Extracts from Animal Physics.

Synoptical view of the Economy of the Human system.

Object of animal physics — The object of animal physics embraces all that belongs to animal bodies, and their functions. In the history of the earth animated nature, as it stands pre-eminently above the rest in excellency, so does it also in the endless variety and number of the creatures that have lived and do at present live on the globe.

Limited in the present extracts to the human body. — So vast a field cannot be embraced by brief extracts such as the present and following will necessarily be. It must therfore be limited, but limited in such a manner as to comprehend as much extensiveness as possible in narrow limits. — This will be obtained by exclusively directing our attention to the structure of the human body which holds the highest place and eminently contains in itself what is found distributed among the various tribes of animated creatures. But our organization exhibits not only the most exalted specimen of nature's work, but the most copious store of knowledge also; the equal of which has been evolved in no other department of science. Hence we are compelled not only to limit the object of our extracts to the human body, but moreover to abridge e= ven this to a few leading points or princi= pal lineaments of the magnificent structure which, even when so sketched, manifests in a striking manner the Goodness and Wisdom of the Great Maker of all.

Synoptical view. To give at once a total and precise view of the subjects to be develloped in the following extracts we shall present all of them epitomized in the present one.

Skeleton -- its mechanism The animal body consists of so lids and fluids. In all the high er species the hard and compact framework is within the exterior covering, and the con= stituent solids of this framework are called <u>bones</u>; their assemblage in their natural or= der and juxtaposition is called skeleton from <u>σκελλω</u> - <u>to dry</u>.

The motion of the different parts of the skele= ton have a close analogy to those of certain parts of machinery. Thus, for example, the mo= tion of the arm upon the shoulder has a play and limits altogether similar to that produced by the ball and socket - joint, while the mo= tion of the fore - arm at the elbow is similar to that of the hinge or cradle - joint. Never= theless, although the mechanical connection of these members, has something in common with the expedients referred to, they are far from being identical with them. In machinery the moving parts are generally connected by inflexible pieces; thus, for example, the parts held together by the ball and socket-joint are firmly connected by the enclosure of the ball in a hollow spherical cavity somewhat greater than a hemisphere. In like manner two parts connected by a hinge are retained in their relative position by a rod, pin or wire passing through a hole in the common centre of the two pieces which form the joint.

Joints or articulations The joints, or as they are technically called, articulations or ligaments, with which the various parts of the skeleton are connected, are formed by certain rough, fibrous & elastic bands firmly inserted in the surface of the parts to be united, in such a manner as to allow free play to the moving parts within the prescribed limits.

Interosseous cartilage The mobility, weight and superposition of the various parts of the skeleton expose them to concussions and friction tending to gradually deteriorate their condition and even to destroy them. To protect them from the effect of concussion the expedient of interosseous cartilage is applied. In those cases where the two bones are only intended to change their relative position within small limits for the purpose of giving a certain flexibility to their combinations and the surfaces connected are on this account flat and equal in magnitude and form: a cushion of cartilage is interposed and firmly attached to both of them, so that the surfaces which it unites admit of no lateral or sliding motion. Thus the softness and elasticity of the cartilage, while it allows the bones to be inclined to each other within certain limits, in any direction; it breaks the effects of collision.

More numerous are the cases, in which a greater play being allowed to the bones, their surfaces must move with a sliding motion one upon the other. In these cases besides the indispensable appendage of ligaments and the provision to present the injurious effects of collision, those of friction also must be prevented; an effect which is obtained by two separate and independent cartilaginous coatings one attached to each osseous surface. These prevent all contact of the bones and the corresponding surfaces which move upon each other are the smooth surfaces of the cartilaginous coating & not those of the bones.

Synovia — its uses It is not enough that the interosseous coating should be endowed with the highest degree of smoothness, polish and uniformity of figure. The very perfection of these qualities combined with the force with which the joined parts are in many cases loaded, would, in the absence of friction, produce a degree of adhesion between the surfaces similar to that which takes place between two surfaces of polished metal when brought into close contact; an effect familiar to all workmen in metal and called the <u>bite</u>. Such an adhesion would obstruct and even arrest the motion of the bones. Now as in the practical construction of machinery, the obstruction arising from adhesion is removed by the lubrication of the surfaces, which form the joints with some suitable liquid or semi-liquid substance; so a similar expedient is employed for the same purpose in the animal economy. Every joint in which the surfaces move upon each other, is provided with a certain viscid, glary liquid resembling in its physical qualities the white of an egg and hence called <u>synovia</u>. This liquid is continually poured over the surface of the cartilaginous coatings, so as to produce the same effect upon them as oil, for example, does upon the axle and the box of a carriage-wheel. In fact, strictly speaking this liquid by its interposition between the cartilaginous surfaces prevents their mutual contact, and its molecules being infinitely small and infinitely smooth spherula, have the effect of the most perfect imaginable friction-rollers. By this admirable provis=

ion, therefore, the obstructions which would arise from both friction and adhesion, are removed. The apparatus by which this lubricating fluid is secreted, is called synovial membrane, which surrounds the joint on every side and extends it's beneficial effect to the surface of the connecting ligaments as well as to the cartilaginous coating of the bones.

Muscles We must not omit seeing how the various movements of which the bones are susceptible are imparted to them. The apparatus by which the motions are immediately produced, are fibrous bands and masses of flesh called muscles: the fibres which form muscles are generally ranged side by side parallel to each other. They are extended between the bones, to one or both of which they are intended to impart motion; or one end only is attached to the bone. The muscle itself is not however immediately connected with the bone. At the extremities it gradually takes the form of tendinous fibres, totally different in their physical character from the fibres of the muscle itself.

Tendons These tendinous fibres are sometimes collected into a single cord, called a tendon, which is inserted in the bone so firmly that before it can be detached from it, the bone itself would be broken. Sometimes their extremities are spread out on a line of greater or less

length, being attached to the bone along a cor=
responding line. In such cases the tendinous
connections of the muscles with the bones are
called aponeuroses.

When two bones are connected by a muscle, it
generally happens that the normal action of
the muscle is to impart motion to one only
of the two bones. In this case the bone which
it moves is to be regarded as a lever, - the point
where the tendon of the muscle is inserted being
the point of application of the power and the
point where the two bones are united being the
fulcrum. It is customary to call the point
where the tendon of the muscle is attached to
the bone to be moved, the insertion, and the
point where the other tendon is attached to
the connected bone, the origin of the muscle.
The distinction cannot however be always strict=
ly observered, as in some cases the muscle acts
indifferently in imparting motion to either bone.

Muscular power of contraction. The property by which the mus=
cles move the bones is a power
of contraction which constitutes their peculiarly
distinguishing character, since no other parts of
the animal organization participate in it.
By this power they are enabled to diminish
their dimensions measured in the direction
of their fibres; and since these fibres are ex=
tended between the origin and the insertion,

it follows that by such a contraction the tendon of the insertion is drawn towards that of the origin, and consequently the bone in which the insertion is made, is drawn towards that in which the tendon of the origin is planted. The tendon or aponeurosis has no contractile powers and may be compared to straps by the intervention of which the contractile elasticity of the muscle is conveyed to the bones.

Antagonistic and congenerate muscles The contractile force of the muscles has no reaction, that is, there is no corresponding extensible force; so that in all cases in which a bone is moved alternately in contrary directions, the action of two muscles placed on oposite sides of it, is necessary. The two muscles which thus exert opposite actions are said to be antagonistic. From the absence of the extensible force, it follows besides that a bone which is susceptible of numerous different motions relatively to that with which it is connected, must be moved by the action of as many different muscles. It frequently happens that certain motions of the bones are effected by the united action of two different muscles, which on this account are called congenerate.

Muscular tissue. When a muscle is contracted between its origin and its insertion it undergoes no real diminution of volume, since it suffers an increase of dimensions in a direction transverse to that of its contraction which is commensurable with the decrease of its dimensions in the latter direction. Muscles examined with a microscope in the process of contracting show their striæ approaching each other. These striæ are marks which cross transversely the fibres of the muscles. When the muscular tissue is submitted to a microscope of moderate magnifying power, each fibre is found to consist of a number of fasciculi all similar to the original fibre.

Voluntary and involuntary muscles. The contractible power of some of the muscles is called into action by the will, and these are called voluntary muscles. Such are those which impart motion to the principal parts of the body. But the will has no controll whatever over other muscles, which are consequently called involuntary muscles. The heart and the muscles entering into the structure of the stomach and intestines are examples of this class. These muscles, except the heart, do not present striæ. There are also some muscles which are to a certain extent subject to the will, but also act independently of it. The muscles which move the chest in respiration present examples of this class.

Animal energy and muscular action. — All muscles absorb a certain amount of animal energy by their contraction, which consequently cannot be maintained continuously without exhausting the animal power. We find accordingly that nature has so regulated the organization that all muscular action which is independent of the will is intermitting, so that the intervals of muscular repose are on the whole equal to those of muscular tension. Thus the muscles which produce the incessant motion of the heart are never in a state of tension for more than a moment.

The Blood The fluid by which bones and flesh are nourished, is the blood. Having its fountain in the heart, it is propelled from it by the strong muscular action of that organ through a system of flexible tubes called arteries, which, like the trunk and branches of a tree, are of a large calibre at their point of origin, and grow gradually less as they ramify through the system until they terminate in another set of pipes called, from their extreme minuteness capillaries. Thence the nourishing fluid passes into another system of tubes called the veins, through which it is carried back to the heart. The form and distribution of the veins is something like that of the arteries, their trunks entering the heart and their minute ramifications being connected with the capillaries. But while the blood passes in the arteries from the trunks to the branches, it passes in the veins from the branches to the trunks.

In passing from the arteries to the veins through the capillaries the blood undergoes a remarkable change in its physical qualities. Having given up its nutritious elements to the organs through which the capillaries conduct it, it is carried back by the veins to the heart to receive a fresh supply of the nutritive constituents. Its color is also visibly changed, the arterial blood being bright red, and venous blood blackish red.

Lymph and chyle. — Another system of tubes originating in all parts of the body consists, like the veins and arteries, of ramifications and trunks conducting from every part of the body, but more especially from the intestines, to the heart a fluid which in in some parts is colorless and in others whitish. This fluid is called lymph and the vessels which thus conduct it are called lymphatics; what is taken up from the intestines is termed chyle. As in the veins, the lymph flows from the branches of the lymphatics to the trunks. These trunks discharge their contents into the venous trunks at points near those at which the latter enter the heart; so that after the confluence of the lymphatics with the veins, the contents of the latter are a mixture of venous blood and lymph. The lymph contains a part of the nutritive elements by which the venous blood is renovated.

