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The 12th at Night these Lights are said to have appeared again, as also on *Saturday* the 18th, to a very great degree, but I saw them not; the Weather still frosty with little Snow.

Feb. 22. At  
Night.  
23, 27.

Hard Snow.

A Thaw and some Rain, and but little Frost afterwards, only dry cold Winds, till the 27th, when the Frost returned very sharp, with exceeding cold Winds, at N. E. and S. E. for a Fortnight or more, without any Snow, and did a great deal of hurt.

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VII. *Observations on the Muscular Fibres of Fish.*  
By Mr. Leeuwenhoeck, F. R. S.

Delft, April 11. 1721.

**I**N my Letter to this Honourable Society of the 24th of *January* last, I treated of the great Number of Vessels that I had observed in the Fibres of the Muscles. I now take the liberty of presenting you with the following Observations, hoping there may be something in them for your Entertainment.

It has been affirmed to me by several Persons, and in particular, by a certain very learned Foreigner, that Nature, in all her various Productions, constantly observes the same Course and Manner of Operation. To this Assertion my Observations do by no means agree; neither those, that I have made upon the Generation

neration of Animals, and the Seeds of Plants; nor yet those that I have made upon the Muscles and Muscular Fibres of different Animals, forasmuch as the Muscles of Fishes are not provided with any Tendons. On this occasion, I have lately examin'd anew the Muscles of the Cod-fish, upon which I have made the following Observations.

After the late Discoveries I had made of the small Vessels in the Muscular Fibres of the Whale, the Ox, the Sheep, and the Mouse, I was apt to imagine, that the same Fabrick would hold in the Muscular Fibres of Fish likewise: but as this could not be certainly concluded, having at that time in my house a part of a fresh Cod, I cut off a piece of the Fish, with Intent to examine it with my Microscope some Days afterward.

This piece of Fish I cut into small Slices, some according to the length of the Fibres, and others directly across them, in order to observe, whether these Muscular Fibres were composed of great Numbers of small Vessels running according to the length of the Fibre. And in effect I found, that, when I had cut the Fibres dexterously through, there appear'd in the Microscope as great a number of small Vessels running along these Fibres, as I had formerly seen in the Muscular Fibres of a Whale.

But what appear'd to me the most remarkable, was, that in a great number of Fibres, in which I was not able to discover any Vessels running according to their length, I observed abundance of small Vessels, which seem'd to me to proceed from the Membranes encompassing the Fibres. For in one Fibre these Vessels appear'd to come out of the Circumference, or circular Tunicle of the Fibre, and to pass on to the  
opposite

opposite part of the Tunicle. And in another Fibre cut transversly, I saw Vessels arising from the Circumference, and dividing themselves into smaller Branches about the middle of the Fibre ; all which, as far as I could perceive, ended again in the Circumference of the Fibre. In one Fibre I saw at least fifty of these Vessels running through one another.

Upon this Discovery, I found I had been mistaken in what I had at first imagin'd, which was, that the Vessels, which arose from the Membranes, proceeded no farther, than just through the Tunicle of the Fibre, and so discharged the Fluid into the Fibre for its Nourishment. Whereas, now I perceiv'd, that the Vessels, which arose from the Membrane, and entred into the Fibre, did not end there, but spread themselves into smaller Branches proceeding every way from the inside to the Tunicle of the Fibre. This caus'd me to think, that the nutritious Juice might circulate in these small Vessels, just as the Blood does in the Veins and Arteries; and that what the Muscular Fibres received from them, might be no more than what ouzed thro' the Tunicles of these small Vessels, as I have said of the small Vessels in Land-Animals, which have no other end than the Artery coming from the Heart, and the Vein terminating in the Heart; the Artery and Vein thus making one continued Vessel.

Having now a great number of Fibres lying before me, in which I could see very plainly the Vessels just now treated of, yet I could not discern in the transverse Sections of the Fibres any appearance of those Vessels, which run along their length, and compose the greatest Part of the Body of each Fibre. This I imputed to the cutting of those Vessels not directly

rectly across, but something obliquely, by which their Apertures had been clos'd in such a manner, that I could not perceive them, nor the least Resemblance of them.

I have several times observ'd, between the Muscular Fibres of the Fish, a great number of Vessels lying together, which compos'd what is commonly call'd a Membrane, which Vessels surrounded the Muscular Fibres, and lay so many of them together, that the thickness of the whole *Fasciculus* of Vessels was equal to that of a Muscular Fibre, and, as I imagin'd, was afterwards to be dispers'd in smaller Ramifications between the Fibres.

