

184 of it were in metallic canals. There is a portion in the system where these Contractions happen but not visible to the best microscope, and therefore Hales might miss of seeing what really existed.

D.^r White goes too far in using the Arguments of White-bright the Petropolitan, and proceeds by calculation to shew how prodigiously small these motions must be; but White-bright's calculation will not hold. Haller also should have shewn that a certain cause of the Dilatation of the Arteries given could not be extended to the Arteries of that size. It affords no Conclusion because it goes a great deal too far, and goes not only against Irritability but flexibility and Elasticity. Haller gives proofs of these every where, while he is at much pains to establish the doctrine of Rigidity in the small Vessels. P.^r XXXVI. "Ratio

motu". That change of the state of the Arteries which he speaks of is only to be explained from their flexibility or contractility. But Haller has given another proof of the flexibility of Arteries, that is in the circumstance of Derivation. When w^r he wounded Arteries on purpose he found that there was immediately a conflux of fluids in all Directions, not only from the larger to the smaller, but a retrograde motion took place, he calls this Derivation, and speaks of it as a Power

unknown, but to me it is of easy solution. If I depend upon this, that the Arteries are full continually, and when that fullness is taken off there is room for their contraction. All these are proofs of irritability or an admitting of tension; and contractility. ~~But~~ the cause of that tension is taken off. Auenhark and others have observed that on many occasions you can see a retrograde motion from a single Branch into a common trunk, and by and by passing off by another Branch, this is more rare in living animals but especially occurs in dying ones, when the Action of the Heart has ceased. And there is this Oscillation or Ballanement from one part of the small vessels to another; whether is it owing to the vessels being full and therefore contracted? The question is whether it may not be produced in elastic vessels? if the flexibility be considerable it may be accompanied with an Elasticity, which may change its Direction. But I suspect something more, the alternate irregular motions in dying Animals are the most analogous to the motions below the motions of the Heart and Sinus Venosi. A retrograde motion is made into the veins, hence the sinus venosi become turgid, now if elasticity be equal to this in the small arteries, it might have had place in the Arteries and veins also. Therefore these oscillations in dying Animals I consider as a presumption of

136 their irritability. But they are no proof of the oscillatory motions in the still smaller vessels, they sufficiently disprove rigidity. Let us consider then if there is any necessity for a new power. It does appear that the power of the Heart and Arteries, carry on the fluids in every part of the system, and there is no doubt but the same thing takes place thro' the Veins back to the Heart since the venous motion is so strictly connected with every power of the heart and Arteries. When a ligature is applied upon an Artery, the contractility beyond the ligature is powerfull enough to push the blood into the corresponding veins. We can, by interrupting the power of the Heart, ^{and Arteries} stop all motion of the Veins. Injured fluids pass more easily into the various secretories of the Body, and the power of the heart and Arteries can even force red blood into these secretories where it is more difficult; therefore they will more readily be able to propel the blood where it is more easy. In this subject there are two mistakes, the first is, that (it is said) there are a great part of Arteries beyond the beating system: in that we may be mistaken, there are very few points in the body in which there are not sensibly beating Arteries, and therefore there is no room for minuteness of subdivision, below the beating parts and utmost extremity of Arteries. But the disappearing of the pulse may be its growing less and less

and after it is altogether imperceptible it may still exist and extend farther than we can discover by much; nor is there any room for supposing it to stop all at once and that the Blood is propelled in quite a different way. The second supposition is on a false foundation, that the power of the heart and Arteries don't extend beyond the alternate acceleration and relaxation. But beyond that does not the Blood move by the apistamus of the impulse of wave succeeding wave. Therefore? or no reason for supposing a part of Arteries in which the power of the Heart and beating Arteries do not take place. But as it appears there is no necessity for this theory. Let us see if there is in fact any such power. This depends upon stimuli.

Lect. XXIX. Dec. 19th.

