hæmorrhages often take place from them, and occasionally from other parts; great debility and emaciation ensue, and, in particular, such activity of absorption, that ulcers recently healed generally break out, and even the callus uniting broken extremities of bones has, in some instances, disappeared; these symptoms either go on to death by inanition, or else they combine themselves with, and greatly augment the danger of, any other disease that may be contracted at the time; but they all speedily disappear when fresh vegetables are taken, and have been thought to yield particularly to the use of the vegetable acids.

It is important to observe here, that, while the main cause of these symptoms is certainly the use of salted provisions (which is much more effectual in producing them than the use of merely innutritious articles of diet), all observers agree that other causes, which cannot alter the ingesta, nor exert any other but a *vital* agency on the composition of the blood, particularly Cold, and Mental depression or inactivity, contribute powerfully to the production of the disease.

It is also important to observe, that, in this case, where the composition of the blood is undoubtedly in fault, as well as in others already considered, where morbid alterations of the blood are only presumed to exist, although the cause is general to the whole body, great part of the symptoms (hæmorrhages or ecchymoses and ulcerations), are strictly *local*, and take place particularly in the skin and in the mucous membranes.

III. Precisely similar symptoms are seen, in a few cases, at all periods of life, in persons who have not lived on salted food, sometimes in persons previously quite healthy, often repeatedly recurring in the same individuals, and from causes altogether unknown. To these cases, the names of Hæmorrhœa Petechialis, and of Purpura Hæmorrhagica have been given, of which the first expresses best what is known of the disease; for the tendency to effusion of blood is by no means confined to the skin or subcutaneous cellular membrane, but has been observed to take place, sometimes so suddenly and copiously as to be fatal, in various internal parts; on mucous membranes, on serous membranes, even within the pericardium, and in the brain.

Such cases of sudden and copious hæmorrhage are sometimes attended with febrile symptoms; and in many cases of this disease, it is certain that symptoms of internal inflammation have accompanied the appearance of petechiæ, and that the remedies for inflammation have been evidently beneficial. But the reason probably is, that many of the cases of purpura are in fact complications of different inflammatory diseases with the peculiar state of the blood, which leads to these symptoms; and which may perhaps have existed previously, and not shewn itself until inflammation and febrile action were excited; in like manner as petechiæ shew themselves occasionally even in the early stages of contagious fever and of smallpox; but generally in constitutions previously weakly, and in which the blood may be supposed to have previously undergone a certain degree at least of morbid change. In many cases of this disease, blood taken from the arm has appeared preternaturally fluid; but it must be observed, that in some, at least of the more complex cases, the blood has coagulated firmly, and shewn the buffy coat, within a very short time after some of these passive hæmorrhages have taken place.

IV. Another case of disease, which may be confidently ascribed to a morbid state of the blood, is the disease of the extremities, characterized by spasms of the limbs, and by inflammation going on rapidly to gangrene, and that of the kind called Dry Gangrene, (in which the fluids appear to be somehow diverted from the diseased parts), which has been frequently observed to be endemic in certain districts; and has been ascertained, by many observations, and by experiments on animals, to be the effect of the use of rye, infested with the parasitical plant called Ergot. That the blood must be much altered in this disease is sufficiently obvious; but the particular character of the alteration effected has not been ascertained.

It is highly probable that the blood must undergo some change in various other cases, where local diseases are gradually excited by ingesta taken for a long time together; such as the emaciation and tremors produced in some persons by mercury; and especially the Colica Pictonum, *i. e.* obstinate constipation, with frequent vomiting and severe pain of abdomen, ultimately often attended with wasting and palsy of various voluntary muscles,—which is produced in many persons by lead, habitually introduced in small quantities for a long time, in whatever way, into the system. The inquiries of ANDRAL have established the fact, that no change of texture in the stomach or bowels necessarily or even frequently attends this disease; but the nutrition of the muscles in the paralytic cases, is both much diminished and changed by the action of the lead. Still, however, it may be doubted whether the lead affects the sensations and functions of one part, and the nutrition of another, by first changing the blood, or whether it is merely carried by the blood to these different organs, and there acts on them, after a time, as a poison.

As the chemical department of Physiology and Pathology advances, and especially as the laws peculiar to Vital Affinities are developed, we may hope that important discoveries will be made in regard to the essential nature of the changes that take place in the living body, in the diseases which have been mentioned in this chapter.

CHAPTER XIII.

OF DISEASED STATES OF THE NERVOUS SYSTEM.

The share which the Nervous System appears to have in producing or altering disease in other parts of the living body, has been repeatedly under consideration. We are here to treat of the pathology of those cases only, in which the functions of Sensation, Thought, and Voluntary Motion are themselves altered or perverted.