Circulation. After this mixture of blood and lymph is discharged into the cavities of the heart it is, by the muscular force of that organ, propelled to the lungs through a system of flexible pipes

called the pulmonary arteries. In the lungs this fluid mixture of blood and lymph is acted upon by the air received into them by respiration; and here it undergoes the final change by which it recovers all its nutritive qualities, & is reconverted into bright arterial blood.
After undergoing this change the blood is propelled from the lungs through another set of pipes called the pulmonary veins back to the heart, where it is received into another cavity from which it is driven as before through the arteries into the capillaries and back to the heart through the veins. Such are the phenomena which constitute what is called the <u>circulation of the blood</u>.
Respiration. Respiration is a function intimately connected with circulation. The atmospheric air drawn into the lungs in breathing penetrates into the air-cells of these organs, and there acting on the blood through the tissues, some changes of great importance take place. The oxygen of the atmosphere is absorbed and the carbonic acid with which the venous blood is charged, is liberated. This double effect produces the final change by which the blood recovers its arterial character. It is unnecessary to add that the air which we expire is charged with a quantity of carbonic acid instead of the oxygen given up. Circulation of the blood and respiration are therefore the phenomena which constitute the

proximate source of nutrition. By the first of these two processes the nutritive principles are deposited in every part of the system, and a portion of what the body rejects is received in exchange, and as the circulation of the blood imparts nutrition, so the circulation of lymph collects the nutritive principles which mixed with the blood pass to the lungs: there the noxious elements are expired and the necessary oxygen to reconstitute the nutritive power of the lymph.

Nerves. In assigning the muscular apparatus as the proximate agency to which the motions of the body are to be ascribed, we have advanced one step, but only one, to the origin of that motion. What, it may be asked, causes these muscular contractions which are themselves the cause of bodily motion? What conveys the dictates of the will with such promptitude and precision, at every moment, to any one, or to many at once, of several hundred muscles distributed throughout the body? This wonderful effect is produced by the still more wonderful apparatus of the nerves. These complicated threads, originating in the brain, diverge from it as from a centre in thousands of directions to every part of the system. Their main trunk proceeding from the back of the skull down a central perforation in the backbone, throws out on both sides through lateral orifices innumerable ramifications which

extend to every part of the body.
Every muscle receives one or several nerves, each one of which is enclosed in a sheath or covering called neurilemma. The nervous filaments thus enclosed traverse every part of the muscle in directions parallel to each other and perpendicular to the muscular fibres. Most of them pass on to other muscles and are inoperative relatively to that which gives them passage. But some terminate in the muscle, or according to opinion of some physiologists, after looping themselves upon the muscular fibres, they rejoin the filaments by which they arrived at the muscle, and thus return to the brain.
Brain. The brain is not only the origin of the nerves but it exercises upon them a power, whatever that may be, in virtue of which the nerves receive their activity, so that if the nerve be cut anywhere between the muscle and the brain, all power of the will over that muscle ceases and the member to which the muscle imparts motion becomes paralysed. It is not even necessary to cut the nerve to produce this effect. If the brain be submitted to a certain compression at the origin of the nerve, the muscles are paralysed and do not recover their activity unless the compression is removed. The manner in which the will influences the brain and the brain the nerves, are deep mysteries to the psycologist and

physiologist. The latter influences how=
=ever present a striking analogy with the Voltaic arrangement; the power of the brain over the nerves may certainly be il=
=lustrated by the power which a Voltaic battery exerts upon a conducting wire, the arrangement of the nerves also rela=
=tively to the brain is aptly exemplified by comparing it to a circuit relatively to the battery. Physical researches directed to the discovery of the influence which the brain exercises on the nerves, and of which those of Galvani have obtained great celeb=
=rity; seem to indicate a still closer con=
=nection between the nervous system in connection with the brain and the Voltaic arrangement than that of a mere simi-
-larity. Nervous cords are certainly, like metallic wires, good conductors of electricity: moreover if after paralysing a member by cutting the nerve which connects its muscle with the brain, the extremity of the nerve leading to the muscle be put in connection with a Vol=
=taic battery, the muscle will be contracted and the member will be moved in the same manner as by the action of the brain adapted by the will. Numerous experi=
=ments of this kind have been repeated

with surprising effects.

Nerves of motion and ~ nerves of sensation ~ The nerves have another function equal in physiological importance to that, in virtue of which they impart motion to the members. They are the conductors by which impressions produced in all parts of the system, whether by external or by internal causes, are transmitted to the brain, and by which the corresponding sensation is produced. Thus the optic nerves transmit to the brain luminous impressions, the acoustic nerves sonorous impressions, the olfactory nerves odoriferous impressions, and generally the nerves ramified in every part of the body transmit to the brain the affections of the different members, when by contact with other members or with external bodies or otherwise they are modified. Physiological researches have led to the interesting discovery that the nerves, which constitute the mechanism of sensibility are altogether distinct from those, which constitute the mechanism of mobility. The latter have been accordingly called the nerves of <u>motion</u> and the former the nerves of <u>sensation</u>. Notwithstanding the complete independence of these two nervous systems, so far as relates to their respective functions, they are they are often united mechanically together, so that their fibres form a single nervous cord. In such cases, however, they frequently diverge one from another, like the branches of the letter Y before arriving at the brain, so that one branch includes only the fibres of the nerve of motion, and the other only those of the nerve of sensation. If in such cases, the latter branch be cut, the organ to which the nerve is appropriated loses its sensibility, but retains all its mo=bility. If on the contrary, the other branch be cut, the organ retains its sensibility, but becomes paralysed. If in fine, both branches be cut, the organ is paralysed and rendered insensible.

Digestive apparatus --- The nutritive matter supplied by the lymphatics to the blood is eliminated from the food by an apparatus called the alimentary canal, consisting of the stomach, the liver, the intestines, the pancreas and other appendages. From the mouth, a pipe called the oesophagus conducts the food to a bag called the stomach, within the cavity of the abdomen, immediately below the heart and lungs. From this cavity a flexible pipe called the intes=tine, measuring many feet in length, proceeds, and being coiled up is packed into the lower part of the abdomen. Into this pipe, the liver sends one communication and the pancreas another. The food under-goes a succession of changes, the first of which is effected in the stomach, and in its course there are mixed with it certain juices from the liver, the pancreas and the coats of the intestine. The nutritive principle is gradually eliminated from the food in its passage through the stom-ach and the intestines. This principle, by a species of capillary action called ex-osmose penetrates the coats of the stomach and intestine, and is received into the count-less minute ramifications of the lymphatic system with which they are surrounded. But let us pass to see more in detail some of the principal subjects contained in this synoptical view.

~ The Bones and Ligaments ~

The frame work by which the softer parts of the organisation are sustained, consists, like the body, of three distinct parts; the head, the trunk and the members. — Before we speak separately of each of these parts some general observations must be premised.

Number of bones — The number of
and their growth — bones which properly belong to the general framework or skeleton is 198 when the development of the organization is complete; for distinct bones are more numerous in infancy than in youth, — in youth than in manhood, and in manhood than in old age. Bones receive in successive stages of growth accessions of constituents or of compactness, which gradually give them that hardness which constitutes the osseous character.

Their constituents — Bones consist of
and structure. — organic, that is animal, and inorganic elements, in the proportion of about 33 to 67: of the 67 parts of inorganic elements according to the analysis of Berzelius and Middleton about 51 are Phosphate of lime, between 11 and 12 Carbonate of lime, 2 fluorid of Calcium, something more than 1 of Magnesia wholly or partially in the state of phosphate, and a little more than 1 of Soda and Chlorid of Sodium. It is not agreed among Anatomists, whether these proportions are invariably the same at all periods of life or not; it is certain however that their mechanical qualities vary as has been

stated above. The structure of the bones presents besides characters admirably well adapted for the purpose of giving solidity to the frame and aptitude to resist ordi=
=nary causes of disturbance: a portion of them is more compact and hard than the rest even in the same individual bone; for example, the columnar bones of the legs which form pillars upon which the weight of the body is sustained, require and possess a corresponding degree of compactness and firmness; the temporal bone, in which the organ of hearing is mounted, is as dense and hard as mar=
=ble, whence it has been called the <u>os pe=
=trosum</u>, and on account of this quality is eminently suited to propagate to the auditory nerves the undulations of the air. In some of the bones or in some portion of them for which a certain amount of elasticity is required, their structure assumes a cartilaginous character. In others, as the bone of the elbow and that especially of the heel, for which all the tough=
=ness of a rope is required, the fibrous struct=
=ture is predominant.

The form of the bones is infinite=
=ly various, a classification however of them has been received and found

found practically convenient: it resolves the skeleton into four divisions, i.e. Long bones, Short bones, Tabular bones, and irregularly formed bones. To the first division belong the principal bones of the legs and arms; to the second the small bones of the wrist and ankle. The bones which form the roof and sides of the skull, are examples of the third. The vertebrae present examples of the last class, to which generally belong such bones as are symmetrically divided by the Median plane.

Median plane. ~ This imaginary plane passing in a vertical direction through the centre of the body, and from the middle of the front to the middle of the vertebral column, is of great use in defining the position of different organs of the body.

Compact and cancellated tissue of the bones. ~ A section of a bone at at right angles to its surface consists externally of parts, which are dense and close in texture, having a resemblance to ivory; and internally of parts, whose texture is open, reticular and cellular. Anatomists have accordingly denominated the former the compact, and the latter the cancellated tissue. This combination, which results from a gradually increased vicinity of the fibres of the same reticular texture, produces the greatest amount of strength with the least amount of weight.

Vascular apparatus of the bones and Periosteum. ~ The bones like the rest of the body need nutrition, which produces growth and repairs waste. They are accordingly provided with a vascular apparatus, consisting of a multitude of small canals, which traverse the bones longitudinally and are called Haversian canals from Havers, who first directed attention to them. These canals vary from the two-hundredth to the two-thousandth of an inch in diameter, and give passage to blood-vessels and nerves. They are surrounded by a series of concentric lamellae, between which, other canals like the Haversian, have been discovered with the assistance of microscopes of great power; which besides have detected innumerable minute canals connecting the lamellae with each other and with the central Haversian canals. This stupendous vascular apparatus of the bone is completed superficially by a membrane, which covers them, called the *perios-teum*, in which innumerable blood vessels and nerves ramify and thence pass into the bone through its superficial pores.

Adaptation for leverage

It is a principle in mechanics, the efficiency of a force, which acts upon a lever, as it is the greatest when its direction is at right angles to the lever, so it decreases indefinitely as the obliquity of that direction is increased. Now the form of a body renders it generally necessary that the muscles should be disposed on the surface of the bones, being parallel to and in almost juxtaposition with them; an easy and economical adaptation therefore, of the muscular force to impart motion to the limbs seems to be incompatible with the form of the body. But the inconvenience is removed by a simple expedient, which is otherwise rendered necessary for other mechanical purposes. The bones are usually enlarged in a considerable proportion at the joint where they form, what is called the head of the bone, the muscle being thus bound to pass over a prominence without leaving the surface of the bone is bent into a proper direction to give it greater power over the bone. In certain cases the leverage of the muscle is augmented in a greater or less degree by being inserted in the extremity of a projection issuing from the bone called a *process* or *tubercle* or *tuberosity*: the apparatus in this case becomes that of a rectangular lever.

Connections Three kinds of joints or connections are observable in the skeleton, the synarthrosis, or immoveable joints, diarthrosis, or moveable joints, and amphiarthrosis, or joints partaking of the character of both the former. Examples of immovable joints are found in the principal bones of the skull, those of movable joints in the bones of nearly all the members, and examples of the intermediate class in the bones of the vertebrale column.