Most of the Arteries of the living Body alternately contract and together with the Heart propel the Blood. And as the Heart is the foundation of this motion it will be greatest nearest the Heart; and less and less as you recede from it, and you may expect that at a great distance from the Heart it will cease altogether, and the blood go on uniformly. It has not yet been explained how far this action of the Arteries goes on, but it has been supposed that ~~this~~ ^{it} ceases long before the end of the system, and that the impulse of the blood almost ceases at the same time; hence

158 a new power, an oscillatory motion, has been shewn
of. How far any such power takes place is obscure
to say, and I have observed with regard to it that
there is no means of making it evident to our sense
as it must take place in vessels so small that
many of them escape our best microscopes. I mean
did that the Physiologists, who with the help of mi-
croscopes have not been able to observe any such
motion, can not conclude negatively. And therefore
we say that this motion depends, either upon the
necessity of such a power being employed, or up-
on certain Phenomena only to be explained upon the
supposition of its having place. 1st against the ne-
cessity of such a new power I observed, that there was
sufficient evidence of the Heart and Arteries being
able to propel the blood along these last and re-
turn it by the Veins to the Heart. The power of the
Heart has been spoke of as going no farther than
the alternate relaxation and contraction, or the
alternate retardation and acceleration which is
relating it unfairly; I take no advantage of
W. & H. bright's Calculus. The dilatation and con-
traction must be greater in the Aorta and legs
and less along the system, and if it be so it must
be immensely little in the extremities, but if it be
taken even three times greater still the size of

the Dilatation will be too small to be seen, and 159
object to microscopes, therefore it is not certain that
the Pulse ceases. Wave is universally succeeding wave,
the Motion of the Artery decreasing, and will come to
quite imperceptible at last. 2^d the rate very un-
fairly the extent of the power of the Arteries, when
we reckon the impetus of the Blood depending upon
the Heart and Arteries quite vanishes when the pul-
sation ceases. For the impetus of wave succeeding
wave. I added yesterday that there is room to believe
that both these powers extended to the utmost limits
of the Arteries. I said that we could perceive it ve-
ry near to the extremities. The reason Haller gives
that the red blood and injected matters penetrate al-
most into the smallest vessels of the system cer-
tainly argue against any great number of de-
creasing vessels. Indeed too much industry has been
used in this, when it has been also extended to the
sweataries and applied to the several excretories of
the Body. We take in the Vessels of the Testes
or I would say that a
even this consideration does not touch a general
power; For long extended secretories and excretories
are certainly very rare. Each of them are adapted
to particular uses and depending upon a contractile
power of their own, and are always induced with com-
pression and stimuli; this however does not affect the
general power. But further there may be powers that
carry fluids thro' long Vessels, that we have no distinct

100 Idea of, as in the Vessels of Vegetables, where Humours
are filtrated thro' a porous texture, and acted by
adhesion and friction. In the case of our nerves,
I have no regard to this consideration: Unless there
is a peculiar circumstance, that gives a particular
reflexion to the light, you cannot distinguish between
hollow and solid. Another objection made to this is
that the Nerves are considered as hollow canals;
because we see a great portion of the Animal system
consisting of hollow tubes we think the whole to be
tubular. I shall shew elsewhere that Nerves are not
hollow tubes; their motion is such as is found
in the whole Texture of Vegetables, or in the most
part of their substance. Wisdom Powers in na-
ture adapted to this purpose that we have
not thought of, as Electricity, There is a power
analogous to Electricity in Vegetables; and I have
no doubt, that what we call the Nervous fluid is trans-
mitted along the Nerves in a manner; This indeed
is but conjecture; but it is fit to ballance con-
jecture by conjecture, and prevent ourselves from being
mislead. I find no arguments of sufficient weight
with regard to excretories. Calculs shewing how
little force the Heart exerts in them are quite im-
maginary. The powers in them may be totally dif-
ferent and either oscillatory or not. The
effects of Stimuli in excreting Excretion are all

facts. But all these arguments, to 161
then from the power of stimuli in Inflammation
may be explained by the power of Ateries, their
irritability which perhaps extends over the whole
system. How it applies to establish an oscilla-
tory motion out of the reach of the Heart I can not
perceive. To all the basis of Inflammation can any
body say that it depends upon vessels of a certain
size, whether, Capillary or not? Who will say that
the Power of stimuli acts only upon Capillaries
of the third order and not upon those of the first,
and as far back as the Heart itself. They may if
you please, be more irritable. Inflammation pre-
sumes universal irritability. That it must con-
stantly begin in Vessels of a smaller size, I see no
reason. Merely in evacuating excretories and leav-
ing empty space behind, they naturally draw
from the Arterial system. But if there be a sym-
tem that extends from the excretories to the surtories
and from these to the Arteries, and so back to the
Heart, this Argument too will apply to estab-
lish universal irritability. The Balance in the
the small vessels of Dying Animals are proofs of
stimuli, but do not disprove the oscillation of small
Vessels. But there is no question with regard to the pos-
sibility of such oscillatory motions. It appears that
Arteries are not only flexible but irritable and con-

