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On the General Anatomy, Physiology, and Development of the Nervous System.

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The Arteries. The term "Artery" is applied by anatomists to the branches and branches of the great vessels, springing from the Ventricles of the Heart. Like many other terms used in scientific nomenclature, this appellation was applied from the prevalence of an erroneous idea, as to the functions of these vessels. Derived from the Greek, the word artery signifies air vessel, and until the time of Galen the function of carrying air was ascribed to them. He, however, demonstrated, that in the living body these parts of the vascular system contained blood; although after death they are usually found empty. In Man and the higher forms of animals, there are two distinct systems of effete bloodvessels proceeding from the Heart: the function of one, being to circulate the impure blood through the lungs, where it may receive fresh oxygen, and the accumulation of carbon and hydrogen may be removed; that of the other, to carry the blood, thus purified and oxygenated, through the body. The names "Pulmonary" and "Systemic" are given respectfully to these different systems of arteries.
I shall first proceed to notice some facts connected with the general distribution of arteries.

The General Distribution of Arteries. The arteries are distributed throughout the animal system by branching. This may take place in different ways. Thus, an artery may end by dividing into two or more equal or unequal branches, or during its course, it may give off lateral branches. The angles at which these leave the parent trunk, are different in different situations.

Thus, we find every degree of acute, and sometimes obtuse and right angles presented in their distribution. It was supposed, that the force and velocity of the circulation through a branch, was influenced to a great extent by the angle at which it quitted the main trunk. This opinion however Prof. Weber has shown to be untenable. Such a circumstance could have little or no influence, on the passage of fluid through a system of elastic tubes, which are constantly kept full, and the progress of whose contents meets with much resistance at their extremities.

The trunk of an artery diminishes, in proportion to the number and size of the branches given
off. An artery which runs a long course without giving offsets, does not lessen in calibre or height. A piece taken from the terminal end of the common carotid artery, will weigh as much as a similar piece taken near its aortic extremity. Mr. Hunter found that the calibre of the long carotid of the camel, underwent no decrease throughout its whole extent. Sauerwein states however, that he observed the carotid artery of an otter, to have become narrower in a portion of its course of six inches in length, for which space no branch had been given off. The sum of the areas of the branches, into which an artery divides, is as a general rule, greater than the area of the parent tube. The area of each separate branch, being however less than that of the vessel from which it takes its rise. The increase of the available capacity of the arteries has been much overstated, especially by the mathematical Schools of Physicians. Exceptions have been observed to the above rule; one of the most notable, being in the case of the common iliac and the middle cerebral;
the sum of their boxes, not being greater than the box of the termination of the aorta. It has sometimes occurred to me, whether this circumstance may not in some way be connected with the obliteration of the hypogastric arteries at the apatation of foetal life. (I do not wish to express this as an opinion, but merely as a surmise.) The ratio of the increase of the area has not been correctly estimated, as far as I am aware. It has been said, that at each division the area increases as two to three. This I believe, is generally held to be a great deal too great. I am estimate.

Arteries frequently anastomose or insinuate. Such junctions are very frequent amongst the smaller arteries, also they are not wanting amongst the larger. The effect of such union is to equalise circulation, and to equal the effects of local interruption or injury. The general anastomoses of arteries may be described under the following heads.

1. Anastomoses by insinuation, or by loops, in which two vessels running in opposite directions open into each other by their straitened, and form a loop. 2. Anastomosis by transverse
Communication, as when two parallel trunks are united by means of a branch, at right angles to their own direction; for example, the anterior communicating artery of the Brain.

3. Anastomosis by Convergence, in which two arterial branches unite to form a large artery, as in the union of the vertebral arteries to form the basilar trunk. The tortuosity of some arteries, as the labial, is easily accounted for by a consideration of the mobility of the parts; but we meet with great tortuosity in other situations, where the purpose of the arrangement is not equally clear. I may adduce as instances, the long coiled ovarian arteries of the Rams and Bull. The physical effect of such tortuosity must be to diminish the velocity of the circulating fluids, by increasing the surface of foreign friction. Sir C. Bell, believing that the arteries were instrumental in propelling the blood, supposed that the tortuosity would increase the rapidity of the circulation through the testicle. It is however generally admitted that the arteries have not this power, hence such an opinion cannot be entertained. In some situations, an artery is seen to
divide into a number of branches, which again unite into a trunk. A familiar instance of this arrangement is seen in the incisuary of the pig. This arrangement, must evidently have the same physiological effect as that produced by the great tortuosity of a trunk. But in some animals, and in some situations, it appears to serve other purposes. The uses however of the "Reticulum", as it is termed, will be again referred to in another part of this paper. It will be sufficient in this place, to mention some of the principal situations in which it occurs. The internal carotids of Ruminantia, on arriving at the sides of the Sella Turcica, subdivide into innumerable twist, which again unite to decompose the arterial trunks. It was to these instances of its occurrence, that the term "Reticulum" was applied by Galen. This arrangement however is not found in the Scolipede or the Horse. It takes place in some Carnivora, as the Cat and Lion, but it is not observed in Man, or in the higher Quadrupedia, or in animals (as the small Rodentia) where the vertebral arteries are
Larger than the internal Carotids, and are, the chief arteries for the supply of blood to the brain. Moreover, we do not find it in the plantigrade carnivora. In the tardigrade sloths and lorises, the brachial and femoral arteries, by dividing into many branches, which again divide, have a similar plexiform arrangement. The same is observed in the extremities and tail of the anteaters. They are also observed in the orbits of many mammalia, and birds (Ruff & Bachers), giving origin to the arteries of the eyeball. In theseeous Animals, we find many and remarkable instances of a similar division. Dr. C. Pache was the first to give an accurate account of the subdivision of the brachial and caudal arteries in the Porpois. But previously, John Hunter had described the great tendency to division and tortuosity existing in the whole arterial system of the Whales and Dolphins. He found that in animals of this tribe, "the intercostal arteries divide into a vast number of branches, which run in a serpentine course, between the pleura, ribs and their muscles, making a thick substance, somental,
similar to that formed by the Aeromatic Artery of the Spinal. These vessels everywhere lying the sides of the Thorax, pass in between the ribs, near their articulation, and also behind the ligamentous attachment of the ribs, and anastomose with each other. The Medulla Spinalis is surrounded with a network of arteries, in the same manner, more especially where it comes out from the brain, where a thick substance is formed by their complication and convolutions, and these vessels most probably anastomose with those of the Thorax. [S. Hunter.] The Anterior Tibial artery, in many aquatic birds, is often accompanied by an enveloping plexus of its smaller anastomosing branches, which reunite and join it again at the heel joint. Many instances of Retia Murabiliæ have also been observed in birds. Müller and Eschricht, have given a description of these, in their paper on the arterial and venous Retia Murabiliæ in the liver of the Thuny. Such are a few of the best-known examples of these arterial networks.

I have mentioned them here, merely to show the various circumstances under which
They occur; their probable causes in their several situations, will be noticed hereafter. It is, I believe, at present a matter of doubt, as to whether the arrangement of the efferent and afferent vessels in the Malphigian Corpuscles of the Kidney, are instances of Retia Mirabilia, or whether, as Mr. Bowman supposes, the vessel is to be considered a vena, establishing an analogy between the renal and portal Circulations. This latter opinion so generally held, I believe to be the more probable, being borne out, as it is, by the existence of a renal portal circulation in Fishes reptiles and Birds.

