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On the Circulation

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A few words, on the gradually increasing com=
=plexity of development of the vascular System in
the animal series, may advantageously preface
a consideration of the mode in which the Circulation
of the Blood is maintained in its normal con:
=dition in the highest form of development – as it
exists in man. This will be the more interesting
because we find that some animals exist without
any distinct vascular apparatus at all and hence
the question naturally suggests itself, under what
conditions does a vascular system become necessary
to the due maintenance of nutrition?

To answer this question it will be necessary to
consider the general Structure of these animals.

The lowest class of animals have no intestinal Tube, properly so called, but merely a cavity in the body communicating with the Exterior and in no way differentiated from the general substance of the animal, some creatures indeed only form this Cavity at will, when it is required for the reception of some article of food, by Extension of the body over and around the material until it is completely Enveloped; such a process occurs for Example in the Amoeba; but, in short, be the cavity permanent or otherwise, as it has no peculiarity of Structure it is not adapted for effecting any preparatory action on the food, which latter is therefore absorbed directly by the tissues them-selves, and applied to their nourishment and growth.

All animals with this characteristic are included under the Protozoa.

Proceeding a step higher we shall find that the medusae, actinia & other animals classed under the Coelenterata, as distinguished from the remainder of the Radiata, are remarkable still from the the absence of any proper vascular system and also from the peculiarity of their

alimentary canal. The mouth, it is true, in these animals opens into a distinct cavity having a wall which separates it from the surrounding parts of the animals' body & which may be considered analagous to a Stomach, but this organ instead of continuing with its proper walls to an ending externally, opens, after a short course, into the cavity of the body so that the alimentary matters, having undergone doubtless some change whilst in the Stomach, finally reach the tissues which they are destined to nourish by entering the general cavity of the animal, just as we have seen the unprepared food to do in the ~~previous~~ previous class of animals.
The large size and greater development of many of these animals renders a simple central cavity inadequate for approximating the nourishment sufficiently to the tissues and hence we find the cavity as a consequence prolonged by a series of radiating canals passing throughout the body of the animal & which communicate with a circular canal at its margin; in this way the fluid matters are brought into a proximity with every part of the tissues suffi=
(ciently)

=ciently close to enable them easily to obtain their nutriment. The passage of the fluid along these canals is effected by the contractile action of the whole body, and in these arrangement we seem to have the first indications of the composite and secondary origin of the se=parate vascular system, which we find from embryological investigations to be developed in the higher animals from a combination of the primary layers, the animal and the vegetative layers, of the embryo.

It is only in the next class, the Echinoder=mata, that we find that the high development of the organism is such as to require the separation from the food of a new nutritive matter (the chyme) & consequently the existence of a complete intestinal, digestive, tube, and immediately in conjunction with this appears the vascular system, for the ali=mentary matter when received into the mouth & elaborated in the intestinal canal is now no longer able to come in contact with the tissues it is to nourish and is in fact phy=siologically as far separated from them by the walls of the digestive tube as it is in many cases whilst still without the organism, and the primary function of the Circulatory System, that of conveying the nutritive fluid from the Elaborating organ to the tis: sues for which it is destined, is immediately called into play.

In Each Succeeding class of Invertebrate, the lower, less developed, forms Exhibit numerous instances of the absence of any vascular System but as my object now is merely to mark a few points in the progressive development of that system, I Shall only refer to Each of these classes in so far as they are illustrative of that point.

I have spoken above of the primary function of the vascular System as that of conveying the prepared nutritive material to the tissues to be nourished but there are two other points which require to be mentioned here.

Primo. The Tissues which receive nourishment are constantly throwing off Effete matters in re: turn, & a function, scarcely if at all Secondary to the above mentioned is that of affording a channel by which these Effete substances may be conveyed to some organ or organs, provided for their elimination.

Secundo. In many animals the food is not suf:ficiently elaborated for the use of the tissues, previous to absorption from the intestinal canal, & consequently requires some further preparation before it can be applied to nutrition, this then is effected by its being passed during its course in the circu:lation, through certain other organs commonly called blood-glands.

Hence, the Vascular system may contain

1.° imperfectly developed nutritive material, as de-rived from the intestinal canal (chyle)

2.° material ready for use in the growth of tissues or chyle which has been passed through the final elaborating organs.