162 Don't suppose it to take place without beginning at the Heart. Every view of the operation of Aterias leads us to this supposition. Various causes are supposed to occasion this oscillatory motion; heat, the composition of the Blood and its constant volutine motion, the Heat when increased, may give dilatation and contraction, proving a stimulus; but is there any such heat ordinarily in the ^{extreme} vessels? That Hypothesis I shall take notice of in another place. This heat must be life and death you approach the extremes. Heat uniformly the same, can be no stimulus. With regard to the Blood consisting of Particles that are movable, volatile and Ateric, I would allow it to be often, but not constantly such. Its constant adhering, will not allow, proves a stimulus. The constant acromony of the Blood, becomes familiar to our Nerves; you must suppose either an increased acromony, or increased sensibility of the Nerve to account for this. What is occasional cannot be brought in as one of the ordinary means employed by Nature. With regard to the volutine motion of the Blood it goes on slowly, and it is promoted by constant motion. There is no alluding that air is constantly escaping and giving the intumescence necessary to such volutine motion. But I would conclude that there

is an oscillatory power from the Heart to the most extreme Ateries, and that a power remains to carry it on, in the returning veins on the one hand, excretories on the other, or that nature has added, powers different and unconnected with these; which leads to the means of promoting the Circulation.

Lect. XXX Dec. 22^d.

I have no doubt but that the Blood is propelled in the Veins by the Heart and Ateries. Some have said that the Blood is not propelled in this way any farther than where we see pulsation. What ever accident interrupts the Action of the Heart yet the action of the Ateries is added, and when the motion of the Blood ceases in consequence of Ligature, yet it does not follow that the Heart and Ateries only were stopped; the same thing may interrupt oscillatory motion. It is true that as in drowned persons the motion of the Heart is renewed, I have shown that one single pulsation is not sufficient for that effect, but that many are requisite, and therefore the Action of all the Ateries have been brought in. Haller then is wrong in the conclusion he draws from this example. Also the Arguments for the contractibility of Ateries in Part IX only apply to a simple Contractility of Ateries. I have said before if that was the

Let case the Arteries only restore so much of the Elastic force as was lost in their dilatation. Here Haller throws in the motion of the Blood after Death. "A motu general" When the irritability and contractility of the Muscles is lost the whole system of Vessels appears remarkably flaccid. This flaccidity allows the Blood to be moved by weight alone. This effect of weight is various according as the fluids are more or less thin, hence lividities are more considerable in those who died of Putrefaction. An Elastic air variously moves and impells the Blood. Haller goes on "invenio majoribus sanguis celerius movetur." there must be an acceleration as in the Arteries from the diminution of the cavity of the larger Veins. He seems to take this acceleration of the Venous Blood for an increased impetus; Hence he hints "simul frictio minuitur. But friction and adhesion to the sides are one and the same thing. I should have added before that Haller says he never observed any adhesion. "verum cum impediatur". He adds that the weight of Blood every now and then is resisting to its return; But the Heart gains as much in one part as it loses in another by this weight. He observes that little or no assistance is to be expected

to form the contractility of Veins; it is to be observed that the Veins are elastic but that they can give no additional force to the Blood. Haller adds that this motion is purely simple elasticity. However the experiments of Mr. Herschauer tend to show that the Veins are considerably contractile, and irritable as in the case of ligatures employed by him. But this experiment is not sufficient & that may be owing to their being stretched beyond their natural tension. It is then an ambiguous experiment. But he has rendered the matter much clearer by showing, that the touch of the scalpel, the tearing by the forceps, tend to irritability. But of this I doubt; and I think all his experiments have been made too nigh the Heart. The only question remaining is to say to what lengths the Muscular fibre may go along Veins. Unless then the experiments be made far from the Heart I deny this application. Tho I would not directly coincide with Dr. Haller that they have no contractility yet I would look out for other powers. He takes up these in V. We must take these which he speaks of separately. But first merely from swellings from the ends of Arteries, what ^{we} should be less than in the Veins; therefore in the extreme Veins the Blood should be more viscid. I find nothing in this for I don't perceive that the