Arteries in their course usually choose the most protected situations. Thus in the trunk, the principal artery has the great mass of viscera in front of it, and behind it is well protected by the osseous framework. So in the limbs, the chief arteries will be found on the aspect of flexion, rather than on that of extension. In illustration of the tendency of arteries to seek protected situations, we may state, that arteries which would be very liable to pressure, in some instances seek an osseous protection from the neighboring
bone. Thus, in most carnivora, many ordinaria, edentata, monotremata, marsupialia, insectoria, and quadrumania, animals with free prehensile use of their arms, the tracheal artery passes through an osseous canal, above the union, condyle of the humerus. An approach to this has been occasionally observed in the same edentata in man; the artery, which in these cases deviates from its usual course, turning round a prominence of bone, to which it is bound by fibrous bands.

In most parts of the body, the artery runs in a sheath of dense cellular tissue. Such a sheath does not necessarily enclose the artery alone, veins and nerves may be likewise included. In some parts the arteries want this investment. The arteries within the cavity of the cranium may be taken as examples of this latter fact. The artery is connected to the sheath by means of fibers of cellular tissue, stretching between the one and the other, but the connection between the artery and this investment is not very close. The union is so lax, that it allows the elastic artery when cut, to shrivel back within its adventitious covering. Frequently on entering
an organ, the artery receives a sheath from the serous covering of the organ; we have examples of this in the liver, spleen, and kidney. Before entering the substance of an organ, an artery sometimes ramifies into a minute network, and thus subdivided, penetrates the proper tissue of the part. The Cerebral ramification on the pia mater, and the ephaptic on the tunica vasculosa of Sir R. Cooper, may be cited. The Arteries terminate in the Capillaries. The only exception (if it be an exception) is in erectile tissue, as in that of the Corpus Cavernosum penis.

Different observers have given different accounts of their termination in this situation. It is generally assumed that they end here, as in other parts, in the capillary network. Valentin, however, considers that the minutest arterial twigs terminate directly in the venous cavities, by widened orifices. This however has not been confirmed. Müller describes the arteries of the Corpus Cavernosum as terminating in two ways. Some, which he calls the "nutritive" arteries, end in the ordinary manner in a capillary network, leading in the usual way to the veins. Others, which he terms, the "erectile" arteries, and which he describes as short...
tendril-like trunks, coming off from the trabeculae.
Arteries, project into the vein, so as to be covered
by its lining membrane, and end abruptly by
dilated extremities. These little arteries may
be single or in tufts. This account has been
confirmed by Krause, Hyphol and Erole. Miller
and Krause suppose that the dilated extremity
of the artery opens into the venous cavity; this
however has not been confirmed by observation,
and Miller himself allows that they may be
merely arterial diverticula. Various opinions have
been held by the older anatomists, as to the
probable terminations of arteries. It will be
sufficient here to enumerate some of them,
stating at the same time, that there is no
foundation for credence being given to any
of them. One opinion was, that the arteries
terminated by a few months in large vessels.
Another, that they were continuous with the
ducts of glands; a third, that they were
continuous with lymphatic vessels; a fourth
[And this obtained universal belief during
the last century] was that they ended in
four vessels than the Capillaries, vessels
which admitted only the colour of part of

Wagner (Wagner Physiology, translated by J.R. Miller 1844) says, "The finer vessels that are known in the human body are of less diameter than blood corpuscles, and measure no more than from the 6/100 to the 8/100 of a hair in diameter. There are consequently no vessels, and these are conspicuous enough in the frog, that transmit no blood corpuscles, nothing but corpuscles like those of the sparrow. In this statement, I would oppose the following quotation taken from my notes of Dr. Sharpey's lectures (delivered at Linnd. Col. London). "Direct evidence of the existence of vasa serosa cannot be got. We have injections, much finer than the red blood particles, which would penetrate into finer vessels. Dr. Sharpey took the web of a living frog, and put it under the microscope; he then adapted the biconvex to the instrument. He then took another frog's foot, which was very minutely injected, and subjected it to an equal magnifying power. Had there been serous septum, on comparing the injected specimen with the web of the living animal, he ought to have seen many more septa than in the living web, and the meshes between them should have been much smaller. This however was not the case. The meshes and size of the network were exactly the same in both specimens. If vasa serosa had been present, they would in all probability have been filled.
He bled. The names Vasa Serosa, or Vasa
mammary, were applied to these. The reason
for the assumption of such tubes, was
that in their existence, many influential
architects in pathology and medicine were
founded, especially Boerhaave's theory of
inflammation. He supposed that inflammation
was an "error loci"; the red particles getting
into the vasa serosa, and from their small
calibre blocking them up. It is sufficient
here to say, that we have every positive
and negative proof against their existence,
and that is not the slightest reason for
its assumption. (Vide note on opposite page*).

Structure of arteries. An artery may be said to
consist of superimposed layers on coats, which
differ from each other in the structure of
their tissues, and in the properties which they
possess. It has been the custom to speak
of an artery as consisting of three coats, to
which the terms, External, Middle, and Internal
or Sclerotic, Muscular, and Serous, have been applied;
later researches however, have shown that these
coats are respectively made up of other layers,
differing equally in their texture and endowment.
And that hence, the three coats of which an artery is commonly said to consist, may be further subdivided into other, or secondary, coats. As however, the division of an artery into three coats has been so long and extensively adopted in medical treatises, and as moreover, it is the natural division which presents the examination with the naked eye, I think it will not be improper to arrange, what information I have been able to collect as to the arterial structure, under a similar division.

The Internal Coat. (The following description of these coats is the substance of that given by Henle.) The internal coat, to the naked eye, appears as a colourless delicate transparent membrane, elastic but easily broken, especially in the transverse direction, so that it cannot be stripped off in large pieces. longitudinal wrinkles are observed in it as a post mortem appearance; most probably depending on a contracted state of the artery after death. On examining it microscopically, it is found to consist of two structures, 1st. An innermost, or epithelial layer of the scaly variety, this
as described by Heule, is a thin simple layer of elliptical or rhombic particles, which are sometimes elongated so as to resemble spindle shaped fibers. These epithelial elements have round or oval nuclei, which however may disappear; indeed the whole structure sometimes becomes indistinct. These epithelial scales may be obtained for examination by scraping the intima of an artery with a knife, but the epithelium can rarely be separated as an entire layer. The different intervening forms between the elliptical or polygonal scale, and the much more elongated form described above may be met with in the same artery. The outer structure, entering into the formation of the inner coat, is that which has received the different names of "Fissurated," "Perforated," "Reticular," or "Tinted" membrane. It consists of one or several, thin brittle transparent filing layers, which may be scraped off the internal surface of an artery, in the form of fine shreds, having a great tendency to curl up at their upper and lower borders, setting themselves up. The layers are marked separately by fine pale streaks, principally following a longitudinal direction, joining each other obliquely in a
out of a long network. Hence considers these lines to be reticulating fibres formed upon the mem-
braneous layer. The membrane is also perforated by numerous round, oval or irregularly shaped
apertures of different sizes. When there are several
layers of perforated membrane, it often happens
that the outermost layers lose their membranous
structure; the transparent structure of being
in the arcus of the fibres disappearing, and leaving
only the longitudinal network. Such a degenerate
fibrillate membrane, reduced to a mere reticulation
of fibres, is sometimes spoken of as constituting
a distinct coat. The fibres are quite similar to
true fibres of elastic tissue, resisting the action
of acetic acid. In fact it seems probable, that
the perforated membrane is merely a modification
of elastic tissue. It is on this structure, that
the thickness of the inner coat mainly depends,
but the number of layers of which it consists
takes much in different situations. In cases
where the epithelial layer has disappeared, the
fibrillate membrane forms the innermost lining
of the vessel.