3.° Effete matters passing onwards to the Ex:cretory organs.

It is the mixture of these materials to which the common term "Blood" is applied.

We must not however forget that the effete matters themselves are to be looked upon as nu:trient in relation to the excretory organs by which they are eliminated, as ably expressed in the law of Treviranus that each part of the body in respect of its nutrition, stands to the whole body in the relation of an excreted substance.

Only there is this important difference between excretory and other organs, that the former only continue to exist as a consequence of the presence of that which forms their nutriment Whilst tissues generally, exist for other purposes than that of using up particular materials and consequently the absence of the nutritive matter proper for the latter is directly injurious to the normal activity of the animal body.

It is necessary then (in order that the chyle may be duly elaborated, the effete matters brought to the excretory organs, and the tissues generally obtain their due nourishment) not only that a channel should exist but that means should also be provided by which the blood may be kept in continual motion from one part to another. The nature of the channels and means of locomotion vary, not in their essential nature, but in their degree of development as we ascend the animal series.

It will I think be at once conceded that it is quite unnecessary from a physiological point of view, to consider that the circulatory system must invariably present a continuous closed canal, for as we find the tissues in the lower ~~animals~~ Radiata imbibing their nutriment by direct contact with the chyle so we may suppose that they can do so in other creatures which are nevertheless provided with disconnected tubes to bring the fluid to the part & to remove it again; How far this is really the case is still a matter of dispute amongst Histologists, the appearance of the vascular system in many worms, arthropoda and particularly insecta, is that of one or two principal vessels opening into cavities in the substance of the bodies of these animals, from which other vessels again pass off to other cavities or to meet the principal vessel, many histologists however affirm that these lacunæ (sinuses) are all of them lined with a continuation of the inner layer of the larger vessels so as to keep up the continuity of the whole system. It is a question only to be decided by observation because, as mentioned above, the former hypothesis is quite admissible, as physiological

considerations do not interfere neither do me-
-chanical.

The principal vessels, possess the power of comply-
-ing with the second indication by means of the
contractile, muscular structure developed in their
walls externally to the lining membrane, but
here again the series affords examples of great
variety of modifications.

It would lead me too far were I to attempt to
trace minutely the gradual development of the
several portions of the circulatory system upwards
to man, but a consideration of a few of the
lower forms exhibits how the agent of motion
at first very indistinctly separated from an exten-
-sive portion of the ~~vascu~~ vascular tubes, is gradually
more and more developed in one or several parts
which then take on special functions. To take
first the Echinodermata (in which however we
must beware of confounding with the proper
vascular system another set of tubes communicating
with the external medium and only latterly dis-
-tinctly differentiated as the Water vascular system) -
this series of vessels appears to afford a free com-
-munication ~~with~~ between the tissues and the

aerating medium & perhaps corresponds in some ~~de~~ degree to the ramifying air tubes of the insecta.)

We find then in the asterias a contractile organ situated in the central portion of the animal and connecting two rings which surround the digestive canal the structure of these parts and especially of the vascular ramifications has not been fully investigated; on the ~~the~~ other hand in the Holothuridae, whilst the vessels which ramify on the digestive canal, are very distinctly traced as also those which ramify generally through the bodies of these animals, a distinct central organ is not very well made out.

From the higher worms we gain an illustration of further advancement; for in many of these we find a dorsal & ventral central vessel connected by transverse anastomoses; it is generally the dorsal vessel and sometimes one or more of the connecting lateral tubes which are enlarged and apparently so developed as to act more particularly as the propelling agent or agents, it is only in a few specimens however that the presence of a valvular arrangements indicates more distinctly the functional peculiarities of these parts and even here it would appear that when the organs of respiration are well developed the action of the contractile organ is ~~spent~~ primarily exerted sometimes upon the branchial, sometimes upon the general circulation.

The existence, in numerous specimens amongst the Arthropoda, of a more defined form or even of muscular structure in particular portions of the vascular canals indicates more distinctly in such specimens the special functional characters of those parts; even in this class the arrangement of the central organ is very variable, in some it is a short and dilated cavity, in others a more elongated structure apparently representing a great part of the central vessel, which is situated beneath the dorsal integuments. The other portions of the vascular system are more or less perfectly developed, but in some groups the greater portion of the circulation appears to be performed through non-differentiated cavities throughout the body of the animal.