166 quantity taken from the Venous Blood by ex-
cretion can affect the Vins, considering the frequency
of the Circulation, as is evident in the Midnight.
Suppose $\frac{1}{2}$ of Blood thrown from the Heart at
each contraction, and a Drachm, and $\frac{1}{2}$ into the
Kidneys. If there is a grain of the fluid, that is
a 60th part abstracted it would give a much more
copious secretion, than takes place. If every
minute would make nearly a quarter of a pound
in an hour which could never affect the fluidity
of the remaining Mass, Now as it is even much
less in the real secretion the effect must be still
less considerable. Take extraordinary basis of
quick secretion of urine; and you will find the
effect can never be considerable. I would observe
again that all that portion of fluid resorbed into
Vins can not answer the effect here mentioned; take
notice that it is coagulable by itself, and should ne-
ther favour the Coagulation of the venous Blood in
case of accidental stagnation. But farther says
Haller the Vins get a quantity of fluid added, he has
not touched this in his larger work. The Blood in
the Arteria pulmonalis is still venous, The lungs
show a considerable exhalation which is also venous
Blood from the end of the Arteria pulmonalis.
But Haller seems to reason that nature's efforts in

extraordinary occasions answer, to account for 167
her ordinary functions. There is no doubt but the Blood
would turn acid if it had not a new supply from
the Aliment. That means of supplying venous
Blood mentioned by Haller is neither true nor ne-
cessary, and wrongly explained.

Lect. XXXI. Dec. 25.

Haller imputes the motion of the Venous Blood
intirely to the Heart and Arteries; yet in Par.
CLXXIII, as if the Blood were but weakly propul-
sed by these, he has recourse to other power. We may as-
sume a muscular power in the Vins, and even when
they can not be demonstrated, but as it is mostly
over the whole system, it can not be supposed
sufficient to propul the venous Blood. next as
to his saying the venous Blood is more fluxile,
have shown that secretion can have no sensible
effect upon it. If the more fluid exudum were to
continue, it would affect the density or fluidity of
the Blood. A supply is necessary, and the ordinary
supply is by aliment. P. CLXXII "adjuvit prolema
viscoz". That the muscles
in their contractions become at least thicker in one
part of their length, as well as of considerable firm-
ness, and when contiguous to veins will press the
Blood towards the Heart, is not to be doubted; the
frequency of pulse, heat and redness ought not to be

168 can mention first, as there were the last proofs
mentioned by Haller of increased Arterial motion.
There is another consideration here which I am
surprised should have escaped Haller, viz: that the
muscles compress the Vessels that are in their own
substance. However, that the Blood is squeezed out
of these Muscles is not certain. Haller seems to ob-
serve this and says "pallidum nunquam videtur".
That the change of colour is not evident to our eyes, &
the colour of the Muscle may remain the same
from the Ballance of the Arterial Blood yet
this consideration may still have place. A trial of
it might be made if the Arm of a strong man is
immersed in a large cylindrical glass tube and sur-
rounded with water, during the Contraction of the
several Muscles of the Arm it may be observed
whether the water rises or subsides, the water upon
trial does subside and shows the Bulk of the mem-
ber to be diminished, which is a presumption
that this is one of the propelling venous powers.
It has been taken notice of almost by every writer
that in the Abdomen the Muscles relax and con-
tract, and that in their Contractions the whole
Abdominal viscera are more or less pressed, &
that the Blood in the veins, in the crural position
which is most frequent, is by this means helped
forward. But really the alternate action of the
Muscles can have no effect. The Abdominal mus-

cles yield and the viscera follow them. It is no less
preposterous than it is the most gentle Action; therefore
"in Abdomine Diaphragma prestat, & abdo-
minalium musculorum conplementa prestat" is pos-
sible. It is the Diaphragm, and the united pressure
that have any effect there. Every effort that we
make in a full inspiration, as to squeeze out the
thick urine &c, propells the venous blood. It is
assisted by a full inspiration and some contrac-
tion of the Abdominal Muscles. These do frequently
occur in the Actions of Life, and may propell
the blood in the Cava descendens. He adds also in
the same Par: assistance arising from the pulsation
of the Arteries. I mentioned before that what of
the heart's force was lost in dilating the Arteries
was recovered by their contractility, and that the
same thing might be said of the pressure of the
air, that the resistances arising from that were
compensated by its reaction, but that this advan-
tage could not go far, therefore in the ordinary
state of Arteries the pulsation can not have place
here. He adds another power, that of divulsion "*non-
dum satis cognita*". He began to suspect a
singular power in this. So in P. CLXIII. he says
"*quocunque fuerit*". If by *non dum satis cognita*
and *quocunque fuerit*, he means that it is not
sufficiently attended to, he is right. But the thing

