

XVIII. *Observations on a particular Manner of Increase in the Animalcula of vegetable Infusions, with the Discovery of an indissoluble Salt arising from Hempseed put into Water till it becomes putrid.*
By John Ellis, Esq; F. R. S.

Read May 28,
1769.

HAVING, at the request of Dr. Linnæus, made several experiments on the infusion of mushrooms in water, in order to prove the theory of Baron Munchhausen, that their seeds are first animals and then plants; which he takes notice of in his System of Nature, p. 1326, under the genus of *Chaos*, by the name of *Chaos fungorum seminum*: it appeared evidently that the seeds were put into motion by very minute animalcula which proceeded from the putrefaction of the mushroom; for by pecking at these seeds, which are reddish, light, round bodies, they moved them about with great agility in a variety of directions, while the little animals themselves were scarcely visible, till the food they had eaten had discovered them. The satisfaction I received from clearing up this point led me into many other curious and interesting experiments. I looked carefully over Mr. Turbervill Needham's, F. R. S. very ingenious memoir on this subject, vol. XLV. p 615, of the Philosophical Transactions:

Transactions: I mean as to the experiments, many of which succeeded with me, some not*. I own, his

* The ingenious Mr. Needham supposes, those little transparent ramified filaments, and jointed or coralloid bodies, which the microscope discovers to us on the surface of most animal and vegetable infusions when they become putrid, to be zoophytes or branched animals: but to me they appear (after a careful scrutiny with the best glasses) to be of that class of *Fungi* called *Mucor* or Mouldiness, many of which Michelius has figured, and Linnæus has accurately described.

Their vegetation is so amazingly quick, that they may be perceived in the microscope, even to grow and seed under the eye of the observer.

Mr. Needham has pointed out to us one that is very remarkable for its parts of fructification. See Phil. Trans. vol. XLV. Tab. v. fig. 3, a, A; this, he says, proceeded from an infusion of bruised wheat.

I have seen the same species arise from the body of a dead fly, which was become putrid by lying floating for some time in a glass of water, where some flowers had been, in the month of August, 1768. This species of *Mucor* sends forth a mass of transparent filamentous roots, from whence arise hollow stems, that support little oblong-oval seed vessels with a hole on the top of each; from these I could plainly see minute globular seeds issue forth, in great abundance, with an elastic force, and turn about in the water as if they were animated.

Continuing to view them with some attention, I could just discover, that the putrid water, which surrounded them, was full of the minutest animalcula, and that these little creatures began to attack the seeds of the *Mucor* for food, as I have observed before in the experiment on the seeds of the larger kind of *Fungi* or mushrooms. This new motion continued the appearance of their being alive for some time longer: but soon after many of them arose to the surface of the water, remaining there without motion; and a succession of them afterwards coming up, they united together in little thin masses, and floated to the edge of the water, remaining there, quite inactive during the time of observation.

As this discovery had cleared up many doubts, which I had conceived from reading Mr. Needham's learned dissertation, I

reasoning is very specious and plausible, but too metaphysical for a natural historian. Yet I cannot forbear relating one of the experiments which I tried in consequence of his discovery, that animalcula were produced in various infusions, notwithstanding the greatest heat was given to the liquor.

On the 25th of May, 1768, Fahrenheit's thermometer 70 degrees, I boiled a potatoe in New-river

put into the same glass several other dead flies, by which means this species of *Mucor* was propagated so plentifully, as to give me an opportunity of frequently trying the same experiment to my full satisfaction.