The skeleton of the head. The skull is a hollow shell of a [illegible] form wider behind than before. It occupies the upper and hinder part of the head, and [illegible] below and in front the bones of the face. All this is the skeleton of the head, the larger portion of which is

The skull, extending from the summit of the nose and eyebrows to the back of the neck, and from ear to ear; there is an internal base extending nearly horizontally between the ears and backwards, from the eyebrows to the back of the neck. The brain is included within this chamber.

The Parts of the skull This shell is not however of one piece, but the bones forming the roof, sides & floor of the cranial cavity are eight in number, which in the infants head are loose and gradually become jointed and ae quire the hardness which suits their purpose. These eight bones in a completely formed skull are immovably jointed together by the first class of articulation described above: their names are _frontal_, _occipital_, _sphenoid_, _ethmoid_, two _parietal_, and two _temporal_. The frontal bone occupies the forehead and part of the temples, extending from the eye-brows and summit of the nose to the highest point of the skull: the occipital bone extends across the back of the skull and at the base of it is bent towards the neck, forming thus a part of the same base, and precisely that which rests on the summit of the vertebral column; it contains the _foramen magnum_ / through which the spinal chord passes. The front part of the basis is partly formed by the sphenoid, which laterally has its extremities, called wings, bent upwards: the wings lap over the edges of the lateral plates of the skull, binding them firmly together. The ethmoid bone, which is placed directly behind the nose and behind the cavities of the eyes forms the remaining part of the front of the base. These four bones are symmetrically divided by the median plane; the double bones parietal & temporal are symmetrically placed relatively to that plane: the first pair is placed laterally between the frontal & the occipital bones; the temporal bones are partly wedged among the other bones, which form the base of the skull, partly bent upwards like the sphenoidal wings and ending over each ear.

The sutures. The edges of these several bones, which form the exterior shell of the skull, are jointed together in a peculiar and admirable manner, so as to possess all the mechanical requisites to give security from external disturbance to the delicate organ, which it is their purpose to protect. They are partly connected in such a manner that the projecting parts of one are inserted in the indentations of the other, and these projecting parts are engaged in one another like those of two boards, which in cabinet making are dove-tailed together. This mode of connection is called true suture, the firmness of which is further secured by another arrangement. Some portions of the edges overlie alternately those of the contiguous tabular bones, and as this arrangement resembles the scales of fishes, it is accordingly called squamous suture.

Vitreous table. The interior surface of the skull differs from the exterior, the latter is tough, the former hard and brittle, called on this account vitreous table. The brittleness prevents adaptation of sutures and the parts of the interior surface are consequently united by simple apposition a sufficient connexion, which is strengthened besides by two projecting ribs, one of which extends along the middle of the head from the frontal bone to the projecting parts of the foramen magnum

and the other, which intersects the first at right angles passes across the occipital bone.
The purpose of the difference of structure of the two surfaces of the skull, or one of the purposes is to protect it from fracture and piercing.

Facial bones. The bones of the face with the exception of that of the lower jaw, are immovably articulated with each other and with those of the skull. They present five cavities leading by as many canals and foramina to the internal chamber of the skull. The two uppermost are destined for the organ of vision, the nasal cavities for the olfactory organs, the buccal cavity for the organ of taste, mastication and articulation, as well as a part of the apparatus of voice, respiration and deglutition. The cavities of the organs of audition are in the temporal bones. the structure of each one of these cavities is more advantageously examined, when each one of the organs comes under review. It will be enough to observe, that the immovable articulations of all these bones are so firm and perfect, that great exertions of anatomical and mechanical skill is required to separate them without fracture: and it is well known, that the bones of the head continue for an indefinite time to hold firmly together, when the rest of the skeleton is dissolved and even decomposed.

The lower jaw. The lower jaw, as has been observed, is the only exception of immovable bone in the head, and about this a few observations must be added. It has a horse-shoe shape, the convexity being turned towards the front of the mouth: the inner extremities are turned up towards the ears at an obtuse angle with the other parts. The upper edges of these branches called <u>rami</u> are formed into concave cavities, technically called the <u>sigmoid notches</u>. The horns of these notches nearest to the temporal bones, called <u>condile</u> are protuberances nearly hemispherical and form the joints upon which the jaw moves: they play into corresponding sockets provided in the skull with a hinge-like motion. but on account of their spherical form, besides their vertical motion, the jaw has a certain small play laterally as also forward and backward by which the summits of the teeth of the lower, can be rubbed in any direction against those of the upper jaw, so that the food between them can be treated exactly as grain between mill-stones.

The chin. It will be observed, that the external surface of the horse-shoe is inclined outwards in front of the face at a slight obtuse angle with the teeth. This form is exlusively characteristic of man. The same peculiarity, although not equally apparent is found in the upper jaw.

The trunk. After the skeleton of the head, that of the trunk follows next: it consists of three parts, the vertebral column, the thorax and the base in which the spine is implanted.

The vertebral column. The vertebral or spinal column is the pillar by which the head is sustained and it is the shaft to which the whole framework of the trunk is attached, and the remaining members of prehension and locomotion are appended to it. the spinal column therefore is the connecting link between all

Its numerous and important offices combined with great simplicity

the members and plays, the principal part in the mechanical structure of the body. It is moreover a hollow tube containing within it one of the most delicate & important organs of the body, the spinal cord which requires protection both from external disturbances and from internal injourious strain or flexure: means of exit must also be given to the thirty-one pairs of lateral nervous processes issuing from the cord. With all this it must have flexibility and freedom of play, but such as not to prove injurious to the spinal cord and nerves diverging from it, and to the innumerous blood-vessels, which enter it and issue from it. It must have elasticity in the vertical direction to intercept incidental shocks, which would otherwise be injurious to the brain. If a problem of similarly numerous & complicated conditions were proposed to the most consummate mechanician, he would pronounce the structure of such a tubular column utterly impracticable.

Its implantation and structure This admirable piece of mechanism is planted in the pelvis (a concave mass of bone extending from hip to hip) in the same manner as the mast of a vessel is fixed in the kedson. It consists of a series of ring-shaped bones one over the other, called <u>vertebrae</u> - the perforation or <u>vertebral</u> <u>canal</u> of each ring being an irregular hole approaching the circle, but the outer ring is oblong; the two rings are not concentric, but the entire of the canal is more towards the external surface, leaving thus a mass of bone nearly semicilindrical in the inside of the ring called the <u>body</u> of the vertebra, which supply the basis of mutual support.

Its flexibility and elasticity But the structure of this column requires elasticity for lateral inflexions on every side without exposing the spinal cord, and elasticity also in a vertical direction, without which the momentum of any blow or concussion on the lower part of the body would be propagated with unmitigated effect to the head.

This desired elasticity is obtained by another admirable expedient. The contiguous surfaces of the vertebrae are not in immediate contact: between the flat surfaces of the bodies are interposed thick disks of cartilaginous substances, which expand and firmly adhere to the surface of the bones, thus completely enclosing the spinal cord as if placed in a continuous tube. The disks are highly elastic, resisting and flexible and give consequently to the shaft all desirable pliability & vertical elasticity, and as this elasticity protects the head from injurious shocks, so the cartilaginous envelop protects the spinal cord from exposure.

Intervertebral foramina. Another important office of the vertebral column is to afford passage to the ramifications of the spinal cord. This is obtained through lateral notches cut in the edges of the rings, so that when two such rings are superposed, the lateral notches in the upper edge of one, coinciding with those in the lower edge, produce a lateral orifice on each side, which offer exits for the nerves. With this provision the solidity of the vertebra is preserved and the orifices, or as they are called, the intervertebral foramina are obtained.

Ligaments The intervertebral foramina however weaken somewhat the strength of the colmum, but an accessory provision of *ligaments* more than restores the requisite strength. Along the front of the column (we call front that part which has the same direction as the face), each vertebra is strapped to those, which are above and below it, by tenacious fibrous ligaments which are inserted in the middle of the convex sides of the body and stretched tightly over the edges of the intervertebral disks. To afford further strength and security, another series of similar ligamentous straps is extended over these, connecting in pairs every third vertebra, and to render assurance doubly sure, another series of similar straps, stretched over this latter, connects the body of each vertebra with that of the fourth or fifth, above or below it. This series of fibrous straps, extending over the entire length of the front of the column, is called by anatomists the *anterior common ligament* and its purpose is to resist all backward strain of the column. A similar expedient is applied to the inner surface of the bodies of the vertebrae. Each vertebra is strapped to that which is above and below it. This system of ligaments extending throughout the whole length of the vertebral canal is called the *posterior common ligament*. Its mechanical function is to resist all undue forward strain of the spine. Both these ligaments concur at the same time to impart firmness to the column.

Transverse and spinous processes. Besides the provisions already described, others are specially appropriated for the purpose of giving proportionate leverage to the muscular power applied to produce the movement of the spine, as it produces those of all the other parts of the body. From the part of the bony ring, which is behind the points, where it joins the body of the vertebra, three levers project, two lateral and one central opposite to the body of the vertebra. The two lateral levers are denominated from their direction the transverse processes, and the central lever is called the spinous process: this last is generally more or less inclined downwards. The ends of these levers are the points of insertion of various spinal muscles, which act upon the vertebra in the same manner as a mechanical power acts upon a rectangular lever.

General view of the spinal column The component vertebra which are designated according to their numerical order, counting from the highest downwards, are grouped in three classes, the cervical, dorsal & the lumbar. The first of these classes contains the first seven, the second the next twelve, and the third the last five, making in all twenty-four distinct vertebra in the adult. In infancy there are nine others, which gradually are connected together by the ossification of the intervening cartilage and form the <u>sacrum</u> and the <u>coccyx</u>. In its normal position, the vertebral column has curvatures somewhat resembling those of an Italic *f*: the change of curvature being made by, what in Geometry is called, a point of inflexion. This curvature, which imparts so much gracefulness to the human frame, is a means of protection against concussions, which, taking part in the rest of the body, would be propagated to the base of the skull. The intervertebral disks do indeed provide against this injurious effect, but not so effectually as the curved form of the spinal shaft.

Base of the spinal column The sacrum may be called the base* of the vertebral column; for, although connected with and forming part of it, yet, on account of its transverse dimensions, and chiefly on account of its steadiness, it is the immediate support of the upper part; it is firmly wedged between the <u>haunch</u> bones, the two large and irregularly-shaped bones, which form the pelvis: called also, on account of their want of similarity to any familiar object <u>ossa innominata</u>. The same bones protruding laterally form the hips.

The Atlas and the Axis. The uppermost or first vertebra, on account of its being the immediate support of the head is called the Atlas. It differs from the others having no semicylindrically formed body in front, the space, which such a body fills in the inferior vertebrae being cut open, so as to enlarge towards the front the aperture enclosed by the ring. The spinous process is also wanting. The reason for which the semi-cylindrical body is cut open, is, in order to allow the introduction of the odontoid process, a continuation of the semi-cylindrical body of the second vertebra, which on this account differs likewise from the others. The odontoid process is a pivot, on which the first vertebra, which immediately supports the head, turns. For this reason the vertebra, to which it belongs, is called the Axis.