Of these cases, the greater number, and in a practical view the most important, have likewise been already considered; viz. those cases, in which the affection of the Nervous System, although often an obvious, or even the most important part of the symptoms, is manifestly consequent on other changes, by which the diseased state is more essentially characterized. We have stated in what manner the functions of the Nervous System are frequently affected by mechanical injury, by heat, cold, electricity, &c. by poisons, and by the influence of imperfectly arterialized blood in asphyxia; again, how they are often altered, either by sudden diminution, or sudden increase of the flow of blood to the brain; by hæmorrhagic effusion there; by inflammation and its consequences; by the different forms of idiopathic and eruptive fevers, and by the kind of inflammatory action which frequently accompanies these; how they are affected sympathetically, in cases of disordered secretions, especially of the primæ viæ; and more uniformly in cases of suppression of excretions, especially of that at the kidneys; and how they are variously altered in cases of organic disease affecting the brain itself, or its envelopes, or by serous effusion within the cranium. And we have found that in all these cases the affection of the Nervous System may proceed to absolute Coma, and to death from that cause.

Now, there are cases, some of them frequent and important, in which changes in the functions of Sense, Thought, and Voluntary Motion,—similar to those which have been enumerated as proceeding from these different causes,—take place independently of the application of any of these; or where these have been applied in a degree so very much less than that which is often unattended with any such effect, that the action of some additional cause is clearly manifested. These necessarily imply corresponding changes in the Nervous System, which is the physical agent concerned in all these functions; but as all changes, healthy and morbid, which take place in the nervous matter, corresponding to mental acts, are known to us only by their effects, it is impossible for us to do more, in regard to the morbid changes thus *originating* in the Nervous System, than state the symptoms by which they are made known, the circumstances in which they are observed, and the effects which result from them.

Two general observations, however, may be premised on these strictly nervous affections, and their connexion with the state of the vascular system. 1. That as the healthy action of any part of the Nervous System, when strongly excited, appears to be attended with some increase in the flow of blood to that part, and as the total inactivity of any part usually leads to a diminished supply and consequent wasting,—so it is reasonable to suppose, that a morbid increase of the activity of the changes in any portion of nervous matter, although not originating in, may readily *become attended by*, an increased determination of blood thither; and although we cannot affirm that this is a general law, yet many facts in the history of diseases indicate that it is a frequent and important occurrence. 2. That the state of the Nervous System most favourable to the *original excitement* of such nervous disorders, is generally that which attends great weakness, and in which both the fulness of the vessels, and the strength of vascular action, must be supposed to be below the average *.

I. We have various instances of Sensations undergoing much change, both in kind and intensity, for which we can assign no reason, either in the application of any known external agent to the Nervous System, or in any altered action of the vascular system. There are cases, not only of original defect of sensibility in the eye or ear, general or partial, *i. e.* either congenital amaurosis or deafness, or insensibility to certain colours or sounds, without any unnatural appearance either in the exterior parts, or in the nerves of these organs; but there are cases likewise of such affections coming on in the progress of life, without apparent cause, without benefit from remedies applied, either to the state of the circulation in the head, or to the condition of any part by which the organs of sense may be thought to be sympathetically affected, and without change of structure of the parts, or with such change only as may be regarded as the effect, not the cause of their disease.

The Anæsthesia or loss of common sensation in more or less of the surface of the body, although often manifestly the result of injury of some part of the Nervous System, and coexisting with other symptoms of palsy, occurs in some instances without such accompaniments, and when no cause whatever appears for it on dissection. Much more frequently we meet with cases of pain, referred distinctly to individual parts of the body, often very intense and very lasting, which the whole history of the cases shews to be strictly *nervous*; *i. e.* to be an alteration of the function of

* "Lorsqu' un individu a perdu dans un court espace du temps une très grande quantité du sang; lorsque convalescent d'une maladie longue, il a été pendant très long-temps privé de toute espece de nourriture; lorsqu' à la suite d' une inflammation aiguë il reste en proie à une phlegmasie chronique, lorsqu' en un mot, il a beaucoup perdu sans reparer, il arrive souvent que l'impressionnabilité des centres nerveux devient d' autant plus grande que la quantité du sang diminue, et que le systeme musculaire s'affaiblit. Dans cet état, l'hyperemie la plus legerement douloureuse peut determiner dans le systeme nerveux les desordres functionnels les plus graves."—ANDRAL, Precis, &c. t. i. p. 18.

the nerves of the part, for which no adequate cause exists, either in any diseased structure, or in any diseased action of vessels.

Such pains have the general name of Neuralgia, and the following appear the most important facts regarding them.

1. They occur (chiefly in adults, and in persons whose health is otherwise disordered) in all parts of the body, but most frequently in the head and abdomen. Many headaches, and especially those which affect one side of the head, and recur at pretty regular intervals, and have the name of Hemicrania, are of this description; so also is the severe pain of face termed Tic Douloureux. Some cases of Angina Pectoris appear from their history to have no more permanent origin. Many cases of Gastrodynia, and of pains, even fixed and violent, referred to different parts either of the abdomen or sides, or to the situation of the uterus and back, appear to be of this description; and some cases of severe pain of the hip-joint, of the feet, or other parts of the lower limbs, are more correctly referred to this head than to Rheumatism.