Lastly, those jointed coralloid bodies, which Mr. Needham calls chaplets and pearl necklaces, I have seen frequently very distinctly. These appear not only on an infusion of bruised wheat, when it becomes putrid, but on most other bodies, that throw up a viscid scum, and are in a state of putrefaction. These then are evidently no more than the most common *Mucor*, the seeds of which are every where floating in the air; and bodies in this state afford them a proper and natural soil to grow upon. Here they send downwards their fine transparent ramified roots into the moisture which they float upon, and from the upper part of the scum their jointed coralloid branches rise full of seed into little grove-like figures. When a small portion of these branches and seeds are put into a drop of the same putrid water the scum floats upon, many of the millions of little animalcula, with which it abounds, immediately seize them as food, and turn them about with a variety of motions; as in the experiment on the seeds of the common mushrooms; either singly or two or three seeds connected together, answering exactly to Mr. Needham's description; but evidently without any motion of their own, and consequently not animated.

I am satisfied Mr. Needham's observations have convinced him long before this, that they must be vegetables: for my part, I own I have never seen a zoophyte extend its branches, and grow out of water. I hope I have already cleared up that point, in shewing the absurdity of Dr. Pallas's *Corallina terrestris*, Phil. Transf. vol. LVII. p. 415.

water

water till it was reduced to a mealy consistence. I put part of it, with an equal proportion of the boiling liquor, into a cylindrical glass vessel that held something less than half a wine pint, and covered it close immediately with a glass cover. At the same time, I sliced an unboiled potatoe, and, as near as I could judge, put the same quantity into a glass vessel of the same kind, with the same proportion of New-river water, not boiled, and covered it with a glass cover, and placed both vessels close to each other.

On the 26th of May, twenty-four hours afterwards, I examined a small drop of each by the first magnifier of Wilson's microscope, whose focal distance is reckoned at $\frac{1}{30}$ th part of an inch, and to my amazement they were both full of animalcula of a linear shape, very distinguishable, moving to and fro with great celerity; so that there appeared to be more particles of animal than vegetable life in each drop.

This experiment I have repeatedly tried, and always found it to succeed in proportion to the heat of the circumambient air, so that, even in winter, if the liquors are kept properly warm, at least in two or three days the experiment will succeed.

In Mr. Needham's experiments he calls these *spermatic animals*, Philosophical Transactions, vol. XLV. p. 644 and 666; what I have observed are infinitely smaller than real spermatic animals, and of a very different shape; the truth of which every accurate observer will soon be convinced of, whose curiosity may lead him to compare them; and I am persuaded he will find they are no way a-kin to that surprizing part of nature. And though some philo-

philosophers of great reputation have agreed in sentiment with Mr. Needham, yet I am satisfied, that whenever this subject is taken up again, and properly attended to, the world will be convinced they have been too hasty in their conclusions.

At present I shall pass over many other curious observations, which I have made on two years experiments, in order to proceed to the explaining a hint, which I received last January from Mr. De Saussure, of Geneva, when he was here; which is, that he lately found one kind of these *animalia infusoria*, that increases by dividing across into nearly two equal parts.

I had often seen this appearance, in various species, a year or two ago; as I found upon looking over the minutes I had taken when I made any new observation; but always supposed the animals in this dividing state to be in coition.

Not hearing till after Monsieur De Saussure had left this kingdom, from what infusion he had made his observation; his friend, Doctor De la Roche, of Geneva, informed me, the latter end of February last, that it was from hempseed.

I immediately procured hempseed from different seedsmen, in distant parts of the town: some of it I put into New-river water, some into distilled water, and some I put into very hard pump-water; the result was, that in proportion to the heat of the weather, or the warmth in which they were kept, there was an appearance of millions of minute animalcula in all the infusions; and some time after, some oval ones made their appearance, as at TAB. VI. Fig. 1. *b. c.* These were much larger than the first, which still continued;

nued; these wriggled to and fro in an undulatory motion, turning themselves round very quick, all the time that they moved forwards. I was very attentive to see these animals divide themselves; and at last I perceived a few of the appearance of Fig. 1. *a.*, as it is represented by the first magnifier of Wilson's microscope; but I am so well convinced by experience, that they would separate, that I did not wait to see the operation: however, as the following sketches, which I have drawn from five other species, will very fully explain this extraordinary phenomenon, there will be no difficulty in conceiving the manner of the first. See Fig. 2, 3, 4, 5, and 6.