Thorax. The twelve dorsal vertebrae besides the various offices they have in common with the others, are the supporters of the thorax, a bony cage, intended for the protection of the lungs and of the heart. It consists of three parts, the dorsal vertebra themselves, the sternum and ribs. Each of the twelve vertebrae is articulated and tied by ligaments to two ribs, which consequently are twenty-four in number. The ribs are divided into three classes, true, false and floating ribs: but all of them terminate in front in cartilaginous straps, by which the first fourteen, counting downwards, are connected with the sternum or breastbone and these are the true ribs. The eight following, improperly called false ribs do not extend across the chest each being connected with the cartilage of the rib above it. The last two, which are also included in the number of false ribs, on account, however, of being unattached to the others, are called floating ribs.

This structure of the thorax, produced by the combination of the slightly movable articulations of the ribs with the vertebra, called by anatomists amphiarthresis, and the flexible cartilaginous extremities on the side of the sternum, is admirably adapted for the functions of the chest. While the great vital organs of circulation & respiration, included within the thorax, have adequate protection, the structure, here described, accommodates itself perfectly to the never-ceasing mechanical action resembling the opening and closing of the boards of a bellows, by which respiration is maintained. In their normal position, the oval rings, formed by the ribs are inclined downwards from the vertebra; but when for the purpose of inflating the lungs, the capacity of the chest must be enlarged, the ribs genrally and more especially the false ribs, are drawn upwards, by which the oval rings are rendered more horizontal. When on the contrary the air, which has inflated the lungs, is expired, the same bony rings are pressed downwards to their extreme limits, so as to diminish the capacity of the chest. In this manner with every inspiration & expiration in the act of breathing, the ribs are moved alternately upwards & downwards, with an oscillating motion upon their articulations with the vertebrae; & the perfection of the mechanism by which this is accomplished, & that by which it has a selfrestoring power, will be understood, when it is considered, that its action is maintained without intermission being repeated thirty or forty times per minute for a man's whole lifetime.

The members of locomotion and prehension

The last section of bones which complete the skeleton are the members of locomotion and prehension. The members of prehension are connected with the upper part of the thorax, one on each side: they consist of three principal parts, the scapula, the arm & the hand. The scapula popularly called the shoulderblade is attached to the ribs on the side of the vertebral column and adapted for the support of

The scapula and clavicle

the arm. It is a large flat triangularly-shaped bone, so situated, as to give to the external corner of the back an angular appearance. The external & superior corner of the scapula is connected with the summit of the sternum through a slender cylindrical bone articulated with both. The chief purpose of this bone, called clavicle, & commonly the collar-bone, is to keep at a fixed distance, asunder the scapula & sternum, & thus it gives free play to the arms & protects the ribs.

The arm and fore-arm

The arm is composed of two sections, the upper one of which consists of one bone called the humerus, vulgarly the arm; the lower, called the fore-arm consists of two bones of nearly equal length, called the ulna & radius. At the external corner of the scapula is found a shallow spherical cavity, called the glenoid cavity, corresponding in form with the head of the humerus which is articulated with it and retained by proper ligaments, which leave nevertheless full freedom of motion. The humerus extends from the glenoid cavity to the elbow: it is an irregular cylindrical bone, the upper extremity of which is turned towards the scapula, & fills its cavity. The humerus, by this joint is capable of taking any position within the limits of an extensive

... having its vertex in the joint. ... is a bone that has a greater play than any other member of the body. The lower end of the humerus is formed into two semicircular pieces called condiles with flat and parallel sides, somewhat resembling those of the ends at which the legs of a compass are united. This extremity is articulated with the superior extremities or heads of the radius and ulna, which have a corresponding form. The radius and the ulna are placed in juxta-position and connected together by a strong fibrous membrane throughout their whole length, and by ligaments at either end. At the lower end of the radius is an enlargement to receive the articulations of the wrist to which the hand is appended. The connection of the radius with the ulna is such, that they are capable of revolving around one another, imparting thus a similar motion to the hand.

The wrist and the hand. —

The wrist consists of eight small bones ranged in two rows one above the other, and so placed as to surround and protect the blood-vessels and nerves which pass from the arm to the hand. Combined with the ligaments, they form a strong short tube, which bears great external force without being compressed. Although each of these bones has a limited mobility in relation to the adjacent ones, their combination gives to the hand the freedom upon the wrist, which is rendered manifest in the countless examples of manipulation. The constituent parts of the skeleton of the hand are the metacarpus and fingers. The first is composed of a range of long thin bones articulated with the wrist-bones, four of which are placed parallel and in juxta-position; they are connected by ligaments at the knuckles, having very little independent motion and form the framework of the palm and back of the hand. The fingers are articulated to these bones. The first bone of the metacarpus has more play, and is inclined more towards the palm of the hand. At its extremity the thumb is articulated in such a position, that it can at will be brought in opposition to each of the fingers, a faculty of the highest importance in all processes of manipulation. It may be remarked that the several levers, by the combination of which, the skeleton of the arm from the socket of the scapula to the extremity of the fingers is formed, diminish progressively in length. The humerus is longer than the fore-arm, the fore-arm than the metacarpus, the metacarpus than the phalanges and each phalanx than that which succeedes it. By this arrangement the humerus makes as it were, the first rough approach to the object of prehension. The fore-arm by its inflexion on the humerus, comes nearer to it; the hand revolving and the phalanges with motions successively smaller and nicer, are brought nearer and nearer the object until it is seized.

The leg and foot. – Between the members of prehension and those of locomotion, there are obvious analogies. Thus the hip and the shoulder, the knee and the elbow, the ankle and the wrist, severally present resemblances of structure, which are strikingly apparent. But on the other hand there are differences between them, which are no less striking. Thus the socket of the scapula is extremely shallow, giving consequently a very wide play to the humerus; the corres=ponding socket of the haunch or hip-bone is deep looking obliquely downwards and fit to receive the spherical head of the femur, the longest and largest bone of the skeleton. The character of this joint is mani=festly that of the ball and socket, and although it does not give to the femur the same exten=sive play of the humerus, which is not needed, it gives to it the firmness and stability neces=sary to render the legs a secure support for the incumbent weight of the body. To add to this firmness the hip-joint, besides the ligaments and other fibrous coverings, similar to those which connect the humerus with the scapula: it has an additional ligament, called the cotyloid, which is a fibrous ring surrounding the edge of the spherical socket increasing its depth. The skeleton from the knee to the ankle, to which the appellation of leg is particularly applied, consists like the fore-arm of two bones placed parallel to each other. The one much thicker than the other is called the tibia, the other the fibula or occasionally the peronea. The foot consists of three principal parts; the tarsus or upper instep, extending from the ankle to

the inflexion, where the foot turns hori-
zontally: the <u>metatarsus</u> or lower instep,
extending from the inflexion to the origin
of the toes, the bones of which, like those
of the fingers are called phalanges. The up
per bone of the tarsus, which forms the
ankle-joint is pulley-shaped and has
the motion of a hinge: it is called <u>astra-
loges</u>. Six other bones are placed under
and around it, the principal one of whic[h]
is that of the heel, another is placed a
little in front and the four others are pla[ced]
between this and the five metatarsal bon[es]
which extend to the [or]igin of the toes.

The form of [the] foot and its pos[i]
tion is admirably adapted to the suppor[t]
and locomotion of the body, and by the
combined effect of the ankle, knee and
hip joints, the centre of gravity of the bo[dy]
in the act of running or walking, adva[n]
ces forward in a line nearly horizon[tal].
Many other mechanical observations
might be added with regard to the foo[t]
as well as with regard to all the other
limbs of the human skeleton. But th[ose]
which we have made, deficient as they a[re]
suffice to impress the mind with the [i]
dea of its exquisite structure in a sim[p]
ly mechanical point of view.

Muscles.

In the animal economy no organs occupy as large a space as the muscles. They constitute nearly the whole of what is commonly called *flesh*, being that part of the animal, which when used as food, is distinguished from the fatty parts by the term *lean*.

We have already said how the muscular structure consists of fibrous bands ending in tendons, and how these bands possess the characteristic power of contraction, which is the immediate cause of the voluntary and involuntary movements of the body. A few more observations will suffice here.

The muscles are a statical as well as a dynamical apparatus.

First, we must remark that the muscular system is not a mere apparatus for the production of motion, but muscles are in a state of statical action, and even more habitually than in that of dynamical action. It is commonly admitted that the nerves, ~~in~~dependent of the will, maintain a constant action over the muscles, and the power of the will consists in either augmenting or diminishing the intensity of this action within certain limits either for dynamical or for statical effects. All this is rendered manifest by observing that no position of the body can be found while we are awake, however stationary it may be, in which innumerable voluntary muscles are not in a state of statical action. If we stand erect, the muscles which hold the lower members in a state of extension and those which support the spine and head in the erect position, must be in a state of voluntary tension. If we sit with the back unsupported, the same will be true of the vertebral column and the head. To prove that this is the case, it is enough to observe that the moment the control of the will is suspended by sleep all the joints become relaxed, the knees and hips sink, the spine bends forward, and the chin falls upon the breast. Another evidence of the same fact is taken from the sense of fatigue and exhaustion, which attends the static no less than the dynamical condition of the body.

Number of the muscles: Considering the infinite variety of motion of which all the parts of the body are susceptible, we may infer that they must be numerous. We accordingly find them variously estimated by different authorities. The medium of the various estimates in round numbers is 400.

Their classification and nomenclature. Muscles are named and classed either from their form, their position, or their action. Thus we have the <u>deltoid</u>, <u>dentylic</u>, <u>rhomboidal</u>, <u>square</u> <u>triangular</u>, <u>scalem</u>, <u>long</u>, <u>oblique</u> &c...., all which terms explain themselves, being obviously taken from the approximate form of the muscle. Then we have them named according to the region of the body in which they are placed: those of the face being called the <u>facial</u>, those of the neck <u>cervical</u>, of the arms <u>brachial</u> &c.. But the most important principle in the muscular nomenclature is that which depends on the action of the muscles. The muscle by whose contraction the effect of bending a limb is produced is called the <u>flexor</u>, and that which produces the effect of extending the limbs in a straight line is called the <u>extensor</u>. The muscle which moves the arm from the trunk is called <u>abductor</u>, and that which moves it to the trunk <u>adductor</u>. A muscle which lowers a member is called a <u>depressor</u>, and one, which raises it an <u>elevator</u>. A muscle which expands is called a <u>dilator</u>, and one which compresses a <u>compressor</u> &c.

Muscles act on the softer parts of the system. We have so far regarded the muscles as agents by which bones are moved; their power is, however, equally extended to the softer part of the system, on which their play is no less important, than on the members of the skeleton. Thus this dynamical apparatus affects the whole structure of the body, the interval cavities of the trunk, the skeleton and the external parts.

Their admirable mechanism.

