mint to be wrong; He gives the ordenary opinion with regard to both "ea ergo percurrunt" he adds in

CXXIII "etsi multa &c. vocamus"

He points out so many circumstances, the foundation of the calculations, and none of them sufficiently ascertaind, and therefore it is superfluous for me to give you any estimation or calculation here; I would almost say they have all been building in the Air. Senaac says justly, little genius, a great deal of presumption, long Calculations and few conclusions appear in such attempts. I would add an obvious one; It is true we may make some Comparison of these Calculas but in none can we conclude absolutely, for at the same time that the Heart is raising the blood to such a hight it is pushing it thro' the circulation with considerable force. I have said, that the motion of the Heart is

a muscular power, and of a peculiar kind from its being subject to a peculiar irritability. From the Paragraph of Haller referd to, you will se how they have explaind the manner in which the Blood issues out of the Heart; but what ever be its velocity it is constantly suffering retardation from various causes; It is of more importance to consider these Resistances; These have been variously enumerated and estimated

Consideration of the Resistances of the Blood

The first is, that the Arteries are at all times in a state of distention; there is then no empty space in the Arteries to receive the Blood thrown out of the Heart; the Blood therefore must be thrown out with such a force as to occasion a dilatation of the Arteries sufficient to receive the new quantity of blood thrown into them. In order to make such way for its motion, the blood must be pushed forward in the Arteries dilated; during the Hearts con-

traction there is but a third part moving into the Arteries, therefore there are 2/3ds to be thrown out, and this must be done against the form resistance of the Arteries.

The Contraction of the Arteries restores fully the force of the Heart lost in dilating them; whether they do more is to be considerd after. Therefore the necessity of dilating the Arteries is to be left out and not considerd as thro' the whole course of the Blood. Another resistance arises from the surrounding parts, such as other Vessels, cellular Membrane, Muscles &c. all these concuring resist the Dilatation. But they are all too in some measure Elastic, and therefore restore what was lost of the Hearts motion; to them is added the whole weight of the incumbent Atmosphere, which has given a high Idea of the Hearts force. But the pressure of the air returns the same force that was lost in moving it, therefore all these resistances do not retard the motion of the Blood except by their Friction, a circumstance

common to all motion. Another resistance arises from the quantity of Blood to be moved and often also contrary to its gravity. But if you could make an estimate of the modification it gives to the Impetus of the Blood, we might make some use of it, tho' you can hardly consider a posture of the Body in which the Ballance of the Heart is not the same. Therefore with rezard to the Hearts Action, considerable variations in the posture have no effect, tho' they have with rezard to the quantity and impetus in flowing into any particular part. The Retardation of the Blood is supposd to arise from its moving from a narrower into a wider capacity. The Vessels as I have said move from the Heart in form of a diverging cone, the Branches as you proceed from heart are constantly of larger capacity than the Trunks. The retardation of the Blood is in this Proportion; the slowness will be inverly as the squares of the Diameter. It is agreed that an enlargement in general

takes place, but the degree of it is not determined; whither it is in uniform proportion or considerably varied over the system, as Senac and Haller are of opinion, whereas Haller has said that in the capillaries the case is different. I have dissented from him; I have shewn that every Ramification must give an enlargement of Cavity. With regard to Haller thinking the trunks to the Branches as two to three, in measures which he has taken from Senac, he was in a great mistake. We may take the square of the Diameter for the Area of a circular section. Haller has taken the sum of the Diameters squared that number, suppose the Diameter is as 12, the square as 144, and the trunk divided into two Branches, the Diameter of each of them is 8, the square 64, the sum of these 128 will fall short of the square of the Diameter of the trunk; but if you take the sum of the two Diameters

it will exceed by a great difference the Diameter of the Trunk. Senac gave matter but did not take Estimates, and such as he has are far short of Hallers. When we have allowed retardation from any estimate, the resistance arising from that will be difficult to settle. The diminution of the Hearts velocity will appear very considerable. Haller has observed that the state of the Circulation is not according to such calculations, that the velocity is considerably greater. CLXII If so it will give a presumption of some considerable falacy attending these calculations, but we can not say any thing till we estimate the considerable force raised from the Arteries —

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I have said we can not admit of such Enlargement as Haller has given. It is not necessary to enter into the subject of the extreme by greater velocity of the Blood in the extreme Vessels; we shall else where consider this more perfectly —