Although the class of Mollusca would furnish specimens of all grades of vascular development, as ~~[illegible]~~ gradual almost, as may be selected from the series generally, yet we advance in the higher forms to a grade of ~~[illegible]~~ completeness beyond that last indicated so that the higher mollusca exhibit a very distinctly separated central organ which in some cases consists of two portions and ~~[illegible]~~ has often a well marked muscular structure & an investing membrane. Finally in the class of the Vertebrata with a small exception the existence of a central distinct organ is complete and universal. Hence it is ~~[illegible]~~ seen that whilst the vascular system, as a whole, has two great functions to perform; viz; to secure intercommunication & to provide the agents for transmission; it is only by a gradual developement, that, portions of the system, more and more distinguished from each other, are set apart for the special performance of one or other duty.

It is necessary, then, in sketching the mechanism of the Circulation to consider 1° the Heart as the central motor organ 2° the influence of the transmitting structures arteries capillaries & veins; and 3° certain external forces which, though not essential to, exert more or less influence upon the Circulation.

I dismiss at once anatomical description &

proceed to consider the functional action of the Heart.

As the heart has a double circulation to maintain the organ is provided with two muscular cavities for that purpose, the right and left ventricles each of which is supplemented by a secondary cavity the auricle. The valves of these cavities prevent more or less completely the passage of Blood in the wrong direction. The propelling force originates in the muscular fibres, which from their peculiar arrangement admit of concentric contractions by which the diminution or obliteration of the cavities is effected, whilst the relaxation of the muscles passively allows of redilatation by the inrushing Blood.

The Ventricle is the real pump and is therefore provided with thick muscular walls the degree of development being proportionate to the obstruction which has to be overcome. This cavity on receiving a supply of Blood through the auriculoventricular opening contracts upon it and the Blood, being insinuated behind the valves which in the mean time have lain against the walls of the cavity, presses them forwards so that they meet across the orifice which communicates with the auricle and thus regurgitation is prevented; but as there is no equal counterpressure exerted from the side of the latter cavity these valves would be everted were it not for the tendinous attachments which connect their margins and part of their ventricular surface to the walls of the ventricles. During the contractions of the ventricles it is necessary that these attachments should be shortened as the surfaces approximate, which is effected by muscular developments (musculi papillares) which, being associated in action with & extending into the general muscular arrangements of the walls, keep up a due proportion of tension; By this means the only exit left for the compressed fluid is by the arterial orifice and thus the whole of the Blood is expelled from the ventricular cavity. As the walls now relax the obstruction to the opening of the auriculo-ventricular valves is removed, and the return of the blood from the arteries would also be allowed but for the existence of the Semilunar valves, ~~which~~ which whilst forced inwards and across the orifice by the same process as occurs with the other valves, are restrained in their action not by tendinous or muscular attachments as above described, but by their baglike form which causes their margins to meet centrally and afford mutual support.

One microscopist believes that he has detected mus: cular fibres in all these valves, which serve, in the former class, to prepare them for shutting and in the latter to initiate opening. I can well con: ceive the action of the former class, which, by separating the valves from contact with the walls of the ventricular cavity, would admit of the passage of blood behind them, but it is the same action which one would think most required in the semilunar valves also, and not any additional power to aid in their ~~oppos~~ reopening.

Any material check to the venous return during the contraction of the ventricles is obviated by the distension of the auricles which during that period gradually become distended with blood, when the ventricles relax – the auricles remain for a time in a state of distension whilst the superfluous blood passes onwards into the ventricle; the auricle then contracts and, by the addition of its contents to that which has already flowed on, the ventricle is replied &

the series of Phenomena recommence. The function of the auricle is certainly a purely secon:
:dary one and I think that portion of the heart might with great propriety be considered morpho:
logically a development of the venous system. Its presence admits of the onward flow of the venous blood with much less interruption than could otherwise take place as it prevents any check during ventricular contraction, and only acts partially in opposition to the flow when itself contracting to fill the ventricle and the occurrence of an interval during which the ventricle and auricle are both passive diminishes still more the circulation.