The middle coat. This is the thickest of all the
artificial linings, and is relatively thicker in some
arteries than in others. In the larger arteries it is made up of many layers, thus upwards of 50 have been counted in the aorta, 28 in the Carotid, and 15 in the Subclavian artery. Frequently between these layers fragments of fenestrated membrane may be found. Hence the fenestrated membrane is not confined to the internal coats. In colour it is of a brown or reddish yellow; the internal layers are frequently found to be redder than the external, but this is probably a postmortem appearance, depending on haemorrhage of blood. This coat consists of distinct circular fibres, disposed round the vessel, although each fibre does not form a distinct ring. Under the microscope, the fibres may be found to consist of two kinds, one being quite analogous to the unstippled muscular fibre, the other closely resembling the fibres of yellow elastic fibre; the former are pale bluish white, soft flattened fibres, measuring from two to three thousandths of an inch in breadth; they present, here and there, the appearance of elongated irregularly compacted corpuscles, and longitudinal striæ on their surface. The yellow nuclear fibres lie amongst them, frequently alternating with them in layers. They, the elastic fibres, join together as usual in an irregularly reticular
In the addition of acetic acid, the soft fibres become indistinct, and the elastic fibres and nuclei better observable. This coat is thicker in some parts of an artery than in others; thus at the convexity of the aorta, it will be found of greater thickness than in that part of the artery near the ventricle. The contractility of the artery is dependent on this coat. As a general rule, the elastic fibres are relatively in greater proportion in the middle coat of the larger arteries, while the smaller obtain the larger share of unstripped fibres. Yet, it is not true that the large arteries are totally destitute of the latter type, for they have been proved, (as will be afterwards shown) to possess total contractility, although in less proportion than the smaller branches. And we know that the power of contracting on the application of a stimulus is not an endowment of the elastic fibre.

The External Coat. A difference exists in the construction of this coat, in the larger and smaller arteries. In the smaller it consists of interwoven fibres of elastic and cellular types, whilst in the larger and middle sized arteries, two distinct coats may be enumerated, viz. the external layer of genuine elastic tissue, which is perfectly distinct in larger
arteries, but becomes gradually less appreciable in those of smaller calibre, and 2. An external cellular coat, consisting of an entanglement of ordinary filamentous tissue. The filaments are closely interwoven, and in the larger and middle sized arteries they chiefly run diagonally or obliquely round the vessel. Towards the exterior of the artery, the tissue becomes more open, and the reticular arrangement more lax, as here the vessel is connected with its sheath or other surrounding parts. In the smaller arteries, this cellular coat is usually of great comparative thickness.

Some arteries, as those within the skull, and in the vertebral canal, are very thin in proportion to their calibre. This does not depend upon the entire absence of any of the proper tissues; all the three coats are present, although the external and middle are comparatively very thin.

The following is an account of the structure of arteries but one or two degrees removed from the Capillaries in size. According to Heber, Capillaries of more than two of an inch in diameter consist of the primitive simple membrane forming the wall of the smaller capillaries but the longitudinal musculoform corpuscles, which lie upon or are embedded in it, are more numerous
and elongated; a scaly epithelium exists on the inside of the primitive membrane, and on the outside is superadded a layer of nuclear cylindrical elongated in a direction across the diameter of the vessel. This layer corresponds with the middle or muscular coat of the arteries; and accordingly in vessels of greater size the characteristic circular fibres of that time appear in the layer in question, as well as the nuclei. Outside of all, a layer containing longitudinal nuclei marks the position of the cellular coat. It is probable that in a higher stage of development, the nuclei form the elastic fibres, whilst from the intervening spaces the circular fibres take their rise. In vessels of 1/2 of an inch in diameter, the striped membrane may be discovered, although in some cases it is altogether wanting. In still larger vessels the primitive membrane, with its longitudinal cylindrical corpuscles may have disappeared, and this is generally the case in the arteries, whilst, according to Baule, in the veins it frequently remains, although converted into one or more layers of longitudinal fibres, which are parts of the elastic kind, and partly pale flattened and parallel. Such a coat is to be found between the subintima and circular fibrous coat of many veins, or, when the subintima is wanting, immediately under the epithelium. Between small arteries and veins but two or three degrees removed from the Capillaries
his size, no difference of structure can be perceived. The coats of the arteries receive distinct Vasae Vasaorum for their nourishment. These are both arterial and venous. The Arteriolar arteriolar are not direct openings from the cavity of the vessel into the coats, but they are little twigs given off from small branches, which arise either from the vessel which they are destined to nourish, or from a neighbouring artery; these divide into smaller branches in the sheath, and on the surface of the vessel before they enter its coats. They form a network in the tissues of the external coat, which may be regarded as a sort of incubus or bed for their division; from this a few penetrate the middle coat, and follow the circular course of its fibres; some have been discovered in the internal coats minute capillaries supply the blood from these nutrient arteries, which however they do not closely accompany, and discharge it into the satellite vein or veins accompanying the artery.

Arteries are generally accompanied by larger or smaller nerves, but the vessel itself when in an healthy condition is insensible. Nerves however are distributed to the coats of the arteries, probably for governing their contractile movement.
The sympathetic system is the chief source of these nerves, although some are furnished by the cranial spinales. They formplexuses round the larger arteries, and run along the smaller branches in the form of fine bundles of fibres, which here and there twist round the vessels, and single nerve fibres have been seen lying closely accompanied by minute arteries. There is less certainty as to the extent and mode of distribution of the nerves in the arterial coats; some observers state that plexuses may be traced as far as the middle coat, and Valentin describes them as ending there in a network. The principal feature of interest connected with the Chemical Composition of the arterial fibres is that Chemical analysis of the middle coat leads to results coinciding with what the microscope and apparatus have taught us, as to its structure and properties. Dr. Bichat has found in this coat a proteinic compound which neither cellular or elastic tissue contains, and Dr. Donders has proved the same more perfectly. When he says citric acid is applied to any compound of protein, it forms with it what is termed Rancho proteinic acid, which with ammonia produces a yellow Rancho proteinate of ammonia. On applying this test, with the requisite
Concerning the coats of the blood vessels, he found that the middle coat alone assumed the characteristic yellow colour. The other coats as well as all the coats of veins remained unchanged in colour. He found also that potash acts on the middle coat of arteries, as on organic muscle, separating its fibres, making them granular, and finally depolyonising them. Chemical examination therefore confirms the claim of this coat to the affection Muscular.

Development of Arteries. Under this division of my subject I shall first endeavour to give a slight sketch of the general development of blood vessels, and then subjoin what I have been able to collect respecting the mode of formation of the larger and smaller arterial trunks.

Development of blood vessels generally. Two views have been prevalent amongst the later Physiologists, as to the mode of formation of blood vessels. One party following the views of Schwann, who described the process as consisting solely in the direct transformation of nucleated cells; another clasp agreeing with Platten, Prevost and Lebert, who consider that new blood vessels are never formed except as offshoots from previously
existing respects. To the late valuable researches of Kölliker however, we are indebted for the reconciliation of these apparent discrepancies. His observations were made on Bhabraeinae larvae, but Dr. Paget has found that the mode of formation described by Kölliker, holds good in Mammiferous animals. The researches of Schwann on this subject, led him to express himself in the following manner: "Among the Cells," he says, "of which the germinal membrane consists, several at certain distances from one another, by lengthening out on different sides into star-like figures, form the primary capillary vascular cells. These elongations of different cells encounter, grow together, the septa between them are removed, and so a network of fine canals of various diameter is extending; for the produced portions of the primary cells are much smaller than the bodies of the cells. These prolongations, or anastomosing Canals of the bodies of the cells, however enlarge until they are of equal size one to another, and also to the bodies whence they spring, consequently until they have formed a network of Cannaliculi of equal dimensions."