The proportion of the number of the animals, which I have observed to divide in this manner, to the rest, is scarce 1 to 50: so that it appears rather to arise from hurts received by some few animalcula among the many, than to be the natural manner in which these kind of animals multiply: especially if we consider the infinite number of young ones which are visible to us through the transparent skins of their bodies, and even the young ones that are visible in those young ones, while in the bodies of the old ones.

But nothing more plainly shews them to be zoophytes than this circumstance; that when, by accident, the extremity of their bodies has been shrivelled for want of a supply of fresh water, the applying more fresh water has given motion to the part of the animal that was still alive; by which means this shapeless figure has continued to live and swim to and fro all the time it was supplied with fresh water.

I cannot finish this part of my remarks on these animals, without observing, that the excellent Linnaeus

næus has joined the *beroe* with the *volvoox*, one of the *animalia infusoria*. The *beroe* is a marine animal found on our coasts, of a gelatinous, transparent nature, and of an oval or spherical form, about half an inch to an inch diameter, divided like a melon into longitudinal ribs, each of which is furnished with rows of minute fins, by means of which this animal, like the *animalia infusoria*, can swim in all directions with great swiftness. In the same manner I have seen most of these minute animals, which move so swift that we could not account for it, without supposing such a provision of nature, which is really true; but cannot be seen till the animals grow faint for want of water; then, if we attend, we may, with good glasses, plainly discover them*.

I come now to a singular property, which I have discovered in hempseed, of producing an indissoluble

* I have lately found out, by meer accident, a method to make their fins appear very distinctly, especially in the larger kind of animalcula, which are common to most vegetable infusions, such as the *Terebrella*: this has a longish body, with a cavity or groove, at one end, like a gimblet: by applying then a small stalk of the horse-shoe *Geranium* (or *Geranium zonale* of Linnæus), fresh broken, to a drop of water in which these animalcula are swimming, we shall find, that they will become torpid instantly, contracting themselves into an oblong-oval shape, with their fins extended like so many bristles all round their bodies; the fins are in length about half the diameter of the middle of their bodies. Before I discovered this expedient, I tried to kill them by different kinds of salts and spirits; but though they were destroyed by this means, their fins were so contracted, that I could not distinguish them in the least. After lying in this state of torpidity for two or three minutes, if a drop of clean water is applied to them, they will recover their shape, and swim about immediately, rendering their fins again invisible.—For the different states of this animalcule, see TAB. VI, Fig. 5. *a, b, c, d.*
salt,

salt, when infused for some time in water: and as hempseed is known to be an efficacious medicine in some particular cases, these experiments may demand a stricter enquiry from the professors of physic, which may possibly turn to the benefit of mankind.

EXPERIMENT I.

On the 25th of February last, I put half an ounce of hempseed to about two ounces of New-river water in a vial, and covered it close with paper, to prevent the dust coming to it: by the 25th of March it became very putrid, and had thrown up a viscid scum to the top. Fahrenheit's thermometer in the house was, during this time, from about 44 to 52 degrees. I examined this scum with a common magnifier, of about an inch focus, and could discover it to be full of regular-shaped salts, which lay on the surface; some of a square, others of an oblong figure.

Applying some of the scum to a slip of glass, I placed it in the single or Wilson's microscope, making use of the fourth magnifier, and it exhibited the crystals represented before fig. 7; but as the stirring of the scum had obscured the precise figure of the salts, I applied a hair pencil to them, dipt in clean river water, and separated them from the mucilage that had besmeared them; yet, notwithstanding this addition of water, their figures were not in the least impaired or melted, but their outlines were rather more exactly defined. Nor were the millions of mi-

nute animals that were swimming over them, and all round them, in the least affected by the salt*.

