Abraham Trembley & the Creature that Defies Classification

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A Naturalist in the Enlightenment

[2] This story takes place in the first half of the 18th century in the Netherlands, one of the European countries that had a tradition of natural history research. Abraham Trembley, a young man from Geneva, is serving as a tutor to the two sons of Charlotte Sophie van Aldenburg, a German noblewoman married to a Dutch British-born nobleman and diplomat, Count Willem Bentinck: Anthony, six years old, and Albert, three years old. Trembley has studied theology, philosophy, and mathematics, but his passion is natural history (minerals, plants and animals) and the very art of teaching (the theme of one of his books). Capturing little animals, generally called “insects,” and observing the germination of seeds or the activities of bees in a hive are some of the ways he uses to hold the attention and excite the curiosity of the two boys.

[3] Trembley teaches natural history alongside the use of written language, mathematics, morals, and religion, in addition to everything else appropriate to the raising of young nobles – especially as the mother has separated from the Count and does not have permission to visit the children, who stay with their father. Despite the intimate friendship of Charlotte Sophie with the great rulers of the time, Frederick the Second of Prussia and Marie Thérèse of Austria, she spends her life contesting her family properties. Displaying great charm and lively personality, quick-witted and witty, capricious and fond of distraction and entertainment, Charlotte Sophie travels through Enlightenment Europe, but not without suffering the reputation of a scandalous woman. The adventurous life of this free-spirited historical woman, Voltaire’s “grande amie”, will earn her biographies and starring roles in novels (and a Dutch film in 1996).

[4] Count Bentinck lives with the boys in a house named Zorgvliet, literally “care flies,” reflecting the spirit of close contact with nature that inspired its construction in the late 1640s by the statesman and poet Jacob Cats.

[5] Preserved 17th-century plans of Zorgvliet show its series of gardens, hedge-covered tunnels and an ornamental system of ponds and interconnected paths.

Encountering a Curious Creature

[6] Our story begins on a summer morning in 1740. As usual, Trembley is outdoors with Anthony and Albert in the gardens of the house. They are looking for aquatic life in the ponds. Outfitted with a net trap, they collect everything that seems interesting so that they might observe it closely later.

[7] Inside an outbuilding, Trembley has assembled workspace for managing and observing specimens. On the windowsill are many glass containers where Trembley keeps insects and aquatic plants. The boys are observing what they have taken from the pond. With hand magnifiers, they notice some tiny green shapes attached to the aquatic plants they have just collected.

Imagine the boys pointing their fingers and shouting at Trembley impatiently: “Look at that! There is a tiny leaf of grass on this small plant!”

[8] Using a magnifying glass, Trembley observes what looks like a kind of parasitic plant. They are cylindrical bodies, measuring less than 2 mm, with arms or threads at the top of the body.

[9] He jostles the container gently and places it facing the sunlight, to see whether something happens. The agitation of the water decreases the size of the thready bodies, but when the water calms, they slowly extend to their original size. This intrigues Trembley very much and he draws the children’s attention to it: “Look at this, boys! These ‘things’ apparently have some kind of voluntary movement.”

Later, Trembley writes:

> Thinking that the polyps were plants, I could scarcely imagine that this movement was their own. Yet, those slender threads projecting from one of their extremities did appear to move by themselves and not in response to the agitation of the water. The more I attended to these arms, however, the more it seemed that

> it had to come from an internal cause and not from an impetus external to the polyps. [Besides,] this contraction and all the movements I saw the polyps make as they extended once again roused sharply in my mind the image of an animal. I likened them at first to snails and other creatures that contract and extend. [Yet] I was still influenced, I admit, by their shape and their green color. I thought it not impossible that they might be sensitive plants […].

Trembley is facing a dilemma: the creature's body has a green color, like a plant; yet, it seems to have voluntary movements, like an animal!

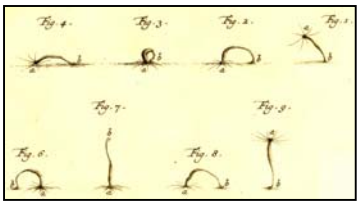
What does this dilemma mean? Throughout Western Europe, wealthy people are enthralled by nature. Several people have assembled "cabinet of curiosities," collections of various specimens from nature. They make observations of plants and animals, draw them, and discuss their findings in salons, the popular social gatherings of the day. Some are amateur scholars; others are natural philosophers who devote themselves to systematic studies of natural history. Some seek the pleasure of knowledge about the world; others are motivated by the purposes of admiring and knowing God's creations. Many share a belief that the Creator has establish a natural and immutable order. Thus, there is a consensus that each creature is a living representative of the first organisms from the very beginning of the world.

[10] In addition, they share the ancient idea of "the great chain of being": that all creatures on earth, from minerals to men, exist on a scale of perfection, from lowest to highest. Naturalists largely aim to explore this natural order and express it in their classification systems.

[11] Among many different proposals, one system acquiring popularlity throughout Europe was developed by Swedish physician and naturalist Carl von Linné. In 1735 he proposed his classification in a small book (more like a leaflet), containing only 11 pages in its first edition: the *Systema Naturae*. Linné will publish many enlarged editions of this work, incorporating descriptions of plants newly discovered and collected around the world, up to his 13th edition in 1770, containing about 3,000 pages!

[12] In addition, Linné seeks to understand behavior and to know how divine creations are able to perpetuate themselves, or reproduce. Several perplexing questions arise from such studies. For example, "If the chain of beings is continuous and gradual, where are the connection points between them? Shouldn't there be

‘missing links’ in the chain of beings? Would ‘zoophytes’ (organisms that share characteristics of both plants and animals) be those missing links?”