Other Causes of retardation. first the flexures of the Arteries. If a flexure is without diminishing the capacity, no other resistance happens but that of a greater quantity of the fluid applied to the sides of the flexure. I see no friction; for where flexure happens there is dilatation and some times elongation; now this this Portion so dilated is Elastic yet there is always some momentum lost. But if we can suppose, in the various changes of the canals, that there is a diminution of the capacity, it will make a great odds. If you inject the carotid, by laying the Arm across the Body you can almost entirely stop the Injection says Haller; this in the dead body; But in the living body, I believe in the various motions the diminution of the capacities is very inconsiderable. Indeed the flexion that is made where an Artery is changed into a Vein I would suppose considerable resistance; but as most of the Blood rather passes by Anastomoses than by the reflexion of the Arteries

Another resistance is that which the various angles make in passing from their respective trunks. If a fluid moves through a strait canal, the force which moves the fluid every where parallel to the Axis is the chief, and very little pressure will be made to the side. If an Aperture is made any where but in the upper part, it will appear to be nomore than the effect of the gravity of that Aperture. The lateral pressure of fluids is only in consequence of some resistance given to their direct flow which last will always be made considerable, and the lateral is constantly diminishing from an acute to a right angle. But the lateral may as an effect of Angles increase to such a proportion as to be equal to it. I would add that this consideration is not of such weight in the

 Animal Oeconomy as has been supposed commonly. In the Places of flexure, not resistance can produce any effect. Therefore after all that has been said of Angles affecting the motion of the Blood, it may be so in some degree; but it is difficult to apply the Reasoning in any one instance. Haller says the greatest go off at greater angles, the lesser, at lesser. By small vessels near the Heart passing off at right Angles, the force of the blood is diminishd and the danger less, and thus the impetus is proportiond to the smaller vessels.

Resistances from Anastomoses of the small Arteries. It is certain that opposite currents must meet with each other, this is a considerable resistance to the motion of the Blood in the extreme vessels, therefore there should be frequent rupture. I therefore believe that, especially in the extreme vessels, the enlargement of Capacities takes place, and accounts for few obstructions

One of the most considerable resistances is that which arises from the friction of the fluids against the sides of the Vessels. There are two views of mechanical friction, one that arises from the inequalities of the sides of the Vessels, this we may call the friction of Attrition, which is almost the only one that has been considerd till of late. The other is the mutual adhesion of every two surfaces in Nature to each other. There are scarce two bodies in nature that do not adhere. Air which is Elastic has considerable adhesion to all other Bodies. With regard to the first of these in the Animal System I take it to be inconsiderable, because all our

 vessels are of a perfect polish, and such friction chiefly takes place in the case of solid applied to solid. Fluids are friction wheels moving round their own centers preventing friction. And physiologists who have most considerd this have not attended to its nature. The other, towit, friction of adhesion may be considerable, but some things can make this less so. 1st. fluids applied take it off, or diminish it. now here are our fluids applied to due surface. This is the case of the Arteries and Veins and the friction of adhesion in them is that of fluid and fluid. which will be various according to the various nature of these fluids, most of which have much viscidity. the Animal Blood is a fluid quite sui generis, a heterogenious Mass and who's parts do not mix but are kept perfectly blended together by motion, and so passing thro' very subtile Canalls

will have the resistance we would expect.
That is done by heat, but chiefly by another fluid which keeps it from running into concretions, and which does not readily unite with the coagulable Lymph preserves the fluidity and obviates friction of adhesion. Particularly it is in the larger Vessels. where the globules are, in considerable number, and that there is any viscidity in the red Globules, I shall afterwards shew to be falacious and therefore they never concrete with one another. But there are smaller vessels where they do not enter. and where we do not suppose the viscid and tenacious excluded. There are other fluids, as the watery serosity that will answer the same effects; this we shall more particularly afterwards explain. I should have spoke of the adhesion of the particles of the fluids to one another, but all the same observations are to be made to the one as to the other, and the same thing

prevents the adhesion of the particles to the sides as that of one of them to another.

But still there is a considerable adhesion in Hydraulics, and I doubt not of its taking place in the Animal Oeconomy. Hales and Savages by slitting up a portion of the Intestines and injecting part of the Mesenteric arteries, and examining them at different distances from the cutting, found the motion much greater in the larger than the smaller vessels, and this is imputed to friction depending upon the inequality of surface of the solid to the fluid. But it will be much more easily accounted for in another way, and even upon D^r. Hales's experiments.