2. They have been stated to follow evidently the course of certain nerves; but this is neither uniform, nor characteristic, as distinguishing them from other diseases of nerves themselves. But they are chiefly characterized by the suddenness of their attack (which is repeated often at pretty regular intervals), and frequently of their abatement also; by the total absence of heat, and swelling, and often of tenderness when they are external, and of febrile symptoms when they are internal, even although their intensity be extreme; by frequently appearing to be determined by sudden changes of weather; by occurring chiefly in persons of nervous temperament, and in connexion frequently with other nervous affections; and by abating frequently under the use of remedies called Tonic (perhaps more properly specifics), rather than under antiphlogistic treatment.

3. These pains, although hardly ever observed during violent inflammatory diseases, are by no means incompatible, but on the contrary frequently combined, with such

inflammation as is subacute, or tends but little to disorganization, in the parts where they occur. Even in that case, however, they retain their character in some degree, and are benefited only partially by the antiphlogistic, and often chiefly by the more specific remedies subsequently used.

Besides the nervous pains, there are certain cases of other uneasy sensations, such as Vertigo, or morbid sensations of Heat, or of Cold, the pathology of which appears to be the same. And the rare and singular cases of that modification of morbid sensation formerly mentioned, as spectral appearances *, are equally unconnected, either with inflammation, or even decided congestion of blood, or organic disease.

II. There is a large class of Spasmodic Affections, which would appear to originate in morbid action of the motor nerves, and of the parts within the spinal canal and cranium immediately connected with them; certainly without either inflammation or organic lesion of these parts, and without distinct evidence even of vascular congestion there, as an essential condition, although it may often be an aggravation, of their existence. These spasmodic diseases may in general be distinguished from those which depend either on the effects of inflammation, or on organic disease, by their being unattended with insensibility; and indeed, in several of these, the spasms may be said to denote rather a *perversion* of Voluntary Motion than strictly Involuntary Motion.

Although there are many cases of Epilepsy (*i. e.* of habitually recurring fits of convulsion with insensibility) in which no organic lesion is perceptible on dissection, yet the frequency of organic disease, in cases of epilepsy, the singular obstinacy of the disease, its manifest aggravation by such causes as forcibly impel the blood towards the head, and its gradual injurious effect on the mental powers, render it highly probable that in every case of that kind some orga-

* See Physiology, p. 209.

nic alteration exists, although it may be confined to structure too minute to be detected.

Of the other Spasmodic Diseases there are three divisions, obviously distinguished from one another, in one of which the affection of the voluntary muscles is general and irregular, and seldom dangerous; in the second it is equally general, but much more uniform and violent, and attended with very great danger; in the last it is confined to certain of the muscles concerned in respiration, and is uniform in its character, and always attended with inflammation, of greater or less violence, in the mucous membrane of the air-passages.

The *first* of these divisions comprises a number of cases, in which the spasms vary so much, that it is impossible to rank them together under one general description; but the most definite cases of the kind are the following.

a. The involuntary motions of one side of the body, increased by attempting any definite movement, and attended by much weakness of the lower extremity of that side, which are known by the name of Chorea, which occur chiefly between the ages of ten and fourteen, and often abate entirely, under various treatment, within a few months; in some instances, however, going on, either to permanent amentia, or to fatal hydrocephalus.

b. The fits of Convulsion, affecting many parts of the body, but commencing generally with uneasy feelings in the abdomen, and with the sensation called Globus ascending thence to the throat, and exciting a spasm of the glottis,—called Hysteria, differing from epilepsy in being unattended with insensibility; in the paroxysms being more generally excited by some evident cause, and recurring often more frequently within a short time, but much less pertinaciously throughout the life of the patient:—a disease hardly ever seen in the male sex, and admitting of very great variety as to the nature of the spasms, the frequency of their recurrence, the other affections of the nervous system, and of the secretions of the body attending it, and also as to concomitant affections of the vascular system, the pulse being full and firm, and evacuations of blood useful in some cases, while in others there is great weakness and advantage from stimulants.

The variety as to the symptoms and history of the disease is in fact such, that there is hardly any other disease, the symptoms of which may not be imitated, more or less exactly, in persons liable to hysteria, by affections which are simply nervous, and which are evidently akin to hysteria, and are generally designated by that name. Thus violent fits of coughing, or of vomiting, dependent on peculiar sensations, which seem to reside in the nervous system only, without any indication of disease of the bronchiæ, lungs or stomach, are not uncommon in persons liable to hysteria. Fits of convulsion in children, without insensibility, as from teething, or from worms, or disordered bowels, are often more analogous to hysteria than to epilepsy, particularly as to their ultimate results.

c. The rare, but well marked, and easily distinguished, state of the voluntary muscles called Catalepsy, in which the limbs retain any position in which they are placed; a state never of long continuance, often combined with hysteria, but which, as it evidently implies a perversion of the mental act of volition, is generally excited by mental causes, and attended with more or less aberration of intellect.

