THE ESSENTIALS OF PHYSIOLOGY.

Willm. Pritchard

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PHYSIOLOGY.

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BY

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PREFACE.

THE elaborate treatises published, of late years, on Physiology, both Human and Comparative, with the numerous articles which have appeared, from time to time, in the Medical periodicals of this country and the Continent, afford abundant opportunities to the Physiological Inquirer, for the Study of this branch of Medical Science.

Many of these devote a large portion of their contents to the consideration of the Structure and Functions of the Nervous System, which have been most carefully investigated and most scientifically treated.

For this attention to so important a part of the Animal Structure, we are doubtless indebted to the discoveries of the late Sir Charles Bell, who has led the way in a pursuit of a most important character, and has opened up a wide field where others, still, have ample opportunities of enriching our stores of Medical Knowledge, and of adding their names to the list of discoverers in Physiological Science.

But the other important structures of the Animal Kingdom have not been neglected: all parts have received attention, and there is now no part, perhaps, respecting which we do not possess the most accurate information regarding its structure, and as perfect an acquaintance with its functions as can be attained, apparently, by human research.

And yet, what different results are frequently presented to our notice! The direction, nay, the very existence of a fibre, or a set of fibres, is freely and fully canvassed; and one inquirer contends for the correctness of views, which another regards as wholly untenable, and unsupported by accurate investigation.

This result, however unsatisfactory, is to be expected in the prosecution of researches, which are directed to the examination of the most delicate Structures of the Human body, and in which it is necessary to employ the most powerful microscopes that can be used, consistently with safety to the explanation of the object exposed to their magnifying power. Let us hope that these differences may be reconciled, ere long, and that we may soon attain to a fixed result in our investigations of at least the structures of the Animal fabric.

It would be difficult, if not impossible, for the student of Medicine to peruse the works and treatises alluded to, the time at his disposal would not suffice for the purpose, and it is questionable if he would derive an advantage corresponding to the labour necessarily employed in the pursuit; a condensed view of the essential matters contained therein would be more useful and more profitable to him, until he should have a better opportunity of studying the subjects to the fullest extent.

With this view, the "Essentials of Physiology" have been written. It is the ardent hope of the Author, that they may be found to have effected so desirable an object, in a satisfactory manner. In its construction he has availed himself of all the important Physiological works of the present day, and amongst these he has been especially indebted to Valentin's able work on Physiology, which contains an originality of views and a soundness of theory rarely to be met with.

7, Percy-street, Bedford-square,

October, 1860.

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INTRODUCTION.

The term *Physiology* is derived from the Greek words, *φύσις*, *Natura*, and *λόγος*, *lex;* and strictly means, that Science which treats of the laws of Nature. It is, however, not used in this extensive sense, but is confined to the Study of the Laws which regulate the *Animate* as distinguished from the *Inanimate* world. In the former are included both the Animal and Vegetable kingdom, hence we have the terms *Animal* and *Vegetable physiology;* the latter being confined to the study of the laws which control the vegetable kingdom, whilst the former relates to those of the animal kingdom.

There is no distinct term applied to the study of the laws that influence the Inanimate world, although *Natural Philosophy* usually indicates this; but as this term embraces the whole of Nature, we are still without a term which might be applied to the study of the laws of the Inanimate world, although that of each division is represented by the terms Mineralogy, Geology, &c.

As may be supposed, the science of Physiology received attention at all periods, the records of which have passed down to us; as no student of medicine, practitioner or otherwise, could be supposed as passing years in the study and practice of medicine without endeavouring to investigate the uses or purposes of the several parts, in a healthy state, the diseased condition of which he was called on to treat and remedy.

Accordingly, in the earliest ages, the founders of the Healing Art—Hippocrates, Aristotle, Galen, &c.—directed their attention to the Physiology of Man; but many circumstances retarded the progress of Physiological Science, not the least of which has been the difficulties which so often existed of obtaining human subjects for dissection.

In more modern times, these difficulties have much diminished, and accordingly we find that Human Physiology, emancipated from the theories engendered by the dissection of lower animals, has progressed with great rapidity: in its pursuit, the names of Haller, Ruysch, Malpighi, Leeuwenhoek, Mascagni, Harvey, Hunter, Bichat, Majendie, Schwann, Bell, Valentin, Kolliker, Todd, Bowman, Kiernan, Sharpey, and a host of others of less repute, stand prominently forward.

Although our native country scarcely rivals either France or Germany, in the pursuit of Physiological Science, it has done much in the important discoveries which its sons have made, and which may justly be considered as the first of all discoveries made in the pursuit of medical knowledge,—namely, *the Circulation of the blood* and *the Functions of the Spinal nerves.*

In the 17th century, the immortal Harvey made the first grand discovery in Physiological Science, the Circulation of the blood; but, strange as it may appear, he laboured for twenty years before he could succeed in having his theory recognised, although it is supported by incontestable proofs and irresistible arguments, and was almost reduced to poverty by his efforts.

The present century boasts the second great discovery in Physiological Science, namely, the *Functions of the Spinal nerves.* This was effected by the late Sir Charles Bell, in the memory of many now living, and, like Harvey, he was but ill rewarded for his discovery. He survived it but a few years, and left the field of his discoveries to pursue his profession elsewhere.

There is little encouragement for the pursuit of Physiological investigation in this country; none, indeed, it may be said, but the physiological chairs in the several Universities and Schools of Medicine, and the revenues of these are seldom sufficient to encourage any attempt to pursue the subject.

The late Marshall Hall has also contributed to our knowledge of the Nervous System; and although his views cannot be regarded as discoveries, they are of much importance, and are characterized by an originality and comprehension which reflect credit upon his memory.

Within the last thirty years several new labourers in the field of Physiological investigation have appeared, and foremost amongst them must stand the name of Schwann, who, in the year 1838, first showed that animal organisms are originally composed of cells, and that their higher morphological structure arises from these elements—a theory which is now generally received, and promises to lead to most important results.

The improvements made in the use of the Microscope, and our better acquaintance with the laws which govern the distribution of the rays of light, have assisted much in the advance of Physiological science: in this direction appear the names of Wagner, Brun, Beale, Hogg, Quekett, Hassall, &c., to all of whom the student in medicine is much indebted, although many of the facts now brought forward as discoveries are to be found in the works of Mascagni, Leeuwenhoek, &c.

In the use of Microscopical instruments of high magnifying powers, much care is required to avoid the errors which are likely to arise from the effects produced in the examination of both fluids and solids, from the changes which take place in the motions of the former when composed of different secretions, and in the various degrees of opacity produced in the latter, from the evaporation of the fluids which they contain, giving rise to the appearance of bodies which are produced by the greater or less degree of transparency of the objects experimented upon.

ESSENTIALS OF PHYSIOLOGY.

LIFE — VITAL PRINCIPLE — VITAL ACTION.

All objects in Nature may be divided into the *Animate* and *Inanimate:* the former are characterized by the possession of a certain vital or living principle termed *Life;* the latter do not possess this.

Animate bodies are characterized by the possession of a certain degree of *organization*, which is necessary to their existence, the destruction of which tends to their dissolution, and their return to the Inanimate kingdom, from which their elements have been derived.

This *Organization* is marked by certain peculiarities, which are not met with in the mineral kingdom; the *form* of all organized bodies tends to present rounded or convex surfaces, whereas that of the mineral kingdom is characterized by the formation of straight lines and angles of greater or lesser acuteness, the result of *crystallization*.

Organized bodies possess, within themselves, the power of reproduction, or growth, which enables them to take in, or absorb into their interior, a certain portion of the surrounding solids or fluids, to digest or alter them, and eliminate from them the nutritious particles which contribute to the maintenance of their vitality, the support of their structure, and to the enlargement or growth of their form, By this means they are enabled to attain a certain size and form, which is more or less limited according to the species of the individual, although in special instances these are capable of much modification, and are subject to considerable variety.

The power of growth is thus inherent in organized bodies, and is the result of that organization which is, in fact, an assemblage or combination of special organs, which are appropriated to the performance of one or more functions, which, by their combination of action, produce the material necessary to the growth and maintenance of the individual.

In Man and the higher classes of the Animal Kingdom, the organization is the most perfect, and is composed of a number of organs, each of which is as essential to the well-being of the whole as to the performance of the function assigned to it by Nature; hence Man possesses a variety and superiority of functions not to be met with in any other portion of the Animal kingdom.

There is thus a connexion between the functional organization of the individual, and his position in the order of Animate beings, to which he belongs; perfection of organization produces perfection of function of the individual; and although a greater complexity of organization may be present, this is necessary to the production of the more perfect being.

It may be considered that more elaborate structures and a more perfect organization are necessary to the formation of the atomic constituents of the more perfect animals, as being further removed from the Mineral kingdom; but that in those of a lower grade, this superiority of structure is not necessary; and thus an inferior degree of organization is sufficient to produce and maintain the individual.

By the inherent power of growth possessed by the Animal kingdom, each individual adds to its structures new productions, which contribute to its further increase or repair the losses which all living bodies are constantly undergoing: the addition is made from within, and extends thence to the external surfaces, so that the individual grows or supports his frame by interstitial deposit, and not by the aggregation of particles to his external surface.

But the modifications of organization are infinite, and extend from the greatest complexity of structure and functions, as in Man, to the utmost simplicity, as in the polypes, in which we can recognise but a little beyond the characteristics of the mineral kingdom.

The *Mineral* or *Inanimate* kingdom does not possess this power of inherent growth, but increases in size by the addition of particles to its external surface; to which increase of size there appears to be no limit, except that which arises from the deficiency of corresponding material, or from the agency of surrounding influences; but in this progressive increase there is no change of material, no alteration of structure, no new product: the first and the last particles deposited are strictly similar in shape, size, and composition, and the smallest atom is as perfect in itself as is the largest mass of crystalline matter, which is but the aggregation of numerous particles of the same material attracted to each other by those principles of cohesion by which they are influenced. It results from this, that each particle of the mass is perfectly independent of all the rest: it may be detached from them without any injury to its composition; it still remains perfect in itself. It is otherwise in the Animate kingdom, where a separation of a single part may be destructive to the whole, and from which no one organ may be removed without compromising the perfection, or even the integrity, of the individual.

In the more highly organized beings this natural dependence of organs upon each other, and the dependence of the individual on the perfection of them, is most evident, as few parts can be removed without danger to the whole, and no one organ without compromising the safety of the individual.

Man, therefore, standing at the head of organized beings, is, as it were, a compound of numerous organs necessary to each other, to the individual, and to the species, the removal of any one of which is inimical to the well-being of the whole.

It is otherwise with the lower classes of organized beings, in which the removal of several portions of their frame may be effected without in the least compromising the formation of the remaining organs, or the safety of the individual.

The lower classes of animals thus present an analogy with the Mineral kingdom, as seemingly composed of similar particles collected together, but independent of each other; whilst Man and the higher classes of animals appear to be composed of a heterogeneous mass of particles, compounded to form one perfect whole, and each dependent on the other for its own integrity and continuance in the fabric as a portion of organized being.

In the higher classes of animals we observe, also, a complexity of tissues not to be seen in less highly organized beings: thus in Man we find tissues or productions of various degrees of consistence, from the fluid to the hard resisting solid; from the watery humour of the eye to the more consistent synovial secretions of the joints; from them to the more resisting muscles and other soft parts, until we arrive at the osseous system, presenting a flint-like resistance in the enamel of the teeth and in the petrous process of the temporal bone.

In the less highly organized being a uniformity of tissue is generally to be observed; a mass of soft matter without any hard material, or again, an external covering of resisting calcareous matter enclosing a small portion of nearly homogeneous soft substance.

We thus observe that the degree of the Vitality possessed by the animal is in proportion to the extent of organization, and conclude from this that there is an intimate connexion between Life, or the Living principle, and Organization. Not that Organization will create life: of this we have no instance in Nature; but that the living principle which exists in and has been given to the germ of the future animal, is only brought to maturity in proportion to the organization which it possesses, and which it is enabled, by means of this living principle, to develope into a state of perfection or otherwise; that according as the organization proceeds, so does the vital principle expand, as it were, with it, until the individual assumes that perfection of organization which is observable in Man, the head of the Created World.

The progress of Organization proceeds in accordance with the laws of Nature which influence and govern the germ in the formation of the future being (laws the action of which it is impossible to understand), and which proceed from the commencement to the termination of his career: they constitute the laws of progressive development, which place Man before us in the various phases of animated matter, ascending from the lowest condition, in which he enjoys only a vegetative existence, through those of the animal kingdom, until he arrives at a point above all others, and becomes the Human Being.

The discovery of the precise nature of that Life, or Living principle, which exerts so powerful an influence on Man and all Animated creation, has long been sought for by philosophers, as well as physiologists, from the earliest ages down to the present moment; but their efforts have been vain, and we now stand in the same position, with regard to this subject, as that occupied by the first philosopher who entered upon its investigation.

Nor can we even define Life: we may attempt a definition of it, by stating that it is "that principle which enables man to perform certain actions, or execute certain functions;" but this is not a definition of Life itself: it is but a declaration of the phenomena which result from the living principle; and we are compelled to acknowledge that we can judge of it only by its effects, and that we are wholly unable to unfold or understand the extraordinary agent imparted to us by our Creator, which enables us to "live, and move, and have our being." Other properties in Nature are equally beyond our powers of investigation: the *attraction of gravity*, the *affinity* of bodies to each other, are examples of this; we know them only by their effects or results; and although we may state that bodies crystallize by the attraction of certain particles to each other, we are still unable to understand the nature of the principle which impels them, as it were, to unite. An apple from the tree falls towards the earth by the attraction of gravity; but who can say what this is, or attempt to explain the principle which draws one body more or less distant to approach another?

There are laws of Nature in the Physical World imparted to material structures by the Great Creator; these laws govern them, as the Vital Principle governs Man, and exert an influence on them not less powerful, although productive of less important results, than that which calls the germ into existence, and from the embryo in the womb developes the human being.

We have seen that Life depends upon organization for its development and maintenance; but it must not be supposed that it is the result of organization: the body after death frequently presents no trace of organic lesion to account for the cessation of life; and yet the vital spark has fled, never to be recalled, its particles decompose and separate, and may afterwards enter into new beings possessed of animation; but the life of that body has ceased, and no effort of man can recall it into existence.

But the extent of Organization necessary to the enjoyment of the *Vital Principle* is apparently trifling. A simple cell constitutes the entire organism of such plants as the Protococcus nivalis (red snow), or the Palmella cruenta (gory dew), and in this simple structure resides the vital principle on which the integrity of the plant depends.

As we ascend in the scale of Organization, we find that the number of cells increases, and their characters vary, so that the more complex plant is a combination of these; and this closely resembles the arrangement present in the Animal kingdom.

But whatever the extent of organization may be, its perfection is necessary to the maintenance of life: if it be destroyed, either by physical or chemical agents, life ceases; the seed which has lain dormant, it may be for a thousand years, will, if its organization be perfect, spring into activity when planted in the ground, and will form a new plant; but if crushed, or if it have fermented by the action of heat and moisture, its *living principle* is destroyed, and it will no longer germinate.

In the same manner, in Man, if the organization of any part be destroyed, by mechanical or other means, it dies, and is thrown off from the body; and if the disorganization should affect a part necessary to the life of the individual, this perishes, and the whole body dies.

There are some agents which will destroy life without affecting the organization, or at least to an extent appreciable by the use of the finest instruments. Of this character is Electricity, which seems to act directly on the vital principle, without affecting the tissues or structures of the body: in some cases, parts of the body have been charred by the agency of the electric fluid, as from lightning; but in others no such results have been observed, and death seems to have been caused by the instantaneous destruction of the living principle.

It is a remarkable fact that the blood, under such circumstances, does not coagulate; it loses its power of coagulability, which is essentially a vital power, and perishes instantaneously. Shall we say that the more powerful poisons which destroy life so instantaneously—such as hydrocyanic acid, chloroform, under some circumstances, nicotin, &c. &c.—act in a similar manner upon the living principle, and destroy life without implicating the organization?

The power of *Repetition* or *Reproduction*, possessed by many portions of the vegetable kingdom, and in some individuals of the lower classes of the animal kingdom, whereby a part may be removed or cut off, and this will form a fresh individual of the same species, does not negative the preceding proposition: in these there is no destruction of organization: the part separated is perfect in itself, its tissues are not destroyed, it possesses within itself the principles of vital action independently of the parent trunk from which it has been severed, and not only retains its vitality but developes this further, so as to form another individual of the same species.

Life cannot be created by Man; it must spring from Life. There is no instance of a living structure being developed from inanimate matter, except through the agency of a previously living principle. The myriads of insects which occupy the earth, air, and water have all sprung from similar objects, and have derived their life through countless generations of living beings sprung from the first of its species.

Various terms have been used to designate the action of the vital principle in the production of the living body, in the maintenance of life, and in the execution of the several phenomena connected with a living being. Of these, the term *Vital Action* is the least objectionable and the most comprehensive, as it may be applied to all the phenomena produced by the action of the vital principle, from the simplest to the most complicated.

Man presents this vital action, in his growth and progressive organization, in its most perfect and comprehensive form, as he may be considered as passing through the various phases of the vegetable and animal kingdom until he arrives at the summit of the latter.

At first, the germ, or impregnated ovum, seems to possess little more than the characters of a vegetable seed: its structure is analogous and its growth is corresponding; it derives nutrition from the parent, expands, enlarges, and increases in vital activity.

As yet, the germ of the future being possesses no innate power of motion, and so far resembles the vegetable seed; but this state soon passes away, and the germ begins to acquire an organization and power of motion, and thus ascends from the vegetable to the animal kingdom.

And yet, during this first stage of Man's being, the Vital principle is in activity; or, in other words, the vital actions are called into operation, and by their influence the ovum soon becomes the embryo: from the simple cellular structure, resembling that of plants, the rudiments of the several tissues, which are afterwards to form the perfect structure, are laid down and gradually expand and develope themselves; the vessels begin to circulate the nutrient fluid, and to elaborate from this all the various component parts of the human body—here the rudiment of a hard and resisting bone is deposited, there the germ or nucleus of a future muscle; in another is laid the material from which a brain, an eye, or an ear is to be formed; and all these from the same material, and by vessels which are constituted in precisely the same manner.

Why or by what means does one set of vessels elaborate and lay down the rudiments of a bone, another those of a muscle, a third the elements of a future brain, &c.? How is it that these are deposited in the vast majority of cases in those places where they will afterwards be required; and this, too, months before they will be called into activity or use? Simply by the Vital Actions going forward in the tissues of the ovum—the result of a Vital Principle, which conducts and regulates these in obedience to the laws of Nature, imparted by an all-wise Creator, but which must ever be far beyond the scrutiny of Man. The acorn produces the lofty oak, the grain of wheat the waving corn, the human ovum the Intellectual Man; and yet each of these presents a close resemblance in their primitive condition. How different is the result! How mighty and wonderful the Principle, inculcated and implanted in each, which impels it onwards to its future destination!

The Laws of Nature, which are the laws of Providence, endow the germ with, as it were, an *organic intellectuality*, and it progresses under the guidance of this to its anticipated perfection.

This is the first stage of Vital action: it is that of simple nutrition and growth.

But as the ovum increases, the Vital actions become more fully developed, Life and Organization proceed, *pari passu*, with equal steps, and new phenomena present themselves. Innate motion is the first of these: the *punctum saliens*, the rudiment of the future heart, is seen to beat; and the first pulsation commences of that structure which is to "beat on," perhaps for a hundred years, millions of times without ceasing, without fatigue, without rest, until it rests for ever. This is muscular action, the great characteristic of Animal life; in a short space of time other muscles are formed, and the embryo begins to move in the womb of the mother.

We need not at present follow the successive changes which take place until the perfect being is formed: these will be considered more fully hereafter.

This Muscular action of the more perfect animals is produced by the *contractility* of the fibres of which each muscle is composed, and is caused by a peculiar arrangement or shortening of the muscular fibres, and so far is a physical action, and in no respect differs from any other physical agent placed under similar circumstances: the contractibility, on the contrary, is a *Vital phenomenon*, and its exercise, therefore, a *Vital action*.

Muscular Contractility is the great and most obvious characteristic of Animal life. If an object possess an innate power of motion, which enables it not only to contract certain portions of its frame, but also to pass from one locality to another, the Animal life of the object cannot be questioned.

The Vegetable kingdom presents examples of motion, but this is not produced by muscular contractility; it is the result of extraneous agents acting upon the body. A flower expands and contracts its leaves; but this motion is caused by the physical agency of heat and moisture, and is in no way analogous to the contractility of muscular fibre.

We have similar instances of contractility in the human body without muscular action. The skin, for example, contracts and expands under the influence of heat and moisture; but this is a physical, not a vital phenomenon, although occurring in a vital or living tissue, and is not the immediate result of a vital action; it cannot be considered as a vital phenomenon.

In the consideration of Vital actions—that is, in the study of Vital phenomena—we must always bear in mind that Life manifests itself only to us through the agency of physical means. A muscle contracts, but a muscle is composed of fibres; these are formed of physical material, and may be resolved into their elementary forms as any other substance may be. The eye sees; but the eye is a piece of mechanism, the most perfect, it is true, that can be constructed for this purpose. The object is formed upon the retina as upon a glass, the optic nerve conveys the impression of the object to the brain, which completes the sense of sight; but all these are material structures, and are subject to the laws which govern the physical world. In like manner, the ear hears, the tongue tastes, and the stomach digests; but all these actions are caused by physical agents under the control and influence of physical laws.

Many of the Vital actions may be imitated or closely approximated by Man. By means of physical and chemical agency, he can produce optic and acoustic instruments to resemble the eye and ear; he may change food into a substance resembling chyle; but he can go no further. His eye sees not, his ear hears not, and his chyliferous fluid will not nourish, unless exposed to the action of the living body: he cannot impart to these the Vital Principle; and all the physical and chemical agents at his command will not communicate to his productions any one of the Vital phenomena: he may construct the mighty Leviathan of the deep, which crosses the waters of the Earth at his command, or form the powerful engine which, at his bidding, raises the riches of the earth from its recesses, and dries up its waters: he may encompass the world with an electric chain, which conveys his wishes from one hemisphere to another with the rapidity of the lightning's flash;—but the feeblest plant which "bends before the storm," and "sighs at every blast," defies his ingenuity, and the smallest seed which the lowliest of the Vegetable kingdom produces laughs to scorn his skill: he cannot impart to the productions of his hand the smallest spark of Vitality. It is vain to attempt to ascertain what the exact nature of Life, or the Living Principle, is: we cannot understand it, we cannot define it; we know that it is a certain Principle attached to our Material being by an all-wise Creator, which is endowed with certain properties, and produces certain results; but beyond this we cannot proceed.

ORGANIZATION.

The Organization of Man comprises the assemblage of a number of organs, each of which has a special function to perform, and thus constitute—1. The Organic functions; 2. The Animal functions; 3. The Reproductive, or Generative functions.

THE ORGANIC FUNCTIONS

Are those which contribute to the support of the material fabric or organism of which Man is composed, and comprise the great functions of Digestion, Circulation, and Respiration, with the subsidiary functions of Absorption, Secretion, and Excretion.

In the Organic functions, Man closely resembles the Vegetable kingdom, inasmuch as, like this, he takes in a certain quantity of extraneous matter which he converts into nutriment for his support. This being acted upon by the atmospheric air is circulated through the body, and forms the different tissues of which this is composed, supplies the deficiencies in them, or repairs the defects induced by action, by decay, or injury.

These several functions are executed by different organs, the composition of which presents but little difference, although the office or function performed is so dissimilar.

It is true that, externally, they present but little resemblance to each other: the Stomach, the great organ of the Digestive function, is widely different in form and figure from the Heart, the centre of the circulation; this has no resemblance to the Lungs, the organ of the function of respiration. Yet, in their intimate composition, all these organs differ but little from each other, being composed of a number of cells containing in many instances the same material, and, in all, materials whose ultimate organization is analogous. The Stomach, for example, forms a large bag or cavity for the reception of the food, and is composed of a number of coats or coverings of which the muscular forms the principal. The Heart also forms cavities for the reception of the blood, and is composed chiefly of muscular fibres, which are formed of cells enclosing in their interior the contractile fibrillæ. The Lungs contain but few muscular fibres, yet their structure is also cellular; and if we could detach the fibrillæ from the cellular cavities of the muscular fibre, there would be little difference in the primary composition of all these organs.

It would appear that there is no analogy between the soft and hard tissues of the human body; as, for example, between the muscles and the bones, or osseous tissue; and yet we find they present a close resemblance in their organization. The basis of the bones is cellular tissue, in the cells of which the bony or osseous matter is deposited, instead of fibrillæ, as in the cells of the muscular structure.

So is it with the Nerves or Nervous structures: the basis of these is cellular tissue, in the cells of which Neurine is deposited, thus constituting them a portion of this peculiar system.

The *cellular tissue* forms the basis of all the structures of the body; and it is only the deposit in its cells, of one structure on another, which forms this into a muscle, a bone, a nerve, or any other of the component parts of the body. Some suppose that the enamel of the teeth presents an exception to this remark; but recent investigation has shown that this may well be questioned.

The component cells of the more permanent tissues are frequently held together by an *intercellular substance,* which presents little, if any, trace of organization, resembling gelatine in its composition: in various forms of cartilage there is a large amount of intercellular substance, in which the cells are scattered at irregular intervals.

The Adipose tissue of the human body is composed of distinct cells, which have the power of forming the fatty matter contained within them from the blood, precisely as the other secretions are eliminated by their secreting cells. In some cases, these cells are dispersed in the interstices of the areolar tissue; but in other cases, and more frequently, are collected in masses forming the true adipose tissue, as in the omentum, &c. The shape of these cells varies much: they are usually spheroidal, or egg-shaped, but become polyhedral when compressed.

In the cells of Cartilage is deposited the solidifying ingredient of this tissue, named *Chondrin;* but in all cases where cartilage is about to pass into the osseous or bony tissue, the chondrin disappears, and its place is supplied by gelatin, the principal animal ingredient in the composition of bone.

That Animal organization depends considerably on the agency of the cells which enter into its composition is now generally maintained, thus resembling closely the structure of plants which present a cellular structure. Each cell possesses an independent action in itself, and by this means the various processes of Nutrition and Reproduction are effected.

Each Cell is composed of an external *Cell-wall*, the composition of which is Albuminoid, and essentially the same in every part; and an internal *contained* structure. It is in this last alone that the greatest diversity exists, as necessary to the composition of the various substances of which the body is formed.

The *Cell-wall* not only forms the contents which it encloses, but it also possesses the power of growth, enlargement, reproduction, &c., so as to minister to its own existence and the exercise of its functions.

Most Animal Cells contain in their interior, either attached or lying free within the cavity, a peculiar body, of a round or oval shape, which is termed the *Nucleus*. Although the size of the Nucleus is tolerably uniform, being about the 15000th part of an inch in diameter, its consistence varies much, being sometimes nearly solid, as if composed of a number of granules: in other cases, the consistence diminishes towards the centre, and not infrequently presents a vesicular appearance, being possessed of an external covering, which encloses small granules of apparently fatty matter, named nucleoli. It is remarkable that the lining membrane of the nucleus is dissolved by acetic acid, whilst its contents are unaffected by this test; hence the latter may be obtained in a free state by the agency of this acid.

In the nucleus of the Cell-wall appears to reside the principal vital energy of the Cells; the Cell-wall appears to possess little of this power.

Cells may be originally produced in the midst of an organizable *blastema* formed for this purpose, or from the parent cell, by frequent subdivision, or by the disintegration of the nucleus, each fragment of which will produce a perfect cell. The development of Cartilage affords a good example of the development of Cells from the parent Cell.

The development of cells in the blastema (corresponding to the coagulable lymph of less modern physiologists) extends not only to the formation of the tissues of the body, but also to the reparation of wounds and ulcers, by which they are united, filled up, &c., the granulation of the latter being composed of cells thus formed.

The existence of *Cells* is not confined to the solids of the body; they are found also in the fluids—as the Blood, Chyle, and Lymph.

A Chemical analysis of the Animal tissues and products shows that the *proximate principles* of the Animal and Vegetable kingdom present a striking analogy, so that they may be regarded as the result only of different combinations of these, being composed of three or four elements, of which the atoms are combined in ternary or quaternary proportions, instead of forming a binary composition. It may be remarked, however, that the Vegetable kingdom is intermediate in its composition between the animal and mineral kingdoms, for whilst albumen and gelatin, which form so large a proportion of the animal kingdom, are quaternary compounds, the cellulose of plants is composed of but three elements.

The vegetable kingdom thus elaborates food for the animal, and by the combining of the oxygen, hydrogen, carbon, and nitrogen of the inorganic world, presents this in a form which the animal kingdom does not possess the power to combine. Water, carbonic acid, and ammonia, a compound of hydrogen and nitrogen, form the nutriment of plants, which transferred to the animal kingdom subserve its purposes, form its tissues, and are again resolved into their constituent parts, which are again to be taken up by the vegetable kingdom. The Vegetable aliments are the means of introducing a large quantity of the hydrates of carbon, such as starch and the different kinds of sugar, into the Animal composition. They undergo a combustion into carbonic acid and water, or exist as soluble bodies in particular fluids, such as the blood, the bile, and the urine; or perhaps contribute, by means of their elementary constituents, to the production of other substances.

Organization thus results from the mutual interchanges which take place between the elementary constituents of various bodies.

THE

ASSIMILATIVE FUNCTIONS.

THE Human body, as all Animal life, is constantly undergoing change; the older particles which form the several tissues are being absorbed, or taken up, to be discharged from the body as effete, whilst new particles are being as rapidly formed, to supply the place of those removed.

This process of constant change continues under all circumstances, whether the body is in motion or at rest, during waking or sleeping, so that it would appear that there is a continual waste of material in the support of life or the living body, although this may be quiescent as possible.

A person lying constantly at rest makes use of but little exertion, yet there is a considerable expenditure of material which must be supplied from the external world, to support the strength and maintain the life of the individual: the heart continues to beat, the blood to circulate, the skin secretes, the brain is in action; and from these alone a certain waste results, which must be supplied.

But the change is greater than that merely caused by the exertion or action of any part of the living body. It is a law of Nature, that all bodies, animate or inanimate, are constantly undergoing a change, and in obedience to this law are continually being changed; so that it is supposed that the whole body undergoes a change once every seven years, or that in a life of seventy the body is removed and renewed ten times.

But under usual circumstances, when the mind and body are both actively engaged, the waste of the material of the human structure is much more rapid; and hence the necessity of a larger amount of new matter being supplied to it.

This matter is supplied to the body from the external world. Certain substances are found alimentary or nourishing to the body when taken into the stomach, and through these, which constitute the food or aliment of the animal, the new particles are elaborated and conveyed to the different tissues of the body.

Before, however, the food is fit to supply the place of the animal tissues, it must be assimilated to these by certain organs of the body: these constitute the Assimilating organs, and the functions performed by them the Assimilative functions. They are those of 1. DIGESTION: 2. RESPIRATION; and 3. CIRCULATION. The first of these receive the food, and convert it into a milky fluid, the *chyle*, which being conveyed with the venous blood into the heart, is propelled by it through the pulmonic circulation; it is here exposed to the atmospheric air, and is thus converted into perfect or arterial blood; it now enters the general circulation, and in the smaller arteries of the body is assimilated to the various tissues of which this is composed.

DIGESTION.

Digestion consists of three important offices: namely, 1. The reception of the food; 2. The conversion of the nutrient particles of this into chyle; 3. The expulsion of the non-nutrient particles from the body. It is divided into eight different stages, according to the processes necessary to the completion of this function; these are, 1. *Mastication;* 2. *Insalivation;* 3. *Deglutition;* 4. *Chymification;* 5. *Chylification;* 6. *Separation;* 7. *Absorption;* 8. *Defœcation.*

The first process to which the food is submitted in the human body is that of Mastication.

The food is usually taken into the mouth in a form more or less solid; it is here exposed to the action of the teeth, which break it up, separate its fibres, and reduce it to a soft pulpy mass prior to being swallowed.

The principal agents in effecting these changes are the teeth, the tongue, and the muscles of mastication.

The teeth in all animals are wisely suited to the kind of food which each is destined to make use of. In the Graminivorous class, although some are formed for cutting or cropping the food, the principal teeth are broad and flat, for the purpose of grinding it into the necessary consistence. In the Carnivorous tribes the teeth are strong and sharp, some of them pointed, for the purpose of tearing their food, whilst the remainder are broad and flat, somewhat resembling those of the graminivorous class. The teeth of man partake of an intermediate character, as he is destined to feed on animal and vegetable food.

The incisor and canine teeth are little used by Man, as the process of cooking to which his food is generally submitted and the use of certain instruments supersedes to a considerable extent the action of these teeth. The molar teeth are those most used, and their action is to bruise and break down the material of which the food is composed. This is accomplished (the food having been taken into the mouth) by the *muscles of mastication* moving the lower jaw against the immovable superior maxilla in different directions, namely, upwards and downwards, and alternately from side to side: the first of these actions bruises the food between the teeth, and is accomplished by the elevator muscles, the *temporal* and the *masseter*. But these muscles, from the obliquity of some of their fibres, will also communicate to the lower jaw the lateral or grinding motions; thus, the middle fibres of the temporal directly raise the lower jaw, but the posterior fibres will draw this backwards, whilst the anterior fibres will draw it forwards, and the internal a little from side to side; in like manner, the anterior fibres of the masseter will draw the inferior maxilla forward, whilst the posterior will draw this bone backwards, as well as elevate it, so as to assist in triturating or grinding the food between the molar teeth. The action of the *internal pterygoid* muscles is to elevate the jaws directly. But when one muscle only acts, it will have the effect of throwing that side of the jaw towards the opposite, so that these muscles will either compress or triturate the food according as they act conjointly or separately. The *external pterygoids* are the principal agents in communicating the lateral or grinding motions to the lower jaw; and as they draw the condyles of the inferior maxilla forwards, they tend at the same time to open the mouth.

But little muscular action is necessary in the *depression* of the lower jaw, as gravity alone is sufficient for this purpose; still, the smaller muscles attached to the base of the inferior maxilla tend to this action, namely, the *digastric*, *mylo-hyoid*, *genio-hyoid*, &c. The *buccinator* muscle is of use in compressing the cheeks chiefly against the gums and teeth, so as to prevent the food from passing between these.

Whilst the food is thus being ground and triturated, the tongue is actively engaged in turning it from side to side, in collecting the scattered fragments from different parts of the mouth, and placing them between the teeth. To this end, its numerous muscles admirably adapt it, as by their action its tip is depressed, elevated, or directed to every quarter, as may be required; and as these act in harmony with the masticating muscles, every portion of the food is carefully submitted to the action of the teeth.

As mastication proceeds, the salivary and mucous glands about the mouth pour their secretions into its cavity, and thus the food becomes impregnated with saliva and mucus. The former acts as a solvent on the food, completes the process of Insalivation, and thus assists materially in the digestive process; the latter does little more than lubricate the food, and prepare it for the act of deglutition, or swallowing.

When the food is thus *Masticated* and *Insalivated*, its several particles are collected together by the tongue, so as to form the *alimentary bolus*, when deglutition takes place.

DEGLUTITION is a compound action, as not only has the alimentary bolus to be swallowed, but the larynx is to be protected, and the food prevented from passing upwards into the posterior nares.

Deglutition is performed in the following manner: the lower jaw is raised so as to afford a fixed point of attachment to the muscles engaged in deglutition, whilst the mouth is closed to prevent the particles of food escaping anteriorly. The alimentary bolus is now placed on the dorsum of the tongue, the tip of this organ is raised and pressed against the hard palate, it is now rendered convex and shortened from before backwards by the action of the *lingualis* and *genio-hyo-glossus* muscles. This action has the effect of forcing the alimentary bolus into the *isthmus faucium*, whence it passes rapidly into the pharynx; at the same moment the larynx is drawn upwards and forwards beneath the root of the tongue by the *genio-hyoid*, *mylo-hyoid*, and *digastric* muscles, the result of which is that the glottis or upper opening is covered and protected by the root of the tongue and by the epiglottis, which is compressed upon it. The *velum pendulum palati* or soft palate, is raised by the *levatores palati* muscles, and stretched laterally by the *tensores palati*, so that its posterior margin touches the back of the pharynx, and it forms an inclined plane directed downwards and forwards. This action closes the upper extremity of the pharynx, and thus prevents the food being passed upwards; at the same time the muscles of the pharynx prepare this cavity for the reception of the alimentary bolus. In the quiescent state, the pharynx is closed, or nearly so, but at the first stage of the act of deglutition it is expanded from before backwards by the elevation of the larynx, as already described, assisted by the *stylo-pharyngei* and *palato-pharyngei* muscles, which have the additional action of expanding it from side to side; the *constrictores isthmi faucium* now close the fauces in front, and the *constrictores pharyngis* muscles contract on the alimentary bolus, which is rapidly forced downwards through the pharynx into the œsophagus, the *superior*, *middle*, and *inferior* acting consecutively.

As soon as the alimentary bolus enters the œsophagus, all the muscles relax, and the parts fall into their natural or quiescent state, by the effect of gravity and especially by the descent of the larynx, and thus remain until the act of deglutition is about to be repeated.

The alimentary bolus passes more slowly through the œsophagus, the muscular fibres of which contract from above downwards, so as to resemble the motions of a worm, hence termed its vermicular action. The bolus thus descends into the stomach. The *tonsils*, or *amygdalæ*, serve to lubricate the food as it passes through the pharynx, and also the surfaces of this cavity; and as these glands lie between the lateral half arches of the palate, they are compressed by the muscular fibres in their interior, and their secretion is forced outwards at the moment of deglutition.

The swallowing of fluids is accomplished in a similar manner, but with less muscular action.

The *Epiglottis*, although useful, is not indispensable to the act of deglutition, as it has been frequently destroyed by disease and gunshot wounds, and this act has not been impaired thereby. The soft palate, however, is essential, as, when destroyed, the food, and especially fluids, are frequently thrown upwards into the posterior nares, and so forward tnrough the nasal openings in front, the patient being compelled to close them with his fingers, or other mechanical means, to prevent such disagreeable results.

The food being received into the stomach remains in its cavity for a considerable time, but varying according to its nature, and especially as to its digestibility. As a rule, the more fluid or softer portions pass rapidly from it into the duodenum, or are taken up by the absorbents of the stomach, and are thus at once conveyed into the general circulation. In proof of this, the odour of turpentine taken into the stomach may be detected in the urine in the course of a few minutes after it has been swallowed; and the peculiar odour imparted to this fluid by asparagus, and other vegetables, may be detected in nearly an equally short period.

That portion of the food which undergoes digestion in the stomach, and which is destined to supply the nutritious particles necessary to the blood, is first converted in the cavity into a peculiar fluid named *chyme*. This change is effected in the left or great bulging extremity of the stomach, which is separated or shut off from the pyloric end by the circular muscular fibres which surround it, near to the junction of its middle and pyloric thirds. By the contraction of these fibres, the stomach presents an hour-glass shape, and may be considered as a double rather than a single cavity. By the contraction of the oblique fibres at the cardiac extremity, and also of the longitudinal fibres, the mass of food is kept nearly in constant though gentle motion, so that each portion may be successively exposed to the action of the coats of the stomach, and become impregnated with the *Gastric juice* and other secretions of the mucous membrane and glands. The food is prevented from re-entering the œsophagus by the sphincter of the cardiac orifice, and so is exposed to the pressure of the stomach itself, the diaphragm, and abdominal muscles; but this pressure is slight, and has but little influence on the digestive process.

In the course of from three to four hours generally, the food is converted into chyme, and is gradually passed towards the pyloric end as this change is effected; that which is most exposed to the stomach is first changed, and is consequently the first to reach the pylorus.

Although this orifice is usually closed by its valve and circular muscular fibres, it offers no resistance to the properly digested food, which passes at once into the intestines; but in case any undigested portion should present itself, the pylorus contracts, and it is again returned to the cavity of the stomach to be completely digested. If, however, it be wholly indigestible, it is finally passed into the intestines, whence it may be expelled.

This power of selection on the part of the pylorus has been attributed to some peculiar property in its structure, which enables it to distinguish between the digested and undigested food; but this seems to be an error on the part of physiologists, as the selection is more apparent than real, the rejection of the undigested mass being owing to its acting as an irritant to the mucous membrane lining the muscular fibres, which are thus thrown into a state of contraction, and throw back the morsel or object. After some repetitions of this process the strange body ceases to act as an irritant, and is permitted to pass. In this manner, pins, needles, pieces of pencil, coins, and even clasp-knives, have been swallowed and passed into the intestines.

The chief agent in the *Chymification* of the food is the *Gastric juice*, which is derived from the *vertical gastric glands*, clusters of which may be easily recognised by a low magnifying power in the mucous membrane: they are distinct from the follicles which secrete the mucus of the stomach, are more numerous than these, and of a complex structure.

The *Gastric follicles* or *glands* are arranged in bundles or groups on the mucous membrane, and open in the bottom of pits, from three to five in each, which give to the membrane, under the microscope, a somewhat honeycomb appearance.

The Gastric juice, although constantly present, is secreted more abundantly on the entrance of food, or other stimulus, into the stomach, when the mucous membrane becomes turgid with blood, the numerous minute papillæ erect themselves through the coating of mucus, and pour forth their secretion.

As the Gastric juice is of a decidedly acid character, its solvent property is attributed to a free acid which it appears to contain. This was long considered to be the *hydrochloric*, but later physiologists consider it rather to be the *lactic* acid; but this may not only be furnished by the stomach, but may proceed from the decomposition in the stomach of the hydrates of carbon or other substances. Other acids, as the butyric and acetic, are occasionally found in the stomach, these productions being influenced by the ingesta.

The Gastric juice also contains a peculiar organized compound named *Pepsin*, which somewhat resembles albumen. When the mucous membrane of the stomach is digested in warm water, and subsequently in cold water, pepsin, not being soluble in the former, is obtained. When evaporated to dryness, there remains a brownish viscid mass, having the odour of glue. Pepsin appears to be united with the acids in the stomach, with which it forms compounds, having still an acid character. In this state it acts powerfully on albuminous substances, preparing them for being acted upon by the free acid of the stomach.

That the Gastric juice acts as a solvent on the food is proved by the experiments of Spallanzani and others, who introduced food in hollow perforated balls, and found that digestion was accomplished; as also by the submitting of food to the action of the Gastric juice taken from the stomach of a living animal, when the same results were obtained.

The ancient physiologists attributed digestion to the muscular action of the stomach, to fermentation, putrefaction, and decoction; but these theories are not now received.

The Nervous influence has a powerful effect on the digestive process, promoting or suspending this according to the state of health and vigour of the individual; but its influence is most probably indirect, and operates through the agency of the Gastric juice, the secretion of which depends much on the state of the nervous system.

It is a remarkable fact that cold lessens considerably the solvent process of the gastric juice and digestive influence of the stomach generally, so that cold fluids taken into the stomach in large quantities must be inimical to the digestive process. The higher temperatures also injure the process, which is most rapidly performed under a temperature of from 96° to 105°. These remarks apply only to warm-blooded animals.

There is much variety in the digestibility of various substances used as food by Man: of albuminous matters, the fibrine of blood offers less resistance than the albumen of hard-boiled eggs; muscular fibres are more easily digested than tendinous or ligamentary structures; hard cheese is but slowly digested, and frequently passes intact into the duodenum. According to Frerichs, the thicker muscles of the adult offer more resistance than the smaller of young animals. Boiling or roasting to a moderate extent, assists the digestive process.

The *Casein* of milk is precipitated by the action of the gastric juice, as is seen in the action of rennet.

Vegetable albumen, legumin, gluten, and gelatin, are freely dissolved in the stomach; but in the denser structures, such as tendons, ligaments, and cartilage, the gelatin is with difficulty dissolved.

As a general rule, the smaller the substance the more easily is it digested; hence the advantage of a perfect mastication of the food, and where this cannot be effected, of the reduction of the food into small portions by artificial means.

The moderate use of stimulants, such as salt, pepper, and mustard, is considered to promote digestion, as causing an increased flow of the gastric juice.

The quantity of gastric juice secreted by the healthy adult in twenty-four hours, has been variously estimated at from fourteen to seventeen *pounds*;* but this estimate cannot be received, as the whole of the ingesta seldom reaches its amount; other estimates place it at one-fourth this quantity, which still must be excessive.

Digestion cannot be said to be completed in the stomach, as the fluid produced in it differs from the *Chyle* in several essentials.

Chyme is a homogeneous pultaceous mass, of a grey colour, of a slightly acid taste, but varies according to the food taken, being of a creamy aspect when oily substances have been taken, and of a whitish colour when farinaceous food has been swallowed in quantity; it is often mixed with undigested or partially digested matter.

The *Chyme* passes from the stomach into the duodenum, and is here submitted to the action of three additional fluids, namely, the mucous secretions from the glands and mucous membrane of the intestine, the *Bile*, and *Pancreatic Juice.*

The *Glands* of *Brunner* are the principal sources of the mucous fluid, which is supposed, by Bidder and Schmidt, to possess a solvent power, and to be especially active in the solution of albuminous matter, and in the conversion of starch into sugar.

The *Bile* is secreted by the liver, and is poured into the duodenum in large quantities from the gall-bladder and liver through the ductus communis choledochus

* This is probably a misprint for *ounces*.

during the digestive process. This fluid has a double action :—1. It assists in the formation of the chyle, with which some of its ingredients unite, and are thus taken into the general circulation ; 2. It separates the *Recrementitious* from the *Excrementitious* portions of the intestinal contents, precipitates the latter, with which other of its ingredients unite to form the fæces, or feculent matter, to be discharged from the system.

That these effects are produced by the bile, is shown by mixing this fluid with newly formed chyme, in a glass vessel, when the mixture separates into three portions :—1. A reddish brown sediment, which precipitates to the bottom ; 2. A whey-coloured fluid, which occupies the centre ; and 3. A creamy substance which forms on the top. The first of these is the excrementitious portion, the second is the dissolved albuminous and other matter, whilst the last is composed of oleaginous matter, destined, with the preceding, to be taken into the system, and form the recrementitious portion of the food.

As the Bile is easily decomposed under the test of chymical experiment, its component parts are with difficulty ascertained. Berzelius and Mulder suppose that a neutral organic substance, *bilin*, forms the principal ingredient ; whilst, on the other hand, Liebig and his followers are of opinion that certain organic acids are united with soda, to form fatty salts, so as to resemble a soap. According to Strecker, the bile contains a mixture of two soda compounds, one of which is formed by the cholic and the other by choleic acid.

The choleic acid is decomposed by putrefaction into ammonia, taurin, and a resinous mass. Its sulphur is probably due to the taurin, which Redtenbacher regards as an acid sulphite of aldehyd-ammonia. The dyslysin, which is precipitated in the course of the alimentary canal, may be obtained from cholic acid by continued boiling in dilute hydrochloric acid. The quantity of bile poured daily into the duodenum, is estimated at fifty-six ounces, or nearly four pounds avoirdupois; an estimate far beyond the actual quantity, as the amount of food taken is scarcely sufficient to supply this secretion alone.

The *Pancreatic Secretion* is also poured into the duodenum. This fluid closely resembles the saliva, from which it is said to differ only in not containing *sulpho-cyanic* acid. The pancreatic juice has been found by M. Bernard, to contain an organic compound which has the power of emulsifying fatty matter, so that the oleaginous matter in the chyme is thus prepared for absorption; it is also supposed to assist in the conversion of starch into sugar in the intestines.

The pancreatic fluid of animals in a healthy state is poured out in considerable quantities during the time of digestion only. Its character seems to be very easily altered by abnormal circumstances. Leuret and Lassaigne, Tiedemann and Gmelin, Bernard and Frerichs, inserted a tube into the pancreatic duct of living animals and birds; but the fluids thus obtained differed essentially from each other: for some of these observers found considerable quantities of albumen, which were not detected by others. On the other hand, almost all remarked an alkaline character of the fluid so obtained. But the watery extract of the fresh pancreas of the cow has an acid residuum.

As a healthy secretion can scarcely be expected under the performance of such an experiment, the results are seldom satisfactory.

The *Chyle* thus formed in the duodenum is a milky fluid closely resembling the blood, although not of a red colour; it contains albumen, fibrin, fatty matter, and salts, with a trace of oxide of iron. It has been supposed that the milky colour of the chyle was owing to the oil globules, but this opinion has been set aside by Mr. Gulliver, who attributed it to the presence of a number of extremely small molecules or globules, which he has described as the *molecular base* of the chyle. The diameter of these molecules is estimated at between 1·24000th and 1·36000th of an inch.

Chyle coagulates like blood, and separates into serum and clot: the latter contains many of the chyle corpuscles, surrounded with an oily film; the former also has some chyle corpuscles suspended in it.

It is only in the thoracic duct that the chyle begins to have a pinkish hue.

As the alimentary mass passes from the duodenum through the jejunum and ileum, it is exposed to the action of the absorbents or lacteals, which, opening on the inner surface of the mucous membrane, take up the chyle, or recrementitious particles, and convey it through the mesentery and mesenteric glands into the thoracic duct, and thence into the general circulation.

As the small intestines are in the human subject about thirty feet in length, and the lining mucous membrane is thrown into numerous folds, the *valvulæ conniventes*, which probably increase this surface at least threefold, and as the intestinal contents are propelled onwards in a spiral or corkscrew direction, the chyle is fully exposed to the action of the lacteal vessels, so that it is completely absorbed into the system.

The most active absorption takes place in the jejunum, hence its name (*jejunus*, hungry); but it continues in the ileum down to the colon, or large intestine, into which the excrementitious portion of the food passes to be expelled from the body, constituting the last step of the process, namely, *defæcation.**

As soon as the intestinal contents are passed into the *cæcum*, or *caput coli*, they assume all the characters which distinguish the fæces of the animal—that is, become changed in colour, and of an odour more or less disagreeable. This change has been attributed to the secretion of the vermiform appendix, but without sufficient grounds, and again to the putrefactive process

* For intestinal glands, see *Secretion*.

with as little reason: the true cause of the change is still unknown. The fæces pass slowly along the large intestines until they reach the rectum, whence they are finally expelled. In this course, they are exposed to the absorbents of the large intestines, which take up some of the watery portions of the fæces, and such nutritious matter as may have escaped the absorbents of the small intestines.

The act of defæcation, or expulsion of the fæces, is effected by the combined action of the lower part of the large intestines—especially the rectum, the abdominal muscles, and diaphragm—which overcome the resistance of the sphincter ani muscle for this purpose. This act is only partially voluntary, and in some casés is completely beyond the control of the will.

The sphincter ani, although a voluntary muscle, has a peculiar action. It is usually in a state of contraction, so as to close the anus; but when influenced by the will, as in defæcation, relaxes so as not to oppose the expulsor muscles; this is a reflex action transmitted from the intestine to the lower part of the spinal cord.

Although the term *solution* has been applied to the action of the various fluids on the alimentary mass, it must not be supposed that this process is that of simple solution, corresponding to the solution of gelatin, albumen, or other substances, out of the body. It is true that it does resemble this, but the digestive process advances farther, and *assimilates* the food to the blood itself, and this not only in its arterial character and internal composition, but also by imparting to it that vitality which is so essential to the maintenance and repair of the living structures of the body. No approach to this change can be made out of the living body, which preserves the power of imparting, to the inanimate mass of food, a portion of the vitality which it possesses, in order that it may derive from this, a fresh accession of vitality and strength.

This is one of the mysteries of Nature which alike defy the scrutiny of Man and his powers of ingenuity to imitate, and which, although acting in obedience to certain fixed natural laws, are the result of the providential dispensation of an all-wise Creator.

RESPIRATION.

As Life is sustained by the abstraction of certain elements from the external world, so decay or death is produced by the return of these in one form or another to the source from which they were originally derived. All the phenomena of the living body are the result of constant interchanges between the organic and inorganic world.

In Digestion, the elements taken in are derived from the animal and vegetable, rarely from the mineral world. In the function of Respiration, the elements of nutrition are derived from the atmospheric air, which is absorbed or taken into the system, circulates through it, and is then discharged, or thrown off.

As already so frequently stated, the living body is constantly undergoing a certain amount of *waste* or *decay*. One source of this is the formation of carbonic acid, which is constantly being expelled from the body in the excretions and in the expired air.

Carbonic acid is composed of carbon and oxygen; the former of these is derived chiefly from the food taken into the body; the latter is obtained from the atmospheric air, and hence we have the two great sources from which the expenditure of carbonic acid is supplied.

Respiration is the most extended function in the animate world, as no life, even in the most humble form, may subsist without this process; the meanest vegetable breathes, and is as dependent on this function for its humble life as Man himself is. Unlike the function of digestion, respiration is constantly going forward, and cannot be suspended, except for a few moments.

The function of *Respiration* consists in the alternate inhalation and expulsion of atmospheric air from the lungs; in these organs, the inspired air is exposed to the blood in the venous capillaries; a mutual interchange takes place, the venous blood absorbs oxygen from the atmospheric air, which unites with the carbon of the venous blood, and forms carbonic acid, which is expelled in the expired air.

Some physiologists consider that the union between the oxygen of the air and the carbon of the blood does not take place in the lungs, but in the general capillary circulation; that oxygen is absorbed in the lungs, unites with the arterial blood, and in the capillary circulation meets with carbon formed in the decomposition of the several tissues, forms carbonic acid, which is taken up by the venous blood, is carried with it to the pulmonic circulation, and is here passed off from the body with the expired air. This is the more probable theory.

The process of Respiration is thus divided into two acts, namely, the *Mechanical* and *Chemical.* The *Mechanical* is the mechanism by which respiration is performed; the *Chemical* is composed of the several changes which take place between the blood and the atmospheric air. *Mechanical Respiration* is divided into *Inspiration* and *Expiration.*

Inspiration, or the inhalation of the atmospheric air, is produced by the expansion of the chest, and consequently of the lungs contained within its cavity; this is effected by several powerful muscles, which are hence called the muscles of Inspiration.

The Chest or Thorax is enlarged during inspiration, in every direction, namely, in the vertical, or from above downwards; the transverse, or from side to side; and in the antero-posterior, or from before backwards.

The vertical enlargement of the thorax is chiefly effected by the contraction of the diaphragm, and its consequent descent towards the abdomen. This is a compound action, and depends on the previous contraction of the trapezius and serratus magnus muscles: of these, the trapezius first acts, so as to fix the scapula; the serratus, acting from this, as a fixed point, draws up and fixes the lower ribs, which thus antagonize the diaphragm, which contracting acts from the ribs towards its central tendon; but this being also fixed by the attachment of the pericardium to its upper surface, the muscular fibres of the diaphragm shorten themselves, obliterate their curve, and thus descend towards the abdomen. These three muscles are supplied respectively by the *spinal accessory* or *superior external respiratory*, the *inferior external respiratory*, and the *inferior internal respiratory*, or *phrenic nerve;* and as these nerves arise from nearly the same point of the spinal cord, they are enabled to act in harmony under the influence of reflex action.

The elevation of the ribs enlarges the thorax in all directions, as these bones are not only raised but are thrown outwards, so as to be separated from each other, whilst their anterior extremities are thrown forward. The principal muscles in raising the ribs are the *intercostal*, the *serratus magnus anticus*, *serratus superior posticus*, and *levatores costorum*; but, in forced inspiration, the *pectorales major* and *minor*, *sterno-mastoid*, and *subclavius*, will assist directly by raising the ribs, and the *trapezius*, *rhomboideus major* and *minor*, and *levator anguli scapulæ*, indirectly, by fixing the scapula, and, still more indirectly, the dorsal mass of muscles by fixing the spinal column.

The principal muscles of ordinary inspiration are the diaphragm, intercostals, serratus anticus and serratus superior posticus; the rest may be considered as the muscles of extraordinary or forced inspiration.

Expiration succeeds inspiration after a brief interval, and is accomplished by the gravity of the thorax, which causes the descent of the ribs and the sternum, and by the reaction of the costal cartilages, which are more or less twisted in the act of inspiration: it is also effected by muscular contraction; thus the abdominal muscles, namely, the *external and internal oblique*, *rectus* and *transversalis*, by compressing the abdomen, force the viscera upwards, and so cause the ascent of the diaphragm into the thorax, in which action the *levator ani* assists; they also draw down or depress the ribs, in which action they are assisted by the *quadratus lumborum* and *serratus inferior posticus*, and by the *latissimus dorsi*, which compresses the lower part of the thorax. The *triangularis sterni* muscle acts in expiration from the ensiform cartilage, and thus draws down the costal cartilages.