Further with respect to the twofold structure of the organ - the two sides act synchronously, the ventricles contracting together and the auricles the same - It is I think generally held that whilst the auricles are not completely emptied by each contraction the ventricular cavities are so; it follows therefore of necessity that the two ventricles must be capable of holding an equal amount of blood otherwise we should gradually get an accumulation in one or other of the circulatory systems.

A Single Series of Phenomena is called a Rhythm the time of a Rhythm may be conveniently divided into sixths - it has then been found that the ventricular Systole and diastole are of Equal duration, Each occupying 3/6 ths that the auricular Contractions occupy only 2/6 th and that they do not follow immediately on the ~~diastole~~ Systole but commence after a pause = 1/6 th & continue until the Commencement of the next systole.

Were the vessels a set of rigid tubes we should of course perceive as a result of the hearts action an intermitting propulsion of the blood „en masse" by a distance proportionate, in any vessel, to the capacity of the vessel under observation & to the amount ~~through~~ thrown out of the ventricle into the aorta. Such however is not the case for microscopic observation shews us that the Capillary circulation is carried on in a continuous Stream whilst it does not require such refined aid to observe that that of the venous System is of the same character. It is upon the Structure of the ~~[illegible]~~ arterial walls that the change in the character of the motion depends

On the Contraction of the ventricle a certain amount of Blood is forced into the aorta, this increases the pressure in that part and as the force is exerted through the fluid in all directions the arterial walls bear a large proportion of this pressure, under a due amount of which their elastic walls yield and are distended, but their elastic recoil continues to react upon the column of blood which then stands under greater pressure in the arterial tubes than in the veins - The tendency of course is to equalize this pressure by forcing the blood onwards through the capillaries until the veins become so distended as to balance by their elasticity the tension of the arterial coats; and were this effected the circulation wd cease were it not for a new accession of force from another ventricular contraction. If the arteries and veins were directly connected or by large tubes which would offer little resistance to the onward passage of the Blood the pressure would be very rapidly equalized but the small arterial subdivisions & the capillaries so retard the motion of the fluid through them that the passage of the Blood onwards can only be very gradually effected.

It is evident that the arterial tubes must be in a state of permanent tension apart from the additional strain which they suffer at each systole for, were it not so the capillary circulation would undergo a retardation of a different character from that which would result from the independent action of the heart inasmuch as the current would be most rapid immediately after the arteries were fully distended and the auricle full and would almost cease when the arteries, having fully equalized the pressure, were waiting for, or undergoing, redistention by the systole, moreover such a state of things would not admit of any variations in the rapidity of the cardiac rhythm without serious changes in the state of the general circulation: on the other hand the overdistention which permanently exists supplies a compensatory force for any slight variations which occur. That such a state of matters does exist is shewn very plainly by the Haemadynamometer of Poiseuille by which it has been satisfactorily ascertained that the pressure to which the column of blood is exposed is equal to about 4 lb. 4 oz. to each square inch of surface and that this varies to a very slight extent as the distance from the heart diminishes only indeed somewhat as is due to friction and like disturbing causes; from this Standard he has calculated the amount of absolute pressure on the Column of Blood in different arteries of the body such as the radial in which he found it Equal to 4 lbs. from these Calculations it has been erroneously argued that, by the time the vis a tergo which originates in the Cardiac Contractions, has reached the capillary circulation it will be almost entirely expended; but this is quite fallacious for the pressure remains there as in other parts equal to the same amount per square inch as in the larger arteries. On the other hand it has been thought necessary, with equally little accuracy to calculate that the heart itself contracts with a force of enormous magnitude whereas its real force is only such as to equal a pressure above mentioned of about 4 lb. avg per square inch.

It is observed that the pulse, which is the indication of the distention of the arteries longitudinally & transversely by the increased amount of Blood forced into them, does not become apparent in all parts of the body at the same time; it has have been deduced that the phenomena are of the following nature — Each impulse of the heart is first given to the column of Blood in the aorta by which it is transmitted to the arterial walls of that part and distends them; these react upon the distending force & compress the adjoining part of the column, from which the impulse passes to the next and next, becoming less perceptible as the force of the Heart is equalized by the elastic resilience of the vessels. These are however not exactly the facts for ~~if~~ it implies that the blood passes onwards in Stages and that the whole force of the heart is expended where the pulsations cease which would render the phenomena of the circulation very different from what we find them.

