

II. *A Letter from Mr Anthony van Leuwenhoek, concerning the Seeds of Oranges, &c.*

Delft in Holland, the 6th of Feb. 1703.

I Have formerly, according to my small capacity, abundantly demonstrated, that almost all Seeds are only made for the nourishment of the young Plant within them (which is a small Particle of the Seed, as little as it appears to our Eyes) till it be able to spring forth from the Earth; but forasmuch as I lately met with the Seed or Kernel of an Orange, in the middle of which, to my great surprize, I found another compleat Seed; I have taken the liberty to send to you my Observations about the said Kernel, and the growth of it.

I have several times open'd the Kernels of Oranges and Limons, and often found that what we call a Stone, Kernel or Seed, is improperly so call'd, and that when we have stript it of Skin or Membrane, we shall frequently find that two Seeds are inclos'd in that Membrane, to wit, under the Skin, and without side of the Kernel there is a small Seed, the like of which has not occur'd to me in other sorts of Seeds.

'Tis true, you shall often find in Hazel-nuts, Almonds, Peach and Apircock Kernels, a double Seed or Kernel, but then each of them is inclos'd in a double Membrane, that have no communication with one another but in a bare simple contact, but have each of them a distinct Stalk or String, by which consequently they receive their proper nourishment.

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In the Month of *November* last, two Gentlemen made me a Present of *Surinam* Oranges, and in the first I open'd I found eight and thirty compleat Kernels, but in neither of two others could I meet with four good Seeds; I open'd several Kernels of the first Orange, one of which, surrounded with its Membrane, I caus'd to be drawn, as you will see in Fig. 1. A B C D.

When I had stript one of these Kernels of the outmost Membrane, I discover'd that there lay a String under it, that caus'd a little protuberance in the first Skin, represented in the said Figure by A B C, from which String, not only the Seed, but the Plant within it receives its increase and nourishment. Fig. 2. E F shews you the same Seed separated from its first and hard Skin, which is only given to it, as I conceive for the defence of the inward parts; whereas Nuts, Almonds, Peach stones, &c. are arm'd with strong and thick Shells, F G represents the aforesaid String, which I parted a little from the Seed itself, that I might render it the more visible, and which String is not only joyn'd to the Seed at F, but extends its small Vessels also thro the second Membrane from F towards E, the seat of the Plant, and in order to its nourishment, but those Vessels are so exceeding fine and small, that they escape the sight before you trace them to their journeys end.

Now we may certainly conclude that the said String does actually comprehend in its self as many distinct Vessels, as are to be found in the Orange-Tree when it is arriv'd to full maturity; for if all these Vessels were not in the young Plant whilst it lies involv'd in its Mother, the Kernels Womb, whence can they proceed afterwards? but this is so self-evident, and will be so easily granted me, that I need not say more on that topic.

Tho the said String was very small, yet I was resolv'd to try if I could give you a sight of the Vessels within it, and I succeeded several times, but not without a great deal of
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trouble to me before I could place it in such a position, as my Limner might be able to draw it exactly.

Fig. 3. H I K L M N represents a part of the same String cut across, which Fig. 2. F G gives you entire, and in its whole length.

The said Particle of the String at H I M N has abundance of exceeding small Vessels, but very hard to be seen, about I K L M they grow larger, and consequently more visible; and thus you may see a great many, tho not all of the Vessels.

After I had made this observation, I was thinking whether these great Vessels were not the origin or source of the contexture of that Membrane which covers the Seed; and on the other side, whether the former describ'd by H I M N were not the feeders of the Seed and Plant.

I had also plac'd a piece of another string of the Kernel of an Orange before another Microscope, of which I have given you a rough draught, only to show how the utmost Membrane incompasses the String in order, as I suppose, for its strength and defence.

Fig. 4. O P Q represents the said String cut across, R S T V that part of the hard Membrane that surrounds it, T V Q W are faintly shewn that infinite number of Fibres, particularly at Q W, that Nature uses in the contexture of such a small String.

The last Phenomenon suggested to my thoughts, that those long Fibres represented by Q W were design'd to add a stiffness and solidity to the outward Membrane, for the better defence of the internal Vessels.

I have often observ'd that the outmost Membrane R S T V did compress the String so closely, that there remain'd little space between them.

In the said Fig. 4. X Y Z is represented that Membrane, which surrounds the Kernel or Seed and the Plant; the said Membranes are very thin, and particularly the inmost of them.