The *Diaphragm* acts as a muscle of expiration, by drawing inwards the lower ribs, if these have not been previously fixed.

The ordinary muscles of expiration are the abdominal muscles, quadratus lumborum latissimus dorsi, serratus inferior posticus, and triangularis sterni: the extraordinary are those which assist in fixing the spine and pelvis.

As the chest or thorax becomes enlarged in inspiration, it follows that the lungs are expanded with it, as they are compelled to keep in close contact with the inner surface of the chest by the atmospheric pressure, otherwise a vacuum would be formed between the outer surface of the lungs and the inner of the thorax, which is a physical impossibility; the result is, that the atmospheric air rushes into the lungs, through the trachea, to prevent this vacual tendency, and these organs become distended with this fluid. If an aperture existed in the side of the thorax the air would rush equally in through this, provided the aperture equalled the glottis in size; if less than this, the atmospheric pressure through the glottis would prevent the air entering through the smaller aperture, as takes place in small wounds of the thorax; at the same time the pressure on the external wound will have some effect, and some air will enter the thoracic cavity.

The act of *Inspiration* is slow, and occupies at least two-thirds of the time consumed in the complete act of respiration; as from 15 to 20 acts of respiration take place in the minute, it follows that about two seconds are consumed in inspiration and one in expiration: by this means, the inspired air is more completely exposed to the blood in the capillary vessels of the lungs, and the carbonic acid is rapidly expelled.

A common bellows affords a good illustration of the action of the thorax in respiration; by the separation of the boards of the bellows a vacuum would be formed between them, were it not that the atmospheric air rushes through the aperture to fill the cavity. Now if we suppose the bellows to be lined with an elastic bag which expands with the sides at will, we can understand that this bag will be filled with the air, and on compression of the walls that this air will be again expelled, either through the aperture by means of which it entered, or by any other aperture provided for the purpose.

In Man the air passes to and from the lungs through the nasal cavities, as well as by the mouth, and, if either be closed, the other is sufficient to sustain life.

Nature has well provided against any lengthened interruption to the function of respiration, as the air-passages are so constructed as to remain constantly open under ordinary circumstances; thus, the larynx, trachea, and bronchial tubes are formed of resisting cartilaginous structure, which cannot be closed unless under considerable pressure; the larynx is the only part liable to much alteration, as it is provided with chordæ vocales, to assist in the formation of the sounds of the voice, and to regulate the transmission of the air to and from the lungs, which are acted upon by muscles, and thus may be closed spasmodically when exposed to irritants, or from constitutional causes; but this will be more fully considered when we treat of the formation of the voice.

The *Structure of the Lungs* is admirably adapted to the mutual exposure of the atmospheric air, and blood, as it consists, not of one large cavity, but of a number of small cavities, the *air-cells* of the lungs, by which means the surface available for the exposure is increased many hundred times.

M. Rechoux has calculated the number of air-cells in the human lungs at *six hundred millions*, and that 18,000 of these are attached to each terminal bronchial tube.

That this arrangement increases the surface available for the purpose of respiration, is at once apparent, if we take a pint or quart measure empty, and calculate the area of surface upon its interior. Now let us fill the measure with extremely small shot, or other spherical bodies, and the surface becomes enormously increased—increasing, in fact, in an inverse ratio with the size of the shot used.

The *structure* of the air-cells differs from that of the trachea and bronchial tnbes, as they do not contain cartilaginous tissue: they are composed of a lining mucous membrane, on their free surface; external to which is a thin layer of muscular fibres, according to some physiologists, and next a thin layer of areolar tissue.

Although the presence of muscular fibres cannot be demonstrated in the air-cells of the lungs, the phenomena presented in the disease of Asthma, and the relief obtained in this by stramonium and other antispasmodic medicines, leave no doubt of the contractibility of these structures, and we may infer their muscularity.

The contractility of the air-cells may operate advantageously in the healthy state, as by the constriction of the air-cells, the atmospheric air will be forced more rapidly and more perfectly into contact with the venous blood in the capillary vessels; nay, the air may by this means be retained in them for a certain length of time until the necessary changes are more completely effected. That this is the case is rendered highly probable from the fact that it is extremely difficult to extract the air from the lungs when respiration has once been performed; even under an air-pump they cannot be emptied of this fluid.

This minute subdivision of the air-cells of the lungs is only to be found in warm-blooded animals.

The quantity of air respired at each act of respiration varies considerably: in ordinary inspiration, 20 cubic inches are about the quantity usually taken in; whilst in forced inspiration ten times this, or 200 cubic inches, may be forced to enter the lungs. Mr. Hutchinson, whose experiments on this subject are so interesting and valuable, states that he found 70 cubic inches to enter a thorax of moderate capacity, under a pressure of 104 lbs.; that when 190 cubic inches are forced in, a pressure of 326 lbs. is necessary; and when 200 cubic inches are made to enter the pressure rises to 452, and this without taking into account the effect of the elastic pressure of the lungs themselves.

The *Capillary vessels* of the lungs ramify on the opposite surface of the air-cells, and thus a certain extent of membrane intervenes between the atmospheric air and the venous blood; but this is found not to prevent the ingress of the air, although it prevents the escape of the blood externally. This is in accordance with the laws of *endosmose*, in which we find that the more subtle fluids pass freely through membranous surfaces to join the more dense; still there is no doubt that the passage of the air through the tissue of the air-cells is a vital action, and we should be much in error if we supposed that the laws of endosmose are not regulated and controlled by the vitality of the animal tissues, as there are many instances in the living body where these laws are inactive, as in the stomach, bowels, blood-vessels, &c., under many circumstances.

That the interposition of a membrane does not prevent the transmission of the atmospheric air, is proved by experiment. If venous blood be enclosed in a bladder, and hung up in a current of air, it is changed into arterial, and becomes of a bright red colour.

If venous blood drawn from the arm be covered with a piece of talc, it is rapidly changed into arterial.

If a large vein, such as the internal jugular, be opened in a living animal, and exposed to a current of atmospheric air, the blood in its interior is seen to become of a bright red colour.

The atmospheric air having been brought into contact with the venous blood, that important interchange of the constituents of these fluids takes place which constitutes

THE CHEMICAL ACT OF RESPIRATION.

The *Atmospheric air* is found to consist, under ordinary circumstances, of three ingredients—viz., oxygen, nitrogen, and carbonic acid. In 100 parts of atmospheric air the proportions of these are, oxygen 20, nitrogen 79, carbonic acid 1. Of these, the carbonic acid is an adventitious ingredient, being produced by the respiration of animals and plants, and by the decomposition of both animate and inanimate matter, and need not therefore be considered in the present inquiry.

When the atmospheric air is brought into contact with the blood in the venous capillaries of the lungs, the oxygen and nitrogen are partially absorbed or taken into the system, and the place of them is supplied by carbonic acid and nitrogen exhaled. Of the oxygen, eight parts are absorbed at each inspiration, so that twelve parts remain, whilst the quantity of nitrogen is unchanged, as much being exhaled as is absorbed.

Valentin states that the carbonic acid in expired air, in ordinary respiration, ranges between 4 and 4·5 per cent.; but if the lungs be distended to the utmost, that the quantity increases to between 7 and 8 per cent.

The place of the absorbed oxygen is filled by carbonic acid, so that the exhaled or expired air is composed of oxygen 12, nitrogen 79, carbonic acid 9.

This was the opinion formerly entertained by physiologists, who considered that the quantity of oxygen absorbed, exactly equalled that contained in the carbonic acid exhaled; but more recent investigation has proved that this is not the case, and that a larger quantity of oxygen is absorbed during inspiration than is exhaled during expiration, the excess of oxygen being consumed by uniting with the original components of the body, to form the several compounds, as phosphoric acid, water, &c.

The quantity of oxygen absorbed is also found to vary considerably, according to the strength and vitality of the individual, the age, the sex, the temperature of the surrounding atmosphere, and the degree of exertion used. The nature of the food will likewise influence the consumption of oxygen, animal requiring more than farinaceous diet.

It would appear from these facts—as, *à priori*, should be expected—that the consumption of oxygen varies according to the vital powers of the individual, and the degree to which these are excited.

Numerous experiments have been performed to ascertain the quantity of carbonic acid thrown off from the lungs by various animals. The following experiments, performed on animals enclosed in a limited quantity of air, show some of these results:—

	Temp. at 32°.	Temp. 59° to 68°.	Temp. 86° to 106°.
	Grammes.	Grammes.	Grammes.
Canary	0·325	0·250	0·129
Turtle Dove	0·974	0·684	0·366
Two Mice	0 531	0·498	0·268
Guinea Pig	3·006	2·080	1·453

As carbonic acid is given off in the excretion of the skin, as also in other of the secretions of the body, it is impossible to ascertain the quantity excreted by one particular structure.

In order to ascertain the entire quantity of carbonic acid set free, with as little disturbance as possible to the respiratory functions, Professor Scharling constructed an air-tight chamber of sufficient size to enable a person to remain in it for some time without distress, and eat, drink, and sleep in it. From experiments performed, the following calculations were made as to the quantity of carbon consumed in 24 hours:—

		Weight.	Grains.		Oz. Troy.
No. 1.	A male, æt. 35	131 lbs.	3387	or	7·0
2.	,, æt. 16	115½	3453		7·2
3.	Soldier, æt. 28	164	3699		7·7
4.	Girl, æt. 19	111	2540		5·3
5.	Boy, about 10	44	2054		4·3
6.	Girl, æt. 10	46	1930		4·0

Professor Liebig endeavoured to ascertain the relative quantities of carbon given off in the form of carbonic acid, by comparing the quantity of carbon taken in as food with that contained in the fæces and urine. The difference he assigned to the respiratory function; but his experiments were not conducted with sufficient care to obtain a satisfactory conclusion. He estimates the quantity given off per diem at 13·9 oz.; but this is evidently excessive. We may infer from Scharling's experiment, that the actual quantity given off amounts to between 7 and 8 oz., when the individual is in a state of comparative rest. If to this we add from 1 to 3 oz., according to the state of exertion, we shall have from 9 to 10 oz. as the quantity given off daily; and this is the most probable quantity.

Professor Scharling ascertained from other experiments, that the carbonic acid given off by the skin amounted to from $\frac{1}{30}$ to $\frac{1}{50}$ of the whole amount; so that if we take the average at $\frac{1}{40}$, out of 8 oz. of carbonic acid given off, the skin will exhale $\frac{1}{5}$ of an ounce.

From the quantity of carbonic acid exhaled during respiration, the air of densely crowded places, such as theatres, &c., if not frequently renewed, becomes most oppressive and dangerous. Fortunately, from its greater gravity, it descends towards the surface of the earth, and here becomes absorbed by vegetables and plants, and decomposed into its elements of carbon and oxygen.

The poisonous effects of carbonic acid are frequently seen from the burning of charcoal in close rooms, in brewers' vats, deep wells, &c.; numerous cases of almost instantaneous death have occurred from the respiration of this gas in a concentrated state. A lighted candle should always be introduced where the presence of carbonic acid gas is suspected, as if the air will support combustion it is found also to support life. The light should be passed down to the lower part of the suspected reservoir, as from the gravity of the gas it lodges in this part, whilst the upper stratum of air may be comparatively free. Some fatal cases have occurred in breweries from the neglect of this precaution.

Dr. Snow has ascertained by experiment that carbonic acid gas acts most powerfully when the normal quantity of oxygen has been reduced, and hence that the process of respiration vitiates the air, not only from the production of the carbonic acid, but by the destruction of the oxygen; so that in this state it is more dangerous to life than when a surplus of carbonic acid has been introduced whilst the normal quantity of oxygen has not been lessened. He concludes, from experiments on lower animals, that the presence of 5 or 6 per cent. of carbonic acid in atmospheric air respired by the human subject is dangerous to life, and that even the half of this quantity would soon be fatal if formed at the expense of the oxygen. From this it would appear that the stimulus of the oxygen acts as an antidote, or antagonist, to the destructive influence of carbonic acid.

The respiration of carbonic acid, although not immediately fatal, tends to depress the vital energies, and to produce diseases of an asthenic character; hence the necessity in all crowded dwellings, workshops, factories, &c., of dispelling this gas as effectually and as rapidly as possible, and of supplying a constant current of pure atmospheric air.

As the combustion of candles, gaslights, and almost every description of flame, produces carbonic acid, and destroys oxygen, the influence of these in vitiating the air should be opposed by the most perfect ventilation. In these cases, the burning flame may be made to correct the evil which it induces, by placing over it a tube, or other contrivance, for the escape of the vitiated atmosphere.*

The debility felt in the ascent of mountains is produced by the rarity of the atmosphere, which thus contains in a given bulk but a small proportion of oxygen.

The use of *Nitrogen* in the atmospheric air seems to be as a diluent to the oxygen, as it is found by experiment that the respiration of pure oxygen acts as a powerful stimulant to the lungs, and will bring on inflammation of these organs. Guinea pigs, and other animals, confined in glass vessels containing pure oxygen, suffer in this manner.

Under ordinary circumstances, there is no difference in the quantity of Nitrogen contained in the inspired and expired air, so that equal quantities are absorbed and exhaled. MM. Regnault and Reisat have found that when warm-blooded animals are not fed upon their

* As plants exhale carbonic acid during the night, the presence of them in bedrooms is objectionable.

accustomed food, or when food is altogether withheld, an absorption of nitrogen takes place; whereas, under opposite circumstances, the quantity of nitrogen in the atmosphere has been increased. In the hybernating animals, the absorption of oxygen and nitrogen is found to exceed the exhalation of carbon.

As already stated, physiologists are divided as to whether the carbon of the venous blood unites with the oxygen in the capillaries of the pulmonic circulation to form carbonic acid; or that this union takes place in the capillaries of the general circulation, carbonic acid being formed in them, and thence conveyed by the veins to be discharged from the lungs.

From the preceding observations, it will be gathered that the latter theory is probably the more correct one, and this is that now generally received.

We have now to consider the changes effected in the blood by contact with the atmospheric air.

The blood circulating in the venous system is of a dark red colour, and in this state enters the right side of the heart; from the right ventricle, the pulmonary artery conveys the venous or dark blood, by its capillary branches, to the air-cells of the lungs, on the outer surface of which these ramify and anastomose with the corresponding branches of the pulmonary veins, so as to form a complete network of vessels. As the venous blood passes through the capillary circulation, it is exposed to the contact of the atmospheric air, is converted into arterial blood, which is received by the capillaries of the pulmonary veins, which convey it to the left side of the heart, to be propelled through the general circulation.

The arterial blood, thus formed, differs from the venous in—

1. Colour.
2. Temperature.
3. Constituent parts.

The Arterial blood is of a bright red or scarlet colour:

this change is owing to the separation of carbonic acid from the venous blood, and to the absorption of oxygen from the atmosphere. The experiments of Magnus show the relative proportions of the gases in venous and arterial blood, thus:—

	Venous Blood.	Arterial Blood.
Carbonic Acid . .	71·6	62·3
Oxygen	15·3	23·2
Nitrogen	13·1	14·5

The change in the colour of the blood is assigned to the action of the oxygen on the red corpuscles, and especially on the iron which is contained in the Hæmatin, although some physiologists assert that the colouring matter of this substance does not depend on the presence of iron in it.

The difference in the temperature of the Venous and Arterial blood was at one time considered to be very great. But more recent investigation has proved that this is not the case, and that it seldom exceeds 1°. That the arterial blood contains a larger quantity of heat cannot be questioned; but it exists in it in the *latent state*, and is given out in the capillary circulation, thus forming the great source of the animal heat which sustains the temperature of the body during life. The blood parts with a considerable portion of its heat during respiration, this being carried off with the respired air, or with the watery vapour which is present in this.

It is found, that whatever the temperature of the inspired air may be, that of the expired air is heated to the same temperature as the blood—namely, 97° to 98°: this increase of temperature is derived from the arterial blood, and forms a considerable waste of the vitality of this fluid in cold climates. Again, in warm climates, where the temperature exceeds that of the blood, the temperature of the expired is less than that of the inspired air.

The venous blood *loses a large portion of its water* during expiration; this passes off from the lungs in the form of watery vapour, which becomes condensed in cold weather on the external air passages or other exposed surfaces, as is seen in the colder months of the year. The quantity of water thus exhaled is estimated at from sixteen to twenty ounces in the twenty-four hours; but this seems to be an over-estimate. This water is derived from the fluids absorbed, and also from the union of oxygen and hydrogen in the construction of the animal tissues, and in the decomposition of these.

The expired air also, usually, contains more or less animal matter, in a gaseous state; this gives to the breath of the animal much of its peculiar odour, and in some cases, is more or less offensive, from the presence of decayed teeth or other causes tending to decomposition—as in phthisis pulmonalis, gangrene of the lungs, abscesses in the mouth, caries, &c. The expired air frequently contains some of the elements of the food taken, which are conducted from the alimentary canal to the respiratory organs, and thence exhaled. Camphor, turpentine, alcohol, asparagus, and other substances, are easily recognised in the expired air.

There can be no doubt that arterial blood contains a higher amount of vitality than the venous, which it imparts to the various structures of the body, endowing these with the necessary vigour, as these suffer materially when blood imperfectly arterialized circulates through their vessels. The brain affords a strong example of this, its functions being rapidly destroyed under the influence of the dark or venous blood; this injurious effect results both from the deficiency of oxygen and the presence of an excess of carbonic acid.

Mr. Hutchinson has performed numerous experiments to ascertain the capacity of the lungs during respiration, and has invented instruments for this purpose;

a detailed account of which, although of much interest, would be out of place here. By means of an instrument termed a *Spirometer*, he examined 1923 men, most of them vigorous subjects, and found that the vital capacity varies with the height of the body, the volume of air increasing eight cubic inches for every inch of height. But the results obtained do not lead to such a simple progression with numerical accuracy. They are as follows:—

Average Vital Capacity in cubic inches, according to Hutchinson.

Height in Inches.	Experiment.	Calculation.
60 to 61	174	174
61 " 62	177	182
62 " 63	189	190
63 " 64	193	198
64 " 65	201	206
65 " 66	214	214
66 " 67	229	222
67 " 68	223	230
68 " 69	237	238
69 " 70	246	246
70 " 71	247	254
71 " 72	259	262

The use of the Spirometer in ascertaining the condition of the lungs, must be extremely valuable.

The act of Respiration affords an illustration of the reflex action of certain portions of the nervous system: the principal nerves engaged in it are, the *spinal accessory*, or *superior external respiratory* of Sir Charles Bell, the *phrenic*, or *inferior internal respiratory*, the *posterior thoracic*, or *inferior external respiratory* supplying the trapezius, serratus magnus anticus, and the diaphragm, the intercostal nerves supplying the intercostal muscles, and the branches of the lumbar plexus supplying the abdominal and the lumbar muscles engaged in this process.

The action of these muscles under ordinary circumstances is wholly involuntary—that is, takes place without any interference of volition. When Expiration has been performed, a slight interval of rest takes place; this gives rise to no perceptible uneasiness, but if prolonged beyond a few seconds, at first an uneasy, and then a distressing sensation arises in the cavity of the chest, tending to the act of inspiration; the want of inspiration, not affecting the sensorium, is transmitted to the spinal cord, whence the reflex action proceeds to the nerves of inspiration, and this act follows.

Here we observe a sympathy of action between the nervous filaments of the pneumo-gastric, which supplies the lungs, and the nerves of inspiration, by which the necessities of the individual are made manifest to the nerves of inspiratory motion, without any exertion of the intellect, which excite the muscles to contract, so as to produce the desired result.

But other nerves participate in this sympathetic action: the portio dura of the seventh pair, the fifth nerve, the glosso-pharyngeal, all assist in preparing the air-passages for the free transmission of the atmospheric air. If these should be closed, by the irregular action of the nerves or of the muscles supplied by these nerves, the act of inspiration could not be performed, and death would result; this, however, seldom takes place, except through the agency of the muscles of the glottis, which are occasionally thrown into spasmodic contraction, and prevent the ingress of the atmospheric air. The act of inspiration is thus a compound action, and requires the combined action of the respiratory nerves for its perfection; and this is induced not only by the indirect sympathy which exists between these nerves, but also by the more direct sympathetic action which results from the close relation which the principal nerves bear to each other in their origin from the medulla oblongata and spinal cord.

Before the act of Respiration has been performed, the lungs of the fœtus are of a dark red colour, and sink in water: their relative weight to the rest of the body is considerably less; and this holds good even where artificial respiration has been effected, as in this no influx of blood takes place into the lungs, as occurs in natural inspiration.

Some cases have been lately recorded in the Medical journals, in which partial inflation of the lungs has taken place, although the child has not been born alive. This is an important fact in connexion with medical jurisprudence.

The cause of the first act of inspiration has been assigned by physiologists to the stimulus of the atmospheric air upon the external surface of the body; but this is no doubt a vital action, and dependent on the laws of the animal economy, which are brought into activity, by a vital necessity, the exact nature of which is not to be explained. It is, however, certain, that stimulating the skin, by slaps on the surface, or by the sprinkling of cold water on newly born infants, will excite the act of inspiration.

ASPHYXIA.

The term *Asphyxia* is applied to that state of suspended animation which is induced by the stoppage of the act of respiration by mechanical or chemical agents, as hanging, drowning, the inhalation of certain gases, &c.

In this, all the symptoms are present which we should expect to arise from the imperfect decarbonization of the blood: the countenance becomes livid, the eyes suffused, the tongue protrudes from the mouth, and by degrees the body assumes a wholly or partially livid appearance, and death supervenes.

The non-carbonized blood acts directly on the brain and nervous system, paralysing them, and ultimately the muscles supplied by them. It doubtless acts directly on the muscular fibres themselves, but it is impossible to ascertain the precise amount of this action, which is independent of the nervous filaments distributed to them.

In *hanging*, the act of respiration may be arrested by mechanical pressure on the laynx or trachea or by compression of the principal nerves of inspiration.

In *drowning*, asphyxia and death are induced by the spasmodic closing of the glottis, caused by the irritation of the particles of water first taken in, coming into contact with the chordæ vocales. As this action continues for some time after death, the lungs in drowned persons, who have not been long under water, do not contain any of this fluid.

Asphyxia may be induced, in the inhalation of gases, either by the spasmodic constriction of the muscles closing the glottis, or by the direct action of the gas on the blood and nervous system: the former takes place in the inhalation of the irritating gases, as the nitrous acid, sulphurous acid, chlorine, &c.; the latter from the inhalation of carbonic acid; carburetted hydrogen and sulphuretted hydrogen appear to combine these two actions. Other gases, which do not produce either of these effects, may prove fatal by occupying the place of the oxygen, so as to induce death indirectly.

THE CIRCULATION.

The Circulation is the last in order of the three great assimilating functions: for as the functions of digestion and respiration assimilate the food and convert it into arterial blood, so the circulating vessels convey the blood to the different tissues of the body, and assimilate this fluid to the various component parts of the body.

From the blood are also eliminated the several secretions, which either assist in the performance of other functions or are thrown off from the body as excretions.

As already stated, every tissue in the body is constantly being changed; the older materials are being absorbed and so removed from the body, whilst new materials are being deposited in their place: this change calls for new elements of nutrition, which are produced from the food taken into the body, and are conveyed by the circulating vessels to its minutest and most distant part.

The whole of the component parts of the body, although absorbed and taken into the circulation, are not at once thrown off as excretions: many of them are decomposed into their elements which form new combinations, and are thus returned to enter into and form a portion of the new tissues.

The *active* agents in the circulation of the blood are, 1. The heart; 2. The arteries; 3. The veins. The *passive* agent is the blood; if, indeed, this fluid, possessed as it is of vitality, can be considered as a perfectly passive agent.

The complicated organization of Man and the more perfect functions which he enjoys require a corresponding organization of the circulating system; hence we find in him, and in animals most closely resembling him, an arrangement of the circulating organs not found in the lower and less highly organized animals.

Man possesses a complete double circulation, namely, a *Pulmonic* and *Systemic;* each of which may be said to be distinct from the other, although connected by means of their blood-vessels and the heart.

The Pulmonic Circulation is that of the blood through the lungs, and is performed as follows: the right ventricle of the heart having received the venous blood from the right auricle, propels it through the pulmonary artery and its branches through the lungs, where it is converted into arterial blood; this is taken up by the pulmonary veins, which convey it into the left auricle, whence it passes into the left ventricle; at this point the Systemic or General Circulation may be considered as commencing: the left ventricle contracts, propels the blood into the aorta, and thence over the whole arterial system, whence it passes through the capillary circulation into the veins; these convey it back to the heart; it enters the right auricle, whence it passes into the right ventricle, to be again transmitted through the lungs.

The two circulations communicate only through the heart, if we except the trifling anastomosis between the bronchial and pulmonary vessels; and thus may be considered as distinct.

Two different qualities of blood are in constant circulation: one is, the venous, dark, or carbonized blood; the other is the arterial, red, or decarbonized blood. The first circulates through the veins and right side of the heart; the last through the arteries and left side of the heart. The pulmonic circulation is an exception to this, as the pulmonary artery conveys the black or venous blood, the pulmonary veins the red or arterial blood.

The arrangement of a double circulation as in Man is repeated in adult mammals and birds; but in reptiles, fishes, and lower tribes of animals, a single circulation only exists, the ventricles communicating by a gap in the septum; or there being but one auricle and one ventricle or, finally, no heart, but a circulation of vessels only.

The object of the Pulmonic Circulation is to discharge from the venous blood the carbonic acid which has been generated in the capillary circulation and taken up by the veins, as also to absorb a certain quantity of free oxygen to assist in the formation of some of the compounds of which the body is formed, as phosphoric acid, &c. By its means also the new-formed chyle is exposed to the action of the atmospheric air before it enters the general circulation.

The object of the Systemic or General Circulation is to maintain the life of the individual, and to repair the waste which is constantly going forward in the system.

The *Portal Circulation* is a minor circulating system contained within and forming part of the Systemic Circulation: thus the blood, which has been collected by the veins connected with the function of digestion, instead of directly entering the vena cava, is returned by a separate trunk, the *vena porta;* this again breaks down into branches, which ramify through the liver, prepare the secretion of the bile, and join the venæ hepaticæ, which finally open into the inferior vena cava, and thus join the general circulation.

The Portal Circulation may be considered as subsidiary to that of the lungs, and to aid these organs in the separation of carbon from the blood.

The HEART in Man consists of four cavities, two auricles and two ventricles, placed one on each side, and named respectively the right auricle and right ventricle, the left auricle and left ventricle.

The *Auricles* are placed at the base of the heart, and form but a small portion of its bulk, although these cavities are somewhat larger than those of the ventricles. They are so named from their supposed resemblance to a dog's ear. They do not communicate in the adult, being separated by a muscular partition, the septum auriculorum; they possess but a thin layer of muscular fibres, most of them being collected into bundles, forming the "musculi pectinati."

The *use* of the auricles is to receive the blood, the right from the vena cava, the left from the pulmonary veins, and hold it until the ventricles are prepared to receive it from them; they thus act as reservoirs to the ventricles. They have no influence on the general circulation, their muscular coat being sufficient only to propel the blood into the ventricles, and occasionally to cause a slight regurgitation in the veins from which they receive the blood.

Each auricle communicates with its ventricle by means of a large opening, the auriculo-ventricular opening, except during the action of the ventricle, when this aperture is closed by its valve.

The Ventricles form the largest portion of the heart, at least four-fifths; and of this the larger portion is formed by the left ventricle, whose muscular coat is much thicker and stronger than that of the right ventricle. Like the auricles, they do not communicate, being separated by the "septum ventriculorum." Their cavities are somewhat less than those of the auricles, and that of the left is a trifle less than the cavity of the right ventricle.

The *Pulmonary artery* arises from the upper extremity of the right ventricle, and by its means the blood contained in this is conducted into the lungs, being propelled along the artery by the contraction of the right ventricle; as the pulmonary artery ultimately breaks down into capillary branches which ramify on the outer surface of the air-cells, the venous blood in them is exposed to the atmospheric air, and becomes changed into arterial, parting with its carbonic acid, and a portion of water, and absorbing oxygen gas. (*See* RESPIRATION.)

The arterial blood is now conveyed by the pulmonary veins arising from the capillary arteries, by corresponding capillary branches from the lungs into the left auricle: this propels the blood through the left *auriculo-ventricular opening* into the left ventricle, which contracts, and forces the blood into the aorta, and so through the general circulation.

As the Ventricles of the Heart are the great agents in the circulation of the blood,—the right through the Pulmonic, the left through the Systemic System—they are provided, and especially the left, with powerful muscular fibres: these consist of two sets, a superficial and deep, composed of oblique fibres; the former are common to both ventricles, the latter are confined to one. They take an obliquely spiral course round the ventricle, and thus contribute mainly to the obliteration of its cavity, and the consequent propulsion of the blood from its interior.

In the interior of each ventricle, the muscular fibres are collected into bundles forming the *Carneæ columnæ*, the most important of which are those which are attached by means of the *Chordæ tendineæ* to the edges of the auriculo-ventricular valve, and finally into the zona annularis, as they perform the office of retaining the valve, in the auriculo-ventricular opening, when the ventricle contracts.

The action of the auricles is simple, as it is confined to forcing the blood from their cavities into the ventricles: as the blood enters the right auricle at its opposite extremities by the descending and ascending cava, the two currents are prevented clashing, by means of the tuberculum Loweri, which directs them inwards towards the auricular appendix. The Eustachian valve may assist in directing the current from the inferior cava; but as it is frequently obliterated in the adult, its use is not of importance. The contraction of the auricle then forces the blood downwards through the auriculo-ventricular opening into the ventricle; but as the cavæ are unprovided with valves at their extremities, some regurgitation takes place, as is seen in the large veins at the root of the neck.

The blood from the auricle having filled the ventricle, this contracts; the auriculo-ventricular opening is closed by the blood being forced upwards against the inferior surface of its valve, the attachment of the carneæ columnæ to the edge of which now proves beneficial, as this would pass back into the auricle, in consequence of the shortening of the ventricle from its apex to its base during its contraction, but that the carneæ columnæ contract equally with the ventricle, and thus prevent this taking place.

It is stated by some physiologists that the carneæ columnæ also act in drawing down the tricuspid valve;

but as this would involve a double action in the muscular fibres of these bodies, it is not probable that such takes place, especially as such action would interfere with that harmonious contraction of all the muscular fibres of the ventricle so necessary. The tricuspid valve is depressed by the blood being forced against it by the contraction of the auricle.

That portion of the tricuspid valve which is turned towards the opening of the pulmonary artery has had assigned to it the office of preventing the blood entering the pulmonary artery during the contraction of the auricle, by Lieutaud (hence called the Septum of Lieutaud) and other physiologists; but this also is an error, as the pulmonary artery is closed by its own valve at this moment. These observations apply to the bicuspid valve of the left auriculo-ventricular opening.

The muscular fibres of the ventricle contracting, compress the blood in its cavity; it can escape but in one direction, that is, towards the artery, whose valves are forced upwards by the current of blood which enters the vessel, and is carried by it through the pulmonic circulation in the case of the right ventricle and pulmonary artery, and through the systemic circulation in that of the left ventricle and aorta.

The contraction or systole of each ventricle is followed by its dilatation or diastole, induced by the reaction or elasticity of its muscular fibres; this produces a vacual tendency in the ventricular cavity, which assists in drawing the blood, as it were, from the auricle, so as to fill the ventricle. Each ventricle thus acts as a suction- as well as a forcing-pump.

The pulmonic circulation is thus carried on principally by the contraction of the right ventricle; but some physiologists contend that the alternate contraction and expansion of the chest and lungs assist in this; as in the former the blood-vessels are more or less compressed, so as to press the blood onwards towards the left auricle, and in the latter act there is a vacual tendency in the lungs, which causes the blood to rush onwards. This view is strongly supported by the influence which artificial respiration evidently exerts in aiding the circulation, and by the relief obtained by a full inspiration, in many cases where the heart feels uneasy and oppressed. The act of sighing is doubtless frequently induced for this purpose.

The action of the left auricle and ventricle is similar to that of the right side of the heart, and need not be entered into more distinctly.

The left auriculo-ventricular opening is provided with a valve, which consists of but two portions: hence it is named bicuspid, or mitral. The carneæ columnæ of the left ventricle are stronger, but less numerous, than those of the right ventricle.

In the contraction of the heart, the auricles act together; so do the ventricles: the four cavities act alternately, so that during each pulsation there is a double contraction; but that of the auricles is not felt in the pulse. The auricles and arteries, the ventricles and veins, act simultaneously. The semilunar valves, which lie in the orifices of the pulmonary artery and aorta, offer no impediment to the flow of blood from the ventricle; their office is to prevent the reflux of the blood into the ventricle when the arteries react or contract.

The left ventricle, by means of its powerful muscular fibres, propels the blood with considerable force into the aorta, so that its impulse is felt at the extreme points of the system, and in the smallest arteries, exceeding the size of the capillary vessels. This gives rise to the alternate distension and contraction of the arteries, which is known as the *pulse*, and is felt usually at the wrist, although to be distinguished with care in all the more superficial arteries.

The contraction of the ventricles causes the action which is known as the *beating of the heart*; it is generally felt in the interval between the fifth and sixth ribs on the left side, a little below the nipple of the left breast.

The beating of the heart has been assigned to the elongation of the heart immediately prior to its contraction. Kewisch observing that when a muscle contracts, the length of its fibres diminishes, while their transverse fibres increase in size, attributed the impulse of the heart to this.

Others assign it, and more correctly, to the resiliency of the heart, which being confined by the large blood-vessels at its base, the apex is thrown forwards at the moment of contraction.

The quantity of blood capable of being contained in each of the cavities of the heart is estimated at from 3 to 4 oz. Now as the quantity of blood in the body is estimated at about one-eighth the weight of the individual, it will amount in a person weighing 144 lb. to 18 lb. If we calculate the pulsation of the heart at 74 to the minute, allowing 3 oz. of blood to be propelled at each beat, 222 oz. will be passed into the circulation in this space of time, and the whole quantity will pass through the heart in about 75 seconds: but it by no means follows that the whole of the blood passes through the heart in this manner, as that which circulates in the cardiac vessels and in those nearest the heart may pass respectively through the heart in the course of one minute, whilst the circulation in the lower extremities may not pass for some minutes.

The impulsive force of the left ventricle has been the subject of numerous calculations, and of the most varied character. Some estimate it at 40 lb., others so low as 4 lb. According to Valentin, the contraction is equal to $\frac{1}{50}$th part of the weight of the body; of the right ventricle, to $\frac{1}{100}$th part of the same weight. In a man weighing 150 lb.—rather more than the average weight—this would give an impulsive force of 3 lb. to the former, $1\frac{1}{2}$ lb. to the latter—a power much less than is evidently in action during life. Hales fixed a long glass tube in the carotid artery of a horse, and found that the column of blood ascended more than 78·7 inches, before its weight formed a counterpoise to the current force of the blood.

This experiment has been frequently repeated, and with similar results. From these, it has been estimated that the heart in Man exceeds a force of 13 lb. at each systole, sufficient to propel a column of blood in the aorta to the height of 7½ feet. Hering having met with a malformation of the parietes of the thorax in a calf, wherein the heart protruded externally, availed himself of it to ascertain the impulsive force of the cavities of the heart. He introduced a glass tube of sufficient length into the right ventricle, a second into the left ventricle, and a third into the right auricle. The blood, of course, rose just so far as the hydrostatic pressure of the liquid column could be sustained by the corresponding part of the heart. The minimum of the right ventricle was 20·36 inches; that of the left, 38·86. The corresponding maximum were 23·7, and 38·55. The right auricle gave a result of 7·91, or about one-third the pressure of the right ventricle. The contraction of each ventricle drove its column of blood from 1·7 to 2·24 inches upwards, and that of the right auricle from 0 59 to 1·14 inches.

The number of pulsations of the heart per minute varies considerably at the different periods of life. In the very young it ranges from 130 to 140; in the adult it is about 74; and in the old subject, sinks to from 60 to 50. It is found also to be affected by exercise, by mental excitement, the state of the health, and many other causes.

THE ARTERIES.

The *Left Ventricle* having propelled the blood into the aorta, the trunk of the arterial system, the fluid is conveyed by this vessel, and its several branches, to the different parts of the body.

The *Arteries* are composed of three coats: an external areolar, a middle fibrous, and an internal serous lining membrane. The External coat, formed of areolar tissue, is loose and spongy on the outer surface, but becomes more condensed where it is in contact with the middle coat. Its use is to give toughness to the artery, and to allow of the vasa vasorum to break down in it before entering the middle coat.

The Middle is the strongest coat of the artery; its structure consists of the yellow fibrous tissue, or "*tissu jaune*" of the French anatomists, and corresponds to the same tissue in the ligamentum nuchæ of lower animals, the ligamenta subflava, &c.; its fibres are longitudinal and oblique. In this coat, reside the strength, elasticity, and contractility of the arteries.

The Internal lining membrane of the arterial system belongs to the class of serous membranes; it is thin, smooth, and polished.

The Middle coat of the artery is that which is most instrumental in the circulation of the blood; but the exact nature and extent of the assistance which it renders have been the subjects of almost endless controversy amongst physiologists, and are still undecided.

The strength of the middle coat is considerable, and has been found sufficient to support a weight of some pounds. The aorta of the cow will sustain a weight of 24 lb., and the smaller arteries a lesser weight, in proportion to their size.

The elasticity of the middle coat of the arteries is apparent on the least examination.

That the middle coat of arteries possesses contractility cannot be questioned, as a divided artery is known to contract in both its longitudinal and transverse measurements; but the question arises whether the contractility is due to its elasticity or to an independent power of contractility corresponding to muscular action.

Muscular fibre cannot be demonstrated in the fibres of the yellow tissue. On laying bare the carotid of a living animal, we see no phenomena which would in any way prove a capacity of instantaneous contraction; and generally (if not always) even an artificial mechanical irritation has no effect. Against these may be adduced the facts, 1. That a divided artery contracts, as before stated; 2. That if a ligature be applied to an artery, the vessel will empty itself of blood beyond the ligatured parts; 3. That cold applied to a bleeding surface causes a constriction of the bleeding veins; 4. That the arteries of a recently dead subject resist the passage of an injected fluid, the resistance passing off after a short lapse of time; 5. That in the act of blushing, the blood is driven to the vessels of the cheeks without the other parts of the body participating. It would be impossible to enter here fully into the discussion of this question: it will be sufficient to state, that the prevailing opinion amongst modern physiologists is that the larger arteries only are elastic, but that the smaller or capillary arteries possess an independent muscular contractility.

The elasticity of the arterial system is of use, 1. In moderating the impulse of the left ventricle; 2. By reaction, in propelling the blood onwards; 3. In preventing the current of blood being stopped in the interval between the contractions of the ventricle.

It is evident that if the aorta were a rigid inelastic tube, the whole power of the left ventricle would be exercised upon it, and that possibly rupture would take place: this indeed occurs when the elastic power is impaired; in consequence, however, of its elasticity, the impulsive force of the ventricle is divided in propelling the blood and in distending the artery; a portion of the force is thus expended in the middle or elastic coat, whose principle of elasticity is brought into play, and reacts upon the blood in its cavity; this is propelled onwards, so as to keep up a continuous flow of the blood in the capillary vessels, and to prevent the blood in the larger vessels losing the impetus which has already overcome the vis inertiæ common to it and all bodies: there is a considerable gain in this respect, as the left ventricle, when it contracts, meets with a body in motion and not in a state of rest.

The *pulse* is felt almost simultaneously in all parts of the body: a slight difference of time in the beat of the more distant vessels may be occasionally felt, but it is so extremely slight as to be with difficulty recognised; this results from the impulse of the left ventricle being given to the whole column of blood in the arterial system, and which may be supposed to be a solid substance, so that the shock received at the cardiac extremity is communicated directly to the extreme end: that such is the case is fully proved by the fact that when an artery is divided the blood is thrown out per saltum at each systole or contraction of this ventricle; but as the artery is not a perfectly rigid tube, some little time is expended in the *arterial wave* reaching the more distant arteries.

The elasticity of the arteries answers the same purpose as is effected by the air-chambers in the fire engines, and almost all engines which are used to propel water to a considerable distance: the action of this is to moderate the stroke of the pump, to receive a portion of the power in the elasticity of the contained air, and to give this out when the pump is not in action, so as to keep the water in constant and equable motion, in which state it passes out from the extremity of the water-tube.

The results that ensue from a rigid arterial tube are manifest in the advanced periods of life, when the arteries lose their elasticity and become converted into bone: aneurism and rupture of the blood-vessels are the consequence.

The muscular fibres present in the smaller vessels are of the non-striated class. The presence of muscular fibres in the larger arteries would be rather prejudicial than otherwise to the circulation; as in case of those contracting independently of the heart, a serious impediment would be offered to the flow of blood through the whole system, to be followed in many cases by instantaneous death. This action in the smaller vessels is of little consequence, as its effects are but local, and are neutralized by the freedom of the anastomosis amongst these vessels.

Most, if not all, the phenomena in the larger arteries attributed to muscular action are the results of the resiliency of the elastic power, or of the organic contractility which almost all living structures possess to a greater or less extent.

The capacity of the arterial system is tolerably uniform; that is, the capacity of the branches is generally equal to that of the trunk from which they proceed; thus, if the area of the trunk be 50, that of its branches will be about the same. It appears, however, from Mr. Paget's admeasurements, that there is seldom an exact equality between the area of a trunk and that of its branches, the area sometimes increasing and sometimes diminishing: the former appears to be the rule in the upper part of the body, the latter in the lower; thus the area of the external carotid is to that of its branches as 100 to 119, whilst the area of the abdominal aorta, just before its final division, is to that of its branches as 100 to 89.

It follows from this arrangement that the current of blood in the lower parts of the body, and far removed from the heart's action, receives a greater amount of the impulsive force of the left ventricle, whilst the vessels of the brain and upper parts are preserved from undue propulsive power by the capacity of the smaller vessels exceeding that of the larger.

The Arteries terminate in their capillary branches, which communicate with the capillary branches of the venous system. By some physiologists the capillary circulation is considered as a distinct system; but this separation is nearly an artificial one, as the functions of each set of vessels correspond to the system to which it belongs, and the structure is nearly analogous. It is customary to speak of capillary arteries and capillary veins, and it would be extremely difficult to describe these vessels without adopting this distinction; nor can we suppose an intermediate order of vessels which are neither arteries nor veins, and perform a species of mixed function.

The *capillary* vessels are so called from their extreme hairlike minuteness, and are found in all parts of the body, but especially in the skin and mucous membrane, which are composed chiefly of a network of capillary vessels. The capillary arteries want the elastic or middle coat, but possess muscularity and independent contractility, as is seen in blushing, local inflammation, and other local actions: some terminate in anastomoses, others in the capillary veins, whilst others open on the free surface of the several tissues, thus depositing the structures from which these are formed, or elaborating the various secretions. The more minute capillaries carry only the serum and colourless particles of the blood, but under inflammation become enlarged and admit the red corpuscles.

The blood in the capillary arteries flows in a continuous stream, and not per saltum as in the larger arteries.

The network formed by the capillary circulation is found to vary in the different tissues; in the muscular system these run parallel to the fibres, in the interstices between these, and communicating by a few transverse branches; a similar arrangement is observed in the Nervous trunks, but in the Nervous centres a minute network is formed which traverses every part of the structure: this is also the case in glands, the air-cells of the lungs, the skin, mucous membrane, &c. This arrangement is doubtless influenced by the functions of the parts supplied, and is the result of the actions necessary in the exercise of these, regulated by the principle of vital action which is inherent in all the structures of the body.

The sectional area of any capillary network is estimated by Volkman to be four hundred times greater than that of the arterial trunks which supply it; hence the circulation is less active in the capillary system, and the necessary secretions are more perfectly elaborated from the blood.

As the different tissues of the body and the various secretions are formed from the blood in the capillary arteries, the nutritive particles of this fluid and the oxygen received during the respiratory process are separated from it; the former enters into the elements necessary for the support of the body, the latter unites in larger proportions with the carbon formed in the decomposition of the tissues and forms carbonic acid; this is taken up by the capillary veins, to be conducted to the heart and lungs, to be again renewed and decarbonized, again arterialized, and fitted for general circulation.

The junction of the carbon and oxygen in the capillary vessels is attended, as in cases of combustion, with the evolution of heat, which supports the temperature of the body, and forms the animal heat of the individual.

The Arteries are supplied with blood not directly from their own cavity, but from the neighbouring smaller arteries; these terminate in the coats of these vessels, and finally in small capillary veins, forming the vasa vasorum: they are easily injected, and form a beautiful network in the areolar tissue, before entering the middle coat.

The nerves of the arteries are derived from the Sympathetic System; and hence these vessels, as well as the heart, are independent of volition, although influenced by emotions, which have their seat in the cerebro-spinal system; blushing is an illustration of this and the opposite condition—great paleness, frequently induced by mental impressions.

THE VEINS.

The *Veins* are a distinct set of vessels from the arteries, not only in function or office, but also in structure: their coats are thin and comparatively weak; they are found collapsed in the dead subject, although containing blood; they possess little elasticity, and but slight contractility.

The Veins are also composed of three coats, an external, formed of condensed areolar tissue, a middle fibrous, and an internal serous lining membrane. The middle coat possesses no muscular fibres,* excepting in the inferior vena cava; and the internal is thrown into numerous folds of a semilunar shape, forming valves.

The middle coat of the veins has been described by some as partaking of the nature of the middle coat of the arteries, and possessed of elasticity; but such property in the veins, although so useful in the arterial system, would be most injurious to the circulation of the blood, as tending to destroy the action of the valves, and thus impair most seriously the venous circulation.

Let us take, for example, the Internal Saphena Vein, which, from its superficial course, and the use of articles of dress, is most liable to occasional compression, and from its position in the lower extremities is disposed to have its cavity in a state of considerable distension; if, from the combined influences of these and other causes, the cavity of the vein become much distended, and the vein itself possessed elasticity, this would cause an enlargement of the cavity

* Kölliker describes muscular fibres in the middle sized veins.

of the vein, a separation of the edges of valves, and the consequent destruction of their valvular action.

The weight of the whole column of blood would thus be thrown on the lower part of the limb, and a rupture of the vein would most probably be the result.

This is, indeed, the cause of formation of that state of the venous system which is known by the term Varicose; a state which, if the veins were elastic, would be present in every person, and not confined, as it is, to a few.

The veins arise from the capillary arteries by small branches, termed capillary veins, which again unite to form the various branches and trunks, and finally terminate, with the exception of the veins of the heart, in the venæ cavæ ascendens and descendens.

There are two sets of venous trunks, the *superficial* and *deep:* the former lie almost immediately beneath the skin in the subcutaneous areolar tissue, although sometimes beneath the fascia; the latter accompany the arteries in pairs, one lying on each side of the artery, and forming the *venæ comites*, excepting in the large arteries, such as the carotid, femoral, &c., which have but one vein accompanying them.

The valves are most numerous in the smaller veins; some of the large veins possess no valves, as the vena porta and venæ cavæ.

The circulation of the blood in the venous system is towards the heart: in effecting this, the veins are nearly passive, the inferior vena cava only possessing muscular contractility, to enable it to assist in the propulsion of the blood. The venous circulation, then, is carried on or maintained, by :—1. The vis à tergo from the capillary vessels; 2. Pressure of surrounding muscles and neighbouring arteries; 3. Gravity; 4. Contraction of inferior vena cava; 5. The vacual tendency in right auricle.

The vis à tergo, or impulse from the capillary arteries, is continued along the capillary veins and thence into the venous trunks: it is considerable, as it is more or less under the influence of the left ventricle, as well as the muscular contractility of the capillary arteries themselves. This action is analogous to the ascent of the sap in trees, which is exceedingly powerful. If the stem of a vine, or any tree in which the sap ascends rapidly, be cut across, and a bladder be tied on the cut surface, the sap ascends with such power as to burst the bladder. If a bent tube be attached to the cut stem, and mercury poured in so as to indicate the pressure exerted, the sap is found to rise with a force equal to from one to three atmospheres, from fifteen to forty-five pounds on the square inch and upwards. The ascent of the sap is partly, but not wholly, due to the vis à tergo derived from the point at which the absorption takes place.

This action, in which we cannot suppose there is any muscular contractility, is assigned to endosmosis, but is a vital action in the plant, not in itself analogous to endosmosis.

The pressure of the surrounding muscles propels the blood onwards towards the heart; as, when the veins are compressed by muscular contraction, the blood is forced in every direction, but as the valves prevent it passing backwards, it must flow onwards towards the heart. This action is seen in bleeding from the arm, the flow of blood being increased at each contraction of the muscles. The pulsation of the arteries acts in the same manner.

Gravity is favourable to the venous circulation in the upper parts of the body, but is evidently unfavourable to that in the lower parts.

The contraction of the inferior vena cava, will force the blood onwards into the right auricle, and thus assist in the general venous circulation.

As stated in treating of the action of the cavities of the heart, they become distended by their own resiliency after their systole; the vacual tendency thus formed will cause a flow of blood towards the right auricle, and contribute to the venous circulation.

Notwithstanding these influences, the circulation in the veins is extremely languid, as compared with that in the arteries. On comparing the external jugular vein with the carotid artery, it is found that the estimates obtained by the hæmadynometer may be 10, 15, or even more than 70 times greater for the latter than the former. The carotid of the dog gives an ordinary height of 5·9 inches of quicksilver, but the external jugular vein only from ·08 to ·59 inches. The carotid of a rabbit gave 4·09 inches, its external jugular vein only ·28.

According to Ludwig and Mogk, the jugular vein of the dog gives ·08 to ·52 inches of mercury, the tracheal vein ·49 to ·6, and the femoral ·43 to ·93.

Much power is supposed to be lost in both the arterial and venous circulations, by the angular division of the vessels; but this is an error, as the column of blood being a continuous one throughout, is impelled onwards as a whole, and thus the division of vessels has little, if any, injurious effect. It would be far otherwise if the vessels were filled and emptied at each stroke of the heart.

The languid circulation in the venous system is easily proved by the facility with which the blood is arrested in even the largest vein, the pressure of a finger being sufficient for this purpose. Where a vein is cut across, the pressure need not be applied to the upper extremity of the vessel, as the valves prevent the retrograde course of the blood, except in the case of varicose veins, when, from the destruction of the valves, both ends must be compressed.

The Pulmonic circulation wants the assistance of muscular contraction; but this is more than counterbalanced by the pressure of the parieties of the thorax during expiration. Inspiration assists by forming a vacual tendency in the lungs, which attracts the blood to these organs.

The *Portal Circulation*, or that of the Vena Porta, is peculiar. As the portal vessels possess no valves, and are but little exposed to muscular contraction, it is maintained principally by the vis à tergo and by the vacual tendency in the hepatic veins. The Portal circulation is still more languid than that of the general venous system, as is ascertained in the frequency of hemorrhoidal tumours.

The *Cerebral Venous* Circulation is peculiar, inasmuch as the larger veins are formed in folds of the dura mater, unaccompanied by arteries, constituting the sinuses, which are discharged by the internal jugular vein.

The flow of blood in the sinuses of the dura mater is altogether free from muscular contraction, and from all kinds of arterial pressure, as being enclosed within the bony parietes of the skull; it must, therefore, be assigned to other causes, and these may be referred to as:—1. Gravity; 2. the Vis à Tergo; 3. the General Impulse of the Brain, produced by the Heart and Arteries; 4. the Impulse caused by Respiration.

The effect of gravity on the venous circulation in the sinuses of the brain is remarkable, and cannot be questioned, as its influence is considerable in almost every position of the body.

In the erect posture the blood flows rapidly from the sinuses, and hence the frequent occurrence of fainting on rising suddenly from the bed or from the recumbent posture; this being caused by the immediate and rapid descent of the blood from the cerebral veins. To recover from the fainting fit, it is necessary to place the person again in the recumbent posture, so as to restore the balance of the circulation.

The influence of position on the venous circulation of the brain is equally evident in all cases of tendency of blood to the head, inflammation of the brain, &c., in inversion of the body, and under all circumstances where the force of gravity operates against the flow of blood.

The vis à tergo is derived, as in the general circulation, from the capillary arteries, and may be extended along the venous branches to the blood in the sinuses.

The impulse given to the venous circulation of the brain by the action of the Heart and Arteries is considerable: in addition to that generally induced by this on the circulation, the cerebral substance is forcibly compressed by the large arteries at its base—viz. the Internal Carotid and Vertebral, so as to cause it, in cases of exposure of the brain, to be forced upwards at each systole of the arterial system; this compression must result in the flow of the venous blood, as the only agent which will yield to its influence, and hence an increased flow of blood in the sinuses.

A similar impulse is communicated to the brain during the act of Respiration, this organ being raised or elevated during expiration and depressed during inspiration, the effects of the alternate distension and diminution of the Cerebral sinuses and Venous Circulation generally.

Dr. Clutterbuck and some others have contended that the quantity of blood circulating in the brain must be uniform, and cannot be liable to this alternate condition, as the cerebral contents cannot be compressed and expanded to correspond to the supposed altered condition of the vascular system: but this theory, however specious, cannot be supported, or reconciled with the numerous facts which almost daily present themselves; nor does it affect the question of the Venous Circulation, as this may alternate with the circulation of the Arterial System. Venous congestion is of frequent occurrence, and may result at the expense of the arterial circulation, or from the diminution of the Cerebral contents from other causes.

THE BLOOD.

The Blood is originally formed in the vessels of the fœtus from the maternal circulation, from which it derives its nutritive elements, and by which, doubtless, all deleterious principles are removed from it, corresponding to the process of respiration in the adult.

This fluid, after birth, is renovated from the aliment taken into the stomach, and is decarbonized in the lungs.

The *Blood* is a compound fluid, and consists, whilst circulating in the vessels of the living body, of two ingredients: one a thin, transparent, and nearly colourless fluid, named the Liquor Sanguinis; and floating in this a number of corpuscles, some of which are of a reddish hue, and give to the blood its red colour, whilst others are devoid of colour.

When drawn from the body, the blood spontaneously separates into a fluid and solid portion. This process is termed the *Coagulation* of the blood: the first is named the *Serum;* the second the *Crassamentum* or *Clot.*

The *Serum* corresponds to the Liquor Sanguinis, except that it does not contain fibrin; this joins and enters with the clot, or crassamentum, which is thus composed of the Fibrin and Corpuscles with a small portion of serum, entangled as it were in these.

In consequence of the greater specific gravity of the clot, this sinks in the serum on coagulation, the latter forming the upper part of the mass.

The Serum thus formed is of a pale yellow colour, and is composed chiefly of albumen, which is coagulable by heat, a small portion only remaining fluid. This is the *serosity* of the blood, and forms the gravy of meat.

The Serum holds in solution certain salts, and contains a free alkali-soda, which gives it an alkaline character.

The *Fibrin* of the blood forms the upper portion of the clot, when this has stood at rest for a little time; it is a tenacious substance, of slight consistence, of a yellowish colour, and may be obtained separately by stirring, or "whipping" newly-drawn blood with a bunch of twigs, to which the fibrin will adhere in the form of a stringy substance.

The *Corpuscles* form the lowest portion of the clot, and may be obtained separate from the rest of the blood by passing this through a filter, having mingled with it some substance which retards, but does not prevent its coagulation: the corpuscles only remain on the filter. This experiment cannot be performed on human blood, as from the small size of the corpuscles these pass at the same time through the filter.

It is difficult to ascertain the exact relative quantities of Serum and Crassamentum contained in blood, as these are found to vary under different circumstances. Generally speaking, the proportion of serum is greatest in cases of debility and lessened vital action, as in prolonged diseases, weak constitutions, the female subject; but again, in many diseases attended with debility, the serum is lessened in quantity, and may be nearly absent, as in cases of fever, cholera, &c.

According to calculations based on analyses made after Professor Andral's method, the whole solid matter contained in the blood of the male is 210 in 1000; in the female, 190 in 1000; but these exact proportions cannot be ascertained, as it is difficult to separate the solid from the fluid portions of the body, or to designate what is solid and what is fluid; as in the decomposition of solids there is a tendency to form fluids, which thus appear in excess.

The proportion of Albumen is tolerably uniform, as it usually amounts to about 70 in 1000.

The proportion of the Corpuscles is more variable, ranging in the healthy male from 140 to 180 in 1000; and in the female from 70 to 160 in 1000.

The average proportion of Fibrin in the Male is from 2·5 to 4; and in the Female from 1·8 to 3.

The solid portion of the blood is found to contain also some *fatty* matter, some of which seems allied to the peculiar fatty acids of Neurine; whilst others have some of the properties of cholesterine, urea, uric acid, &c.