It is a wonderful mechanism, whether we consider the countless effects, which it is capable of producing, or the limited space, to which the complicated system is confined. Muscles are everywhere on the trunk and around the members, superposed in layers, the number of which is determined according to the proportion which their number and magnitude bears to the superficial extent of the parts, over which they are distributed. The number of layers varies in different regions of the body from one to six. To appreciate still better the infinite superiority of the muscular system over all artificial contrivances of human invention, let us observe, that not only each voluntary muscle is subject to the command of the will, but in many cases, different sets of fibres of the same muscle may be called into action at its dictates separately or successively: and that, to produce a single motion, the combined action of many muscles is often required, the intensity of their forces being so nicely proportioned, that the motion or vigor to be imparted is the exact mechanical resultant of the same forces. The promptitude also, with which springs so various receive and execute the dictates of the will, cannot fail to excite admiration.

Examples. Following the division of the body into the head, the trunk and the members, which we have adopted in the descriptions of the skeleton, we should now severally examine the office, the form and the adaption of the muscles distributed among these different regions of the body. But the exposition of the muscular system, even as rapid as the preceding one of the skeleton would be too voluminous and unnecessary for our purposes. It will be enough, to mention a few examples.

Facial muscles. The face presents a group of them, as the various and numerous effects, including the play of the most important organs, clearly evince. An apparatus of about seventy pairs of muscles, spread over the head, face and neck, is appropriated to the purpose of imparting to the tegumentary covering of the forehead and skull, to the eyes, eyebrows and eyelids, to the nose and nostrils, to the cheeks and temporal integuments, to the lips and chin, the motions of which they are severally susceptible, and which give expression to the endless varieties of sentiment, passions and mental emotions, having in each individual, characters so peculiar, as to afford means of his immediate identification and to distinguish him from all others. A stratum of five or six muscles of considerable surface but little thickness, covers the entire surface of the head from the brows to the back of the neck, called, according to their local positions occipital, frontal and auricular, the action of which is to move the scalp with the hair, the ears, the integuments of the forehead and temples and the brows. By their contraction the eyebrows are drawn upwards, the skin of the forehead is thrown into transverse folds and wrinkles, the scalp and hair move backwards and forwards, and the features thereby are made to express various and often opposite emotions. Joy, surprise and astonishment are attended with or expressed by a certain elevation of the brows.

The eyes and eyelids with their appendages are moved by other muscles, of which, however, one only, called the orbicular is superficially visible. These muscles, besides governing the entire play of the eyeball and eyelids, the flow and suppression of tears, they combine with the muscles above mentioned in effecting the gestures of the brows in the expression of anger and menace as also in those of love, grief, satisfaction and anguish. One of the most voluminous muscles called the masseters aided by another, is appropriated to the motion of the lower jaw. The motion is subject, in the act of masticatiation, to a greater amount of resistence, than any other facial gesture.

Brachial muscles. The double muscles which extend along the front of the humerus from the shoulder to the elbow, is called the biceps, from having two origins, which are not far removed from each other upon the scapula. The common tendon of the biceps commences a little above the hollow of the arm and passing under the muscles of the forearm is inserted in a small process issuing from the radius. Immediately within the upper part of the biceps is another muscle called the brachialis anticus, which extends along the lower half of the arm. Its origin is in the front of the humerus, below the deltoid and passing before the bend of the elbow, it is inserted in a process of the ulna. Thus while the biceps acts upon the radius, the internal brachial muscle controls the ulna. Only one muscle, called the triceps cubiti, lies upon the back of the humerus. As its name implies it has three heads or origins, one attached to the border of the scapula immediately below the cavity of the shoulder-joint, a second is attached to the external & upper surface of the humerus, the third to the opposite upper part of the same humerus. The lower extremity of this muscle is attached to the part of the muscle called olecranon, which projecting from its upper end, forms the point of the elbow.

The muscles of the fore-arm are necessarily numerous and complicated, having under their control the numerous motions of the hand upon the wrist, a considerable share in those of the fingers, and in certain cases producing the flection and extension of the fore-arm on the elbow-joint, in which case they cooperate with the corresponding muscles of the humerus. These muscles are nineteen in number: their bodies or bellies, as they are technically called, being placed chiefly in the upper half, give that peculiar tapering or fusiform shape, with which every one is familiar. These muscles terminate above in single tendons, which are attached either to the humerus, a little above the elbow, or to one or other of the bones of the fore-arm a little below it, but chiefly to the former, with which thirteen of them are connected. The bodies of these muscles terminate at a considerable distance above the wrist, hence the lower tendons, which descend to the wrist, and more yet those, which descend to the hand and fingers, are very long. From such an arrangement it appears that the force of the brachial muscle transmitted along their tendons to the various parts of the hand in which they are inserted, would cause them to separate from it, when the hand is inclined towards the arm and to take the direction of the base of a triangle, of which the hand would be one side, and the arm the other, forcing thus the integument of the wrist outwards from its natural position. But this does not happen, for two semicircular ligaments called the _anterior_ and _posterior_ annular _ligaments_ surround the wrist outside the tendons. These two ligaments form a powerful bracelet, by which the numerous tendons running from the brachial muscles to the hand, are bound to the wrist, whatever position the hand may assume. Besides the motion imparted to the hand by the brachial muscles, there is another system of muscles established on the palm of the hand, which are more especially appropriated to the motion of the thumb and fingers. Four of these, which form what is called the ball, are appropriated to the motion of the thumb: some others, which form the thick, fleshy part or mass on the inner board of the hand, are appropriated to the motion of the little finger. The chief part of the muscles, which move the other fingers are the brachial muscles; there are however interosseus muscles: which lie between the metacarpal bones, the action of which is to open and close the fingers, and which also have some slight effect in inflecting them upon the palm. The annular ligaments, which retain the tendons upon the wrist, are only a part of a more extensive system of membranous binding, enveloping generally the muscles & their tendons. Thus the tendons of the brachial muscles, after passing within the annular ligament of the wrist, are confined on the hand and fingers by ligaments which retain them in their position.

Nervous System.

The nerves, as we have already observed, are the primary agents in the motion of the limbs: it is in fact through their action, that muscles are contracted and relaxed.

The nervous system has besides another office to perform, that of transmitting to a common centre the sensations, which we are accustomed to refer to the different parts of the body. We may say, that the nervous system is like a connecting link between the faculties of the soul and the body in as much as through them the spirit infuses, its virtue into the bo-y in every possible way, dependently as well as independently of the will: through the nerves also it receives from the body and from every external thing capable of affecting the organs, all kinds of impression, which upon reaching, we may say, the spirit, and passing from the body to the soul, are themselves transformed from the corporeal to the spiritual condition, from the inanimate state to that of life which is the life of the soul itself.

If the framework or skeleton of the body and the muscular system present so many ad-mirable qualities, as we have seen; yet those presented by the nervous system must be ex-pected to be greater, and so in fact they are, a circumstance, which renders a synoptical exposition of the nervous system a difficult task.

Two parts of the nervous system. In man the nervous apparatus consists of two parts, which though not altogether independent of each other, are so distinct in their functions, that it is convenient to explain them separately. The first is denominated the cerebro-spinal and the second the ganglionic system, or great sympathetic nerve. The former presides over the functions of sensation and volition, the latter over those of nutrition and circulation. Each system consists of central and circumferential parts; central, from which the nervous influence diverges to the circumferential, and circumferential, from which it converges to the central parts. The central parts consist of masses, more or less considerable, collected in certain regions of the organism; the circumferential or radiating parts consist of innumerable cords, called nerves, issuing in trunks from the central parts and dividing into innumerable ramifications, which becoming more minute, as their number increases, are spread over all the organs of the body.

The same two parts of the nervous system have been denominated sometimes from their respecting functions the nervous system of organic life and the nervous system of animal life.

Cerebro-spinal system. The central part of this system is a soft mass of whitish and grayish matter, differently disposed in different parts, in the cavities of the skull and in the vertebral canal. That part, which occupies the skull is called the *encephalon*, from 'εγκέφαλος (in the head); the part in the vertebral canal is called the *spinal cord* or *spinal marrow*.

The encephalon. The encephalon consists of several distinct parts, differing in form, substance and function; the principal are the *cerebrum* the *cerebellum* and the *medulla oblongata*. The first of these principal parts, which is well known under the appellation of brain, constitutes by far the largest portion of the encephalic mass, extending over the entire skull.

The cerebellum is cased immediately below the hind part of the cerebrum; but a fold of a membrane, to be mentioned hereafter, intervenes between them. The medulla oblongata is the origin of the spinal cord, connected through *peduncles* or stalks with the cerebrum and the cerebellum. That is to say, the connection between the cerebrum and the medulla oblongata is made by two peduncles, which diverge from each other upwards: three pairs of peduncles issue also from the cerebellum, one directed upwards to the cerebrum, another downwards to the medulla oblongata and the third forward called the *pons Varolii*.

Besides the above mentioned principal parts, the encephalon contains other parts of a complicated and admirable structure. The *corpus callosum* forms the roof of a cavity, which contains the corpus striatum, the Thenia semicircularis, and other structures. It is divided into two compartments, the upper and the lower, the former of which is again divided into two by a vertical longitudinal partition, which coincides with the median plane and is called the septum lucidum. The two chambers into which the septum lucidum divides the upper compartment are called lateral ventricles, the chamber below the horizontal partition being called the third ventricle, between which and the upper compartment there is a remarkable structure called the velum interpositum or choroid web. But it is sufficient to have mentioned some of the structures of the encephalic cavity; a detailed description and explanation of their probable object requires much more space, than is compatible with a simple extract. A few more remarks may be added relatively to the three principal parts of the organ.

Description of the brain. The brain, or cerebrum is divided at its superior surface by a fissure extending along the middle of the head in the median plane. This channel, which commences at the lower part of the forehead and terminates a little above the nape of the neck is called the longitudinal fissure. The two symmetrical parts, into which it divides the cerebrum are called hemispheres.

The cerebrum consists of a multitude of

large vermiform convolutions having the appearance of coils of thick vermicelli, gathered up confusedly together

Lobes. Anatomists have divided each of the cerebral hemispheres into parts called lobes. The anterior lobe is limited by a curved fissure, concave backwards, called the sylvian fissure; the other lobe extends from this fissure backwards to the limit of the cerebrum. This second lobe is subdivided by some anatomists into two sections. The depressions by which the convolutions of the lobes are separated, are called anfractuosities, but English anatomists call them sulci or grooves.

The substance composing the cerebrum consists of white matter internally, coated externally by a thin layer of grayish matter which has been called the cortical matter, from its relation to the white matter, being analogous to that of the bark of a tree to the wood within it.

Description of the cerebellum and the medulla oblongata. The structure and substance of the cerebellum differ from those of the cerebrum. It is not formed into convolutions, but laminated and foliated like the leaves of a book. On making a section of the cerebellum in the direction of the median plane, a remarkable internal structure is presented, called from its peculiar appearance the arbor vitae. This is produced by the extension of processes of white mattie from the centre into the laminae, which consist of gray matter. The medulla oblongata presents the form of cords: its structure does not differ from that of the spinal cord, nay it forms part of the spinal cord itself.

The cerebro - The nervous matter composing spinal cord. The cerebro spinal axis, besides the protection it receives from the bony casing in which it is deposited, is enveloped within this casing, by three membranous coats, placed one within the other and called the <u>dura mater</u>, the <u>arachnoid</u> and the <u>pia mater</u>.