Such a Seed or Kernel being cut across, you would think the Particles of which it is compos'd, to be nothing but irregular Globules squeez'd or compress'd close together.

Fig. 5. A B represents such a Seed divested of its Membranes, and which seem'd to have but one Plant within it, whereas I have often seen under the Membranes another small Plant, which lay as if it were squeez'd into the substance of the Seed, and so is not to be seen till the Seed, be stript of its Membranes, contrary to those of Nuts, Peaches, Almonds, &c. which where there is two of them, lye entire and distinct in their proper Membranes, as I have hinted to you before.

I have likewise observed under the Membrane or Skin of an Orange-kernel three distinct Seeds with their Plants, but some of them indeed, much bigger than the others.

These Seeds with their inclosed Plants are easily divided into two Lobes or distinct parts, insomuch that they do not seem to have been united but only where the small Plant lies; so that the whole Kernel, Fig 5. A B, was fram'd by Nature for no other use, in my opinion, but to foster and nourish the tender Plant within, till it be able to stand alone, and draw its subsistence from the Earth about it.

Having split the Seed, Fig. 5. A B, into two parts, one half of which is represented by Fig. 6. C D E F, together with part of the Plant, that would have been a Tree sticking close to it, you may see the Plant it self at C, no bigger than a grain of Sand to the naked Eye.

That which induced me to give you so exact an account of the Anatomy of an Orange kernel, was, because I discovered (to my great wonder) another Seed or Kernel, together with its Plant, in the heart of the former.

The counterpart of the aforesaid Kernel is designed by Fig. 7. G H I K, and G the little pit or bed of the Plant, and in the said Figure between H and K, the concavity wherein the second Seed also lay, *vid.* D F in Fig. 6.

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This Phenomenon was wholly new to me, tho I had dissected many sorts of Seeds before, *viz.* to see in the middle of one Seed or Kernel another compleat and perfect Seed ; especially when I consider'd that from the Vessels arising out of the String, and dispersing themselves through the Membranes, both the Kernel and Plant are produced ; and yet these same Vessels must insinuate themselves into the very heart of the first Seed before they can produce a second Seed and Plant within it ; when I considered all this, I say I was struck with admiration, and could not forbear crying out, Oh the inscrutable Wisdom of God, &c.

I thought it would not be amiss to place such a small Plant as is represented by C in Fig. 6. before a Microscope, and cause it to be delineated, as you may see in Fig. 8. L M N O P Q, whereof Q L M is partly that which Nature intends for the body and root of the Tree, N O P the Leaves wherewith the young Plant is already provided, and O P represents that part of the Leaf which is next the light, and something protuberant, by reason of the inclos'd smaller Leaves.

In the said Fig. 8. by M N and P Q are shewn the two sides of the Plant torn off from the Kernel, to which it was united, and from which it did receive its nourishment.

Moreover, I took the said young Plant as it stood before the Microscope, and turn'd it a little about, in order to shew the two largest Leaves, whereas in the former position I could see but one of them.

Fig. 9. S T V represents the two great Leaves in this posture, between those said Leaves, according to all appearance, are shut up a great many small ones, but because I could not unravel them so as to give the Limner a full view of them, I would not suffer him to take any notice of them, yet when I came to cut the Leaves across as they lay involv'd in the bed of the Plant, I imagin'd that I saw the small Leaves abovemention'd ; and when I cut after the same manner that part of the Plant which is to be the body
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and root of the Tree, I discovered within the small Particle that which was design'd for the Pith, and even the Wood itself, and all that as plainly as if I had been observing with my naked Eye a young Plant of an inch thick.

I endeavour'd as far as I was able, to describe the texture of the Pith, as it appear'd to me in Fig. 10. W X Y Z, in the said Figure you may observe a great many small Particles, which at first sight one would be apt to take for irregular Globules, but plac'd in a right line, and all of them of greater length than breadth, but I look upon them to be nothing else but small Pipes or Vessels, whereby the Plant receives its nourishment, and who can tell but every one of them is cover'd with a distinct Membrane.

These said parts, which compose the Pith of the Plant are not to be discover'd, unless with a sharp Knife you cut off a piece from the Seed after it is stript of the Seed, and place it immediately before the Microscope; for all the moisture is so soon exhal'd after it is cut, that one shall not be able to make any observation.

Moreover, for my own and others satisfaction, I took a little Copper-box, and put into it some Sand, which for its whiteness, and because it is us'd to scour Tin, we call scouring Sand; this Sand was very dry, but was something moistn'd by the Seeds which I mingl'd with it, having newly taken them out of an Orange.