The *Salts* contained in the blood, as obtained from the incinerated mass, form from 6 to 7 parts in 1000. More than half is composed of the Chlorides of Sodium and Potassium; the remainder is composed of the tribasic Phosphate of Soda, the Phosphates of Lime and Magnesia, Sulphate of Soda, a little Phosphate and Oxide of Iron. Of these, the principal portion is contained in the Serum: the earthy phosphates are most probably combined with the Protein compounds, and the iron is nearly confined to the red corpuscles.

The Blood is found to undergo much alteration from its healthy composition, from the excessive generation of some of the ingredients which usually enter into its composition, from the introduction of foreign substances from without, and from the effects of morbid poisons. Carbonic Acid, Urea, Lithic Acid, Cholesterine, and other biliary elements, may accumulate in it from not being thrown off in the various secretions, and become productive of injurious results. Saline solutions introduced into the blood retard or prevent its coagulation. In malignant fevers, where the system frequently suffers from a morbid poison floating in the atmosphere, of a vegetable or animal nature, or both of these combined, in the bites of serpents and rabid animals, the whole current of blood becomes altered, as if by the influence of a "fermenting" agent.

In disease of the kidneys, where an excess of albumen appears in the urine, the quantity of albumen in the blood is sensibly diminished.

Coagulated blood frequently presents a peculiar appearance known as being "*buffed*" and "*cupped;*" and these were, until recently, regarded as certain indications of inflammatory disease—an opinion which has been set aside by more accurate examination.

It has been found that the presence of an excess of fibrin in the blood delays its coagulation: hence the red globules have more time to descend to the bottom of the clot, and the upper stratum presents a more decidedly yellowish appearance; this forms the buffy coat. When the buffy coat undergoes a slow contraction, characteristic of its being highly elaborated, it draws in the edges of the upper stratum of the clot, so as to give to it a "cupped" appearance.

The buffy coat may present itself from merely the absence of a due proportion of the red corpuscles: this takes place in chlorosis, a disorder which is more the result of debility than of inflammation.

The Coagulation of the blood is not the consequence of its being removed from the body, or its being exposed to the atmosphere, as this change takes place in the interior of the body when the blood escapes from the vessels, as in aneurism, internal hemorrhage, apoplexy, &c. In these states the blood does not putrify nor decompose, unless when exposed to the atmospheric air, and may remain for years without undergoing much alteration. When once discharged from the vessels, and coagulated, the blood never becomes organized, as it has lost its vitality, and becomes a foreign body; although the term "organization of the blood" is frequently met with in surgical works, and in some cases is treated of as a kind of union between fractured bones and other divided parts. Being dead, t cannot accept of a vital action.

The coagulation of the blood, although influenced by chemical and mechanical agency, is essentially a vital process; or, to speak more correctly, is the departure of the living principle from the blood; but may be retarded or prevented by certain agents—

as constant motion, the admixture of salts, freezing, &c.; but in these cases it is the mechanical or chemical results that are asserted; the vital action is independent of them. It is, however, remarkable, that blood may be frozen for a short period without destroying its power of coagulation; when it becomes thawed, coagulation takes place. In this case, the act of freezing suspends the mechanical results, which take place on the obstructing cause being removed.

Electricity, violent mental emotions, and excessive fatigue (as in animals hunted to death), destroy the coagulability of the blood: in these it would appear that the vital principle is at once or gradually destroyed, and that the vital action necessary in the coagulation of the blood does not take place; hence the other results are prevented from following. This statement, although founded on the authority of John Hunter, is not supported by recent observation, as the blood has been found coagulated in animals killed by lightning; and Mr. Gulliver has found clots of blood in animals killed from hunting and other violent exertion.

The period of time which elapses before coagulation takes place varies much: it usually occurs in from five to seven minutes after the blood has been drawn. If a large quantity of blood be withdrawn from an animal at the same time or at short intervals, that which flows last coagulates the more rapidly but less firmly; if collected in a shallow dish, coagulation takes place more rapidly than in a deep vessel. Menstrual blood does not coagulate, although in excessive hemorrhage from the arteries at the menstrual period, the later effusions of blood coagulate.

In Medical Jurisprudence, evidence is frequently given as to the nature of stains found on the dress, &c., of suspected persons, as decisive of their being produced by human or other blood. On this subject, Valentin states, "Where but small quantities are concerned, chemical examination cannot afford any trustworthy results, since the blood does not contain any characteristic and peculiar substances, and its small amount of iron furnishes no indication. A microscopic examination is often equally inconclusive. If the blood-stain is to be extracted with a watery fluid, we must not select pure water, but a liquid which, like a solution of salt or sugar, does not affect the form of the blood corpuscles. If these exhibit oval forms it will follow that the blood does not come from Man or any domestic animal, but from a bird, fish, or reptile. If their shape be spherical, they may belong to some fishes, the domestic mammalia, or Man. But there are generally insuperable difficulties in deciding whether they are those of a Man or a mammal. It has certainly been maintained that the medical jurist may be guided by the smallness of the structures remarked under the microscope. But, apart from the circumstance that smallness of diameter may be due to previous desiccation, we must remember that the average diameter of the human blood corpuscle equals 1-3560th of an inch, while that of the dog is 1-3330th, the cat 1-4400th, the pig 1-4220th, the horse 1-4720th, the ass 1-4010th, the cow 1-4320th, the sheep 1-5310th, and the goat 1-6350th. Hence, even under the most favourable circumstances, we could only recognise the blood of some of the mammalia, such as the domestic ruminants ; and should never be really entitled to affirm that we had human blood before us."

ABSORPTION.

As the human body depends for its support on the introduction of the nutritive portions of the food into the system, it is necessary that it should possess the power of taking up these and of carrying them into the general circulation. This power is possessed by a distinct set of vessels, termed the *Absorbents*, and the functions performed by them is that of *Absorption*.

But these vessels have a more extensive office than that of taking up the elements of nutrition; they also remove the effete matter from the system to be discharged in the excretions; they assist in moulding the different structures, the bones, muscles, &c.; they excavate the former, so as to form a medullary canal in their interior, make perforations in them for the transmission of blood-vessels and nerves, remove such portions as are superfluous, and in like manner act upon the softer tissues so as to give them a regular and symmetrical shape.

The Absorbents also take up matter exposed on the surface of the skin, the mucous membrane, or in any part of the body, from whence they absorb not only that which is useful to the body, but also that which may be injurious; they are at once the builders-up, the modellers, and the destroying agents of all the structures; and this not only in health, but also in disease. The absorbents take up effused or extravasated blood; they remove the callus of bones, absorb the softer tissues when the seat of inflammation or abscess, and remove by their action the mortified hand or the gangrened foot.

The absorbents consist of the *Thoracic Duct*, which is the trunk of the absorbent system, the *Lacteals*, and the *Lymphatics*, which form its circulating vessels. We shall commence with the description of the Lymphatics.

The *Lymphatics* are spread throughout every portion of organized structure in the body, but the principal vessels run along with the blood-vessels and more especially the veins. If we take the lower extremities, we find that the principal lymphatics accompany the saphenæ veins, and the femoral vein and artery, hence they are divided into the *superficial* and *deep* sets. They ascend chiefly along the inner side of the foot, leg, and thigh, and terminate in the lymphatic glands of the groin: some communicate with the popliteal and other glands as they ascend; but others, on the contrary, have no connexion with a gland until near their termination.

The vessels entering the gland are termed the *vasa afferentia*, and are more numerous, but of less calibre than those passing out of the gland, which are named the *vasa efferentia*.

In like manner the absorbents of the upper extremities, head, and neck, are arranged with regard to the blood-vessels and terminate in the lymphatic glands of the axilla, neck, anterior and posterior mediastinum, &c. The lymphatics of the trunk present a similar arrangement.

The *Lymphatic glands* are composed of a congeries of vasa afferentia and vasa efferentia, which freely communicate. Some physiologists suppose that there is an intermediate arrangement of cells between these vessels, but this opinion is not generally received. They are covered externally by a layer of condensed fibro-cellular tissue.

Kölliker thus describes the structure of the lymphatic glands. "The larger lymphatic glands, in their normal condition, consist, like the supra-renal capsules, of an *envelope*, of a *cortical*, and of a *medullary* substance. The *envelope* encloses the gland completely, with the exception of one or more places, where the larger blood-vessels enter and the efferent lymphatic vessels pass out; this may be designated the 'hilus' of the gland. The envelope is more delicate on the glands situate in the large cavities of the body than on those of the external regions; in structure it is wholly composed, in Man at least, of connective tissue, in which are interspersed numerous fine elastic fibrils (nuclear fibres), and their formative elements, the plasmatic cells. The *cortical* substance, which is perceptible on the whole surface of the gland, except the hilus, forms a soft juicy layer, with various shades of yellowish white, reddish yellow, or reddish grey, measuring, in large glands, two, two and a half-and three lines in thickness. The *medullary* substance occupies the interior of the glands; in the external glands it is of a whitish colour, but in those of the viscera is more reddish grey."

There is a peculiar arrangement of the lymphatic system in reptiles and some birds; namely, the existence of muscular sacs termed *lymph hearts*. Into these cavities several lymphatics open, having their orifices provided with valves to prevent regurgitation. But one vein proceeds from each heart, to conduct the lymph into the venous system.

According to Goodsir, Kölliker, and others, there are within the lymph-vessels, or between them, collected in cells like the acini of secreting glands, in all the more perfect lympathic glands, numerous minute *corpuscles*, or cytoblasts, spheroidal or disk-shaped, about 3000th of an inch in diameter, which are supposed to assist in the elaboration of the lymph.

The use of the Lymphatic glands is unknown: they have been said to delay the process of absorption, to expedite it, to secrete a peculiar fluid, or to effect some change in the fluids that pass through them ; but these theories are little more than conjecture.

Many fluids as they pass through the lymphatic glands cause an inflammation of them, and sometimes abscesses, or sloughing of their tissues: they are generally, but not always, of a poisonous nature, morbid, animal, or vegetable. Syphilis, the plague, typhus fever, glanders, are illustrations of the first of these; the bites of serpents, rabid animals, dissection wounds, are examples of the second; the malaria of tropical climates illustrate the third.

It is somewhat remarkable that the matter produced from such glands does not always partake of the same poisonous character as that which has originally produced the disease. The matter of a syphilitic bubo is considered as not to produce syphilis; that of the plague will produce plague, as proved in the case of a French surgeon, who chivalrously inoculated himself with the matter from a bubo, and fell a victim to his rash experiment.

The lymphatics of the lower parts of the body terminate in front of the second or third lumbar vertebra, behind the aorta and vena cava, in the *receptaculum chyli.*

The *Lacteals* arise from the mucous surface of the small intestines, pass in the folds of the mesentery through the mesenteric glands, and finally terminate in the receptaculum chyli. They are precisely analogous to the lymphatics in other parts of the body, and are termed lacteals from the colour of the fluid (the chyle) which they usually convey.

The *Thoracic duct* proceeds from the receptaculum chyli, and conveys the chyle and lymph into the left subclavian vein.

The lymphatics of the right side of the head and neck, and right upper extremity, form a distinct trunk, which terminates in the right subclavian vein.

The structure of the lymphatic system is composed of three coats: the *tunica interna* consists of an epithelium, whose cells are elongated, and of a simple elastic reticulate coat which is rarely double, and has its fibres disposed in the longitudinal direction; the *tunica media* is composed of transverse smooth muscular fibres, with fine elastic fibres, also disposed transversely; lastly, the *tunica adventitia*, made up of longitudinal connective tissue with scanty networks of fine elastic fibres, and a layer or smaller number of smooth muscular fasciculi running obliquely and longitudinally. The structure of the Thoracic duct differs a little from the foregoing, but so slightly as to be scarcely worthy of notice.

The lining membrane of the lymphatic system closely resembles that of the veins, and, like this, is thrown into numerous folds of a crescentic shape, forming valves which follow each other at short intervals, the greatest in Man being about two-fifths of an inch. This has the advantage of cutting off small columns of fluid, so that the reflux of lymph in any considerable quantity is prevented.

While the large absorbent trunks are plentifully provided with valves, they are frequently absent from the commencement of the lymphatics. They cannot be detected in the lacteals which run in the middle of the intestinal villi.

The Thoracic Duct and Lymphatic System generally have been described by some physiologists as being elastic and composed of the yellow tissue, corresponding to that of the arterial system. Such a structure would negative the action of the valves of the lymphatics, as in that of the venous system; its existence may well be questioned, although not so prejudicial in this as in the venous system.

The Experiments performed on the Thoracic Duct to ascertain its strength, all tend to negative the presence of elastic fibres in the trunk and vessels of the lymphatic system, as they are found to bear a large quantity of quicksilver without yielding or rupturing; indeed, it is owing to the great resistance of the external coat that these experiments are followed by success, as it is found necessary to allow of the column of quicksilver to remain for a considerable time before it makes its way into the branches of the Absorbent System.

It has long been a question whether absorption is performed exclusively by the lymphatic system, or that they are assisted in this function by the capillary blood-vessels and more especially the veins.

Numerous experiments performed by Tiedemann and Gmelin, and others, in which odorous and saline matters taken in with the food, or injected into the intestines of an animal, were found in the blood of the vena portæ and other vessels, but not in the chyle, support this view. The substances used in the experiments were various, and consisted of ferro-cyanide and sulphate of potash, salts of lead, indigo, madder, &c.

Majendie also performed numerous experiments in support of the same view. He enclosed poisons, such as opium and strychnia, in a portion of the intestine of a dog, and isolated it by means of ligatures: he now tied the lacteals, leaving the blood vessels free, and found that poisoning took place in the course of a few minutes after the intestine was returned into the abdomen.

He again tied the veins proceeding from the intestine, leaving the absorbents free, but found that poisoning was delayed for upwards of one hour.

He performed experiments also on the limbs of animals, into which poisons were introduced, and the veins and lymphatics secured or free as in the former experiments, and found the same results.

As lymphatic vessels might have passed along the coats of the blood-vessels in these experiments, he cut these across and connected them by means of glass tubes, and found that poisoning still took place as in the former experiments.

But these experiments, although apparently so conclusive, do not prove that absorption is performed by either the veins or arteries, as this function may be performed exclusively by the absorbent vessels, and they may empty their contents directly into the blood-vessels, so as to be found in them, and thus conducted into the general circulation. It is impossible to isolate the blood-vessels so completely as to separate their absorbents from them.

Absorption is found to be much impeded by the application of ligatures round a limb, or by the presence of tumours, or other bodies, which retard or impede the circulation of the blood, so that the parts below the compressing body become swollen and œdematous. But as the absorbents are obstructed in such cases equally with the blood-vessels, and as the œdema may be produced by increased effusion as well as by diminished absorption, the theory of venous or arterial absorption gains but little support from such observations.

The use of cupping-glasses over a poisoned wound is followed by similar results, but is liable to the same objections, as to the theoretical action of the vessels.

The advantage to be derived from these remedies in the cases of poisoned wounds, snake-bites, &c., is obvious. The use of cupping-glasses, suction by the mouth or other means, the application of ligatures round the poisoned limb, should never be delayed for a moment.

The comparatively small size of the thoracic duct was supposed to favour the theory of absorption by means of the blood-vessels; but it has been found by experiment that the contents of the thoracic duct flow rapidly along its interior. Bidder performed various experiments on animals, and found that in one minute cats gave from 4·42 to 7·68 grains, and dogs from 25·67 to 43·17 grains from the thoracic duct.

Vierordt calculated from the amount of azotized food taken, and the nitrogenous contents of pure chyle, that from 4½ to 7 pounds of chyle flowed along the thoracic duct of a Man in the space of 24 hours.

In one of Majendie's experiments half an ounce of chyle was obtained in five minutes from the thoracic duct of a middle-sized dog, and other experiments have met with similar results.

From these facts we may conclude that the size of the thoracic duct is sufficient for all purposes, with the aid of the blood-vessels; and that if certain substances are found in these and not in the latter, the absorption is due to the lymphatic system, which conducts them into the vessels to which they are especially attracted by the greater affinity of the blood for such substances. To assign to the blood-vessels the power of absorption is to endow them with the function of a distinct system, and to complicate their function in a manner inconsistent with the general harmony and functional action which characterize the laws of the Animal Economy.

Absorbents have not yet been traced into the brain, bones, cartilage, and other structure; but as vessels permeate these, absorbents doubtless pass in with them, as there is no reason why one set of vessels should be excluded from their tissues whilst they are supplied by others.

Absorption.—As the lymphatics of the intestines take up the chyle from these cavities, it had been supposed that these open directly on the interior of the intestine; but recent investigation has shown that such is not the case, and that the lymphatic vessels commence on the villous surface of the intestines by a cul de sac, or blind extremity, the lymphatics of other parts of the body presenting a similar arrangement; and that these extremities form a network of vessels similar to the capillary vessels of the arterial and venous systems.

These extremities are endowed with a vital power of action, by means of which they are enabled to take up or *absorb* most of the fluids presented to them, and to act upon various solids in such a way as to disintegrate their particles, and carry them or their constituent principles into the circulation, for the purposes already stated.

This process has been compared to the passage of fluids through membranes, as first and most accurately investigated by M. Dutrochet, who found that, according to the density of fluids, they passed in or out of the enclosing membranes, so as to mix with other fluids of greater or less density. Thus M. Dutrochet found, by using an instrument which he named an Endosmeter, that if a denser fluid occupied its interior, and was exposed, through the membrane composing it, to a fluid of lesser density, the latter passed *in* through the membrane, constituting *Endosmosis;* but if, on the contrary, the instrument contained the less dense fluid, it passed *out* of the membrane to join the more dense fluid, constituting *Exosmosis.* In these changes the power of attraction was found to be so considerable as to raise the fluid in the tube to the height of several inches.

This theory has been adopted and extensively applied to explain the phenomena of absorption, the absorbed fluids being supposed to pass through the lining membrane of the absorbent vessels, by the process of endosmosis.

But it has been overlooked by M. Dutrochet, and most of the succeeding physiologists, that the phenomena of endosmosis and exosmosis, however applicable to inanimate membrane, are by no means so to the living structure, and that it is quite possible that these will not take place through a living structure.

That such is the case is proved by the stomach, urinary bladder, and other hollow viscera retaining their fluid contents, without permitting of the escape of them except by the natural passages. Again, in Ascites, in which disease there is an accumulation of fluid in the cavity of the Peritoneum, there is no exosmosis of the fluid into any of the abdominal viscera. The same remarks applying to hydrocele, and other collections of fluid in various parts of the body.

The Phenomena of Absorption have been also assigned to Capillary Attraction, which causes the ascent of the fluid in the vessels to a certain extent, whence they are propelled onwards by other agents.

Absorption is a vital action, and cannot be explained on mere mechanical principles. The vessels not only absorb, but they are capable of selecting certain fluids and rejecting others: in the intestines, for example, they absorb only the chyle or nutritious particles of food; they reject the excrementitious portion.

Few substances in a solid state are taken up by the absorbent vessels, even although finely powdered. Mercury is an exception to this, as metallic mercury may be taken up and detected in the blood-vessels; finely powdered charcoal has also been taken up and found in the veins. The colouring matter with which sailors mark their arms and breasts has been known to remain undisturbed for many years.

Foreign bodies composed of iron, when taken into the body, will be partially acted upon in the intestines and stomach; but this is the result of simple attrition, and not of absorption. Some years since, in London, a sailor used to exhibit himself as a swallower of clasp-knives; on his death, several were found in the intestinal cavity, in most of which the iron or steel was more or less acted upon.

The source of the motion of the contents of the Lymphatic System is with difficulty ascertained, as although possessed of valves, it is less under the influence of muscular contraction than the venous system; and its trunk, the thoracic duct, is perfectly free from such, as it rests in close contact with the spinal column through the greater part of its course. It is also but little affected by the vis à tergo from the capillary system.

The principal agent is the thin layer of muscular fibres that form the middle coat of the lymphatic system.

HUNGER—THIRST—FOOD—DRINK.

The Constituents of the Human and all living bodies are constantly undergoing waste, or deterioration, in the exercise of the Functions necessary to Vital Action, in the formation of the several tissues, the excretion of different fluids, and in the removal of the effete materials, and the substitution of newer matter in their place.

These changes are but little felt by the individual, and might proceed to an injurious extent, but that

Nature has implanted certain Sensations, which indicate their progress, and call imperatively for fresh sustenance to repair the losses which take place.

These Sensations are those of Hunger and Thirst: the former indicating a want in the system of more solid food, the latter of fluids.

The Sensation of Hunger, which needs not be described, is especially and first felt in the region of the stomach, whence it appears to spread over the whole abdominal cavity, and finally to produce more general symptoms, such as languor, weakness, fainting, and nausea.

This Sensation has been usually attributed to the action of the gastric juice upon the coats of the stomach, as it has been found, by Hunter and others, that this fluid will dissolve the coats of the stomach, and cause their perforation, as has been found in the bodies of criminals executed in a state of health, and of persons dying suddenly from accidents.

But this is not the only cause of the disagreeable sensations dependent upon hunger. The Nervous influence operates powerfully in inducing these, as also in removing them. Mental impressions will act in both of these directions, according as they are agreeable or otherwise; and many substances, which are non-nutritious—as tobacco, opium, &c.—are known to allay the feelings of hunger, by lowering the sensibility of the nervous filaments of the stomach.

The Sensation of Thirst, on the contrary, is usually and most powerfully felt in the tongue, throat, and fauces, and is produced by an arid state of the mucous membrane lining, these sympathizing with a similar condition of the gastric membrane.

As most, if not all, articles of food contain both solid and fluid matters, they will generally allay both sensations of Hunger and Thirst. Water will relieve these, and jellies, meat, &c., will assuage thirst as well as alleviate hunger.

The food of animals consists of *azotized*, or *nitrogenous*, and *non-azotized*, or *non-nitrogenous*, substances: the former of these are consumed more especially by the carnivorous, the latter by the herbaceous tribes; the omnivorous, as Man, partake of both. The principal azotized substances are albumen, fibrin, and casein; the non-azotized are fat, starch, gum, dextrin, alcohol, &c.

Although the azotized substances are the most nutritious, they will not support life, except for a short period. The use of the non-azotized is also necessary.

Milk is the only substance which contains all the elements necessary for nutrition. The albuminous in the casein, oleaginous in the butter, and the saccharine in the sugar of milk. The egg affords a similar example as provided for the sustenance of the embryo of oviparous animals.

Tiedemann and Gmelin, Majendie, and many others, have performed experiments on animals to prove the necessity of mixed food, and with nearly the same results: the animals, fed on one description only, dying in a few days. Sloughing of the cornea, and destruction of the eye, was a frequent result of these experiments. Potatoes seem to be the only vegetable which will support life for a considerable, if not indefinite time.

The beans of coffee, the leaves of the Chinese and Paraguay tea, contain an alkaloid which has the same composition. Both these and caffein yield Carbon, Hydrogen, Nitrogen, and Oxygen. Some have concluded that the peculiar effects of these drinks are due to the large amount of nitrogen contained in these alkaloids; but this opinion is scarcely tenable.

The *non-azotized* substances are prepared, as it were, by the herbivorous for the use of Man and carnivorous animals, and converted into the azotized materials, which afford a much larger amount of nutritious particles, which are thus absorbed into the system without having to undergo a succession of changes to fit them for the purposes of the animal, although all the elements of azotized are found in the non-azotized substances.

But the *azotized* or quaternary compounds are not absorbed direct into the system. They are acted upon by the digestive organs, and are then broken down into their constituents of albumen, fibrin, and casein, before entering into the formation of the tissues of the body.

The exclusive use of azotized or non-azotized food is as little able to maintain the body as a supply of merely inorganic matter.

The vegetable elements are the means of introducing a large quantity of the hydrates of carbon, such as starch, and the different kinds of sugar. But these combinations do not, as such, form permanent constituents of the solid animal tissues. They undergo a combustion into carbonic acid and water, or exist as soluble bodies in particular fluids, such as the blood, the bile, and the urine; or perhaps contribute by means of their elementary constituents to the production of other substances.

The starch granules in the cells of potatoes and other vegetables are unchanged by cold water; but in hot water they form a paste which is converted into dextrin by sulphuric acid, or by the fermentative process, and is thence easily transformed into grape sugar. Food which contains much starch—as potatoes, flour, sago, and arrowroot—is, therefore, best treated with hot water.

The cellulose in the walls of vegetable cells, which so closely resembles starch, is digested with difficulty. Woody cells, such as the stones of cherries, plums, &c., and the epidermis of the stalk and leaves, will pass unchanged.

Pectin, or vegetable gelatin, and the pectic acid produced from it by alkalies, is found in juicy fruits, stalks, and roots. It yields materials for nutrition rather than for development.

The digestibility of fat, like that of cellulose, depends partly on its mode of aggregation, its fusibility, and the quantity which is introduced at once.

Albumen, fibrin, and casein are introduced in the fluid or solid form. The coagulated albumen of eggs is acted upon with more difficulty than in the fluid state, although many exceptions occur to this. It is remarkable that fluid albumen undergoes in the stomach a species of coagulation.

Drinks are rather subsidiary to the nourishment of Man, at least in the adult state. Water affords but little nutriment, and the various kinds of wines, spirits, &c., act more as stimulants than as vehicles of nutritive matter: they are, however, of essential service when taken in moderate quantities.

The quantity of fluids taken into the system is much greater than that of solids. A horse weighing 938 lb. received daily 22 lb. of hay, $4\frac{1}{2}$ lb. of oats, and 66 lb. of water. The daily requirements of a milch cow amount to $\frac{1}{30}$th of the corporeal weight in hay, and $\frac{2}{15}$th in water, or $\frac{1}{6}$th in both together.

It has been found that an adult will live about three weeks without any food; but if drinks which contain no proper nutritious substance are made use of, life may be prolonged to eight or ten weeks.

The comparative digestibility of various articles of food, and the time consumed in this process, have been most satisfactorily ascertained by Dr. Beaumont, who met with a man named S. Martin, in whom a fistulous opening into the stomach existed, the consequence of a gunshot wound. This orifice was closed by a valve which could be pushed back so as to admit of numerous experiments of a highly interesting nature, from which the following results were obtained:—

The temperature of the stomach was almost uniformly

100° Fahrenheit; but this was raised one or two degrees by muscular exertion.

The Secretion of the gastric juice was increased by the introduction of mechanical irritants, so as to be collected in considerable quantities; but still more so by alimentary substances, salt, pepper, and other stimulants of a like nature.

Cold water and ice checked the secretion; but when a reaction took place, the quantity became increased.

Digestion of a meal usually took place in from three to four hours; but many substances were digested in a much shorter space of time, and others occupied a much longer period.

A breakfast consisting of hard-boiled eggs, pancakes, and coffee, was digested and removed from the stomach in two and a quarter hours.

Two roasted eggs and three ripe apples were digested in one hour and a quarter.

A dinner of roasted pig and vegetables was digested in two and a half hours.

A dinner of boiled dried codfish, potatoes, parsnips, bread, and drawn butter, was digested in two hours. In half an hour the bread and parsnips could not be distinguished; some potatoes were distinct after one hour.

Dr. Beaumont has published a useful table, pointing out the periods of time necessary to the digestion of different substances. Thus he found that rice and tripe became converted into chyme in one hour; eggs, salmon, trout, apples, and venison, were digested in one hour and a half; tapioca, barley, milk, liver, fish, in two hours; turkey, lamb, potatoes, pig, in two hours and a half; beef, mutton, and fowl, required from three to three and a half hours; whilst veal required a longer time.

In drawing conclusions from these experiments, it must be borne in mind that the person operated upon, although his digestive powers appear to have been by no means inconsiderable, was not in a normal or healthy condition. The fistulous opening in his stomach must have impaired the action of this organ, and the numerous experiments performed upon him must have tended to increase the impairment of the digestive function. In the perfectly healthy state, the digestive powers will necessarily be greater, and a shorter time consumed in the chymification of the food.

We may reasonably conclude, however, that food, such as is ordinarily consumed in this country—meat forming a large proportion — is, under ordinary circumstances, converted into chyme, and is expelled from the stomach in four hours; but as this process is only one step to perfect digestion, which is completed in the duodenum, a further lapse of time is necessary to the chylification of the food, and the subsequent absorption of the chyle into the system, when digestion is perfected. If six hours be assigned for the completion of this process, it is probable that this is about the correct period necessary.

When the process of chymification is going forward in the stomach, this organ is disposed to reject the addition of any food of a strong character, such as meat, whilst it is inclined to receive fluids of a moderately stimulating nature, such as coffee, tea, &c.; and the use of these appears to promote rather than to impede digestion.

At the same time it must be observed, that certain rules will not apply to all individuals; and that many persons suffer from the use of fluids, &c., during digestion, from which others derive a benefit.

The Digestive function varies not only in power, but in its desire for different articles of food, in the several periods of life. The desire of the young subject for all substances that partake of a saccharine character is remarkable, whilst they are equally averse to fatty and oleaginous substances. In adult life, this taste or desire is reversed; the latter being preferred, whilst the former are almost universally disliked.

ANIMAL HEAT.

All living bodies possess the power within themselves of generating heat, or caloric, by means of which they are enabled to sustain a temperature generally beyond that of the medium within which they are enclosed.

This power is necessary, not only for the simple purpose of sustaining the external temperature, so as to promote the comfort of the individual; but is essential also to the performance of the principal functions of life, as most of these are impaired or arrested by an undue degree of cold.

The development of heat is not confined to the animal kingdom, but extends also to the vegetable world, as trees, grass, flowers, &c., are found to give out a certain portion of heat from their surface, so as frequently to thaw the snow in their immediate neighbourhood, an effect not wholly resulting from the increased temperature of the earth itself.

The power of generating heat is best developed in the warm-blooded animals, and is well shown in Man, although birds generally are enabled to sustain a higher temperature.

In consequence of the possession of this power, Man is enabled to resist the effects of cold in all the climates of the world, not excepting the Arctic regions, although a continuance in these will ultimately destroy life, as doubtless entailing on the vital powers a constant exertion of its vital principles, which becomes at last inimical to their further existence and ends in dissolution.

Of all animals, Man possesses the greatest power of sustaining an uniformity of temperature, and of accommodating himself to the climate in which he may live. Birds, which stand so high in the class of warm-blooded animals, do not possess this power, and die rapidly when exposed to a higher or lower temperature than that which appears to be natural to them. It is true that the superior intelligence of Man enables him to avail himself of various means to assist him in supporting the necessary temperature; but, independently of this, he appears to possess an innate power of regulating his temperature, which no other animal enjoys; and this we should, *à priori*, expect when we reflect on his higher degree of organization, and especially of his nervous system, the influence of which on the production of animal heat has been proved, by the experiments of Sir Benjamin Brodie, to be considerable.

And yet Nature has left Man the least protected, physically considered, of all animals: his skin is all but unfurnished with any external covering, and wants that with which other animals are so remarkably provided.

The average of the human temperature is 97°, and it is found that it rarely exceeds this, except by a few degrees. The highest temperature met with in the experiments of John Hunter was 103°, in a case of hydrocele which had been operated upon and followed by severe inflammation. Other observers have, however, met with a greater increase of temperature in the human body. M. Roger has found the temperature of the skin to be raised in children to 108·5° of Fahr., and others, in cases of fever, to 106° and 107°.

All parts of the body are not of the same temperature. As a rule, the nearer the heart the higher the temperature, and *vice versâ;* the lower parts of the body are generally one or two degrees less than the upper; the sole of the foot has been found, by Dr. John Davy, as low as 90°. Similar results ensue from the tying of the arteries, as for the cure of aneurism, in which the limb below the ligature falls in temperature from one to two degrees, and does not recover unless the circulation is re-established.

Human temperature is influenced also by the states of activity and repose: rest reduces it, exertion increases it—at least, bodily exertion. Mental exertion, on the contrary, rather depresses the animal temperature, provided the physical powers are quiescent; but we frequently observe, that when combined with physical exertion, as in speaking, in the pulpit, at the bar, the Houses of Parliament, and elsewhere, the development of animal heat becomes excessive. That this effect is not wholly produced by the physical exertion may be asserted, when we do not find the same results on the Stage, where the Mental exertion is of a less decided character.

The various temperaments of individuals also affect the power of developing animal heat. Ross, in his sojourn in the Arctic regions, found that persons of a light or sandy hair endured the cold better than those with black hair and dark skin; and it is a remarkable fact, that the light and sandy shades predominate amongst the inhabitants of the colder regions. How far this may be the effect of the influence of the predominance of white in these regions has not been investigated.

The power which Man also possesses of resisting excessive temperature is very remarkable, as exemplified not only in warm climates, but under extraordinary circumstances. It is by no means uncommon on the Continent for persons to enter a baking oven and remain there for a considerable length of time. Sir Charles Blagden and others sustained a temperature varying from 198° to 211°, and in another experiment remained for eight minutes in a temperature of 260°, but this could only be sustained in a dry atmosphere; where this is charged with moisture, as in the hot and vapour baths, so as to repress the cutaneous exhalation, a temperature of 112° has been found insupportable.

Motion, under these circumstances, is found injurious, as the moisture which surrounds the skin is rapidly removed, and thus the barrier between the super-heated air and the surface of the skin is destroyed.

Fat persons generally suffer from an excess of temperature, but they do not seem to possess the power of resisting cold or of sustaining the animal temperature equally with other persons.

Persons of a highly developed nervous system generally are enabled to sustain well the animal temperature; but this rule does not apply to what is usually termed a nervous temperament, as hysterical females: in these, the contrary seems to be the case. In lunacy, the temperature is usually low, and the sufferers ill sustain the effects of cold. The use of the cold shower-bath is highly objectionable in many cases of lunacy, unless exclusively applied to the head.

In old age, the temperature of the body is little less than that of the adult, although the sustaining powers are so much inferior. Children cannot sustain a low temperature as well as adults, although the temperature of their body is in excess. The frequent exposure of children to cold to make them "strong and hardy," is at once unnatural, cruel, and injurious. The strong may survive it, but it kills the weak.

SOURCES OF ANIMAL HEAT.

There are three sources from which the animal heat may be, and most probably is, derived; these are:—1. Respiration; 2. The Nervous Influence; 3. The Food.

Heat is generally produced out of the body by the union of the carbon of the fuel and the oxygen of the atmospheric air, causing combustion and the formation of carbonic acid.

During Respiration, the union of these elements also takes place in the lungs, whence a species of combustion may be supposed to arise, producing heat, and forming carbonic acid: the former is absorbed into the arterial blood, the latter is expelled from the lungs in the expired air.

It may be supposed from this, that the temperature of the arterial blood considerably exceeds the venous; but accurate investigation has proved that this is not the case, the only sensible difference being about one degree. The Caloric generated in the lungs and absorbed by the arterial blood, exists in this, not in a sensible, but in a latent state, the capacity of the arterial blood for heat being so much greater than that of venous.

The Caloric existing in the latent state in the arterial blood is carried into the capillary system, where, on the blood being changed into venous, it is given off, and produces the increased temperature of the body.

When treating of the Function of Respiration, it was stated that some physiologists contended that the union between the carbon of the venous blood and the oxygen of the atmospheric air did not take place in the lungs, but in the general capillary system; so that the Caloric, according to this theory, is developed in the capillary circulation, and at once given out.

But this is not the only chemical source from which the temperature is derived. Not only during Respiration, but also in the breaking-up and new modelling of the various tissues which are constantly going forward, various chemical changes are being effected: the carbon of the tissues unites with the oxygen in the arterial blood to form carbonic acid; the oxygen and hydrogen unite to form water, or watery vapour, whence Caloric is developed, and the Animal Temperature sustained. Again, in the formation of the sulphuric and phosphoric acids which are found in the constituents of the body, heat is also developed: indeed, when we reflect on the numerous chemical changes which are going forward unceasingly in the destruction of the old fabric, and the formation of the new tissues, in most of which heat is developed, we find numerous sources from which the heat of the body is supplied.

Another important source from which the Animal Heat is derived is the conversion of the carbon of the food into carbonic acid, by the junction of its carbon with the oxygen in the system. As already stated elsewhere, the food of animals is composed of azotized and non-azotized substances; the former being the support generally of the carnivorous, the latter that of the herbaceous animals. A considerable amount of heat is formed in the oxidation of these elements of nutrition, which is so essential, during which carbonic acid, water, and ammonia are formed, developing heat in considerable quantity.

Fat is one of the non-azotized elements of food, and accordingly the inhabitants of all cold climates are found to be in the habit of consuming large quantities of fat, oil, &c. The Northern Russians are stated to eat tallow with their bread, as peasants in this country eat cheese; the Esquimaux tribes consume large quantities of the fat of the seal, whale-blubber, &c.; and the Laplanders drink the train-oil from their lamps: these habits are the results of the necessity of the system to develope a large amount of Heat to resist the depressing effects of the cold.

The Nervous System is found to exert considerable influence on the production of Animal Heat, although it cannot be supposed to develop this *per se*. Paralysed limbs are usually colder than the sound ones: a difference of 20° and upwards has been noticed; and lunatics, and others labouring under depressed nervous energy, suffer much from cold. Fatigue from long journeys is always attended with great cold of the limbs and body, and is most relieved by the artificial application of heat, as in the warm bath.

But as, in these cases, the circulation is more or less imperfectly carried on, we must attribute some of the cold produced to this cause.

Sir B. Brodie has been the great supporter of the influence of the Nervous System in the development of Animal Heat; and, in addition to the facts stated, has brought forward the results of several experiments in support of his views.

He destroyed the brain and medulla oblongata in animals, and, in some, kept up artificial respiration, whilst, in others, this was not resorted to. He found that in the former, although the circulation was carried on, and the blood was changed in the lungs from venous to arterial, the animals cooled more rapidly than in those which were left undisturbed.

But in these experiments, although the change in the blood took place, it by no means follows that these were so perfect as to cause the development of Heat, so as to resist the influence of the cold air, forced into the lungs during artificial respiration. It must be borne in mind that blood when out of the body, and exposed to the atmospheric air, becomes oxidized without the formation of Heat; and the same doubtless occurred in Sir B. Brodie's experiments, which, indeed, have been repeated by others, but with different results.

It cannot be questioned that the process of Respiration is the great source of the Animal Temperature. The most extended observations prove this: but that the Nervous System also exerts a considerable influence, either directly or indirectly, is equally a matter beyond dispute; and to neither of these may be assigned an exclusive or independent power of supporting the temperature of the individual.

The high temperature noticed in some plants shows that the Nervous System is not necessary in all structures for the development of heat. A thermometer placed in the centre of twelve spadixes of the Arum cordifolium, has been found to rise to 121°, whilst the temperature of the surrounding atmosphere was only 66.°

Whilst the human body possesses the power of sustaining the temperature above that of the surrounding medium, it also enjoys the means of moderating or lessening this as may be required, when exposed to a temperature inimical to its well-being, in the processes of evaporation and of radiation of caloric. The former is effected in the escape of watery vapour, or exhalation from the lungs, and of the sensible and insensible perspiration from the surface of the body; the latter in the general escape of caloric from the cutaneous surface, independently of the exhalation of watery vapours. The effects of these processes are considerable, and, under ordinary circumstances, are found sufficient to regulate the temperature of the body.

The use of artificial clothing in Man, in regulating the temperature, acts by moderating or restraining the escape of caloric from the body; the warmer descriptions of clothing restraining the escape of caloric, the lighter favouring this. It is on these principles that articles of clothing appear to be warm or cool, as they possess no power of generating heat. A lady's muff, and the iron fender of her chamber, are usually of the same temperature; and yet how different the sensation induced by the application or contact of these: the one causes a feeling of cold approaching to pain, the other is followed by a warm and pleasing sensation, simply because the radiation of heat in the former is rapid, that of the other imperceptible: the animal heat is confined by the muff, but is carried off with rapidity by the iron. Hence the use of blankets in preserving ice, by which the absorption of heat from the surrounding atmosphere is prevented by the woollen materials. Snow acts in like manner as a bad conductor of heat: it prevents its radiation and consequent escape. In the voyages to the Arctic regions, houses built of snow were found to be most useful and comfortable; and in more temperate regions, non-conducting materials of houses, such as wood, peat, &c., are found to be warmer in winter, and colder in summer, than those composed of other materials, as iron, stone, &c.

OF SECRETION.

Secretion may be defined as the separation from the blood, by the *Secerning* or *Secreting* vessels, of a fluid or substance differing from the blood in one or more of its essential characteristics.

Although the elements of all the secretions exist in the blood, these are so changed by the union of some and by the alteration of others, as to be no longer recognisable as having once formed a portion of the circulating fluid.

These various changes are due to a principle of action inherent in the secreting vessels, controlled and influenced by the nervous system and sensorium, although frequently acting independently of the latter. Hence are produced the most varied compounds from the same fluid and from similar vessels—bone, cartilage, muscle, nerve, bile, urine, &c. &c.

This process, alone, shows the wonderful action of the Vital Principle, although its mode of action cannot be explained.

The simplest form of secretion is that from a membrane presenting a more or less smooth surface, and but little organization beyond that of possessing vessels and nerves, as in the case of the Serous and Mucous membranes. The former of these pour out from their free surface a serous fluid but little differing from the Serum of the blood, and closely approximating the exudation which takes place from the vessels themselves, without the interposition of a membranous or other structure.

Exudation, however, is not secretion : in it the Serum of the blood *exudes* from the vessels without a change in its composition, and sometimes even the red particles are intermingled with it; examples of both are found in epistaxis, anasarca, &c.

The secretion from the Mucous membranes is of a more elaborate character, and is the result of a secreting power in the blood-vessels, as the blood does not contain a similar fluid.

In the Mucous membrane too, we meet with the first approach to a more compound secreting structure, from which we ascend until we arrive at the most highly organized gland, which differs but little from the first rudiment, except in the aggregation of its structures. The simplest form of a secreting body is that produced by an inversion or indentation of the mucous membrane, as in follicles, the foramen cæcum of the tongue, &c., in which the principal advantage seems to be, that of increased surface, and a greater protection from foreign bodies. A repetition of this duplicature of the mucous membrane to a greater or less extent forms a gland; of this character are the tonsils, prostate gland, &c.

If we now suppose the follicles to be closely compressed, and their cavities to open into a common duct, we have the structure of almost all the glands of the body; the acini or minutest portions of which consist of a granule which on close examination is thus composed, having its vessels and nerves freely distributed on the outer surface; the principal if not the only disputed point being as to the mode of termination of the vessels; Ruysch and his followers contending that the arteries and veins communicate directly with each other; Malpighi and his supporters contending that the artery expands so as to form a species of sac intervening between the artery and vein, into which the secretion is poured. All the theories which have been more recently brought forward are but modifications of these, and extend to little beyond them, except as relates to the tortuosity and shape of the terminating vessels.

Some physiologists describe the arteries as terminating in blind extremities, as in the arteriæ helicinæ of the corpus cavernosum penis, in the sweat or sudoriferous glands of the skin and other structures.

By this peculiar arrangement of the minute vessels, the secreting surface is greatly increased, that of the Parotid Gland being considered to equal two-thirds of the cutaneous surface.

The kidney affords the best example for the study of a secreting gland, as, in it, the secreting and excreting portions occupy different parts of it. The *Secretory* or cortical substance forms its external structure, the *Excretory* comprising its central portion, namely, the Mammillary processes and tubuli uriniferi; so that a *slice* from the outer surface of the gland, all round, to the depth of from three to four lines, would be almost wholly composed of secreting structure. In other glands, on the contrary, the secreting and excreting portions are united in the smallest grain, one of which forms as perfect a gland as the whole organ itself: if from any one of these we cut out a piece much smaller than a pin's head, we shall have a miniature liver, pancreas, &c.

The Process or Function of Secretion is thus reduced to comparative simplicity: the arteries convey the blood; part is expended in forming the secretion, the remainder is returned to the circulation by the veins, whilst the secreted fluid is received by the duct, and conveyed to its destination.

But by what agency can each vessel secrete its own peculiar fluid from the blood? What enables the renal arteries to secrete urine only, the hepatic, bile, the parotid, saliva, &c.? To this we can only reply, the Vital Principle.

The Process of Secretion has been referred to that of *Endosmose* and *Exosmose*; but that there is a *secerning* power in the vessels is too evident to be questioned, which cannot be explained on these grounds.

Secretion is generally independent of the Will: as, for example, in the liver, kidneys, &c.; but all secretions are much influenced by the state of the sensorium and nervous system generally. Distressing news excites the secretion of the Lachrymal gland, the liver, &c.; fear stimulates the action of the kidneys; the expectation of agreeable food causes the saliva to flow. Other nervous impressions have an opposite effect: extreme grief arrests the secretion of the lachrymal gland, and "tears refuse to flow;" it stops the secretion of the bile, and checks that of the colouring matter of the hair, so that the head may change from black to white in the course of a few hours.

This influence of the Mental emotions is produced through the connexion which exists between the Cerebro-spinal and Sympathetic Nervous System.

The effect of Inflammation on the Secreting glands and structures of the Human body varies according to its intensity: if moderate, the natural Secretion is simply increased in quantity, and not altered in its qualities to any remarkable extent. Diarrhœa, Catarrh, afford examples; but when the Inflammation is more severe, the changes produced are, 1. A Suspension of all Secretion; 2. Increased Secretion; 3. Alteration of character of the Secreted fluid. Catarrh will illustrate these various changes: at first the mucous membrane becomes dry from the absence of all secretion; this state is soon followed by a thin serous excretion; this by a mucous fluid, and this perhaps by purulent matter.

In *Serous membranes*, similar alterations take place. But to pursue this question further belongs rather to Pathological than Physiological research, although indeed, the former is but the Physiology of disease.

The *Assimilative* process, by means of which the several tissues are formed, built up, and maintained, closely resembles that of secretion, inasmuch as peculiar substances are elaborated from the blood. By this means, the bones, muscles, nerves, &c., are formed: in this action a higher degree of vital intelligence seems to be in operation, as the secreted matter is not simply deposited, but is laid down so as to form peculiar shapes, size, &c., in which action the arteries are ably assisted by the lymphatic or absorbent vessels.

One great object of the Secreting process is the separation of materials from the body the retention of which would be injurious; as for example, the bile, urine, &c. The former of these fluids, when thrown back upon the system, is less injurious than the latter, as jaundice continues for a considerable time without producing any very serious results; but the circulation of the urinary fluid in the blood is, almost always, productive of the worst results.

It is remarkable that if the glands do not form this fluid, the retention of its elements in the system is not of an equally dangerous character. In suppression of the urine, where no urine is secreted in the kidneys, the disease continues for a considerable time without producing any very serious symptoms, unless when it is the result of acute inflammation of the kidneys (Nephritis). This phenomenon may be accounted for by the excretion of some of the elements of the suppressed fluid being effected by the other tissues of the body; and this view is supported by the formation of imperfectly formed urine in the skin and other structures; and by the jaundiced state of the mucous membranes and skin in suppression of the biliary secretion.

THE SECRETING GLANDS.

The Glandular System has been hitherto divided into two classes or orders; namely, the CONGLOBATE and CONGLOMERATE.

The *Congobate* glands are the lymphatic glands belonging to the Absorbent System, and are in no respect analogous to the true Glandular organ.

The *Conglomerate* glands are the true secreting glands, with the exception of the spleen, whose position can scarcely be fixed, until further investigation has proved its use, and are therefore the only structures to which the term Gland should be applied.

This division of the Glandular System is now becoming obsolete, and should be discarded altogether.

A more appropriate name for the Lymphatic glands would be that of Ganglion, as this implies a knotted structure, and simply indicates an interlacement of vessels in the interior of these bodies without referring to their uses.

The LIVER, the largest gland in the body, is covered externally by two coats—a partial *serous* derived from the peritoneum, and a fibrous coat composed of condensed areolar tissue, which becomes continuous at the transverse fissure with the capsule of Glisson. These enclose the parenchyma, or proper structure of the gland.

Although the human liver does not present the lobulated appearance observed in the pig and other animals, in which two differently coloured substances may be distinguished, an approach to this may be noticed on close examination, showing a partial separation between the *secreting* portion, which is of a dark brown colour, and the *excreting* portion, which possesses a yellow tinge. This difference is more remarkable in some diseases of this organ, constituting the nutmeg liver. This disposition of colour arises from the peculiar arrangement of the hepatic ducts and ultimate branches of the vena portæ and hepatic artery, which form zones around the parenchyma.

The *parenchyma* of the liver is composed of a number of exceedingly small granular bodies the *acini*, each one of which forms as it were a minute liver, being composed of secreting and excreting portions; in the first of which the bile is formed, whence it is received into the latter.

The Hepatic acini, or, as they are more recently named, the *hepatic lobules* or *islets*, are composed of two elements: 1. A *network of capillaries*, which is connected, on the one hand, with the finest branches of the portal vein and, on the other, collects its blood into its central vein, one of the commencements of the hepatic veins; and, 2, A *network of delicate trabeculæ*, which consist solely of cells closely and continuously joined, the *hepatic cells*. These two networks are so closely applied as to leave no intervals between them, to admit of the hepatic ducts which spring from the periphery of the hepatic islets, close to the branches of the portal vein.

The *hepatic cells* are extremely small, and, like most cells, enclose, within their investing membrane, a nucleus and nucleolus, the latter of which appears to contain the essential elements of the bile, with some fat-drops and yellow pigment granules. It is still doubtful whether the hepatic cells are separated from the capillary network, or not, by an investing membrane.

The Liver differs from all other glands in possessing two afferent blood-vessels, the hepatic artery and the vena portæ. The former of these is destined for the general nutrition of the liver; the vena portæ alone secretes the bile. Whilst the latter vessel therefore supplies the secreting parenchyma of which it forms the principal part, the hepatic arteries are lost on the ducts, &c., and enter but little into the formation of the *capillary network* just spoken of.

The portal branches run for a greater or less distance, according to their size, through the parenchyma in the vascular canals lined by the capsule of Glisson, before they proceed to the hepatic lobules or islets. Each of these receives from one or the other of the portal branches from three to five small vessels called, by Kiernan, *venæ interlobulares*, still such a vein never supplies one hepatic islet, but always two or three. Their ultimate twigs, *rami lobulares* of Kiernan, penetrate at right angles in considerable number into the neighbouring lobules, and break up into the capillary network without anastomosing.

The *hepatic veins* spring from one vein, *vena intralobularis*, which arises from the capillary network, forming the secreting parenchyma, and empties itself into the venæ sublobulares, which run along the basal surface of the lobules. The sublobular veins ultimately unite and form the venous hepatic trunks—that is, the venæ cavæ hepaticæ.

The hepatic artery accompanies, for the most part, the portal vein and bile ducts, and is enclosed with them in the capsule of Glisson. It is remarkable, that the veins, which return the blood from the branches of the hepatic artery terminate in the portal veins, and thus contribute to their formation.

The hepatic veins run generally from the thin to the thick margin of the liver, and do not collapse when cut across, as they do not receive an investment from the capsule of Glisson : the other vessels take a more transverse course, and collapse when cut across, owing to their investment from this capsule. Like the portal veins they are unprovided with valves.

The *biliary ducts* proceed from the periphery of the secreting parenchyma, and unite until they form a separate duct for the right and left lobes ; these unite to form the *hepatic duct*, which joins the cystic duct, and thus forms the *ductus communis choledochus*.

The *gall bladder* acts as a reservoir for the biliary secretion which flows into it, taking a retrograde course from the hepatic duct, except during digestion, when it flows from the cavity of the gall-bladder to its destination.

The *Bile* is a compound secretion, and consists of, according to—

Berzelius—	Water	90·44
	Biliary matter with fat .	8·00
	Mucus of the gall-bladder .	0·30
	Osmazome, chloride of sodium, and lactate of soda	0·74
	Soda.	0 41
	Phosphate of soda, phosphate of lime, and traces of a substance insoluble in alcohol . . .	0·11
		100·0
Thénard—	Water	90 90
	Yellow bitter resin . .	3·73
	Yellow matter diffused through the bile . .	0·18 to 0·90
	Albumen	3·82
	Soda	0·51
	Phosphate of lime and oxide of iron	0·41

Tiedemann and Gmelin—1. fat; 2. brown resin; 3. sweet principle of bile; 4. salivary matter; 5. mucus; 6. gall-brown; 7. oleic acid, salts and minute quantities of other substances.

These eminent physiologists have described a principle named Taurin as found in ox bile, but not in that of any other animal.

Thénard, Gmelin, Chevreul, and others, have found Picromel in human bile; Orfila and others obtained it from gall-stones.

The Pancreas.—The structure of the Pancreas is similar to that of the salivary glands. It receives an irregular covering, externally, of condensed areolar tissue forming a fibrous investment, but not a distinct capsule, which passes into its interior, so as to divide it into lobes and lobules, until we arrive at the ultimate lobules of which its parenchyma is composed.

The ultimate lobules are composed of glandular vesicles of moderate size, and mostly of rounded form, constructed of the proper investing fibrous membrane, and an epithelium or lining membrane: the ducts arise from these, unite, and form one common duct, the *pancreatic duct*, or *ductus Wirsungianus*, although a second duct is sometimes found, which enters the duodenum, by a distinct aperture.

The Pancreatic juice is a thin somewhat transparent fluid resembling the saliva. Its use is to assist in the completion of the Function of Digestion, but its particular office has not been determined. Valentin first showed that it converted into sugar that portion of the amylaceous matter that had not been acted upon by the saliva, and had passed unchanged into the duodenum.

According to Leuret and Lassaigne, it is composed, in the Horse, of

Water	99·1
Animal matter soluble in alcohol	00 9
do. do. in water	
Traces of albumen	
Mucus	
Free soda	
Chloride of sodium	
do. Potassium	
Phosphate of lime	
Oxide of iron, a trace.	
	100·0

According to Tiedemann and Gmelin, it is composed, in the Dog, of

Solids	8·72
Fluids	9 28

100 parts of solid matter contained organic substances, osmazome, with a peculiar animal matter coloured red by chlorine . . .	44·32
Caseous substance possibly with another animal substance soluble in water, but not in alcohol	18·44
Albumen with a small quantity of salts . .	42·83
	105·59

THE SPLEEN.—Although this organ is here placed under the head of the Glandular System, its natural position cannot be ascertained, as its use is wholly unknown.

The spleen is covered externally by a serous layer derived from the peritoneum, and a fibrous layer formed of areolar tissue, within which is enclosed the parenchyma, or proper structure of the organ. This is *sui generis*, and possesses no analogous structure in the human body; it resembles the spongy structure of the corpus spongiosum urethræ, more closely, than any other substance, and seems to be composed of a mass of areolar tissue in which no organization can be traced, beyond that of vessels. It is described as being composed of reticulated firm trabeculæ, the *splenic trabeculæ*, and of a red substance enclosed by them, the splenic pulp, in the latter of which are numerous whitish bodies, the *splenic corpuscles*, or *Corpuscles of Malpighi*; these are most frequently found in the young subject, and in cases of sudden death.

The Splenic corpuscles are always found attached to an arterial twig, and are very numerous: they are vesicular in structure, having an investing membrane, and a contained cell, in which an albuminous fluid is found.

The spleen does not possess an excretory duct, and consequently it cannot be supposed to elaborate any secretion.

The uses assigned to the spleen are extremely various, and partake more of the character of conjecture than of theories based upon correct physiological data.

It is supposed to act as a subsidiary organ to the stomach, receiving the blood from this when digestion is not going forward, and again imparting this fluid to the stomach when the digestive process has commenced. The spleen has also been supposed to be the seat of laughter, and again of splenetic humours: and some physiologists have regarded it as nearly useless, and only occupied a vacant space, which might otherwise exist in the abdomen.

This organ has been more recently supposed to supply the chyle with the colouring matter, as this fluid does not present a reddish tinge until after the lymphatics of the spleen have joined the Thoracic duct.*

It has been removed from dogs and other animals with impunity.

The spleen, although seldom the seat of morbid deposits, becomes much enlarged in intermittent fever.

In the fœtus it is developed at the end of the second month, in a fold of peritoneum at the fundus of the stomach, and originates from a blastema which has no connexion with the stomach, liver, or pancreas.

The Kidneys are covered externally by a strong fibrous coat, composed of areolar and connective tissue, which passes in at the pelvis to line the calyces. Within this is the parenchyma of the organ, composed of the cortical and medullary portions.

The *cortical substance* appears at first to be connected through the whole kidney, without any inter-

* Kölliker at one time supposed that the blood corpuscles were affected in their colour by the spleen; but his views have altered. He states, "I am still of opinion that a solution of blood-cells goes on within the spleen, and in this organ much more than in the liver."

ruption. Examined under the microscope, however, it is seen to divide into the same number of segments as there are cones or pyramids present, so as to be composed of a number of lobes connected together in the adult, but distinct in the fœtal kidney. The structure of the cortical substance is essentially vascular, being formed of a congeries of tortuous arteries and veins, which may be filled with differently coloured injections. It forms the secreting portion of the organ.