Some general observations, of practical importance, may be made on the whole of the cases of disorder of the functions of the organs of sense and voluntary motion hitherto noticed, and which are often the source of great uneasiness, but unless they become complicated with others, seldom dangerous.

1. They are in many instances almost precisely similar to the alterations of these functions which may result, either from chronic inflammation and its effects, or from organic disease affecting the portions of the nervous system concerned in them. For example, the amaurosis, for which no cause may appear on dissection, is often not to be distin-

guished from that which may turn out to have been connected with the growth of serous cysts, or hydatids in the choroid plexus, or chronic softening of the optic nerves, or adjoining portions of brain, or effusions of serum into the ventricles. And a simple neuralgia is often not to be distinguished (except perhaps by its more frequently changing its seat) from those pains which may result, either from chronic softening at the base of the brain, or in a portion of the spinal cord, or from pressure, in one way or other applied to the affected nerves in their course.

2. This analogy gives us reason to suspect, that even when no organic lesion appears on dissection, such disorders may often proceed from imperceptible changes in the organization of the portions of nervous matter concerned. And accordingly we find, that these simply nervous disorders are most common in the same description of persons, and under the same external circumstances, as organic diseases *; they are more common in the inhabitants of towns than of the country, more common in those whose lives are sedentary than in those who have much habitual exercise in the open air; several of them are more common in scrofulous than in sound constitutions, and probably all in the children of sickly than of healthy and robust parents.

3. When we have reason to think, particularly from the ultimate result of the cases, that these disorders have really no permanent cause in the *structure* of any part of the nervous system, we may observe that they occur only in certain individuals, and that in them there is a certain peculiarity of the actions of the nervous system, for which we have no more precise or definite expression than Nervous Irritability, or Mobility;—a state which is more common in women and children than in men, and in all persons when in a state of weakness, than when in the full enjoyment of muscular strength; in women, particularly, more common about the menstrual periods, and immediately after delivery, than at other times; more common likewise in those in whom the menstrual flux is habitually excessive,

* See p. 571.

or altered as in Leucorrhœa, or suddenly suppressed, or more gradually obstructed in the different forms of Amenorrhœa, than in others;—in which both sensations and emotions are intensely felt, and their agency on the body is stronger and more lasting than usual; and in which continued voluntary efforts of mind, and steady or sustained exertions of the voluntary muscles are difficult or impossible, the muscular motions usually rapid and irregular, and the "animus, nec sponte, varius et mutabilis." When such a general condition of the functions of the nervous system exists, any portion of it, on which a special cause may act, is apt to fall into a diseased mode of action more or less resembling that which inflammation or organic disease may excite in it. And it is farther of great importance to observe, that this tendency is greatly increased by each repetition of diseased action of this kind; or even by any impression made by sensations or emotions on the bodily organs, so strong as to indicate the existence of this mobility of the nervous system; and therefore, that avoiding all occasions of exciting violent sensations or emotions, is of essential use in correcting the tendency to such diseases. One modification of this nervous temperament, very frequently connected with its other marks, is the disposition of the mind to dwell upon all uneasy sensations, and anticipate danger from them, which so frequently attends all diseases of which permanent uneasy sensations are an essential constituent, and especially disorders of the stomach and bowels, and to which we give the name of Hypochondriasis;—which is chiefly observed in persons of the melancholic temperament, but not confined to them, and is more properly described as a condition of certain functions of the nervous system which accompanies and aggravates many chronic diseases, than as a disease *sui generis.*

4. The nervous disorders in question, are easily excited *sympathetically* by diseases of other parts of the system;—not so much, however, by violent febrile or inflammatory diseases, in which the circulation of the blood is much excited, as by those in which the secretions are much derang-

ed, and many uneasy sensations produced, without excitement of the circulation. Hence the symptoms of these disorders are very frequently combined with Dyspepsia in all its forms, with Constipation, Diarrhœa, and derangements of the Menstrual flux.

5. These nervous pains, or other uneasy feelings, and slighter spasms, are the description of diseases most easily excited by mental emotion, especially in constitutions of the peculiar nervous irritability already described. Such affections, accordingly, in varied and sometimes in unusual forms, have very often been excited by intense religious enthusiasm, and often by the emotions excited by such applications as the metallic tractors (real or fictitious), or the manipulations of those who profess animal magnetism. In all such cases, agreeably to what was formerly stated *, the emotions that may be excited are much heightened by the presence and participation of numbers; and these are the diseases which have been particularly observed to spread by Imitation, nearly after the manner of epidemics.