Platten, on the other hand, from his observations
on the tail of the Tadpole, was led to believe that the BLOODCELTS were only formed by the growth and Coalescence of procepes from previously existing Capillaries. He says that in this growing Tadpole, Capillaries may frequently be observed which end abruptly in closed extramities, and that from these, long narrow offshoots may be seen issuing, which either unite to form a loop with similar procepes from neighboring vessels, or gradually disappear. The arch formed by the union of two such offshoots gradually enlarges, and becomes permeable to blood corpuscles. Prevost and Sebert, who observed this process in the tails of Tritons and Tadpoles, and also in the Chick, give a very similar account of the vascular formation. They believe that vessels are always formed Centrifugally, under the influence of the Circulation, by arches passing from a minute artery to a corresponding vein. They further state, that such arches are formed in the intercellular spaces, from the separation of cells, and not from the Coalescence of branches proceeding from cells, as Schwann described. Kolliker, whose observations were likewise made on the tail of the Tadpole, states that the Vascular formation is a
double process, consisting both in the metamorphosis of cells, and the production of offshoots from tubes already in connection with the circulation. He says that the extremities of the main venous and arterial trunks which communicate by a single arch, elongate by pushing forth narrow pointed processes, which meeting with elongated or star-shaped cells in the substance of the tail, coalesce with them, and thus a single arch is formed. Such an arch becomes permeable to blood, sends forth new processes, which meeting with other radially cells join with them for the formation of secondary arches, and in this manner the capillary network is formed. The prolongation which takes place from the vessel is at first perfectly solid, and may not exceed the thickness of a fibril of fibrous tissue, but by degrees, especially after its junction with a cell, or another prolongation, its size increases and it becomes hollow. This enlargement not only takes place at its point of departure from its parent vessel, but also at its point of junction with the cell; so that a capillary at its first formation will present great irregularity in its form and size. Of the star-shaped cells observed by Schwann, only a few are destined for the formation of blood vessels,
lymphatic vessels are formed from some, whereas from others, and many appear not to undergo a metamorphosis of any kind. Mr. Paget has observed a process corresponding closely with the one described by Holthusen, in the foetal membranes of the sheep. His researches are highly interesting, proving as they do that the plan of development is exactly similar in Mammalia and Reptilia. He notices also that the filamentous prolongation from a vessel may not only enlarge, and become tubular at its points of development, from the parent trunk and of union with the cell, but also at isolated parts, and in such distended parts, groups of blood corpuscles may be seen, although they are shut off from the general circulation by the entire impermeability, or at least partial narrowness of cavity, if such be in the processes of development, of the fine thread-like structure of the rest of the offshoot. These observations therefore tend to prove, that blood corpuscles may be developed in parts not as yet in communication with the general vascular system, and from other materials than those derived directly from the contents of the blood vessels. The walls of the fine tubes as observed both by Holthusen and Paget, appear...
be formed of the membrane of the cell, which is drawn out into the elongating filaments proceeding from these bodies; in structure it appears quite homogeneous. The larger vessels possess delicate walls, with a quite longitudinal fibrous structure, and scattered nuclei embedded in their substance.

Opposed to these observations, we have the opinion of Vogt, who believes that the blood vessels in any instance originate in the cellular interstices, from a simple separation of cells from each other, and that this takes place quite independently of the heart and the general circulation. In this latter opinion his views are quite opposed to those of Lobert and Prevost, for he believes that the channels, at their first formation, have no communication with the previously existing vessels. These channels at first he thinks have no distinct walls, but they afterwards get a delicate membranous lining, formed apparently by a layer of cells, in the midst of which the development takes place.

This mode of production Vogt observed in the formation of the first embryonic trunks, in connection with the heart, and also of the finer vessels in other parts. Volkamer allows that it prevails in the first case, but it is totally at variance with
his observation on the development of the finer vessels. (This mode of formation, as described by Vogt, is strikingly analogous to the manner in which Schleiden and Mayer maintain the amebolyma, or laciferous tissues of plants, is formed.) That Hölter's description is the correct one, there appears little reason to doubt, confirmed as it is by the researches of Mr. Papet, and with it the views of Schwann and Platten are quite reconcileable. The description furnished by Vogt is so much at variance with that given by Hölter, that the difference must either be ascribed to the misconception of appearance, or what is less probable, to the existence of another process by which the development of blood vessels may be effected.

Development of larger vessels. The smaller arteries and veins are, in all probability, developed, primarily in the same manner as the capillaries. The additional coat, which we have seen these vessels, being an after acquisition. It seems not at all unreasonable to suppose, that the several gradations seen as permanent conditions in vessels of successively larger calibre, may represent the successive steps by which a vessel, having originally the simple structure of a capillary, arrives at length...
at the magnitude, and acquires the complex
bifurcations of an artery or vein. Kölliker states that
many vessels, which eventually attain a median size,
are originally derived from round cells, which
unite in single or double rows, and form the
primitive simple mucilaginous tubes of such
vessels, by the coalescence of their cavities and
walls. He thinks that in other moderate sized
vessels, the process of formation is the same as
in the heart, and large venous and arterial
trunks, which are formed not after the manner
of the Capillaries, but by an agglomeration of cells,
in the situation of the future heart, and along
the line of the great vessels, forming at first a
solid mass, but subsequently becoming hollow
within, by a liquefaction in the centre; whilst
the circumferential cells are metamorphosed
into the fibres of the heart, and the several types
constituting the coats of the vessels.

The Arteries may be said to increase in size
and capacity, in proportion to the demands made
on their service. The uterine Arteries during pregnancy
present a good instance of this, as do the ophthalmic
arteries of many animals at a particular
season of the year. It is by this provision,
A fluid is supplied with blood, when the circulation through the main artery is stopped by the application of a ligature or otherwise. Collateral branches, previously of insignificant size, augment in caliber, and afford a passage to the increased quantity of blood which they are required to transmit. In such vessels, the augmentation takes place in length as well as in breadth; hence a tortuous condition of the tubes is increased to commonly observed.

Properties of Arteries. The properties of arteries may be referred to two heads: 1st. Their mechanical properties, properties which they possess in common with inorganic matter; and 2nd. Their Vital Properties, or those with which they are endowed by virtue of their organized structure, and the important place they hold, and functions they perform in the animal body; and which moreover are not possessed by inorganic materials.

Mechanical Properties. The arteries possess a large amount of strength and toughness, by which they are enabled to resist pressure from without. A great part of the strength of these tubes depends on the dense external
Tonic. The internal and middle coats are brittle; this is well exemplified by the well-known fact, that on tightening a ligature round an artery, the internal and middle coats are cut through, the external remaining uninjured. A most important mechanical endowment of arteries is their elasticity. This is a property not only of the external and middle coats, but whose structure the presence of much elastic tissue is observed, but also of the intima that membrane, which many regard as a modification of the same tissue. The elasticity of an artery causes it, on being cut across, to shrink back within its sheath, and it is also extensible and retractile in the transverse direction. An artery when cut across remains patent, in this they differ from venous tubes, whose cut orifices collapse unless prevented by their surrounding connections. The important uses of the elasticity of the arteries will be referred to again, in speaking of the phenomena presented by the arterial circulation.

Vital Properties. The arteries are not endowed with much sensibility. When pain is complained of on the application of a ligature, it depends on the
Accompanying branch of nerve being also included: but, in the normal condition, these tubes are indiscernible.

Vital Contractility. The property of arteries to contract under certain circumstances to a less diameter, than their unaided elasticity would enable them to assume, was unexplained, until the capacity of Hunter, unaided by microscopic observation, led him to consider it a muscular act. This opinion however, fell into disrepute for some time, many writers, including Prof. Miller, although they allowed that the arteries under certain circumstances presented a state of diminished calibre, preferred the production of such phenomena to no particular structure. To Hunter’s researches we are indebted for the anatomical verification of Hunter’s opinion, and late experiments have afforded us abundant proofs of its correctness.