[13] Proceeding with their daily observations, Trembley and his students realize that, beside the ability to contract or extend the “threads” (or arms); the creatures also are able to change location! Indeed, they notice that the creatures even have two particular modes of locomotion. Trembley records both kinds of locomotion in a wonderful drawing. The organism exhibits a movement similar to a worm. After the front end, *a* ,is fastened securely, the back end, *b,* detaches and draws close to front end. Other times, the creature seems to move by somersaults (in the top line, from right to left, and in the bottom line, from left to right). Those are definitely animal features. But the creatures are green and have a plant shape as well! Facing this dilemma — plant or animal? — Trembley must decide.

> [14] **[Think 1]** Based on these observations, what would justify the choice in favor of one classification or the other? Which traits seem most important and “carry more weight”?

At this point (according to what he tells us later in his book), Trembley decides to consider them animals because of their ability to move. That is, he places more significance on this trait than on their green color and their shape, resembling an aquatic plant. He discounts the known capacity of contraction in some sensitive plants. However, still challenged by this apparent dilemma, he decides to continue studying these unusual creatures, and then, a new problem emerges.

Curiouser and Curiouser

Trembley notices that the “arms” sometimes appear in uneven numbers. Thus, it is almost impossible not to compare those arms with the branches and roots of plants, which are not always found in pairs. Again, an analogy with plants! Now, if the “arms” are similar to plants’ branches or roots (he speculates), they should be able to grow again after having been cut off.

[15] Reflecting upon this, he decides to carry out an experiment. Rather than cutting off just one “arm” to see if it grows again, he divides the organism into two pieces. (Remember he is handling an organism less than 2 mm in length!)

> I conjectured that if a polyp were cut in two and if each of the severed parts lived and became a complete polyp, it would be clear that these organisms were plants. Since I was much more inclined to think of them as animals, however, I did not set much store by this experiment; I expected to see these cleaved polyps die.

[16] **[Think 2]** How should the results of the cutting experiment help in making a decision on classification?

After having carefully cut an individual polyp in two places, he places each piece into a small glass dish containing water. At first, it looks like nothing but three little green dots. But at the end of the day, the results of the experiment are not exactly as expected. This baffles him! The pieces have extended completely. In addition, nine days later, neither Trembley nor the boys are able to distinguish one from the other. The pieces have become three whole and identical organisms! This kind of reproduction, in which a portion or a bud is detached from the original organism and then grows into a new individual, is a well-known feature in plants!

[17] **[Think 3]** What should you conclude in the face of this new result? How should this new evidence about mode of reproduction be interpreted with respect to the criteria of voluntary movement and locomotion used earlier?

[18] Trembley knows that parts of some animals are able to regenerate, such as lizard tails or lobster claws. Easily observed in nature, the phenomenon of regeneration has been known since Antiquity. However, the regeneration of a complete animal? —No! Animals do not “replicate” themselves whole. As is known, such an ability is commonly found only in plants. One may cut a stem, leaf, or root — from a manioc (or cassava) plant, say, or a rose bush — and it will grow again into a whole plant.

For Trembley and his fellow naturalists, there is general agreement that to generate a new animal, a male and femlae must mate: sexual reproduction. Besides, it has been broadly accepted since Antiquity that some animals (and plants) can appear spontaneously, as seems to happen with the tiny “animalcules” seen through magnifying glasses and microscopes in grassy infusions or with intestinal worms and worms inside fruits, or with eels. Spontaneous generation seems to be the best explanation available at this time for such cases. Amid so many new findings, Trembley finds himself disoriented: “Plants do not ‘walk’! Animals do not fully regenerate! But these organisms are capable of both!”

[19] **[Think 4]** Facing this dilemma again, is it necessary to conduct more experiments and make more observations,or should you reassess the criteria used to classify organisms as either animals or plants?

[20] Confused, but even more motivated to solve this dilemma, Trembley decides to write to a famous naturalist of the time: René Antoine Ferchault de Réaumur (1683–1757), Director of the French Academie des Sciences. Réaumur has made noteworthy contributions in several areas: in physics (developing a thermometer) and industrial processes (research on the production of steel, glass, and ceramics). Moreover, Reaumur has written on many topics in natural history, such as the formation of pearls in bivalves, the anatomy and physiology of plants and animals, the locomotion of snails and sea stars, the regeneration of parts of crustaceans, the electrical discharge in some fish, spider behavior, silk production, and more. In addition, Réaumur has devoted much attention to insects, whose observations and experiences are detailed in his work *Mémoire pour servir a l'histoire des insects* (*Memoir on the Natural History of Insects*), published in six volumes between 1737 and 1742. The first three volumes of this work have been avidly read by Trembley.

In a letter to Réaumur, Trembley details his observations and experiments. Réaumur, as an experienced naturalist, although betting on the animal nature of the creature, makes no rash decision until he had personally seen them. Thus, he answers Trembley: "If you, sir, happen to have many of these organized bodies, perhaps you can send me some of them?"Immediately, Trembley takes 15 specimens, places them in a tightly sealed glass bottle, and sends them to Réaumur in Paris. However, after nearly a week of travel, the organisms have died by the time of their arrival.

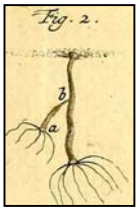
[21] **[Think 5]** Recalling that you are handling small aquatic creatures, why do you think they did not survive the trip? What procedures and care do you think are needed to ensure the survival of these organisms during a several-day trip by horse or carriage from The Hague to Paris?