The *second* order of Spasmodic Affections, which seem to originate in morbid action of the nervous system itself, comprises the very dangerous disease called Tetanus, and the almost inevitably fatal one called Hydrophobia. The first, in a few cases, originates idiopathically from cold, but is much more generally excited by injuries, in which a portion of nerve has no doubt peculiarly suffered, although its injury is often imperceptible on examination. The disease does not commence, however, till some days after the cause has been applied; and of the nature of the changes taking place in the interval we have no information whatever. It is characterized by violent painful tonic spasms, with frequent aggravations, but no absolute relaxation, beginning in the muscles of the hind neck and lower jaw, and extending over the whole muscles of the body; it is unattended with any affection of the functions of the brain

* See Physiology, p. 273.

proper; and is fatal, not by coma, but merely by reason of the gradual failure of the strength of the circulation, which accompanies the repeated paroxysms of spasm, nearly as it accompanies violent spasms of the same description when produced in animals by the action of poisons, or by extensive injury of the spinal cord.

Hydrophobia is likewise produced by the action of the specific cause, and an interval, varying from a few days to several months, likewise elapses between the time of its application and the commencement of the disease; but in this case the cause is a peculiar animal poison, the conditions necessary to the generation of which are not yet ascertained, communicated only by inoculation, and which seems, like the poisons exciting the contagious exanthemata, to multiply itself in the blood during the latent period. The spasms are here first and chiefly in the muscles of the fauces, and are repeatedly excited or aggravated by external causes, by the contact of any fluid with the fauces, or even of cold air with the face; but they generally extend over the body as the disease advances, and death takes place, as in Tetanus, not in the way of coma, but rather by syncope; in consequence of the gradual depression of the heart's action that attends the violent spasms, perhaps in consequence partly of a sedative action of the contagious poison on the heart itself.

Although a congestion of blood on the surface of the spinal cord has been described by some in cases of Tetanus, and although an unusual vascularity in the mucous membrane of the pharynx and œsophagus is common after Hydrophobia, yet these appearances are certainly to no great extent; it is probable that they may be rather effects than causes of the morbid actions; and at all events, they do not afford, by comparison with other cases of inflammation of these parts, any explanation of the peculiar phenomena of these diseases, nor invalidate the conclusion, that they are both to be regarded as strictly diseases of the nervous system.

The *third* head of Spasmodic Affections of this class consists of the two well known spasmodic diseases of the respiratory organs, Hooping Cough and Asthma.

The first of these unites the singular properties of being the effect of a specific contagion, and equally incapable of alteration, as to its duration or essential symptoms, by remedies, as the contagious exanthemata themselves,—of being unattended with any typhoid tendency,—and of being characterized by a combination of the symptoms of bronchitis with a peculiar spasm, chiefly of the muscles of the glottis, which takes place only during the fits of coughing, and narrows the opening there, so as to cause the peculiar crowing sound in inspiration; and which continues long after the febrile symptoms of the first stage of the disease have subsided, and the bronchitis assumed the chronic form.

The danger in this disease is partly from the extension of the bronchitis to all parts of the lungs (when it always becomes dangerous), and from its consequences in the lungs; viz. emphysema in most severe cases,—peripneumony in a few,—and phthisis in many; and partly from the effect of the congestion of blood in the brain during the long continued fits of coughing, in exciting fits of convulsion with insensibility, and sometimes hydrocephalus.

In regard to Asthma (*i. e.* Dyspnœa occurring in paroxysms, with a wheezing sound of respiration, and going off, after some hours, with mucous expectoration, believed to depend on spasmodic constriction of the bronchial tubes), the following facts seem most worthy of attention.

1. Its attacks commence very generally, like epilepsy and gout, after the first sleep, *i. e.* at the time when the blood is perhaps in fullest quantity, its movement slow, and its congestion in internal parts easiest, because it is least solicited to the surface of the body, or to the organs of sense or locomotion.

2. It seems to be always attended with more or less of bronchitis, but this exceedingly various in degree, and also in kind; being slight in the cases that are most purely spas-

modic (or dry asthma); acute, and demanding early and active remedies in some cases that are attended with fever, and where there is but little remission of the dyspnœa; and again quite chronic in other cases, chiefly of older standing, where there is much abatement without disappearance of the cough and dyspnœa, copious expectoration, and little or no fever, and little variation of the symptoms for weeks or months, (humid asthma).

3. The spasmodic nature of the disease appears to be indicated by its distinctly hereditary character, by the exciting causes of many of the paroxysms, by the evident constriction of the bronchiæ during the paroxysm, and the frequently complete and rapid abatement of that state, and by the experience of juvantia and lædentia in many cases of it; and, like other spasmodic diseases, it evidently facilitates its own return. But there are many cases in which the spasmodic paroxysms are neither frequent nor violent, and the chronic bronchitis is the more urgent disease.

4. Although a degree of Bronchitis probably always attends asthma, this is by no means the only pectoral disease on which asthma will supervene. In those who have the tendency to them, asthmatic paroxysms supervene on any cause of permanent impediment to respiration; *e. g.* on disease of the heart, on phthisis, and on the sequelæ of pneumonic inflammation.