The nature and degree of the contractility possessed by arteries, is quite analogous to the same property observed in unstriped involuntary muscular fibres. It is slower, and more enduring than the contraction of voluntary muscle; and unlike the latter, it does not alternate with relaxation. This property of the arteries is always in action.
Countering the distending effect of the heart, and adapting the calibre of the tube to the amount of blood it may receive. In this no doubt, it is assisted by the elasticity of the coats, but we can prove that the vital contractility can diminish the size of the vessel beyond the limit at which the elasticity ceases to operate. From its constant operation, it must offer an increasing resistance to the distending force of the blood, and as the vessel will contract to a greater degree, the less the amount of blood propelled into it, it must keep the arteries in a state of constant tension. From these circumstances, the term "tonicity" has been applied to this contractility, but the fact must not be lost sight of, that like the contractility of other muscular organs, it can be expected to much more violent action, than is done in the balanced condition it usually presents. And on the other hand, it may be diminished, so as to offer less obstacle to the distending vis a tergo, and admit a larger quantity of blood into the vessel than it usually conveys.
That this diminution of the contractile action takes place suddenly in the phenomenon of 
Hering's, and is also concerned in the production 
of erection seems highly probable.
We have before seen, that the amount of 
contraction fibre possessed by the smaller 
arteries, is proportionally greater to the 
quantity of the same fibres with which 
the larger tubes are endowed. The amount 
of contractility consequently is greater in the 
the smaller vessels, and in enumerating the 
proofs of the possession of this property, the 
smaller arteries, in which this phenomenon 
are more easily observed, will be noticed, 
before we speak of the same endowment as 
being possessed, although in a less degree, by 
vessels of a larger calibre.

Proofs of the Contractility of Smaller Arteries.
(a) Mechanical stimuli. On drawing the point of 
a needle two or three times quickly across a 
little artery, in the web of a frog, it will be 
seen gradually to diminish in size. The Con 
traction may occupy several minutes, the 
current of blood as it will become less, and 
on repeating the stimulus, the Calibre will be
to much diminished, that it (the current) may entirely disappear. The contracted state, after occupying several minutes, will gradually become relaxed, and the vessel will resume its original size.

IV. Chemical Stimuli. The same phenomena will take place on the application of alcohol or tincture of mercuric oxide, but from the action of chemical stimuli on the tissue, they are not so well adapted for experiments of this nature.

V. Cold. The mere exposure of a small artery to the air, in a living subject, will produce a gradual but manifest contraction. The same effect will be produced in a greater degree by the application of a few drops of ice cold water, as was shown by Schwann in his experiments on the mesentery of a living toad. Connected with this property is the useful application of cold in arresting haemorrhage.

VI. Electro-Magnetism. Wedeneyer, E. and F. Weber have observed that an increased contraction of arteries is capable of being elicited by this stimulus. The experiments of the Webers were most conclusive on this point: They were performed on the small mesenteric arteries of the frog.
When an artery of from 4 to 4½ of a hair’s line in diameter, was opposed to the electric stream, its transverse measurement was from 5 to 10 seconds became one third less, and the area of its section about one half. On continuing the stimulus, the narrowing gradually increased, until the caliber of the tube became from three to six times smaller than it was at first, so that only a single row of blood corpuscles could pass along it at once; and eventually the vessel became completely closed, and the current of blood through it arrested. During the constriction the walls of the artery became thicker, and the velocity of the stream of blood through it was accelerated. When the irritation was long continued, or the stimulus very powerful, the portion of the artery narrowed by it, lost the power of again contracting, and even dilated until it became double its former size. (The contractility having been exhausted by the repeated stimuli.) The mode in which the Weber’s operated was by sending a rapid succession of shocks through the vessel by means of a coil.

(3) Increased contractility may be called into play by taking off the distending power of the heart.
On placing a small weight on the artery of the
acuteness of a frog, the part below the pressure
will shrunk momentarily from its elasticity,
gravid contraction cease, which will continue
for some time; and on removing the weight, the
artery is seen narrower at that point than the
part above. The same effect will be produced
on cutting through the larger trunks, or on
removing the heart, and in this manner taking
away the disturbing force. Priscenille performed
the same experiment on the artery of the horse of
this mousc, and obtained a corresponding result.


In consequence of this property being possessed in a
very degree by these tubes, the proofs are not so
obvious, although if the experiment be performed
with the requisite care, it may be clearly demonstrated.

I. It sufficiently decides, though by no means striking
degree of contraction slowly follows the repeated
application of mechanical or the galvanic stimulus
to the larger arteries. Many Authors have denied
the contractility of these vessels, because they have
not been able to elicit this result. The probable
reason of this, was twofold: 1st because they treated
too much to slight alone in estimating the effects...
in the calibre of the tube; and, 2nd, because they did not keep up the application of the stimulus for a sufficiently long time. In proof of this the following experiment of Dr. J. B. Williams may be cited. He tied a thin glass tube into the cut end of an artery, and filled the sepulchre as well as the tube with coloured water; the application of galvanoic caused a narrowing of the artery, the reality of which was made manifest by a rise of the fluid in the tube.

1. It is a well-known fact that the larger arteries throb on exposure to cold. This fact is familiar to every one who has noticed the difference of the pulse when a limb is cold, and when it is warm. The Author above quoted says "On plunging into cold water the aorta of an ap'e just dead, it contracted so closely as to obliterate its cavity; and it required some force to pass the little fingers into it." (Williams's treatise on medicine, 1808.)

2. On taking off the presure of the heart, by putting a ligature on one of the larger arteries, more blood is forced out of it, than its elasticity would account for; there is a slow and gradual contraction. The emptying of the arteries after death, is doubtless owing in a great measure to this cause. When
an animal is bled to death, there is a greater amount of shrinking observed in the larger arteries than is attributable to their elasticity. Dr. Parry of Bath made most conclusive experiments on this point. He bled a sheep to death; previously to the extinction of life the circumference of the carotid was \( \frac{130}{70} \); after its death the measurement had diminished to \( \frac{100}{70} \); this contracted state remained until vitality became extinct, after which it relaxed to \( \frac{234}{200} \), at which point it was finally maintained by its elasticity. John Hunter's experiments on the arteries of the horse led to a similar conclusion.

The contractility of arteries continues in action for some time after death. Hunter found that in the case of a woman delivered on a Thursday afternoon, the contractility of the arteries of the umbilical cord was not extinguished on the following Sunday morning.

Surfaces of the vital contractility. We have no proof that it aids in any degree in forcing on the blood; in fact, it could not have this effect unless it alternated with relaxation, and the contraction and relaxation were coincident with the diastole and systole of the ventricles; or unless it produced
A sort of irritative or sensitizing action, commencing at the heart and proceeding rapidly along the arteries; but there is not the slightest evidence of such phenomena occurring. One of its chief uses seems to be the adaptation of the size of the vessels to the quantity of the contents; this could not be effected in every case by the limited elasticity. Another important purpose it serves is the regulation of the quantity of blood which a part is to receive. We know that in the different states of functional activity and rest, an organ must require a varying amount of blood; it is impossible for the heart to regulate the quantity that is to be received by any particular part; it must be the contracted or dilated state of the arteries, that shall at one time, to a certain extent, oppose, at another, freely allow the passage of the circulating fluid. We have also in the action of the vital contractility of the arteries, a beautiful provision to prevent the permanent desiccation of the arterial system. If it were not for this power, which is always new, and always in action, the elasticity might be overcome by the constant distending force of the heart. It has occurred to me, whether perhaps the greater frequency of muscular dilatations...
In the largest arteries, may not partly be accounted for, by the small amount of vital contractility with which they are endowed, for resisting the distending power of the ventricle, and which is not altogether made up for by their augmented elasticity.