170 itself as I said before is easily explained; it is only supposing that the Blood vessels are every where filled, so as to stretch them beyond the state of which their natural contractility would bring them to, that is to say the state they would be in if they were empty. Now if an Aperture should be made there will be an efflux, and that efflux will be in proportion to the tension, and if you suppose the force of the Blood very nearly balanced by the tension of the Vessel, it will likewise throw the Balance on the side of the tension, and produce a retrograde motion towards the aperture made. And we can suppose that the same phenomena would not appear in the large Veins as in the small ones. I do not then see wherein it contributes to promote the motion of Venous Blood by the tension, and may in this tight sustain the humours to the Heart, but it can not promote it unless when you add the power mentioned next "Denique multum potest respiratio in qua alternis momentis, sanguis, per vim de-
"rivationis in lacum pulmonem h." Now besides the contraction of the Auricles and sinus venosi, & the contractility of the whole venous system; but does this propel the Blood? During the diastole of the Heart, it is true the Venous blood is propelled, but during the systole it is retarded; and

in the trunk of the Vena it gives alternate risings and contractions. A free and easy respiration is what especially secures the free motion of the venous Blood, but does not afford it any assistance. "Anastomoses eademque in arteriis faciunt, that is to say where ever there are Anastomoses making opposite streams of Blood they occasion retardation; but then they compensate that by the greater force with which they flow from obstructions to the more free. P. LXXV. "his presideat ut obstruat, ut vultus in homine vultus, qui corpus suum, quantum satis est, exercet, moveat ut ea velocitate que sufficiat ut tantum vultus. "Quinis vena cava cordi reddit omni pulsus, quantum arteria aorta dedit." This is the conclusion of all that is to be said upon the motion of the Venous Blood, that as much is restored to the Heart as taken away from the Arteries. It may. It may not happen that in every pulse there is equal quantities brought and carried away but these inequalities are always compensated in any number of pulsations taken together.

Lect. XXXII. Dec. 24th.
The motion of the Blood from the right ventricle to the left and from the Arteria and vena Pulmonalis to the Heart. In this vessel, as in the lungs the Vessels are alternately contracted and relaxed.

172 I am next to speak of respiration, and shall depart from Haller's order, passing quite over the fluids which are to be considered in a different way from him. The circulation is to be considered from the right ventricle to the pulmonary artery and back to the left Ventricle. The alternate contraction of the Lungs makes the function of respiration not separable from the powers that carry on the circulation 1st I shall refer you to Anatomy for as much of that as is necessary, 2^{ly} I shall consider by what means the Air enters and dilates the Lungs, and is again expelled — 3^{ly} The effects of this upon the motion of the Blood from the right Ventricle to the left, and also what changes the Air undergoes. — 4^{thly} Why the contractions are alternate. And lastly shall give some miscellaneous particulars not brought under the former or Grade. The effects of respiration on the state of the Blood, will come on better in another place.

The Lungs are a Hollow Viscus surrounded in a Membrane that compresses the air, while it is at the same time considerably flexible, and dilatible, and again contractile. They consist very entirely of a cellular substance contractile and elastic, that they are naturally dry and empty and every part communicates with every other of the substance of the Lungs, and all with the Trachea Arteria, which last

communicates with the glottis, and throws out 173 the air into the external Atmosphere. Further the Arteria Arteria is so divided, that Air entering by the trunk can be distributed to every minute Portion of it. The Arteria Arteria and the Bronchia, consist partly of Cartilage partly of Membrane; the former are connected with the latter and there are evidently muscular Fibres which can contract this canal both by its length and breadth, and therefore the Air Vessels of the Lungs in the Arteria & its Branches are of various Capacities. The manner in which the Bronchial vessels terminate in the extreme parts of the Lungs and of the cellular Substana Malpighius's opinion is at present given up; but whether the cellular substance has any determined form, or how more strictly the cells are connected with the Bronchia is not well known. This however has no effect upon the explication I am to give, of respiration. The Lungs appear to be capable of being dilated by air in a certain quantity. I now proceed to the 2^d point — I suppose it is not necessary, with Haller, to define Air; you all know that it is an elastic fluid, pressing in all directions, and therefore