In regard both to Pertussis and Asthma, it is to be remembered, that as the lungs are forcibly compressed during the violent fits of coughing, at the same time that the opening for the exit of the air is narrowed, these diseases furnish the most favourable conditions for the production of Emphysema of the lungs, which accordingly very generally supervenes on both, and is a cause for permanent dyspnœa when either has been violent and of long duration. It has been already stated, that after pertussis this state of the lungs may certainly spontaneously abate; but in asthmatic cases, when the disease becomes habitual, it is probably much more permanent after being once established. After a time it is very generally followed (as already stated) by induration of the liver, and often by ascites; and therefore asthma (although often recurring occasionally for a great length of time, without seriously injuring the constitution), if it recurs very frequently, becomes at length more dangerous than simple chronic bronchitis.

There are some cases, in young children especially, of spasmodic affection of the muscles of the glottis, producing a sound exactly resembling that of hooping cough, recurring occasionally, chiefly after sleep, without cough or indications of inflammation; and which appears to be just on the same footing as other spasmodic or convulsive affections in young children, depending often on local irritations acting on the body, and connected with, or increased by, determination of blood to the brain.

Again, there are many cases, at all times of life, where the symptoms of laryngitis, or cynanche trachealis, are combined with, and aggravated by, spasm at the glottis (as those of acute bronchitis are with spasm of the bronchiæ in violent cases of asthma); are subject to remissions, after the manner of spasm, and are benefited by the remedies for spasm, used in combination with those for inflammation.

III. The next class of diseases of the Nervous System is that of Vesaniæ, or alterations of the mental powers or faculties; which we can have no doubt depend on alteration of the state of the nervous matter in the brain; because we know that it furnishes the physical conditions necessary to the manifestation of all mental phenomena.

The diseased states to which the mental powers are liable, are most easily understood as consisting in, or depending on, alterations of the laws according to which the different thoughts succeed each other in the mind, and of the intensity and duration of the attention fixed on them, rather than of the nature of the mental acts themselves *.

The great and obvious division of these diseased states is into the state of Amentia or Fatuity, and that of Dementia or

* See Physiology, p. 212 and 225.

Insanity, both of which states admit of very considerable varieties.

Both states are very frequently produced temporarily by inflammation, and by different febrile diseases, and more permanently by organic diseases, in which the brain is affected; and both may be suspected to proceed in every case, from some alteration of the structure of the parts of the nervous system, with which the mind is specially connected; but this alteration is certainly in many cases imperceptible by any means yet known for detecting such changes; and some of the forms of both kinds of mental disease commence so suddenly, and abate so completely, that it is difficult to suppose any peculiarity of structure that may exist to be essential to their existence, or to be on any other footing than a great predisponent cause of them.

The state of Amentia is that in which impressions on the senses, although distinctly felt, and exciting certain mental acts, fail to suggest many of those thoughts which in men of sound minds would naturally, and according to the ordinary laws of association of thoughts, result from them. This obviously admits of a subdivision, according as the deficiency lies in the simple suggestion of objects of sense, or of thoughts previously before the mind in connection with each other,—or as it lies in the suggestion of the relations of things (which are perceived by what was described as the faculty of Abstraction), and of the abstract notions which were described, as either naturally attending different acts of mind, or formed by our perception of the relations of things,—and which are the subjects of Judgment and Reasoning. In the first case, there is merely loss of Memory; in the second there is Idiocy; and both admit of many varieties; for in many persons some of the associations by which thoughts are laid together in the mind are retained, while others are lost; and again, in many persons, some of the relations of things are distinctly perceived and remembered, while others are wholly overlooked.

The state of permanent idiocy is probably always the effect of original malformation (often obvious on inspection of the skull) or injury or alteration by disease of some part of the brain; and when it takes place in the course of life (as, *e. g.* after long-continued chorea, or many fits of epilepsy) is seldom removed, and very often a prelude to ultimate coma. The loss of memory, though very often dependent on organic lesion, is often observed in old age, in persons convalescent from febrile diseases, &c. without visible change of structure; and there are some cases (chiefly of the anomalous and slighter affections of the nervous system) where it occurs, even repeatedly, and disappears so suddenly and so completely, that we cannot suppose it to have been connected with disease of structure.

The state of Somnambulism or Reverie, formerly mentioned (p. 280.) although one in which the mind often acts with great energy on certain objects of thought, is yet properly ranked under the head of Amentia, because some of the natural associations of thoughts are suspended, and the conduct of the person affected thereby altered, (sometimes without any hallucination or delusion being perceptible); and when this internal state of the mind ceases, little or no recollection is retained of what passed during it. Short paroxysms of such a state are not uncommon, and have often been unconnected with any very serious disease in persons of the nervous temperament, chiefly in women subject to the slighter nervous diseases; and sometimes recur repeatedly, the recollection of what happened during each being recovered in the next paroxysm. And in some cases this perverted condition of the mental powers has lasted so long, that knowledge previously obtained, or arts previously learnt, have been acquired again, during the suspension of the associating principles which ought to have suggested them; and then the lost association has been suddenly restored, and the mind regained possession of all that had formerly been learnt *.