The *Medullary substance* of the kidney is arranged in the form of cones or pyramids, the *Malpighian pyramids*, in the centre or interior of the organ, which terminate in free pointed extremities forming the mamillary processes. The Medullary substance, improperly so called, presents a striated appearance, from its being chiefly composed of cylindrical tubes, the *tubuli uriniferi*, measuring on an average 0·016‴ to 0·025‴ in diameter. The tubuli uriniferi commence in the cortical substance, and here present the *Malpighian corpuscles*, but attached to the capillary arteries of the cortical substance, so as to form intermediate bodies between this and the tubes; these are first slightly convoluted, but soon become straight, and are separated by small portions of the cortical substance and extremely fine vessels.

The tubuli uriniferi are composed of an external fibrous envelope, the *membrana propria*, firm and elastic, and a lining pavement of epithelium; near the commencement of the tubuli uriniferi, the latter increases in density, whilst the former diminishes.

The Excretory passages of the kidney consist of the calyces, pelvis, and ureters. Their structure is composed of three coats: the outer coat, formed of connective areolar tissue and elastic fibres, passes into the fibrous capsule of the kidney, where the calyces surround the papillæ. The *middle* or *muscular* layer is well marked, and is composed of external longitudinal and internal transverse fibres, least distiuct in the calyces. The internal lining membrane is of the *mucous* class; it is thin, vascular, and without glands or papillæ; it is lined by one layer of epithelium. The chemical composition of the kidney is but little known. Frerichs found 16·3 to 18 per cent. of solid matter, with 72 to 73·7 parts of water. Some fat exists in the solid matter, but its greater part appears to be of an albuminous character. *Cloetta* has lately discovered in the kidneys, inosite, xanthin, cystin, and taurin; *Beckman*, leucin and tyrosin, from which it would appear that some of the constituents of the urine are real products of the kidney, and not merely separations from the blood.

Three substances are found in the urine, which contain a considerable proportion of nitrogen, and may be considered as the principal means of getting rid of so much of this principle as may not be required in the system. These are, *Urea*, *Uric Acid*, and *Hippuric Acid*. The sources from which Nitrogen is derived are, the atmospheric air in Respiration, the azotized food taken into the stomach, and the disintegrated tissues which are about being discharged from the body; so that a considerable quantity is constantly being taken into and discharged from the system.

Urea.—This is the most azotized substance met with in the human body, and forms an important element in the composition of the urine, which receives most of its peculiar characters from this substance. It may be obtained from cyanate of ammonia, the atomic constituents of both being exactly similar; thus, $C_2NO + NH_3 + HO = C_2H_4N_2O_2$. The quantity of urea found in the urine amounts to 3·29 per cent., but varies much according to the quantity and composition of the food taken. Animal food, such as eggs, meat, &c., is found to increase it, whilst vegetable food causes it to decrease; exercise, muscular exertion, tend also to increase the quantity of urea; and total abstinence from food for several days, although diminishing its quantity, will not prevent, as might be expected, its appearance in the urine.

Small quantities of urea are found in other fluids besides the urine. It may be recognised in the blood, and is frequently found in dropsical effusions, in the aqueous and vitreous humours of the eye; and, according to some, may be occasionally met with in the saliva and other excretions.

As Urea is present in the blood, the action of the kidney, in separating it, approaches more to the character of exudation than excretion. Still it is manifest that there is a secerning power in the kidneys, as no other organ separates urea in the healthy state.

It is to the decomposition of Urea that the peculiar odours emanating from urinals are principally due, as it is rapidly converted into carbonate of ammonia; hence urine, which is originally acid, will soon possess an alkaline character, the result of decomposition. This will show the necessity of testing the fluid shortly after it has been expelled from the body.

Urea may be obtained from the urine in the crystalline state by evaporation. When the urine has obtained the consistency of honey, the mass is to be treated with four parts of alcohol, on the evaporation of which and cleansing with water, the crystals are obtained in four-sided prisms. When pure, Urea is devoid of colour, but most frequently presents a brownish-yellow tinge; it is free from smell, has a saline taste, and presents no trace of a free acid or alkali.

Uric Acid.—This substance, although so closely allied to Urea, is considered by many to be a distinct compound. It was formerly termed lithic acid (λίθος, a stone), from its presence in many forms of calculi, hence termed lithates. Like Urea, it abounds most in the urine from the use of animal food, and least when the diet is exclusively of a vegetable character. The quantity found in the urine amounts to ·123 per cent.

In consequence of the great insolubility of uric acid, requiring 10,000 times its weight of water to dissolve it, Dr. Prout considered that it exists in the urine not as a free acid, but as a salt, and most probably the urate of ammonia, which is formed on the evaporation of the urine, and not uric acid; but if the ammonia be expelled, crystals of uric acid will make their appearance. Liebig considered that the uric acid existed in the urine, as urate of soda, deriving the alkali from the blood; and that it is the formed product of the disintegrated tissues, being converted into urea and carbonic acid, by the addition of oxygen.

Uric acid is frequently deposited in the free state from the urine, forming the red deposit so often found in this fluid.

Hippuric Acid, formerly called uro-benzoic acid, is found not only in the urine of the human subject at all ages, but also in that of herbivorous animals. In certain morbid circumstances, as in many cases of diabetes or chorea, its quantity is greatly increased.

If hippuric acid be boiled for some time with sulphuric, hydrochloric, nitric, or oxalic acid, or with soda or potash, it is decomposed into benzoic acid and glycocoll or glycin. The latter substance is found in the after changes of the cholic acid of the bile. The quantity found in the urine is rather less than that of uric acid.

The experiments instituted by Stehberger and Erichsen on persons with extroversion of the bladder, show that traces of some substances introduced with the food soon appear in the urine. Ferro-cyanide of potassium only required an interval of one minute, while the colouring matter of indigo or madder required a quarter of an hour.

The red brickdust sediments of feverous subjects chiefly consist of uric acid, generally in the form of minute tables, and of alkaline and earthy urates. The colour of the whole is produced by a peculiar red matter, the nature of which is but little known.

The following Tables, constructed by Franz Simon from the results obtained by Lehman, will show the composition of human urine under different regimens, and are of much value.

	On mixed diet.	On Animal food.	On Vegetable food.
Amount of urine in 24 hours	1057·8	1202·5	909
Specific gravity . . .	1022·0	1027·1	1027·5
Solid residue from 1000 parts of urine . . .	65·82	75·48	66·41
Solid matter passed in 24 hours	67·82	87·44	59·23

	In 100 parts of solid residue.	Daily amount in grammes.
Urea during a Mixed diet .	46·230	32·498
,, ,, Animal ,, .	61·297	53·198
,, ,, Vegetable diet	39·086	22·481
Uric acid during a Mixed diet	1·710	1·183
,, ,, Animal ,,	1·674	1·478
,, ,, Vegetable ,,	1·737	1·021

	Mixed diet. gramm.	Animal diet. gramm.	Vegetable diet. gramm.	Non-Nitrogenous diet. gramm.
Solid Constituents . .	67·82	87·44	59·24	41·68
Urea.	32·50	53·20	22·48	15·41
Uric Acid	1·18	1·48	1·02	0·73
Lactic Acid & Lactates	2·72	2·17	2·68	5·82
Extractive Matters . .	10·49	5·20	16·50	11·85

The Mammary Glands.—These glands, which exist only in the female subject, approach in character to the salivary glands.

Each mammary gland consists of a number of distinct lobules, from fifteen to twenty-four, separated from each other by prolongations of the investing membrane, formed of condensed areolar tissue. These lobes are irregular in shape, and vary in size. Each is composed of lobules, the smallest lobule being made up of the *gland vesicles.* These are of a round or pyriform shape, from 0·05‴ to 0·07‴ in diameter, and are composed, like other gland vesicles, of a fibrous membrane and a lining pavement of epithelium.

Like the lachrymal gland, the mammary gland is formed by a junction of the excretory ducts of the smaller and larger lobules, from which a single excretory duct proceeds, which runs towards the nipple, receiving smaller ducts in its course. The duct, shortly before its termination, expands slightly, then contracts again, and finally opens on the nipple by a distinct aperture, $\frac{1}{3}$‴ to $\frac{1}{5}$‴ in diameter. No muscular fibres can be detected in the lactiferous ducts.

The *Areola* surrounding the nipple is of a darker colour than the general integuments, being in some females of a deep brown colour; in it are large sudoriferous glands, and large sebaceous glands, with some fine hairs.

The *nipple* is composed of erectile tissue, covered by a delicate prolongation of the skin. It becomes enlarged during excitement, pregnancy, and whilst suckling. On it are the openings of the lactiferous ducts, through which the skin is continuous with the mucous membrane lining the ducts. This forms a distinct division of this class of membranes, in the female subject.

In the male subject, there is no distinct glandular structure, although a rudimentary tissue is to be observed. In some rare cases, the mammary gland is well developed in the male, and in some few instances a *milky fluid* has been secreted; but no authentic case of suckling by the male is on record.

Before puberty, the mammary gland is extremely small, and projects but little; but at this period it enlarges in size, becomes rounded, and projects distinctly.

When impregnation has first taken place, the mammary gland changes but little; but towards the latter months—from the fifth month especially—it enlarges considerably, the increase being accompanied by shooting pains through the breast; the areola darkens in colour, and the nipple swells.

During lactation, its tissue is no longer uniform, but becomes softer, granular, and lobulated; and the reddish-yellow granular parenchyma is distinctly marked off from the lax whitish interstitial tissue, the gland vesicles become distended with milk, and the vessels are greatly increased in number. The enlargement of the nipple and areola is remarkable, as appearing to be the result of an expansion of these structures, and not a spreading of the colouring matter of the latter.

When menstruation ceases, the mammary gland begins to waste, until, in old age, all the gland vesicles have disappeared, and the lacteal ducts only remain, with some fatty degeneration.

The *Milk* is the secretion of the lacteal or mammary gland. It is a white fluid, with a slight tinge of yellow, more or less dense, consistent, and opaque. It is composed of a fluid portion, or plasma, holding in suspension countless round dark shining corpuscles, of variable size, from 0·001‴ to 0·002‴, to others which are too small to admit of being measured. Before pregnancy, the ducts of the mammary gland contain only a small quantity of yellowish viscid mucus; but after this takes place, the gland vesicles begin to enlarge, and form a fatty deposit, in which the fat globules are visible, similar to the milk globules subsequently formed. These are derived from the fatty cells, more or less disintegrated, and, with these, are seen entire cells of the same kind, with or without an envelope, forming the *colostrum* bodies. When lactation commences, the fluid collected in the first three or four days is discharged, and forms the *colostrum*, or immature milk, which is succeeded by the true milk.

The *milk-cells* break down into their elements, the *milk-globules*, before leaving the lacteal ducts, their envelopes and nuclei disappearing, so that the milk presents no trace of its mode of origin. In the milk are found numerous *milk-globules* of various sizes, analogous to the *colostrum* corpuscles.

Human Milk is composed, according to Payen, of—

Butter	5·18
Casein	0·24
Solid residue	7·85
Water	85·80

Specific gravity, 1·020 to 1·025
Ditto of cow's milk, 1·03

Milk is a highly nitrogenized fluid. According to

Mulder's analysis, it contains, in addition to 0·41 of Sulphur—

Carbon	15·10
Hydrogen	6·97
Nitrogen	15·95
Oxygen	21·62

Cow's Milk from which the cream was removed was found by Berzelius, to be composed of—

Caseine, with a portion of the fatty matter	2·600
Sugar of Milk	3·500
Alcoholic extract, lactic acid, and its salts	0·600
Chloride of potassium	0·170
Alkaline phosphate	0·025
Phosphate of lime, free lime, combined with casein, magnesia, and traces of oxide of iron	0·230
Water	92·875

The SALIVARY GLANDS are three in number on each side: namely, the Parotid, Submaxillary, and Sublingual Gland, and present a similar structure, consisting of a fibrous investment of condensed areolar tissue, forming an indistinct capsule, within which is enclosed the *parenchyma* of the gland.

The fibrous coverings of the Salivary glands are continuous with the cervical fascia: that of the Parotid covers the gland on its superficial surface, sends processes into the interior, but gives no covering to its deep surface; that of the Submaxillary gland invests this so as to form a capsule; whilst that of the Sublingual is the least marked, and consists of loose areolar tissue.

The Salivary glands are composed of lobes and lobules, which consist of extremely small granules or *acini*, composed of gland vesicles, from each of which a small radicle or root of the excretory duct arises. By the union of these roots, the excretory duct is formed, and conveys the saliva to the cavity of the mouth.

The Structure of the Salivary ducts is composed of an external fibrous coat, and a lining mucous membrane, covered by a layer of pavement epithelium. The Parotid duct is strong and resisting, whilst that of the Submaxillary is thin, and resembles a vein. A thin layer of smooth muscular fibres is described in the latter by Kölliker.

The Saliva from the Parotid gland is clear and fluid, containing no mucus; whilst that from the Submaxillary and Sublingual is ropy, and contains mucus.

The Saliva contains the *Salivary corpuscles.* These are roundish cells, 0·085″ in size, with one or more nuclei. It is composed, according to Berzelius, in the sheep, of—

Water	98·80
Matters soluble in alcohol (extract of meat, a matter which crystallizes, chloride of sodium in octohedra, chloride of sodium, and a small proportion of sulpho-cyanide of sodium)	0·11
Matters soluble in water only (traces of ptyalin, a considerable quantity of phosphate of soda, chloride of potassium, and carbonate of soda)	0·82
Matters insoluble in water and alcohol (mucus and coagulated albumen, and a small quantity of phosphate and carbonate of lime)	0·05

The Glands connected with the Function of Generation have been sufficiently described with this.

The Amygdalæ, or Tonsils, are examples of the simplest form of glandular structure, being composed of a congeries of *mucous follicles*, or follicular glands, connected together by moderately condensed areolar tissue.

The Secretion of the Tonsils resembles that of the mucous follicles of the mouth and tongue, and is generally supposed to be mucus.

INTESTINAL GLANDS.—The small intestines contain only two kinds of true glands; viz., the *tubular*, which exist everywhere in the mucous membrane, and the *racemose*, seated in the sub-mucous tissue.

The *racemose* glands, *glandulæ solitariæ*, or glands of *Brunner*, form at the commencement of the duodenum, on either side of the mucous membrane, a continuous glandular layer, which is most developed and dense, close to the pylorus, so that here they give rise to a glandular ring, which extends as far as the gall duct. Their secretion is an alkaline mucus, which exerts no digestive action on coagulated protein compounds, and probably subserves mere mechanical purposes.

The *tubular* or *Lieberkhünian glands* are distributed over the whole small intestines, are very numerous, straight, and narrow tubes extending through the entire thickness of the mucous membrane. They secrete the *succus intestinalis*, or intestinal juice.

The *closed follicles of the small intestines* are met with, singly, or in groups; the most important are the *glands of Peyer*, or glandulæ agminatæ, which mostly occur in the lower part of the small intestines, arranged in rounded or oblong bodies, on the surface of the intestine opposite the attachment of the mesentery.

The glandular structures of the large intestines are the *Lieburkhünian glands* and *solitary follicles*: they are very numerous and present the same structure as those of the small intestines.

THE LACHRYMAL GLAND is analogous to the Salivary glands; its secretion, the *tears*, consist of 99 per cent. of water, with slight traces of albumen and mucus, chloride of sodium, and earthy phosphates.

OF THE ELEMENTARY COMPOSITION OF ANIMAL TISSUES.

ALL the structures of the human and other living bodies are composed of certain elementary substances, which by their union form these, and by certain varieties in their disposition produce the numerous structures, of which the living fabric is composed.

There is but little difference in the nature of these: the most and least highly organized bodies present nearly the same constituents, although these vary as to the proportions which they bear to each other.

The softest and the hardest substances alike possess nearly the same constituents, and it is only by the addition of some one or two ingredients that the latter possess the powers of resistance which are so necessary to the function or office performed by them.

Albumen and *Gelatin* are the leading constituents of the various structures of the living body. The soft parts, as the muscles, nerves, &c., possess these, and in like manner the osseous or bony structures are composed of them; but in the latter we have the addition of earthy salts—as the phosphate, carbonate, and fluate of lime—which impart to the bony structures their solidity.

By the removal of these earthy salts, the bony structures may be resolved into nearly the same composition as the muscles or other soft parts; as, for example, in the digestion of bone in dilute hydrochloric acid. By this means, the earthy salts are dissolved by the acid, and the form of the bone remains; but it is now composed solely of animal matter, albumen and gelatin, and becomes soft and unresisting as a piece of cartilage or muscular structure.

With the addition, then, of a few salts, as of soda and lime, a certain proportion of water, some fibrin and residuary matter, albumen and gelatin make up the principal elementary substances which form all the tissues of the body.

Even in the fluids we recognise the same elementary substances, or the constituents, of which they are composed, although in a fluid state: in the blood, the chyle, and the lymph, from which the various tissues are formed, they are found in suitable proportions.

It would appear that the elements of the various tissues are formed in the blood, and that to the secretory arteries is assigned the office of selecting these, as required, in each one of the more compound structures, of elaborating them, and thus building up the several organs.

Albumen is the principal elementary animal substance: it forms the white of egg; it is a whitish, glairy, semi-transparent fluid, and is known by the following tests:—It dissolves in water, ammonia, and acetic acid, also in soda and potash, from which it is again precipitated by hydrochloric acid. It is insoluble in alcohol or ether, but is precipitated from the aqueous solution by alcohol, when it becomes insoluble in water. It is coagulable by heat, acids, iodine, chlorine, tannin, alcohol, &c.

It turns the syrup of violets green, owing to the carbonate of soda which it contains.

It decomposes certain metallic compounds, and is hence used as an antidote to bichloride of mercury, and the sulphates of zinc and copper.

Albumen is found in the white of eggs, the serum of the blood, the chyle, the synovia, and most serous secretions, as well as in most of the solid structures.

Albuminoid substances, also called "*protein com-*

pounds," present similar characters to those which distinguish free albumen. All contain sulphur, which seems to be one of their essential constituents, and cannot be separated from them without destruction of the organic substance. They are very liable to spontaneous decomposition when exposed to atmospheric air, and are resolved with the atmospheric oxygen into water, carbonic acid, and ammonia.

By the prolonged action of caustic alkalies upon the protein compounds, a crystalline substance termed *Leucine* is obtained, in colourless scales, without taste or smell, and soluble in water.

Another compound named *Tyrosine* is obtained by the same reaction, in needle-like crystals.

The analysis of albumen presents the following composition, according to Mulder :—

Carbon	53·5
Hydrogen	7·0
Nitrogen	15·5
Oxygen	22·0
Sulphur	1·6
Phosphorus	0·4
	100·0

Gelatin is found in most of the soft and solid parts of animals—namely, the muscles, skin, cartilage, ligaments, tendons, bones, &c.,—from which it is extracted by boiling water, and which, on evaporation and cooling, yields this substance. Pure gelatin is colourless, inodorous, and is more dense than water.

It is known by the following tests :—

It is slightly soluble in cold, but very soluble in hot water. It is precipitated by tannin, with which it forms an insoluble compound, named tanno-gelatin, the basis of leather.

If boiled for some time in caustic potash, gelatin is decomposed with an escape of ammonia, when two new compounds are formed, namely, *leucine* and *glycine*, or *gelatin-sugar*.

The mode of formation of gelatinous compounds in the animal body is not known, they are doubtless elaborated from albumen.

The composition of gelatin is simple, being—

Carbon	13
Hydrogen	10
Nitrogen	2
Oxygen	5

The Gelatin of Cartilage is sometimes distinguished as *Chondrin:* it differs but little from gelatin.

Fibrin is one of the albuminous or protein compounds: it is contained in the chyle and blood, from which it is easily obtained (*see* BLOOD); it forms the chief part of the muscular tissue, distinguished as Syntenin, and is the basis of coagulable lymph.

Closely allied to Albumen is the substance termed *Casein*, which is its substitute in milk, and forms the principal albuminoid nutriment of young animals during lactation: it nearly resembles albumen, but differs from it in not being coagulated by heat, and is precipitated from its solution by acetic acid.

Casein is also found in the serum, which is diffused through the areolar, muscular, and other tissues, in the blood of pregnant females, especially in that of the placenta; and mingled with albumen, in the yolk of egg, under the name of *vitellin*.

The organic and inorganic worlds are composed of the same *elements*, so that one may pass into the other by the exercise of the vital actions, or from the cessation of them: the inorganic mass being acted upon by the influence of the vital principle is converted into an organic and living being, and in like manner this passes back into the primitive and elementary condition on occurrence of death, or the destruction of the living action.

There is no destruction of even the smallest fabric; all is change: and when the living body dies, it is decomposed, but not destroyed; it separates into the elements from which it was originally formed, and becomes once more a portion of the inorganic world.

The elements most frequently found in the animal body are, oxygen, hydrogen, carbon, and nitrogen; but other elements are also met with—namely, sulphur, phosphorus, chlorine, silicon, fluorine, potassium, sodium, calcium, magnesium, iron, and manganese; and others may be advantageously introduced, such as iodine, bromine, arsenic, mercury, and many other metals.

The gases of the animal body consist chiefly of oxygen, hydrogen, nitrogen, carbonic oxide, carbonic acid, carburetted hydrogen, phosphuretted hydrogen, and sulphuretted hydrogen.

The volatile substances consist, for the most part, of oxygen, hydrogen, carbon, and nitrogen, or of the first three of these only. Hence they are divided into the azotized and non-azotized substances.

Starch, sugar, lactic acid, and the pure oils and fat, contain no nitrogen; but albumen or fibrin, casein, hæmatin, urea, uric acid, hippuric acid, and most other bodies which are found in the animal organism, contain nitrogen, and therefore belong to the class of azotized compounds.

The Azotized or real nutritive constituents of food are vegetable and animal fibrin, vegetable and animal albumen, vegetable and animal casein.

The Non-azotized constituents of food are, fat, starch, gum, sugar, dextrine, bassorine, alcohol, vegetable acids, &c. &c.

OF THE TISSUES.

THE different tissues of the animal body, although resembling each other so strongly in their elementary composition, vary considerably as to form, solidity, and organization.

This must necessarily be the case, as each part of the body has certain offices or functions to perform, which could only be accomplished by the adaptation of the organs themselves to the purposes for which they are intended.

The Bones are hard, firm, and resisting, to form the framework which is destined to support and protect other organs, and to enable them to perform their functions: they are rounded, flat, or curved, as may be best suited to the wants of the individual.

The Muscles, on the contrary, are soft and yielding, as is necessary to that contractility which is their especial function: their shape also varies, being long, short, flat, or round, as may be required in the several parts of the body in which they are placed.

So is it with the various portions of the vascular and nervous systems, and, indeed, with all parts of the animal fabric.

The various extent of organization, possessed by each, and all of these tissues is equally remarkable, and is equally suited to the functions or offices performed by them. Some possess a high degree of organization, and are largely endowed with vessels, nerves, and absorbents; whilst others, on the contrary, possess but little organization, and but few blood-vessels and nerves; the mucous, muscular, and nervous tissues present examples of the former; the fibrous and osseous tissues afford instances of the latter.

The extent of organization possessed by each tissue, not only affects the importance of its position in the animal economy, but also exerts a material influence on its abnormal or diseased condition.

The more highly organized parts present a vitality in disease which does not characterize those of inferior organization: and if we are acquainted with the extent of organization possessed by each structure or tissue, we shall be prepared to expect the various phenomena which they will present when labouring under diseased action.

Those least organized are prone to perish more rapidly, and are thus disposed to run into mortification, or the sloughing process; whilst the more highly organized are enabled to resist this, and present a tendency to effusion from their substance or surfaces, as in the processes of effusion, suppuration, and ulceration, which may be regarded as new actions developed in the organization of the tissues.

The fibrous tissues, such as the tendons, ligaments, fibrous membranes, the osseous structures, are examples of the least highly organized tissues, and the proneness of these to mortification is remarkable; whilst the skin and mucous membranes, muscular tissues, &c., are instances of the more highly organized: these resist the tendency to mortification, and are more disposed to the reparative processes set up by inflammatory action, and, therefore, to a recovery from its injurious effects.

The extent of organization possessed by each tissue should be carefully studied, as an acquaintance with it at once points out to us the morbid action to which it is subject, and the nature of the various phenomena which this is likely to present, either in its course to destruction, or in its attempts to establish a normal action, and thus regain its integrity in the animal economy.

OF FIBROUS TISSUE.

The *Fibrous tissue* forms the basis of the greater portion of the animal structures, and is composed of fibres of variable length, direction, and arrangement, according to the nature and functions of the different structures, into the formation of which they enter. In some tissues the fibres are wholly longitudinal; in others they take different directions, so as to interlace with each other; whilst, in others, they so intersect as to be with difficulty separated.

In some, the fibrous tissue forms almost exclusively the whole of the structure of the part, as in the ligaments, tendons, and fibrous membranes: in others, the fibrous structure forms tubular bodies, in which the proper tissue of the organ is contained, as in the bellies or fleshy portion of the muscles, the osseous fabrics, &c.

Generally speaking, the fibrous tissues present a dull whitish appearance, are dense, firm, resisting, and inelastic, as in the ligamentary structures; but in others they present a shining glistening appearance, as in the plantar and palmar, and other aponeuroses of the body.

Some of the fibrous tissues appear to possess elasticity, as in the muscles, fibro-cartilages, the yellow tissue of arteries, the ligamenta subflava, and ligamentum nuchæ; but this elasticity is the property of superadded tissue in these parts, and does not belong to the fibres themselves, which only yield or react in obedience to the influence exerted upon them.

The property of elasticity, if conferred upon many of the fibrous tissues, would render them unfitted to the offices which they are destined to perform, as these are to connect certain parts firmly together, and to prevent motion, except in some particular directions. If the ligaments of the joints, for example, or of the spine, were elastic, a separation of the bones would result, which would render the articulations insecure, and thus not only affect their stability, but also compromise the safety of the individual.

The *Tendons* of the muscles present good examples of the fibrous tissues: in these, the fibres are arranged in the longitudinal direction, running parellel to each other, and extending from the muscular tissue to the bones, or ôther structures in which they terminate. This arrangement of fibres accords with the action of the muscular fibres, the contractions of which tend to stretch these in the longitudinal direction, but not transversely.

In the *Ligaments*, on the contrary, the strain or tension of the fibrous tissues takes place in various directions, on the motion of the articulations or bones which they connect; hence, in these, the fibres interlace with each other, and are thus best suited to resist the different strains to which they are liable to be exposed.

A similar arrangement is observable in those fibrous tissues which form envelopes enclosing certain organs, as in the fibrous layer of the pericardium, the sheaths of the muscles, tendons, &c., as their office is to confine the contained organs *in sitû*, and limit their too great expansion.

The fibrous tissue is thus found in all situations where strength and resistance are essential, without confining altogether the motions of the parts themselves; and to this end they are characterized by a degree of strength and firmness, not to be met with in any other of the tissues of the body, with the exception of the osseous structures.

Fibrous tissues possess but little organization, few blood-vessels, and but a limited supply of nervous fibre; they are thus wholly insensible in the normal state, and are accordingly prone to the sloughing process when attacked by inflammation: they are also much disposed to the deposit of ossific or calcareous matter.

The periosteum of bones is an exception to these remarks, as it is highly vascular, one of its offices being to permit the blood-vessels to ramify in it, before entering the osseous tissue.

In the more compound fibrous tissues, as fibro-cartilage, we have the superaddition of cartilaginous matter, which endows them with a considerable degree of elasticity.

The *Yellow Fibrous tissue*, the "tissu jaune" of the French physiologists, is met with in the middle coats of the arteries, the ligamentum nuchæ of quadrupeds, the ligamenta subflava, and to a slight degree in the inferior chordæ vocales: it is composed of long single elastic filaments, which frequently interlace so as to form a dense network.

The chemical composition of the white fibrous tissue —as in ligaments, tendons, &c.—is found to be almost wholly gelatin, into which they are resolved by long boiling.

The Yellow fibrous tissue, on the contrary, contains no gelatin, and is almost unaffected by prolonged boiling or by the weaker acids: if kept moist, its elasticity is retained for a considerable length of time. According to Scherer, it consists of

Carbon	48
Hydrogen	38
Nitrogen.	6
Oxygen	16,

and is composed of one atom of protein, and two atoms of water.

Closely allied to the fibrous tissues, but still sufficiently dissimilar to require a distinct consideration, is the *Areolar tissue* of the animal body. This tissue is found extensively diffused in various parts of the body, immediately beneath the skin, between the muscles, and in the interstices which separate the various organs from each other.

The *Areolar tissue* is composed of a network of delicate fibres and bands which interlace with each other, in various directions, so as to form numerous spaces, or areolæ, which communicate freely together. Some of their fibres are composed of the white fibrous tissue, whilst others partake of the yellow or elastic character.

The Areolæ of this tissue contain during life a thin transparent fluid of a serous character, which, in dropsical effusions, is increased considerably, so as to distend the cells or areolæ, especially where the tissue is of a more delicate character, as in the eyelids, penis, scrotum, &c.

The Areolar tissue is soft, yielding, and elastic, it possesses neither sensibility nor contractility, and is but feebly organized, possessing but few blood-vessels or nerves; hence its great tendency to slough or mortification when attacked by inflammation.

This tissue is found in the interior of the organs of the body, in which it presents various degrees of density, according to the particular organ: as, for example, in the mammary and salivary glands, spleen and pancreas, it is loose and expanded, whereas in the liver and kidneys it is close and compressed, and seems to perform the office in these organs of binding their component parts together: it also exists in the fleshy portions of the muscles, and connects the fibres and fasciculi of their organs together, as in like manner in the nerves and glandular system generally.

The Areolar tissue fills up the interstices, which would otherwise exist in various parts of the body, at once separating and uniting the various structures together, allowing of their free motion on each other, and affording transmission to the blood-vessels and nerves which it envelopes.

In many parts of the body, as beneath the skin, in the abdomen, &c., the areolar tissue contains, in its cells or areolæ, a quantity of adipose tissue, whence it is named *adipose areolar tissue*, as distinguishing it from the *reticular* just described: the cells of the former are said not to communicate, whereas those of the latter communicate freely, as is evidenced in cases of anasarca, emphysema, and the artificial inflation of meat as practised by butchers and others. The shape of the areolæ is ascertained by freezing, when the fluid contained forms a small pellicle of ice, which determines the form.

The Areolar tissue may be considered as forming the basis of the fibrous, serous, and mucous tissues as well as that of the various organs of the human body, being more or less condensed in each, and containing in its areolæ the parenchyma, or true tissue, of the particular tissues. Even in the denser structures, as in the bones, its presence may be ascertained by their digestion in dilute hydrochloric acid, and the subsequent maceration of the animal residue in water, when by gentle agitation the whole resolves itself into a network of areolar tissue.

OF THE MEMBRANES.

In different parts of the body, we meet with sheets of tissue, spread out to a greater or less extent, forming coverings for the viscera contained in the cavities, investing and protecting more delicate parts, or lining the exposed surfaces of the animal structure: these are named *Membranes*, and are divided into the *Simple* and *Compound*. They form a most important portion of the human fabric, not only as relates to their anatomical and physiological character, but with reference also to the morbid affections to which they are so liable. Their influence accordingly on the well-being of the animal economy is great, and a perfect acquaintance with their several features, in both their normal and abnormal conditions, is most essential to the study of morbid pathology, and the treatment of disease.

The *Simple Membranes* are the Fibrous, Serous, and Mucous.

The Compound Membranes are composed of two of those, and form the *fibro-serous* and *fibro-mucous* membrane. There is no instance, in the human body, of a muco-serous membrane, and but one example of the continuity of these two classes, namely, the mucous and serous, which is in the *corpus fimbriatum* of the female subject, at the morsus diaboli of which, the lining or mucous membrane of the genital system is continuous with the abdominal peritoneum.

THE FIBROUS MEMBRANES.

These are composed essentially of *fibrous tissue*, and present the various characters already assigned to this: they are the most extensive class of membranes in the human body, as they comprise the dura mater, the periosteum, the fasciæ, aponeuroses, &c.

They are characterized by great strength, density, and resistance, are inelastic, present a dull whitish or glistening appearance, are possessed of few blood-vessels and nerves, are insensible, and prone to mortify or slough when attacked with acute inflammation, are disposed to rheumatic and gouty inflammations, and are frequently the subject of chalky, calcareous, and ossific deposits.

The principal fibrous membranes are the dura mater, the fibrous layer of the pericardium, the periostea, fasciæ, aponeuroses, sheaths of tendons, ligaments, sclerotic, tunica albuginea testis, &c.

Most of these fibrous membranes are continuous: thus the dura mater passes out of the skull, and is then continuous with the external periosteum, and hence with the fasciæ, aponeuroses, &c. The ancient physiologists, from this, assigned to the dura mater the maternity of the fibrous or hard tissues; hence its name. Where not immediately continuous, they are joined by areolar tissue of greater or less density.

The Periosteum.—This membrane, although forming a portion of fibrous membranes generally, deserves a distinct consideration. It covers all the free surfaces of the bones, excepting the exposed portions of the teeth, and serves not only to invest these, but to permit of the larger vessels breaking down in its substance before entering the bony tissue. One surface is firmly attached to the bones: the other is more free, and affords origin to the muscular fibres, and attachment to the tendons and ligamentary structures; it also connects the epiphyses of the bones at the earlier periods of life, and prevents their separation from the shafts.

Unlike fibrous membranes generally, it is extremely vascular, the vessels contained in it being destined to the support of the osseous tissue.

The Dura Mater.—This membrane not only forms one of the investments of the brain, but also serves as an internal periosteum to the bones of the cranium: for this purpose it is amply supplied with blood from the meningeal arteries, which ramify upon it, and then enter the bones, passing into the diploë, when they anastomose freely with the vessels from the external periosteum. This membrane is also of use in forming several folds which separate different portions of the brain, in the formation of the sinuses, and in giving sheaths to the nerves as they pass out from the cranium. The dura mater of the spinal canal does not form a periosteum to the vertebræ: these are supplied with blood from the external vessels.

THE SEROUS MEMBRANES.

These, although most frequently found in connexion with the fibrous membranes, present but little resemblance in their normal condition, and are essentially different, in their morbid or diseased action, and abnormal results.

They are seven in number, namely, the *arachnoid*, the *serous layers* of the *pericardium* and *heart*, the *pleuræ*, *peritoneum*, and *tunicæ vaginales testium;* to these may be added the membrane lining the chambers of the eye.

It will be observed that, with the exception of the peritoneum, all the serous membranes are closely connected with fibrous structures, and are thus more properly compound membranes, but it is necessary to consider each membrane separately, in order to understand its structure, its physiological and pathological phenomena.

The characters of the serous membranes are that they line cavities, those of the Head, Chest, and Abdomen especially, form shut sacs, present a smooth, shining, and polished appearance, possess but few red vessels or nerves, secrete a thin serous fluid resembling the serum of the blood, and are most liable to the *adhesive* inflammation, under which the normal secretion is changed into a dense plastic fluid, *coagulable lymph.*

Although the serous membranes do not possess, in the normal state, red vessels, and nerves can with difficulty be traced into them, they possess a high degree of organization, their vessels carrying the serous portion of the blood, and when inflamed, these become enlarged and admit the red particles. They are composed of condensed areolar tissue, the areolæ of which are so condensed as to become obliterated and do not admit of effusion into them. Effusion, however, takes place freely from their free surfaces, as in hydrocephalus, hydrops pericardii, dropsy of the pleuræ, ascites, and hydrocele, and occasionally from their attached surfaces, although examples of this are extremely rare.

When inflamed, they become highly vascular, and present a network of red vessels.

The serous membranes are described by some physiologists as being "lined by a delicate epithelium, composed of flattened polygonal cells, and lying in apposition with each other, so as to form a kind of pavement, hence termed pavement or tesselated epithelium."

The use of the serous membranes is to line the interior of cavities and their contained viscera, to furnish them with a smooth lubricated surface, which allows of their free motion, and, at the same time, to form folds to sustain and connect them together.

To the class of serous membranes belong the *synovial membranes* of the joints, those lining the sheaths of tendons, and the bursæ mucosæ.

The *Synovial membranes* resemble the serous, in lining cavities, forming short sacs, presenting smooth polished surfaces for the purposes of motion, and in not being possessed of red vessels or nerves. They *differ* from them, in secreting in their normal condition a thick glairy fluid, the *synovia*, which, under inflammation, is changed into serum, and in not being prone to the adhesive process; they also are lined by an epithelium.

It has been disputed whether the synovial membrane lines the cartilaginous surfaces of the joints; but minute investigation, analogy, and the morbid phenomena which they present, leave no doubt that such is the case.

The Serous and Synovial membranes are attached to the subjacent parts by a layer of condensed areolar tissue, forming its chief thickness and strength, and imparting to it a certain degree of elasticity; this forms the sub-serous tissue, and in it the principal vessels and nerves are distributed. This sub-serous tissue is tolerably abundant beneath the pleuræ and peritoneum, but is extremely limited between the arachnoid and dura mater, in the pericardium, and beneath the tunica vaginalis testis.

The lining membrane of the vascular system, the Heart, Arteries, Veins, and Lymphatics, is assigned to the class of serous membranes, as most analogous to them; that of the arteries alone presents a tendency to the *adhesive inflammation.*

THE MUCOUS MEMBRANES.

These are next in extent to the fibrous membranes, and form the great Tegumentary Membranes of the human body, the exterior, generally speaking, being covered by the skin, the external mucous membrane; and the interior being lined by the mucous membrane properly so called. In some situations, the mucous membrane appears externally, as in the conjunctiva of the eye, the lips, the glans penis, and the orifices of the lactiferous and other ducts which open on the free surface of the skin. The teeth are the only structures which are uncovered by tegumentary membrane.

The Mucous Membranes consist of two great divisions: 1. the *Gastro-Pulmonary*, and 2. the *Genito-Urinary.* In the female the lining of the lactiferous ducts forms a separate division

The *Gastro-Pulmonary* division of the mucous membranes extends from the conjunctiva of the eye, through the nasal ducts, the nasal passages, Eustachian tubes, and tympanum, the mouth, throat, and fauces, the larynx, trachea, and bronchial tubes, the œsophagus, stomach, the ducts of the secretory glands, intestinal canal to the anus: at each extremity it is continuous with, and blends with the external skin.

In some situations, the mucous membrane presents a smooth surface, as in the conjunctiva covering the eye, and frontal sinuses; but, in most other parts, its surface is rough and studded with a number of projecting points, the *villi*, *glands*, &c., and even in the former presents this appearance under the microscope.

In like manner, the Genito-Urinary mucous membrane extends from the tubuli uriniferi of the kidneys along the ureters, lining the interior of the bladder and urethra, the external surface of the glans penis, and the internal of the prepuce. It is generally smooth throughout, but is rough and villous in the bladder, and presents a villous appearance elsewhere under the microscope.

In the female subject, the genito-urinary mucous membrane lines—in addition to the interior of the kidneys, the bladder, and urethra—the interior of the vagina, a portion of the uterus externally, the cavity of this, and extends on either side to line the canal of the Fallopian tubes, to terminate, at the morsus diaboli, by being continuous with the peritoneum.

In the same subject, the *Mammary* mucous membrane lines the interior of the lactiferous ducts, and passes with them to their minutest terminations in the substance of the Mammary gland.

The *characters* of the Mucous Membranes are, that they line exposed surfaces, present a villous, rough appearance; are highly organized, being possessed of numerous red vessels and nerves; secrete in their normal condition a thickish tenacious fluid termed *mucus;* are disposed to the *suppurative* and *ulcerative* process, but not to the adhesive, and under inflammation, freely secrete purulent matter, as in dysentery, gonorrhœa, &c.: they occasionally also slough or mortify.

The *Mucous* like the Serous Membranes consist of three coats, the epithelium, the subjacent basement membrane, and the areolar tissue.

The *Epithelium* corresponds to the epidermis or cuticle of the skin, and is most distinct where it lines the mouth, fauces, and œsophagus, as far as the cardiac extremity of the stomach, where it terminates by forming, in the human subject, a fringed, irregular margin: its presence is frequently demonstrated in these parts by its being raised in the form of blisters under the action of boiling water, acids, &c. In like manner, it passes inwards from the anus into the interior of the rectum and intestinal canal, but its presence can with difficulty be demonstrated in these regions: it serves as a protection to the subjacent structures from the irritating matters to which they are occasionally exposed. In the female, the epithelium lines the vagina, uterus, and the cavities of the Fallopian tubes.

The *basement membrane* forms the central portion of the mucous membrane, and corresponds to that of the serous membrane; it is most distinct in the tubuli uriniferi of the kidneys, but is not easily distinguished elsewhere.

The *Areolar Tissue* forms the larger portion of the mucous membranes, and is composed of condensed areolar tissue: it is loosely connected to the subjacent parts, and may be easily separated from them; it is of a fibrous character, and possesses considerable strength and elasticity.

The *Villous* surface of the mucous membranes is so called, from its possessing a number of small projections termed villi. These vary in number, size, and shape, in different situations, and are especially well marked on the dorsal surface of the tongue, and are particularly well seen in scarlatina, and other affections.

Besides these, the mucous membranes present other projections formed from mucous follicles, glands, &c.: these are well marked in the stomach and smaller intestines, where they form the *glandulæ solitariæ*, or the glands of Brunner, and the *glandulæ agminatæ*, or those of Peyer.

The mucous membrane, generally, is extremely vascular and well supplied with red vessels, especially in that of the intestinal canal, whence the secretion of mucus from their surface in the normal condition, and its still more abundant excretion in the more advanced stages of inflammatory attacks. The red vessels terminate in the villi by forming a network of blood-vessels.

The supply of nerves, on the contrary, in the mucous membranes is limited: they possess, therefore, but little sensibility, as compared at least with the skin.

The number of lymphatics opening on the villi of the mucous membranes and other parts is very considerable, and absorption from them is, therefore, most rapid: those of the smaller intestines are named lacteals, from their taking up the chyle, which presents the appearance of a milky fluid.

OF THE COMPOUND MEMBRANES.

The compound membranes are the *Fibro-serous* and *Fibro-mucous*. The dura mater lined by the arachnoid, the fibrous layer of the pericardium, lined by its serous layer, and the tunica albuginea testis, lined by the tunica vaginalis testis, are examples of the former: the lining membrane of the nose and facial sinuses, and that of the hard palate, afford examples of the latter. In all these situations, the membranes are closely adherent, and rarely admit of effusion between them. In this compound state, they do not present any very distinguishing characters as differing from each class of membranes in its more isolated form; each retains its own characters and performs its offices in the animal economy: the union of the two membranes combines these, and thus renders them suited to the duties which they have to perform. In their morbid actions, they retain the disposition to disease which characterizes the simple membrane; but their close connexion leads to a combination in disease, and a tendency in the diseases of one to pass into the other by continuity of tissues, independently of that sympathy of morbid action which exists between most of the tissues of the human body. It is somewhat remarkable that this morbid sympathy is greater between the fibrous and serous membranes, than between any other classes of a membranous character.

Basement Membrane.—This term has been applied, by Mr. Bowman, to an extremely thin layer of membranous expansion, without any definite structure, which is found in one form or another on all the free surfaces of the body beneath the epithelial or epidermic cells: in the skin, it forms the outer layer of the dermis; in the mucous membranes, it lines all the cavities, and is prolonged into all the ducts and ultimate follicles and tubuli of the glands connected with them; in the serous and synovial membranes it forms the innermost layer; and in the blood-vessels and lymphatics it lines their interior, and in their minute subdivisions it forms their sole constituent.

This membrane has been so named by Mr. Bowman, as being the foundation or resting-place for the epithelium-cells which cover its free surface. Professor Goodsir named it *primary* membrane, as furnishing the germs of these cells.

The term basement membrane is to be preferred, as it expresses the position of the membrane without raising a theoretical question of considerable doubt.

The *use* of the basement membrane seems to be, to act as a septum between the extreme capillary vessels of the parts and their free surfaces; and to allow, on the one hand, the passage of the blood through it for the purposes of nutrition and excretion, and, on the other hand, of the absorption of the necessary matters through its tissue into the system. For these purposes its free surface is amply supplied with cells, which form a more or less continuous layer upon it, and may be compared to a spongy structure for the purposes of exudation and absorption, or for exosmose and endosmose. It seems to be the simplest form of membranous Animal tissue, and although possessed of organization sufficient to sustain its vitality, to be directly formed from the nutritive fluid rather than to have passed through any more elaborate process of transformation.

OF THE SKIN.

The *Skin*, or *external tegumentary membrane* of the human body, so closely resembles and is so analogous in almost every respect to the mucous membrane, or *internal tegumentary membrane*, as to justify the consideration of these two structures as one and the same—a position which is supported by the fact that either may be converted into the other without difficulty. Thus, if the mucous membrane be long exposed it is converted into skin, and in like manner if the skin be closely covered and deprived of the strong cuticle which invests it, it assumes all the characters of mucous membrane. Some of the lower classes of animals admit of inversion without injurious results, the exposed surface, whichever this may be, being rapidly converted into skin, and the internal equally transformed into mucous membrane.

The *Skin* is composed of three layers, the epidermis or epithelium, which invests it outwardly, the subjacent basement membrane, and the dermis, or true skin, formed of areolar tissue, which forms its principal portion, is largely supplied with blood-vessels, nerves, and absorbents, and is more or less loosely connected to the subjacent parts by lax areolar tissue.

The *Epidermis* is formed of cells, these being so condensed as to consist of several layers or scales overlapping each other, and leaving small intervals for the passage of the excretory ducts, hairs, &c. This is thin and delicate in some regions, as in the eyelids, lips, and extremities of the fingers; but is thick and firm in other parts where it is exposed to pressure, as in the soles of the feet, palm of the hands, &c. It possesses little organization and vitality, is insensible, and serves the purpose of protecting the true skin, and of restraining exudation and absorption. The Epithelium is also cellular in structure, but is more immediately connected with the process of secretion.

The *basement membrane* resembles that of the serous and mucous membranes, with which it has been already sufficiently described.

The *Dermis*, or *true skin*, is essentially composed of areolar tissue: it forms, as just stated, the principal structure of the skin, and is highly organized, being supplied with numerous vessels and nerves, which endow it with acute sensibility, and excrete the fluids from its external surface. Of sufficient density, it possesses the properties of tension, extensibility, and contractility.

The *Functions* of the Skin are fivefold, namely:—
1. Secretion, or Exudation; 2. Absorption; 3. Sense; 4. Sensibility; 5. As a source or bed of animal heat, to sustain the temperature of the body.

The Secretions, or Exudations from the skin are the cutaneous perspiration or sweat, and the sebaceous or oily secretion.

The *Sweat*, or *Cutaneous perspiration*, is derived from the sudoriferous glands, which exist, in the form of small oval or globular masses, in almost every part of the cutaneous surface, contained in the deepest layer of the true skin.

The mass of each gland is composed of the convolutions of a single tube, which detaches itself from the gland, proceeding in an oblique direction, and opens, through the interstices in the epidermis, on the external surface.

Mr. Wilson has computed the number of these glands, as opening on a square inch of the palm of the hand as 3528, and the average number of pores in each square inch of the body, as 2800, the number of pores is computed to be seven millions, and the length of glandular tubing to be equal to twenty-eight miles.

The secretion from this system constitutes the *sensible* and *insensible* perspiration: the former is that which appears on the surface, on which it rests for a time, and then drops, or may be removed; the latter is that which passes off insensibly, or without notice, in the form of watery vapour. The relative proportions of these vary in different situations, and according as the parts are covered or otherwise: thus, on the face and hands, and all more exposed surfaces, the perspiration passes off in the form of vapour, and is insensible; whereas in the axillæ, and less exposed parts, the perspiration lodges or collects, and becomes of a sensible character.

The entire quantity of both sensible and insensible perspiration is with difficulty ascertained, as it varies so much with the amount of fluids taken in, the temperature and hygrometric state of the atmosphere, and other extraneous circumstances. In hot and dry weather, it is much increased; in a cold and moist atmosphere it is equally diminished, and the suppressed perspiration is then carried off in the urine, or from the intestinal canal. The quantity excreted from the body, including the pulmonary exhalation, has been found to vary from $1\frac{2}{3}$ lb. to 5 lb.: the average quantity may be taken at about $2\frac{1}{2}$ lb. in the 24 hours; of this the pulmonary exhalation furnishes one-third under ordinary circumstances; but this does not increase in proportion with the increase of the cutaneous perspiration.

The sweat, or perspiration, is one of the most dilute fluids of the body, being mostly composed of water, and leaving a solid residue of but $\frac{1}{2}$ to 1 per cent. It contains chloride of sodium and ammonium, and phosphate of lime, with other salts and organic matters. It also contains epithelial scales, and fatty substances, which are due to the admixture of the sebaceous secretion of the skin. The remarkably sour smell of many kinds of sweat appears to depend on acetic acid, partly on volatile fatty acids.

The *Sebaceous* or *oily secretion* of the skin is derived from the *Sebaceous glands*, which although present in almost all parts of the body, are most numerous in those covered with hair, as in the axillæ, pudenda, &c. They are absent in the palm of the hand, and the soles of the feet. They are found to exist in three forms: that of short straight follicles, in masses resembling the sudoriferous glands, and as a number of sacculi, from which a common duct proceeds. A pair of sebaceous follicles usually open along with each hair.

The glands which secrete the wax of the ear are of a tubular character. The Meibomian glands form tubes, the whole length of which is studded with lateral vesicles. The glands which accompany the hairs ramify like a tree, and terminate by globular heads. The sebaceous matter, found on the corona glandis, is furnished by the glands of this part.

The sudoriferous secretion is of use in casting off the excess of watery fluid taken into the system, and which, however useful at the time of imbibition, is no longer necessary in the animal economy. It also regulates the temperature of the skin and of the body generally, and frequently removes injurious matters from the vessels of the body. Like the urine, it is easily affected by the ingesta; turpentine, ammonia, and other substances, are easily recognised in it.

In many, if not in most diseases, the functions of the Skin exercise an important influence; and too little regard is usually paid to the necessity of frequent and general ablution, in order to avail ourselves of the many advantages that result from its healthy action.

The Sebaceous secretion is principally of use in lubricating certain parts, and so protecting them from external agents which would otherwise be injurious. It may be also of service in discharging from the system certain noxious ingredients.

The Mucous membrane, especially that lining the gastro-pulmonary system, is extensively supplied with glandulæ, from the simple form of follicle to the more complicate structures of Brunner and Peyer: these have been already described, and need not be again considered.

The second function of the skin, or that of *Absorption*, is much less active than that of Secretion, the former function being more extensive in the mucous membrane. That the skin absorbs is evident from medicinal substances being taken up by it and conveyed into the system, such as mercury, oils, and other substances. This will take place without friction, although this is generally used for the more rapid absorption of the substance, which is pressed through the foramina of the epidermis by the friction. It is also proved by absorption, in the bath, of water from wet clothes, and of nutritive matter when food cannot be taken in by the mouth The skin also absorbs oxygen from the atmospheric air, and thus assists the respiratory process in the oxygenation of the blood.

The third and fourth functions of the skin, or those of *sense* and *sensibility*, are possessed by it from the nerves of special and general sense distributed upon it. They are the special sense of Touch, and the more general feeling of Sensibility, as evidenced in that of pain: the former resides principally in the extremities, or pulps of the fingers; the latter on any part of the body. It is evident that these sensations are distinct, although furnished by the same nerves, so far as has yet been ascertained; but this will be more fitly considered when treating of the Special Senses.

The fifth and last function of the Skin—that of supporting and regulating the temperature of the body—is one of considerable importance, and is intimately connected with the theory of *Animal Heat* (which see). Whether the heat of the body is generated in the lungs by the union of the carbon contained in the blood with the oxygen of the atmospheric air, and thence is absorbed and carried through the body to the capillary system; or whether, as is more probable, the oxygen is absorbed by the arterial blood in the capillary vessels of the lungs, and conveyed thence to the capillary circulation in the system generally, and there meeting with the carbon of the venous blood, and thus in the formation of carbonic acid developes the animal heat, which is at once given out,—it is certain, that, to the influence of the skin is to be attributed the regulation of the temperature, either by its general diffusion, or by means of the cutaneous perspiration, carrying off its excess, and thus controlling the amount of heat, which might accumulate and become injurious.

This power, possessed by the skin, of controlling the excess of the temperature of the human body is manifest in hot seasons, and in tropical climates, where, although the heat may reach to several degrees beyond the temperature of the blood, the system generally does not exceed its usual standard of 97°.

This power is still more manifest in the case of individuals who have been known to enter baking ovens at a high temperature, and there to remain for a considerable time without injurious consequences.

The excess of heat is carried off by the increased secretion of the cutaneous perspiration, which absorbs the caloric in the formation of watery vapour, and thus is discharged from the body.

The use of warm clothing is beneficial by confining the discharge of the animal heat from the surface of the skin, and not by the possession in itself of any increased temperature. Woollen and fur coverings appear warm, simply from their not absorbing heat rapidly;

a lady's muff and a piece of iron may be of, and, under ordinary circumstances, are of the same temperature; and yet how different the feeling produced by the application of these two materials! one feels warm and comfortable, the other cold and painful. These different results are the consequence of the different powers of absorption and radiation of caloric possessed by the materials themselves.

This subject has been considered when treating of Animal Heat.

The hair and nails, being appendages of the skin, and more especially of its outer layer, the epidermis, or cuticle, may now be considered.

The Hair is found on most parts of the body, but in larger quantity on the head and the pudenda in the adult.

The Hairs are composed of two distinct substances, or layers, the *outer* or *cortical* layer, and the *inner* or *medullary* substance.

The *cortical layer* is a prolongation from the cuticle, and covers each hair to its minute extremity; it is of a laminated structure, the laminæ overlapping each other so as to give to the outer surface of the hair a serrated appearance.

The *medullary substance* forms the interior or pith of the hair: externally, or near the cortical layer, it presents a fibrous appearance, but in the centre possesses more of the medullary structure: it is here distinctly cellular.

The *pigmentary granules*, which give the colour to the hair, are found contained in the medullary substance, and especially in its centre. In some cases the granules are absent, when the pigment is diffused throughout the medullary tissue.

That portion of the hair which is concealed by the skin is fixed into a peculiar sac, the *hair-bulb:* this is formed of two layers, derived from the epidermis. Kölliker has described muscular fibres which pass round it in circles. The portion of the shaft which is fixed in the hair-bulb is either rounded or pointed: here the elements of the cortical substance are changed into horny cells—-the more recently formed being the deepest. They finally merge into nuclei and cell-formations, which are secreted from the blood-vessels which surround the bulb, and form its matrix. From this the growth of the hair proceeds, and extends, most probably by imbibition, to its extremity.

The colour of the hair depends on that of its cortical layer: this in grey hair is whitish red, in red it varies from yellowish to a deep red, and in brown or black hair it is light or dark brown. It proceeds, however, from the pigment in the medullary substance.

The Hair is formed, like the teeth, from a pulp enclosed in a follicle: this is formed by an inversion of the skin, and is lined by a continuation of the epidermis, the external surface of which forms the *bulb*, the soft interior the pulp.

The organization of the hair has been a matter of much dispute. The follicle is evidently vascular, and the bulb may be coloured by minute injection, although vessels cannot be traced into it; the stem of the hair possesses the power of growth, although regarded by some as an excreted substance devoid of organization.

Its organized character is strongly supported by the disease of PLICA POLONICA, in which the hairs split into fibres, at a considerable distance from the bulbs, and secrete a glutinous substance which mats them together; as also by the fact that the colour of the hair may be changed in the course of one night, by strong mental emotion, from black to white.

The loss of the hair in baldness frequently depends upon a diseased condition of the bulbs and surrounding cuticle; and in advancing age is no doubt the result of deficient vascularity, which is more usually constitutional than local; those persons whose circulation is languid being affected by baldness at an early period of life.

The Nails are essentially prolongation of the cuticle or epidermis, with which they become detached in decomposition of the body, from the application of blisters, &c.

Under the microscope, a thin section of the free margin of the nail shows an indistinctly granular grey mass, which is traversed by irregular fissures. If digested in sulphuric acid, or in a boiling solution of caustic potash or soda, this mass is found to be composed of a number of transparent horny scales, which are united by a solid cement.