When speaking of the nerves which supply the arterial coats, it was observed that one of their chief purposes probably was to preside over the contractility of the muscular coat. The phenomena of blushing show how completely the local circulation is under the influence of the mind, which can only act through the medium of the nervous system. According to Valvani, the center of the heart diminishes in size, when a stimulus is applied to the thoracic ganglia from the third onwards.

Phenomena presented by the arterial circulation.

The blood is propelled into the arteries in successive portions, by the ventricular contractions; whilst in the capillaries, as seen in the web of the frog's foot, its movement is sluggish and regular, unless the heart is acting weakly. On opening an artery, in the living subject, we observe that although the blood retains the successive impulses which the ventricular contractions
have supposed upon it, that now its flow is no longer in divided portions, but in a continuous stream, accelerated however at every beat of the heart. The nearer the blood approaches the capillaries, the less is the impulse perceived, until it can no longer be observed. Hence in the arterial system, the successive quantities of blood are blended into an uninterupted stream, in which at last, not even an acceleration can be noticed. The mode in which this change is effected is explained on reference to the mechanical properties of the tubes. That it is not specifically dependent on any vital endowment, is proved by the simple experiment of injecting water in successive portions into arteries in which all elasticity has become extinct; it will be found to flow out at the distal extremity in a continuous stream which is accelerated at each stroke of the piston. So the elasticity of these vessels we are indebted for this effect. At each ventricular systole a portion of blood is propelled against the arterial wall, these yield to a certain extent, becoming proportionally more thin, the greater the amount of dilatation they undergo. During the dehiscence of the valve, the elasticity of the contracted aery ceases, and
reflects as it were, the force which it has received on the blood. In this manner the resiliency acts towards the propelling power, in the interval during which the propelling organs no longer acts. We have seen that there is a certain amount of yielding on the part of the arteries, this to doubt doubt, to some extent, the shock with which the blood is impelled, and furnishes a guard against the danger of rupture. The pressure exercised by the receding arteries is of course propagated in every direction, and would tend equally to propel the blood backward, as in an inward course, were not such an effect prevented by the closure of the arterial valves. As it is a law that elastic bodies return to the state of rest, with the same force as that by which they were disturbed, therefore, by this arrangement there is no loss of ventricular power experienced. All the power of the heart, on the arteries, is expended on the propulsion of the blood, none is absorbed by the arterial walls, (except that which is necessary to overcome the mere friction, which however is very slight); whatever they receive, they return. The resiliency however generates no new force; it merely borrows and pays back, to
Speak the power with which it is exhausted. It is by this process we have been endeavouring to describe, that the flow of blood is rendered equal and continuous. The whole phenomenon may be compared to those which are noticed in the action of a fire engine; during the intervals of the strokes, the water is forced on by the elastic power of the air, its pulsatory accelerations are destroyed, and it issues from the tube in an uninterrupted stream. On the other hand, when the heart is acting feebly, and from the imperfect dilatation of the vessels their elasticity is allowed to remain unimpaired, an acceleration, corresponding with the heart's beat, is perceived in the capillaries. Imperfect working of the fire engine furnishes an apt illustration of this also. Just as in the flight of an arrow from a bow, the reaction which follows is proportional to the force exerted.

In the arteries, when the heart is acting properly, the column of blood must be continuous. There is no empty space; the arterial system however becomes more distended after each beat of the heart. In consequence of the blood being delivered suddenly into them,
The velocity of the blood in the arteries. In estimating the velocity of the blood's motion, we must not form our judgment from the rapidity with which it flows from a vessel when divided. In the latter case, the rate of motion is the result of the entire pressure to which the whole mass of blood is subjected in the arterial system, and which at the point of division in the vessels meets with no resistance. In the closed vessels, on the contrary, the portion of blood can be moved forward, but by impelling on the whole mass, and by overcoming the resistance arising from friction in the smaller vessels. We may state generally, that the velocity of the blood is greater in the arteries than in the veins, or capillaries. It is also greater in proportion to the size of the arteries; its flow being more rapid through the large than through the small tubes. This difference is in doubt owing to the increased capacity of the arterial system as the blood advances, just as the water of a stream widening into
a lake, progresses more slowly. Another
cause is the increase of friction to which
the blood is subject. For Coelius Pansa
the friction is proportional to the amount
of surface over which the circulating
fluid moves. The effect of the friction
in the smaller tubes is however not con-
fined to the circulation through these, it
must also be felt, as we speak, on the
blood in the larger ones. The relative size
of the smallest vessels and capillaries however,
have an influence on the local circulation.

Many experiments have been made to determine
the absolute velocity of the blood, but as
these have generally had reference to the
time consumed in traversing the whole
round of the circulation, they do not come
directly within the range of the subject
of this paper. I shall therefore content
myself by stating that from the experiments
of Hering, Blake, Majendie, Ponscotte, and
Valentin, it appears that the blood completes
the entire circuit in from ten to less than
a minute.

The force of the Blood in the Arteries. This
was a favourite subject of investigation amongst the mathematicians. Physicians, amongst the older experiments made to determine this point, we find one which was performed by Dr. Hale, who introduced a long glass tube bent at the lower part into the artery of a horse, and observed the height to which the column of blood rose in the tube. In later times, Mr. Sydenham's aerodynamometer has enabled us more conveniently to estimate the force of the blood in the arterial. This instrument has been so generally used for this purpose, that I shall not occupy space by its description. Mr. Sydenham found that in the horse and dog the blood supports a column of 6 inches of mercury, or a column of water of feet 1 inch in height. He found the pressure the same in all the arteries which he examined, difference of size and distance from the heart being unattended by any corresponding difference in the force of the circulation. Other observers have confirmed these observations, and they have found moreover, that the pressure of the blood in the arterial system
of all the larger quadrupeds is about the same. Poiseuille estimated the amount of the pressure of the blood in any vessel by multiplying the area of its transverse section by the height of the column of mercury sustained by the force of the blood in any part of the arterial system. In this way he found that as the power capable of supporting a column of mercury is equal to the pressure of half a pound on the square inch, and assuming that the force of the circulation in men is the mean of that observed in animals, then if the diameter of the human aorta be said to be 1.56 inches, the force with which the blood is propelled in the commencement of the aorta will be indicated by the height of 116.5 cm. by this mode of calculation, he estimated the force in the aorta of the man as 11 lbs. 94 grains, and in the radial artery at the human wrist as 14 lbs.