The state of Dementia or Insanity is perhaps most uniformly characterized merely by the unusual energy or fervour with which different acts of thought are performed,

* See Abercrombie on the Intellectual Powers, 3d edition, p. 303.

especially acts of Conception and of Imagination, and Emotions resulting from these. When such acts take place with morbid energy, and the attention is involuntarily fixed on them with unnatural force, so as to exclude all other thoughts, which in the circumstances of the case would otherwise present themselves, and prompt to sudden, capricious, and absurd actions, Insanity may be sufficiently characterized, (as, *e. g.* in some cases of Projecting or Scheming Insanity), although no distinct hallucination or delusion can be detected. But in by far the greater number of cases, the morbid vividness of the conceptions or fancies, in the mind of the madman, overpowering the checks, which, in the natural and healthy state, prevent our believing in the real and independent existence of the images formed in our minds *, he reposes belief in something which he has conceived or imagined, in like manner as all men do in the images presented during sleep; and this erroneous belief, or hallucination, " qua rerum relationes *falsæ* percipiuntur," shews itself in his language or actions, and indicates and characterizes his insanity.

This morbid state of great part of the train of thought in the mind, obviously admits of very considerable variety, without deviation from these essential characteristics.

In some cases, all or almost all the images formed in the mind are equally the subjects of this erroneous belief; so that the patient, although his mind will generally act for a short time in the natural way on any new object presented to his senses, and arresting his attention, yet, as often as he returns to those trains of thought, of which conception and imagination form a large part, relapses into the varied hallucinations that spring from the faith erroneously reposed in the images which these faculties present to him. This is the state of the mind in what is properly called *Delirium*, so common in febrile diseases, and occurring occasionally in the course of many cases of more permanent insanity.

In other cases, it is only in regard to certain objects of thought that the mind acts with morbid fervour, and there-

* See Physiology, p. 219.

fore forms false judgments; and in regard to others, its operations are nearly natural. This is generally the case when there is no febrile action in the system, and the term Mania is then more correctly applied. In some such cases, the subjects of false judgment are very limited and unvaried for a great length of time; and such cases (called Melancholia by CULLEN), are now usually termed Monomania.

Again, there are many cases of mental derangement, where the whole train of thought is much more rapid than natural; and some where it is so rapid that the control of the will over it (see p. 229), is evidently suspended; and the language of the patient so rambling and incoherent as to convey no definite meaning. This is the state to which PINEL, and other French authors, restrict the word Demence. When there is such rapidity of thought, the emotions attending the insanity are generally of the exciting class, either joy or anger.

On the other hand, there are many cases in which the train of thought is much slower than natural, or the succession of acts of thought almost suspended, the mind dwelling almost exclusively on particular images. In such cases, these images are usually attended by painful or depressing emotions, and the term Melancholy is that generally applied.

In many cases, along with, and generally consequent on, the delusions and emotions attending them, there is, at least occasionally, a propensity to violent and outrageous acts; and, in some of them, this propensity shews itself so suddenly, and with so little apparent cause in the previous language or conduct of the maniac, as to have led to the supposition that it is the sole disorder of the mind; but it does not appear reasonable or safe to hold such a propensity to be a sufficient indication of insanity, unless it be shewn to coexist with some mental delusion.

Again, there is a distinction, easily observed in many cases, and of considerable importance, between those forms of insanity, where the delusions rest on erroneous *conceptions* of what has actually been before the senses, and those where they rest on morbid acts of *imagination* only, whereby persons or things are invested with fancied qualities, which are not supposed to have been actually under the observation of the maniac, but of the existence of which he nevertheless entertains a thorough conviction. This distinction is expressed by Dr ARNOLD by the terms Ideal and Notional Insanity*. The delusions in a case of delirium tremens from drinking, which are generally founded on mrobid sensations, and on the recollections of these, are an example of the first kind; and the common hallucination of a combination or conspiracy formed to injure the affected person (who generally supposes, in such cases, not that he has seen or heard proofs of what he alleges, but that he has divined the thoughts of his enemies), is of the last kind, which is probably the more inveterate malady of the two.

The following facts are well ascertained by experience, in regard to the circumstances in which the diseased actions of the nervous system, on which these lesions of the mental faculties depend (but which are known to us only by their effects), are chiefly observed.

1. Abstracting from the case of the delirium of fever, there is only a small portion of the human race who are susceptible of this kind of disease.

2. In a very large proportion, probably a majority, of those who are affected in these ways, a predisposition from hereditary constitution may be traced.

