

I. *A Letter from Mr. Anthony van Leeuwenhoek, F. R. S. concerning the Circulation of the Blood in Fishes, &c.*

*Delft in Holland, August 28, 1708.*

SOME time ago, I viewed the Hearts of several Fishes, and particularly that of the great Silver-Eel, which I cou'd not be weary of looking on, and observing its motion that lasted near four Hours, after 'twas out of the Body of the Fish; and the rather because that Motion was so regular; for when the Blood is protruded out of the Heart, it is not brought into the great Arteries with the same swiftness, which in that case wou'd be over-charged with the great quantity of Blood: but the Blood thus coming from the Heart, is forced into a little white Vessel, almost of the Figure of a Pear, and which one would take for a kind of a Bladder; one Orifice of which was united to the great Artery, and the other to the Heart; in the latter Orifice is a Valve, the use of which is, that (when the Blood is protruded from the Heart into the aforesaid Vessel that I described to be like a Pear) it might not run back again into it: which Vessel having been cut across, I observed the inside of it to be furnished with so many small Particles, that 'twas in a great measure fill'd with them; and these internal Particles I conceive to be made, to the end that when the Blood is protruded into the Vessel, by dilating and contracting it self it may presently force the same into the Great Artery.

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When this Blood at every Protrusion came from the Heart into the aforefaid Pear-like Veffel, the faid Veffel was very much extended in roundnefs; and then immediately the extended Parts were again contracted, or drew themselves in, to the end that they might in this manner regularly, and without intermiffion, protrude the Blood into the Artery: for if this fort of Veffel were not united to the Heart, the Blood cou'd not be conveniently carry'd into the Arteries, becaufe the Arteries cou'd not fo largely extend themselves; and then, in my Opinion, at every Protrusion of the Blood from the Heart, there wou'd be a ftop put to its flowing into the Arteries for a fmall inflant of time: whereas in this cafe the Blood is almoft always running with an eafy and conftant Courfe; tho' at every Protrusion it muft be in fome manner quickned, yet that is fo infenfibly, in my Opinion, that no Body can obferve or feel it.

Now according to this conftant Protrusion of the Blood into the Arteries of Fifhes, without the leaft intermiffion, I am of Opinion, that the fame thing happens as regularly, and after the fame manner, in the Protrusion of Blood out of the Heart into the Arteries of Beafis; and the rather becaufe we always find, that the Great Creator of all things does bring about his Operations in the bigger Creatures, after one and the fame manner, tho' their Hearts are of a different Figure from thofe of Fish.

I have formerly communicated to the Honourable Society fome Discoveries of mine, relating to the Circulation of the Blood in Eels, confifting in this; to wit, that the Blood coming out of a great many fmall Veffels in the Tail of an Eel, falls in, and is united in one greater Blood-Veffel, where is the firft beginning of the Fish-Bones, and where the Blood runs thro' a Valve, which I have not only obferved my felf, but have likewise fhewn to feveral Curious Gentlemen, who view'd it with a  
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bundance of Pleasure and Surprize ; for the Blood-Vein was not only moved in that part where the Valve is, but the Parts about the Blood-Vessel, of the breadth of four or five Hairs, were likewise moved or stirr'd ; from whence it appear'd, that at every Protrusion of Blood into the Heart thro' the Valve, the Blood stood still about an instant of time, and that the same Blood falling thro' the Valve, ran with great swiftness, and was thickest just at its Protrusion out of the Valve, but ran thinner or slenderer like the Figure of a Pear ; and the Vein that received this Protruded Blood, was not intirely fill'd with it, but seem'd for a small space to be as it were empty, and the Parts of it contracted, which we cou'd perceive for a small time, and further observing it, saw the Blood run slowly and leisurely along the same Vessel.