In taking a View of an entire Muscle of a Cod-fish, and the Fibres of which it was compos'd, I found the thick end of the Muscle to equal the Back of an ordinary Knife, and the thinner end not to exceed the thickness of a single Fibre. Many of these Fibres are twice as long as the thickness of the Muscle, and between the Muscles lie what are commonly call'd Membranes, which are nothing else but a *Congeries* of Vessels. These Vessels do not only run between the Fibres, but into the very Substance of every Fibre, as we see, when the Fibres are cut transversly. By these Vessels the Muscular Fibres, and the entire Muscles themselves are so firmly bound together, that they serve instead of Tendons to one another.

In like manner the Muscular Fibres are united to the Bones, by the Vessels proceeding from the Bones, which Vessels compose what in Land-Animals is called the *Periosteum*.

In order to give a clear notion of what I mean, when I speak of the Muscles of a Cod-fish, I have here caus'd two of those Muscles to be delineated, lying close together, as they are united to one another, and separated from the other Muscles, as is represented by *A, B, C, D*, Fig. 1. the Part design'd by *A, B, C*, having been cover'd with the Skin near the Head of the Fish. And it is my Opinion, that the Body of the Cod-fish, from Head to Tail, consists of a continued *Series* of such Muscles.

I have likewise caus'd a single Muscle of the Fish to be represented by *E, F, G, H*, Fig. 2. where *E, H, G*, shews the Thickness of the Muscle; and its thin Edge, which is no thicker than the Edge of a Knife, is marked by *E, F, G*.

When these Muscles had lain several days upon a Paper, yet they were not dry'd so hard, but that I could split them into thin Shivers, one of which is design'd in Fig. 3. between the Letters *I* and *K*, in order to shew the oblique Course of the Fibres, which are represented by small Lines.

I now turn'd my Thoughts to the River-Fish, and particularly to the Pearch; and, as I imagin'd that an old Pearch had no greater number of Muscular Fibres than a young one, but only that the Fibres encreas'd in bigness during the Growth of the Fish, and that the larger these Fibres were, the more plain and distinct must be the small Vessels, of which the Fibres were composed; I sent orders, upon a Market-day, to bring me the largest Pearch that was to be found in the Market; and accordingly, I had one brought me the largest that I had ever seen, weighing three pounds and an half, and seventeen Inches and

and an half in length *Delft* Measure, which is the same with the *Rhinland*.

I cut off four pieces from this Fish, as two from the Back near the Head, and two others from the Belly in the thick part of the Fish, with design to make my Observations upon them the next Day.

Accordingly, at that time, I took a view of the Muscular Fibres both in length and breadth, and found that the Fibres of this great Pearch were not so thick as those of the Cod-fish. Upon cutting them thro' lengthwise, I saw the Apertures of the small Vessels in so great a number, as I could hardly have believ'd, if I had not seen them. I next cut some of the Fibres transversly, and plainly found them thinner in this Pearch, than in a middling Cod-fish, and saw the small Vessels, that compose the greatest part of the Bulk of the Fibre, lying as close together, as ever I saw them in any kind of Fish or Flesh.

To give a better notion of these Muscular Fibres, and of the great number of small Vessels, of which they are chiefly compos'd ; I had, some Weeks before, placed some of them cut transversly in pieces before a Microscope, with design to have them drawn by my Painter, but had been obliged to defer it, by reason of the great Severity of the Weather. These had been a little moistned before they were placed upon the Glass, in order to make them stick to it the better ; and I have caused a small portion of these Muscular Fibres of the Fish, cut thro' transversly, after they were grown dry, and in their shrinking had been torn off from the small Vessels, that encompass them, to be represented, as at *L, M, N, O*, Fig. 4: The openings of the small Vessels in these Fibres were distinctly to be seen, but appeared in such great numbers, and were

so exceedingly small, that it was impossible for the Painter to represent them any otherwise than by Points.

In this Figure are represented what we call the Membranes, but which indeed are nothing else but a *Congeries* of small Vessels, which not only surround the Fibres, but enter into their very Substance. These, in the drying and shrinking of the Object upon the Plate, had been torn off from the Fibres, as may be seen at *P, P, P*.