The *matrix* of the nail lies beneath its surface: it forms elevations and depressions which resemble those seen at the extremity of the finger; vascular loops run in the interior of these moulds, which correspond with the rows of tactile papillæ on the rest of the skin; hence the younger nail cells are secreted. The root of the nail is its thinnest part. The edges of the nail, excepting that which is free, are lodged a groove of the skin, from whence it is gradually being produced.

The nails, like the stems of the hair, are by many considered to be destitute of organization; but it may be well questioned if any portion of the body deserves to be so considered. Organization is not a defined term, and every structure, which possesses the power of growth, must be more or less organized.

THE OSSEOUS TISSUE.

The *Osseous Tissue*, or bony skeleton of Man, forms a firm resisting framework for the attachment, support, and protection of the softer structures.

In the extremities especially, and also in the trunk, the bones afford resisting structures to the action of the muscles, and thus, by the formation of levers of different orders, assist in the execution of the motions which are necessary to locomotion and action generally: in these, the bones are passive, the muscles are the active agents.

In the great cavities of the Head, Chest, and Abdomen, the principal office of the bony system is the protection of the contained organs: in the Head it is exclusively so, but in the Thorax and Abdomen it assists, by affording attachments to muscles, in producing certain motions, which are essential to the functions of the contained organs.

The bones forming the skeleton are of various size, shape, and length, according to the position they occupy and the use to which they are destined. They are classed into the *long*, *flat*, and *irregular*.

The *Long bones* are situated in the extremities, and present the following characters. Their longitudinal extent is greatest in one direction: they are expanded at their extremities for the purposes of articulation, and to give attachment to tendons and ligaments. The shaft is more or less triangular, is twisted upon itself, and is hollowed in its interior to form the medullary canal.

The shaft of the long bones is formed of a dense *compact* bony tissue, but the extremities are composed of *cancellated* tissue, which presents a cellular appearance, and does not possess a medullary canal. The compact tissue, when closely examined, is found to consist of an outer and inner layer of denser structure, with an intervening less compact layer.

The cancellated tissue of the extremities seems to be simply an expansion of the compact tissue which constitutes the shaft; for although the extremities are so expanded in bulk, they are not increased in weight, an equal section of each being of equal weights: the cancelli vary in shape, being triangular, square, and irregular, as best suited to resist impressions on the particular part; and the lamina forming the cancelli are arranged with a similar object in view. A section of the head and neck of the femur exhibits this arrangement in the most perfect manner: the bony plates radiate in great numbers from the trochanter minor, and in such a manner as to give the most direct support to that portion of the head which sustains the weight of the body. In the lower extremity of the femur the osseous plates are more vertical; and in the extremities of the other long bones, a similar mechanical adaptation to the uses of the parts is to be observed.

The compact tissue forming the shaft of the long bones is distributed with a similar view, to give to each bone the greatest resistance possible. In the femur a dense portion, the *linea aspera*, runs at the back of the bone, so as to support the concavity of the arch which this bone forms; and as we trace the compact tissue, towards either extremity, it becomes gradually thinner until it terminates in a thin shell of bone covering the cancellated tissue.

The cancelli are filled with a thin fluid of an oily character, which was at one time supposed to be derived from the marrow in the medullary canal, and to form the synovia or joint-oil: all these fluids are now ascertained to be distinct in their sources, their nature, and their uses.

The *Flat bones* present the following characters: they form cavities, as in the cranium and pelvis, are concave and convex, and are composed of a central layer of cancellated tissue termed diploë, enclosed within two layers of compact tissue, their circumference is usually expanded and has more of the cancellated tissue than any other part of the bone.

In the bones of the cranium, the compact tissue is exceedingly dense and hard, and is thus the more fitted to resist the effects of injurious impressions upon the head. The inner layer has been described as being peculiarly brittle, hence called *vitreous*, from its being more extensively broken in fractures of the cranium than the outer layer; but this is an erroneous conclusion, as its more extensive fracture is the result of the *radiation of the force* employed in inflicting the fracture, and not of the greater brittleness of the bone.

Some of the bones of the cranium present a peculiar disposition of the osseous tissue; thus in the ethmoid, sphenoid, lachrymal, and other small bones, the bone is composed of a dense layer of compact tissue, without any diploë or cancellated structure, which is found to consist of a nearly homogeneous substance, with slight traces of a fibrous character, but which may be shown, by boiling, to be composed of minute granules, in size from 1-6000th to 1-14000th of an inch, connected by some more glutinous material dissolved in the boiling: in the midst of these granules a number of dark spots are to be observed, generally of an oval shape, but sending forth numerous radiating processes of great minuteness: these are the *osseous lacunæ* or *Purkinjean corpuscles*, and are highly characteristic of the true bony structure. These, although once supposed to be solid, are found to be composed of canaliculi, or extremely delicate tubes, the use of which is to permit of the transmission of the nutrient matter which supplies the bony tissue: they are to be found only at a late stage of the development of the bone.

In the petrous portion of the temporal bone, the compact tissue is remarkably dense, and of considerable thickness, and approaches in character to the enamel of the teeth, containing fluate of lime; this gives greater protection to the delicate structures of the organ of hearing, and increases their acoustic properties.

The *Irregular bones* are situated where great strength is required, but little motion, as in the spine, the carpus, and tarsus: they are chiefly composed of cancellated tissue, with a thin covering of compact tissue.

The Ribs cannot be classed amongst any one of the three divisions of the bony system, as they resemble the long bones in their length, the flat bones in forming a cavity, and in being concave and convex, and the irregular bones in being composed of cancellated, with a thin covering of compact tissue.

In the compact tissue of the shafts of the long bones, and the diploë of the flat and cancellated tissue of most of the irregular bones, especially the vertebræ, may be observed a number of canals which traverse them in different directions; these are the *Haversian canals:* they form a network in the interior of the bones and permit of the passage of the blood-vessels through their channels. In the long bones, the Haversian canals are chiefly longitudinal, but these are united by transverse and oblique branches: they are lined by a delicate membrane, a prolongation from the external periosteum, on which the vessels break down to supply the bony tissue.

The Haversian canals vary in diameter from the 1·2500th to the 1·200th part of an inch: their average size is the 1·500th part of an inch.

A transverse section of the shaft of a long bone presents a beautiful arrangement of the Haversian canals: in it, the orifices of these may be seen communicating with each other, and around these, the osseous matter is arranged in the form of cylinders, marked by concentric circles. A similar arrangement exists in the tables of the cranial bones and other bony plates.

The Haversian canals communicate with the medullary canal, in the shafts of the long bones, which may be considered as a Haversian canal of unusual size.

The intimate composition of the osseous tissue has long been the subject of dispute, being considered as laminated, fibrous, and cellular, or areolar.

The *laminated* theory is supported by the casting off of plates of bone in disease, as in exfoliation of the bones of the cranium, and by the laminated appearance which calcined bones present; but as the long bones after amputation exfoliate in rings, and calcination is but a rude process, this theory is now not generally received.

This theory is also supported by the results of feeding animals on madder-root for a time, and then suspending its use, as practised by Du Hamel, when the colouring matter appears deposited in layers; but this appearance is due to the greater affinity of the compact layers for the colouring matter, and is therefore deceptive.

The *fibrous* structure of bones is supported by the fibrous or striated appearance which the growing flat bones present, and by the experiment of macerating the animal structure of the bone, when it may be separated into a leash of apparent fibres; the striated appearance, however, is due to the deposit of bone in areolæ, which have this arrangement, and the latter experiment is set aside by that of Scarpa.

The *cellular* structure of bone was supported by the celebrated Scarpa, who following up the experiment just related, shook out the macerated mass of animal structure without using unnecessary violence, when the whole resolved itself into a cellular mass.

That the bony structure is composed of cancelli, and the osseous lacunæ are plates which form them, as just described, is now the generally received opinion.

The organization of bone is of a limited character: the arteries enter it by means of the external and internal periosteum, and by the *nutritious* foramina. A considerable number perforate the extremities of the long bones, and the circumference of the flat bones by numerous foramina; the minute vessels traverse the Haversian canals. Nerves cannot be traced into the osseous tissue; yet their presence is proved by the effects of disease when much pain is suffered. Lymphatics exist in bone, as is proved by their being rapidly absorbed.

The compact tissue of bone is less highly organized than the cancellated, hence the greater liability of the former to the process of mortification, or necrosis; of the latter to that of suppuration and ulceration, as in caries, white swelling, &c. The mode of growth or development of bone varies in the different classes.

The position of the long bones is first occupied by a cartilaginous bed, although this is preceded by materials of a softer nature. In this bed the *centres* or *points of ossification* appear, three or more for each bone; one for its centre, and one or more for each extremity. From these points the ossification proceeds until the shaft approaches the extremities; these, however, are not united until about the age of twenty-one, the latter forming the epiphyses, the former the apophyses.

It is doubted whether the cartilage is absorbed as the bony matter is deposited, or is converted directly into bone: the former is the more generally received opinion. During this growth, the cartilaginous cells disappear, and their place is supplied by the true bony cells in much greater number, and arranged longitudinally, corresponding to the long axis of the bone. The bone, when formed, still possesses the power of expansive growth, which is accomplished by the interstitial deposit of additional bony matter, and especially between the shaft and epiphyses, until the bone attains its full size in the adult period of life, when the shaft and extremities become consolidated, and the bone is fully formed.

The flat bones are developed between two layers of fibrous membrane, and each, as the scapula and flat bones of the cranium, has usually a centre of cartilage, from which the ossific deposit proceeds, between the membranes. The circumference of the pelvic bones and spine of the scapula present epiphyses, resembling those of the long bones. The deposit of the ossific matter seems to take place in the areolæ of the fibres, which gives to the growing bones an irregularly recticular, and subsequently a fibrous appearance.

The *irregular* bones are developed from one or more centres of ossification, which coalesce and finally unite.

The *Medullary Canal* does not exist at the earlier periods of life, its place being occupied by cancellated tissue, in a more or less condensed state. By degrees, however, absorption takes place, the cancellated laminæ become more condensed, and the canal is formed: its *use* is, besides lodging the medulla, to increase the strength of the bone without adding to its weight, it being a well understood principle in mechanics, that hollow cylinders are much stronger than solid, composed of the same amount of material. The use of the medulla is wholly unknown: it is supposed to act, like the adipose tissue, as a reservoir of nutritive matter, and fill up a space that would otherwise be wholly vacant.

The Chemical Composition of bone consists of two principles:—1. The Animal; and 2. The Earthy Matter.

The *Animal matter* of bone may be obtained in a separate form by digestion in dilute hydrochloric acid, which dissolves the earthy salts, and leaves the animal matter free.

The *Earthy matter* may be obtained from the solution formed in the preceding experiment by the addition of lime, when a hydrochlorate of lime is formed in solution, and the earthy salts of bone are precipitated; or by the process of burning, which destroys the animal matter and leaves the earthy matter as a residue.

A similar separation of the ingredients of bone takes place frequently under disease, as in *rickets* or *mollities ossium*, when the bones are chiefly formed of animal matter; and again in the *fragilitas ossium* incidental to old age, when the bones are mostly composed of the earthy salts.

The *Animal matter* of bone consists of—1. *Albumen;* 2. *Gelatin.* These may be obtained separately by the process of boiling, when the gelatin becomes dissolved, and the albumen coagulated. On removing the fluid and allowing it to cool, the gelatin solidifies, it is also precipitated by tannin, as in the formation of leather.

The *Earthy matter of bone* is chiefly composed of the salts of lime, namely, the Phospate and Carbonate of lime; and in the enamel of the teeth and petrous portion of the temporal bone, the fluate of lime or fluoride of Calcium. The Carbonate of lime forms but one-sixth or seventh of the whole of the earth of bones in the human subject.

The proportion of animal and earthy matter in bone has been variously stated, and differs in different bones, and at the several periods of life. It is estimated, on reliable authority, that the animal matter forms about one-third, and the earthy matter two-thirds: the temporal bone contains 63½ per cent., and the scapula but 54 per cent., or little more than one-half, of earthy matter.

The organization of bone exerts upon this, as upon all the tissues of the body, the most important influence when the subject of disease; the compact tissue possessing but little organization when inflamed, seems incapable of resisting the inflammatory action, and dies or mortifies. We have examples of this in the frequent exfoliation of the bones of the cranium: in this, the outer or compact plate only is detached, under ordinary circumstances; the diploë, or cancellated tissue, being more highly organized, resists the inflammatory action, and sets up a reparative process, that of ulceration or caries; as also in the disease of necrosis, which usually only affects the shafts or compact tissue of the bones, leaving the extremities or more vascular parts untouched.

The *Union of bone*, after fractures, resembles the progressive growth of bone, the ends of the fractured bones being reduced to a soft or semi-cartilaginous state, and a considerable deposit of the same material being added thereto, so as to fill the medullary canal entirely, and to form an enlargement externally: in this, the ossific matter is deposited until the bones are consolidated and united. The formation of a *provisional callus*, as it is termed, encircling the bones as in a ring, to be afterwards absorbed, is an absurdity, and is inconsistent with the laws of the animal economy, which are regulated and controlled by principles of a more scientific and harmonious character.

THE TEETH.

The *Teeth* begin to be formed about the seventh week of fœtal life, at which period, they appear upon the mucous membrane, covering a deep, narrow grove in the jaw, which is gradually divided into a series of open follicles, at the bottom of which the rudiments of the future teeth appear: these commence in the form of small papillary elevations of the mucous membrane, composed of a cellular tissue resembling that in which cartilage is developed; a small arterial branch is distributed to each papilla ramifying upon its base; the papilla gradually enlarges until it attains its full size, when the process of calcification commences, by which it is converted into *Dentine*, the characteristic structure of the teeth.

Dentine is composed of about one-fourth animal and three-fourths earthy matter, and when fractured, presents a fibrous or striated appearance, owing to the presence of minute tubuli, which run from the internal portion of the tooth towards the surface.

In the centre of each tooth, is a cavity, lined by a vascular membrane, from which a canal descends into each fang or root, through which the vessels and nerves enter to supply the pulp or cavity of the tooth.

On that surface of the dentine which is to be exposed at a future time, the Enamel of the tooth is deposited: this is composed of long prismatic cells, the length of which corresponds to the thickness of the enamel, the extremities of the prisms forming the two surfaces of the enamel.

The *Enamel* of the Teeth is almost wholly composed of earthy matter, the animal matter forming but two parts in 100: the salts in it are the phosphate, carbonate, and fluate of lime, with a little of the phosphate of magnesia. It is not organized, and cannot be coloured, as the dentine may be, by madder-root taken internally, although the tubuli of the dentine occasionally penetrate its substance. It is the hardest of all the structures of the animal body, and approaches in density to that of mineral substances. It is thickest where it covers the projecting portion of each tooth, as in the molars, thinnest between these, and at the neck of the tooth.

A third substance, the *Cementum*, or *Crusta Petrosa*, is found around the root of the tooth, where it forms a thin layer, near the termination of the enamel.

The papilla of each tooth is enclosed in a capsule or bag of a fibrous structure, between the inner surface of which and the outer of the papilla a layer of epithelium is formed, by the calcification of a part of which the enamel is formed, the cementum being produced by the conversion of the capsule itself into a bony substance.

About the thirteenth week of fœtal life, the formation of the permanent teeth commences, by means of buds or off-sets from the upper part of the capsules of the temporary or milk teeth, from which they become gradually detached. The three permanent molars, which have no corresponding teeth in the temporary set, are formed in like manner: the first from the capsule of the last temporary tooth, the second from this, and the third from the second.

The temporary teeth begin to make their appearance in the gums, by cutting through the capsule on its free surface at from the sixth to the ninth month; but the period varies much, teeth being occasionally through the gum even at birth. They appear usually in the following order: central incisors, lateral incisors, anterior molars, canines, posterior molars.

The permanent teeth begin to appear about the age of 6 or 7: the last molar tooth does not usually appear before the age of 21, hence called dens sapientiæ.

The number of the temporary teeth is 20, that of the permanent 32.

THE ARTICULATIONS.

The bones forming the Human Skeleton are more or less intimately connected, according to the uses or offices of the parts into the formation of which they enter. In some instances, they are held firmly together, so as not to admit of any motion whatever; in others they are connected by elastic or fibrous tissues, and permit of some motion; whilst in others they are connected only by ligaments, tendons, and muscles, and enjoy considerable mobility.

The simplest form of Articulation is that where two bones lie simply in apposition without any intervening substance. Of this, there are but few examples in the body, the most remarkable being that of the nasal bones, where they repose one against the other by nearly plane surfaces, named Harmonium.

At first view, this Articulation might appear insecure ; but experience has proved that it possesses great security, as it is rarely, if ever, dislocated without fracture. This security is, however, not the result of this mode of Articulation ; but rather from the manner in which the opposite edges of the nasal bones are received into a groove in the superior maxillary bones, whilst their upper extremities are firmly interlocked into the frontal bone. By these means, the nasal bones form an arch, convex anteriorly ; and as violence cannot well be applied but on the convexity of the arch, the materials, forming this, must be fractured before it will yield, so as to allow of a dislocation of the bones.

The next more advanced form of Articulation is that observed in the bones of the Head, and especially in those of the Cranium, to which the term *Suture* has been applied. In this, the bones present more or less of a serrated margin where they are in contact, in consequence of the osseous tissue being projected so as to form a number of *Serræ*, or *teeth*, which interlock with those of the opposite bone ; the *Serræ*, or teeth, of one being received into corresponding cavities in the other. The Serræ present great variety : in some they form very slight projections, scarcely deserving the name of teeth, as in the squamous suture, the lambdoid suture, &c.; in others they project considerably, and are of different shapes, triangular, quadrilateral, pointed at their free extremities, or expanded so as to form a mortice-shaped joint with the opposite bone, as may be found in the coronal, sagittal, and lambdoid sutures. This variety of shape is of much service in connecting the bones firmly together, as it not only tends to the support of one against the other, but also their separation from each other. To the same end, there is occasionally, as in the coronal suture, an alternate overlapping of the bones, so that the frontal, at one part, rests upon the parietal bones, and these again upon it.

But this interlocking of the bones is not met with in the base of the skull; here they rest, by surfaces more or less extensive, against or upon each other, as where the posterior inferior angle of the parietal rests upon the mastoid portion of the temporal, where this abuts against the occipital, and this against the body of the sphenoid bone. This peculiar arrangement is best suited to this portion of the skull, as tending to sustain or support the vault or roof of the cranium formed by the parietal, frontal, and part of the occipital bone. If the serrated suture existed in the base of the skull, blows or violence would easily displace the bones, and depress them inferiorly; but by the existing arrangement this cannot take place, and the bones will fracture rather than be displaced.

On the lateral surfaces of the Cranium we observe the *Squamous* sutures, formed by the Squamous plate of the temporal overlapping the parietal bone: this has the effect of preventing the latter from being forced outwards, in violent blows on the upper surface of the Cranium.

All the Sutures of the Cranium are constructed with the view of giving to this the greatest amount of resistance possible, with the materials employed, so as to protect the contained organ, the Brain: and this object is further accomplished by the arched shape of the Vault of the Cranium, which is not only the strongest form in Nature, but also tends to elude the effects of violence, which in many instances has been known to glide off the convex surface of the bones, without inflicting serious injury.

The mutual support which the bones of the Head give to, and receive from each other, is well illustrated in fractures of the base of the skull, from falls on the head, or violent blows on the upper surface of the cranium, in which, the bones stricken are not fractured, but those in the base of the skull, namely, the petrous bone, sphenoid, and occipital. This result ensues from the radiating of the force which is ultimately expended on the base of the skull, causing the fracture in this situation, by *contre-coup*, as French surgeons have happily named it.

In falls on the head, as in sailors falling down the hold of their ship, and pitching on the vault of the Cranium, the fracture can scarcely be considered as the result of *contre-coup*, as although the roof of the cranium is the stricken part, the force or weight really impinges directly on the base of the skull, and is represented by the whole weight of the body driving upon the condyles of the occipital bone.

The more extensive fracture of the inner table of the cranial bones, which takes place in most fractures, has given rise to the theory that this plate is more brittle than the other, hence it has been named the *Vitreous table;* but this theory is incorrect, as the *radiation of the force* causes the greater extent of fracture of this plate, and not its greater brittleness.

The mode in which the teeth are received into the alveolar cavities forms a distinct articulation, called, from its resemblance to the implanting of a nail into wood, *Gomphosis.* In this, the teeth are not rigidly fixed, as some motion is found in the firmest set teeth; but the articulation is exceedingly secure, and only becomes inefficient from absorption of the alveolar processes, or removal of the soft parts lining them.

Some of the smaller bones of the Head, as for example the vomer and the nasal lamella of the ethmoid, are received into a sulcus formed by others, constituting the articulation named *Schindylesis.*

We now approach the more complicated articulations, in which a cartilaginous or fibro-cartilaginous substance intervenes between the bones, as in the *Sympyhsis pubis,* and the intervertebral articulations: in these the uniting medium is fibro-cartilage. In the symphysis pubis the fibro-cartilage is of nearly uniform structure, although the fibrous tissue predominates in the circumference; but in the intervertebral articulation the fibrous tissue forms the outer structure, and gradually disappears towards the centre, which is semi-fluid, and so arranged as to form a double cone, which acts as a pivot, on which the limited motions of the vertebræ are performed. The double cone occupies the centre of the whole vertebra, but is nearer the posterior part of the body, as being in the centre of motion. The fibrous tissue is arranged in concentric laminæ, the fibres being more or less oblique, and passing from one vertebra to the other, so as to connect them more firmly together.

As these connecting media possess much elasticity, and yield to the motion of the bones, the effects of shocks are thus prevented from extending to the spinal cord and other contained parts.

The bones forming the Sacro-iliac articulation are connected by cartilage forming the articulation named Synchondrosis. This cartilage becomes absorbed in the old subject, and the bones are then united.

The most perfect form of articulation is that found in the extremities, in which a considerable degree of motion is required for progression and other purposes.

The *Structures* entering into the formation of these articulations are bone, cartilage, fibro-cartilage, synovial membrane, and ligaments.

The bones forming these articulations present expanded surfaces, for the greater security of the joints, and are usually convex and concave for the same object, where such is required, as in the hip, knee, and ankle; but in other situations, where this is not so necessary or is otherwise provided for, present plane surfaces, as in most of the tarsal articulations.

The enlargement of the articular surfaces of the bones is an expansion of the osseous tissue, and not an increase thereof, as a defined portion of this, and of the compact tissue, forming the centre or shaft of the bone, are found to be nearly equal in weight. The expansion is produced by an enlargement of the areolar structure of the bone at the expense, as it were, of the compact tissue, as this disappears altogether, or only forms a very thin incrustation on the outer surface, within which the thin lamellæ of the bone are so arranged as to form cells irregular in size and shape, but almost invariably more or less angular, and so disposed as to resist, most effectually, the effects of force or violence applied. This is beautifully exhibited in a section of the neck of the former, in which the osseous laminæ are found to radiate in different directions, and more especially from the trochanter minor upwards towards the head of the bone, and the trochanter major, so as to sustain these in the most efficient manner possible. The cells of the bones are filled with a reddish oleaginous fluid, which increases their power of resistance.

The *Cartilages* covering the articular surfaces of the bones form the *Articular Cartilages*, and afford the best example of true *Cartilaginous* structure: one surface is closely adherent to the bone, except in the early periods of life, being almost identified with it, and only separated by very long-continued maceration; the other surface is free, and is lined by synovial membrane. It is, in fact, covered by a special coat—a perichondrium, which, as a prolongation of the periosteum, extends over a small part of the cartilage, and then gradually terminates without a well-defined border.

The Articular Cartilage lining the convexities of the bones as in the head of the humerus, femur, and condyles of the femur, is thickest in the centre, presenting here a depth of from three to four lines, but becomes thinnest at the circumference, where it is less than a line in depth. That lining concave surfaces, as in the glenoid cavity, and head of the tibia is, on the contrary, thickest at the circumference, thinnest in the centre; so that the cartilaginous surfaces correspond, in producing a tolerably uniform degree of elasticity, in the different positions of the joint.

In its intimate structure, according to Kölliker, articular cartilage presents a finely granular, in fact, almost homogeneous nature, and imbedded in this, thin-walled cartilage capsules. These at the surface are numerous and flat, and lie with their planes parallel to it; further inwards they become oblong or roundish, more scanty, and are disposed in various directions, and finally, in the vicinity of the subjacent bone, they are elongated and directed perpendicularly to it. All these capsules have distinct walls, which, especially on the addition of acetic acid, are readily distinguishable from the matrix, and contain in their interior—viz., the primordial utricle, or proper cartilage cell—a clear substance, often granular, but still with little fat and vesicular nuclei.

The part of the articular cartilage, next to the bone, presents an osseous layer, possessing, as Sharpey pointed out, the structure of cartilage, but with the matrix calcified, and thus exhibiting, when decalcified, a different texture from the ordinary bone beneath.

Articular cartilages, except during the period of development, contain no red vessels or nerves.

In the interior of some articulations, as the knee, lower jaw, &c., are found the *Inter-Articular Cartilages:* these are moveable, and are but loosely connected to the bones; they are of *fibro-cartilaginous* structure, the fibrous tissue being well marked in some, as in those of the knee-joint, but less distinct in others, as in the sterno-clavicular articulations and lower jaw. These bodies are of use in following the bones in the different motions of the bones, so as to present an elastic cushion when the articular cartilage may not be available.

The peculiar basis of cartilage is *Chondrin*, which is of a gelatinous character, from which it only differs in being thrown down from its solution in alcohol, by the hydrochloric and acetic acids, alum, acetate of lead, and protosulphate of iron, which do not affect a solution of gelatin. The chondrin of fibro-cartilage resembles gelatin still more closely. Chondrin appears to be an intermediate body, between albuminoid compounds, and Gelatin proper.

The *Synovial Membrane* is a thin delicate membrane of the *Serous* class, which lines the interior of the articulations, so as to form a shut sac. It is most distinct beyond the free border of the cartilage, and is here usually thrown into folds, so as to present a fringed appearance, and has connected with it small granular bodies of a reddish colour. In the bottom of the acetabulum is a soft body of areolar tissue containing some fat, and similar bodies, but much smaller are found in other articulations. These were formerly described by Havers, who thought he could distinguish ducts, and hence supposed them to be glands, and to secrete the Synovia, hence called Haversian glands. This opinicn is no longer retained, the synovia being produced by the synovial membrane. (*See* MEMBRANES.)

The *Synovia* is a thick glairy fluid, more or less transparent, which contains mucus, and becomes turbid on the addition of acetic acid. It contains a large proportion of water, 97 per cent., mucus, albumen, and other organic matters, as yet but imperfectly known, together with fat, chloride of sodium, sulphates and phophates of the alkalies, carbonate of lime, and earthy phosphates. Under inflammation, the synovial secretion disappears, and its place is supplied by a thin serous fluid, resembling that secreted by the peritoneum and other serous membranes.

The ligaments forming the articulations vary in form, size, direction, &c. The *Capsular* are those which surround the joint as a capsule or bag; the others are usually named from their position—as internal, lateral, &c.

The Hip-joint possesses in its interior a remarkable structure, the ligamentum teres, which, although of a fibrous texture, appears to be of little use as a ligament, its principal office being to conduct vessels to and from the head of the femur.

The ligaments belong to the class of *Fibrous* tissue (see p. 138), they are dense, firm, and inelastic; the fibres take an irregular course, some longitudinal, others transverse, and many decussate with these.

The articulations owe much of their security to the numerous tendons implanted around them, which on being acted upon by the muscular fibres, draw the bones closely together, and sustain much of the strain which would otherwise fall on the joint, and perhaps cause its dislocation.

THE YELLOW TISSUE ("TISSU JAUNE").

There exists, in some parts of the Human body, a structure which closely resembles cartilage, but yet differs from it so essentially as to have received and to merit a distinct consideration. This has been named the *Yellow tissue*, and by the French anatomists, the "*Tissu jaune*," of corresponding significance.

There are but two well-marked examples of the *Yellow tissue* in the Human body, namely, in the middle coat of the arteries, and the ligamenta subflava of the spinal column, although, to these, are generally added, the ligamentum nuchæ, the chordæ vocales, and the epiglottis. Of these three latter structures, the ligamentum nuchæ, although so well marked as an elastic structures, in the ox, sheep, and other of the lower classes of animals, is altogether fibrous in Man, and possesses no elasticity; the chordæ vocales, especially the superior or false, possess but little elastic tissue; and the epiglottis is rather intermediate between the yellow tissue and true cartilage.

The Yellow tissue of the arterial system is best marked in the larger arteries, as the aorta, in which it possesses an unusual thickness, and consists of numerous regularly disposed laminæ, whose elements run in a transverse direction: it is here of a decidedly yellow colour and very elastic. As we examine it in the smaller arteries, it gradually diminishes in thickness, assumes a reddish tinge, and is less elastic, until in the capillary vessels it disappears altogether, its place being gradually supplied by the white fibrous tissue and muscular fibres.

The larger of the middle-sized arteries approach the largest arteries, in the structure of the middle coat, the elastic lamellæ appearing of some thickness.

The elastic plates are seen to most advantage and more regularly arranged in the abdominal aorta, arteria innominata and common carotid; their disposition, however, varies considerably.

In the *ligamenta subflava* of the Spinal column, the yellow tissue is well marked: it here forms quadrilateral plates distinct from each other, and extending between the laminæ of the spinous processes. Its elastic nature admits of the separation of these processes in flexion or bending forwards of the spine, and again assists in strengthening this column.

The Yellow tissue presents but little of the fibrous character in the ligamenta subflava; but this is more apparent in the middle coats of the arteries and the ligamentum nuchæ: they are composed of cylindrical or riband-like fibres, varying in diameter from immeasurable fineness to 0·003 or over 0·005 in thickness.

In the *chemical* relations the yellow tissue presents very definite reactions, still the composition of its substance is not accurately known. In cold concentrated acetic acid, the elastic fibres, except that they swell out a little, are not at all affected; on the other hand, by some days' continued boiling in the acid they gradually dissolve. Nitric acid renders them yellow. In moderately concentrated solution of caustic potash, it remains for a long time unaltered in the cold, except that it swells up and becomes somewhat pale; on being heated with that solution for some days, it is transformed into a gelatinous mass. This tissue does not dissolve in water even when boiled for sixty hours, but after being boiled for thirty hours at 160° (320° Fahr.), in Papin's digester, it is converted into a brownish substance, smelling like gelatin, but not gelatinizing, which is precipitated by tannic acid, tincture of iodine, and corrosive sublimate, but not by the other tests of *Chondrin.*

Although so highly elastic, the yellow tissue is easily cut through by a ligature, and in the tying of arteries, this results from the application of the thread. Although this rupture of the middle coat of the arteries may not be indispensable to the cure of an aneurismal tumour, it can scarcely be questioned that it adds considerably to secure the arrest of the circulation, the separation of the ligature, and the subsequent success of the operation. The middle and internal coats having been cut through, the vessels of the more vascular external coat are implicated in the reparatory process, and pour out coagulable lymph, which assists in closing the divided vessel.

THE MUSCLES, AND MUSCULAR TISSUES.

The Muscles of the human body form generally a reddish fleshy mass, varying in size and form in different situations, according to the uses to which they are destined.

They are classed into, 1. The *Voluntary;* 2. The *Involuntary;* and 3. The *Mixed.*

The *Voluntary* muscles are those which belong to the animal life of the individual, and are under the control of the will; they are situated chiefly in the extremities, but many are also found attached to the head, neck, and trunk: they are usually symmetrical, and correspond on each side of the body. Some few occupy the central regions, as the orbicularis oris, motor uvulæ, and sphincter ani; but the lateral halves of these are symmetrical, and the first and last belong more properly to the mixed class of muscles.

The voluntary muscles are generally of a deep red colour, possessed of fibres more or less longitudinal, and consist of a central larger portion or belly, and two extremities more or less contracted and tendinous; the exceptions, however, are numerous.

This class of muscles is supplied chiefly from the cerebro-spinal system of nerves, although under the influence of the sympathetic system, from the free anastomosis of the nervous filaments of both these divisions.

The *Involuntary Muscles* belong to the Organic life, and are confined to the cavities of the Thorax and Abdomen, with the exception of the iris (?). They are found in the heart, œsophagus, stomach, and intestinal canal, thus forming the hollow viscera: they are not symmetrical, are of a pale yellowish colour, are composed of fibres taking different directions, some longitudinal, some transverse, others oblique or circular, and many, as in the heart, closely interlaced with each other: the muscular fibres of this organ are of a *pale reddish* colour, and do not possess tendons, if we except the chordæ tendineæ of the ventricles.

This class of muscles is supplied with nerves, chiefly from the Lymphatic, or Ganglionic System, and are thus independent of the will, or act involuntarily.

The *Mixed* class of muscles are those which are to a certain extent under the influence of the will, but still act independently of it, as in sleep, &c. The diaphragm, orbicularis palpebrarum, the muscular coat of the bladder, and sphincters belong to this class. The action of the sphincter ani is somewhat peculiar, as its usual condition is a state of contraction: it is only when the will directs it that it becomes relaxed, as in evacuation of the bowels.

Although thus classed, many of these muscles may act so as to change their condition from the voluntary to the involuntary class, and *vice versâ;* thus the voluntary muscles of the extremities frequently act spasmodically, and thus become involuntary muscles; but this is not their normal state, and this only must be our guide in their classification.

Again, some of the involuntary muscles are found to be under the control of some individuals. Dr. Cheyne relates a remarkable case of a gentleman who had the power of suspending the heart's action for some minutes, and of restoring it again; and many persons possess the power of swallowing large substances, and ejecting them from the stomach again: but these cases must be referred to an idiosyncrasy of the peculiar individuals, and do not negative the general action of the muscles.

The contraction of most of the voluntary muscles is arranged after one model: that is, each possesses two smaller extremities of a fibrous or tendinous structure, and an intervening larger fleshy portion, termed its belly. The extremities are attached, but the belly is more or less free, although we have examples of muscles being attached throughout nearly their whole length, as in the vasti, &c.; and it is by the contraction or shortening of the central portion or belly, that the motion of the limb or part is accomplished: thus, for example, if we take the *biceps flexor humeri*, one extremity is attached to the scapula, the other to the radius; these have no power of action; but the intervening portion, or belly of the muscle, possesses the power of contraction, and the result of this is, that the extremities and the parts to which they are attached must be drawn towards each other; but if either one be fixed, the contraction is expended on that which is the more moveable, and this approaches the more fixed, as occurs in flexing the forearm; the radius, and consequently the fore-arm, is raised and approximated to the scapula, and the elbow is flexed; but if the forearm be flexed, the scapula will be depressed towards it, if the action of the biceps be sufficiently powerful.

The more fixed extremity of the muscle is termed its *Origin*, the more moveable its *Insertion;* but it need hardly be stated that these are mere conventional terms, and used only for the purposes of description.

It is necessary, in order to understand the action of the several muscles, that we should be impressed with the fact that the muscular fibres act from their tendinous attachment, or from their fibrous portions, otherwise we shall meet with much difficulty in clearly understanding the action of the more complicated muscles in form and direction.

If we take the *Diaphragm*, for example : the ordinary action of this muscle is to descend from the thorax to the abdomen, as in inspiration ; but its more obvious action would be to draw in the ribs, or draw down the pericardium. But the tendinous portion of the diaphragm is its centre, forming the *central tendon*, this has no power of action : it is perfectly passive, and is firmly fixed by the fibrous layer of the pericardium, and the connexions of this with the thoracic and cervical fasciæ. When the muscular fibres contract, they will act therefore from this, and will tend to draw in the ribs ; but before doing this to any extent, their curved direction will be obliterated, and they will become straight, or nearly so (just as a curved cord is straightened by pulling at each end), and especially if the ribs be fixed by the previous contraction of the serrati and other muscles ; and this is precisely what occurs during the action of the diaphragm in inspiration.

Again, the same muscle possesses some tendinous openings, through which blood-vessels and nerves pass. Now it would, *à priori*, appear that these must be compressed in the action of the muscle ; but the reverse is the case, as the fleshy fibres act from these tendinous openings as fixed points of attachment or origins, and tend rather to increase their size : the œsophageal opening is the only one compressed in the contraction of the diaphragm ; but this is muscular, not tendinous.

Examples of the same kind are found in the opening of the adductor muscles, through which the femoral artery passes, and in the soleus, through which the popliteal descends into the leg ; but the same principle applies, and these apertures are enlarged, not contracted, during the action of these muscles. How erroneous then is the pathology which assigns to the compression of this vessel at these two openings, and its being stretched in its intermediate portion, the frequent occurrence of aneurism in the popliteal artery.

When the fibres of a muscle take a longitudinal course, and stretch directly from one point to another, their action is in a perfectly straight line, and is as economically disposed of as is possible ; but this arrangement is extremely rare, and, more frequently, the fibres take a direction more or less oblique with regard to the tendon, and to the axis of the limb or body. The pronator quadratus is perhaps the best example of a muscle acting in a perfectly straight line. But the oblique direction of the muscular fibres has many advantages; by its means a greater number of fibres may be attached to the tendon, and these, if duly arranged, will antagonize the obliquity of each other, and thus draw the tendon in the diagonal of the forces employed, and thus in a straight direction, as sailors pulling at each side of a rope antagonize each other as to obliquity, and pull in a straight direction.

In some muscles, this obliquity of action of one set of oblique fibres is not antagonized by an opposite set, and the muscle acts in an oblique direction, which may or may not be counteracted by an opposing muscle. The muscle has thus a varied action, and pulls the limb either obliquely, longitudinally, or otherwise, as opposed or not by other muscles. The arrangement of the fibres of a muscle on both sides, or one side only of its tendon, has given rise, from its resemblance to a pen or quill, to the terms *penniform*, *semi-penniform*, &c., which, although now but little used, are of certain advantage as indicating the shape of each muscle, and consequently its mode of action. The direction of the fibres of muscles varies also as to the degree of obliquity at which they are attached to their tendons, which is attended with the advantage of giving to the limbs or body all the compound or complicated motions which may be necessary ; and if we consider the more delicate actions so frequently required in spinning, sewing, playing of musical instruments, in speaking, singing, &c., every note of which requires the action of separate fibres, or the varied action of these fibres antagonized by others, we shall conclude that the arrangement adopted by Nature is that which is best suited to the purposes intended.

We have a few examples of double-bellied, or digastric muscle in the body, as the digastric of the neck, the occipito-frontalis, the circumflexus palati, and omohyoid muscles. All these, except the occipito-frontalis, have their tendons passing through pulleys, so that their action is not in the direction of their fibres, but intermediate between the two bellies, each set acting from the pulley through which the tendon passes. As the occipito-frontalis passes over the convex surface of the cranium, this acts in a somewhat similar manner to that of the pulleys of the other muscles.

The bellies of most of the muscles are enclosed in sheaths formed of the areolar tissue in a more or less condensed form; in some, as between the muscles of the palate, this is extremely lax; in others, as in the muscles of the extremities generally, it is condensed so as to form a fascia: the rectus abdominis, and the muscles enclosed in the fascia lata, are the best examples of this arrangement. This is of use in keeping the muscles in one position, in counteracting the oblique action of their fibres, and in preventing them from interfering with the action of other muscles.

The *Involuntary Muscles* contain no tendons, if we except the chordæ tendineæ of the ventricles. They are wholly composed of muscular tissue and investing sheaths; they form the hollow viscera, and, in their contraction, compress these so as to act upon their contents, and expel them either into other parts, or altogether from the body.

The complicated arrangement of the muscular fibres of the Heart (*see* VASCULAR SYSTEM) endows this organ with the power of contracting its cavity in every direction, both transversely and longitudinally, and thus of completely emptying it of the contained blood. The oblique fibres give to its contraction a twisted or spiral action, which may communicate to the contained blood a similar motion, so as to propel it more freely from the ventricular cavity.

The muscular fibres of the stomach, consisting of longitudinal, circular, and oblique, are enabled by their varied direction to act on the contained mass of food in every direction, and either compress it, roll it about in the larger extremity, or pass it onwards towards the pylorus.

The small intestines are enabled in like manner, by the different action of their transverse and longitudinal fibres, to act on their contents, and by a peculiar vermicular and twisting motion, propel them along the mucous membrane and around the valvulæ conniventes.

In all situations, the direction of the muscular fibres is closely connected with and admirably adapted to the function of the parts to which they are distributed.

In the action of most of the muscles, and especially of those of the extremities, we have examples of the three orders of levers.

The *first order* of levers is that where the power is at one end, the weight at the other, and the fulcrum between these two points, as in the ordinary mode of raising large stones or other bodies.

The *second order* of levers is that where the power is at one end, the fulcrum at the other, and the weight is placed in an intermediate position, as is exemplified in rolling a laden wheelbarrow.

The *third order* is that where the fulcrum is at one end, the weight at the other end, and the moving power is placed between these, as in raising a ladder from the ground, one end being fixed, and the other moved by the power acting on one of the rungs.

The first order of levers, although the most powerful, is that least used in the animal economy, as its use is less productive of extensive motion. The gastrocnemius muscle affords an example of this, as when the foot is raised from the ground, and the ankle joint is extended so as to raise the os calcis, and depress the toes: here the moving power is at the os calcis, the weight is in the anterior part of the foot, and the fulcrum is intermediate between these points, at the ankle joint.

The same muscle affords an example also of the second order of levers when the foot is placed on the ground, and the body is raised by the action of the muscle: here the moving power is at one end, the fulcrum at the other, namely, the anterior part of the foot resting on the ground, and the weight or resistance —that is, the body, is intermediate, at the ankle joint.

This muscle also affords an example of the third order of levers, as when one leg is placed across the other, and the foot is flexed on the ankle joint by the extensor muscles of the toes, and the tibialis anticus muscle; here the moving power is intermediate between the fulcrum, which is behind at the ankle joint, and the weight in front in the anterior part of the foot.

The biceps flexor cubiti also affords a good example of the third order of levers, as when a weight is placed in the hollow of the hand, and this is sustained or raised by the action of the muscles: the weight is in the hand, the fulcrum at the elbow joint, and the moving power intermediate between them, at the insertion of the tendon of the muscle into the tubercle of the radius.

In this position, power is sacrificed to extent of motion, as in raising the hand and weight, these pass through the arc of a circle of considerable dimensions, whilst the extent of motion, at the insertion of the power, is extremely limited.

The extent of motion enjoyed by this means is still more obvious when we hold a rod in the hand, as a fishing-rod, or a whip, the extreme end of which is made to pass through a space of considerable magnitude as compared with that of the part where the power is applied.

The great advantage derived from the disposition of levers in the human body, whereby motion is gained at the expense of power, is seen in the various acts of walking, running, leaping, &c. Man and vertebrate animals generally are thus enabled to pass through a wider sphere of motion than could possibly occur under other circumstances; those animals which do not possess a skeleton, or a resisting medium equivalent thereto, are destined to creep upon the earth, and enjoy but a limited extent of locomotion.

The Muscles generally, as already stated, consist of two distinct structures, the fibrous or tendinous, and the fleshy or true muscular portion.

The *Fibrous* or tendinous portion of the muscle, is composed of *fibrous tissue*, and presents the various characteristics, arrangement, and organization already described as belonging to this structure. The fibres of tendons take a parallel course, and are joined by connective tissue, thin partitions of which extend through the tendinous tissue, and being all connected with each other into a continuous system of parallel tubes, separate the tendinous fibres into numerous larger and smaller groups. The tendons of the muscles have been considered as possessed of elasticity to a slight degree ; but this may be well questioned, as this property is possessed by the muscular fibre itself, and its presence in the tendon would lead to a waste of the muscular power, which would be attended with no corresponding advantage. Still, if we take the plantaris tendon for example, and extend it between two fixed points, and then strike it somewhat forcibly, it evidently possesses a power of reaction that may justify the theory of elasticity being lodged in some of the tendons at least.

Where the tendinous join the muscular fibres, these are either continued into each other rectilinearly, without any distinct line of demarcation, or, the muscular fibres, with rounded extremities and closed sarcolemma, abut on the borders and surfaces of the tendons and aponeurosis, at an acute angle.

The *Muscular tissue* is that by which the various actions of the muscles, and the motions of the living body, are performed. On examination by the naked eye, it is evidently composed of bundles of fibres more or less closely connected by areolar tissue; these are termed fasciculi, and are generally arranged, in the voluntary muscles, or those of animal life, in the longitudinal direction, and nearly parallel to each other. But these fasciculi may be divided without much difficulty, until we arrive at the minutest fibre of which the muscular tissue is composed, and which constitutes its *ultimate fibre*.

Of the Ultimate fibre, there are two classes, the *striated*, or striped, and *non-striated*, or unstriped: the former belong to the functions of *Animal life;* the latter form the muscles of *Organic life*.

Each *striated* or *striped* muscular fibre consists of a number of longitudinal threads, lying close to each other, on the surface of which may be observed a series of distinct transverse striæ: they are enclosed in a simple transparent membrane, composed of areolar tissue, named the *sarcolemma* or *myolemma*, which is not contractile, and becomes wrinkled on the contraction of the muscular fibre contained within.

The Muscular fibre is generally supposed to be cylindrical; but close examination proves it to be somewhat compressed so as to present a polygonal appearance; it varies much in different muscles, in different parts of the same muscle, and in the different sexes, being larger in the male than in the female subject. Mr. Bowman states the size of the muscular fibre as follows:—

	Male. Inch.	Female. Inch.
Largest size of Muscular Fibre	1·192	1·684
Smallest ditto ditto	1·507	1·315
Average ditto ditto	1·352	1·454

Kölliker states that there is little variation in the size of the muscular fibre.

When still more closely examined, the striated muscular fibre is found to be composed of a number of delicate *fibrillæ*, formed of a single row of primitive particles adhering closely together, which appear to be composed of cylindrical cells, with flattened ends, divided by a transverse line indicating the *cell-wall;* to the contraction of these cells, the contraction of the whole mass of muscle is to be attributed. In the uncontracted state these cells exceed in length their breadth, but under contraction these become of equal extent. The diameter of the *fibrillæ* is tolerably uniform, in the relaxed state, being about 1-10,000th part of an inch.

The *striated* muscular fibres are of a fleshy redness in Man, mammals generally, and in birds; but in many amphibia and fishes are white or yellowish. Their colour is not characteristic.

The *non-striated*, or *unstriped*, muscular fibres are pale and yellowish, and are frequently blended with each other, unlike the striated fibre, in which this rarely occurs: they are not marked by transverse striæ, and seem to be composed of a solid and homogeneous structure; they are smaller than the preceding, and although their fibres are arranged in parallel bands or fasciculi, these are interlaced so as to form a complex network, and without any fixed points of attachment.

By the action of dilute nitric acid, these fibres may be separated into fasciculi of cells of a slightly elongated form.

The non-striated muscular fibre, in the smaller arteries and veins, exists without other tissue; but in other situations, it is connected with the various forms of simple fibrous tissue.

Although these two forms of muscular tissue have been assigned, respectively, to the Animal and Organic life, this theory applies only to Man and the higher order of animals In some of the lower tribes, the unstriped fibres are found in the voluntary muscles, and striped fibres are distinct in the heart and lymphatic hearts of birds and amphibia.

Muscular tissue belongs to the class of highly-organized structures, being well supplied with blood-vessels, nerves, and absorbents.

The arteries break down before entering the muscular fibre: they pass in the intervals between the fibrillæ, to which they cannot be traced; it is probable that these derive their nutrition through the myolemma, by a process of imbibition. The veins present a similar arrangement, and convey the blood from the muscle to the general circulation.

The supply of blood to the muscular fibre is necessary, not only for the purposes of nutrition, but also to preserve its power of contractility, which becomes impaired, or wholly lost, if the muscle be deprived of arterial blood, as follows in cases where the abdominal aorta has been tied: the operation produces a paralysis of the lower extremities, which continues until the circulation is re-established. The same result will ensue, if the muscular fibre be supplied with imperfectly oxygenated blood: and this remark not only applies to the voluntary, but also the involuntary muscles, the contraction of the heart being powerfully affected by the circulation of dark blood in its vessels. The loss of contractility results from the absence of oxygen which acts as a stimulant to the muscular fibre, as well as to the presence of carbonic acid, which has a contrary effect.

The Nerves are distributed to the muscles in a manner resembling that of the arteries; their minute fibres pass transversely to the ultimate fibre, but cannot be traced into it, as they form a series of loops, which either return to the same trunk, or join an adjacent one. Kölliker states that *free terminations of nerve-fibres* may be traced into the muscles of the human subject. In most muscles, the nerves are found to come in contact with their fibres at some few limited points, and are never connected with them throughout their entire length; they form the central point of nervous energy in each muscle.

The trunks entering the muscles consist chiefly of thick nerve tubes, so that in 100 there are, on the average, about 12 fine ones. In the interior of the muscles, they become more slender, so that the terminal plexuses consist only of very fine fibres of 0·001‴ to 0 0025‴ in diameter. In particular instances, individual fibres can be directly observed, to become attenuated, without any division of its substance, showing that there is an expenditure of nervous fibre in the muscular tissue.

The non-striated fibres are less liberally supplied with nerves, which are derived almost exclusively from the *Sympathetic* or *ganglionic* system: as this, however, communicates freely with the cerebro-spinal system of nerves, the latter necessarily exercises some influence in their contraction.

The muscular fibres terminate in their tendinous extremities, generally by forming disks or rounded extremities, at which point the myolemma also terminates. The tendinous fibres are attached both to the disks and myolemma, and extend to a variable distance into the body of the muscle, dependent to a great extent on the action and power of the muscular fibre.

Muscles possess the power of inherent growth, and become developed from constant exercise: the powerful brachial muscles of blacksmiths are well known, as are also the muscles of boatmen and others; porters, and others accustomed to carry heavy loads, are characterized by the development of the gastrocnemii muscles. Their power of reparation is extremely limited, the muscular fibre, not being regenerated, its place is supplied by ligamentary fibres, which possess no contractility, and but feeble powers of resistance; hence, the frequency of hernia, after wounds of the abdominal muscular parietes.

The Muscular fibre more closely resembles fibrin than any other of the elementary tissues. According to Bibra, there are in 100 parts of fresh beef 72·56 to 74·45 parts of water. The solid parts (25·55 to 27·44) in a man 59 years of age, consisted of—

A residue insoluble in boiling water, alcohol, and ether	16·83
Soluble albumen and colouring matter	1·75
Substance yielding gelatine	1·92
Extractive matter and salts	2·80
Fat	4·24

The gelatine is derived from the perimysium, the vessels, and neurilemma, but not from the sarcolemma; the inorganic salts and albumen form the muscular fibres, as also the salts of lactic, acetic, butyric, and formic acids, the sugar of muscles, or *inosit*, and the colouring matter.

The Sarcolemma offers considerable resistance to the action of alkalies and acids: it is closely related to the investing membrane of glands, the walls of capillaries, and the cell-membranes of many cells.

The great characteristic property of muscular fibre is its *Contractility*, or power of *contraction*, by means of which the muscle is enabled to shorten itself and thus tend to bring its attached extremities towards each other. Most other structures in the body possess the power of contraction when exposed to certain stimulants, as the skin when exposed to cold; but this is due to the organic contractility of tissue, and is perfectly distinct from muscular contractility.

It has been much disputed, whether this contractility exists in the muscular fibre itself, or is supplied to it from the nerves distributed to it. Certain it is, that if the nervous supply be cut off by the section of the nerve, the muscle loses the greater part of its power of contraction; but experiment proves that, under these circumstances, the muscular fibre retains some of its contractility, and may be made to contract by the application of stimuli directly to it; but as a portion of the nervous influence may still remain in the muscle, it may be questioned if this dormant contractility is due to this or to the muscular fibre.

That the Nervous influence is essential to the irritability and contractility of the muscles cannot be questioned, as we cannot suppose a muscle to contract when wholly deprived of the influence of the nerves; these form a portion of it as a perfect whole, and we might as well expect the muscle to live and contract, without blood-vessels, as without nerves. The endeavour to fix, on a particular structure, one especial office in the animal economy, apart from the rest of the body, is vain: all parts form but portions of one perfect whole, and each, even the most trifling structure, subserves its purpose, and contributes to the general perfection.

As well might we attempt to fix the act of walking, or locomotion, on any one of the structures of the limbs, and support our theory by the experiments of removing alternately the bones or muscles, or arteries or nerves: without any one of these, locomotion is impossible; and yet who would assign to that one, the power of moving from place to place?

A distinction is drawn between the *Irritability* and the Contractility of the Muscular tissue, and yet there is but little difference: the Irritability precedes the Contractility, is the disposition of the fibre to contract, and is evidenced by the act of contracting. Contractility, strictly so called, is the power of executing the mechanical act of contraction of the muscular fibre, and Contractility resides in the muscular fibre, but not as a property independent of the nervous influence.

In the contraction of the muscle, this is changed in form but not in size; it is diminished in its longitudinal diameter, but is increased in its transverse, so that its actual bulk remains the same; although, apparently, as in the contraction of the biceps, &c., the muscle swells up and becomes enlarged: that such is the case is proved by contracting the muscles under water, when it is found that no change takes place in the vertical height of the fluid.

The non-striped, or non-striated, muscular fibres are less affected to contractility by stimuli applied to their nerves than the striated fibres; and when stimulated, the contraction is not limited to the fibres acted upon, but extends to a considerable distance, as in the alimentary canal; the natural stimulants to these fibres are their contents, and the excitement to contract is induced by the effect of stimulants on the extremities of the nerves, and is not transmitted along the nerves, as in the voluntary muscles; thus the Uterus is stimulated to contraction by the mature fœtus, the bladder by the urine, the stomach by food, the heart by the blood, &c.

According to Valentin, the unstriped muscular fibre usually responds to mechanical irritation of its *substance* with greater energy than the striped fibre, and often exhibits a more punctual obedience to such a stimulus than to an irritation of its free nerve-fibres. It is probable that its substance is capable of contracting without the intervention of the nerves. This is especially observable in the strong muscles of the alimentary canal, the urinary bladder, and the internal female organs of most mammalia.

The Muscular fibres are endowed with an *organic expansibility* which enables them to elongate, immediately subsequent to their state of contraction. This is best exhibited in the action of the Heart, which after it has contracted on, and expelled its contents, elongates itself from its base to its apex, before resuming its natural position and shape: to this elongation, has been attributed the impulse of the heart against the parietes of the thorax, forming the heart's pulsation.

The principle of *Tonicity* also exists in muscular fibres: this is that latent state of contractility in which all muscles are found in the healthy living subject, when not in a state of action, and presents a remarkable contrast with the same muscles in the dead subject.

In the dead bodies of most animals, three conditions of the muscular substance succeed each other. There is, first, a space of time during which the muscles retain a greater or smaller residue of their vital activity, or of their capacity of contracting under the influence of proper stimuli. They, next, experience an extraordinary contraction, which gives rise to that peculiar phenomenon called the Rigor mortis, or the stiffening of death. Finally, as putrefaction advances, the muscular substance softens and dissolves with more or less rapidity.

The contractility of the muscular fibre remains after death, to a much longer period in most of the lower animals than in Man. The femoral muscles of a frog frequently respond to the shocks of an electro-magnetic machine three days after death, and sometimes even from five to six days after. A decapitated turtle may move its limbs in answer to an external stimulus, about fourteen days after apparent death.

The contractility of the muscular fibres of lower animals would thus appear to be dependent, more upon the nervous fibrillæ, than upon the Sensorium, as in

Man. As we descend in the scale of creation, the highly developed nervous Centre, the Brain, gradually disappears, and the functions performed by it in Man, and necessary to the lower animals, become transferred in them to the nervous branches, which supply its place.

Contractility is much influenced by temperature, narcotic poisons, and other agents: cold destroys this power rapidly; hydrocyanic acid and wourali lead to the same results, especially in large quantities. It is much increased in Tetanus and from the use of Strychnia, under which the tension of the muscles, after death, is most remarkable.

Generally, in cases of sudden death, as from accident, the rigor mortis sets in rapidly, and is well marked; but, in some forms of sudden death, this power is destroyed with life. The electric fluid has this effect, as in persons struck by lightning: some cases of sudden death from violent emotions are stated not to have been followed by rigor mortis; and animals hunted to death present the same phenomenon.

In the human subject, signs of the rigor mortis may appear (according to Valentin) in the first quarter of an hour after the last breath (a statement which requires further support), and may not commence until eighteen hours afterwards. After death, by hanging, the rigor mortis affects the extensor muscles most powerfully.

The close affinity between the phenomena of muscular contractility and those of the electro-magnetic battery is well and largely treated of in Valentin's excellent Physiological Work;* but it would be out of place here to enter into the subject more fully.