It is true that the pulse is not absolutely synchronous in all parts of the body but it must not be explained by supposing the recoil and recontraction of the arteries in the first portion to be the originators of the like phenomena in the succeeding ones, but by the onward passage of the wave produced by the injection of the column of Blood into the vessels &

which passes onwards in each part of the arterial system as that part becomes distended.

Numerous objections are urged against the opinion that the Heart is the sole motor force in the circulation of the Blood, either on the ground that such force, (admittedly only 4 lb 4 3 to the square inch) is not sufficient to overcome the force of inertia and of friction through such an extent of circulation; ~~and~~ or on the ground that other forces are shewn to act materially and must therefore be recognised - The former objection was founded on such a consideration as the following, that whilst an artery cut across in the living body allowed of a jet of Blood being projected several ~~feet~~ feet, an artificial injection made to supply the force of the heart would not do more than send the water trickling slowly from the orifice - the explanation of this is however simply that so long as the arterial tubes are not distended as in the healthy state, the force of the injection is partly expended on the walls themselves.

It was probably on account of this supposed insufficiency of the Cardiac action that the first endeavours were made to find some supplementary agent - amongst such was one (the belief in which I believe now to be entirely exploded) which supposed that the force of attraction and cohesion which exists between substances in contact, was suspended during life, between the vessels and their contents; such an assumption was altogether devoid of direct proof and could not be brought forward as a possible explanation of what was a supposed fact.

A still more common assumption has been the existence of regular contractions in the arteries themselves similar to the contractions which take place in the heart — these have been supposed to aid the circulation by supplementing the hearts action with an additional power, and two facts appeared to countenance this view — one is the existence in some animals particularly Batrachians of a form of heart the rhythmic contractions of which begin quite distinctly in the veins and passing onwards through the auricles and ventricles, extend into and along the aorta; the other fact is the existence of muscular fibres in the arteries; but it may be objected that these rhythmic contractions are not seen; and, did they exist, their effect would be to increase rather than diminish the intermittent character of the circulation, and moreover were the muscular structure developed for this purpose and not as I ~~believe~~ believe it must be, for regulating the supply of Blood in any particular part by affecting the diameter of the vessels, we should find the development of the fibres proportional to the size of the artery and amount of Blood to be propelled and not as is the case, much more developed in the smaller than in the larger vessels. The explanation offered of this increase of muscular structure in the smaller vessels, was that in them the blood was less under the influence of the cardiac impulse which had become in great part expended before reaching that part of the System but we have already seen that this force is not to any great extent used up until it becomes in:fluenced by the force of friction and attraction in the minute vessels, whilst the actual pressure of the blood is not increased as indicated by the Hoemadynamometer; hence it is evident that this explanation is incorrect.

Capillary attraction even has been asserted as a source of the Circulation of the Blood — on the other hand this has also been brought forward as one of the great hindrances to the Circulation and of the two views the latter is the nearer to accuracy although in fact where the capillary attraction has only to be overcome so far as to effect a displacement of one portion of fluid by anything of the same character the force to move comes simply that of friction, quite different from, and greatly less than would be exerted were it attempted to eject the fluid from a capillary vessel by means of any medium having less affinity for the walls of the tubes.

The great secondary agent however in the circulation which has been put forward repeatedly is the attraction of the tissues wh. are nourished, either by simple attraction, changes in the electric tension; chemical constitution, or Endosmosis. and in support of this doctrine nu-merous vital phenomena are referred to of which the principal are — the contraction of arteries after death; the circulation in acardiac fetuses; the circulation in the vegetable; and vital turgescence — and first as to the nature of this attraction, secondly the phenomena on which the opinion is founded.

Firstly. Some writers considering that the capillaries play an important part in the nutrition of the tissues, ascribe to them the same action upon the circulation as is as-cribed by others to the tissues themselves; considering that the capillaries can be looked upon as passive agents in nutrition, allowing of the approximation to the tissues of their contents, but not in any way aiding the tissues in the selection of nutrient materials, it will be sufficient ~~of~~ to treat now the above views as relating to the tissues themselves.