After the failed attempt, Réaumur writes to Trembley telling him that owing to excessive zeal when closing the bottles with wax, the organisms may have died because of a lack of air. Réaumur advised closing the bottles with cork rather than wax, allowing air to diffuse into the container.

Trembley captures some new organisms and, following Réaumur's advice, stores them in three bottles. However, before sending them to Paris, he takes the bottles with him on a horseback ride of about 15 km. At the end of the route, he finds the creatures are still alive. Now he had found a way to send the tiny organisms to Paris safely.

[22] This time Réaumur receives the creatures alive and immediately starts his studies. He has no more doubts: those small green creatures caught from Dutch ponds are truly animals! Réaumur suggests calling them "polyps" because they resemble octopuses.

Meanwhile, in the Netherlands, pursuing his ongoing observations, Trembley notices something like a small outgrowth: a dark green dot stuck on the side of a polyp's body. Puzzled by this novelty and following a procedure taught by Réaumur, he isolates the individual and keeps observing it closely. He wonders: is he seeing something similar to the growth of a branch? Indeed, the dark green dot grows like a branch. Surprisingly, after some time, the "branch" becomes detached from the body. Then, the "branch" becomes an isolated body similar to the original! A whole new individual!



[23] One more time, Trembley uses the procedure to isolate the organism under observation. He separates the newly detached creature and puts it in another container. Has he just witnessed a new form of reproduction? Once again, the new individual performs the same phenomenon under Trembley's own eyes. The "branch-like" structure arises, grows and (as before) detaches, forming a whole new living being.

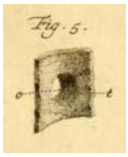
What a fascinating creature! At this point, both Trembley and Réaumur are entirely convinced that they have enough evidence to conclude that the creature is a real animal — however, not without departing from the conventional conception of what plants and animals are, as reproduction by budding is another feature typical of plants!

> [24] **[Think 6]** Once again, how should we interpret the unexpected outcome? How does this new observation help characterize how you classify the creature? Again, should you change your position on the animal/plant distinction? Explain.

[25] Again, Trembley addresses a letter to Réaumur reporting his observations about his “strange” new form of reproduction in the polyps. But Réaumur is not quite convinced and responds by telling him that there should not be any budding: “Maybe you are not observing properly. It is possible that there may be some egg hidden somewhere under the body of the mother polyp, as usually occurs in lobsters, for instance.”

> [26] **[Think 7]** What are some possible reasons for skepticism (like Reaumur’s) about generation by budding in polyps? As Trembley, how would you try to persuade him about the reliability of the new observations?

On reading Réaumur’s response, Trembley focuses once more on the isolated specimens, repeating his observations on the unusual form of animal reproduction. To verify the phenomemon, he isolates a few generations of individuals who are born by budding. But he always observes the same results. All of them generate “branches” and subsequently become new organisms. In addition, Trembley devises an experiment to investigate if there are any eggs “hidden” somewhere in the mother polyp.



[27] To perform the experiment, he takes an individual whose outgrowth is still in its early stages and carefully extracts the dot from the body of the mother polyp. Analyzing the two structures under the microscope, he sees that the outgrowth is nothing more than a continuity of the body of the mother polyp and there is absolutely no trace of something that could be considered an egg.

After his painstaking observations, has Trembley been able to rule out reproduction by eggs, as alleged by Réaumur? Réaumur was skeptical because, like most naturalists at the time, he could not conceive animal generation without the participation of both sexes (i.e., sexual reproduction).

Moreover, Réaumur advocated the theory of the preexistence of beings (also shared by many naturalists of the time) that the offspring of each living being already existed in “seeds” (egg or sperm) within the bodies of the parents, ever since the dawn of Creation. Thus, if polyps are animals, there must be eggs somewhere inside their bodies.

[28] Meanwhile, Réaumur and his friend Bernard de Jussieu (1699–1777), another French naturalist, have been performing an experiment with a species of tufted polyp

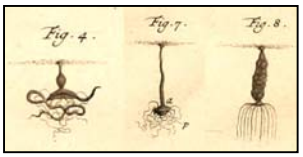
(Lophopus, classified much later as a bryozoan). After months of observations, they have identified, inside the tufted polyps, something similar to dark granules, which they suspect might be eggs.

Now it is Trembley who asks to have samples of these organisms, which seem so different than those he has been dealing with. As soon as he receives them, he starts his observations and confirms what Réaumur and Jussieu have already determined: tufted polyps have eggs! However, the polyps studied by Réaumur have a darkened color; those observed by Trembley were green. During his observations, Réaumur had described the dark polyps as having a calcareous part, which he considered a kind of refuge for the animals.

Trying to understand more about these dark polyps, Trembley spends a lot of time studying the creatures. Finally, he is able to claim that the two polyps are distinct species. Despite his efforts, Trembley knows that it will not be enough to convince Réaumur about the absence of eggs in his original polyps. In other words, it seems a dead end. Will it be?

Both Réaumur and Trembley agree that polyps are animals because of their autonomous movements and mobility. Nevertheless, as is well known, animals cannot fully regenerate themselves, nor can they arise by budding. Are there other criteria that must be considered?