From this Observation I imagin'd, that the same thing happen'd in the Heart of a Humane Creature, *viz.* that there is a gentle and slow Protrusion of the Blood out of the Heart into that Vessel, which we call the Artery, and consequently that there is no such motion there, as what is called a Pulse, and which is felt in the extreme Parts of the Body ; but that the so named Pulses are only caused by the Protrusion of the Blood thro' the Valves that are in the Veins, but I never observed any violent or swift Protrusion of the Blood into the Arteries, as often as I have viewed the Circulation thereof : and tho' the Blood, by the Contraction of the Heart, be suddenly and hastily protruded out of it, yet its slowly carried into the Artery ; whereas on the contrary, it runs into the Heart from the Veins with a violent and swift Course ; from whence it happens, as I suppose, that the remaining part of the Blood in the Veins being unable to follow with so swift a Motion, are as it were violently and *per saltum* drawn or forced thro' the Valves, and that it is this sort of Motion which we take for Pulses in the Arteries. That

That I might satisfy my self in the abovemention'd Observations, I have several times viewed that sort of Motion in my Arm, which we call the Pulse, at the time when my Body was without motion and warm; and after a diligent Consideration of it, I judg'd that that Motion, which we perceive in the Blood-Vessel, was not derived from the Heart to the Hand, but contrariwise from the Hand to the Arm, and so to the Heart: From whence I concluded, that like as in the Tail of an Eel there are no Valves in the Blood-Vessels, as far as I cou'd perceive, and that a great many small Blood-Vessels, are, as it were, united in that part where the Fish-bones begin, and make one large Blood-Vessel, and that there is the first Valve; in the same manner in Humane Bodies, a great many single Blood-Vessels running out of the Hand, are joyned in the Arm, where likewise the first Valve is, thro' which the Blood at each Protrusion falls into the Heart, and that that is what we call the Pulse.

I have several times observed in the exceeding small Veins or Capillary Vessels, a little rising or swelling occasion'd by a stronger Motion of the Blood, which I now firmly conclude, to proceed only from the sudden Motion or running of the Blood thro' the Valves: I have also observed, that in sudden Frights, and otherwise, one feels such Motions at the end of one's Fingers, just as if there were Valves likewise in them, thro' which the Blood gushes; but these sort of Motions, I suppose, do only depend on that quick Motion made by the Blood, when it runs thro' the Valve in the Arm by the Hand, to which we give the Name of a Pulse:

'Tis said, that there are Valves in all the Veins of one's Body; but I can hardly admit that Assertion, for if there were Valves in those Veins, which we can see with our naked Eye thro' the Skin, for instance, either of the Hand or the Arm, we shou'd certainly, in my  
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Opinion, discover likewise the Blood running thro' those Valves: and again if there are Valves in the aforementioned Veins of the Arm or Hand, we should not be able by pressing those Veins with the Finger to drive the Blood back again, which notwithstanding is often done.

Moreover, if there were Valves in the Veins that lie in the Skin expos'd to our sight, there wou'd, in my Opinion, a great many Inconveniencies arise therefrom; for if a Blow or Thrust were made upon that part where the Valve lies, the Blood would not be able to retire back, by which means the Valve or even the Vein it self might burst: whereas, if there are no Valves, the Blood can easily retreat upwards or downwards in the Veins, as we, in Fact, observe of those Veins that run on both sides in the Tail-Fins of an Eel, which do not unite in one greater Vein where a Valve is, at least as far we cou'd follow those Veins with our Eyes.

Having thus far committed these my Observations to Papers, I considered with my self, whether I might not have something of this nature lying by me, having formerly consider'd this Subject of Eels; and I find amongst other Papers, these that follow.

In the Month of *September* 1706, having opened an Eel, and taken out the Guts, the Diameter or thicknes of which was about an Inch and a half; and having also laid open the Heart, I cou'd not discover that part which receives the Blood out of the Great Vein in order to bring it into the Heart.

But to the end that I might better discover that part, I prepared a little Glass-Tube, and put it into the great Vein at a little distance from the Heart, and then blew some Air into the said Vein, as much as might take up the space of about half a Pea: this Air pass'd thro' the Great Vein into a little Bladder that lay on the side of the Heart, the like of which I had never before observed

ved thereabouts; and no sooner was the Air got into that Bladder, but it did, as it were, first contract and then dilate it self, so regularly and in such a manner, that when the Heart contracted it self (just as if it were going to throw out it's Blood,) the aforesaid little Bladder with Air in it was dilated; and this did not happen for a small time, but the Bladder continued in such a Motion above five full Hours together; but indeed in the last Hour it was so faint, that one could but just perceive it; and as for the Heart, its Motion was discontinued.