Simple attraction exercised by the ~~[illegible]~~ tissues on the circulating fluid might at first sight appear an important element in the onward progress of that fluid; but when we consider that this attracting force acts laterally to the course of the circulation upon a mass of fluid extending in each direction past this ~~[illegible]~~ force, it will be seen that, granting a portion to be drawn towards the tissues it will produce a more or less perfect vacuum acting equally upon the column of Blood beyond and behind the attracting agent. i.e. tending to draw indeed some fluid onwards from the arteries, but tending also equally to draw some fluid backwards from the venous radicles. Such an influence could hardly aid in any way the circulation or at any rate, if it did to some extent assist the arterial flow, its action would be worse than nil upon the venous return. On the detection of the fallacy of this view a modification was advanced to the effect that some changes were affected by the tissues on the electric tension of the Blood during its conversion from arterial to venous character – this can only be looked upon as a suggestion founded I believe only upon the general fact that Galvanism has some influence upon the motion of fluids – of a similar nature is a still more recent view that the affinity of the tissues for the Blood (en masse) is greatest when it is highly oxygenated and first entering the arterial capillaries, that having entered, changes occur by which this affinity is lessened, the blood becomes venous, and this portion of the fluid is pushed onwards by a fresh supply of oxygenated blood which has come within the sphere of attraction. Such hypothetical explanations can hardly be considered of great weight so long as it is found possible to explain the phenomena of the Circulation by more simple means.

As to endosmose I need only say that the conditions for the phenomena do not exist unless we consider that the minute bore of capillary vessels is equivalent to the inappreciable pores of the animal membranes in which the phenomena of osmosis are usually observed.

It is not necessary, in denying an hypothesis, to offer an explanation of the phenomena which are supposed to countenance the views combated; but the phenomena above referred to may perhaps be explained without ~~supposing~~ acknowledging any active force in the Circulation apart from the cardiac action. With regard to the post mortem appearances of arteries, this is merely an effect of their natural elasticity, by which they contract upon the contained fluid in the absence of that force which constantly in the living body re distends them; for I have mentioned in an early part of this paper that the arterial coats are in a state of permanent distention, exerting constantly by their resilience a pressure on the blood which is so great as to undergo but little appreciable change in the ordinary phenomena of the circulation.

No deduction can be made from the existence of acardiac fetuses until it has been ascertained satisfactorily that they may exist without vascular connection with a normally developed fetus - in the mean time I am not aware of any recorded case in which ~~at~~ such an independent state of existence has been demonstrated.

The phenomena of the flow of sap in vegetables & of vital turgescence are of more weight than the preceding. Of the former of these it is said that the arteries are proved to play an important active part in the circulation, because in the vegetable the sap flows onwards without the existence of a heart to propel it. I venture to believe that the phenomenon in the vegetable organism is altogether different from that which I am now considering — for if we keep in mind the mode in which the passage of the sap is really effected we shall find that probably here the force of osmosis plays an important part although erroneously ascribed to the process in the animal. The effects of evaporation on the upper parts of the plant tend to favour the change of Endosmosis from those portions which being undisposed are less exposed to evaporation and at the same time constantly absorbing from the ground large quantities of moisture, this action taking place from cell to cell and from tube to tube, and moreover when the leaves are developed the exhalation from their surface tends to induce a greatly increased movement of sap upwards — but even here a great amount of force is evidently propulsive depending probably upon the rapid absorption of water by the roots of the plant which then strives to displace the more dense fluids above — as is proved by experiments which were ~~and~~ instituted to determine the force of ascent of sap; in which a flexible bag connected with a tube of mercury was attached over the cut Vertical ~~[illegible]~~ of Stems when the sap was forced out upon the cut surfaces with such power as to raise the column of mercury in the tube to a surprising extent in some instances to a height of forty inches —

Vital turgescence is after all the stumbling block which appears to many to necessitate the acknowledgment of some special attraction exercised upon the blood by the capillaries, by means of which the amount furnished to any particular part may be proportioned to the requirements of that part for the time being. —