Dura mater. The dura mater, which is the external coat, is a strong, thick fibrous membrane. It adheres in many places to the inner surface of the cranial bones and descends in folds into the fissures, which separate the larger divisions of the cerebral matter, thus forming between them a partition which prevents their displacement and protects them from any undue mutual pressure, which might attend the ever-varying position of the body and its members.

Aracnnoid The arachnoid, from ἀράχνη (spider), or cobweb membrane so called from its resemblance to a spider's web in its texture, is the second coating. Part of it is in immediate contact with, and inseparable from the dura mater. A space intervenes between the arachnoid and the pia mater, filled with a liquid called the <u>cerebro-</u>

spinal fluid, which submitted to analysis by Mr Lassaigne was found to consist of 98½ per cent. of water combined with 0,8 per cent. of common salt and chloride of potassium, with very small proportions of osmazome, albumen, phosphate of lime and carbonate of soda. The use of this fluid, whether secreted by the arachnoid or the pia mater is to prevent the injurious contact, friction and pressure which might attend the changes of position consequent upon the flexibility of the vertebral column and the mobility of the head.

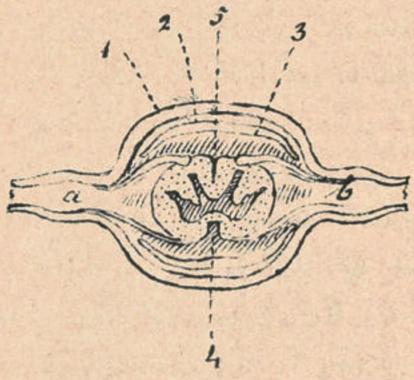
Pia mater. The pia mater, in immediate contact with the nervous matter is a cellular web, having but little consistency, in which an infinity of minute and tortuous blood-vessels are ramified and interlaced in a thousand different directions. One of the uses of this envelop is supposed to be to moderate the force with which the blood is propelled through the delicate cerebral structure. It would seem to act after the manner of a break-water.

Spinal cord. The continuation of the medulla oblongata, after its passage into the vertebral canal, through the foramen magnum, receives the name of spinal cord, which divested of its sheaths and nervous appendages is a rod of cerebral matter descending through the canal to about two thirds of its entire length and terminating in a point. Its transverse section is generally circular and in certain parts slightly elliptical, the larger axis being directed right and left. The cord is traversed longitudinally by several fissures which show that it consists of several distinct cords combining and adhering so as to form a single one.

Nerves. All the nerves of the cerebro-spinal axis diverge from the encephalon and the spinal cord; they are on either side of the axis perfectly similar and symmetrical, a similarity and a symmetry, which may be easily foreseen from the two sections of the body, right and left to the median plane. Anatomists have agreed to name them according to the numerical order of their roots upon the axis, commencing from the summit of the head downwards. Thus the first pair are those, which issue from the summit of the axis and are called olfactory nerves, because they go to the organ of smelling. The next pair in descending order are the optic nerves &c.

Of forty-three pairs of nerves, which issue thus from the cerebro-spinal axis, twelve have their roots in the encephalon and issue to their respective organs through holes properly placed in the bony case of the brain: The other thirty-one issue from the intervertebral foramina, already described, in the spinal column. The twelve which issue from the encephalon are called *cranial*, and the others *spinal nerves*.

Spinal nerves. The annexed figure shows a transverse section of the cord and its envelops made at a point, where a pair of nerves issues from it. 1 represents the dura mater, 2 and 3 the external and internal folds of the arachnoid. The spinal cord itself is in the centre of the figure. It has a median fissure 4 on the anterior side & a deeper one 5 on the opposite side.

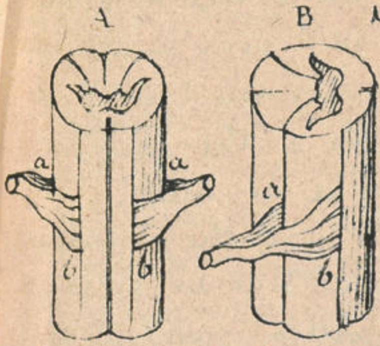


The substance of the cord consists of white and gray matter, but contrary to their arrangement in the brain, the white matter is exterior and the gray interior. The form of the section of the gray matter is shown by the [illegible] part of the cord; it is much less than the white matter. The space between the internal fold of the arachnoid and the pia mater immediately at contact with the cord is filled with the cerebral fluid, already described.

The spinal nerves which issue, as we have said, in pairs, one from each side, a & b of

the spinal [illegible] each two roots are em-
planted in [illegible] issues lateral to
+ and another [illegible] opposite is-
sues lateral to 5, the two [illegible] approach-
ing each other unite to form the nerve
which issues cased in a continuation of
the dura mater through the lateral pass
of the bony envelope provided for its exit.

The manner in which the spinal
nerves are connected with the cord may be
illustrated also by the annexed diagrams A and B, the first of which represents a front + the second a lateral view of a section of the cord. The fibres constituting the larger and posterior root a are the nerves of sensation, while those which constitute the lesser and anterior root b are the nerves of motion.



The series of nerves thus issuing from the spine are grouped by anatomists in four classes, cervical nerves, dorsal nerves, lumbar nerves, and sacral nerves.

[illegible] Nerves generally, whatever be their apparent origin, pass through the system in ramification more or less complicated, and, like electrive wires, discharge

ir functions of motion or sensibility only
their extremities. The nervous cords are thus
ject to endless divisions and subdivisions
til they become at length so infinitely mi:
te as in many cases to escape all obser:
ion, even by the aid of the microscope.
ce each fibre has its own peculiar desti-
tion and special function and this desti:
ion and function is in relation with the
ain, we infer that the various ramifica=
s in successively uniting together as they
roach their origin can never be deprived
heir proper functions nor lose their indi-
uality. In the coalition of the nervous
its there can therefore be no actual mix-
e of nervous substance and the individu-
fibres must be ranged side by side
mechanical juxtaposition, without an
more intimate union. This conclusion
confirmed by direct observation Each
vous cord is ascertained to be a bundle
fibres as represented in the annexed fi-

gure enclosed in a com-
mon sheath, the sub=
ordinate fibres are also
ked funiculi and independently of the com-
on sheath or neurilemma each particu=
r component part has a sheath of its
wn. All these sheaths are composed of

the same fibrous tissue which appears
be nothing more than a continuation of
tissue which constitutes the [illegible] membra
sheath of the spinal cord.
Fontana remarks and Purkinje main
that each of the constituent fibres of a
is cylindrical and formed of two conc
tric tubes. The central tube consisting
peculiar membrane transparent and ho
mous, contains a whitish oleaginous hu
while the exterior tube is formed of a c
substance.
Ehrenberg and the most eminent mi
graphers maintain that there are tw
ers of primitive nervous tubes, which t
nominate _varicose_ & _cylindrical_. The
cose tubes consist of a series of altern
enlargements and contractions, whence
are sometimes called _articulated_ tubes
contain a peculiar transparent liquid,
these physiologists call the _nervous flu_
diameter of these tubes varies from the
to the 8/000th of an inch. They are smal
they pass from the centre to the exterior
of the brain, so that their nodosity is
be visible in the grey part of the cereb
matter. They are found more particularly in
the nerves of special sensation and in the
medullo-cephalic axis. The [illegible] tubes

are, as their name implies, uniform in diameter and show no alternate enlargements & contraction like the former. They are filled with a white, viscid and imperfectly transparent liquid, which flows out readily in globules. They are met with more especially in the nerves of the cerebro-spinal system, in those of sensation as well as those of motion. According to Dr. Vandt the fibres of the nerves of sensation are much thinner than those of motion.

Excitability and senses. Owing to the fact that the nerves endowed with sensibility are different from and independent of those endowed with excitability or aptitude to impart motion, two different subjects present themselves to our investigation connected with the two different qualities. However before we proceed to this investigation some phenomena developed in experimental researches must be mentioned as they demonstrate the difference of the nerves of sensation from the nerves of motion.

If the nerve which connects any member of an animal with the cerebro-spinal axis be denuded at any point of it's course and be submitted to mechanical irritation two effects will immediately ensue: the animal will exhibit unequivocal signs of pain, and the member with which the nerve is connected will be agitated with convulsive motion. In this case the irritating agent stays at once the part of the will on the nerves of motion and of the sense in exciting the nerves of sensation. The excitation of the former descends from the point irritated to the member moved and the impression on the latter descends from the same point to the nervous centre. But the difference between the nerves of sensation and those of motion is rendered manifest by the phenomena already mentioned in the synoptical view, that if one of the two branches into which a single nervous cord be cut before it reaches the brain, the nerve cut loses its sensibility and retains all its mobility or vice versa. This convincing proof is corroborated by other facts which also show that the brain is the centre of excitability and sensation. Thus if a ligature be placed on the nervous cord it will interrupt the propagation of both excitability and sensibility, and if the nerve be irritated below the ligature the excitation will descend to the member and produce, as before, the convulsive motion, but no pain whatever will be manifested. If the nerve be irritated above the ligature the propagation of excitation on the nerve of motion will be stopped, but the manifestation of pain will take place.

Excitability. The excitability of the nerves the power of which resides in the brain is veins as we have said, a deep mystery and presents at the same time one of the most admirable features of psychological and physiological economy. It reveals to us a close connection between the will and the brain, and the aptitude of the will to influence the brain in a variety of manners almost infinite, and each one of them with such accurate precision of purpose, that the smallest limbs of the body and those remote from the source of action obey with surprising accuracy the dictates of the will. Thus of all the innumerable fibres connected with the brain, those only which lead the fingers are acted upon by the brain in the act of writing, or those which lead to the eyes in the act of reading: and the brain in its turn is adapted for this purpose by the dominion of the will; and whether this adaptation of the brain be effected by the action of the will immediately or through some other intervening agent, or whether the adaptation of the brain alone be adequate to the effects intended, or this adaptation be attended (as many facts seem to insinuate), by electrical development, which would be the immediate cause of the action of the nerves upon the muscles, the connection between the primary and subordinate causes and their immediate effects is admirable. ——— This subject, hidden as it is in its cardinal principle, is capable of abundant development of the most interesting character. Take, for example, the act of singing, in which the lungs, the larynx, the tongue and a number of cavities are concerned: each one of these different sections are connected with the brain through their own nervous fibres called into play by the dictates of the will, which adapts for all and every one of them individually, the brain, in due time and proportion, resulting in the intended effect.

The senses. The senses are usually divided into two classes, special and general. The special are those which are susceptible of impressions only by particular physical agents. These senses are seeing, hearing, smelling and tasting. The general sense is that of touch, called the tactile sense, and receives this denomination from its susceptibility of impressions from bodies in whatever state they may exist, or whatever form they may have. By this sense we perceive the qualities of shape, weight, texture, superficial conformation, softness, hardness & temperature: but the special senses are susceptible of only one impression, the sense of vision being susceptible of impressions of light only, the sense of hearing those of sounds, smelling of those of odorous effluvia; and taste of those produced by rapid particles of bodies. The mechanism of the nerves of sensation and their connection with the brain and through it with the immaterial principle to which they transmit their affections, presents a subject no less abundant and of no easier explanation than the one offered by the nerves of motion. But we must limit ourselves to a mere glance at the surface of it.