The column of blood in the tube is not stationary; it is subject to two oscillations: The blood rises at each ventricular systole, and falls during the dilatation. Stiles observed this in the experiments noted above, and Ludwig has recorded
it more minutely. It also acts with each
expiration, and falls during inspiration. These
oscillations are greater than the former;
according to Porticiello, the rise and fall
of the mercury was the same in arteries, the
distance of which from the heart was different,
and in ordinary suspended respiration amounted
to from 34 to 36 inches. The rise during expiration
is caused probably by the pressure of the parts of the
chest and abdomen on the arteries,
for, pressing the hand on the abdomen produced
a similar effect. The decrease of the blood's
impulse in inspiration is in some persons
so great, that the pulse at the radial artery
becomes imperceptible when inspiration is
long continued, and the breath held. It has
been already stated that the force, with which
the blood moves in the arteries, is found to
be much the same in the whole of the arterial
system of the animal; at least in all the
arteries whose calibre allow the introduction
of the tube. Very little of this force of the
arteries is consumed in overcoming friction
in the arteries, we have before seen that
none is expended on the dilatation of the
arterial walls. Dr. J. Young calculated, that the loss of force in the arteries is so slight, that if two tubes were introduced into the aorta, and another into any other artery, even into one as fine as a hair, the blood would rise in the tube from the small aorta to within two inches of the height to which it would rise from the large aorta. We can only speak with certainty however, in reference to aorta whose size permits the introduction of a tube. The force of the blood is increased or diminished in proportion to the weaken or strong action of the heart. Magendie and Valletin, moreover, finds that on drawing blood from an animal, the mercury falls, whilst on returning it, the column again rises. The Pulse. The phenomenon of the pulse is occasioned by the increased quantity of blood that is expelled into the arteries by the ventricular contraction. The pulse is not felt in all parts of the arterial system at exactly the same moment. There is a fractional difference of time between the pulse of the foot, and that, for instance, of the carotid. We shall first state the usual condition of the artery when the pulse occurs, and then give...
Short account of the most probable theories of its propagation.
During these phenomena in question, the artery is distended; there is not the slightest doubt of this. But the distension may take place in two ways, longitudinally and laterally. The former is the most considerable. The longitudinal distension of the arteries produces a change in their form; the straight ones become curved, and those already curved become more so; but they recover their previous form when the ventricular contraction ceases, and their elastic walls recoil. The increase of the curves and the succeeding recoil are well seen in the prominent temporal artery of the aged. With regard to a lateral distension, some doubt has been raised as to its existence; Dr. Parry of Bath denied it, because it cannot be perceived by the eye, and others have followed his opinion. Attempts however have been made to demonstrate it, on the supposition that it might take place, although unobserved. Pennell having laid bare the carotid artery of a horse, fitted to it a tin tube closed at both ends; he then connected with the metallic tube a glass one, by which he filled the apparatus with
water, he found that on each pulsation the
water rose in the glass tube. This effusion
is not satisfactory, for although it is probable
that the rise partly depended on the lateral
dilatation of the artery, yet it might have depended
altogether on its longitudinal distension. The sepul-
chre became curved in the tube to permit of its
dilatation. Florence, filled a steel ring cleft at
one point on the artery of a dog, and he found
that the interval in the ring was widened at each
pulsation; here, however, it is difficult to be
certain that the ring did not previously compro-
the septum to some extent. In fact it must be
a matter of great difficulty to fit a ring exactly
on the artery of an animal. It may be asked,
however, what doubt can there be of the lateral
dilatation, for it is felt whenever we place our
fingers on the pulse? But it must be recollected
that under such circumstances the artery is
compressed and not in its natural condition. The
most powerful argument for the lateral dilatation
of the artery, is the physical necessity for its
dilatation; and this is the ground on which
physiologists appeal to it, for it seems difficult to
prove the doctrine by effusion.
We may thus conclude that the artery, during the phenomenon of the pulse, is elongated and somewhat distended laterally; we now come to consider the manner in which this condition of the artery is propagated from one part of the arterial system to another. The theory advanced by E. F. Virey, and which has been widely adopted is the following: He considers that the impulse given to the blood by the heart reaches first merely the artery nearest the heart. Then by their elasticity again contract, and thus cause the distension of the next portion of the arterial system, which also in its turn by contracting, forces the blood into the next portion, and so on. In this view the arterial pulse is regarded as the effect of an oscillation or undulation, produced first by the pressure of the blood on the aorta by the ventricular systole, and thence propagated along the walls of the arteries, and along the blood itself. So this theory however the following powerful objection, first pointed out by M. D. T. presents itself. One of the first effects of the elastic recoil of the arteries nearest the heart is the closure of the semilunar valves, and the production of the second sound of the heart. The pulse may be arrested in...
Those portions of the arteries close to the heart, ought to follow or at least be synchronous with the second sound. This however is not the case, the pulse throughout the whole arterial system is perceived before the second sound is heard. The theory proposed by McColl to reconcile all the facts of the case, especially those two which appear most opposed, viz. that the pulse always precedes the second sound, and yet is perceived later in the ultimate arteries than in those nearest the heart, is the following. It supposes that the blood which is impelled towards by the left ventricle, does not so entirely enter the arterial system as to dilate the whole arterial system at once, but that as it enters the arteries, it displaces and propels what they before contained, and flows on with what may be called a head wave, like that which is formed when a rapid stream of water overtakes another moving more slowly. The slower stream offers resistance to the more rapid one, till their velocities are equalized; and because of such resistance, some of the force of the more rapid stream of blood just expelled from the ventricle, is deviated laterally, and with the rising of this wave the arteries nearest the heart are
dilated and elongated. They do not at once receive but continue to be distended to long as blood is entering them from the ventricles. The wave at the head of the more rapid stream of blood runs down, propelled and maintained in its velocity by the continuous contraction of the ventricles; and it thus dilates in succession every portion of the arterial system, and produces the pulse in all. The rate of its movement which represents also the velocity of the blood in the arteries during the ventricular contraction, may be estimated by the interval between the pulses near and far from the heart. At length the whole arterial system (wherein a pulse can be felt) is dilated; then it begins to contract, and the contractions of its several parts issue in the same succession as the dilatations, commencing at the heart. The contraction of the first portion produces the closure of the valves and the second sound of the heart, and both is and the prepuce of contractions of all the more distant parts maintain, as already said, that preparing in the blood during the action of the ventricles by which the stream of the arterial blood is sustained between the jets, and is finally equalized. By the time it reaches the capillaries.
The vital properties of the arteries do not necessarily interfere in the production of the pulse; they however are instrumental in modifying its character under certain circumstances, (becoming it harder, softer, &c.) The frequency of the pulse is one of the most important features connected with this phenomenon. Its ordinary range may be stated from 60 to 75 per minute; but of this there are many modifications from various causes. Age, sex, idiosyncrasy produce differences in its rapidity. It is said to be increased on being considerably above the level of the sea; this probably is not owing to the rarefaction of the air affecting directly the circulation, it seems more likely that it increases the rapidity of the heart's action indirectly, by augmenting the frequency of respiration. Poisiville, the experimenter on cold-blooded animals, found that different degrees of rarefaction of the air did not affect the movement of the heart at all, provided their respiration was prevented. Different periods of the day produce an effect on this quality of the pulse; it is more frequent by a few beats in the morning. Posture of the body modifies the rate of pulsation; we owe our knowledge on this subject to Dr. Raye, Robinson, and Dr. Guy of King's College.
The following is the average alteration:—In standing, the number of beats is 81 per minute, in sitting 71, in the horizontal position 66. The cause of the increased frequency of the heart's action is the greater amount of muscular effort necessary to maintain the body in the erect position; that it is not, as some have believed, from the change of the heart's position, is proved by the simple experiment of placing a person erect, and then allowing him to lean against a support, where the pulse will fall to its normal. The acceleration is increased relatively in pulses of different frequency, or in other words, the effect of posture increases in proportion to the rapidity with which the pulse is beating at the time. A person whose pulse is whilst in the horizontal position is beating at 80 will have an acceleration of 10 per cent, whereas one whose pulse is at 60 will only have an acceleration of 5 per cent on assuming the erect posture (Q. E. G.) The effect of posture is not so well marked in females or in children, perhaps from less muscular effort being made. In some diseases, as lithiasis, the change is not so appreciable. The forces moving the blood in the arteries, the
Ventricular Contraction is the great efficient power propelling the blood in the arteries, if other forces have an effect, they are merely auxiliary. In support of this proposition, are two great arguments: 1st. By measurement the force of the heart may be proved to be more than sufficient. 2nd. The beat of the Ventricles may be perceived in the Capillaries, when the heart is acting gently, how much more then does it produce its effect, when its action is strong. The supposed participation of the arterial walls in propelling the blood, has been previously slandered. It has been seen that the elasticity generates its new power; and that from the mode of action and nature of the Vital Contractility, it cannot be proved to serve this purpose. It remains to examine some of the arguments which have been brought forward in defense of the supposition that the arterial Contractility is instrumental in forcing on the blood.