It cannot but be an erroneous assumption that this vital action resides in the capillaries, partly because they are merely passive as regards nutrition, I can understand that such an action might be ascribed to the tissues which when stimulated to increased growth and nutrition would attract to themselves an increased amount of nutrient fluid, but the effect of such attraction, as before mentioned, would not aid materially in the circulation; on the other hand I think that the phenomena under consideration can only be ascribed to changes in the diameter of the vessels which aid, by their dilatation both the amount, and by lessening the friction, the rapidity also, of the blood in those parts, and these changes depend as is not denied, very on the influence of the sympathetic fibres upon the walls of the vessels excited either by peripheral stimuli or or centric influences — It may be objected that dilatation of vessels would tend, from analogy, be expected from increased Stimulus & consequent activity — that such occurs as the result of mental Emotions, when influencing the Circulation, is I believe generally admitted; if it is thought, on the other hand, that Contraction would follow stimuli from local irritation or sympathy it is still doubtful whether that would not also, by increasing the tonicity, render the flow of Blood more easy and rapid; as it has been found that fluids pass much more readily through a rigid tube of small size than through a larger one more flaccid — but in fact we know so little of the effects of vasomotor nervous influence upon the vessels that either view may be maintained with Equal plausibility.

There is another mode in which the circulation is supposed by some to be in part carried on viz: by the act of Dilatation of the ventricles — it was at one time even supposed that the ventricles possessed an active power of dilatation by which a suction force was exerted on the venous return; this theory is I think now totally abandoned but a modified view is held by some to the effect

~~to the effect~~ that as muscular fibres when inactive do not remain in a state of contraction but become again elongated, so in the heart when the contraction of the ventricle is completed the fibres relax and in becoming elongated exert some force by which the ventricular cavity is opened out – I cannot conceive however that the force, if existing, is anything more than sufficient to reduce to a minimum the resistance offered to the ~~[illegible]~~ reentrance of Blood into the cavity, so that none of the force of the circulation is exerted needlessly in making a way for the fluid.

Two agents, external to the circulatory system, are brought forward as important & constant aids to the circulation – Muscular action & Respiratory movements. – Of the former it appears to me that very erroneous views have been prevalent; it is usually stated that when a muscle contracts it presses on the veins and that these having valves which prevent the retrograde movement of the blood it is of necessity forced onwards – this is granted but what follows is that whilst this portion is forced onwards a hindrance is offered to any fresh supply of Blood entering, proportioned exactly to the force employed in expelling the first portions – this latter part is usually overlooked whereas if the duration of ~~contraction~~ rigi: dity be greater than the process of contraction, by so much is the amount of Blood pressed onward by those particular veins diminished – on the other hand it is argued that the flow of Blood must be accelerated because we find it flow faster through the other capillaries & through those veins of the part which are not under the influence of muscular contractions but this is only due to the obstruction to a part of the channel for venous return and in fact proves that muscular contraction is obstructive rather than otherwise – for since the amount of Blood brought by the arteries (to an arm for example) remains the same; whilst 1/3, 1/2 or even 2/3 of the venous return is obstructed it follows of necessity that the return through the remaining parts must take place much more rapidly.

Finally the respiratory movements are thought to aid the circulation by some, and truly, inspiration, by tending to create a vacuum in the chest in which the atmospheric air to play an important ~~in aiding~~ part in forcing the venous return onward to the heart whilst the greater ~~rapidity~~ rigidity and thickness of the arterial coats prevents the counter-balance which would otherwise be exerted on that portion of the circulation. But when an expiration is effected this is all ~~reversed~~ reversed & we have a regurgitation as far as possible, and at any rate a check, in the series and consequently a hindrance equal to the previous assistance; So that, on the whole, these forces in a series of intervals balance each other. The central pulsation is a sufficient indication of the mode in which Respiration as a whole influences the Circulation.

So ~~that~~ it would appear, that, whilst the heart is the primary originator of the force which maintains the Circulation of the Blood, this force acts alternatingly through the resilient coats of the arteries, & that the circulation is liable to some modifications, hindering as well as accelerating, by several occasional causes such as, changes in the nutrition, muscular action & Respiration.