Common Principle — The organs of sense compared with one another vary like the external agents by which they are excited. Nevertheless a close examination of the structure and functions shows that they have been designed and constructed upon a common principle, and at the points in which they differ are the accessories, by which they are modified. The common principle in all the organs is a membrane to be excited by some external physical agent. In the case of the general tactile sense this membrane is the dermal or inner skin, which bristles with minute eminences called papillae, in which the nerves of the tactile sense terminute. The membrane which connects the papillae is spread over the whole body, but not everywhere equally sensitive, the papillae being more numerous in certain places than in others.

The membrane of the sense of taste is the mucous membrane of the tongue and of some other parts of the mouth, which like that of the skin, also bristles with papillae. In the organ of smelling the sensitive part is the pituitary membrane, in that of hearing the membranes of the tympanum and those of the inner ear, and in that of seeing the retina. In all cases the impression is produced by the direct contact of bodies or physical agents with the susceptible membrane.

Special accessories. The accessories of the organs, in which necessarily one differs from another are provisions by which the action produced upon the several membranes is regulated, and by which the action is protected. Thus the epidermis which every where covers the derma is interposed between the object which is touched and the sensitive papillae, and this protecting influence is accordingly varied in different parts of the body, being thinner where the tactile sensibility needs to be greatest. In like manner the epithelium is interposed for the protection of the mucous membrane of the tongue; and since greater sensibility is there required it is proportionally thinner, giving more effect to the agency by which the sense is excited. A similar epithelium protects the pituitary membrane; but it is in the case of the ear and the eye that the protective arrangements are most striking. The force of the aerial pulsations which act upon the tympanum are moderated by a multitude of destructive provisions, which may not inaptly be called dampers placed between the auditory nerves and the external opening of the ear. In the case of the eye, the eyebrows form a shade to give a partial relief from the intensity of the light: the eye-lids are movable screens by which the action of the light can be interrupted at will: the iris which surrounds the circular hole called the pupil, by which light is admitted to the retina is a contractile ring which admits of being expanded and contracted so as to admit a greater or less quantity of light.

Local arrangement. Omitting the many other circumstances in the details of these several organs we may here remark that the mere position assigned to them manifests an admirable design. The tactile organ, which has for office to improve and protect the whole body and every part of it, overspreads the entire body. But the special organs are all seated in the anterior part of the head and in immediate neighbourhood of the brain: the organ of taste is established at the very entrance of the alimentary canal, there to stand sentinel, challenging, as it were, all that ask for admission, and refusing such as it deems unsuitable: the organ of smelling is in like manner established at the entrance of the respiratory apparatus to give notice of the presence of noxious principles in the air inspired: the organs of sight are established in the front of the head, with their axes always directed forward, so as to present without any fatiguing effort a perception of all objects placed before us: the organs of hearing are not presented forwards but are implanted at each side of the skull, the one commanding the range of the hemisphere to the right and the other of that to the left.

Since the excitability has its origin in the brain either influenced or not by the will, and terminates at different parts of the body: and since the senses, having their origin in various parts of the body, terminate in the brain; this organ therefore is at once a principle and a centre: principle of action and centre of sensation. Of this principle and centre something must be added before we pass to the ganglionic system.

Properties of the encephalon. When the structure of the cerebro-spinal axis and more especially that of the encephalon is considered, and when on the other hand we consider the wisdom with which every minute part is adapted to some purpose even in minor organs, the simple inspection of the encephalic organ gives evidence of its numerous and highly important properties although we could never come to discover them. But numerous and diligent experiments specially by M. Flourens on inferior animals and others on man, have partly at least disclosed some of them.

From some experimental researches already mentioned it is plain that the organic laboratory of action as well as of sensation is divided in the cerebro-spinal apparatus, and the integral effect of action and of sensation results from the complexive labour of different parts: the brain, the nerves and the muscles in the process of action, and the membranes, the nerves and the brain in the process of sensation. This double process is of an exclusively physiological character or at least it does not include necessarily psycological questions, but in both of them the operation or labour of the brain is so closely connected with the mental powers that it assumes the character of a physiologico psychological problem, and which consequently cannot be resolved without the concurrence and the accord of both sciences. It is not certainly our scope to dwell on a subject which is still involved in deep mystery. We may observe however that commonly physiologists, disregarding or even despising sound principles of psychology, are led to absurd materialism: the most moderate of them would state that the brain is the seat of the soul, i.e. of the mind, of the will and sensation. Psycologists on the other hand not always perhaps borrow from physiology in due measure and with accuracy the indispensable data which psychology does not afford. But if a psycologist must be to a certain extent a good physiologist, the phisiologist needs not the assistance of psycology provided he keeps himself within the boundaries of its own science. Whatever in fact be the connection of the soul with the body, and wherever be the so called seat of the soul, it is enough for him to observe that the action or passion of the soul on or through the organism attending the admirable union of the two substances does not manifest itself equally every where but more effectively and more perceptibly in certain centres or sections of the organism than in the rest of the system. The method by which Mr. Fleurons and others have come to the knowledge of the action or labour of the encephalic centre is that of subtraction. It will suffice for our purpose to mention some of the experiments.

The removal of the cerebral lobes from a fowl which survived ten months after the operation, caused in the animal the loss of all its senses and instincts, remaining in a state of complete stupefaction and insensibility. These and other analogous experiments which unquestionably reveal the highly important offices exercised by the cerebrum are at the same time an invincible proof that the cerebrum is not the seat of the soul; its removal not being attended by the extinction of life, but the brain is the organ through which the mental faculties influence the body, and through which mental perceptions are received.

The gradual removal of the cerebellum produces a gradual privation of the equilibrium and regularity of locomotion. Total ablation destroys all steadiness and regularity. The office of the cerebellum then is that of a regulating and equilibrating power.

The removal of both cerebral hemispheres destroying all perception renders the animal blind but the removal of the right hemisphere only destroys the perception of the left eyes alone and vice versa. The same cross effect of blindness is produced by the removal of the right or left quadrigeminal tubercles. Similar cross effects are observable in the cerebellum and other subordinate parts; thus Magendie found that when one side of the cerebellum or the pons varolii was cut, the animal was affected by a rotatory motion bearing always towards the wounded side and sometimes so rapidly as to make sixty revolutions per minute. This vertiginous motion was by the same experimentor observed sometimes to be continued for a week without cessation.

The Ganglionic system.

The great sympathetic nerve or ganglionic system consists of a series of small masses of nervous matter called ganglions (tumours or enlargements) connected together by intermediate nervous cords in such a manner as to form one continued chain communicating in the one part by anastomoses with almost all the nerves of the cerebro-spinal system and on the other spreading themselves in innumerable fibres over all the organs of involuntary functions.

The principal part of the ganglionic system which presides over the most important organic phenomena as digestion circulation and secretion and partly respiration is distributed symmetrically on either side of the median plane immediately in front of the vertebral column. It extends upwards into the cranial and downwards into the pelvic cavities.

The ganglionic system is by some physiologists supposed to be as a special nervous system, the ganglions composing it being so many small centres of nervous influence independent of each other and of the cerebro-spinal system. Parmandiere and Burdach besides consider the same system as deriving its origin from the internal organs and terminating in a multitude of points of the cerebro-spinal system. This view, although not much favored by other physiologists, is supported by the fact of the early development of the great sympathetic, that is anterior to that of the rest of the nervous system, and also by its existence in acephalus and other species which are altogether deprived of the cerebro-spinal axis. This question however is still involved in great obscurity and on this account it happens to this the same as to others of like nature, i.e. to be differently resolved by different physiologists; thus ancient and modern physiologists or anatomists maintain an opinion diametrically opposite to the preceding and regard the great sympathetic as emerging by numerous roots from the cerebro-spinal axis, and, after undergoing remarkable modifications in passing through the ganglions to terminate in the internal organ. This view is at present most generally received.

It has been the prevalent opinion of physiologists that the sympathetic nerve possessing no excitability, is also destitute of sensibility. Experiments have been made on the semi-lunar ganglion, (a large centre in the abdominal regions) with the express view of testing its sensibility and the result has confirmed the same opinion un-

-tiel Flourens has proved that this ganglion being irritated produces manifest signs of sensibility, but no such signs were obtained in the same unequivocal manner from other parts of the ganglionic system. Flourens infers from this that the semilunar ganglion is the principal connecting link between the cerebro spinal system and the great sympathetic nerve and that the opinion so long prevalent of the dependence of the gangiionic upon the cerebro-spinal system, is thus if not confirmed, rendered highly probable. We may find in the same connection between the two systems the reason why delirium occasionally attends visceral inflammation, and why the intestinal canal, liver, spleen, lungs and heart are frequently the seat of diseases in lunatics.

Circulation.

The Blood. All vital action and labour are attended by waste of the body which throws off constantly such elements which as it were are used and worn out. Independently of this the body and its organs during the period from birth to maturity are constantly increasing in volume and weight. A source consequently is needed in the system to supply continually fresh constituents to the body and this source is the Blood which on this account is called the nourishing fluid. We have seen already how this fluid is diffused through all parts of the system by a suitable hydraulic apparatus and how the blood itself arises partly from the f[illegible] by the process of digestion, and partly from air by the process of respiration, the constituents which are to be distributed throughout the body. That the blood is suited to maintain the body is proved by its analysis, from which it appears that the materials of which it is composed are precisely the same and in the same proportion. Thus like the body the blood contains from 77 to 79 per cent. of water, the remainder consisting of albumen and fibrine, with other organic compounds, also phosphate of lime and other earthy salts, all of which enter in the formation of the body.

Vital properties of the constituents of the blood. Physiologists have proved by direct experiment that not only the blood itself, but each of its component parts, is the source by which the vital functions are sustained. The process of transfusion proves it clearly. When an animal is bled abundantly & the hemorrhage is continued, fainting and loss of consciousness ensues, and no external sign of life is manifested, & the animal left in this state, dies. But if into the veins of the body, apparently deprived of life, a quantity of blood be injected, similar to that which it has lost, vitality will be immediately restored & according as the quantity of blood thus received is increased, the animal is more and more reanimated. But if the blood injected be previously deprived of its solid disks, it will produce after transfusion no more vital effect than would pure water, & the death of the animal will follow the haemorrhage as inevitably as if no transfusion had taken place. If the serum, the liquid in which the red disks float, be divested of fibrine, i.e. of one of the constituents of bones and muscles before transfusion the permanence of vitality is not restored. From an experiment of Mr Magendie, we find that in such cases the animal falls into a state of extreme weakness, and dies after a few days, manifesting all the symptoms which attend certain destructive fevers.

From the preceding remarks & experiments we infer, that to a certain extent the more abundant is the circulation, the better must be the condition of the body, and such in fact is the case: thus an organ artificially deprived of its due supply of blood gradually loses its magnitude: on the other hand in proportion as the blood received by it is more abundant, the more also its bulk is increased. Hence, since it is found, that muscular action stimulates the flow of blood, bodily exercise improves the condition of the body.