I further observed, that the crystals that appeared first increased in size, and began to vary their forms; for instance, many of the crystals, at the latter end of April, among the rest, were of the form of those in the line of fig. 8. About the 5th of May, many of them appeared as at fig. 9; and at the latter end of May, about the 20th, many of them were of the form of those at fig. 10: most of the variety of forms appearing at the same time.

It was objected by some very ingenious men, to whom I had imparted this discovery, that these salts might be owing to something in the water that I had made use of, which, joined to the oil in the hempseed, might produce this appearance. To obviate this:

EXPERIMENT II.

I prevailed on my friend, Mr. P. Woulfe, F. R. S. to furnish me with some water that had been most carefully distilled, by a very slow process; and at the same time I procured hempseed from a different part of the town, On the 30th of April, I put an ounce of this hempseed to about four ounces of this distilled water, into a glass cylindrical vessel, and covered it carefully with a glass cover; and on the 12th of May I examined the scum, and found it more transparent,

* Mr. Needham observes, in his curious Memoir before mentioned, p. 649, that salt destroys these animalcula; this, I believe, is very true of the common kinds of salt; and which renders the nature of this kind of salt still more singular.

but

but full of the crystals of salts, as represented at fig. 12. Some of the first hempseed put into the same water produced much salt, but not so regular in its figures; these figures, by some means unknown to me, after their crystallization being broke irregularly at their ends, see fig. 13. But yet in this infusion there were many of the original feminal figured salts.

EXPERIMENT III.

I was determined to see what effect the hard pump water of Gray's-Inn, after a month's dry weather, would have on the hempseed in infusion; particularly as I was persuaded from experience, that this water contained a large portion of calcareous earth. Accordingly, on the 5th of May, I put an ounce of the same hempseed with the last which I had obtained, into four ounces of this pump water; and on the 17th of May I perceived the crystals, which, on being put into the microscope, with the same magnifier, gave the appearance represented at fig. 14.

The crystals of this infusion seemed larger and flatter, and something different in their shape; but on examining the mucilage that lay among the seeds at the bottom of the glass, I found an infinite number of the same shaped crystals with those I have called feminal crystals; which were likewise found in the mucilage of the New-river water infusion, and in the distilled water infusion among the seeds.

I must further observe, that the calcareous earth floated in great abundance among the scum of the pump-water, as soon as the putrefaction was ad-

vanced; which did not appear on the surface of the distilled water, and scarcely any on the river water.

The grains of salt produced in these experiments were about the size of the finest basket salt, and of a pale yellowish colour when dry.

Gray's-Inn,
May 24, 1769.

P O S T S C R I P T.

I have since found the same kind of crystals in an infusion of flax-seed in New-river water, and also in wheat that has been infused in boiling hot water; but the crystals were fewer, and did not appear so soon in the flax-seed as in the hemp-seed. And the experiment of wheat infused in boiling hot water does not always succeed.

I have likewise found salts not unlike those of the hempseed, in infusions of a variety of pulse and grain from the East Indies, such as lupines, kidney-beans, vetches, millet, Guinea-corn, and the sesamum or oily grain: but the last yielded a much larger quantity of salt, and in a shorter time, than any of the rest.

The salts of these different substances were also not dissolvable upon applying clean water to them; but by letting the infusions continue to putrefy some weeks longer, they by degrees assumed irregular shapes, and disappeared. I must conclude, then, with this quere, Are not these the oily parts of the vegetables, which float in the scum, on the surface of the infusion, crystallized?

Explanation of the FIGURES, TAB. VI.

These five different kinds of *animalia infusoria*, belonging to the genus of *Volvox* of Linnæus, are here represented both in their perfect and in their divided state. The trivial names are added to distinguish the species.

Fig. 1. represents the *volvox ovalis*, or egg-shaped volvox: at (c) and (b) it is expressed in its natural shape: at (a) the manner in which it becomes two animals, by separating across the middle: this was found in the infusion of hempseed, but is found in other vegetable infusions, particularly in that of tea-feed.