When this was done, I put a small Drop of Water, about the size of a Pin's head, on this small Portion of Fibres, into which it immediately insinuated and swell'd them to the same bigness, as when they were first laid upon the Plate: After which, I desir'd the Painter to draw them, as they then appear'd to him, but to omit representing the small Vessels, and only to design the Circumference of every Fibre, which he did, as appears at *Q, R, S, T*, Fig. 5.

I then clove a grain of Millet thro' the middle, and placing one half of it upon the Glass, beside the portion of Fibres represented in Fig. 4. I desir'd the Painter to observe the difference in bigness between the half grain of Millet-feed, and that portion of Fibres; who told me, that the half grain appear'd larger than the portion of Fibres, and so said likewise a second Person that view'd them. By which one may easily imagine, in how small a space that number of Fibres is comprehended, each of which consists of so many Vessels. I caus'd the Painter to represent the half grain of Millet at Fig. 6.

I likewise made my Observations upon the Muscular Fibres of a Pike, a Roach, Schar, and Flounder,  
in

in each of which I found the Fibres to be composed of small Vessels, like those of a Cod and Pearch.

I had now a mind to examine the Muscular Fibres of the Smelt, to see whether they were likewise composed of Vessels, but not being able at that time to meet with any Smelts, it came into my Head to observe the same in dried Sprats. Accordingly I took the largest of these I could light on, which was a little more than five Inches in length, and I found that the Fibres of the Sprat were but little thinner than those of the large Pearch spoken of before, and that the Vessels of which the Fibres were composed, were nearly as numerous as in the Fibres of the Pearch.

From these Observations some Persons may be apt to conclude, that the Muscular Fibres of Land-Animals are of the same thickness with those of Fish. But for the satisfaction of those, who have not seen the Objects here spoken of, I have caused a small portion of the Muscular Fibres of a large Ox to be delineated, as they appear'd through the same Microscope with the former, to shew the thickness of the dried Fibres, and the Vessels that compose them, as is represented in *Fig. 7.* by *X Y Z.*

I desir'd the Painter to tell me, how many Vessels he could see in the transverse Section of one of these Fibres; who, after some pause, reply'd, That he counted five and twenty Vessels in one Fibre.

Some time after this, I had a small Smelt brought me, of the length of about two Joints of my Finger; and cutting some of its Muscular Fibres transversly, I placed them before a Microscope, and saw not only that these Fibres were twice as thick as those of an Ox, but likewise that they were provided with as great a number of Vessels as the Fibres of other Fish.

Upon



Upon thus observing that the muscular Fibres of Fishes were much larger than those of Beasts, I set my self to consider, for what Reasons the great Creator of the Universe had made this Disproportion between them. All the Satisfaction I could meet with, in my Thoughts upon this Subject was that, as the Fish swim in the Water, their muscular Fibres need to exert very little force, in order to support their Bodies in the Water, because they are very nearly of the same specifick Gravity with the Element, in which they swim. All the force they exert is in their progressive Motion, in pursuit of their Food. Whereas the muscular Fibres of Land-Animals exercise a great force, not only in supporting and moving their own Bodies, but in carrying Burthens and other Labour they are put to. And we must allow, that the smaller and finer the Fibres are, to make a Body of any determinate thickness, the stronger will be the Composition, and therefore the Muscles in Flesh must be stronger than those of Fish. But this I leave to better Judgments.

It justly claims our Admiration, to see the wonderful and amazing Structure of these minute Parts in the Muscles of Beasts and Fish, which never enter'd into our Thoughts; and no doubt there are many other surprising things there inclosed, which will perhaps for ever escape our Penetration.

*I am, &c.*

**P. S.**

## P. S.

I Happen'd yesterday to take up a boil'd Grey Pea, out of which I took a little of the mealy Substance, and laid it before a Microscope, where it appear'd to consist of such like Parts as are found in Rats Dung, every one of which Parts consisted of a great number of very small Particles. But I could not discover any Membranes enveloping those Parts, from whence I concluded, that those Membranes were destroy'd and dissolv'd by the hot Water.

Upon this, I took another Grey Pea, which had not been boil'd, and cut it into very thin Slices, when I not only saw the Membranes, in which the Parts of the mealy Substance had been inclosed, but found likewise, that those Membranes consisted of nothing else but a great number of very small Vessels, like the Membranes, as they are commonly call'd, which surround the Muscles and muscular Fibres in Beasts and Fish.

I intend to prosecute this Subject farther for my own Diversion.