3. In a large proportion also, some of the organic diseases within the cranium, formerly mentioned, (p. 604), are found on dissection, with or without serous effusion, and frequently there are marks either there or in other parts of the body, of scrofulous disease. Where there has been no organic disease, something unusual in the form or texture of the bones of the head has often been remarked.

4. In those thus predisposed, the disease shews itself more frequently between the ages of twenty-five and forty,

* Observations on Insanity, vol. i. p. 72.

than any other time of life: and the earlier it does so, there is the more chance of at least temporary recovery.

5. In those predisposed, mania may be excited by almost any cause adequate to excite any kind of disease; probably the most frequent exciting causes are, intemperance in the use of strong liquor, or in venereal indulgences, the irritation of mercury, long continued external heat, injuries on the head, the suppression of usual evacuations, and mental emotion. The symptoms attending a violent fit of mania, excited by any of these, as well as the nature of the causes, the other diseases with which it may be combined, the juvantia and lædentia, and the effusions in the brain frequently found after such a fit has been fatal, clearly indicate that an increased determination of blood, and frequently even an inflammatory action, has preceded and accompanied the attack; but in every such case, a peculiar predisposition must have existed to give this character to the effect of such morbid vascular action; and in many of the cases, where the predisposition is strong, little or no excitement by any of those external circumstances can be perceived.

The cases of insanity which present the best prospect of a perfect recovery of the mental powers, are those in which the action of a powerful exciting cause is the most manifest, and previous disposition least obvious; but these are also the cases which bear the closest analogy to inflammation, and in which there is perhaps the greatest risk of the maniacal excitement, if not moderated by remedies, quickly subsiding into fatal coma. Such are many of the cases of insanity immediately succeeding delivery.

The Delirium Tremens from drinking (but which almost invariably commences after the excitement from the strong liquor is over) may be said to differ from other cases of insanity, in shewing throughout its course the action on the brain of a substance which affects the constitutions of the patients, on the footing of a poison, but not of a narcotic poison. The mental hallucinations are founded in a great measure on what may strictly be called spectral illusions, and are attended uniformly with tremors resembling but exceeding those of typhoid fever. The effect of this poison to produce this form of disease is manifestly determined by previous predisposition, the effect being seen only in a very small proportion of those to whom the cause is applied. And the specific action of the poison on the brain and nerves appears manifestly to be aggravated and maintained, sometimes by a morbidly diminished, and at other times by an increased, action of vessels,—as indicated both by the symptoms accompanying the mental derangement, and also by the juvantia and lædentia;—the specific effect of opium, in controlling the characteristic symptoms of the disease being sometimes certainly aided by antiphlogistic, and at other times by stimulant remedies.

The peculiar agency of a cause affecting the nervous system in this disease after the manner of a poison, is shewn by the mode of fatal termination of the disease, which is hardly ever preceded by coma, but takes place almost instantaneously, or in the way of syncope.

In almost all other cases of Mania, the immediate danger of death, in so far as it is connected with the mental disease, may be said to depend on the gradual accession of coma; and the fatal result is accordingly very generally preceded by a combination of other of the cerebral diseases, Epilepsy, Phrenitis or Hydrocephalus, &c. and very often Fatuity;—which combinations may probably be owing sometimes to extension of organic disease in the brain, and sometimes to accession of more acute disease there.

The remarkably partial affection of the mental powers, in many cases of Mania and Melancholia, and the limitation of the morbid condition of the mind, in many cases, to its exercise on particular objects of thought, may be thought to favour the supposition of the appropriation of individual parts of the brain, either to particular acts of mind, or to acts of the mind on particular subjects; but it does not appear on examination of this subject, either that the allocation of the different operations of the mind, in the different parts of the brain, proposed by Gall and Spurzheim and their followers, is confirmed by observation of the portions found to be diseased in these cases of partial insanity; or that the forms of the partial insanity itself correspond to their divisions and arrangement of the mental acts.

IV. It is important to state in regard to the complete suspension of the functions of the Nervous System in Coma, that while that state is clearly the effect, and often the final effect, of various external agents applied to the brain, —of concussion,—of mechanical compression,—of narcotic poisons,—of venous blood,—of congestion of blood in a few cases, and inflammation and its consequences in many,—of animal poisons,—and of various kinds of disorganization in the nervous matter itself,—there are also cases, chiefly in persons of the habit described under the name of peculiar mobility of the Nervous System, in whom absolute coma may be the effect of a change of action there, apparently without change of structure, and certainly without perceptible application of any of those causes. Of this the most striking examples are in the cases on record of long continued stupor, occurring chiefly in women, and in the circumstances stated above, (p. 636) which have been described as Hysteric Coma; and from which there may be speedy and perfect recovery. This is important as an unequivocal example of great alteration of those imperceptible changes in the Nervous System, which attend the different acts of Sensation, Thought, and Voluntary Motion,—without any such alteration of its texture, as is incompatible with the speedy restoration of all its vital powers.

FINIS.

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