Fig. 2. is the *volvox torquilla*, or wryneck. At (a) is represented its divided state, at (b) and (c) its natural shape; this is common to most vegetable infusions, as is the following.

Fig. 3. is the *volvox volutans*, or the roller. At (a) the animal is separated, and becomes two distinct beings, each swimming about and providing for itself; this is often the prey of another species of this genus, especially while it is weak by this separation, not being so active for some time till it can recover itself. At (c) the animal appears to be hurt on one side; this impression, in a little time, is succeeded by another on the opposite side, as at (b), which soon occasions a division.

At

At (*d*) is the side view, and at (*e*) the front view of the natural shape of the animal.

Fig. 4. is the *volvox oniscus*, or wood-louse. At (*a*) is the natural shape of it, as it appears full of little hairs both at the head and tail; with those at the head it whirls the water about, to draw its prey to it; the feet, which are many, are very visible, but remarkably so in a side view at (*d*). At (*b*) it is represented beginning to divide, and at (*c*) the animals are ready to part: in this state, as if in exquisite pain, they swim round and round, and to and fro, with uncommon velocity, violently agitated till they get asunder. This was found in an infusion of different kinds of pine branches.

Fig. 5. is the *volvox terebrella*, or the gimblet. This animal is one of the largest of the kind, and is very visible to the naked eye. It moves along swiftly, turning itself round as it swims, just as if boring its way. (*a*) and (*b*) are two views of its natural shape. (*c*) shews the manner of its dividing. When they are separated, the lower animal rolls very awkwardly along till it gets a groove in the upper part. (*d*) represents one of them lying torpid, by means of the juice of the *horsehoe geranium*, with its fins extended. This animal is found in many infusions, particularly of grass or corn.

Fig. 6. is the *volvox vorax*, or the glutton. This animal was found in an infusion of the Tartarian pine; it varies its shape very much, contracting

Contracting and extending its proboscis, turning it to and fro, in various directions, as at *a, b, c, d, e*. It opens its proboscis underneath the extremity, when it seizes its prey. The less active animals, that have lately been divided, such as those at Fig. 2. *a*. and Fig. 3. *a*, serve it as food when they come in its way: these it swallows down instantly, as it is represented at Fig. 6. *b*. and *i*. At (*f*) it is ready to divide, and at (*g*) it is divided, where the hinder part of the divided animal has got a proboscis or beak, to procure nourishment for itself, and soon becomes a distinct being from the fore-part.

Fig. 7. represents the appearance of the salts in hempseed, after a month's infusion, from the 25th of February to the 25th of March, in New-river water.

Fig. 8. The salts, about a month after, April 25, appeared in this manner.

Fig. 9. These figures represent them about the 5th of May, or ten days after.

Fig. 10. About the 20th of May, they exhibited the figure of precious stones.

Fig. 11. These I have called seminal salts, as these small figures are to be seen in most of the infusions, rising at different times, and exhibiting these shapes, when they first appear distinctly,

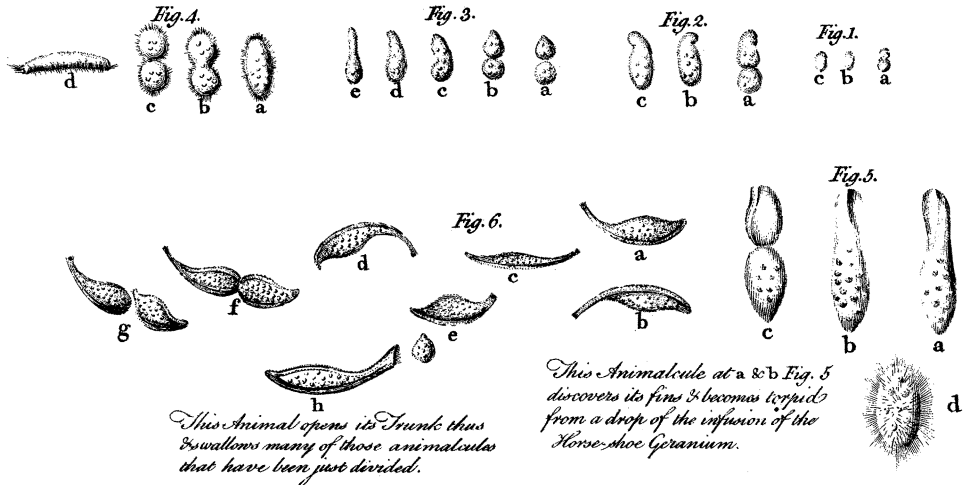
Fig. 12. represents the salts of hempseed in distilled water, that had been infused from the 30th of April to the 12th of May.