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Viscidity is not perceptible in the common heat of the Animal Body. Hales injected various liquors into the mesenteric Arteries and observed what time they took to pass, and Savages has repeated those experiments, but both their

conclusions are wrong: for the slower progress of the fluids is owing to the diminished capacity of the canals, and even Hales proves this by allowing that the liquors passed more slowly in proportion to their astringency. The liquors passed much more slowly when liquors were added externally, therefore that retardation is inconsiderable from friction and much more owing to the diminished capacity of the Vessels. I would not say upon the whole then, that there are no retardations at all. There may be some, tho' inconsiderable. And it may be a doubt that the Heart can overcome those resistances and therefore Physiologists have had recourse to the action of Arteries. It is a dispute whether the Arteries be elastic, returning the same force which they received from the Heart, or whether they be muscular and return a much greater force than they received; and give me leave to say this point is of more importance than

any other in Physiology. Dr Haller has endeavoured to shew the force of the Heart to be enough, while Dr White has denied it to be sufficient, and inserted for a muscular power of the Arteries. A Dissertation De arterarum & venarum vi Irritabili by one Forshaw has just now come into my hands; if what the Author has advanced be true it will shorten our reasoning considerably. Mr Forshaw & others who argue for the action of Arteries thus reason in this manner, that there is a muscular coat which adds a motion to the force of the Heart, and that it is of an Irritable and contractile nature as Forshaw says; and lastly that the irregularity in the distribution of the Blood is owing to the Arteries. If that distribution be owing to stimuli they say such a stimulus is in the muscular coat of the Arteries. Then they allege that the force of the Heart is not sufficient to move the blood with so much velocity in the extreme vessels also. They say that the Arteries are

able to extraordinary dilatations, to Erosions and Ossifications, and when these happen that the parts supplied by the diseased Artery are afflicted with gangrene. On the other hand their antagonists, say that there is an appearance of Muscular fibre, but then it is of a peculiar kind, and as proof of irritability, & that the inequality of the blood can be explained by other causes, that the Arguments are good in favour of the force of the Heart as being sufficient. The question turns upon a few principal points which are these. First, The existence of muscular structure. secondly, Irritability; and last by the various proofs of these. With regard to the first, in the Arteries three are strata of Fibres, not in the Veins, unless in that portion called sinus venosus next to the Heart. Therefore Anatomists have made them real muscular Fibres. However of late Doubts have been raised. They are different in their situation from what appears in

180 muscles. Muscles are much more loose, have a much larger proportion of cellular membrane, and blood vessels. In the muscular coats of the intestines, and sinus venosi there is a much greater similetude to muscles than in the Arteries, where the appearance is much more tendinous. But Anatomists have made no observations on the distributions of blood Vessels along them, which Hales has remarked. Another question I would put is to say whether there are are not Muscular coats that differ considerably in formes and compactness; whether tendinous fibres are a continuation of fleshy fibres? if it be so the strength is soon reconciled; and there may still be contractility in this, tho' not so great. In the muscular coat of the Intestines the fibres are thin and soft. The Bladder of urine is indowed with more irritable fibres, which are much more pale and compact than even those of Arteries. There is one fact in favour of the muscular coat of Arteries. Lason has shewn in what manner muscular coats were affected in the case of Phthisis. This observation still wants repetition; but will be, after such repetition if found to hold, a strong presumption. Further we would think that nature had provided a muscular coat for the motion of the Blood. But for strength a cellular coat is entirely sufficient according to ventzing[illegible] experiments. Therefore this coat is not given to the Arteries merely for the sake of Strength. Considerable wounds that do not reach the muscular coat give Aneurism. Nor is it well founded to say it was given for Elasticity, for nobody says there are longitudinal fibres (upon which Elasticity depends). This Elasticity depends upon cellular substance alone, and yet this elasticity is much greater by length than breadth, as you will observe in Savages. But tho there are doubts at

tending this reasoning, the presumption is for muscular coat. Verschuir owns it to be very different from other muscles and is obliged to have recourse to some other cause, that there are different conditions in the human body suited to irritability, that may be, but it is not yet near well enough ascertained. Verschuir says the muscular power is greater farther from the Heart, his reason says that the arteries near the heart should correspond to it. Whereas there being more inequality of distribution in the Arteries more remote from the Heart, a greater muscular force is required. It is necessary to seek for surer evidence of their irritability. Hales who fluctuates on this subject, alledges, no irritability in the Arteries. Some of his arguments are bad, because the Arteries shew no sensibility: he ties a Nerve, the Animal expresses pains; this argument would say that

the nerves of the Arteries were not sensible. The argument is good for nothing since the very quantity of cellular Membrane occasions the deceit. He seems to give a more decisive proof regarding their relation to stimuli. Chemical stimuli do give an appearance of sensibility, but that is no proof: for those stimuli act upon every part of Animal substance and even a long time after death, and also in the fibres of Vegitables. Haller alledges that mechanical stimuli produce no irritability; but he makes the trial in circumstances that are not fair, as on the arteries some time after the Hearts motion has ceased, for they are then in their contracted state, as appears in the Bladder of urine, which altho a most irritable organ, when in its full contraction shews no irritability at all ——— ———