The length of time during which contractility remains, after death, is much increased by the process of artificial respiration, the organic contractility being maintained by the circulation of the oxygenated blood; whether this acts directly on the muscular fibres, or indirectly through the nervous influence, is not shown.

* Translated by W. Brinton, M.D. H. Renshaw, 356, Strand.

Mr. Erichsen has shown that, if the coronary arteries of the heart be tied in a dog or rabbit, after the spinal marrow has been divided, and the circulation is maintained by artificial respiration, the pulsation of the heart will only go on, for about twenty-three minutes after the death of the animal, instead of continuing, for ninety minutes, as it will do under other circumstances.

But, in this experiment, as much additional violence is done to the heart in the tying of the arteries, some of the result must be attributed to this. It cannot be questioned that the circulation of decarbonized blood acts injuriously on the contractility of the muscular fibre, independently of its indirect influence through the nervous system.

The expenditure of oxygen, in the contractility of muscular fibres, is considerable ; and, to supply this, the respiratory process is accelerated, where exercise is resorted to.

The contractility of the muscular coats of the arteries, independently of the tonicity which keeps them in a contracted state upon their contents, is evidenced by their gradual contraction, when emptied of blood, and by their still more contracted state, when exposed to the atmospheric air and other stimulants.

It has been ascertained by the researches of MM. Becquerel and Breschet, that the temperature of a muscle rises when it is thrown into a state of energetic contraction. The increase is usually about 1° Fahr., but will exceed this, under prolonged muscular action. But this increase of temperature extends to all other parts of the body, and is the general result of an increased respiration, and a consequently increased consumption of oxygen.

In connexion with many of the muscles, and most frequently with their tendinous portions, we meet with sacs of condensed areolar tissue forming *bursæ mucosæ*, which are placed wherever the muscle is exposed to much friction. Two large bursæ mucosæ lie beneath the gluteus maximus muscle, separating it from the tuber ischii and trochanter major; one between the deltoid muscle and head of the humerus, &c.: they vary in size and number according to the use which is made of the muscles, and become developed with rapidity. They belong to the class of *serous membranes*, although called *mucous*, and closely resemble the Synovial membrane of the joints.

Portions of bone (*Sesamoid bones*) become frequently developed in the tendons of muscles when exposed to much friction, as in the peroneus longus tendon, where it passes through a groove in the os cuboides, in the muscles of the great toe and thumb. The Patella may be, and frequently is, regarded as a large sesamoid bone, formed in the tendon of the Rectus femoris muscle; so also is the os pisiforme, a similar production in the tendon of the flexor carpi ulnaris. Like the bursæ mucosæ, the sesamoid bones become rapidly formed, where tendons are exposed to severe friction in gliding over bony surfaces.

The Muscular fibre is frequently changed into a substance resembling fat (*adipocere*): this change is usually found amongst the muscles of the back, especially in old females; and in some cases extends to muscles in different parts of the body.

The Heart is especially liable to fatty deposit. The tendons, like all fibrous tissues, are most subject to bony and arthritic deposits.

THE NERVOUS SYSTEM.

THE NERVOUS SYSTEM is that which displays the greatest variety in the different classes of animal life, presenting the highest degree of development in the higher orders, and the lowest in the lower orders.

In Man it presents two great divisions, 1. *The Cerebro-Spinal System;* 2. *The Sympathetic* or *Ganglionic System.*

The *Cerebro-Spinal System* consists of, 1. The Brain; 2. The Cerebral Nerves; 3. The Spinal Cord; 4. The Spinal Nerves.

The Brain is composed of, 1. The Cerebrum; 2. The Cerebellum; 3. The Medulla Oblongata.

The *Cerebrum* forms by far the largest portion of the Brain, and consists of two lateral masses or hemispheres, partially separated from each other. This part of the brain seems to preside more especially over the voluntary functions, and bears a close relation to the *Intelligence* of the individual, and the influence of the *Will* over the voluntary actions, although it is impossible to distinguish the exact extent of the influence exerted by it, as a part of a perfect whole, and to assign to any one part, its precise office, independently of those with which it is more or less intimately connected.

This portion of the brain appears to preside, also, more especially over the organs of locomotion, being principally formed by, or at least more distinctly continuous with, the anterior pillars of the spinal marrow, whence the principal motor nerves proceed.

The *Cerebellum*, on the contrary, presides more especially over the Functions of Animal life, and over the sensitive powers of the individual, being continuous with the posterior pillars of the spinal marrow, of which it may be regarded as an expansion or Ganglion.

The *Medulla oblongata*, although usually considered as a portion of the brain, is rather an intermediate structure between this and the spinal cord, being continuous with both, inferiorly descending to form the latter, and superiorly ascending to expand into the Cerebrum and Cerebellum. From it proceed the principal respiratory and gastric nerves.

The *Spinal Cord* is lodged in the spinal canal, hence its name, and extends from the foramen magnum to opposite the first lumbar vertebra, where it terminates, by forming a ganglionic expansion, in the cauda equina, a leash of nerves which proceed outwards, to supply the lower parts of the body and lower extremities.

From the Spinal Cord, proceed the Spinal Nerves, which are destined to convey sensation and the power of motion, to the various parts of the body supplied by them.

The functions of the Spinal Cord are essentially dependent, in Man, on the influence of the Cerebrum and Cerebellum, as its severance from them destroys all its powers; it yet, however, seems to act to a certain extent independently of these, and to be the centre of particular actions and reflex actions which do not require the immediate cognisance of the Sensorium, and may be effected without its immediate participation.

The Sympathetic or *Ganglionic System* is situated chiefly in the neck and cavities of the Thorax and Abdomen, and consists of a number of *Ganglionic* expansions, from which the nerves proceed to supply the various parts. It presides almost exclusively over the Functions of Organic life, supplying the principal organs of Circulation, Digestion, and Respiration. It does not possess a distinct centre, unless the *Great*

Semilunar Ganglion is regarded as such, each ganglion appearing to be the centre of the nervous impressions which proceed from it; at the same time as all the ganglions are more or less intimately connected, either by direct filaments of communication, or by means of the frequent and intimate anastomosis of the nervous filaments of the system, the influence of one ganglion must necessarily be extended to the others.

In the lower classes of Animals, the Nervous System gradually diminishes in the order given; the Brain, medulla oblongata, and spinal cord successively disappear, until the only portion of the System left is that which is analogous to the Sympathetic; and thus, in the lowest classes, Life may be said to consist of the Organic alone, without intelligence, sensation, or sensibility.

The Cerebro-Spinal System — namely the Brain, Spinal Cord, and Nerves—is essentially composed of two substances, a *white*, or *medullary*, or *fibrous*, and a *grey*, or *reddish-grey*, or *cortical* substance. Of these, the white forms much the larger portion, although the relative quantities vary in different situations.

In the Cerebrum generally, the grey matter is external, hence its name of cortical substance, and forms the principal part of the convolutions which mark the outer surface of the hemispheres; but, in the interior, this relative position is frequently reversed, the white or medullary substance being the external, the grey forming the internal parts: examples of this are found in the optic thalami, tubercula quadrigemina, corpora albicantia, &c. The corpus striatum presents a peculiar arrangement of the white and grey matter. The grey forms the outer and principal part of the mass, whilst the white passes through this, so as to form a striated or fibrous appearance.

In the Cerebellum, the white matter forms the smaller portion, the grey composing the greater part, as well as the exterior of this portion of the brain: in it, the white matter presents the appearance of a tree, hence named the *arbor vitæ*, which spreads out towards the external or grey matter, which is arranged in laminæ or plates, and does not form convolutions as in the hemispheres of the cerebrum. In nearly the centre of the stem of the arbor vitæ is a nucleus or ganglion of greyish matter, with a serrated border, forming the *corpus dentatum*, or *ganglion of the cerebellum.*

The grey substance, forming the laminæ of the Cerebellum is found to consist of an *inner rust-coloured*, and an *outer grey layer*, of nearly equal and uniform thickness, except in the fissures, where the inner layer is generally the thicker.

The *inner rust-coloured layer* contains nerve-fibres, and large collections of free nuclei. In the meshes of the nerve-fibres are situated immense numbers of dark round corpuscles of 0·002‴ to 0·004‴ in size, which appear to be free cell nuclei, and very frequently present a distinct nucleolus. The nerve-fibres, diminished in diameter, pass out of the rust-coloured layer into the outer grey layer, which consists of two layers, the inner of which contains nerve-fibres and large nerve-cells; the outer a finely granular, pale, slightly yellowish substance. The large cells of the grey layer, discovered by *Purkinje*, are different from these.

The *structure* of the spinal cord and medulla oblongata may be considered together. In these, the white matter forms the outer or cortical substance, which encloses the grey matter, which thus forms the centre of the spinal cord: it is here disposed of in the form of two crescentic bodies, one in each lateral half of the spinal marrow, having the concavities turned outwards, and their convexities directed towards each other, and connected by a transverse band of grey matter.

The fibrous structure of the white nervous substance is well marked in some situations, as in the several commissures, the crura cerebri, and at the bottom of the sulcus which divides the anterior pillars of the spinal cord; in many others it is quite indistinct.

The grey matter is the more vascular of the two structures, hence its somewhat reddish colour. It has been considered by Gall and Spurzheim, and others, to act as the matrix of the white substance, as wherever this comes in contact with the grey matter, it seems to increase in size, and become considerably enlarged. Of this substance, the principal ganglions are composed.

Two sets of white fibres are distinguished in the Cerebro-spinal centres, which as they appear to ascend from the spinal marrow, and then diverge into the Cerebrum and Cerebellum, whence they converge to form the commissures, are named the *diverging* and *converging* fibres. As, however, there is no reason to suppose that the fibres ascend from the spinal cord to the brain, rather than that these descend to the spinal cord, the terms are conventional, and may be misapplied. The term "radiating" is more applicable, as indicating an arrangement, regarding which, there can be no doubt.

The *diverging* or *radiating* fibres may be traced outwards until they terminate in the grey substance, forming the periphery of the cerebrum and cerebellum. In this grey matter, the *converging* or *transverse* fibres are supposed to arise, and thence to pass across from one hemisphere of the cerebrum to the other, and form the different commissures, as the corpus callosum, or great commissure, the anterior and posterior commissures, the fornix, &c.; and in like manner, in the cerebellum, to take a transverse course, and form the Pons Varolii, or great commissure of this organ.

In the Spinal Cord, a different arrangement is found. The nervous substance here forms one continuous ganglionic mass throughout, the external fibrous substance, connecting it superiorly, as just stated, with the cerebrum and cerebellum, and the grey or vesicular portion occupying its centre, and forming the proper centre of a portion of the fibres, entering into the roots of the nerves.

The Spinal Cord is composed of two lateral masses, perfectly symmetrical, and united by the grey matter in the centre.

We are thus led to observe, that each part of the cerebro-spinal mass is closely connected with the rest, and that no one occupies an isolated position; and may thence infer that the functions of all are intimately connected also. Although observation may justify us in assigning, to one, or other portion of this mass, an especial influence in conferring a special sense, or in the endowment of a particular action, it can only possess this, as derived from the cerebral mass as a whole, and not as being generated in that particular part.

It is remarkable that, as the white fibres ascend to their destination, they meet with masses of grey matter, on emerging from which they appear much increased in size. A good example of this is the ascent of the white fibres from the spinal cord, the anterior columns of which, forming the crura cerebri, meet with the grey matter in the optic thalami, and corpora striata: the posterior columns, in like manner passing into the crura cerebelli, meet with the corpus dentatum, or ganglion of the cerebellum, in the centre of the arbor vitæ, and expand into the branches of the structure to terminate in the laminæ; hence, as already stated, these ganglia are supposed to generate the white fibres, and are regarded as a matrix to these.

This office of the grey matter may be well questioned, as conveying the idea that one structure is generated from the other, which is inconsistent with the general rules of the animal economy, in which each tissue grows of itself, and does not spring from any other.

It is more probable that these masses of grey matter, scattered throughout the substance of the brain, act as so many sensory ganglia, subservient to the general purposes of the brain, and developing sensations or powers necessary to the functions of the individual.

This opinion is strongly supported by the fact that grey matter, in the form of ganglia, is attached to all the nerves of special sense and of common sensation.

It would appear, from observations made on the lower classes of animals, that the Cerebral Hemispheres, and the lateral lobes of the Cerebellum, are structures superadded to the great cerebral ganglia in Man and the higher classes, as the former progressively diminish as we descend in the scale of Creation.

The *Medulla Oblongata*, although generally regarded as a portion of the brain, is more properly the superior extremity of the spinal cord, of which it forms an expansion. Its strongest claim to be considered a portion of the brain rests on its giving origin to the eighth pair of nerves, which preside especially over the important functions of Respiration and Digestion—functions which present little analogy with those presided over by the spinal cord and spinal nerves generally; and to its being centre of the more important reflex motions.

The Medulla Oblongata is composed, like the spinal cord, of two lateral masses, each of which is formed of three bodies: these are, *anteriorly*, the *Corpora Pyramidalia*, next the *Corpora Olivaria*, and posteriorly, the *Corpora Restiformia*.

The *Corpora Olivaria* have no analogous structures in the spinal cord, unless we consider that the Vesicular Grey matter in its centre forms the analogue. The Corpora Olivaria are composed almost wholly of grey or vesicular matter, which is formed of three different portions, or ganglionic centres: the *anterior* forms the nucleus of the olivary body, the *lateral* that of the Restiform body, and the *posterior* that of the Corpus Pyramidale.

The *Corpora Pyramidalia*, or *Anterior pillars of the Medulla Oblongata*, are composed of fibrous structure, arranged chiefly in the longitudinal direction; on the mesial line, in front, they are separated by a deep fissure, into which a process from the immediate investing membrane of the cord penetrates, and at the bottom of which the fibres take a more transverse course, and evidently decussate, those of the right side passing to the left—an arrangement, to which is attributed the phenomenon of pressure on one side of the brain, being so frequently followed by paralysis of the opposite. Superiorly, the pyramidal bodies pass up beneath the Pons Varolii, to terminate in the Crura Cerebri, some of their fibres also passing to the Crura Cerebelli.

The *Corpora Olivaria* are of short longitudinal, and still shorter transverse extent, and form a slightly projecting eminence of an almond shape, on each side of the corpus pyramidale, situated in the sulcus between these and the restiform bodies. The external fibrous portion of each olivary body is connected above with the Motor tract, with the Corpora Quadrigemina, and Cerebellum; and below with the Anterior pillars of the Cord. The Vesicular portion in its interior presents a serrated appearance, hence named *Corpus dentatum*, and is especially connected with the origins of the hypoglossal, and glosso-pharyngeal nerves.

The *Corpora Restiformia*, or posterior pillars of the Medulla Oblongata, pass superiorly into the Crura Cerebelli, and inferiorly descend to form the posterior pillars of the Cord. They are separated from the Corpora Olivaria, in front, by a superficial groove, in which the roots of the par vagum and glosso-pharyngeal nerves are found, and, still more inferiorly, by a superficial groove continued downwards throughout the lateral surface of the Spinal Cord from the Corpora Pyramidalia, and, posteriorly, are separated from each other, by a fissure less deep than the anterior fissure, separating the pyramidal bodies, and in which the decussation of fibres cannot be distinguished. A band of filaments of an arched form, hence called *arciform filaments*, crosses over to the anterior and lateral columns on each side.

The origins of the Pneumogastric and Glossopharyngeal nerves may be traced to the ganglia contained in these columns.

Two small bands of fibrous structure, which are found between the Restiform bodies, and form that portion of the Medulla Oblongata which lies on each side of the posterior fissure, are described as the *Posterior Pyramids.* Superiorly, they pass upwards into the Optic Thalami, and, inferiorly, into the posterior columns and posterior part of the lateral. A partial decussation takes place between these fibres; their grey nuclei are regarded as the ganglia of the true Acoustic nerves, or portio mollis of the seventh pair.

The Medulla Oblongata affords origin to four pairs of what are generally described as Cerebral Nerves—viz., the sixth, seventh, eighth, and ninth—with the exception of the spinal accessory nerve, which arises more inferiorly from the Spinal Cord. Of these, the sixth is a motor nerve, and arises essentially from the motor tract of the Corpora Pyramidalia. The Glossopharyngeal and Pneumogastric, nerves of special function or office, appear in the sulcus between the Corpora Restiformia and Corpora Olivaria, arising chiefly from the ganglia contained in the Corpora Restiformia. The ninth, or lingual nerve, being a motor nerve, is found in the lateral groove separating the Corpora Pyramidalia and Corpora Olivaria, and arises from the motor tract in the former of these bodies.

The functions of the Medulla Oblongata are evidently of a compound character, and consist of a Motory and Special nature. To the special arrangement observed in it, the Corpora Olivaria and the ganglia of the Corpora Restiformia, may be assigned the special function bestowed upon the Pneumogastric and Glossopharyngeal nerves, which, notwithstanding the numerous and elaborate experiments performed upon them, is not yet determined. Its motor portion contributes to the origin of the sixth and ninth nerves.

To these may be added, as a Function of the Medulla Oblongata, the Presidence of the Reflex motions, as first accurately distinguished and classified by the late Marshall Hall.

That these functions are of independent existence in the Medulla Oblongata is not to be supposed; its connexion with the various parts of the Cerebrum and Cerebellum above, and its continuity inferiorly with the Spinal Cord, show that it is indebted to the former of these for the creation of these functions, and the power of exercising them—itself being the resting-place for the principles, whatever these may be, which enable it to perform its offices as a portion of the Animal Structure.

The experiment performed by Mr. Grainger, in which, notwithstanding that the brain had been removed, a young puppy could perform the act of suction, and other motions relating thereto, does not negative this position, as the functional office still was persistent in the Medulla Oblongata, and nerves of suction; and all actions are more independent in the lower animals than in Man, the perfection of whose organization is dependent, not only on its perfection of structure, but also on the intimate connexion which exists between all its parts, whereby each part, whilst discharging its own duty, is enabled to minister to the completeness of the functions of all. Doubtless, had this experiment been carried farther, and the Medulla Oblongata itself been removed, the puppy would still have continued to suck by virtue of the nervous influence persistent in the nerves themselves, as numerous experiments have proved the persistence of the nervous influence in the nervous filaments for many days, after even death had taken place.

THE SPINAL CORD.

The *Spinal Cord* is a continuation downwards into the Spinal Canal of the Medulla Oblongata. It is somewhat circular in shape, but varies much in the different regions both as to size and shape. In the neck, it is large and flattened antero-posteriorly; in the upper part of the dorsal region it is small and nearly circular; and in the lower part and upper portion of the lumbar region it again expands and becomes slightly flattened. Its size is found to depend much on the size and number of the nerves given off by its several portions, being largest where these are large and numerous, but small where these are small and not numerous

The *Spinal Cord* consists of two lateral halves or masses, perfectly symmetrical, and partially separated by an anterior and posterior groove on the mesial line, in front and behind, continuous with and corresponding to the grooves or fissures which separate the Corpora Pyramidalia and Corpora Restiformia of the Medulla Oblongata. It possesses pillars analogous to these, and bearing the same name. On the lateral surface of the Spinal Cord a superficial groove also exists, separating the anterior and posterior pillars; and beyond this is a double sulcus, in which the roots of the spinal nerves arise.

The external surface of the Cord is composed of white fibres, but much less of a fibrous character than is seen in many parts of the Cerebrum. Its interior is composed of grey matter, arranged in a double crescentic form; as already described, the extremities or cornua of each crescent are turned towards the roots of the spinal nerves, with which a continuity may be distinctly traced. A portion of white fibrous, or tubular substance, separates each cornu from the fissure in which the roots of the spinal nerves are found. This is much larger in the anterior than in the posterior pillars; hence these are sometimes described in conjunction with its corresponding lateral pillar, as the antero-lateral pillars. The subdivision of the cord into so many pillars is unnecessary, nearly artificial, and totally unconnected with its physiological relations.

Detached ganglia, such as are met with in the Cerebrum, Cerebellum, and Medulla Oblongata, are not found in the Spinal Cord, its grey substance forming a continuous ganglionic structure throughout: its structure is therefore much less complicated than that of any of these, and its functions necessarily accord with this simplicity of structure, as being nearly limited to two, namely, those of Sensation and Motion.

The central grey substance of the Spinal Cord may be traced upwards into the Corpora Striata and Optic Thalami, but not further. It has thus no connexion with the grey matter forming the periphery of the hemispheres. Its relative extent as regards the white substance varies much. There is less in the dorsal than in the cervical or lumbar region. In the lumbar region it is much augmented; the expansion in this region being the result of an increase of this substance, whilst that of the cervical is owing to the enlargement of the white substance.

This difference is no doubt owing to the greater necessity for excito-motory actions in the rectum, genital organs, and lower limbs than in the upper extremities.

The relative proportion of the grey matter is also much greater in the Spinal cord of the infant—the reverse of the arrangement which characterizes the cerebrum; hence the greater excito-motory influence at this period of life, and the lesser development of the intellectual functions.

The middle portion, or grey commissure, contains, in the fœtus, and in most cases in the adult also, a canal, *canalis spinalis*, with cylindrical epithelium, and around this a grey substance, the *central grey nucleus*.

The *Spinal Nerves* arise from the lateral pillars of the Spinal Cord by two *Roots:* one of these is first seen in the groove on the lateral surface of the Corpus Pyramidale, or anterior pillar; the other in the corresponding groove on the lateral surface of the Corpus Restiforme. On tracing the roots into the substance of the Cord, a portion of these fibres is found to be continuous with the grey or vesicular structure in its centre: some of the fibres of the posterior roots are supposed to traverse the grey matter, and become continuous with the motor root of the same side, and the sensory root of the opposite side. The filaments forming the posterior root of each nerve are larger than those of the anterior, with the exception of the sub-occipital nerve, whose anterior is much the larger, and whose posterior is sometimes altogether wanting.

The *Anterior* Root of each nerve is the *Motor* portion, the posterior root the sensory portion: the former, therefore, endows the parts which it supplies with motion, the latter, those supplied by it, with sensation; and, although these portions become inextricably united in each spinal nerve, as well as in the plexuses and various anastomoses, there can be no doubt that the filaments remain perfectly distinct to their termination.

To the late Sir Charles Bell, Physiology is indebted for this its greatest discovery, and one second only to that of the Circulation of the Blood by the immortal Harvey. The truth of the theory has been proved by numerous experiments on Animals, in which *Motion* has been destroyed by the division of the anterior roots, and *Sensation* by that of the posterior roots; as also by the results of disease and accidents, in which the destruction of motion or sensation has followed the injury or destruction of either of these roots.

That the columns or pillars of the Spinal Cord agree in function with the roots more immediately derived from them, is not so certain; indeed, more recent researches tend to the opinion that this is not the case, and that we must look for some other source of the motor power and of sensation, than those, to which they have hitherto been assigned.

The *Roots* of each Spinal nerve pass out from the spinal canal through the intervertebral foramen; and in the foramen, or a little to its outer side, a ganglionic expansion is formed upon the posterior root only, after which the two roots unite and form a *Spinal Nerve*, which divides immediately into two *branches*, an anterior and a posterior, to supply the different parts of the body.

Each spinal nerve is thus a *compound* nerve, being composed of motor and sensory filaments, which endow with motion and sensation the parts which they respectively supply. As the motive power is transmitted to these parts *from* the Spinal cord by the motor filaments, they are sometimes named *efferent;* and as Sensation is conveyed from the more distant parts to the Spinal cord by the sensory filaments, these are distinguished as *afferent:* a combination of these two forms the *excito-motory* or *reflex* actions of the Spinal Cord and Medulla Oblongata.

Examples of the reflex action are frequent: as, for instance, when a stimulant is applied to a certain part, the sensation caused by its application is conveyed along the sensory filaments to their origin, and hence a suitable and corresponding motive power is transmitted along the motor filaments. This is accomplished independently of the Will, and in many cases in opposition to this, as frequently in the expulsion of the fæces and urine, and of the fœtus from the womb, &c.

The Medulla Oblongata is supposed to be the especial seat of the Reflex action from the circumstance that the Pneumogastric and Glossopharyngeal nerves arise from it; and no doubt from the extensive and important distribution of these nerves, they participate largely in most of the reflex motions; and hence the Medulla Oblongata becomes, as it were, the centre of the most important of these.

To Reflex action may be assigned also many of the irregular movements which take place in nervous and other disorders, as in Convulsions, Hysteria, &c. The irritation in these cases may be in the bowels, the uterus, or other of the viscera, but being borne to the Spinal Cord or Medulla Oblongata by means of the *afferent* sensory nerves, the reflex action is transmitted by the *efferent* or motor nerves to the parts moved.

It will be remarked that the afferent and efferent nerves do not always correspond to the same part of the Spinal Cord, and that motion may be transmitted from a far distant portion of this, from that, which receives the morbid or injurious impressions. In Hysteria, the source of the irritation is usually connected with the Uterus, and yet there are few muscles of the body or limbs that may not be affected in the Hysteric Convulsion.

Independently of the sympathy which exists, indirectly, between all the structures of the body, this phenomenon may be explained by the continuity which exists between the different parts of the Spinal Cord, Medulla Oblongata, Cerebrum, and Cerebellum.

Dr. Brown-Séquard * has paid considerable attention to the structure and functions of the spinal nerves, the white and grey matter, and has formed the following conclusions from his experiments, &c., concerning the transmission of sensitive impressions, and of the orders of the will to muscles in the cerebro-spinal axis.

1. The laying bare of the spinal cord, and its free exposition to the action of the atmosphere, instead of being a cause of loss or diminution of sensibility, as it had been said, seems to be followed by a marked

* Lancet, vol. ii. 1858.

increase of sensibility in the parts of the body which are behind the place where the cord is exposed.

2. The laying bare of the spinal cord, even in mammals, is very rarely followed, after a number of days, by any kind of accidents (meningitis, myelitis, &c.) producing a diminution of sensibility.

3. The posterior columns of the spinal cord are not, as it had been imagined, a bundle of fibres from the posterior roots of the spinal nerves, going up to the encephalon.

4. The restiform bodies are not a collection of fibres chiefly from the sensitive nerves of the various parts of the body, going up to the encephalon, and therefore the cerebellum is not the recipient, through the restiform bodies, of most of the sensitive fibres of the trunk and limbs.

5. Deep injuries to the posterior columns of the spinal cord, are always followed by a degree of hyperæsthesia, which appears in all parts of the body behind the place injured.

6. All the parts of the encephalon which are situated in its posterior or superior side are like the posterior columns of the spinal cord in this respect—that a marked degree of hyperæsthesia always follows a transverse section upon any one of them.

If a complete transverse section is made upon any part of the restiform bodies, sensibility becomes very much increased in every part of the trunk and limbs. Hyperæsthesia is also, but at a less degree, one of the results of a transversal incision in the cerebellum, in the processus cerebelli ad testes, and in the tubercula quadrigemina.

7. A section of either the anterior or the lateral columns is followed by a certain degree of hyperæsthesia.

8. The hyperæsthesia is greater after a section of the posterior columns and the posterior horns of grey matter, and the neighbouring parts of the lateral

columns and central grey matter, than after a section of any other part of the spinal cord.

9. The power of transmission of a nervous exudation, either for sensation or for movement, may exist in parts of the nervous system which are not excitable.

10. The posterior columns of the spinal cord are much less sensitive than they are said to be, and it even seems that their apparent sensibility depends upon the fact, that when they are irritated, the posterior roots, which are very sensitive, are also more or less irritated.

11. The restiform bodies seem to be deprived of sensibility to mechanical excitation.

12. Of the fibres sent to the spinal cord by the posterior roots, some go transversely which do not seem to be employed for the transmission of sensitive impressions. Others go upwards and others downwards, both of which are conductors of sensitive impressions. These two sets of conductors, the ascending and the descending, seem to go ultimately into the central grey matter of the cord, or into the anterior columns, after having for a short distance passed through the posterior columns, and, most likely, also, through the lateral columns and the posterior grey horns.

13. The transmission of sensitive impressions to the encephalon takes place chiefly in the central grey matter of the spinal cord, and for a small part in the anterior columns.

14. The decussation of the conductors of sensitive impressions, coming from the various parts of the trunk and limbs, does not take place in the upper part of the pons Varolii, nor beneath the tubercula quadrigemina, nor in the medulla oblongata, as has been imagined: it takes place in the spinal cord for the sensitive impressions conveyed by the posterior roots of the spinal nerves.

15. The decussation of the conductors of sensitive impressions in the spinal cord takes place very near

their place of entrance into this organ, some above and others below this place.

16. The transmission of sensitive impressions through the spinal cord takes place in some definite direction, and not, as several German physiologists have thought, in almost every direction.

17. Every small portion of a transverse section of the conducting zone, in a lateral half of the spinal cord, contains conductors of sensitive impressions, coming from all the points of the body on the opposite side, which are behind the place of this small portion.

18. The sensitive impressions made on any point of a lateral half of the body, are transmitted to the sensorium, by conducting elements distributed in all parts of the lateral half of the spinal cord on the opposite side.

19. Most of the elements which are employed as conductors of the purely tactile impressions, seem to pass by the same parts of the spinal cord, as those which transmit the impressions which produce pain.

20. The posterior columns of the spinal cord, are not directly employed in the conveyance of the orders of the will, to the muscles.

21. The grey matter of the spinal cord seems to have an important share in the conveyance of the orders of the will, to the muscles.

22. The lateral columns of the spinal cord have a notably greater share in the conveyance of the orders of the will to muscles, in the upper parts of the cervical region, than in the dorsal and lumbar regions.

23. The anterior columns of the spinal cord everywhere, except in the upper part of the cervical region, have a great share in the voluntary movements.

24. The decussation of the conductors for voluntary movements in animals, seems to take place chiefly, but not entirely, where the anterior pyramids cross each other.

THE FUNCTIONS OF THE CEREBRO-SPINAL SYSTEM.

Man, in common with the lower classes of animals, possesses the powers of growth, nutrition, and reproduction, and in some of the phenomena attendant thereon is surpassed by some of these; but he surpasses all other beings of Creation in the possession of a Nervous System which, in its Functions, if not in the relative proportions of the whole or parts thereof, presents no approach in the Animal Kingdom.

By many he is surpassed in strength, by a still greater number in swiftness. He cannot attempt to rival the elephant, or the horse, or the lion, in the extent of his physical powers; he cannot traverse the air so as to approach the birds in their passage through the atmosphere; the depths of the sea, occupied by countless myriads of living and powerful beings, are all but closed against him; and yet how immeasurably does he surpass all these in the vigour of his intellect, the power of his reasoning faculties, and the extent and depths of his inventive faculties!

The monarch of the forest, before whom all other animals tremble, and from whom they flee to escape destruction, quails before his presence, and by a kind of instinctive knowledge knows his powers, and avoids, if he does not flee from, his most dangerous enemy. In vain, does the eagle soar aloft, and cleave the air with his powerful pinions; Man, by the aid of his intellectual faculties, seeks him in his highest abode, and brings him down to earth, as his victim. The mighty monsters of the deep plunge into their vast abyss to escape his anger, or his desire to obtain the riches with which Nature has endowed them; but their size and strength avail them not: their swiftness of flight is vain, and the mighty depths of the unfathomable ocean afford them no protection. His weapon follows them thither, and expiring, they render themselves up to him as his legitimate prey.

For this Supremacy in the Created World, Man is indebted to the possession of an Organ which, whilst it controls and regulates the functions of the various parts of the body which minister to his maintenance and support, also endows him with a commanding order of intellect which alone renders him Master and Lord of the World and its Wealth.

The *Functions* most evidently possessed by the Cerebro-Spinal System are those of Motion and Sensation, as just especially alluded to; by means of these, Sensation, or rather the power of Sensation or Feeling, is given to most of the structures of the body, and Motion is conferred upon a particular structure, the Muscular System.

Sensation resides in the extremities of the nerves, and more especially in those of the skin; but is imperfect or absent altogether unless these are connected, directly, or indirectly, with the Sensorium or Centre of Sense.

Whilst conferring this power of Sensation or Feeling, the Brain, the great centre of the Cerebro-Spinal System, is itself wholly insensible, and may be removed in large slices, in the lower classes of animals, until by degrees its larger portion is altogether destroyed, and this without exciting pain, or immediately destroying the life of the animal; it is only when the sensory nerve, or some of its principal branches are irritated, that sensation is developed, and the animal feels pain. Majendie and other physiologists have repeatedly performed this experiment with the result stated, and accidents and diseases in Man prove that the same observations are applicable, so far as the Sensibility of the Cerebral substance is considered.

Motion, or the power of Motion, more correctly speaking, on the contrary, arises from the Cerebro-Spinal System, and is conveyed thence along the nerves to the destined parts, which are thrown into contraction, and motion ensues. The *Motive* act resides in the muscular fibre; but the *Motive principle* exists in the Brain, is developed or formed there, and the action of the muscular fibre is wholly secondary.

These may be said to be Simple Functions of the Cerebro-Spinal System; but a combination of these forms the first or simplest of the Compound function, and constitutes, as already stated, the Reflex Action of the Nervous System.

But, as modifications of *Sensation*, the conferring of certain powers of ascertaining the form, size, taste, &c., of the external world is also possessed by the Cerebro-Spinal System, from the mode in which the nervous filaments, both motor and sensory, are interlaced in an inextricable manner. The Cervical, Brachial, Lumbar, and Sacral plexuses are thus formed; in addition, they anastomose freely with each other, prior to their being distributed.

The use of these plexuses and of the various anastomoses of the nervous filaments is, doubtless, to connect all the nervous filaments in one sympathetic action, so as to produce the compound and complicated motions possessed by the parts which they supply. But these may also subserve an additional purpose, that of being the nuclei of the *reflex motion* of these parts, and of thus acting independently of the Medulla Oblongata and Spinal Cord. This view is strongly supported by the reflex power still continuing in the limbs of frogs and other animals, after the connexion with the larger nervous trunks has been destroyed.

The sub-occipital, and most of the dorsal or intercostal nerves do not enter to any considerable extent into the formation of any of the plexuses, a fact which is explained by the simplicity of action of the muscles which they supply.

The *Functional* uses of the Spinal nerves present a simplicity which is not observable in those of the Cerebral nerves: the former are limited to those of Motion and Sensation, whilst the latter not only include these, but extend to the endowment of the Special Senses, of Smell, Sight, Hearing, Taste, and Touch, with the latter of which, only, the Spinal system is immediately connected.

There can be no doubt as to the Functional office of the First or Olfactory nerve, of the Second or Optic, the Third or Motores Oculorum, the Fourth or Pathetic, the Sixth or Abducentes, of the portio mollis of the Seventh or Acoustic nerve, or of the Ninth or Lingual nerve; but of the remaining nerves, namely, the Fifth or Trigemini, the portio dura of the Seventh, and the Glossopharyngeal and Pneumogastric branches of the Eighth, physiologists are not decided as to the especial uses of them.

Of the *Fifth*, or *Trigemini*, the motor portion of this nerve, which does not enter into the formation of the Casserian Ganglion, is generally admitted, as supplying the principal muscles of mastication with the motion essential to mastication; but of the much larger portion of this nerve, the Ganglionic division, from which the first, second, and the larger portion of the third divisions arise, it may be asked, what are the functional uses or offices of these nerves? Do they convey simple sensation to the parts supplied by them, or do they contribute to any of the Special Senses? That any of these branches contribute motory powers is not supposed.

Of all the nerves of the body, the branches of the fifth have the most varied termination, and perhaps the most extensive anastomosis; its first or ophthalmic division sends branches to the lachrymal gland, the globe of the eye, the conjunctiva, the mucous membrane and external integuments of the nose and nasal sinuses, the skin of the forehead, the upper eyelid, and scalp. The second, or superior maxillary branch, sends branches also to the mucous membrane of the nose and nasal sinuses, the mucous membrane of the Eustachian tube, upper part of the pharynx, soft and hard palates, the interior of the inferior maxilla, its gums and teeth, the skin of the inferior eyelid and cheek, side of the nose, temples, and upper lip, and some of the small muscles beneath the jaw. The third or inferior maxillary branch is distributed to the skin of the temples, part of the external ear, lower part of the face, the skin, muscles, and mucous membrane of the lower lip, the inferior surface of the mouth, the gums and teeth of the lower jaw, and great part of the surface of the tongue.

The first division of the fifth nerve sends filaments of communication to the lenticular ganglion, the second to the Spheno-palatine or Meckel's ganglion, the third to the Submaxillary ganglion. They anastomose freely with the portio dura of the seventh, the glossopharyngeal, and branches from the cervical plexus, distributed to the skin of the face and temple. It is remarkable, however, that the fifth nerve does not anastomose with its fellow of the opposite side, and that the filaments of either do not cross the mesial line, so that, in paralysis of one nerve, sensation is lost only on the same side, the loss of sensibility being well marked and limited to the right or left half of the lips, tongue, &c.

It is the generally received opinion, that the branches of the fifth nerve convey simple or common sensations to the parts supplied by them; and experiments on animals and the results of disease support this theory; but a question arises here as to the office of the Gustatory branch of the third division, a large branch which is distributed to the anterior and lateral parts of the tongue, and sends filaments to the internal pterygoid and other muscles, the tonsils, &c., its ultimate distribution being to the deep tissue of the tongue, the mucous membrane and small conical papillæ near its tip or apex. Is the office of this nerve not also that of being the nerve of the *Special Sense of Taste?* This is but a modification of simple sensation, and may be communicated to the nerve, from its connexion with the ganglionic structures already spoken of. But this is conjecture, and cannot be proved.

But we may also regard the fifth nerve, from its extensive and varied distribution, thus uniting the several parts supplied by it in sympathetic and harmonious action, as the principal sympathetic nerve of the Head and face.

That there is a class of nerves in the Human Body which perform this office, and which may be well distinguished under the head of *Nerves of Associate Functions*, can hardly be questioned. When we see that under the influence of one impression, one set of muscles only is thrown into contraction, whilst, under another impression, another and totally distinct set of muscles is acted upon, we are justified in concluding that this may be considered one of the functional uses of the fifth and other nerves.

The *Glossopharyngeal*, of the eighth pair, is probably, also, a nerve of this class, its principal office being to unite the various parts together, in the performance of the compound and complicated act of deglutition; a use which is most consistent with the varied distribution of its filaments, and reconciles the complicated results of the numerous experiments, performed upon it, by Alcock, Reid, and others.

This nerve forms a portion of the pharyngeal and tonsilitic plexuses, and sends filaments to join the sympathetic, facial, and pneumogastric nerves; by means of its tympanitic filaments, unites with branches from the fifth, facial, and sympathetic nerves, and is finally distributed to the principal muscles of deglutition, the mucous membrane of the mouth, fauces, and palate, the muscular substance of the tongue, and especially to the large papillæ and mucous membrane at the root of this organ.

The Functions of this nerve have been variously stated, as being that of common sensation, motion, compound, and lastly that of the special sense of taste, and numerous experiments have served to prove each and all of these theories. Its principal function is more probably that previously assigned to it, namely, that of Associate Function.

The difficulty attendant on deciding as to the functional uses of the glossopharyngeal nerve will be seen from the following extracts from Valentin's Physiology:—

"When the glossopharyngeal nerve of a dog, or other domestic animal, is examined immediately after its exit from the skull, we frequently get evident signs of pain. From this it has been inferred that sensitive fibres are originally present. The glossopharyngeal nerve does not belong to that class of nerves which is chiefly sensitive.

"On stimulating the smaller root of this part of the eighth nerve, in newly killed calves or cats, Volkmann has observed contractions of some of the pharyngeal muscles (the stylopharyngeus and constrictor faucium medius). Still this motor influence cannot be compared with that of the vagus and accessory nerves. For instance, it often happens that irritation of the pneumogastric and accessory causes vigorous contractions after the glossopharyngeal has ceased to afford any. Hence many observers have been unable to verify the motor influence of this nerve.

"These facts sufficiently prove that the greater part of the glossopharyngeal nerve is composed of neither sensitive nor motor elements. On the other hand experiment shows it to be a sensuous nerve, which is destined to effect the true sensations of taste."

We will regard the tongue as the special representative of the organ of taste. This organ is chiefly supplied by branches from three nerves, the trigeminal, the glossopharyngeal, and the hypoglossal (ninth)."

All observers unite in stating that the manifold movements of the tongue are due to the hypoglossal nerve, while the most important gustative impressions are effected apparently by the glossopharyngeal. But many consider the latter the sole nerve of taste, and regard the trigeminal nerve as only effecting the sensations of touch and pain; while others suppose it to be also capable of recognising true sapid impressions.

The Pneumogastric branch of the eighth pair is also of extensive and varied distribution, and of frequent anastomosis with other nerves.

Immediately after its exit from the cranium, this nerve forms a ganglion, which at once denotes it to be a *sensory* nerve, and proceeds onwards to its destination, sending filaments to the pharynx, to assist in forming the pharyngeal plexus, the superior and inferior laryngeal or recurrent nerve to the larynx, to supply its mucous membrane and muscles, *cardiac* filaments to the cardiac plexus, and then enters the thorax; it here forms the principal portion of the pulmonic plexuses, as also the œsophageal plexus, and finally terminates in the stomach and solar plexus, or semilunar ganglion.

The Pneumogastric nerve anastomoses, in this course, with the portio dura of the seventh, the glossopharyngeal, spinal accessory, lingual, and sympathetic nerves, with branches from the cervical and brachial plexus: it supplies muscles and mucous membrane, and is connected with the three great Functions of Organic Life—namely, Respiration, Circulation, and Digestion, connects them together and with the Sensorium, and indirectly with every other part of the human body.

What are the Functional uses of this nerve? In reply to this inquiry, the results of a few experiments may well be first shown. It must be borne in mind that as the pneumogastric nerve anastomoses with the spinal accessory, it is stated to receive motor filaments from this, and thus to resemble a compound or spinal nerve, composed of both Sensory and Motor filaments.

Recent experiments show that, when the filamentous roots of the vagus (pneumogastric) of a newly killed animal are cut through at their origin from the Medulla Oblongata, their irritation can cause various muscles to contract. And some observers assert that the upper rootlets of the spinal accessory give rise to pain. Now as some experiments on the living animal establish beyond all doubt that the vagus is sensitive and the spinal accessory motor, it would seem that both of these nerves possess mixed qualities.

On irritating the roots of the vagus in a rabbit, the animal shrieks with pain. When the same nerve is pinched in a newly killed dog, vigorous contractions of the soft palate, the œsophagus, and the stomach often follow. It may be further proved that the roots of the pneumogastric nerve exert an important influence on the functions of the heart. The small muscles of the larynx are undoubtedly governed by those trunks which proceed from the union of the vagus and accessory nerves.

Many assert that stimulating the roots of the pneumogastric, in recently killed animals, causes these parts to contract, while others make the same statement of the spinal accessory. This contradiction may be due to two causes. Some of the bundles which lie midway between the vagus and accessory may be assigned to either nerve, according to the judgment of the observer. In addition to this, we shall see that there are many facts which indicate that a sort of transfer here occurs, so that a stimulus, applied to an anterior rootlet of the pneumogastric, may excite the action of the other fibres, and even of those which belong to the accessory nerve.

When the two inferior laryngeal nerves, or the cervical trunks of the vagus, are cut through in a new-born animal, it soon dies of suffocation. But if a fistulous opening be, at the same time, made into its trachea, life may be maintained for a while. This is caused by the circumstance, that in paralysis of the laryngeal muscles the vocal cords shut up like a valve, and thus close the glottis.

Many observers conclude with Schiff, that the paralysis of the vagi seriously disturbs the nutrition of the lungs.

From the preceding observations, we may reasonably conclude, that one of the functions of the Pneumogastric nerve, is that of being a Nerve of Associate Function, corresponding in this to the fifth, or trigemini, and the glossopharyngeal nerve: it connects, as already stated, the great Functions of Organic Life, not only together, but also with the Sensorium; and regarding it in this light, we may explain, on the principles of reflex action, the varied and apparently contradictory results, which appear from experiments performed upon it, and its principal branches, on irritating which, the sensory filaments become afferent, and convey to its anastomosing filaments the injurious impression which excites the motory filaments which it contains, as also those of the other motor nerves which supply the various parts.

This review of the Functions of the Cerebral Nerves, places before the Physiological inquirer the uses of those nerves which are not questioned, and the more important facts regarding those which are still to be investigated and decided. Let us hope, as we progress in throwing a new light on the important class of Functions presided over by this System, that such will open the way to more accurate investigation and more satisfactory results. We have gained much by the discoveries and researches of Sir Charles Bell and Marshall Hall; it is our duty to avail ourselves of them, and prosecute our researches until the truth becomes manifest.

The Special Senses of Smell, Sight, Hearing, Taste, and Touch, are enjoyed by Man and most other animals: the first four are conferred directly by the

Cerebral, the last chiefly, if not exclusively, by the Spinal System.

But the Functions of the Cerebro-Spinal System, which give to Man his supremacy in the rank of created beings, are those of the Intellect, comprising Perception, Judgment, and Reason, generalized under the head of Intelligence.

The first act of Intelligence is that of Perception, whether the object be of a moral or physical character; and this may be considered as but a modification of sensation, as we cannot conceive Perception to take place, without a mental or physical impression being made upon some portion of the brain. Judgment follows Perception, and this is perfected by the Reasoning faculties.

In the exercise of his Intelligence, Man exerts his *Will* on most occasions, although, in many, the Perception and Judgment are exercised involuntarily; but to enter at large into this subject would be out of place here.

That the Brain is the organ of the Mind cannot be questioned: on its organization and normal condition depend the Mental faculties; if compressed or seriously injured, the mental powers are destroyed; nay, if an undue quantity of blood is sent into its interior, the Mind wanders, and the Intellect is lost.

That the Soul of Man is identical with the Mind, and depends on physical organization, is a position that cannot be maintained: it must be regarded as a Divine Essence appended to Man by an all-wise Creator, the nature of which defies, and will ever set at nought, all our attempts to discover its nature and unfold its mysteries. We believe in its existence, and that such a belief is implanted within us is one of the most convincing proofs that it does exist; a just Creator would not implant such a belief and hope in Man, only to deceive him.

Physiologists and Psychologists generally have erred in endeavouring to establish an intimate connexion between them: they are best considered apart and distinct from each other. The ancient Greeks and Latins acknowledged, and drew this distinction in their various terms of ψυχὴ, φρήν, and νοῦς, *Anima*, *mens*, and *animus;* and we shall do well to follow their example.

But to which portion of the Brain are we to assign each one of its various functions? how isolate each faculty of the mind, and refer it to this or to that organ? By what means are we to distinguish the influences of the grey, as apart from that of the white substance? What shall enable us to understand how a certain configuration, such as the optic thalamus, or the tubercula quadrigemina, is essential to certain results?

We seek in vain to explain these mysteries, and are compelled to confess the finity, the inferiority of the Intellect of Man, and to recognise, in so doing, the existence of a Higher Power, as far above Man as he is above the smallest atom in Creation; before whose Wisdom his sinks into insignificance and comparative nothingness.

Nor can we attempt to define, either, the agent, by which the Will or the Intellect transmits its various messages, along the several cords, by means of which the Eye sees, the Ear hears, the Heart beats, and the Muscles contract. There is but one agent in Nature which approaches it in character, namely Electricity; but how can the same agent produce such varied results, and enable the Mental faculties to weigh and reason upon the impressions made upon them? We shall conclude, with the immortal Shakespere, that "there is more in this world than we dream of in our Philosophy."

THE CEREBRAL NERVES.

Nine sets of nerves proceed from that portion of the Nervous System, which is lodged in the cavity of the Cranium, and are hence called Cerebral; although, as will be seen, but the smaller portion only, arises from the Cerebrum or Cerebellum.

They are termed pairs, from the circumstance that one nerve exists on each side, perfectly symmetrical and corresponding to each other. But the term pair is not a happy application, as some of the nerves consist of three branches, as for example the eighth, which consists of the Glossopharyngeal, Pneumogastric, and Spinal Accessory, and this, in reality, is composed of three pairs of nerves, and not of one only. They are classed together as a single nerve, as they pass out of the cranium by the same foramen, and are more or less intimately connected together; but in most other respects they are distinct nerves, and should be considered as such.

In like manner, the seventh pair is a double nerve, on each side, being composed of the portio mollis, and the portio dura; so that this consists of two pairs of nerves.

Without counting the divisions of the Fifth nerve, there are thus twelve pairs of Cerebral nerves, instead of nine, as usually described.

Of all the nerves which are termed Cerebral, there is but one, the Olfactory, which arises distinctly from the Cerebrum; the rest arise from the prolongations of the Medulla Oblongata.

All sensory nerves either arise from ganglionic structures, or have one or more of these attached to them in some part of their course: this is not the case with the motor nerves.

The *First* or *Olfactory* nerves arise by three distinct roots from the Cerebrum: their ganglion is situated on the cribriform plate of the ethmoid bone, immediately before the exit of the nerve. Its ganglionic structure is much better developed in some of the lower classes of Mammalia, which possess a more powerful olfactory sense, than in Man.

The *Second* or *Optic* nerves derive their ganglionic structure from the Tubercula Quadrigemina, as also from the Tuber Cinereum.

The *Third* and *Fourth* cerebral nerves are motor, and do not possess ganglia.

The *Fifth* or *Trigemini* is a compound nerve, resembling the Spinal nerve: the Casseian ganglion is the ganglionic structure of its sensory filaments; the motor portion of the nerve has no connection with this ganglion.

The *Sixth* is a motor nerve, and does not possess a ganglion.

The *Seventh* nerve consists of two distinct nerves: the *Sensory portion*, or *portio mollis*, is the true acoustic nerve, and derives its ganglionic structure from a small nucleus of grey matter, which lies on each side of the fourth ventricle. The *motor portion*, or *portio dura*, is a nerve of respiratory motion, and does not possess a ganglion.

The *Glossopharyngeal* branch of the eighth pair of cerebral nerves derives ganglionic structure from the *corpus dentatum* of the Olivary body: the function of this nerve is, as already stated, much disputed, and may be considered as still *sub judice*. This nerve occasionally arises in Man by two roots, so as to form a compound nerve resembling the Spinal nerves.

The *Pneumogastric* nerve, like the preceding, derives its ganglionic structure from the Corpus dentatum of the Olivary body. The spinal accessory is a motor nerve, and does not possess a ganglion.

The *Ninth* or *Lingual* nerve supplies the muscles of the tongue with motion, and does not present a ganglionic structure, although, as remarked before, a few of its fibres of origin may be traced to the Corpus dentatum of the Olivary body.

OF THE DISTRIBUTION OF THE CEREBRAL NERVES.

The mode in which the Cerebral nerves are distributed varies much.

The *Olfactory* filaments form extremely minute branches, which pass between the fibrous and mucous layers of the pituitary membrane to the villi, on the surfaces of which they are distributed, forming at their termination slight ganglionic expansions.

The *Optic* nerve at its termination spreads out into an exceedingly thin layer of nervous matter, which forms the nervous layer of the Retina.

The *Portio Mollis*, or *Acoustic* nerve, presents a similar disposition at its termination, being spread out upon the internal surface of the cochlea semicircular canals and vestibule.

The remaining Cerebral nerves do not present any particular disposition, in their termination. The *Fifth* anastomoses freely with most of the Cerebral nerves. The *First*, or *Olfactory*, does not anastomose with any other nerve.

OF THE FUNCTIONS OF THE CEREBELLUM.

The Cerebellum, although forming a part of the Brain properly so called, is generally supposed and admitted to preside over certain functions, namely—those of the Animal Life of the individual, and especially over those Sensory manifestations, which are connected with the reproduction of the species.

As this part of the Brain is highly developed in those animals, including Man, which are characterized by a complicity of their motor powers, it is supposed by some to exert a special influence on this Function; but its comparatively slight connexion with the antero-lateral pillars of the Spinal Cord, from which the Spinal Motor nerves arise, would lead us to conclude that the influence of the Cerebellum on the Motor principle, is rather that of connecting its various actions, than of originating or developing the Motor power. This is supported by the fact, that the Cerebellum is most developed in Man, whose complicity of Motor action exceeds that of all other animals, although he is surpassed, by many, in the extent of Motor power enjoyed.

Experiments on all classes of Vertebrated Animals lead to the same conclusion, as on the removal of the Cerebellum the power of combining muscular action is lost in them, and they can no longer perform the combined action necessary in walking, standing, flying, &c., although they still retain the motor power itself, as is evidenced in the motion of the wings, limbs, &c., the reflex action of these, and the power of voluntary action.

The results of accident and disease in Man support this view of the Functions of the Cerebellum, as the Motor function is not destroyed in these, but the power of combining muscular action. These also show, that the Cerebellum has but little influence on the Mental faculties, or the Will, as they remain unimpaired, although this should be extensively inflamed.

Phrenologists have advanced the theory that the Cerebellum presides over the Sexual passion; and there are many and strong arguments in favour of this being one of its functions. It is generally large in individuals whose sexual appetite is strong, and disease of the Cerebellum, too frequently, induces excitement of this, or its destruction, to admit of our denying the intimate connexion which exists between them. Cases of persons who have died in, or from, the indulgence of the sexual appetite, frequently disclose an effusion of blood in the immediate neighbourhood of the Cerebellum.

The Cerebellum may be supposed to preside especially over the Nerves of the Associate Functions, as those which appear to belong to this class — namely, the fifth, pneumogastric, and glossopharyngeal, are intimately connected with the Corpora Restiformia and their prolongations upwards to the Cerebellum.

OF THE RESPIRATORY NERVES.

To Sir Charles Bell we are indebted not only for the discovery of the distinct functions of the roots of the spinal nerves, but also for the arrangement and classification of the Respiratory System of Nerves, or of those nerves which are particularly engaged in the act of Respiration. It is much to be regretted and condemned, that modern Physiologists so frequently pass over the name of this distinguished man, and whilst they avail themselves of his discoveries, scarcely acknowledge the source whence they have been derived.

It is true, that some of the positions advanced by Sir Charles Bell have not been supported by more recent research; but he has done much towards the elucidation of the subject, and has left sufficient to others, to complete his discoveries, if possible.

Sir Charles Bell erred in endeavouring to extend his theory regarding respiration, beyond its legitimate limit, and in including nerves, in his respiratory system, which are but indirectly and remotely connected with respiration. A useful addition to the description of the respiratory nerves is derived from classing them into the *Nerves of Respiratory Motion* and *Nerves of Respiratory Function.*

Let us first consider the *Nerves of Respiratory Motion.* Sir Charles Bell assigned the origin of the Respiratory Nerves of Motion to a distinct tract which he supposed to exist on the lateral surface of the Spinal column, and which he distinguished as the *Respiratory Tract:* this theory is set aside by more recent investigation.

The Principal Respiratory Nerves of Motion, and respecting whose action there can be little or no doubt, are the *Spinal Accessory* of the *eighth nerve,* or *superior external* Respiratory nerve; the Phrenic, or *inferior internal* respiratory nerve; and the posterior thoracic branch of the brachial plexus, or the *inferior external* respiratory nerve.

These nerves, all, arise from nearly the same point of the Spinal Cord, and, therefore, must be supposed to act more in harmony together, as will be found necessary, on studying the action of the muscles, which they supply. These are the three principal muscles of inspiration, the Trapezius, Serratus Magnus Anticus, and the Diaphragm; the first of these being supplied by the spinal accessory, the second by the posterior thoracic nerve, and the last by the phrenic. These muscles will be found to act together, in respiration, in the following manner: the trapezius first fixes the shoulders and scapula; the serratus magnus anticus having thus a fixed point of origin, raises or rather fixes the lower part of the thorax; and the Diaphragm, having gained a fixed origin from these, contracts and descends towards the abdomen, as in Inspiration; the action of these muscles is thus rather consecutive than simultaneous.

The *portio dura* of the seventh nerve was described, by Sir Charles Bell, as the *Respiratory nerve of the face,* and controlling the action of the facial muscles, indirectly connected with the acts of sucking and whistling; but this theory is questionable, although it cannot be doubted that the nerve assists in these motions; it is now considered to be the exclusive motor nerve of the muscles of the face, eyelids, &c.

In addition to these respiratory nerves, we find the intercostal, thoracic, and lumbar nerves contribute most materially to the Respiratory movements.

The Respiratory action is evidently a Reflex motion. The Sensitive impression arises in the lungs from the necessity of oxidizing the blood, and of assisting in unloading the lungs: this is communicated to the Sensory portion of the Spinal Cord, and motion is transmitted along the respiratory nerves to the muscles.