This was done on the 19th of *November* in the Evening about 7 of the Clock, after which I carried the same Box adays in the Waistband of my Breeches, where I us'd to put my Watch, and a nights I plac'd it within a large Tin Bottle fill'd with hot Water, which my people put into my Bed to warm it, by which means the little Box was also kept warm till the morning; and after I had repeated this practice three days following, I open'd the Box, and took out one of the Seeds, but could not discover any change in it.

On the 25th of *November* about 6 a Clock in the Evening, after that the Sand and the Seeds had been six days in a continual warmth, I open'd my Box again, and observ'd that the Root was pufft forth a small matter out of the Membranes of the Seed, as you may see in Fig 11. A B C, A B being that part of the Plant which was to become the Root, and B C D the rest of the Seed involv'd in its Membranes.

Moreover, I took another Seed out of the said Box, which having cleansed from the Sand, and separated from its Membranes, I took the two Lobes of the Kernel that inclose the Plant, as you may see in Fig. 6 and 7, and with fine Pins parted them a little asunder, that I might show the top of the Plant describ'd in Fig. 8. by O P Q.

Fig. 12. E F G H I represents the Seed, which, as I said before, had lain six days in the Sand, and was divested of its Membranes.

E F shews that part which is destin'd for the Root, F G and I F are those parts, from whence the young Plant receives its nourishment, and which by two Pins K and L are divided from each other, in order to discover that part of the inclos'd Plant, which will be the body of the Tree, which is represented by H, and may be seen with the naked Eye.

Fig. 13. N O P Q R shews how far the Seed can shoot out its Root in 12 days, which is also divested of its Membranes, and plac'd sideways before the Glass, that the Strings, whereby the two parts of the Seed are united to the Plant, may be the more easily discovered.

N O R shews the Root, O P and Q R the Seed or Kernel divided into two equal parts, O R the strings united to the Plant, and from which it draws its first nourishment.

When I cut those Strings across and close to the Plant, I found in each String three Vessels, thro which I concluded that most of the Nourishment was derived from the Seed to the Plant.

I separated the two parts of the Seed with two Pins from each other, that they might be the better viewed by the naked Eye, as you may see here in Fig. 14. S T X shews you the Root, T V and W X the two halves of the Kernel, and Y that part which is to become the body of the Tree, much larger than H in Fig. 12.

After I had proceeded with my Copper-box about 18 days after the manner above mention'd, I open'd the same, and caus'd the Limner to draw the Plants as far as he could see them spring out above the surface of the Sand.

Fig. 15. A B C D E represents the Copper-box, C the Seeds as they with their Plants and Roots were risen above the Sand.

Fig. 16. F G H shews you the cover of the said Box.

Having caus'd this Box be thus delineated, I pour'd out all the Sand from it, and then observ'd with great wonder, that all the moisture was gone from the Sand, without doubt drawn away by the Seeds, of which I had put sixteen into the said Box, all which had shot out their Roots and produc'd Plants, some of which were indeed much bigger than the rest; and two or three of the Seeds had brought forth double Plants, amongst them there was one that yielded three Plants, which I have also caus'd to be drawn, tho the Roots and Plants were contus'd and jumbled together, which I attribute to the presture, and too great nearness of the other Seeds about it.

Fig. 17. A A A represents the said three Plants, and B B B the three Roots.

When I observ'd how dry the Sand was which I had pour'd out of the Box, I fancy'd with my self, that if I had put a little more Water into the Sand, or fewer Seeds, there would have been a greater increase both of the Plants and Roots.

Then I took a Glas Tube, that was large enough to hold the Sand conveniently, and hermetically seal'd at one end, and about twice as long as is here represented in Fig.

18. I K L M N O ; in this Tube I put 5 or 6 Seeds, and laid between each of them a little wet Sand.

This Sand was very fine and white, and of that sort which is us'd for the making of Glass ; I had taken it above 12 years ago out of a Glass-house, and had kept it always dry in my Closet in a Money-bag ; it was digg'd, as I am told, in the Bishoprick of *Liege*.

I proceeded with this Tube as I had done before with my Copper-box, having stop't it with a piece of Cork, *vid.* Fig. 18. L P Q M.

On the tenth day I observ'd that the Seed was come to that maturity, that the part which Nature intends for the body of the Tree, was grown up as high as the Cork ; I pour'd a little Sand out of the Tube, that the Limner might more easily perceive the Germination of the Plant, and cut off part of the Cork, and upon the twelfth day it appear'd as in the said Fig. 18. R S T.