Trembley Seeks Clues Regarding the Polyps' Nourishment



[29] Trembley has never seen his polyps feeding. So, he does not know how (or if) polyps are able to absorb nutrients. In a usual morning of observations, Trembley notices a polyp apparently using its tentacles to capture a "worm" (an insect larva). It makes a movement to bring it toward its… "Wait!! Is that a mouth?!?" A few minutes later, the worm has been captured within this polyp! Paying as much attention as possible to this new event, Trembley notices that the worm is now placed inside a "tube," which he concedes must be a stomach. These tiny creatures have a gap, a mouth, between their tentacles. What a curious organism!

It is worth recalling the story up until now. First, Trembley had thought that the polyps might be plants because of their green color, their structure, and their apparently stationary way of life. Then, he changed to considering them animals, owing to their voluntary locomotion. However, continuing with his observations, he realized that those organisms could reproduce in a manner

similar to plants. Now, Trembley is aware that these organisms have the ability to take in food, as animals do!

> [30] **[Think 8]** Do you think that just the action of trapping a supposed prey is sufficient to classify an organism as an animal? If so, how should we deal with apparently carnivorous plants (such as the Venus fly trap, sundews, or pitcher plants)?What further information, if any, would help resolve this dilemma?

Trembley is aware that the capture is only half a response.A similar situation is observed in carnivorous plants, as well. Yet, he realizes that the polyp had not merely captured the worm; it seemed to have ingested it and placed it inside the polyp's "tube." Thus, Trembley thinks that this case must be studied in the light of nourishment. Of course, both animals and plants absorb nutrients, but in different ways.

[31] In pursuing this new effort, Trembley uses a theoretical framework published in *Elementa Chemie* (*Elements of Chemistry*), by the Dutch physicist and botanist Herman Boerhaave (who, like Réaumur, is an authority on studies of natural history). In his book, Boerhaave distinguishes plants and animals based on their mode of nourishment.

He claims that nourishment in plants occurs because of the absorption of nutrients directly from the soil through the roots; in animals, the action of absorption happens through inner vessels. To him, animals are similar to hydraulic machines that absorb nutrients and transport them in fluids in internal vessels to all parts of the body. Following Boerhaave's ideas, Trembley dissects his polyps trying to find the lacteal vessels that are so basic to nourishment in animals.

[32] In the first experiment, he cuts a polyp lengthwise, splitting it along the stomach ("tube"). After that, Trembley put the halves under a microscope and, instead of finding the "lacteal vessels," the only thing he can observe are identical small green granules distributed throughout both internal and external sides of the "stomach." He then tries instead a transverse cut. and places each half in separate glass dishes, labeling each. Yet, this time, the severed polyp needs only one day to regenerate completely rather than nine days (as in the previous experiment).

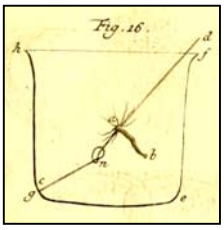
[33] The second experiment is inspired by ideas from Italian naturalist Luigi Marsigli (1658–1730) in his 1725 book, *Histoire Physique de la Mer* (*Physical History of the Sea*). Marsigli claimed that some marine plants have glands or vesicles able to extract nutrients from seawater that will also work when the organism is immersed in some sort of "nutritive juices." Trembley considers putting some of his polyps in "nutritious juice" to test whether polyps can absorb nutrients through all the parts of their body. However, he is unable to find an appropriate nutritive substance.

As we have seen, Trembley has sought support from different sources available at the time about knowledge of the nourishment of animals and plants. Yet, apparently, none of these seems to shed light on the polyp nutritional system.

> [34] **[Think 9]** How would you characterize the contributions of this knowledge to his research?

[35] Despite the shortcomings of contemporary sources, Trembley does not give up trying to understand the polyps' nourishment. Returning to his observations, he pays attention to the features that he had noticed in the previous cutting experiment: the granules arrayed along the lining of the polyp's stomach.

To analyze these granules further, Trembley allows an isolated polyp to take in a "worm." After some time, he takes this polyp and, observing it under the microscope; he realizes that the granules look swollen and filled with dissolved particles! The observation of these filled granules leads Trembley to plan his most ingeniouis experiment yet: turning the polyp inside out! Can you imagine inverting a creature less than half a centimeter long by 2 or 3 mm thick (like reversing the fingers of a glove)? Later, Trembley reports:



> It occurred to me that if the granules which were on the external surface of the skin were closer to these nutritive juices, they would be the first to became filled with it, and perhaps the polyp would be nourished as thoroughly as when the juices pass first into the vesicles in the lining the walls of the stomach. (…) [So] I thought of inverting them so that the external surface of their skin would form the walls of their stomach. I had very little confidence that I would see this experiment succeed, but I did not believe [it was a] proper [reason] not to try it.

To perform the intricate task, Trembley proceeds through a series of careful steps until the polyp is inverted. In the end, he ties the inverted polyp, situating it in the middle of a glass receptacle,

in such a manner that it does not touch the sides or the bottom of the jar, thus preventing it from turning itself back.

By thoroughly studying his inverted polyp, Trembley learns that the creature not only survives but also keeps reproducing and capturing and ingesting food.

[36] Obviously, this unique experiment will likely encounter doubt and skepticism. Aware of this, Trembley invites other naturalists to testify to his experiment. Among his guests are Pierre Lyonnet (1708–1789), his friend and Dutch naturalist; Jean-Nicolas-Sébastien Allamand (1713–1787), another Dutch naturalist; and Bernhard Siegfried Albinus (1697–1770), a German anatomist who lives in the Netherlands (and will later become Boerhaave's successor). All of them witness the experiment of the inversion of the polyp carried out by Trembley.