Fig.

Fig. 13. shews the form of the salts when the putrefaction had begun to separate their parts into laminæ in the distilled water.

Fig. 14. are the figures of the salts that appeared from the hempseed, infused in hard pump-water about twelve days, from the 5th of May to the 17th.

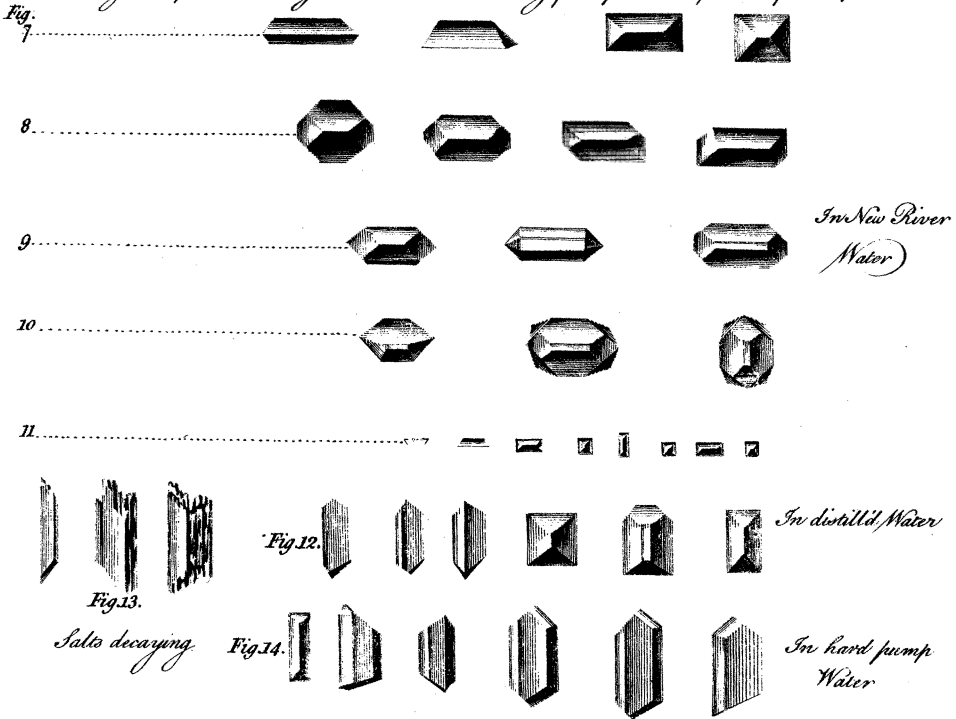
The Figures of 6 kinds of Animalcula infusoria, that increase by dividing across the middle into two distinct animals.



This Animal opens its Trunk thus & swallows many of those animalcules that have been just divided.

This Animalcule at a & b Fig. 5 discovers its fins & becomes torpid from a drop of the infusion of the Horse-shoe Geranium.

Figures of Salts, not dissolvable in Water, arising from a putrid infusion of Hempseed.



In New River Water

In distilled Water

In hard pump Water

Salts decaying