The first act of Inspiration in the newly-born infant is also a Reflex action. Here the impression is made by the atmospheric air coming in contact with the skin, and proceeds also from the instinctive desire in the infant to inflate the lungs, and enter upon its new form of existence. Hence the advantage derived to the newly-born infant, in forcing as it were the first act of Inspiration, by blowing upon the surface, into the mouth, &c., and from slapping it on the nates and abdomen.

The Nerves of *Respiratory function* are the pneumogastric of the eighth. These supply the larynx, trachea, and lungs, and thus preside especially over the Functional act of Respiration. As this nerve communicates freely with the fifth cerebral nerve, with the portio dura, and with the principal nerves of inspiration, we have a direct chain of nervous communication, by means of which the Sensory impressions made upon the skin and lungs are transmitted to the respiratory muscles.

The act of Respiration, although ordinarily an ivoluntary one, is still, to a certain extent, under the control of the Will. Its involuntary action is well exemplified in the act of sneezing, in which a convulsive and sudden expiratory motion is induced to dislodge an irritating substance from the nasal passages. This motion is induced through the agency of the fifth nerve, and has no connexion with the functions of the olfactory, as it is equally, and perhaps more powerfully, induced by inodorous than by odorous substances—as by particles of sand, glass, a feather, and not unfrequently by the contact of the atmospheric air, and of light. In weeping, laughing, &c., the respiratory muscles act involuntarily: they act voluntarily in speaking, singing, &c.

Injuries and diseases of the Spinal Cord affecting the origins of the Great Respiratory Nerves—namely, the spinal accessory, phrenic, and posterior thoracic—are followed by immediate suspension of the Respiratory action, and soon lead to dissolution, as this is followed rapidly by the cessation of the Heart's Action. When the Spinal Cord is compressed below the origins of these nerves, Respiration is continued for some time, although the respiratory nerves, which arise below the seat of injury, are paralysed.

The Phenomena attendant upon a state of *Asphyxia*, which is, correctly, a total, or nearly total suspension of the vital functions from impeded respiration may now be understood. It is produced by hanging, strangulation, drowning, the presence of foreign bodies in the fauces, pharynx, larynx, &c., by the inhalation of carbonic and other injurious gases. In these, the act of respiration is arrested; dark blood circulates through the lungs and body, and the person becomes insensible; the skin assumes a livid appearance, the tongue generally protrudes, and the eyeballs are staring.

In the state of Asphyxia, the renewal of the Respiratory action should be the first means resorted to; this is best accomplished by making an opening in the layrnx and trachea, which should be kept pervious by means of a tube, and artificial respiration performed by the alternate compression of the parietes of the thorax and removal of this, when their elasticity will accomplish the act of inspiration. The use of bellows, and other forcible means of expanding the lungs, is objectionable, as likely to produce emphysema of these organs.

The opening in the larynx or trachea should be, at least, equal to the natural size of the rima glottidis. Nothing can be more absurd than the use of a quill or small canula, as, in the natural state, these are scarcely of sufficient size to sustain life. What, therefore, can be expected from them in a state of Asphyxia?

THE SYMPATHETIC OR GANGLIONIC SYSTEM.

The *Sympathetic System* forms a distinct division of the Nervous System, and, although connected with the Sensorium and the nerves derived therefrom, acts independently of this under ordinary circumstances. It presides especially over the Functions of Organic Life, on the exercise of which mainly depends the maintenance of Life—namely, Respiration, Circulation, and Digestion.

The term *Ganglionic*, as applied to the System, should be discarded, as although characterized by the presence of numerous ganglia, these are not confined to it, but are found in the head, the spinal nerves, &c.

The origin of this System has been assigned to some nervous filaments, which connect it with the sixth nerve; but this theory is absurd: it has no origin, but exists as an independent system.

Unlike the Cerebro-Spinal System, it has no centre corresponding to the Brain, unless we regard the Semilunar Ganglion as such; and the serious results of even slight accidents to this would lead to the inference that this acts as a centre to the Sympathetic System. The justly celebrated Bichât maintained that each separate Ganglion formed an independent nervous centre, and a distinct source of nervous power. This theory is not now recognised.

The Sympathetic System is characterized by the presence of numerous Ganglia, throughout its course. These are situated on each side of the Trunk, in front of the Spinal column in the Cervical, Dorsal, and Lumbar regions, and in the Pelvis, in front of the Sacrum, at the lower extremity of which the last Ganglion is lodged, forming the *Ganglion Impar*.

The number of these Ganglia varies in the different regions, being in the Cervical three, although sometimes but two; in the Dorsal twelve, in the Lumbar five, and in the Sacral three or four: these are all connected by a nervous trunk, which descends from one to the other, although, occasionally, an interruption of this takes place.

The first Cervical Ganglion sends numerous filaments upwards along the various arteries, and especially the Internal Carotid, which communicate with all the Cerebral nerves, and the various ganglia in the head, and others more numerous, which communicate with the nervous filaments and plexuses of the neck.

The remaining Ganglia of the Sympathetic distribute, in like manner, numerous filaments which join the several plexuses; no plexus existing without sympathetic filaments.

In the Thorax, they contribute largely to the Cardiac, Pulmonic, and Œsophageal plexuses. In the Abdomen, they form, almost exclusively, the plexuses which supply the small and large intestines, and glandular viscera; and, in the Pelvis, they contribute numerous filaments to the Hypogastric Plexus, to supply the Genito-Urinary organs, in both the male and female subject, and send numerous filaments along the arteries into the extremities. They also communicate with each spinal nerve as it escapes from the spinal canal, so that every nerve in the Human body is connected with the Sympathetic System.

This System is found to contain nervous fibres of both classes: the white, or tubular, which are most probably derived from the Cerebro-Spinal System; and the grey, which may be regarded as the true sympathetic fibre. From this arrangement, the filaments are more or less of a compound nature.

It is remarkable that the nerves, proceeding from the semilunar ganglion to the digestive organs possess but little of the white fibre, being almost exclusively composed of grey matter.

The enlargements of the nerves, to which the term ganglia has been applied, are due to the addition of a new element, the ganglion corpuscle to the nerve fibres, in which numerous corpuscles are seen deposited around the bundles of primitive nerve-fibres, which penetrate the ganglion, and may be obtained in a more or less isolated state. Fine sections, which exhibit these structures in their natural position, lead to the conviction that they possess a proper sheath, which has probably a physiological import. At the margin of the ganglion, there are frequently found a few corpuscles, arranged in a circle enclosing the others.

The whole is surrounded by a concentric and apparently *fibrous* membrane, on which are remarked numerous oval nuclei. These nuclear structures, sometimes also, cover the free surface of the ganglion corpuscle, so as to prevent all recognition of its substance, nucleus, or nucleolus. The admixture of such vaginal processes gives to the nervous fibre a whitish grey colour, which is soon converted into a reddish grey by putrefaction, thus explaining the peculiar reddish colour of the sympathetic fibres. They have been sometimes mistaken for nerves, but they evidently belong to the class of areolar tissues or investing membranes.

It becomes a question, what is the relation of the medullary contents of the nerves to the very different substance of the ganglion corpuscles? Is it a true proximity or otherwise? Whether the ganglion corpuscle floats in a modified nervous content, or whether the latter only occupies its neighbourhood? In any case, it would appear that the membrane which encloses the nervous medulla dilates to receive the ganglion corpuscle. It is also possible, that the same nerve-fibre is interrupted by a second corpuscle, at a further point of its course.

When a nerve enters a ganglion, its component fibres separate and pass through the ganglion in different directions, so as to be variously distributed among the branches which pass out of it, coming into contact with the ganglion corpuscles as just described. Some fibres may terminate in the cells of the ganglion, and new ones may originate in them, so that the number of fibres entering a ganglion does not correspond with those which emerge from it.

The structure of the sympathetic nervous filaments is composed of grey matter, which is enclosed in an investing membrane of areolar tissue, as just noticed; they present a reddish grey colour, which may be owing to their investing membrane being acted upon after death.

The only material difference between the sympathetic and spinal ganglia is, that the latter in general appear to be less red and vascular, and to contain less of the vascular or grey neurine. The interlacement of fibres is more obvious in them.

THE FUNCTIONS OF THE SYMPATHETIC SYSTEM.

That the Sympathetic is a distinct portion of the Nervous System, is strongly supported by the fact that the parts, which it supplies, are not excited to a sensitive feeling by any tactile impressions, which would be the case if its connexion with the brain were of an intimate character.

Under morbid impressions, however, the state of sensibility becomes excessively painful, as is evidenced in cases of peritonitis, from which we infer that the organic sensibility extends to the nerves of the Cerebro-Spinal System, which become excited, and develope a painful feeling which would not otherwise exist.

On irritating the denuded sympathetic trunk, or its intestinal branches, in a living mammal, it sometimes happens that no sensation of pain at first occurs, but on prolonging the experiment, they appear quite unmistakably. The ganglia respond to irritation more slowly, and branches which come from a series of ganglia, still more faintly. These facts support the opinion, that the ganglion corpuscles oppose the undisturbed conduction of a stimulus, which is not the case in the ganglia connected with the roots of the spinal nerves.

In the performance of experiments, and in drawing conclusions from them, physiologists err much in not distinguishing the effects produced by irritating a nerve, so as to ascertain how much is caused by the direct action of the nerve, or indirectly by means of its sympathy with other nerves, or from reflex action.

The Sympathetic filaments endow the parts which they supply with motion, and to their agency, are to be attributed the involuntary motions, by means of which the heart, stomach, intestines, &c., perform their several functions, and which proceed day and night, during sleep or waking, if not uninterruptedly, at least, with the regularity which is essential to the maintenance of life.

These actions, however, are not uninfluenced by the Sensorium. The action of the Heart is increased, lessened, or suspended altogether, by various moral impressions made upon the brain. The Heart throbs on beholding a dear and long absent friend; it flutters and faints when we lose, or are likely to lose, one whom we love and esteem ; it ceases to beat—alas, how often ! —when the object of our attachment has passed away for ever !

The Stomach and Intestinal Canal are affected nearly to an equal extent by various Mental impressions. The stomach will reject, or refuse to digest, its food on the receipt of painful intelligence, nay, even on hearing a disagreeable sound : the intestines will act under similar circumstances. All show that they are intimately and closely connected by sympathetic influence, exerted through the agency of the great sympathetic nerve, the pneumogastric or lesser sympathetic, and indeed through the general connexion which exists between all the nerves of the body ; and, although the sympathetic chain may not always be stretched so as to affect every link of its structure, and we may thus appear to possess a more or less independent action in some parts of our Body ; if the Cord be once touched, the whole frame responds, and we acknowledge that each part is but a part of one vast whole, united and separated, combined and dissevered, by the Laws of an all-wise Creator, to preserve the Creature of his hands until Death shall call him away,—"That we are fearfully and wonderfully made."

THE STRUCTURE OF THE NERVES.

The proper structure of each nerve is composed either of *white, medullary, fibrous*, or *tubular* substance, of *grey* or *vesicular* substance. or of both of these combined. The first is observed chiefly in the motor nerves, the second in the sympathetic especially and the sensory nerves, and the combination of these two, in the various compound nerves of the body.

Like the Muscles, the Nerves may be divided into numerous fibres, and these into fibrillæ, until we arrive at the last, or most minute fibrilla, of which the nerve is composed, thus corresponding to the ultimate fibre of the Muscular System. The nervous substance is enclosed in a thin, delicate, transparent membrane composed of areolar tissue, which forms its sheath, but does not interrupt the continuity of the nervous substance from the origin to the termination of the nerve. Within this membranous tube is a hollow cylinder, of a material known as the *White substance* of *Schwann*, which differs in composition and refracting power from the true nervous substance, which forms the central axis-cylinder. The tubular sheath varies in density, being stronger in the trunks of the nerves, than in the Brain or Spinal Cord, and causes the nervous substance to exude from the cut extremities of a nerve. The diameter of the tubuli varies from the 1·500th to the 1·14000th part of an inch. The red vessels do not penetrate the investing membrane.

The *Grey* or *gelatinous nervous fibres* do not present a tubular envelope, and want the white substance of Schwann: they are composed of cell nuclei, resembling the unstriped muscular fibre, and are smaller than the tubular fibre.

Although the Nervous fibres are continuous throughout the nerve, they frequently interlace with others, but still retain their distinct structure, so that, in the most compound nerve the motor and sensory fibres remain distinct to their terminations.

The ultimate distribution of the nerve-fibres is not recognised with equal facility. Thus in the skin and tongue, they are usually distributed in the form of loops; but although these are seen in the conical papillæ of the tongue, they cannot be recognised in the fungiform papillæ, the nervous structure not being capable of being traced near their free extremities.

The Nervous trunk is enclosed in a general sheath of areolar tissue, forming its *Neurilemma*, and is analogous to the Myolemma of the Muscular structure: this is dense and resisting, and presents a minute network of red vessels, which break down on it, to terminate on the investing membrane of the nerve-fibre, without entering its substance, so that this appears to derive its nutrition, by a process of imbibition.

The Nerves are highly organized: they are less disposed to Organic Morbid alterations of structure than most of the other tissues of the body; they are, however, prone to Functional derangement, which in many cases is dependent on an altered state of the Brain or Spinal Cord. When cut across, the divided extremities, if the interval between them be considerable, become united by areolar tissue, but not by nervous fibre: this seems to possess the power of transmitting impressions along the course of the nerve. But if the cut extremities are in apposition or nearly so, an exudation takes place from the nervous substance, which finally forms nervous matter and unites the divided extremities.

It is remarkable, however, that Nervous tissue is rarely regenerated; although constantly being removed, and its place supplied by fresh Nervous matter, as is incidental to all the tissues of the body, if once destroyed or disorganized, it is seldom reformed. In Cerebral Apoplexy, where the Cerebral substance is extensively injured, the power of reparation does not extend beyond the consolidation of the tissue implicated; and in paralysis of the nerves, or their terminations, as in paralysis of the Retina, constituting *Amaurosis*, the restoration of the nerve never takes place.

The Chemical Composition of Nervous matter consists of Water, which forms a considerable portion, an Albuminous, and a Fatty substance, which forms most of its solid structure.

The Fatty matter contains, in addition to the ordinary fatty matters, Cholesterine and Cerebric and

Oleo-phosphoric acids. The Cerebric acid contains Phosphorus, Nitrogen (not found in ordinary fat), and a large proportion of Oxygen. The quantity of Phosphorus in the Brain is considerable, being from one-twentieth to one-thirtieth of the whole solid matter.

The Central Nervous fibre, according to Kölliker, is found to swell considerably in concentrated acetic acid; it dissolves however with difficulty, and even after several minutes' boiling, although pale, is still unaltered. When boiled longer with acetic acid, it dissolves just as coagulated albumen; on the other hand, the sheaths and some of the contents remain undissolved. Alkalies (potass, soda, ammonia,) when cold attack the axis-cylinder but slowly; still it becomes pale instantaneously in caustic soda, and swells up to 0·004‴ to 0·005‴, or over 0 006‴ in diameter.

From these and other tests, Kölliker considers that it may be concluded, perhaps with certainty, that the axis-cylinder is a coagulated protein compound, which however, differs from fibrine, inasmuch as it does not dissolve in carbonate of potass and nitric acid, and offers more resistance to acetic acid and alkalies.

When we consider that the Brain, alone, is supplied with blood by four large arteries, namely, the Internal Carotid and Vertebrals, and that the maintenance and renewal of its substance cannot require so large a supply of blood, we are led to the conclusion, that much of this is expended in providing the Cerebral substance with the Principle, whatever this may be, which ministers to its several Functions.

That the Brain requires a certain amount of Arterial or Oxidized blood, with the other organs of the body to sustain its *excitability* and *power of action*, will be admitted; but is not this the representative of the Principle which sustains it?

The Brain does not secrete a particular fluid that we can recognise apart from its own tissue, as we find the liver, kidneys, &c., to do. To what, then, are we to assign this excessive expenditure of arterial blood? Certainly to some active principle generated by it, and diffused throughout the Nervous System.

The Phenomena attendant upon the alternate states of sleep and activity support the theory that such a principle is required, and is in more or less constant operation. During a state of activity, when the mental or bodily powers are exerted, this principle stimulates these to act and produce their several results; but being diminished in quantity or power, or expended altogether, they are unable to continue their action, and *fatigue* is induced.

Sleep now follows, and constitutes the dormant state of our Mental and Physical powers: during its continuance the principle of action is developed or secreted in the Brain, and we awake refreshed; that is, supplied with a new store of Active Principle. Mere rest is not sufficient for this purpose, as the recumbent posture without sleep refreshes but little ; and Man, too often arises from his sleepless couch, more exhausted than when first he stretched his wearied limbs upon it.

There is a certain degree of mental activity during sleep, constituting *dreams*. When these are continuous, and of a depressing character, they appear to exhaust the Nervous Principle, and we awake unrefreshed ; but when, on the contrary, dreams are light and pleasing, we awake from our slumbers re-invigorated, no exhaustion of the Nervous Principle appearing to take place; or, if such occur, the loss is more than counterbalanced by the healthy action of the system during our state of repose.

To what peculiar class of agents shall we refer this Principle of Nervous action? To none, of the nature of which, we have any knowledge. Electricity presents many points of resemblance to it, and is found to act most powerfully as a stimulant to all Nervous Structures. But there is a Vital principle in action, beyond, and above this, which enables the Mind to think, the Eye to see, and the Ear to hear. Will the electric battery supply us with the means of producing these wonderful results? It will not; and we must assign the vivifying principles to an agency beyond our comprehension, and which defies all our research. We must rest content with a certain limit to our knowledge, uncertain as the limit may be, and feel assured that whatever may be the Nervous Principle, it is the result of wise and inscrutable laws.

MEMBRANES OF THE BRAIN AND SPINAL CORD.

THE Brain is covered by three membranes, viz., the *Dura Mater*, *Arachnoid*, and *Pia Mater*.

The *Dura Mater* forms the external of these membranes and is more immediately connected with the bones of the cranium, of which it forms the internal periosteum, than with the brain. Its outer surface lines the internal surface of the cranial bones, to which it adheres, by prolongations of the areolar tissue and by the numerous arteries which pass from it, to enter the diploë of the bones, supply their texture, and anastomose with the arteries derived from the external periosteum. The meningeal arteries are not accompanied by veins, as in other parts of the body; the venous blood from them is collected in the diploë, and is returned by veins which empty themselves either into the external veins, or pour their blood into the sinuses of the dura mater. The *internal surface* of the dura mater is lined by the arachnoid membrane (except in the sella turcica), which is closely adherent, and gives it a smooth glistening appearance.

The Dura Mater is composed of two layers: the outer or periosteal layer is of a whitish yellow, rough, and more vascular than the inner layer, which is white and presents a glistening appearance. These two layers may be separated at the early periods of life, but in the adult state are so identified, especially in the situation of the sinuses, that no separation can be effected.

The Dura Mater is reflected inwards in different situations, so as to form folds, or processes, to support the hemispheres of the cerebrum, and separate them posteriorly from the cerebellum—viz. the *falx cerebri*, *the tentorium cerebelli*, and the *falx cerebelli*. By means of these, the different divisions of the brain are parted off from the other, and, in cases of violence, the effects are less easily spread from one to the other. In the folds are contained the sinuses, or larger veins of the dura mater, by means of which the venous blood of the brain is collected, and returned to the general circulation.

The folds of the Dura Mater may be considered as formed by a duplication or folding inwards of the inner layer, the sinuses being formed at the points where this takes place. The sinuses or great veins of the Dura Mater differ from veins generally, in the great strength of their coats, and their not being subject to pressure from the surrounding parts. In their interior are found crossing their cavities, more or less obliquely, fibrous bands, the chordæ Willisianæ, at one time supposed to be the tendons of the dura mater, then considered to be of a muscular structure, and to produce the motions of the brain, which are now known to be caused by the pulsation of the arteries at its base, and by the act of Respiration.

The *Dura Mater* sends prolongations or processes along the cerebral nerves, as they pass out of the cranium, which are continuous with the external periosteum and other fibrous textures; hence its name, as being the supposed matrix of the fibrous or *hard* tissues. The uses of the Dura Mater are numerous: viz. 1. It forms a covering for the brain; 2. It acts as an internal periosteum to the cranial bones; 3. It forms folds or processes to support different portions of the brain; 4. It contains the sinuses of the brain; 5. It forms coverings or sheaths for the cerebral nerves.

The *Dura Mater*, *per se*, is a *fibrous membrane;* but taken in conjunction with the layer of the arachnoid, which lines its inner surface, is a *compound* or *fibro-serous* membrane: its fibres are very distinct, especially in the falx cerebri, and decussate with each other so as to interlace in almost every direction. In some cases the membrane becomes perforated, and then presents a network appearance, which, however, does not interfere with its office. Like all fibrous structures, it is liable to calcareous or bony deposits, and rapidly sloughs when the subject of inflammation.

The *Arachnoid Membrane*, so called from its extreme delicacy (ἀράχνης-εἶδος), lines the inner surface of the dura mater and the outer surface of the brain, and according to most physiologists the interior or ventricles of the organ. Unlike the pia mater, it does not pass in between, but across the convolutions of the brain. The outer surface of the arachnoid membrane is so closely adherent to the dura mater, by connective or condensed areolar tissue, that effusion either of serum or blood can scarcely take place between them; it is, however, but loosely connected with the pia mater. On this subject, Kölliker states that, in many places, it is adherent or even blended with the pia mater, especially upon all the convolutions and the projecting parts at the basis of the brain; and where this intimate adhesion does not exist, the two membranes are connected by numerous processes. Accordingly, in the case of the brain, there is no continuous sub-arachnoid space, but numerous larger and smaller spaces, only partially communicating with each other. The larger of them, which are found between the *cerebellum* and the *medulla oblongata*, and below the pons, the cerebral peduncles, the Sylvian fissure, &c., or at least the former, pass directly into the sub-arachnoid space of the cord, whilst the former corresponding to the sulci, over which the arachnoid extends like a bridge, may perhaps communicate with each other, but the majority at least are not connected with the abovementioned larger spaces. The arachnoid is nowhere connected with the lining of the cerebral ventricles; its structure is the same as that of the spinal arachnoid, and its outer surface is likewise furnished with an epithelium.

The Arachnoid membrane belongs to the class of Serous membranes, and presents all the characters of these, in both the normal and abnormal states.

The *Pia Mater* forms the immediate investing membrane of the brain, and forms a delicate network of areolar tissue, in which the vessels break down, before entering the substance of the organ. It forms processes or folds in the interior of the brain, as the velum interpositum, the plexus choroides, and passes between the convolutions into the sulci. Besides its numerous vessels, the pia mater contains some indistinctly fibrous and connective tissue, without elastic fibres; and occasionally, at the base of the brain, some pigment cells.

The Pia Mater cannot be classed with any of the membranes of the body, being *sui generis*, and composed chiefly of areolar tissue: its principal office is to form a basis for the smaller vessels to ramify in before entering the substance of the brain.

Membranes of the Spinal Cord.—These correspond to the membranes of the brain, and consist, like them, of three—the Dura Mater, Arachnoid, and the Pia Mater, but present peculiarities which render a distinct description necessary.

The *Dura Mater*, as it descends from the Cranium, is firmly attached to the circumference of the foramen magnum; from which it passes downwards into the spinal canal, to form the external covering of the Spinal cord. Its *outer* surface, however, is not connected to the vertebræ, being separated from these by an interspace, in which there are loose anastomosing bundles of connective tissue, gelatinous fat, and cells containing serum. This space also contains the well-known plexus venosi, and finer vessels. The Dura Mater of the

Cord does not, therefore, form an internal periosteum to the vertebræ; from it, processes are prolonged outwards on the spinal nerves, as they emerge from the spinal canal, which are gradually lost on the neurilemma, without being continuous, as is the dura mater of the brain, with the external periosteum. The inner surface of the dura mater of the spinal cord is lined by the arachnoid; although Kölliker states that "Nothing is found here except an epithelium composed of polygonal cells, and there is not a trace of a special membrane." The Dura Mater of the spinal cord is less vascular than that of the brain, and consists of parallel, mostly longitudinal fibres, of connective tissue, and of a network of fine elastic fibres. It belongs to the class of fibrous membranes.

The *Arachnoid* membrane of the Spinal Cord lines the inner surface of the dura mater, and is thence reflected along the spinal nerves and ligamenta denticulata, on the outer surface of the pia mater covering the cord. It belongs to the class of serous membranes.

The *Pia Mater* is the immediate investing membrane of the spinal cord, which it closely embraces, passing into the anterior and posterior fissures, in the form of thin processes, and furnishing delicate sheaths to the roots of the nerves. It contains, for the most part, ordinary connective tissue, along with a few elastic fibres. In the pia mater of the cervical portion of the spinal cord, and also in other parts, fusiform or stellate brownish pigment cells are found, which, in the former place, frequently impart to it a brown colour. The Spinal Pia Mater is much more dense, but less vascular than that of the brain.

The ligamenta denticulata are prolongations of the pia mater, covered by the arachnoid membrane. On this subject Kölliker states, that the ligamentum denticulatum possesses no epithelium, and, like the thickened stripes of the pia mater, to which it is attached, has exactly the same structure as the dura mater.

By means of the ligamenta denticulata, the Spinal Cord is completely suspended in the spinal canal, and being separated from the bones by a considerable interval, shocks are with difficulty transmitted from these to the nervous substance, which is usually not affected by the motions of the spinal column.

OF THE SPECIAL SENSES.

MAN, in common with most of the lower classes of the Animal kingdom, is endowed with the power of receiving the peculiar impressions of bodies in general, and of transmitting them to the Sensorium, which thus constitute sensations of a certain character: these form the Special Senses, and are, in order of connexion with the Nervous System, those of—1. Smell; 2. Sight; 3. Hearing; 4. Taste; 5. Touch.

OF SMELLING.

The Sense of *Smell* is limited to the Nasal Cavity, and is confined to that portion of it, on which are distributed the filaments of the Olfactory nerves—namely, the Septum narium, and the outer wall of the Nose, including the superior and middle, but not the inferior spongy bone.

These parts are lined by a thin fibro-mucous membrane, the pituitary or Schneiderian membrane, the upper portion of which is non-ciliated, and forms the olfactory part, the lower being of the ciliated character.

The Olfactory filaments are derived from the nerves of the same name, they descend from the cranium through the cribiform plate of the ethmoid bone, and run between the fibrous and mucous layers of the pituitary membrane, in the latter of which they are finally distributed.

The irregularities of the nasal cavities are well arranged, not only to increase the mucous surface, but also to impede the air, and the odoriferous particles which it may contain, in their progress through them, as they communicate to these, an undulatory or irregular motion which separates the particles and brings them, more directly, into contact with the sensitive portions of the mucous membrane, by means of which their peculiar characters are more impressed on the olfactory filaments.

The Sensitive impressions, thus made, are conveyed by the olfactory nerves to the Sensorium, and the sense of smell is the result.

It had been supposed that the *sinuses* of the facial bones assisted in the extension of the Sense of Smell; but as these do not receive filaments from the olfactory nerves, and are well marked in animals, as in greyhounds, whose sense of smell, is by no means acute, his opinion cannot be maintained.

That the sense of smell is confined to Olfactory nerves is fully established. Experiments, performed by Valentin and others, demonstrate that destruction of these nerves destroys the sense of smell without impairing that of sensibility; and irritation of the olfactory filaments is not followed by any muscular action, either of a direct, or reflex character.

That the Sense of Smell is impaired by the division of the branches of the fifth nerve distributed to the nasal cavities, does not negative this theory, as the result is to be attributed to the dry and otherwise deranged state of the mucous membrane, which follows this experiment.

The Sense of Smell varies much in different individuals, and, like all the senses, may become improved, by frequent practice in the smelling of different odours. At the same time, it will become insensible to the exposure of most odours, for a considerable time.

Various odours also affect it differently, and more or less powerfully, as musk, camphor, assafœtida, &c. Some of these affect the Sensorium to a remarkable extent, and will induce sickness and fainting.

The effects of contact of fragrant odours on the mucous membrane of the nose, which act mechanically or chemically upon it, as ammonia, nitrous acid, and most other gases, must not be confounded with the sense of smelling. These are modifications of common sensation, which is given to the nasal cavities by means of the filaments of the fifth cerebral nerve distributed upon the mucous membranes, which are generally supposed to preside over the sensibility, or common sensation, of this structure.

A third set of nervous filaments are found in the nose, derived from the Spheno-palatine or Meckel's ganglion. No especial use has been assigned to these; but there is much reason to believe that, on them, depends the sympathy which exists between the senses of smell and taste, and possibly also of hearing, and that these are thus nerves of Associate Function; a view which is supported by the ganglionic origin of their filaments, and their intimate connexion with the fifth nerve.

The passage of the air through the nasal cavities from the pharynx will cause a sense of smell, as well as when passed from before backwards; but as we cannot propel the air through the upper part of the nose, this is endowed with a feeble sense of smell.

The Sense of Smell is impaired or destroyed by the obstruction of the air-passages, as in the case of polypi and other tumours, by congestive inflammation of the mucous membrane, and by the frequent use of snuff, &c., which tends to blunt its acuteness and to cover the mucous membrane with its particles.

OF SIGHT.

The Eye, the organ of Vision or Sight, is lodged in Man in the Orbital Cavity, where its delicate structures are protected from external violence.

The Eye is simply an optical instrument, and in no way differs from that which is made by human hands, except that its structures are living, and the impressions made upon the retina are conveyed to the Sensorium. It is composed of various lenses, concave and convex, whose office is to refract, or collect the rays of light reflected from a luminous body, and thus to form, on the bottom of the eye, where the retina is placed, an image of the object, which impresses the brain, through the medium of the optic nerve, in such a manner as to convey to the Sensorium most of its external characters. The eye is thus strictly analogous to a camera obscura.

If we add to this, that the eye is possessed of certain muscles which move it in different directions as required, a definite idea may be formed of this beautiful and perfect adaptation of the simplest mechanical means to the production of the most extraordinary results.

The Eye of Man is nearly spherical. The external case, as it were, is formed of two resisting structures, the sclerotic coat and cornea. The former is a fibrous structure, and forms about the posterior four-fifths of the globe of the eye: it is opaque throughout. Its use is to enclose the more delicate parts of the eye, and to afford attachments to its muscles. The Cornea forms the anterior fifth of the globe of the eye, is of a horny or laminated texture, and is transparent, for the purpose of admitting the rays of light into the interior of the eye: it forms thus a kind of transparent glass fitted into the anterior margin of the sclerotic coat. But it has an additional office, that of collecting the rays of light, and directing them towards the pupil.

There are only two forms of the lens in the human eye—namely, the *concavo-convex* or *meniscus lens*, as in the Cornea; and the *double convex lens*, as in the lenticular body, in front of the vitreous humour.

The external case of the eye, thus formed by the Sclerotic coat and Cornea, must be provided with an optical apparatus in its interior, as follows: there are required—1. A dark coat, or lining, to absorb the rays of light; this is formed by the choroid coat: 2. A Sensitive mirror, to receive the image of the object, and transmit it to the Sensorium; this is provided in the Retina: 3. A concavo-convex lens, to collect the rays of light from the different surfaces of each object, to concentrate them and direct them inwards towards the Retina; this is accomplished by the Cornea and a double convex lens, which collect the rays of light and form a focus at such a point, as may present an image of the body observed, on the internal surface of the Retina: 4. A curtain, by means of which, the quantity of light entering the eye may be regulated; this is found in the Iris, a species of curtain hanging near the anterior part of the cavity of the eye, with a movable opening in its centre, through which only the rays of light pass, and so capable of contraction and dilatation as to allow but a few, or many, of them to enter, as may be necessary.

The Eye is thus a simple optical instrument, possessed of Vitality, and acting intelligently as required, without assistance.

In order to understand the Physiology of Vision, it will be necessary to consider, but as briefly as possible, the laws which regulate the transmission of light:—

1. Light travels in parallel rays through a medium of uniform density.

2. When the rays meet with a medium of increased density, they become refracted (or changed in direction)

towards a line, which falls perpendicularly to the surface of the body, which they enter.

3. When the rays meet with a medium of diminished density, they are refracted from this perpendicular line.

4. When the rays of light fall upon a convex lens, they are collected, and if this be a double convex body, they come to a point—that is, form a focus at a greater or less distance according as the convexity of the lens is less or greater, the lesser distance resulting from the greater convexity. Those rays which enter the lens at a distance from its central axis are disposed to form a focus at an earlier point than the others, and thus to produce a certain amount of *Spherical aberration.* The image, formed by the refraction of the rays of light, in coming to a point or focus, will be an inverted one.

5. If the convexity of the lens be too great, the focus will be formed in front of the mirror or reflecting body; if too slight, the focus will be formed beyond this; or if this be an opaque body, no focus will be formed.

The interior of the eye is occupied by the vitreous humour, or body, posteriorly, the crystalline lens in front of this, and, still more anteriorly, by the anterior and posterior chambers, filled by the aqueous humour, and partially separated by the Iris, but communicating through the pupil.

The *Crystalline Lens* is lodged in a sulcus or depression in the anterior surface of the Vitreous humour. It is doubly convex, its posterior surface presenting a greater convexity than its anterior. The use of this body is to collect the rays of light, which enter through the pupil, and to cause these to converge into a focus on the concave surface of the Retina.

The *Vitreous humour* fills the greater portion of the posterior part of the interior of the eye. The aqueous humour fills the anterior and posterior chambers. The use of these humours is to correct the Chromatic aberration, to which the different coloured rays are subject. The violet rays are the most refrangible, and are soonest brought to a focus; the red are the leas refrangible, and form a focus at the greatest distance from the Lenticular body. The difference in the density of the crystalline lens will assist in the attainment of this object.

The *Choroid coat* lies between the sclerotic and the Retina, and forms an exceedingly thin, delicate layer of membrane. It secretes the *Pigmentum nigrum*, or dark paint, which gives to the Retina its reflecting power, and absorbs the superfluous rays of light.

The *Retina* lines the interior of the Choroid coat, and the external surface of the Vitreous humour. Its nervous layer is formed by an expansion of the Optic nerve, which penetrates the *pars cribrosa* of the Sclerotic coat at its back part, a little to the nasal side of the central axis of the globe of the eye, expands and forms it. The exact mode of its termination is with difficulty ascertained: it appears to divide into numerous fasciculi of fibrils, which spread out and form a net-like plexus of nervous matter. A vesicular layer of nervous fibres covers this on its outer surface. To these layers are principally distributed the branches of the *Arteria Centralis Retinæ.* The outer layer of the Retina forms its largest portion, it constitutes the *Membrana Jacobi*, which is composed of a series of layers of elongated "rods," terminating in "cones."

In the centre of the Retina, and the central axis of the globe of the eye, the nervous fibres derived from the optic nerve are deficient: here is placed the *yellow spot of Soemmering.* The vesicular layer only exists here.

The *Iris* forms a movable curtain in the interior of the eye, and hangs suspended between the anterior and posterior chambers, immediately in front of the Crystalline lens. It is perforated nearly in its centre, but somewhat nearer the nasal side, by an aperture forming the pupil.

The Structure of the Iris consists of two sets of muscular fibres; one, *radiating*, from its outer circumference towards the margin of the pupil, the other circular, surrounding the margin of this opening, although slightly beyond it. It is exceedingly vascular, and is well supplied with nerves from the third and fifth and Lenticular ganglion. The Iris belongs to the class of involuntary muscles, and forms an exception to the rule, of this class being composed of unstriped fibres.

The motions of the Iris are of a Reflex character; the rays of light fall on the Retina, producing sensation, from which follows the contraction or dilatation of the pupil, as may be necessary. This action is referred by some to the influence of the fifth nerve; but as rays falling on the surface of the Iris have no effect on this membrane, it is evidently a reflex action derived from the sensibility of the Retina.

Certain narcotic poisons act powerfully on the iris. Belladonna causes the dilatation of the pupil, whilst opium, on the contrary, causes it to contract. The action of belladonna has been assigned to a paralysis of the circular fibres only, being induced by this narcotic, when the radiating fibres contracting dilate the pupil; but as the action of belladonna is especially on the Nervous System, it is more probable that the Retina is partially paralysed by its use, and that the pupil thus dilates in unison with its normal action. This view is supported by the fact that belladonna, in excess, will cause total paralysis of the Retina, and induce amaurosis.

The effect of Opium on the Iris must be explained on different grounds. This drug is not found to paralyse the Retina, unless the Sensorium is destroyed by its influence; in moderate doses, this drug rather stimulates the retina, and increases the visual powers, so as to render a contraction of the pupil necessary—a state which becomes persistent, during the influence of the narcotic.

The Contractions of the Iris have also been referred to the stimulus of the rays of light, which may act directly on the muscular fibres, causing them to contract; or may cause a turgescence of the vessels of the membrane so as to distend it, and produce a contracted state of the pupil. But these opinions are set aside by the fact, as already stated, that the rays of light, which fall upon the surface of the Iris, produce no effect upon its contractions.

Vision is accomplished by the formation of an image of the object looked upon, on the internal surface of the Retina. The impression made upon this produces a Sensation of a peculiar character, which is conveyed to the Sensorium by the Optic nerve, and completes the Sense of Sight.

The Image is formed in the following manner: The rays of light are reflected from the object, and impinge on the outer convex surface of the cornea, which collects them from distant points. In passing through this structure, they become refracted towards the perpendicular line; those which fall on the circumference of the cornea impinge upon the Iris, and are reflected, showing the colour of this membrane; those which pass nearer its centre converge, and pass through the pupil, they now penetrate the crystalline lens, by means of which, they are again refracted towards opposite sides, and are collected so as to form a focus or point behind this body, and, in the normal state, upon the anterior surface of the Retina; the Image is consequently inverted; but this state is corrected by the Sensory powers of the Retina and Sensorium. That this is the case may be proved by means of the eye of a recently killed animal, on which the image is distinctly formed in an inverted position.

The Eye possesses the power of adapting itself to the varied distances of different objects, and is, by some, supposed to be acted upon by the *ciliary processes*, or by its external muscles, so as to accomplish this end; but these can have little influence on the diameters of the eye, and we are still unable to offer any physical explanation of the cause of this extraordinary power.

The greater, or lesser convexities of the cornea, and crystalline lens, produce the difficulty of vision in the states of *myopia* and *presbyopia*. *Myopia*, or *near-sightedness*, is caused by a too great convexity of either, or both of these bodies, and occurs usually in early life; in this, the image or focus is formed in front of the retina, and is thus unseen. *Presbyopia*, or *far-sightedness*, on the contrary, is induced by the flattening of one, or other, or both of these bodies, and is the defective vision of advancing age; in it the focus is formed beyond the retina, and the image is imperfect.

Both these conditions may be corrected by the use of artificial lenses, which supply the defect of the natural structures.

The Eye, in the uneducated state, can convey to the Brain no peculiar property of the object seen—such as form, colour, distance, &c. This power is acquired by education, in which the hands or fingers are essentially useful; hence, infants are impelled to feel the objects placed before them, in order to ascertain their qualities, and persons born blind, but restored to sight at a subsequent period, have recourse to the same means to accomplish the desired end. The power of distinguishing colours is not enjoyed by many, whose visual organs are otherwise perfect.

Although a double image is formed upon the Retina, the impression of a single object only is transmitted to the Brain. This is doubtless the result of education, by means of which the same portions of the Retina in each eye are brought to accord, and act in harmony; it is also influenced by the junction of the optic filaments in the optic commissure, although not dependent on this. This power is impaired or lost in squinting, injuries of the head, &c.; it is, to a certain extent, under the control of the Will, as by acting on the eyes so as to alter their visual axis, a double object may be perceived on the retinæ.

For a most elaborate and scientific view of this subject, we must refer to Valentin's Physiology, in which the phenomena of Light and Vision are most ably considered.

OF HEARING.

The *Ear* is the *Organ of Hearing*, and is composed of three portions, the *External, Middle*, and *Internal Ear*.

The *External Ear* consists of the Ear properly so called, and the external auditory meatus, or canal.

The use of the External Ear is to collect the vibrations of the air, and transmit them through the meatus, to the membrana tympani, which is thus thrown into corresponding action. The exact influence of its peculiar shape in Man is not easily ascertained, but its more or less flat position, on the side of the head, enables him to collect the sounds from different quarters.

The *Membrana Tympani*, or Drum of the Ear, separates the external from the Middle ear, or Tympanum: this contains the ossicula, or small bones of the Ear, which are so arranged as to form a movable chain of bones which receives the impressions of the vibrations from the membrana tympani, and transmits them to the internal ear, lined by the acoustic nerve: for this purpose, the cavity of the Tympanum, although closed on its outer side by the membrana Tympani, communicates on its anterior wall with the external atmosphere, by means of the Eustachian tube.

The *Internal Ear*, or Labyrinth, consists of the Cochlea, Semicircular canals, and Vestibule: these are irregular cavities in the petrous portion of the temporal bone, and are lined by the *portio mollis* of the seventh cerebral nerve, or true Acoustic nerve. This nerve expands like the Retina, and is supported by a thin transparent fluid, which assists in the communication of sounds.

Sounds are produced from vibrations of the external atmosphere, but the vibration of solid bodies may produce sounds also, although not without the aid of the atmosphere, as no sound is produced *in vacuo*.

The Vibrations necessary to constitute the sound are collected by the external ear, which is more or less movable for this purpose, and are transmitted along the external meatus to the membrana tympani; this having a support from the atmosphere on its internal surface also, is thrown into corresponding vibrations, but is connected with muscular fibres to regulate these by the different states of tension induced in the membrane, so that it may be relaxed or made tense according as the corresponding muscles, the Laxator or Tensor Tympani muscles, are thrown into a state of contraction.

The modified vibrations of the membrana tympani are conveyed along the ossicula, and are, through them, conducted to the Acoustic nerve, which receives the impressions and conveys them to the Sensorium.

The sense of Hearing varies much, in different individuals, not only as to its extent, but also as to its state of perfection. Some will hear a noise, but are wholly incapable of distinguishing between the various refinements of sound, and can scarcely recognise the difference between an acute and a grave note. Such are destitute of the sense of Harmony, as it may be termed. A somewhat analogous defect has been noticed, as existing in the visual perception of some persons, who cannot distinguish colours. Both these defects rest in the Sensorium, and are natural deficiencies, or, to speak more correctly, are congenital defects, which cannot be supplied by Art. Even amongst experienced and educated singers, and other artistes, a true appreciation of sound, from which results correct intonation, is rarely to be met with; to the possession of this faculty much of the success of some is to be ascribed, rather than to other qualities which they may possess.

OF TASTE.

Although the Tongue is essentially the organ of the sense of Taste, this is enjoyed to a lesser extent by the palate, and lining membrane of the mouth and fauces.

For the perfection of this sense, bodies must be in either a fluid state or possess a certain degree of fluidity in their composition: solid bodies are insipid, and only become sensible to taste, when dissolved, as alum, rock salt, &c.

All parts of the tongue possess the sense of Taste, but its principal seat is in the posterior half of the organ, and especially in that part, immediately in front of the foramen cæcum.

It has been much disputed whether the gustatory branch of the fifth, or the glossopharyngeal nerve, is the nerve of Taste; and although the authority of Valentin is much in favour of the latter contributing largely to this sense, it is the prevailing opinion that on the former depends this sense. But this has been fully considered when treating of the Nervous System, and need not again be enlarged upon.

The connexion between the senses of Smell and Taste is maintained, most probably by the branches of Meckel's ganglion, which descend from the nose to the mouth, and by the general anastomosis of the fifth nerve.

OF TOUCH.

The sense of *Touch*, or *Feeling*, resides in most parts of the skin, but is more especially developed in the extremities of the fingers. It is also fully developed in various parts of the mucous membrane, as in the lips, tongue, and fauces, the extremities of the urethra and glans penis, vagina, &c. But mere sensibility must not be confounded with the sense of Touch, by which we are enabled to ascertain the external qualities of the bodies felt, as their form, size, &c. Many parts which are extremely sensitive to pain, and to contact with foreign bodies, do not possess this capability, and are therefore devoid, or nearly so, of the sense of *Touch*, or *Tact:* the inside of the thighs and arms affords examples of this.

For the perfection of this sense, simple contact is seldom sufficient, as it is necessary to use friction, either by passing the fingers over the foreign body or this over the fingers, by which the slightest inequalities, or varieties of form, are ascertained.

The Sense of Touch is increased to a wonderful extent by cultivation, especially where the Sense of Sight has rendered this more necessary: blind basket-makers will select the coloured twigs with which they work, from the difference of surface produced by the application of the various colours; persons deprived of sight frequently play the violin, and other stringed instruments most perfectly, the Sense of Touch, as also that of Hearing, being developed more fully in consequence of the loss of vision.

The Tongue possesses a most acute sense of Touch: the finest hair is felt upon its surface, and even when the fingers fail to ascertain the qualities of certain bodies, contact with the Tongue immediately recognises them. The tip of the Tongue possesses the most perfect Sense of Touch.

This Sense is thus distinct from sensibility, although possibly a modification of common sensation.

The structure of the skin has been already considered, but we may ask, in what part of this organ does the Sense of Touch reside? In the Sensory papillæ with which this is furnished.

From the observations of Kölliker and others, we find that these papillæ are essentially composed of two orders, a vascular and a nervous. The former is destined to supply the epidermis, nails, &c., with nutrition; the latter to preside over the common and special sensation. The nervous papillæ receive filaments from the Sensory nerves, which terminate in the papillæ by forming a peculiar "axile" body, which forms its central portion; pressure against these produces the Sense of Touch. The thickness of the epidermis influences considerably the sensibility of the papillæ, those parts which are covered with a dense layer possessing but little sensibility to touch, as over the heel, &c.: the hands of blacksmiths, and labourers generally, become hardened from a thickening of the epidermis, and do not possess an acute sense of Touch.

This sense is very deceptive under many circumstances, as in the ascertaining of the temperature of different bodies, especially under extreme degrees of heat and cold, which will produce precisely the same feeling in the skin, although it may be well questioned if this is not the result of sensation, as distinct from Touch, rather than of this sense.

It may be observed that the sense of Touch is chiefly derived from the Spinal Cord, the only Cerebral nerve which appears to convey it, being the fifth or trigemini.

OF THE HUMAN VOICE.

ALTHOUGH all animals possess the power of uttering certain sounds, by means of which their wants, feelings, or passions may be known, Man alone possesses the power of extending these almost infinitely, of combining them, and of thus forming an expansive language, which serves to express his ideas, and give utterance to his thoughts.

All languages are but the combination of certain sounds; and as the Music of Ages has been produced from seven notes, so the languages of countless millions have been formed from a peculiar arrangement of a few sounds, expressed in certain letters.

The Human Voice has been compared to a wind, a stringed instrument, &c.; it is, in fact, a combination of instruments; the air passing upwards and downwards through the larynx and trachea, tubular instruments, form its analogy with the wind instruments; the vibrations on the chordæ vocales, its resemblance to a stringed instrument, as the Æolian harp. It more closely resembles, in conformation, the flageolet, than perhaps any form of instrument, the upper expanded part being represented by the larynx, the contracted part by the trachea.

The Larynx is essentially that portion of the Respiratory tube, which is most intimately connected with the formation of the voice: its development and organization in youth, in puberty and age; in the male and female subject; in the perfect and the imperfect male, cause infinite modifications of it, so that individuals are often as easily recognised by the sound or tone of their voice as by any of their external characteristics: indeed, this has frequently supplied the want of knowledge of these, and identifications of persons have been formed from the sound of their voice, when all other means have failed.

The Larynx, accordingly, presents a complication of structures not met with in the Trachea. It is composed of a number of distinct cartilages, namely the *Thyroid*, *Cricoid*, and the *Arytenoid*, which are more or less movable, although the last are far more capable of being moved than the former. The Thyroid Cartilage is the largest of these, and forms the remarkable prominence in the neck of Man known as the Pomum Adami. On its development the depth of the voice seems principally to depend; in the youth, before puberty, it is but little developed, and the voice is thin and feminine; but at puberty the Thyroid Cartilage enlarges, the voice breaks, and the deep tones of the adult are formed. This development does not take place in Eunuchs, and their voice remains *puerile*. In some males, this cartilage is but little developed, the voice remains thin and weak, and the sexual powers are generally feeble. In females, it undergoes but little change at puberty, and the voice changes much less remarkably than in Man, until after the cessation of the Menses, when the tone of the voice alters considerably, and approaches the masculine character. Few females, even of our most accomplished singers, retain their silvery tones after this period.

To the expansion of the Thyroid Cartilage, is then to be attributed the production of the deep tones, which characterize the male adult voice.

The *Cricoid cartilage* lies beneath the preceding, being attached to it, by means of muscles and ligaments: it forms the only perfect ring in the respiratory tube, and is hence but little capable of change, and can have but a moderate influence, on the tones of the voice.

The Arytenoid cartilages are two in number, and are placed on the superior and posterior edge of the cricoid; they are extremely movable, and afford attachment to the chordæ vocales. Most of the laryngeal muscles are connected to them, and by the action of these on the cartilages, the chordæ vocales are relaxed or made tense, are separated or approximated, so as to enlarge or contract the rima glottidis, and thus effect the several changes in its capacity, on which depends mainly the production of the various sounds.

In the formation of the acute sounds, the chordæ vocales are made tense, and the rima glottidis is contracted: these changes are effected by the inter-arytenoid and crico-arytenoid laterales muscles. In the formation of the deeper tones, the chordæ vocales are separated and relaxed by the crico-arytenoidei postici muscles; and on the almost infinite modification produced by these, are produced the several degrees of sound, between the most acute and the most grave notes.

The muscles attached to the Thyroid Cartilage are also instrumental in producing these changes. The Thyro-hyoid will elevate the thyroid cartilage in front, so as to make tense the chordæ vocales; the crico-thyroid have a similar action.

But the muscles attached from the sternum, &c., will assist also in the formation of the different sounds. In the formation of the deeper tones, the larynx becomes depressed, generally towards the sternum, and in that of the acute notes, it is elevated towards the os hyoides, thus elongating or shortening it in the vertical direction, as is effected in the Trombone and other wind instruments.

The *inferior laryngeal* or *recurrent* appears to be the principal nerve, which confers motion on the laryngeal muscles, as when this is divided on each side, they become paralysed. The character of the superior laryngeal nerve is almost exclusively afferent, as when it is irritated, the only muscle thrown into action is the crico-thyroid.

When we reflect that the range of the human voice will extend, although rarely, to the compass of two octaves, and that, in this range are included, in some singers, as many as 2000 minor tones, we shall form some idea of the extreme delicacy of motion, of which the laryngeal muscles are capable, when fully educated.

The Voice is principally used by Man in the formation of speech, which is accomplished by the succession of several sounds, constituting Articulation. The tone of the speech depends much on the state of the chordæ vocales, and on the development of the larynx, but the articulation, or modification of the necessary sounds, is effected by the lips, mouth, tongue, and fauces; hence their division into labial, oral, guttural, &c. The vowels are of simplest construction, and are produced with the least action of the oral and other muscles. The consonants, generally, require the combined action of one or more parts. The rapid and regular production of these, results in the formation of Speech.

Singing is effected in the larynx, throat, fauces, mouth, and nasal passages; the integrity of each, and all of these, being necessary to its perfection. The acute and grave notes are produced as in speaking; but the resonance, which constitutes singing, is imparted from the upper air-passages, the greater tension required in the formation of the acute tones, being caused by the tense or constricted state of the chordæ vocales, and isthmus faucium, the deeper or base notes being formed in the lower parts, the acute in the more elevated.

On the capacity of the Thorax, and the power possessed over the Respiratory muscles, enabling the individual to expel the air from the lungs with greater or less force, depends mainly the strength or power of the voice in Man; but examples are not wanting in some of the lower classes of animals, in which extremely loud sounds are produced by a comparatively small Respiratory organ; frogs and some monkeys afford disagreeable and discordant examples.

Stammering is a deranged state of the faculty of speech, and is most frequently a nervous affection, which produces a spasmodic action of the muscles engaged in articulation. Some stammer, only, on attempting to articulate certain letters, others do so at every attempt to speak. It is remarkable, that stammerers will sing, and deliver set pieces of prose, and poetry, without interruption. Females seldom stammer, although more subject to nervous disorders generally than males.

The cure of stammering is best effected, by educating the muscles in the production of the sounds most easily formed, and thence proceeding to the more difficult. The articulation of the separate letters should first be practised, and when this has been accomplished the formation of words should be proceeded in. The performance of operations for the removal of this affection is empirical and dangerous.

IRREGULAR ACTIONS.

There are certain actions which are incidental to the Human Subject, and which, though of frequent occurrence, are not necessary to the well-being of the animal economy—namely, *Vomiting*, *Sneezing*, *Sighing*, *Laughing*, and *Weeping*.

These have been usually considered with the organs more especially engaged in their execution; but the researches of the late Marshall Hall will justify their being placed in a distinct position, as being the results of the Reflex actions, elucidated by that eminent physiologist.

Vomiting.—This act, which consists in the ejection of more or less of the contents of the stomach, is the result of a great variety of causes, some of which act directly on the organ; whilst others produce the effect, by their action on more distant parts, vomiting being induced by the sympathy which exists between them and the stomach, and gives rise to a series of reflex actions, implicating not only this organ but several other parts of the body.

The most frequent cause of Vomiting is the entrance of certain nauseous, or otherwise injurious matters, into the stomach, as unwholesome or disagreeable food, the stronger acids, nauseous medicines, an excess of biliary matter, &c. In these instances, the impression is made directly on the mucous membrane of the stomach, which excites the muscular fibres to contract forcibly, and expel the obnoxious substance. The use of the stronger acids excites instantaneous vomiting, and, in some cases, even before the fluid reaches the cavity of the stomach. There can be no doubt that an injurious impression is made, at the same time, on the nervous fibrillæ of the stomach, and that it is through their agency, that the muscular fibres are thrown into a state of contraction.

Vomiting is also induced by the influence of agents acting upon more distant parts. Tickling the throat with a feather, or the introduction of the finger or other foreign body into the fauces, will excite immediate vomiting. In these instances, the act of vomiting is the result of the Reflex action; the irritant is applied to the fauces, the disagreeable sensation is propagated to the pharyngeal nerves, thence to the medulla oblongata, whence the motive action is distributed to the muscular fibres of the stomach, by means of the pneumogastric nerves, and vomiting results.

These actions are independent of the Sensorium, but impressions made upon this are equally capable of exciting the act of vomiting. Disagreeable intelligence has been known to induce this, and many persons are affected with nausea by the effect of certain odours or harsh sounds; and although these act directly on the olfactory or acoustic nerves, the disagreeable impression is made upon the stomach through the medium of the Sensorium, influencing the pneumogastric nerves.

Injuries of various kinds are frequently followed by vomiting, especially those affecting the head, abdominal viscera, the testes, &c. Indeed, there are few injuries of a serious nature which are not followed by nausea and vomiting, these being induced by the strong sympathy which exists between the stomach and almost all parts of the body.

Sea-sickness is characterized usually by severe vomiting, in which, not only the contents of the stomach are ejected, but also those of the duodenum, from which quantities of bile are discharged, by a retrograde action, into the stomach, and thence ejected.

The principal cause of sea-sickness is most probably the unusual motion of the vessel, as similar motion on land, as in swinging, will induce vomiting; but other causes are in operation at sea, as the disagreeable odours in the vessel, the smell which arises from the sea, &c.

It is remarkable that nauseous medicines, such as tartar emetic, will excite vomiting if injected into the veins, the rectum, or other parts of the body, although no portion may enter the stomach. Arsenic acts in like manner, showing that medicines have a specific action on this organ, independently of their local effects.

Some persons have the power of vomiting at will. The author met with an instance of this some time since, in which the individual could swallow whole eggs and other substances, and again eject them at will. Others possess a spurious kind of rumination, in which undigested, or imperfectly masticated, food is thrown back into the mouth, to be again masticated. This is frequently the result of a disordered stomach, but it may also take place, when the organ is in a healthy state.

The precise mode in which vomiting is effected has been the subject of much investigation. Majendie contended that the stomach was altogether passive in the act of vomiting, and supported his theory by experiment. Having injected tartar emetic into the veins of dogs, and in other cases introduced it by the mouth, he states that he never saw the stomach itself contract, and that when the stomach was drawn out of the abdominal cavity, so as to be free from the action of the abdominal muscles and diaphragm, vomiting was suspended until he returned the viscus to its natural place. In some of his experiments, he found that pressure of the hand, in place of the action of the abdominal muscles, led to vomiting. In another experiment, having removed the stomach, and supplied its place by means of a pig's bladder, he found that vomiting took place as if the stomach were in its natural position.