Having done this, I took the Plant out of the Glass-Tube, and caus'd the Limner to draw it, as you may see in Fig. 19. A B C D E F G H, only you must observe that this Plant had but one Root A C D H, but because others have more, I caus'd him to describe them together, as you will see in B C.

In this last figure F G represents that part which is to be the Tree, D E the Seed or Kernel, which being surrounded with its Membrane, I took them off, that I might the better expose to your sight those parts thereof that serve for the nourishment not only of the Root, but of the upper parts of the Plant likewise, as also the short string D.

Now forasmuch as I have observed in the Roots of several other Germinating Plants, that a great many small Roots of unspeakable fineness sprung from them, I plac'd the same Plant, fig. 19. with that part of the Root which is describ'd by C, before a common Microscope, and then shew'd the Limner the infinite number of short small Roots

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springing out of the great one, and caus'd him to draw it.

Fig. 20. KLMN shows a small-part of the great Root, which appear'd to the Limner as thick and as large as the space between K and N, and the small Roots appear'd growing out of the sides of the great Root, as is represented between M and N.

Now if we conclude (as it is but reasonable) that even the smallest Roots are surrounded with such other rows of exceeding small Roots, how ought we to be surpriz'd at the wonderful workmanship of God, and especially when we proceed to the Dissection and Anatomy of the Roots, (and the Body, and of all those strings which serve to convey its nourishment to the Plant) and to the observation of their Texture thro our Glasses.

Thus we may see with our naked Eye, how a small Particle no bigger than a course Sand (as the Plant is represented in Fig. 6. by C) is increas'd in bulk, within the space of eleven days, as I have shewn already in Fig. 19. AHGF; and all this is brought to pass by Heat and Moisture in a closed Vessel; a plain demonstration that the Plant, and all that belong'd to it, was actually in the Seed, that is to say, not only the young Plant, its Body, Root and Fruit, but even the Seeds thereof also, in order to perpetuate the species, so long as the Earth shall have a being, and so long as the Sun shall shine upon it.

In the month of *December* last, I took another Glass Tube longer and larger than the first, as you may see Fig. 21. ABCDEFGH, and stop't both ends with a piece of Cork, boring a small hole in the upper Cork, and filling the Tube a little higher than BG with dry scouring Sand, which I first moistn'd with a little Rain water; but one must take care of making the Sand too wet, for that will rot the Seeds, neither must it be too closely compress'd, lest it should hinder the young Plant from pushing forth its Root or Branches.

In the upper part of this Sand thus dispos'd, I set two Kernels of an Orange that was brought from *Curacao*; but whereas I put the other Seeds into the Sand immediately as soon as I took them out of the Orange, I did not set these last till some days after they had been out of the said Orange, for which reason they were dryer than the others, and consequently demanded a longer time before they cou'd sprout out, but in the space of three weeks, by the warmth of my body only, they had Germinated, as is shewn in the said Fig. B C F G.

Now, that the Limner might have a better view of the Seeds which were cover'd with Sand, I pour'd out some of it, and then they appear'd as B C G.

Between A B G H are represented the long Roots with their small twigs and branches against the sides of the Tube.

Since the above-mention'd time, I observ'd but very little change in the Plant in some days, the reason of which I suppose to be that all the moisture was exhausted by the Plant, wherefore I pour'd a little more Rain water into the top of the Sand, and then the Plant grew bigger, inso-much that in five weeks time 'twas got almost to the uppermost Cork D E, and the Roots also were spread into more Branches, and had not only extended themselves to the lower Cork, but one little Root had insinuated itself between the Cork and the Glass, and had there shot forth another Branch.

Whereas the external Membranes of these Seeds are very thick and hard, and that part of the tender Plant which Nature has design'd for a Tree is not able to bore thro' it, or burst it asunder, as happens in the Plants of Nuts, Almonds, Peaches, &c. The wise Creator of all things has found out an expedient for this also, to wit, that this Plant shall not spring up in a right line thro' the Seed or Kernel, but out of the sides thereof, as you may observe in Fig. 19. between D and F, and Fig. 21. between N and O.

After that one of these Seeds had lain near six weeks shut up in the Glass-Tube, and had grown in proportion to that time, I observ'd that one of its Leaves was wither'd or corrupted; whereupon I open'd both the Corks, and pour'd out the Sand, which being very dry came away easily, but a small branch of the Root had so insinuated itself into the Cork, that I could not separate them without violence.