Analysis of the blood. The blood, as has already been insinuated is a fluid, in which float innumerable solid particles, of such minuteness, that a drop of blood no larger

-ran might be suggested from the point of a needle contains myriads of them. These corpus cles have a regular and constant form, possess organization & pass through a regular succession of phases, having a beginning, development & end. They consist of three species - red corpuscles, - white globules - and white granular particles, to which last, observers, on account of their smallness, have applied the name of globulines.

Red disks. The red corpuscles have the form of flat disks a little concave in the middle, swelling upward towards the edges, which are slightly rounded. The contact of water changes their form into that of globes. These corpuscles in the case of mammalia are filled with an homogeneous & semifluid matter, but in the case of other vertebrated animals, they contain a single solid kernel. The diameters of the disks varies according to the best observations from 1/3125th to 1/3000th of an inch.

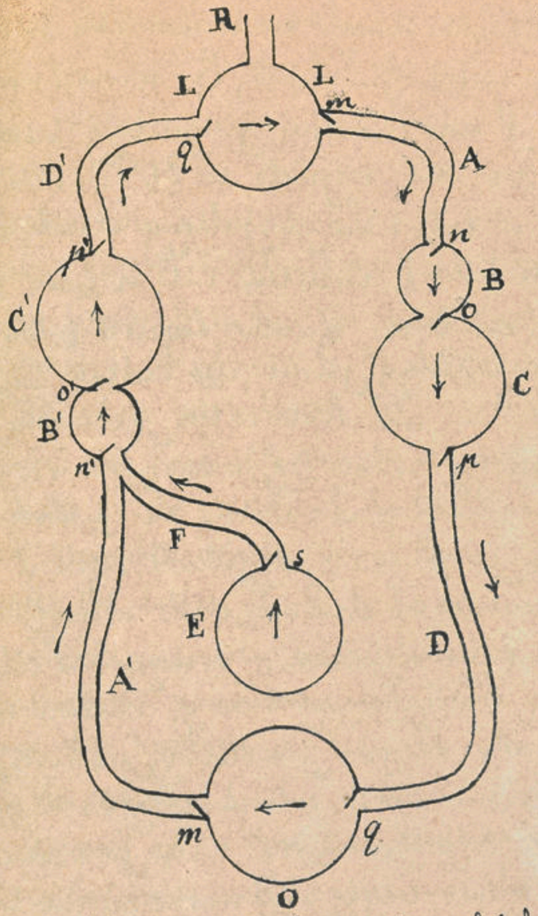
White globules. The discovery of the white globules is due to recent observers. They are spherical and their surface is granulated. They appear to consist of a thin vesicle, the interior of which is filled with solid granulated matter, consisting usually of 3 or 4 grains. The diameters of the globes varies from 1/2500th to 1/3000th of an inch.

Granular particles. The third class of solid particles which are supplied by the chyle to the sanguineous fluid consists of very minute granulations; they have a globular form & are either isolated or irregularly agglomerated, & have a diameter not exceeding 1/8000 of an inch.

It appears from the observations of Dr. Donné, that the granular particles form themselves into the white globules by accumulation & by investing themselves with an albuminous envelope. By a subsequent process the white globules are gradually converted into the red corpuscles, the place of this change being probably the spleen. In fine, the red corpuscles after having been fully developed are dissolved & converted into a fibrinous fluid & pass into the organs, to the nourishment of which they contribute.

Sanguineous fluid. The fluid in which all those particles float is a transparent, limpid & colorless liquid; it is the vehicle which conveys & spreads the nourishing elements through all the parts of the body & this function manifestly requires an apparatus constructed on a circulatory principle.

Illustration of the circulatory principle or mechanism. To convey a general idea of the process of & mechanism of the circulation we may avail ourselves of an artificial apparatus represented in the annexed diagram.



Conceive the blood prepared to nourish the organ in the vessel LL from which it is transmitted throug the pipe A, valved at m & n into B & C, two compartments separated by a valved partition o. In C there is another valve p, which opens into the pipe D, through which the blood is propelled through the system. Let O represent one of the organs, which the blood is intended to nourish traversing it by means of innumerable small tubes, through the coating of which it conveys the nourishing principles, receiving what is rejected by the organ in exchange by the principle of <u>endosmose</u> & <u>exosmose</u>.

The blood after thus giving up its nourishing constituents being no longer able to dis-charge its vital functions, is driven through the tube A' into another propelling vessel B'C' similar in all respects to BC. But the tube A' before it enters the propelling vessel, receives another tube F inserted into it near n' & this tube conducts another liquid consisting of the nourishing principles called lymph & chyle, which are elaborated from the food. The propelling vessel B'C' transmits the mixture of the two liquids through the valves o'p' and the pipe D' to the organ L. where it is diffused & placed in contact with atmospheric air, supplied by respiration through the tube R, it parts with a large portion of carbon in combination with oxygen previously received, forming carbonic acid, which escapes through R. In the same organ L the blood is thus elaborated, i.e. lymph, chyle & atmospheric air supplying it with all those nourishing & vital principles of which it has been deprived in passing through O, & those principles which would render it unfit for vital action, are taken from it. Suppose now, that the sides of the compartments BC, B'C' have a contractile power, in virtue of which they are alternately contracted & relaxed, i.e. while B is contracted, C is relaxed & vice versa, & so in like manner the two sections of the compartment B'C'. When the sides of B are relaxed, the valve o is kept shut by the contraction of C, but the valve n is opened & B is immediately filled with blood from L. Then the valve n is closed & o is opened by the contraction & relaxation of the respective sections of the compartments, & the blood is driven from B to C. The next contraction of C transmits it from C to large O. Conceive also the other propelling apparatus B'C' constructed on precisely the same principle, & the sides of the section B' to be contracted & relaxed simultaneously with those of B &, consequently, the sides of C' to be contracted & relaxed simultaneously with those of C. With this provision the uninterrupted flow of the blood through the system is secured. Now this is precisely the case.

Organs of circulation. The two compartments B C, B'C' represent the two sections of the principal organ of circulation, the heart, which consists of four compartments, two lesser, B & B', called *auricles*, & two larger, C & C', called *ventricles*, which receive the blood from the auricles. Each ventricle is below the corresponding auricle & separated from it by a valve; the side of the heart represented by the apparatus BC in which the nourishing blood from the lungs (represented by L L) enters is the left side of the heart. From this the blood is propelled through the arteries, represented by D into the organism of the whole body represented by O. Thence, after having nourished the organ & taken from it the rejected elements through the coating of the capillaries, it passes into the veines, A', by which it cis conveyed to the right side of the heart where it enters mixed with the lymph & chyle. The circulation from the left to the right side of the heart pervades the whole body, & on this account is called great circulation. The circulation from the right auricle B' & ventricle C' through the arteries D', which convey the blood straight to the lungs, & through the veins A to the left side of the heart is called the lesser circulation, or pulmonary circulation. We shall terminate our synoptical observations by adding a few remarks on the various organs concerned in the process of circulation.

The heart. A vertical section of the heart made by a plane parallel to the breast & back present the internal structure of the organ, i.e. a cavity divided into 4 chambers by one vertical partition which precludes all communication between the right & left sides and by two others nearly horizontal but a little inclined to one another, each being valved to open & close the communication between the auricle & corresponding ventricle. These valves are of a peculiar structure and differ from each other; the one, which opens the communication between the right auricle and right ventrical is called the tricuspid valve, the other mitral valve. The auricles & ventricles are constituted by powerful muscles especially those of the left ventricle, whose propeling power must be greater than that of either auricle, or that of the right ventricle.

The alternate states of the ventricles & auricles during their contraction & relaxation are called systole & diastole. Between the systole of the ventricle & that of the auricle the entire heart is for a moment in a state of repose. The position of this most important organ is very nearly in the longitudinal axis of the body, & its distance from the point where the neck joins the shoulders, is about one third of the entire length of the trunk. Thus the superior members are under a much more immediate influence of the heart than the inferior.

The Arteries. The system of tubes or as they are called vessels in which the great or systemic circulation is effected, plays a part so important compared with that of the pulmonary circulation, that, when the terms "arteries" "capillaries" & "veins" are used without any qualifying adjunct, they are understood to apply to the vessels of great circulation. Commencing from the arteries of this circulation their fountain head as we have seen already, is in the left ventricle of the heart from the contraction of which the blood is propelled, entering first in the largest artery, called the aorta the embouchure of which is at the upper & inner corner of the ventricle. The tube forming the aorta passing upwards is bent into the form of a shepherd's crook & passes downwards behind the heart & between it & the spinal column. From the upper part of the aorta branches diverge two of which bending under the clavicles descend along the arms taking the name of brachial arteries; & where the aorta descends other branches diverge right & left, descending along the leg where they take the name of femoral arteries. These branches diverge successively into ramifications, more & more multiplied in number, & smaller & smaller in calibre, until at length they assume the extremely multiplied number & minute calibre, to which the name of capillaries has been given. The arteries are flexible tubes composed of three coatings the innermost of which is a thin & extremely smooth membrane, which lines the ventricles & is adapted so as to allow free flow to the current of the blood. This tube is sheathed in another consisting of a thick yellowish, highly elastic substance of annular structure and of involuntary muscular fibres, the rings composing it having their planes at right angles to the direction of the artery. This is again invested with an external coating of dense & close cellular texture. This provision besides the protection affor-ded by it to the same vessels being endowed with elasticity & muscular influence, secures the uninterrup-ted flow of the blood, notwithstanding the intermitting activity of the heart. The pulmonary arteries, the fountain head of which is the right ventricle, rami-fy from a single tube, the embouchure of which is likewise at the upper corner of the ventricle, into innumerable branches, until they become capillaries by which the blood is diffused through the spongy & cellular substance of the lungs, & coming in contact with the air vesicles, is exposed to the action of the air by which these are inflated.

Veins. The veins in the greater & lesser circula-tion commence with the capillaries, where the arteries end. They run into each other like tributaries into a river & then combining form tubes of lar-ger & larger calibre until they form the two main trunks, the embouchure of which enter the muscles, i.e., those of the pulmonary veins the left, & those of the systemic circulation the right auricle. The veins like the arteries are flexible tubes similar in their internal & external coating: but the in-termediate envelop of annular structure, is replaced by a thin coating of longitudinal, loose & extensible fibres. Thus an artery even though empty preserves its tubular form, while an empty vein collapses. The elasticity & contractility of the vein is much less than that of the arteries. But veins are valved & their valves from their form are called <u>semilunar</u> <u>valves</u>. They are formed by folds of the lining membrane of the vein. Their opening is towards the heart & prevents the reflux of the blood towards the capillaries, a provision which diminishes the labor of the propelling force of the heart.

The apparatus of respiration and the lymphatics are closely connected with the circulation of the blood. But as the first, besides the office of refitting the blood for nutrition, has other other important offices to perform, so the lymphatics, besides supplying the blood with the provision of the nutritive substance taken up from the digestive apparatus, have other functions to perform in connection with various glandular systems. Thus the apparatus of respiration & the lymphatics together with numerous other parts of animal organism require separate explanation. ..... Sed haec hactenus .....