The analysis of results obtained through extensive experiments and observations allow Trembley to explain (in the light of Boerhaave's theoretical framework) that polyps do not contain any structures similar to those found in an animal body. Indeed, Trembley finds that polyps have neither "lacteal vessels" nor anything that looks like roots, as claimed by Boerhaave. Yet, the fact that the polyps (even inverted) perform digestion internally, fits the conception of more complex animals as consumers.

Bringing together all these findings, Trembley reaches the main conclusion that the polyp can be a simple animal, formed by a single "nutritive vessel," i.e., a "tube" open at one end. The whole polyp is the nourishing vessel, unlike other animals (such as worms or caterpillars) whose vessels are located inside their bodies.

Initially, Trembley was more inclined to believe that polyps are animals, primarily because of their movements. But the number of "intermediate" plant characteristics he found raised doubts. Thus, he had sought more and more evidence. Only now does he feel confident in declaring a final position. Recounting his investigations, he writes:

> In order to be able to decide that a particular organism is neither plant nor animal but belongs to some intermediate class, it would be necessary to know precisely all the attributes of plants and animals. As we have seen above, we are still very far from such knowledge. Only when we succeed in acquiring it, can [we] create classifications of other organisms. In the meantime, it is much more natural to consider the

polyps and various other organisms which have been given the name zoophytes as animals which show more noteworthy similarities to plants than other animals.

Trembley's Polyps: From Ponds to Fame

The unusual property of the regeneration of polyps that leads to the formation of two new individuals arouses the curiosity of many people. Réaumur, for instance, is judged worthy of presenting the phenomenon to the Academie des Sciences, in Paris, with Trembley's permission.

Over a period of days, Réaumur is able to demonstrate the regeneration of polyps to both scholars of the Academy and to the royal court, always leaving the audience stunned with the "marvelous" ability of a small organism to "rebuild" itself.

Yet, the presentations are not limited to the French Academy only. After some time, many scholars in several places in Europe become aware of the "incredible" property of regeneration of the "pond's phoenix." This is made possible because of Trembley's "strategy of generosity." Namely, he distributes live specimens throughout Europe. For this purpose, he has made another technical achievement. To ensure that the specimens will arrive alive in the most distant places, Trembley sends the polyps not alone, but inside glass containers with aquatic plants, developing an aquatic system suitably conditioned to withstand long-distance travel. Moreover, this is accompanied with detailed instructions, both for the care of the organisms, and for doing the experiments oneself. He thereby contributes to the consolidation of a practice already known to experimental naturalists of the time: the virtues of replicating experiments.


PHILOSOPHICAL
TRANSACTIONS
The CONTENTS

[37] However, even after many public presentations, people are still not fully convinced that an animal, after having been cut two or three times, can reproduce. There is heavy distrust among scholars, especially in England. After the subject appears in the prestigious journal *Philosophical Transactions of the Royal Society*, the discovery is a matter of criticism, ridicule, and skepticism for many people.

[38] **[Think 10]** Why, even after several public presentations witnessed by many credible people, might some people reject the complete regenerative ability of polyps? How might you respond to such skeptics?

[39] In London, notoreity, skepticism, and disbelief about the remarkable features of polyps spread quickly in the halls of the Royal Society. Sir Martin Folkes (1690–1754), President of the Society at the time, hoping to settle the matter, writes to Count Willem Bentinck, Trembley's patron, asking him, as a landed gentlemen (and thus more trustworthy to his peers), to attest to the reliability of Trembley's experiments. Bentinck promptly asks Trembley to prepare a package of polyps and send them to the President of the Royal Society.

As soon as Folkes receives the organisms, he follows Trembley's instructions and performs the regeneration experiments at his own home under the scrutiny of 20 Fellows of the Royal Society. Shortly afterwards, Folkes repeats the experiment at a meeting of the Society and over the next week, more than 150 people are able to witness it. Through these public presentations and others, Folkes manages to quell the criticism and ridicule of many "unbelievers," at least in London.

Now, Trembley — a hunble tutor of the children of a prominent diplomat — becomes a celebrity, not only in one, but two of Europe's greatest intellectual centers, Paris and London. The experimental skills that he developed, such as the isolation of polyp individuals, the elaboration of an experimental series, the replication and variation of experiments on polyps, the sharing of results among the community of scholars, has lead him to fame among naturalists and the European scholars of the 18th century.

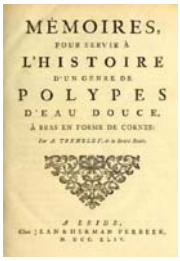
[40] All these elements seem worthy of merit. In 1743, 3 years after the beginning of his studies on polyps, the Royal Society honors Trembley with the Copley Medal, the most presitigious scientific award of the time. Folkes presents the citation:

> We are not less sensible of your great candor, and the Readiness you have shown not only to transmit to us faithful abstracts of your own experiments, but also to send us the Insects themselves, whereby we have been enabled to examine by ourselves, and see with our own Eyes the Truth of the astonishing Facts you had before made us acquainted with.

Even so, Trembley's spirit of generosity and his fame as the naturalist who discovered the "phoenix" elicits not only interest and respect, but also jealousy and envy.

[41] Henry Baker, an ambitious English naturalist who has studied chemistry, becomes aware of Trembley's works on polyps. As a Fellow of the Royal Society, he has access to the correspondence between Trembley and Folkes. Finding an opportunity to improve his own reputation, Baker quickly performs some of the experiments that Trembley described in the letters but has not yet formally published. Therepon, Baker publishes, in 1743, a short work entitled "An Attempt Towards a Natural History of the Polype." It reaches the public before Trembley can publish his book.