For your better satisfaction, I caus'd that Plant, with the Cork, as it was hanging to it, to be describ'd by my Limner.

Fig. 22. I K L M N represents the said whole Plant, whereof L M N shows the body, and forasmuch as it had put forth 3 leaves at the top, M points out to you the said Leaves.

I K L is the Root with its twigs and branches; L N O the Seed or Kernel still surrounded with its Membranes; and lastly, I P shews the Cork that stop't the bottom of the Tube, together with the Root sticking to it.

Now if we renew the comparison (which I have formerly made) between the Animalcula in *Semine Masculino*, and these Plants; tho' those Animalcula are a thousand thousand times smaller than a Plant in an Orange-kernel; and tho' we can't make our observations of the growth and encrease from time to time of the said Animalcula in their Mothers Womb; yet we may firmly conclude that the Laws and Orders which the Great and Wise Creator of all things has prescrib'd to himself in the production of his Creatures, both Animate and Inanimate, are homogenous and univocal, and that as the Earth is the common Womb of Plants, so is the *Tuba Fallopiana* in Animals of most of all those Creatures that are form'd *ex Semine Masculino*; for as the Animals in the Womb receive their Nourishment and Increase (as I have often said) by a string, till they come into the Air and World, so are all Seeds (at least as far as we know) supported and fed by a little string,
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nd the Seeds that are cast into the Earth do again convey by the same string, whereby they receiv'd their Increase, Nourishment to the Seed or Kernel.

We have discover'd that there are some Animalcula which have no Males among them, and the same is observable among a few species of Fishes also.

These Animalcula and these Fishes may be compar'd to some Seeds, that have no other substance in them besides the Plant itself and the Membranes that envelope it; such are the Seed of the Beach tree, and, if I mistake not, the Seed of Cresses likewise.

Amongst the Seeds, whose Strings (whereby their Nourishment, &c. is deriv'd to them) I have not formerly discovered, there are the Wall-nut and the Chestnut, but within a few days I have also found out their strings.

A little while before the last Sickness and Death of the famous *Christian Hugenſ*, Lord of *Zuſlichem*, being together in his Study, he told me, that we were arriv'd to the utmost degree of knowledge in our observations of Heavenly Bodies, and consequently that there remain'd nothing more to be seen or said concerning them: I might likewise say, that we have penetrated so deeply into the great secrets of the Seeds both of Animals and Plants, that we seem to be at the end of our Discoveries; but however I may be mistaken in those Sentiments.

Now since I have been able, with a little Sand and Water, shut up in a Copper-box or Glass-Tube, and a moderate heat, to bring certain Seeds to maturity, which in our Climate are of a long and tedious growth, what can those men say for themselves that talk so much of the influx of Celestial Bodies, *viz.* the Sun, Moon and Stars, and that will not allow us to Plant and Sow our Seeds, but at such an age of the Sun and Moon, and under such a Sign and Constellation.

For my part, I know no other secret in Vegetation, but a compleat heat of the Sun, and a just quantity of Water
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may, I shall not stick to say that the Increase and Nourishment of all Plants is included in Water; for let our barren and unfruitful Downs, that consist of a very fine Sand, be brought to such a Level that they lie but a foot higher than the Moats and Ditches round about them, so that the Rain water be not drain'd away as it falls, such Land shall not only produce good Grass, but even Rye, Barley, and several other Fruits.

III. *Some new Observations upon the parts and use of the Flower in Plants.* By Mr Sam. Morland.

THe nice and curious Texture of the Flower and its Furniture, obvious to common view, hath invited and employ'd the enquiries of many Learned and Sagacious Persons. But since these noble Searchers into the History and Operations of Nature, don't seem so happily to have reacht her design in this case as in many others, 'tis hop'd the Ingenious will not disdain a new attempt to account for the Fabrick and use of these parts; whereby the propagation of Vegetables will be render'd more-intelligible, and the ways of Nature appear more harmonious, and of a piece. It hath been long ago observed, that there is in every particular Seed a Seminal Plant conveniently lodg'd between the two Lobes which constitute the bulk of the Seed, and are design'd for the first nourishment of this tender Plant.

But the admirable Dr *Grew*, to whose generous Industry and happy Sagacity we are indebted for the best improvements of this part of Knowledge, is the only Author I can find, who hath observed that the *Farina* (or fine powder which is at its proper Season shed out of those *Theca* or
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Fig. 1c.