(a.) It has been argued from the analogy of the dorsal heart in insects, which Contracts and shuffles the blood; but this is really an elongated heart. It is nothing more than a series of Ventricles with valves between them. It is not analogous to an artery.
(b) From the contraction of the arterial bulb in fishes. Here however we have a distinctly muscular structure whose contractions are rhythmic, a thing not seen in the human body. There is no proof that the other arteries of the fish contract rhythmically, as does this.

(c) The heart is wanting in cardiacus foetuses. It has been asked what moves the blood in these cases, if it be not the instrumentality of the arteries. It may be answered that in a large number of these cases, there is a perfect twin foetus at the same time, and that through the placental medium the heart in the perfect foetus moves the blood in the acardiac. But even supposing only a single foetus to exist, is it not probable, that from arrest of development, its heart has remained in the primary condition of a simple tube, which has been mistaken for a blood-vessel; but which is analogous to the permanent condition of the cardiac organ in being lower in the scale of creation.

The effect of the respiratory movement is doubtless an auxiliary in the propulsion of the circulating fluid. But it is by no means to necessary force, or keeping the chest perfectly
Still the blood moves on, although ordinarily, at each effusion the blood is expelled with greater force, owing to the pressure on the arteries of the chest and abdomen.

Singularities of the circulation in different parts.

In the arrangement of the arteries, which are employed in transmitting the blood to the brain, we observe provisions against disturbance to the equability of its flow, also against an undue amount of its tension taking place, and to some extent the blood must be retarded by the amount of friction which it undergoes in passing through the sluggish course of the carotid and vertebral arteries. The first object is effected also by the wide anastomoses which occur between the larger vessels, and in like manner by the net works into which the arteries are divided before they enter the organs. Disturbing moreover must be guarded against by the ovoid canals through which the carotid arteries especially pass. The involutions of the arteries provide also to some extent, against the effect which would ensue on the stoppage of any one arterial branch. It is by these arrangements that the central circulation is rendered equable.
And uniform, remaining unaffected in a great degree by those influences by which the flow of blood through other parts is liable to be disturbed.

The use of the retina quadrable. There can be no doubt of the general physiological instinct which attaches itself to these vascular pleats. Their occurrence, however in such various situations and in creatures whose modes of living and positions in the scale of beings are so different, has contributed not a little to involve their uses in obscurity, and to make their probable purpose a ground of dispute. In every instance the blood in traversing these must undergo a retardation, first, from the wider area of the space through which it passes, and secondly, from the greater amount of friction which it undergoes. But we cannot suppose this to be their only purpose in all situations, and according we have had various theories enunciated to account for their existence. Some of these I shall now subjoin.

Where the retina quadrable occurs on the Cornea by the side of the Sclera fascia, there can be little doubt that it serves a similar
purpose, and probably more effectively, with the anastomoses which we find ordinarily taking place between the Cerebral Vessels.

In the Ruminants, their occurrence has been connected with the position in which the animals holds its head whilst feeding; it being supposed that these pleurae guard against the effect of gravitation on the blood. Although this theory wears at first sight an air of probability, yet an objection presents itself in the non-existence of a similar arrangement in the Horse, whose circulation is opposed to the same influence. Again it has been given as a reason for its occurrence on the Carotids of Bovidae, that its use is to prevent the effects on the Cerebral circulation of the enormous strains which these animals take in seizing their prey. At least, in these it cannot be specially provided to prevent the effects of gravitation. In the limbs of Vertebrate Mammalia, it has been said, that the existence of the 6th Pleurae is connected with the slow enduring contraction of their muscles. This I think can be hardly accounting when its presence in the flippers of the porpois...
is called to mind, the movements of which organ are remarkable for their rapidity. It seems more probable, that when they are found in the brachial and carotid arteries of animals well fitted for climbing and prehension, their use may be to obviate the effects of the long continued pressure which the main trunk would otherwise undergo, in the ascent of trees. These movements being continued for a great length of time by the slow moving blood. It has occurred to me, that perhaps a similar reason may be given for the presence of the reticulum variabile in the anterior tibial artery of the swan goose. In the movement of swimming, especially when the animal is propelling itself against an adverse stream, these arteries I should suppose are, to some extent, under the influence of the pressure of the current, and it has suggested itself to me, that the occurrence of the plexiform arrangement might perhaps be intended to obviate its effect on the circulation through the extremity. A purpose of much higher physiological
Importance was assigned to the sacrificed and convoluted arterial plexuses of Cetaceans by John Hunter. He believed that they were intended as reservoirs or stores of arterial blood, to be supplied by the animal whilst it remained under water. The prolonged duration of time during which these animals will remain under water, without rising to the surface for the purpose of breathing, is well known. The Spermaceti Whale has been observed to remain submerged for an hour at a time. Whether this extraordinary arrangement met with in so many parts of the arterial system of these creatures be intended for the above mentioned end, is yet to be determined. But at least, the opinion of John Hunter is not to be passed by without due consideration. It has been suggested that during its transit through these plexuses, the blood undergoes some peculiar chemical change, of this however we have no proof, and I believe the theory is not generally received. The doctrine of the bloods retardation, in its passage through the Pellicae Muratida, is doubtless true, in all cases of their occurrence; although in some situations they appear
to serve other purposes.

Some structures are liable to great temporary differences in the quantity of the blood which they contain. Such structures have received the name of erectile. The Corpora Cavernosa and Corpus Spongiosum penis in the male, and the clitoris in the female, also in a less degree the nipples of the mammary gland, are structures of this nature. In the Corpus Cavernosum, which is the best example of an erectile tissue, this peculiar property mainly depends on venous spaces, and on the muscular fibres to which all the venes of the penis are opposed. Miller however believes that his discovery of the helicine arteries throw a new light on the phenomena of erections. He says "although no openings can be discovered in the coats of these fine arterial efferences, yet there is no doubt but that it is through them, that the blood which is ordinarily carried into the tissue of the Corpora Cavernosa by the minute nutrient branches of the arteries, is in the act of erection poured directly into the venous cells and sinuses. When the arteries of the Corpora Cavernosa is injected with size and varicose, the injected matter always fills the venous cells; and if it is afterwards washed from them, the arteries themselves will be seen injected. The means by which
during life, they are enabled to force blood into the cells. It must be an increased attraction exerted between their coats and the blood, by the nervous influence transmitted to them by the spinal cord, in consequence of which an increased quantity of blood flows to them. The direct opening of the helicine artery into the second cavity however cannot be considered as proved. The existence of these arteries is denied by Valentin and Krüger, who think that what Müller called helicine arteries were small arteries running in the septa and bands of fibrous tissue which intersect the corpus cavernosum, and which when torn across, assume a contorted somewhat spiral figure. On the other hand the observations of France Bichat still appear to confirm Thielers original observation as to the existence of the arteries, whatever may be the purpose which they serve.

I have thus endeavoured to draw from the sources which lay within my reach, an account of the structure and physiological use of the arterial system; which, imperfect as I fear it must necessarily be, will I hope not be found to be altogether erroneous. If however any of the principal observations and theories which I have put to be considered as unimportant or mistaken, their introduction in this paper will I hope be attributed rather to the effect of misunderstood study, than to wilful carelessness or thoughtless indifference on the part of the writer.

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