[42] **[Think 11]** Is this fair? Is this plagiarism? Given his social status as a "mere" tutor, what can Trembley do? Was Trembley's "strategy of generosity" a mistake? What might be the consequences for Baker?



[43] Finally, in 1744 — four years after having found those tiny green creatures — Trembley, supported by his patron Count Bentinck ,publishes his own book: *Mémoires pour servir à l'histoire d'un genre de polypes d'eau douce, à bras en forme de cornes* (Memoirs Concerning the Natural History of a Species of a Freshwater Polyp with Arms in the Shape of Horns).

In his book, Trembley accurately describes all the experiments and observations, illustrates them with drawings, just as we have encountered in our story. In addition, he includes tables testifying to his systematic records of the day-to-day studies. Within a few months his work is republished in Paris and becomes widely distributed. His experimental work begins to be cited, along with that of Réaumur and others, as a model to be followed by anyone who wants to reveal the functioning of organisms.

[44] [**Think 12**] Recall Charlotte Sophie, the mother of Trembley's tutees. How do you think she might have contributed to the investigations if she had been invited to participate?

Epilogue

[45] In the 18th century, when the Enlightenment spread throughout many parts of Europe and rational thought challenged religious dogmatism, the idea of a natural order was paramount. Accordingly, organizing and classifying all forms of life was a goal for many naturalists. Yet some organisms

– so-called zoophytes – with their uncomfortable mixture of traits from both plant and animal categories – posed difficult problems.

Guided by such problems and equipped with careful experimental abilities, Trembley performed many procedures and observations, as well as creating and devising new techniques and instruments to try to understand the nature of his polyps in depth.

> I kept, at the same time, several glass jars which contained polyps operated; So I was able to distinguish each jar through a number or letter and I used these same marks in my notebook to discern the polyps. No one but myself handled these jars and I was always careful to avoid making any mistakes when I had to change water. I have always taken precautions with all the polyps used in the experiments recorded in this memoir.

However, Trembley did not bestow visibility to the small freshwater creatures just to persons dedicated to the study of living beings and linked to the scholarly community. Through the end of the 18th century, many scholars and well-informed amateurs from various parts of Europe wished to see for themselves the most interesting feature of the polyps: their exotic reproductive modes! “How is it possible for an animal to regenerate itself completely? Or, even stranger, how is it able to reproduce by budding, like a plant?” Because of these unusual features, the polyps – later named hydra (*Hydra viridissima*) by Carl von Linné – became a major topic animating conversations in the erudite salons of the European nobility.

Throughout his journey, Trembley faced the “zoophyte dilemma”: were these tiny organisms animals or plants? At some point, Trembley asked himself, “Is it possible to draw a clear line separating the kingdoms of plants and animals? Have I discovered a new class of organized bodies between the two kingdoms? A planimal, perhaps?” Nowadays, that might certainly sound like a joke! Or not?

> [46] [**Think 13**] What does the case of “Abraham Trembley and the Creature that Defies Classification” reveal about the following aspects of the nature of science?:
>
> - the role of interpreting observations [Think 1, 3, 9]
> - the role of theory in interpreting evidence [Think 4, 6, 9]

- the role of experiments [Think 2, 4, 7, 8, inversion experiment]
- the role of new and alternative explanations and unexpected results [Think 3, 4, 6, 8]
- response to criticism [Think 7, 10, witnessing of experiments, sharing of samples]
- the material culture of science [Think 5]
- ethics in scientific conduct [Think 11]
- the role of gender and access to science [Think 12]

References

Berçot, F. F. (2018). *História da biologia e natureza da ciência na formação inicial de professores: uma sequência didática sobre reprodução animal no século XVIII nos estudos de Charles Bonnet e Abraham Trembley*. São Paulo. Tese (Doutorado em Ciências Biológicas, Biologia/Genética) – Instituto de Biociências, Universidade de São Paulo. [Access here]

Dawson, V. P. (1987). *Nature's enigma: The problem of the polyp in the letters of Bonnet, Trembley and Réaumur, Memoire 174 of the American Philosophical Society*. Philadelphia: American Philosophical Society.

Le Blond, Aubrey. (1912). *Charlotte Sophie, countess Bentick, her life and times, 1715-1800*. London: Hutchinson. [Access here]

Lenhoff, S. G., & Lenhoff, H. M. (1986). *Hydra and the birth of experimental biology, 1744: Abraham Trembley's Mémoires concerning the polyps*. Pacific Grove: Boxwood Press.

Prestes, Maria Elice Brzezinski; Martins, Lilian Al-Chueyr Pereira. (2014). Observação e experimentação animal no século XVIII: Os estudos de Abraham Trembley sobre a hidra. *Acta Scientia*, 16 (2); 345-369, 2014. [Access here]

Ratcliff, M. J. (2009). *The Quest for the Invisible: Microscopy in the Enlightenment*. Farnham: Ashgate Publishing.

Trembley, A. (1744). *Mémoires pour servir à l'histoire d'un genre de polypes d'eau douce, à bras en forme de cornes*. Leide: Chez Jean & Herman Verbeek.