I caused moreover a Pike-fish to be brought me about two Foot long, and open'd it immediately whilst it was in its full strength of Life, and observ'd not only the Motion of the Heart, and the regular Motion of that part which receives the Blood, and brings it into the Heart, but also the Motion of that other part, which receives the protruded Blood from the Heart, and carries it gently into the Arteries.

Now because very few have any manner of knowledge of the Heart of a Pike, and the Motion thereof, I have caused such a Heart, with the Vessels and Instruments belonging to it, to be drawn by my Painter.

*Fig. 1.* A, B, C, D, shews the Heart of a Pike; D, E, F, A, represents that part into which the Blood is brought from the Veins; and C, D, G, that other part which receives the Blood from the Heart, to carry it into the Arteries.

Now when the Heart receives the Blood which is conveyed into it, it dilates it self into its utmost roundness; and then that Instrument or Vessel describ'd by A, D, E, F, does at that very instant fall as it were quite down from its Swelling or Extension, and discharging it self of its Blood into the Vessel C, D, G, all Parts of it become extended by the sudden pouring in of the Blood; and no sooner is it so dilated, but it draws it self in a-

gain, and is contracted on all sides, to the end that it may force the Blood into the Arteries. In short, when A, D, E, F, is contracted, and throws the Blood into the Heart, the Heart is dilated; and when the Heart shrinks it self in, and is contracted by the Discharge of the Blood, C, D, G, is dilated; and these three several Motions happen in so short a time, and are perform'd so regularly, that those who have observ'd it curiously, are quite astonish'd at it: and from hence we can't but conclude, that such a Motion as this cou'd not be brought about, unless the Vessel A, D, E, F, had a Valve at A D, where it is joyn'd to the Heart, which Valve is to prevent the Blood that is thrown into the Heart, from returning the same way; and so likewise there must necessarily be another Valve at C, D, to hinder the Blood, that is protruded from the Heart, from flowing back into the same.

I have also taken the Heart of a Salmon, and caused that to be drawn, as you may see in *Fig. 2.* H, I, K, L; in which Figure K, L, M, represents that Instrument that was describ'd in *Fig. 1.* by A, D, E, F; as I, N, O, shews that which in *Fig. 1.* was C, D, G.

Moreover in *Fig. 2.* I shew you the Instrument K, L, M, cut open, to the end that we might discover, as well as we could, with the naked Eye, the Sinewy Parts and their Branches; all which appear'd as in *Fig. 3.* P, Q, R, S, T, in which Q, R, is the Part that was joyn'd to the Heart, and is the same that in *Fig. 2.* is represented by K L; in the said *Fig. 3.* you may observe how the Sinewy Parts and their Branches run from Q, R, to T; this Instrument, or Vessel, is very soft in its Parts, and it seems to me also, that it is not strong.

*Fig. 4.* V, W, X, Y, is that Vessel dissected, which in *Fig. 2.* is represented by I, O, N; which Vessel is exceeding thick and strong, and is like the Instrument described

scribed by *Fig. 3.* and is provided within with strong Sinewy Parts, to the end that when the Parts are extended by the Blood that is pour'd into them, they may be able both in roundness and length to carry the Blood into the Arteries: these Parts, by reason of the great number of them, cannot be delineated in such manner as they ought.

These my new Positions will appear strange to a great many People, and I make no question, will meet with much Contradiction; because it has been the fix'd Hypothesis of all the Learn'd Men, both past and present, that have exercis'd themselves in Anatomy, that the Arteries receive such a Motion from the Heart, as we call the Pulse: whereas I have now shewn, that the Heart does protrude the Blood gently into the Arteries; and that the Blood, which flows from the Veins into the Heart, causes such a sudden snatching or revulsion, that it can't so immediately pass thro' the Valves; in which part also the Veins are a little narrower, by which means there is a kind of a stop or intermission in the Circulation of the Blood: and this, I say, is the Cause of that Motion, which we call the Pulse.

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