But these results are not supported by more extended observation. In a case which occurred to Lepine, the abdominal muscles were torn, and the stomach forced out of the cavity, by an injury. The stomach was seen to act repeatedly, and so powerfully as to expel its contents. In many diseases also, the act of vomiting is evidently the result of the contraction of the stomach only. In strangulated hernia, and peritonitis, this is frequently to be observed. In the earlier stages of these affections, there is an evident action of the abdominal muscles; but in the more advanced the patient "gulps up" the contents of the stomach, without the aid of the surrounding muscles.

We may therefore conclude, that although vomiting is, most frequently, the result of violent action of the abdominal muscles and diaphragm, still that the stomach may participate in this, and even act altogether independently of it.

In the natural state, whilst digestion is going forward, the muscular fibres of the stomach are seen to contract, so as to propel the food towards the pylorus, and again towards the great bulging, or left extremity, of the organ. In vomiting, the latter action is increased, so that the contents of the stomach are forced upwards into the œsophagus; the sphincter muscle at the cardiac orifice offering but little impediment, the œsophageal fibres now contract, and again the pharyngeal muscles, so that the contents of the stomach are expelled with considerable force from the mouth, and occasionally through the nares.

This is, throughout, a retrograde or reversed action of the muscles, and is frequently extended to the whole intestinal canal, which ejects its contents upwards, as in cases of strangulated hernia, through the mouth, the fæces being frequently discharged in this manner.

Vomiting is a well-marked example of *Reflex action.*

The impression is made, in many cases, on distant parts of the body: this is conveyed to the Medulla Oblongata by the afferent nerves, and the spasmodic action is transmitted along the efferent nerves to the abdominal muscles, the diaphragm, and the muscular coat of the stomach.

Sneezing.—This is the result of the Spasmodic action of the principal muscles of *expiration*, induced generally by the presence of some irritating substance in the nasal passages.

Sneezing is usually preceded by a sudden forced inspiration, which is almost immediately succeeded by a convulsive action of the abdominal muscles and diaphragm, which forces the air from the lungs upwards through the posterior nares, and thence through the anterior openings, a small portion only passing out through the mouth. In violent sneezing, the spasmodic action extends to the latissimus dorsi, and other muscles of the back and shoulders, so that there appears to be a general convulsion of the frame.

The peculiar odour of the irritating body has little, if any influence in the production of sneezing, as bodies which possess no sensibly odorous qualities are known to excite this act most powerfully, as powdered glass, fine dust, white hellebore, &c. The injurious impression is, therefore, not made upon the olfactory filaments, but upon the filaments of the fifth nerve distributed to the mucous membrane. In support of this, it may be remarked that impressions made upon the retina are frequently followed by sneezing, as on first waking in the morning, or exposure to the rays of the sun, looking at very white bodies, as snow, &c.: here the olfactory nerves are by no means affected, and, to the influence of the fifth nerve on the visual organs, must be assigned the spasmodic action, which induces sneezing. This is very well marked in cases of infantile ophthalmia, in which, the least exposure to a bright light is instantly followed by violent sneezing.

In cases of influenza, when the mucous membrane of the nares becomes inflamed, the atmospheric air will act as an irritant, and induce sneezing.

The act of Sneezing is somewhat analogous to that of vomiting, being the result of the spasmodic action of nearly the same muscles, and, like it, is a reflex action, the afferent nerves being the filaments of the fifth, the efferent those of the principal respiratory nerves.

Sighing.—This action is produced by a sudden and forced action of the principal muscles of *expiration*, usually preceded by an indistinct act of inspiration, by which the expired air is forced outwards by the oral passages. It is most frequently the result of a moral impression, and this generally of a painful or disagreeable nature; but is never induced by a mechanical irritant, as in sneezing and vomiting. Sighing, however, may be caused independently of a moral impression, and frequently takes place in a congested state of the lungs or heart, the act of sighing serving to assist in relieving these organs of an undue quantity of blood, by increasing the circulation.

The influence of sighing on the action of the heart is very manifest If a deep inspiration be first taken, and then the air be expelled by sighing, the action of the heart will be found to be suspended for a few seconds, after which, it will beat irregularly, for several pulsations.

Laughing.—Although all animals utter sounds significant of the passions or feelings which may influence them, there is none which appears to approach Man in the somewhat strange, but very characteristic act of laughing. This is the result of repeated and forcible acts of inspiration, followed by rapid expulsions of the air from the lungs, accompanied by peculiar sounds made in the throat and back part of the oral cavity. It is generally induced by agreeable impressions made on the Sensorium, but may also be caused by tickling the soles of the feet, the sides, &c., from the continuance of which dangerous symptoms, and even death, may ensue. This is a reflex action. It is remarkable that tickling cannot be caused by the individual himself, although so easily provoked by another.

Weeping is also peculiar to the human subject, although the hunted deer is said to shed tears over his misfortunes. It is, generally, the result of painful impressions, although hysterical fits of laughing and weeping are frequently induced by joyful tidings. The principal characteristic is the sudden effusion of the tears, the secretion of the lachrymal gland, which is attended by convulsive action of the respiratory muscles.

Yawning and *Hiccough* are minor irregular actions. The former is a slow inspiration with open mouth, or widened nostrils, followed by a short expiration. The latter consists of violent impulses, produced by irregular spasmodic action of the diaphragm. Hiccough is most frequently caused by the presence of an irritant in the stomach, and often attends the last stage of fevers, strangulated hernia, and peritonitis.

OF GENERATION, OR REPRODUCTION.

Man, as a finite being, is destined to decay and perish, but is provided with the means of continuing the species in the act of copulation, or connexion of the two Sexes.

The especial function of the Male, in the process of Generation, is brief and transitory, and consists in the introduction of the Seminal fluid into the generative organs of the Female. Her function, on the contrary, is more lasting, and extends not only to the reception of the impregnating fluid, but also to the production of the ovum, its gradual development in the embryo, the fœtus, and child; the expulsion of this from her womb into the outer world, and, to a certain extent, its support during several months of its existence.

That the Function of the Female is the more extensive and complicated of the two, cannot be doubted; but their comparative importance is a question that cannot be raised, as either is vain, and cannot be exercised, without the co-operation of the other.

Male Organs of Generation.—These consist essentially of the *Testes*, *Vesiculæ Seminales*, and *Penis*. The subsidiary organs are the Prostate Gland, Vesiculæ Prostaticæ, and, perhaps, Cowper's Glands. The first secrete the Seminal fluid; the second retain it in their cavities until it is ejected; and the last, or Penis, lodges the semen in the vagina of the female, by its introduction into this organ.

The *Testes* are two oval, or rather ovoid glands, which are contained in the cavities of the Scrotum.

The *Testis* is covered externally by a reflection of the tunica vaginalis, beneath which lies its immediate investing membrane, the *tunica albuginea testis*, a strong fibrous structure, which gives to the gland a moderately firm consistence. The proper structure of the testis, or *parenchyma*, is contained within this, and is composed of a number of exceedingly small delicate tubes, the *tubuli seminiferi*. These tubuli seminiferi are collected into bundles or masses, partially separated by processes, sent inwards from the internal surface of the tunica albuginea, and uniting at the back part of the testis, to form the *Corpus Highmorianum*. The tubes anastomose frequently; their diameter does not vary much, being from 1-170th to 1-195th part of an inch; they unite into straight vessels, the tubuli recti, and finally in the *vas deferens* or *excretory duct* of the testis; this becomes convoluted to form the epididymis, passes along the spermatic chord, and terminates in joining the duct of the vesiculæ seminales of the same side to form the *common ejaculatory duct*, by means of which the Semen is conveyed to the prostatic portion of the Urethra, whence it is expelled during the act of Copulation.

The Semen is secreted but slowly in the tubuli seminiferi, and ascends in like manner through the vas deferens: the rapidity is increased by voluptuous feelings, and restrained in the absence of these.

The *Semen*, or Secretion of the Testis, consists of a fluid, the *Liquor Seminis*, in which the Seminal Animalcules, or *Spermatozoa*, are diffused, which are set free by the rupture of the Seminal cells before they leave the tubuli seminiferi. The exact nature of this fluid cannot be easily ascertained, as it is usually mixed with the prostatic and other secretions. It consists of a large proportion of water, some albumen, and a peculiar principle termed *Spermatine*.

The Spermatozoa are developed in cells, by the rupture of which they are set free. They consist of an expanded portion, or head, from which proceeds an elongated process, or tail, generally tapering to a point of about the 1-50th part of a line in extent. They possess the power of motion, and may be seen to move in the liquor seminis, for many hours, after their emission from the body. They are supposed to be the fertilizing portion of the seminal fluid.

The Generative power in Man seldom appears before fifteen or sixteen years of age. At this period, the Sexual organs increase in development, and the Seminal fluid first makes its appearance, accompanied by a strong desire for sexual intercourse. This power ceases only at a very advanced period of life, and is supposed to continue as long as the Male can perform the act of coition. Cases frequently occur of men begetting children after 70 years of age, and some are not wanting of similar instances up to and above the 100th year.

The *Vesiculæ Seminales* are situated on the under surface of the bladder, and are generally supposed to act as reservoirs of the Semen: they, however, secrete a fluid of their own, which mixes with the Semen, and is discharged with it. This fluid is found, in considerable quantities, in the vesiculæ seminales of the old subject.

The ascent of the semen from the testes along the vas deferens, has been long regarded as an example of capillary attraction, aided by the contraction of the abdominal muscles; but the existence of muscular fibres in the testes and vas deferens, as described by Kölliker, will account for it more satisfactorily. This celebrated physiologist has described a thin layer of muscular fibres, which he names the *inner muscular coat of the testicle*, as lying between the tunica communis testis and the parietal layer of the serous membrane, and a similar layer of *smooth muscular fibres* between the fibrous coat of the vas deferens and its lining mucous membrane: to the influence of these, the ascent of the semen may well be assigned.

According to Mr. V. Ellis, the vesiculæ seminales are surrounded, externally, by an envelope, which is composed in part of connective tissue, and in part, especially on the posterior surface, of distinct muscular fibres, which pass between the convolutions, and from one end of one seminal vesicle to the other, so as to form a broad muscular band, the *compressor vesiculæ et ductus seminis.*

The *Prostate Gland* is, by some, considered as amongst the genital organs of the male subject, although its exact office is still a subject of investigation. It surrounds the neck of the bladder and commencement of the urethra, and consists of three lobes, two lateral and a middle lobe.

The Structure of the Prostate Gland has been recently described as composed of muscular fibres; "the glandular substance scarcely constituting more than one-third or one-half of the entire mass." Proceeding from within outwards, we first meet with the thin mucous membrane, whose epithelium is composed of two layers of cylindrical cells, next a yellowish layer of longitudinal fibres, which partly extends from the *trigonum vesicæ* to the *caput gallinaginis*, but is in another part unconnected with the muscles of the bladder: this layer consists of connective tissue, elastic fibrillæ, and smooth muscular fibres, in equal proportions. It is followed by a thick stratum of circular fibres of the same structure, which is connected with the *sphincter vesicæ,* and extends as far as the caput gallinaginis, and which is named the sphincter prostatæ.

Beneath these, lies the proper structure of the gland, which consists of a reddish grey material, somewhat dense, and may be split up into fibres, which radiate in all directions, from the caput gallinaginis to the outer surface of the organ. It consists of muscular fibres collected into bundles, and of from thirty to fifty compound racemose glands, of a pear shape, differing from ordinary racemose glands in their loose structure, the pedunculation of many of their vesicles, and the slight development of the smallest lobules.

The gland vesicles are pyriform, or roundish, and contain brown pigment granules.

The Secretion of the Prostate Gland, resembles that of the vesiculæ seminales, consisting of a brownish mucous fluid. It is supposed to be ejected with the seminal fluid, and to assist in generation; but its exact use is not known.

The *Vesicula Prostatica* is situated in the caput gallinaginis, and between the ejaculatory ducts. Its cells are yellowish white, and lined by a cylindrical epithelium. Under the microscope, it seems composed of connective tissue, elastic, and muscular fibres. This structure has been named the *Uterus Masculinus;* but its analogy to the female uterus is extremely remote. Its precise use is unknown.

Cowper's Glands cannot be regarded as amongst the genital organs. Their secretion is ordinary mucus, which most probably assists in lubricating the bulb.

The *Corps innominé of Giraldes*, is a small linear body, situated at the upper end of the testicle in the spermatic cord, and extending along the cord on the side furthest from the vas deferens. It is about half an inch long, of a whitish colour, and consists of tubules and vesicles of various shapes, containing a fluid more or less clear. This structure is best developed in youths, from six to ten years of age, and is regarded by Giraldes as the remains of the Wolffian body.

The *Penis* is composed chiefly of areolar tissue, by the influx of blood into the cells of which the erection of the penis is effected: this forms the *corpora cavernosa penis:* the former are covered by a dense fibrous structure, the distension of which gives to the penis, when erected, a sufficient degree of resistance; they terminate in a cul de sac, behind the glans penis, which is formed exclusively by the expansion of the corpus spongiosum urethræ.

The *Erectile tissue* of the corpus cavernosum penis is composed of a congeries of blood-vessels, especially of arteries, which anastomose freely with each other, so as to form a vascular sponge, as it were. Arteries of a peculiar character, and terminating in cul de sacs, have been described by Müller and others, under the name of *arteriæ helecinæ*, as projecting in tufts into the venous cells. Arteries have recently been discovered as proceeding from the extremities of these, to terminate in the sinuses like the other twigs of the arteries. Kölliker has described muscular fibres in connexion with the erectile tissue of the corpora cavernosa.

The *Corpus Spongiosum urethræ* is, in like manner, formed of erectile tissue, but more of a venous character; as this forms the *glans penis* in front, it becomes distended with the corpus spongiosum urethræ, and simultaneously with the erection of the body of the penis, formed by the corpus cavernosum, although the cells of these bodies do not communicate and may be filled with differently coloured injections. It is evident that the distension of the erectile tissue of both of these structures takes place in sympathy and under the influence of the Reflex action.

The exact mode by which the erection of the penis is accomplished is much disputed. Some consider that the arteries pour their blood into the cells of the erectile tissue, whence it is subsequently taken up by the veins: others conceive that the arteries form a congeries of tortuous vessels, which communicate with the veins.

When excitement takes place, the blood is driven forward into the erectile tissue, by the increased action of the arteries, aided by the occasional spasmodic action of the *erector penis* and other muscles, whilst the compression of the veins, which occurs at the same time, impedes its return, so that the distension of the penis results.

This action is produced by a nervous impression, and is evidently of a reflex character, the impression being conveyed to the Sensorium, the action of the vessels and muscles results. The impression may be purely nervous and proceed from mental action, directed towards an especial object; or it may be caused by mechanical irritation, as in the act of copulation, being applied to the glans penis, the most sensitive portion of this organ.

Distension of the penis frequently takes place from other causes, as from irritation about the neck of the bladder, or of the bladder itself; from a distended state of this organ, when the urine is allowed to collect, as during sleep; from injury of the spinal marrow, as in hanging, and fractures or dislocation of the cervical vertebræ.

This state is also present in some cases of disease, as occasionally in Tetanus, excitement of the Cerebellum, and general excitement of the organs of generation from excessive venery, when it forms an affection named *priapism*, and is frequently of a most painful character. It is one of the attendants of gonorrhœa, and forms the painful attacks of chordee so well known in this disorder.

The *urethra* is contained within the corpus spongiosum, which surrounds it unequally, and is lodged in the sulcus, on the under surface of the corpora cavernosa penis, whence it extends through the glans to its external orifice. Although this canal is the common excretory duct of the urine and semen, these fluids are never discharged simultaneously, except under disease or debility. During excitement, the seminal fluid is poured into the bulb of the urethra, whence it is forcibly ejected by the spasmodic action of the ejaculatores seminis muscles, which surround this portion of the urethra. The spasmodic action, doubtless, extends to the muscular fibres of the vesiculæ seminales and prostate gland, and these are at the same time emptied of their contents.

The lining membrane of the urethra belongs to the class of mucous membranes: it is smooth, and presents a number of mucous follicles or lacunæ, which serve the purpose of lubricating its surface.

The Corpora Cavernosa are covered by a layer of condensed areolar tissue, forming the *fascia of the penis*, which is further covered by a prolongation of the skin from the abdomen, &c. This is thin and more delicate than in most parts of the body, and in front forms the prepuce.

Around the corona glandis are lodged the sebaceous glands termed the *glandulæ Tysoni.*

Female Organs of Generation.—These, notwithstanding the apparent difference, present a striking analogy to the male organs. They consist essentially of the *Vagina*, *Uterus*, *Fallopian tubes*, and *Ovaries*; but there are, in addition, subsidiary organs, as the Clitoris, the Labia, and numerous glands which, although not essential to generation, are subservient to it. The Clitoris corresponds to the penis, or male organ, and like this is composed of erectile tissue, and becomes distended under sexual excitement. The Labia may be compared to the Scrotum, and the Ovaries correspond to the Testes. The Female organs which have no analogues in the male are, solely, the Vagina and the Uterus, as even the Fallopian tubes have a close resemblance to the vas deferens; and as the latter conveys the semen to the Vesiculæ Seminales, the former conduct the Ovum to the cavity of the Uterus.

The *Vagina* of the female is the cavity which admits the male organ in the act of copulation: its lining membrane is rough and thrown into folds, and it is surrounded by erectile tissue which becomes distended under excitement. A fold of membrane, *the hymen*, partially closes it at a short distance within the vulva: this is usually ruptured, and is seldom well marked.

The walls of the Vagina consist of an external fibrous layer, a middle muscular layer, well marked during pregnancy, and the internal lining membrane, as just described. The erectile tissue is closely connected with the external and middle coats, and serves to compress the vagina during excitement.

A number of sebaceous glands are connected with the external genital organs of the female: they are found on the labia majora and minora, and around the orifices of the urethra and vagina. Numerous mucous glands are also met with in the same situations, provided with excretory ducts. At the lower end of the bulbs of the vestibule, at the side of the vaginal entrance, are met with the *two glands of Bartholini:* these are ordinary racemose glands, half an inch in diameter, with pyriform gland vesicles, 0·02‴ to 0·05‴ in diameter, and have excretory ducts from seven to eight lines long, and half a line in diameter, which open close to the external orifice. These glands are analogous to Cowper's glands in the male subject, and are supposed to be the principal source of the fluid ejected by the female during excitement, when they have been seen to escape in jets, from the contraction of the muscular fibres in the ducts.

The *Uterus*, or *Womb*, is composed of three coats; an external parietal, formed by the peritoneum, a middle or muscular, and an internal lining mucous membrane.

The Muscular coat is of a pale reddish colour, and consists of three indistinct layers of fibres. The *outer layer* consists of longitudinal and transverse fibres; the *middle layer* is the thickest, and is formed of flat fasciculi, running transversely, longitudinally, and obliquely, interwoven with each other. In this layer are the large vessels, especially veins; hence in the pregnant uterus it presents a spongy appearance. The *innermost layer* is formed by a network of fibres longitudinal, transverse, and oblique. Towards the external *os uteri* are well developed circular fibres, beneath the mucous membrane, forming the *sphincter uteri.*

The mucous lining membrane of the uterus is of a reddish white colour, and is closely connected with the muscular fibres. In it are found numerous small glands, the *uterine tubular glands* which secrete the uterine mucus. In the cervix uteri are found numerous follicles and short vesicles, forming the ovula Nabothi, which are nothing but enlarged mucous follicles.

The *Ovaries* correspond to the testes of the male subject, and contain the ova enclosed in their ovisacs, the rupture of which allows of the escape of the Ova, and forms the corpus luteum of the Graafian vesicle. The discharge of the ova may take place without coition, but they become impregnated only from the seminal fluid. The ovaries are connected to the uterus by the *ligaments*, which are impervious.

The structure of the Ovaries consists of an external lining of peritoneum, and of a firm white fibrous coat, the *tunica albuginea*, within which is the parenchyma of the organ. This is composed of ovisacs, the *Graafian vesicles*, small round sacs, $\frac{1}{4}'''$ to $3''$ in average size, and closed on all sides; their number varies from 30 to 100 in each ovary, and may extend to 200.

The *Graafian vesicle* consists of a thin membrane forming the sac, and enclosing the ovum or *ovulum*. When the vesicle bursts, the ovulum passes out surrounded by the cells of the cumulus and neighbouring parts of the epithelium. The *cell membrane*, or *vitelline membrane*, surrounds the yolk, as a clear transparent ring, whence it is called the *zona pellucida*. In mature ovula a vesicular nucleus, the *vesicula germinativa*, is found enclosing a nucleolus, the *macula germinativa*, or spot of Wagner.

The *Fallopian tube* conveys the ovum to the cavity of the uterus, with which it communicates: during coition the fimbriated extremity grasps the ovary, and receives the ovum into its cavity.

The Fallopian tubes are composed of three coats an external peritoneal, a central muscular, and an internal mucous lining membrane. At their free extremity they present an irregular appearance forming the corpus fimbriatum, in which is an opening by which the ovum is received into the cavity of the Fallopian tube, when impregnation takes place.

The Ovum descends gradually along the Fallopian tube into the cavity of the Uterus, where, in successful impregnation, numerous changes take place, for the purpose of maintaining and developing the ovum.

Impregnation can only occur, as just stated, from the contact of the seminal fluid with the discharged ovum. It has been stated by some that impregnation may be effected without actual contact with the semen, by the *aura seminalis*, or by an absorption of this fluid; but these theories cannot be supported.

The Age of Puberty appears at an earlier period in the female than in the male subject; frequently in this country at, or even before, the age of twelve. It is marked by numerous changes in the individual. The mammæ enlarge, the external form becomes developed, and the Menstrual discharge appears, accompanied by an increase of sexual desire.

The discharge of the Menstrual fluid takes place periodically, at intervals of about four weeks, but subject to some variety. Before it appears, there is an increased flow of blood to the genital organs, and an excess of sexual feelings; at this time, or immediately after the menstrual flow, impregnation is most likely to occur. This flow of blood proceeds from the lining membrane of the Uterus, and is usually accompanied and preceded by pains in and about the pelvic region, and by general constitutional disturbance.

The Menstrual fluid generally ceases to flow about the age of forty-five, but may continue for a few years longer; when it ceases, the female cannot be impregnated, although the sexual appetite may remain.

There is usually no flow during pregnancy and lactation, although its occurrence during the latter is not infrequent.

The Menstrual fluid differs from blood in being of a less consistence, of a less bright red colour, and in not coagulating.

Fœtal Development.—The changes which take place in the cavity of the Uterus, after impregnation, may be divided into those which occur before the descent of the ovum, and those which ensue after it has entered the Uterine cavity.

The descent of the impregnated ovum along the Fallopian tube generally occupies two or three days. During this period, the cavity of the Uterus becomes lined by a flocculent membrane, which closes the os uteri and the openings of the Fallopian tubes. As the ovum descends through the Fallopian tube, it receives an additional layer of albuminous matter from its lining membrane, and is surrounded by a fibrous membrane. This new envelope forms the *Chorion*, through which the subsequent nutrition of the embryo is derived. The flocculent lining of the Uterine cavity forms the *Decidua;* at first, this is a single layer, but as the ovum descends into the Uterus it pushes this membrane before it, and thus receives a covering from it: the decidua then consists of a double layer, that lining the Uterus or *decidua vera*, and that lining the ovum or *decidua reflexa*. At first, these are separated by a considerable interval, but as the embryo enlarges they approach and finally coalesce. The communication with the Fallopian tube is subsequently closed.

The ovum, having detached the decidua vera from a portion of a cavity of the Uterus, becomes adherent by the effusion of coagulable lymph, which becomes organic, and forms the *Placenta*.

At an early period, the Decidua appears to be actively employed in preparing for the nutriment of the embryo, its cellular tissue being so abundant as to form a bed into which the tufts of the Chorion are received.

The *Placenta* is the organ or body, by means of which, the embryo is to derive its future sustenance from the Mother, and soon establishes a communication with the Uterine vessels on the one hand, and the Fœtal or Umbilical vessels on the other. At first, and probably for a few months after impregnation, the Placenta forms a single mass, in which these sets of vessels communicate, but after this period they become detached so as to form the Placenta into a duplicate mass, one being the Maternal, the other the Fœtal portion of the Placenta.

Although communication must exist between these two portions of the Placenta, for the purposes of the nutrition of the Fœtus, and the oxidation or purification of its blood received through the Umbilical arteries, no vascular anastomosis can be proved to exist, by injection or otherwise, unless it may be at the very early periods of fœtal life.

The exact period of this more complete separation of the Placenta into its Maternal and Fœtal portions seems to have altogether escaped the attention of Physiologists, although a question of considerable importance, as bearing on the independence of the circulation of the latter, and the propagation of disease from the mother to the fœtus. That diseases are propagated from the mother to the fœtus, is fully established, as in Syphilitic and other affections; but there certainly appears to be a limit to this, as regards a period of fœtal existence in which the embryo is more independent of maternal circulation. That a time does exist at which this comparative independence is established, is proved from the vitality of the fœtus continuing some hours after the death of the mother, and by the non-propagation of disease contracted by the mother in the advanced periods of pregnancy. A striking analogy is thus established between the Human Placenta and that of some of the lower tribes of animals, in which the Placenta may be very easily separated, although the rudimentary structure of Man does not correspond in this, as in so many other instances, to the advanced development of the similar structure in lower animals.

The Maternal portion of the Placenta derives its vessels from the Uterine arteries, and returns its blood by the Uterine veins to the Maternal Circulation: the Fœtal portion in like manner derives its blood (in an impure state) from the Umbilical arteries of the Fœtus, and returns it (in a pure state) by the Umbilical vein to the Fœtal Circulation. The Nutrition of the Fœtus and the purification of its blood are thus effected, without a direct vascular communication, and doubtless by a process of imbibition or endosmose.

The Umbilical arteries of the fœtal portion of the Placenta terminate in minute, tortuous ramifications on its villous surface, each artery communicating with another, and with a branch of the Umbilical vein, forming a villous tuft, which not unfrequently projects into the maternal portion. The maternal vessels present a similar arrangement, their lining membrane alone separating them at their extremities from the villous tufts just described.

The essential and almost peculiar membranes of the Fœtus are the *Chorion* and *Amnion.*

The *Chorion* is a thin, delicate membrane, investing the inner surface of the decidua reflexa and the under surface of the Placenta, whence it is continued for a short distance, and is lost upon the Umbilical Cord: its outer surface presents a slightly villous appearance, and is more or less intimately connected by means of its villous tufts with the decidua reflexa and the Placenta: its formation has been already alluded to.

The *Amnion* is also an exceedingly delicate membrane: it lines the interior of the preceding, to which it adheres on its outer surface, its inner being free and in contact with the Liquor Amnii, which it secretes.

It is developed as the Chorion, and may be regarded as derived from the inner surface of the envelope which invests the ovum. Its use is to secrete the Liquor Amnii, which seems to be of service only in allowing of the motions of the fœtus, in staying its weight, and in preserving it from shocks and injuries. Some have regarded it as contributing to the nourishment of the fœtus; but this is extremely doubtful, as it possesses but little nutrient matter, being almost wholly composed of water.

Connected with the early periods of fœtal life, but lost or degenerated in the more advanced, we meet with the *Omphalo-Mesenteric vessels*, the *Umbilical Vesicle*, and the *Allantois*.

On examining the incubated egg, the yolk is found to be enclosed in a thin membrane, which sends processes into its interior, which divide it into numerous cells of small size at first, but which soon increase in calibre and diminish in number. As this process takes place, the investing membrane becomes consolidated, and forms the Germinal Membrane, or, as it has been named by Bischoff, from its being the substance from which the whole structure of the future embryo originates, the *blastodermic vesicle*.

The Germinal membrane soon becomes vascular, and from it proceed two large trunks, which enter the embryo at a point corresponding to the future Umbilicus, and form the *Omphalo-Mesenteric* or *Vitelline* vessels.

The *Umbilical vesicle* is the rudimentary Digestive Cavity, formed by a doubling in, as it were, of a fold of the Germinal Membrane: it may be detected on the umbilical cord until a late period of pregnancy.

The *Allantois* is a kind of bag which projects from the lower end of the body of the embryo, and gradually enlarges so as to nearly enclose it, the extent of its surface corresponding nearly with the extent of surface by which the Chorion is in vascular connexion with the decidua. In Man, the Allantois conveys the fœtal vessels to but one portion of the Chorion, and as the vessels increase in size, they pass directly from the fœtus to this membrane, when it ceases to form a distinct sac In its earlier state, the allantois receives the urinary secretion from the rudiments of the kidney, but when the true urinary bladder is formed, it communicates with this by a duct which generally becomes obliterated before birth, and forms the Urachus, or suspensory ligament of the bladder, although in some cases this duct has remained pervious, and served to discharge the urine from the Umbilicus.

A primitive streak, or groove, is the first indication of the future embryo. This soon enlarges, whilst its two margins are raised to form the *laminæ dorsales.* These grow towards each other, so as to enclose a cavity, the *primitive tube.* In front, this tube dilates into several vesicles, in which are deposited various parts of the cerebral substance, the Spinal Cord being laid down in its remaining cylindrical portion, on the sides of which are deposited the rudiments of the future vertebræ.

The first rudiment of the skull is in the form of a membranous capsule, which gradually merges into a cartilaginous covering, subsequently converted into bone.

The blastema adjoining the inferior surface of the skull produces a series of pairs of processes, from which the chief structures of the face and neck are formed : by degrees, the thoracic and abdominal cavities are developed from involutions of the germinal membrane. The extremities are at first absent, but subsequently project in the form of small stumps. The fingers and toes are at first united, so as to form a kind of web.

The eye is developed early, and first appears as a hollow vesicle, to which the optic nerve is attached. The labyrinth of the ear also begins as a hollow vesicle, having a handle continuous with the brain ; the nose is also developed by similar vesicles. In the advanced embryo, almost all the surface of the body is covered by a very fine down. The copious desquamation and fatty secretion of the skin result in a caseous substance, which covers many portions of the fœtal body, and is capable of protecting it, like an ointment, from the injurious action of the liquor amnii.

Peculiarities of the Fœtus.—It will not be necessary here to consider the more minute particulars which distinguish the fœtus from the adult human being, as these are generally connected with the progressive development of the several structures, and have been already treated of in the consideration of these. It is essential, however, to point out the more remarkable peculiarities attendant upon fœtal life, as they are nearly confined to this, and seldom have any office or use shortly after birth: their use being to develope a certain phase of human existence, and then to disappear from their sphere of activity.

Why we should have distinct structures in the fœtus to call into existence the future being, which are wholly unnecessary to the form they have assisted in producing, is difficult to state. It is in obedience to certain laws which influence and control the development of Animal Life, and which reign throughout the whole Animal Kingdom; nay, we might almost say, throughout the whole Creation. In obedience to these Laws, Man, the Lord of the Creation, is formed, and with him the worm that creeps upon the earth, and yields its life to the tread of his foot. Man, in the earliest stages of his existence, is as the worm; but whilst this is destined to crawl "an abject worm" upon the surface of the Earth, Man is destined to occupy a higher sphere of Existence, to occupy its summit, and bears within his first, his earliest state of existence, his worm-like structure, if not the rudiments, the elements of his higher Nature, guided in their progressive development through all the phases of animal life, to the perfection of his structure, controlled by Mysterious Laws existent in the little fluid from which he derives his animated existence, and through this back to the first dawn of created beings. Who shall unfold them? Who shall break the seal that screens them from Mortal eyes? Who shall explain their action, and lay bare their mysterious agency? This is not given to Man: his Reason will lead him so far, and no farther; and when he has arrived at the extreme, to which this will conduct him, he stands aghast at the wonders which he has disclosed, and contemplates in the distance the still more startling wonders which are shut against him for ever. All he has seen, all he has discovered, is the result of one Harmonious Action, disposed by an All-wise Providence, and ministering to the perfection of Creation—that which he may not see, and may not have disclosed to his researches, flows equally from the same Source, and influenced by the same Infinite Wisdom. The finite being cannot comprehend Infinity.

Not the least remarkable amongst the peculiarities of the Fœtus are those which are not essential to this period of life, and seem to perform no office or function in it, although they are developed at an early stage of fœtal existence, and may be found in a state of advanced formation long before the results are required.

Fœtal Circulation.—The Heart of the Fœtus is essentially a single one, as its auricles, and consequently its ventricles, are united by means of the *foramen ovale*, an oval aperture in the *septum auriculorum*, which allows of the free passage of the blood from the right to the left auricle. This opening is provided with a double valve of crescentic form, and resembiing two half doors, which close upon each other. These valves will not permit the flow of blood backwards from the left to the right auricle, as they are closed by this action.

In like manner the two great Circulating Vessels, the Aorta and Pulmonary Artery, are essentially but one vessel, as they are united by the *Ductus arteriosus*, which springs from the angle of bifurcation of the latter, and taking an arched course, joins the Arch of the Aorta on its concave side, opposite to the origin of the left subclavian artery.

If we examine the terminations of the internal iliac arteries in the pelvis, we find a remarkable disposition of these vessels. They are much larger than the external iliac, curve upwards along the sides of the bladder, and terminate in the *Umbilical Arteries*, which enter into the cord, and twist round the Umbilical vein to their termination in the Placenta.

The Umbilical vein arises in the Placenta, forms the principal vessel of the Umbilical Cord, and enters the Fœtus at the Umbilicus. It here turns upwards, and ascends, in the edge of the falciform ligament of the liver, to the longitudinal fissure of this organ, which it traverses until it arrives at the extremity of the transverse fissure: it here gives off branches to the left lobe, and divides into a right or transverse branch, and the *ductus venosus;* the right branch joins the vena porta, forming subsequently its left branch, and enters the right lobe of the liver, which it supplies; the ductus venosus traverses the rest of the longitudinal fissure, and joins the vena cava, and then empties its blood into the right auricle of the heart.

By means of the umbilical vein, as just alluded to, the pure blood from the placenta in part circulates through the liver, but its larger portion is conveyed by the ductus venosus to the right auricle of the heart. It is here joined by the blood returned through the superior and inferior venæ cavæ, and passes partly through the foramen ovale into the left auricle, and partly into the right ventricle. The two ventricles are now filled and propel the mixed blood into the aorta and pulmonary artery; but these, united by the ductus arteriosus, are as one vessel; part of the blood circulates through the pulmonary artery in the lungs, the rest circulates through the branches of the arch of the aorta in the upper part of the body, namely, the head, neck, and upper extremities, and by the descending aorta into the abdomen and lower extremities: the larger portion of this descending column, however, is returned by the umbilical arteries to the placenta, to be again purified and again returned to the fœtus by the umbilical vein.

As this theory supposes that the pure blood from the placenta is mixed with the blood of the fœtus in the right auricle, to be again circulated in the fœtal system, some have supported the theory that this admixture does not take place; but that the pure blood, conducted by the Eustachian valve, passes directly through the foramen ovale into the left auricle, thence into the left ventricle, whence it passes, by means of the branches of the arch of the aorta, into the more highly developed structures of the head, neck, and upper extremities; whilst the impure blood crosses the canal of pure blood in the right auricle, without any admixture, descends into the right ventricle, whence it passes, by the pulmonary artery, partly into the lungs, whilst the larger portion is transmitted, by the ductus arteriosus, partly into the descending aorta, to supply the lower extremities, or "less noble" parts, the larger portion being transmitted by the umbilical arteries back to the placenta.

This is named the figure-of-eight circulation; but, as it supposes that the different currents of blood pass each other without mixing, which can hardly occur, this theory is not generally received, the former theory being the more approved; but as this also contains an anomaly which can be scarcely recognised as existing—namely, that impure blood may continue to circulate in the fœtal system *ad infinitum*,—it is exposed to this most serious objection. It is highly probable that the true fœtal circulation has yet to be discovered.

It is to be remarked that in the fœtus the Umbilical vein carries the pure blood, the Umbilical arteries the impure blood. The difference between these is not as distinct as between the arterial and venous blood of the adult. In the early periods of fœtal life, the blood-cells are nucleated, more intensely coloured, and larger than the blood-corpuscles of the adult.

Immediately after birth, on the first act of Inspiration, the Single Circulation of the Fœtus becomes the double one of the warm-blooded animals. The lungs being distended, a flow of blood instantly takes place into their tissues; this returns into the left auricle and closes the valves of the foramen ovale, and consequently this opening also, in which state it remains throughout the future life of the individual, who now possesses a double heart and a double circulation.

The *Lungs* of the fœtus are well developed before birth, as being required immediately on its expulsion from the womb, although they do not perform any special function in utero. Before inspiration takes place, they are dense, of a dark mahogany colour, and sink in water. After inspiration, they become distended, assume a bright red colour, and float in water, as they contain a certain portion of atmospheric air. These alterations have been usually regarded as tests of the child having lived; but some recent facts and more careful observation prove that they are not conclusive on this point, and should be received only with much caution.

Amongst the thoracic viscera of the fœtus is found the *Thymus Gland* or *Body*. This structure appears not to be confined, as to function, to fœtal life, as it does not begin to disappear until one or two years after birth. Its use is wholly unknown, although it is found to contain a clear fluid, which is supposed to contribute to the nutrition of the fœtus and young child. The Thymus gland is composed of a number of small vesicles or tubes seated upon a central canal, the cavity of which communicates with their interior. In the adult it has degenerated into areolar tissue containing some fat.

The *Thyroid Gland*, although well developed in the fœtus, cannot be considered as one of the peculiarities of fœtal life, as it continues in adult life, and frequently enlarges, especially in the female subject.

The *Liver* is of large size in the fœtus, extending into the left hypochondrium; its right and left lobes are nearly equal. Its peculiar circulation as regards the umbilical vein has just been noticed. It doubtless assists in decarbonizing the blood of the fœtus, the lungs being inactive at this period of life, hence its larger development, the carbon being expended in the formation of the tissues of the body, and not, as in the adult, thrown off from the system.

The *Kidneys*, although but little used in fœtal life, are well developed at birth, and present a lobulated appearance, as in the ox, &c. They are surmounted by

The Supra-Renal Capsules.—These are equal in size, if not larger, than the kidneys at birth, and are still more developed, in proportion, in the earlier embryo. According to Ecker, they consist chiefly of closed tubes which lie close to each other, contain a fluid, nuclei, and a number of fine granules, and are surrounded by a dense capillary network. Their use is wholly unknown. In the adult they have degenerated into areolar tissue, and can with difficulty be recognised.

The *Testes* in the fœtus are lodged in the cavity of the abdomen beneath the kidneys, until about the seventh month, when they begin to descend toward the scrotum, in which they are usually found at birth, although the descent of one or both of them may be postponed to a later period, or suspended altogether, without an impairment of the sexual function. They are guided in their descent by a fibrous structure which stretches from their lower extremity to the spine, or tubercle of the pubes. This was first described by John Hunter, who named it, from its supposed office, the *Gubernaculum Testis.* The descent of the testes is more properly, from the position of the fœtus in utero, an ascent, and must be caused by some active agent to produce the necessary result. This office has been assigned to the cremaster muscle and to the abdominal muscles; but the change in position of these glands is more probably owing to the gradual expansion of the walls of the pelvis, acting on them through the gubernaculum testis, until at last they become exposed to the pressure of the abdominal muscles in the inguinal canal, when the movements of the infant will press them towards the scrotum.

The Wolffian bodies are bean-shaped structures, which lie in front of the kidneys and supra-renal capsules, and gradually disappear as the former enlarge. Their use is unknown.

The *Sexual Organs* are ill-devoloped at birth in both sexes, hence mistakes occur occasionally as to the sex of the infant. In some cases, an admixture of the sexes is found, constituting a species of *hermaphrodism*, but of this there is no perfect instance in the monstrosities of the human subject, the irregularities extending only to a confusion of the sexes, in which the generative function of either is destroyed. In such cases, the external characteristics of the sexes are also usually intermixed, developed mammæ being found with a beard and strong voice. It is remarkable that, in many of these cases, the sexual appetite seems equally confounded, the individual possessing this towards each sex, and not exclusively to one.

Of the Special senses, the least developed is that of Smell, and the infant, accordingly, is seldom seen to exert it, whilst those of Sight, Taste, Touch, and Hearing are in a state of constant activity. In the Eye, the pupil is closed by the membrana pupillaris, until the seventh or eighth month, when it disappears. In the lower classes of animals the continuance of this membrane after birth causes the blindness of their young for several days.

The Pregnant Uterus.—The Physiology of the Pregnant Uterus, embracing the relations which exist at the different periods of fœtal life, between the mother and fœtus, rarely receives that attention which the subject merits, if we only reflect on the important influence which it exerts on the practice of midwifery.

As so much has already been stated, in the preceding pages, respecting the Function of Generation, it will not be necessary to enter into the consideration of such points as have been treated of: it will be sufficient to give a succinct description of the Pregnant Uterus and its contents, so as to present the subject in a more distinct and compact form than may be collected from a description of each part separately.

Up to the period of delivery, the Fœtus is lodged in the Uterine cavity, floating, as it were, in a quantity of watery fluid, the Liquor Amnii; the only connexion with the mother is by means of the Umbilical cord, which is composed of the *Umbilical Vein* and the two *Umbilical Arteries*, connected by loose areolar tissue, and enclosed in a delicate cutaneous covering, which is continuous at one extremity with the amnion, and at the other with the skin of the fœtus. This cutaneous investment of the Umbilical cord scarcely merits the name of skin, as it differs so essentially from true skin, and presents an abrupt margin where it becomes continuous with the fœtal skin at the umbilicus. Its structure is little more than condensed areolar tissue, destitute of red vessels or nerves, and possessed of so little organization, that when the cord has been cut across and tied after the birth of the child, it desiccates, shrinks up to the fœtal skin, and finally drops off altogether.

The *Umbilical Vein* is usually described as being in the centre of the cord, and the Umbilical arteries as twisting round it; but the fact is that the Umbilical vein is also tortuous, and that these vessels entwine round each other. The Umbilical arteries carry the impure blood from the fœtus to the mother, the Umbilical vein returns the pure blood from the mother, to the fœtus. It must not be supposed, however, that the fœtal blood passes into the maternal system, and *vice versâ.* Notwithstanding repeated investigations, it cannot be proved that there is a direct communication between the maternal and fœtal circulations : the vessels of the latter proceed only as far as the external surface of that portion of the placenta which belongs to the fœtus, and is hence called the fœtal placenta ; whilst the vessels of the mother, or Uterine vessels, in like manner proceed again as far as the corresponding surface of the maternal placenta and there terminate.

The most minute injections cannot be made to pass from either of these systems to the other; the vessels on either side break down into extremely minute vessels, and are generally believed to terminate in the formation of *cells*, a membranous septum intervening between the maternal and fœtal system, either as a distinct membrane, or a structure common to the cells of the mother and fœtus. So distinct are the two circulations, that the placenta is frequently filled with two differently coloured injections, which meet at the point of junction or separation alluded to, but do not pass it.

The *Maternal Placenta*, or rather the Maternal portion of the placenta, is formed by the Uterine arteries which traverse the substance of the Uterus, emerge from its internal surface, enter the Placenta in branches of considerable size, and finally break down in this, as just stated. It follows from this, that the only serious hæmorrhage which can take place from the Maternal System, must arise either from rupture of the maternal portion of the placenta, or a detachment of this from the inner surface of the Uterus. Hæmorrhage may arise when the decidua vera is detached from the inner surface of the Uterus; but it is rarely of a severe character, although frequently leading to abortion. When delivery takes place, the Uterus contracts closely on the placenta, and when this is discharged, a further contraction occurs, so as to close the orifice of the uterine vessels, and prevent hæmorrhage from them.

In like manner, the fœtus will only lose blood from its own system, so that if the placenta be detached, the application of one ligature to command the fœtal circulation in the cord will be sufficient.

But the Fœtus requires to be nourished, and its impure blood has to discharge its noxious qualities, and be returned in a pure state from the maternal system. Both these objects are attained through the membranous lining of the cells, as in the process of Respiration in the adult, and of Absorption of the Chyle from the cavity of the intestines.

That this interchange of fluids does take place through the lining membrane of the cells, or *cell-wall*, is supported by analogy, by the absence of other means to accomplish these objects, and by the fact that diseases are transmitted from the mother to the child. Syphilis affords a remarkable and a melancholy example of this. Both portions of the placenta are firmly connected by the villous tufts which project from one into the other, so as to render their separation extremely difficult, if not impossible.

The *Membranes* which invest the fœtus in utero are from within outwards, the *Amnion*, *Chorion*, and *Decidua;* these have been already sufficiently described. The Amnion is the immediate investing membrane, and from its free surface exudes the Liquor Amnii, which, although considered by some to assist in the support of the fœtus, is usually regarded as of use only in sustaining the fœtus, and allowing of its motions in utero. The Chorion lies between this and the Decidua; it is, like the Amnion, an exceedingly thin membrane, and is prolonged, as this is, over the free surface of the placenta to a short distance on the Umbilical cord. The Decidua is a flocculent membrane, and consists of two layers, the Decidua vera, lining the inner surface of the Uterus, and the Decidua reflexa, which covers the outer surface of the Chorion.

Changes in the Uterus.—At each menstrual period there is an increased flow of blood to the Uterine vessels, causing the Uterus to enlarge and become looser in texture. This is attended with a congested state of the mucous membrane lining the Uterus, which becomes thickened and softer. When the menstrual discharge takes place, this fluid exudes from the capillary vessels, the epithelial lining of the body and fundus of the Uterus is for the most part thrown off, and its cells are found in large quantities mixed with the blood and mucus which fill the Uterine cavity. In difficult menstruation, portions of the mucous membrane may be detached and thrown off.

When pregnancy occurs, the Uterus becomes considerably enlarged in its cavity and external walls, the increased substance of which amounts, on an average, to twenty-four times the original bulk: this increase is progressive, until the fifth month of pregnancy, from which period a diminution usually takes place.

The chief seat of the changes, by which the increase in volume of the Uterus is effected, is in its muscular substance, although much must also be assigned to the great enlargement of the Uterine vessels. The enlargement of the muscular substance is due to the increase of the muscular elements existing, and to the new formation of similar elements. The former is so considerable, that the contractile fibre-cells are found to increase from seven to eleven times in length, and from two to five times in breadth.

Whilst the muscular coat is thus enlarging, the mucous membrane becomes thicker, softer, and more vascular, and its tubular glands increase in size. As pregnancy advances, the mucous membrane becomes more or less identified with the decidua vera, whilst that portion near the placenta joins this structure.

The Serous Membrane of the Uterus also becomes slightly thickened during pregnancy, and the ligamentum teres enlarged, and its muscular fibres further developed. The Uterine nerves also enlarge and expand, but it is doubtful whether new nerve-fibres are developed.

After delivery, the Uterus gradually diminishes to nearly its former size, the additional muscular fibres disappear, and the various structures return to their original state. It is stated by Kölliker that the mucous membrane is completely thrown off after parturition, in the form of the decidua and placenta uterina, and thus has to be entirely formed anew. This theory can hardly be reconciled with the rapidity with which impregnation so frequently takes place after delivery.

The Uterine Circulation, during pregnancy, may well be regarded as possessing a certain degree of independence of the General Circulation of the mother (although the Uterine vessels are connected with the Maternal vessels), which renders its separation from the mother an action which may be considered as necessary to the restoration of the Maternal system to the unimpregnated condition. It has been generated and developed for a special purpose, and this once attained, its continuance is no longer required, and it is cast off from the system, either in the form of blood, or of the discharges from the womb which take place after delivery. It is on this principle, only, that we can account for the great quantity of blood which is frequently lost during delivery, without making a serious impression on the mother.

This is a wise provision of Nature, as otherwise the extra quantity of blood, which must necessarily be thrown back on the Maternal System, would be productive of a plethoric condition, likely to lead to serious results.

OF OLD AGE AND DECAY.

THE contemplation of the decay of that complicated, but most perfect structure, Man, which Nature has been once so careful to construct, on which she has apparently employed the best resources of the material world, and to have exerted her own ingenuity to the utmost, is not a pleasing duty, and yet the Physiologist may derive, even from this, some sources of gratification, as he may behold, in the decay, much of that providence and solicitous care which have characterized the building-up of the fabric which is now to waste and pass away into the elements of which the Inanimate World is composed.

This decay is progressive, and does not take place equally in all structures: some begin to decline much sooner than others; and it is remarkable that those which are characterized by the possession of great physical power are the first to feel the ravages of time, whilst the more delicate structures, and those especially connected with the Intellectuality, continue not only perfect, but to increase in vigour to an advanced period of life. The muscles, bones, and blood-vessels first give way, and it is not for many years after these have given evidence of decay, that the Nervous System manifests symptoms of participating in the decline of the system.

It is impossible to assign any particular period of life at which a decline of any one structure manifests itself, as this is liable to great variety in different individuals: one will begin to decline at a very early period, another not till considerably advanced in years.

Amongst the earlier symptoms of the decay of the system is the change which takes place in the structure of the arterial system, the fibrous coat of which becomes gradually converted into patches of bone of greater or less size: this is usually preceded by an atheromatous or cheesy deposit, which gives way to the ossific matter.

This alteration first takes place in the larger vessels, as the aorta, femoral artery, but will subsequently extend to the smaller vessels, although seldom to those of less calibre than the radial or ulnar artery.

The ossific deposit, in the coats of the arteries, is sometimes very extensive, and may be recognised during life as producing a white state of the skin, with white, thin hair, often observed in advanced age.

The influence of this change on the other structures of the body is considerable, as it materially deranges the circulation of the blood in all parts, and necessarily impairs their functions. This is a source of aneurism, rupture of blood-vessels, apoplexy, &c., and causes death much more frequently than is generally imagined. To this cause may also be assigned, in many instances, the change in the colour of the hair, and baldness, which occurs so early in some persons, as the capillary circulation becomes much impaired, and, as a necessary consequence, the hairs, which are nourished exclusively by this, suffer in proportion.

The Heart, the great centre of the circulation, is less disposed to ossific deposit at an early period of life; but this also is liable to such, and more especially the aortic valves, and the left auriculo-ventricular valves, which thus add to the general derangement of the circulation. At this time, the pulse diminishes in frequency of beat, sinking as low as 40, and thus we have the circulation impaired by the effects of—1. The ossification of the arteries; 2. The alteration in the tissues of the heart and valves; 3. The diminished beat of the heart, both in power and number.

In advancing age, the bones undergo material changes: the animal matter becomes diminished, whilst the earthy matter begins to predominate. At first this produces only an increased weight of the bony skeleton, as in adult life; but in more advanced years, the earthy matter is largely in excess, whilst the animal tissues diminish considerably; hence the bones become brittle, and are easily fractured, as occurs in the neck of the thigh bone and elsewhere. In old age, the quantity of earthy matter diminishes also, and becomes expanded, so as to give to the bones a honeycomb appearance; so light do they become, that a bone of an old subject will frequently float in water.

The muscular fibres in the old subject become pale and soft, and the bellies of the muscles relaxed and flabby. This is no doubt owing to a deficit in the deposit of fibrin in the myolemma. The muscular fibres also become changed into a yellowish substance, resembling fat, named adipocere, whole muscles presenting this alteration of structure. This is frequently to be observed in the muscles of the back and lower extremities, rarely in other situations.

The tendinous portions of the muscles, in common with the other fibrous tissues, become thickened in advanced life, and are liable to ossific deposits in their substance: this renders them less resisting than in the young subject, and frequently leads to rupture, as of the tendo Achillis, from any unusual exertion, as in dancing.

The Nervous System is not *materially* affected until more advanced life, although those parts which preside over the motion and sensibility of the body participate *functionally* in the general decay of the system. The Intellectuality, as already remarked, retains it vigour to an advanced age; and although the acuteness of the intellect may be lessened, the perception will remain unimpaired, and the reasoning powers, the judgment, &c., will advance to a matured perfection rarely seen in the younger subject. Of this we have several remarkable examples in the present day: the Prime Minister of England, Lord Lyndhurst, Lord Campbell, Lord Brougham, and other eminent men of advanced age, are still distinguished by a vigour of intellect, a power of reasoning, and a depth of judgment rarely to be met with at any period of life.

The Special Senses of Sight and Hearing seem to suffer more frequently, and at an earlier period of life, than those of Taste,* Smell, or Touch. The decay of Sight is usually caused by the physical alterations which take place in the lenticular bodies of the eye, the cornea and lens, which lose their normal convexity, so as to interfere with the formation of the visual object at the proper fixed point on the retina. The defect of Hearing may be, and is, produced by a number of causes, such as mechanical obstructions affecting the meatus auditorius externus, or the Eustachian tube, a diseased state of the bones of the middle ear, or tympanum, or a defective state of the Acoustic nerve.

But the changes incidental to advanced age are not confined to the internal structures of the body: the external form alters considerably, the rounded shape of the limbs of the young subject disappears, and the muscles and bones give to the limbs especially a more irregular surface. By degrees, the muscles diminish in size, and the points of the bones in different situations become more visible. Much of this alteration in shape is owing to the absorption of the fat, or adipose tissue, from beneath the skin, and between the muscles: this substance now appears to acquire a tendency to be deposited about the internal organs, and more especially in the omentum, from which the abdomen becomes protuberant, and the individual suffers considerably in respiration and his power of progression.

Not the least remarkable of the external changes

* Is not this increased in power?

which take place in advanced age is the alteration in the curvatures of the spine, and the consequent effects of this on the condition of the lower extremities. At the earlier periods of life, the spinal column forms three graceful curves in the cervical, dorsal, and lumbar regions, by which the centre of gravity is maintained, and the equilibrium of the body preserved without difficulty; but, in advanced age, these curves are obliterated, the spine forms but one curve, convex posteriorly, concave anteriorly; the pelvis is thrown forwards, and the lumbar concavity disappears. The centre of gravity is now deranged, and the old person seeks to restore it, by bending the knees and depressing the head, the whole body presenting thus the three curves which had previously existed in the spinal column.

The Spine loses also its elasticity, the intervertebral cartilage disappears from several parts, and its place is partially supplied with bone, which is thrown out irregularly on the surface of the vertebræ, so as to connect them closely together, and destroy their mobility.

These changes in the shape of the spine, and external form, generally, in advanced life are frequently the results of debility and of certain physical alterations of structure which are incidental to an increase of years; but they are also frequently the results of bad habits, and are most observable in persons whose occupations lead to the stooping posture. That they can be resisted, if not prevented altogether, is manifest from the erect attitude of soldiers, and others who have acquired the habit of maintaining the body and limbs in as straight a position as possible.

The Physical changes which take place in advanced life lead to a corresponding change in the moral and general habits, which now occurs. The exercises and amusements which were so pleasing in youth become distasteful, and advancing Age begins to seek and enjoy a state of rest which has become congenial to his tastes and necessary to the well-being of his comparatively fragile structures. Were he still to indulge in the excesses of youth, the neck of his femur would fracture, his tendo Achillis rupture, or his aorta give way. Nature whispers to him the danger of his former pursuits, and he almost instinctively avoids them.

At the same time, his Nervous System participates in the general alterations which the more physical structures undergo. He is less easily excited, his passions are less strong, his feelings generally less acute, and he looks upon the external world rather as an observer of its actions, than as an active participator of its toils, its cares, its amusements, or its follies. One passion alone increases with age, namely, Avarice.

We have, thus, a gradual separation of Man, as he advances in age, from the surrounding world, and a corresponding preparation for that change which must take place sooner or later—a final dissolution and a separation of his structures into the elementary principles of which they were originally formed; there is nothing sudden, nothing violent, and the human frame passes away, even as it had been built up, slowly and progressively.

There is, then, no such thing, strictly speaking, as *sudden death*, except from external violence, poisons, &c. Although life appears, so frequently, to terminate suddenly, from a rupture of a blood-vessels, disease of the heart, apoplexy, or some other of the ills to which "*Humanity is Heir*," the diseased alteration, which has led to this result, has been progressing for many years, and the fatal termination is but the necessary consequence of the advance made in the diseased structure.

There is, thus, Harmony even in the decay of Nature; and Man, her noblest work, ceases to exist on earth as his existence first commenced, in obedience to Laws which work incessantly and harmoniously, and form but a portion of one *Perfect Whole.*

He must pass away; but, as a Philosopher, he will console himself with the assurance that so perfect a Whole has not been constructed, that it may grow up, and flourish, and perish without an End, without a Result; that Creation should be vain, and leave, when it has ceased to be, only a blank. Such a termination is inconsistent with the INFINITE WISDOM which has called Creation forth and Man into being.

Man perishes, but not for ever; the dissolution of his Earthly form, which only separates him from his Eternal, emancipates him from that which made him Mortal, and he dies but to live, as in the expressive language of the Ancients,

'MORS JANUA VITÆ."

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THE END.