List of figures/slides and their respective references

Slide 02

Abraham Trembley, portrait - https://pt.wikipedia.org/wiki/Abraham_Trembley#/media/Ficheiro:Abraham_Trembley.jpg

Trembley and the Boys by the pond - Trembley, A. (1744). Mémoires pour servir à l'histoire d'un genre de polypes d'eau douce, à bras en forme de cornes. Leide: Chez Jean & Herman Verbeek. Pg.1. https://www.biodiversitylibrary.org/item/130183#page/23/mode/1up

Slide 03

Publicity image of the 1996 Dutch film Charlote Sophie Bentinck – https://www.imdb.com/title/tt7033846/?ref_=ttep_ep2

Book cover of The Marriage Contract, by Hella S. Haasse - https://www.amazon.com

Portrait of Charlotte Sophie van Aldenburg - https://nl.wikipedia.org/wiki/Charlotte_Sophie_van_Aldenburg

Slide 04

Lithography of Zorgvliet in The Hague - https://www.abebooks.com/Lithography-lithografie-Hague-Zorgvliet-Zorg-vliet-Sorghvliet/30942835994/bd

Slide 05

Gardens of Sorgvliet in The Hague - https://dhzhw.wordpress.com/2012/06/11/landgoed-sorghvliet-anno-1690/#jp-carousel-99

Orangery; Sorgvliet in The Hague - https://dhzhw.wordpress.com/2012/06/11/landgoed-sorghvliet-anno-1690/#jp-carousel-106

One of the artificial ponds, Sorvglie - https://dhzhw.wordpress.com/2012/06/11/landgoed-sorghvliet-anno-1690/#jp-carousel-98

The Cats House in 1964, Sorvgliet - https://nl.wikipedia.org/wiki/Catshuis

Slide 06

Trembley collecting aquatic insects - Trembley, A. (1744). Mémoires pour servir à l'histoire d'un genre de polypes d'eau douce, à bras en forme de cornes. Leide: Chez Jean & Herman Verbeek. Pg.149.

https://www.biodiversitylibrary.org/item/130183#page/197/mode/1up

Slide 07

Trembley and the boys in the "lab" - Trembley, A. (1744). Mémoires pour servir à l'histoire d'un genre de polypes d'eau douce, à bras en forme de cornes. Leide: Chez Jean & Herman Verbeek. Pg.229.

https://www.biodiversitylibrary.org/item/130183#page/289/mode/1up

Slide 08

Polyps in a glass jar (left) - Trembley, A. (1744). Mémoires pour servir à l'histoire d'un genre de polypes d'eau douce, à bras en forme de cornes. Leide: Chez Jean & Herman Verbeek. Planche 3, Mem. 1. https://www.biodiversitylibrary.org/item/130183#page/107/mode/1up

Polyps on a duckweed - Trembley, A. (1744). Mémoires pour servir à l'histoire d'un genre de polypes d'eau douce, à bras en forme de cornes. Leide: Chez Jean & Herman Verbeek. Planche 1, Mem. 1. https://www.biodiversitylibrary.org/item/130183#page/101/mode/1up

Slide 09

Polyps moving its arms and body (figs 1 and 2) - Trembley, A. (1744). Mémoires pour servir à l'histoire d'un genre de polypes d'eau douce, à bras en forme de cornes. Leide: Chez Jean & Herman Verbeek. Planche 2, Mem. 1.

https://www.biodiversitylibrary.org/item/130183#page/103/mode/1up

Slide 10 Scala naturae - Ramon Llull's Ladder of Ascent and Descent of the Mind, 1305. https://en.wikipedia.org/wiki/Great_chain_of_being#/media/File:Die_Leiter_des_Auf-_und_Abstiegs.jpg

Great chain of beings - From Didacus Valades [es], Rhetorica Christiana, 1579. https://en.wikipedia.org/wiki/Great_chain_of_being#/media/File:Great_Chain_of_Being_2.png

Slide 11 Carl von Linné, portrait - https://pt.wikipedia.org/wiki/Lineu#/media/Ficheiro:Carl_von_Linn%C3%A9.jpg

Systema Naturae, cover 1th edition (1735) - https://fr.wikipedia.org/wiki/Systema_naturae#/media/Fichier:Systema_naturae.jpg

Systema Naturae, cover 13th edition (1770) - https://openlibrary.org/books/OL14044409M/Systema_naturae

Slide 12 Natural History of Many Curious and Uncommon Zoophytes, cover (1786) - https://www.biodiversitylibrary.org/item/131537#page/11/mode/1up

Sea cucumber and sea pens - Natural History of Many Curious and Uncommon Zoophytes. https://darwin.lindahall.org/25_ellis_b.shtml

Slide 13 Locomotion in polyps (figs 1 – 9) - Trembley, A. (1744). Mémoires pour servir à l'histoire d'un genre de polypes d'eau douce, à bras en forme de cornes. Leide: Chez Jean & Herman Verbeek. Planche 3, Mem. 1.

https://www.biodiversitylibrary.org/item/130183#page/106/mode/1up

Slide 15 A polyp cut into two parts (figs 1 and fig 2) - Trembley, A. (1744). Mémoires pour servir à l'histoire d'un genre de polypes d'eau douce, à bras en forme de cornes. Leide: Chez Jean & Herman Verbeek. Planche 11, Mem. 4.

https://www.biodiversitylibrary.org/item/130183#page/385/mode/1up

Slide 18 Lizard tail regeneration. Image credits: Francois Mignard.

https://www.zmescience.com/science/lizards-can-only-regrow-imperfect-tails-due-to-faulty-stem-cells/

Lobster limb regeneration. - https://bubblydiver.com/can-lobsters-regrow-limbs/

Slide 20 René Antoine Ferchault de Réaumur, portrait. - https://pt.wikipedia.org/wiki/Ren%C3%A9-Antoine_Ferchault_de_R%C3%A9aumur#/media/Ficheiro:Reaumur_1683-1757.jpg

Réaumur, 1737, Mémoires pour servir à l'histoire des insectes, tome IV, cover. - https://openlibrary.org/books/OL6974008M/Me%CC%81moires_pour_servir_a%CC%80_l%27histoire_des_insectes.

Slide 22 A polyp of the second species found by Trembley (left) - Trembley, A. (1744). Mémoires pour servir à l'histoire d'un genre de polypes d'eau douce, à bras en forme de cornes. Leide: Chez Jean & Herman Verbeek. Planche 5, Mem. 1.

https://www.biodiversitylibrary.org/item/130183#page/116/mode/1up

Octupus anatomy. Illustrated by George Edwards, in (1694-1773).
https://www.sciencephoto.com/media/433578/view/octopus-anatomy-18th-century

Slide 25 Female lobster carring eggs.
https://www.mainelobsternow.com/media/magefan_blog/2017/04/Homarus_americanus_eggs.jpg

Slide 27 Bud taken from a polyp (fig 5-6, fig 9-10). - Trembley, A. (1744). Mémoires pour servir à l'histoire d'un genre de polypes d'eau douce, à bras en forme de cornes. Leide: Chez Jean & Herman Verbeek. Planche 8, Mem. 3.
https://www.biodiversitylibrary.org/item/130183#page/277/mode/1up

Slide 28 Bernard de Jussieu (1699-1777), portrait. -
https://pt.wikipedia.org/wiki/Bernard_de_Jussieu#/media/Ficheiro:Bernard_de_Jussieu.jpg

A 'feather polyp '.Trembley, A. (1744). Mémoires pour servir à l'histoire d'un genre de polypes d'eau douce, à bras en forme de cornes. Leide: Chez Jean & Herman Verbeek. Planche 10, Mem. 3.
https://www.biodiversitylibrary.org/item/130183#page/287/mode/1up

Glass jar containing "feather polyps". (*Nereis lutaria*), from Pierre-Simon Pallas (1778), in: Ratcliff, M. The Trembley Effect or the birth of marine zoology. Int. J. Dev. Biol. 56: 425-436 (2012).
https://ijdb.ehu.eus/article/pdf/123520mr

Slide 29 Polyps capturing and ingesting worms (Figs : 1, 2, 4, 7 and 8) . Trembley, A. (1744). Mémoires pour servir à l'histoire d'un genre de polypes d'eau douce, à bras en forme de cornes. Leide: Chez Jean & Herman Verbeek. Planche 6, Mem. 2.

https://www.biodiversitylibrary.org/item/130183#page/191/mode/1up

Slide 31 Herman Boerhaave (1668-1738), portrait -
https://pt.wikipedia.org/wiki/Herman_Boerhaave#/media/Ficheiro:Herman_Boerhaave,_by_Cornelis_Troost.jpg

Elementa Chemiae, 1732, cover.
https://upload.wikimedia.org/wikipedia/commons/5/50/Elementa_Chemiae-Boerhaave.jpg

Slide 32 A polyp under microscope with cross-section. Trembley, A. (1744). Mémoires pour servir à l'histoire d'un genre de polypes d'eau douce, à bras en forme de cornes. Leide: Chez Jean & Herman Verbeek. Planche 4, Mem. 1.
https://www.biodiversitylibrary.org/item/130183#page/113/mode/1up

Slide 33 Luigi Ferdinando Marsigli (1658-1730), portrait.
https://pt.wikipedia.org/wiki/Luigi_Ferdinando_Marsigli#/media/Ficheiro:Luigi_Ferdinando_Marsigli.jpg.

Histoire physique de la mer, 1725, cover. https://gallica.bnf.fr/ark:/12148/bpt6k3116211

Slide 35 An inverted polyp (figs 12-16). Trembley, A. (1744). Mémoires pour servir à l'histoire d'un genre de polypes d'eau douce, à bras en forme de cornes. Leide: Chez Jean & Herman Verbeek. Planche 11, Mem. 4. https://www.biodiversitylibrary.org/item/130183#page/387/mode/1up

Slide 36 Pierre Lyonnet (1706-1789), portrait.
https://en.wikipedia.org/wiki/Pierre_Lyonnet#/media/File:Lyonnet_Pierre_1707-

1789.jpg

Jean-Nicolas Sébastien Allamand (1713-1787), portrait. https://en.wikipedia.org/wiki/Jean-Nicolas-S%C3%A9bastien_Allamand#/media/File:J_N_S_Allamand.jpg

Bernhard Siegfried Albinus (1697-1770), portrait. https://pt.wikipedia.org/wiki/Bernhard_Siegfried_Albinus#/media/Ficheiro:Bernhard_Siegfried_Albinus.jpg

Slide 37 Trembley's paper in Philosophical Transactions. https://royalsocietypublishing.org/doi/pdf/10.1098/rstl.1742.0005

Slide 39 Martin Folkes (1690-1754), portrait. https://en.wikipedia.org/wiki/Martin_Folkes#/media/File:Martin_Folkes_by_James_Macardell.jpg

Slide 40 Copley medal. https://www.cai.cam.ac.uk/research/notable-research/caius-copley-medallists

Slide 41 Henry Baker (1698-1774), portrait. https://en.wikipedia.org/wiki/Henry_Baker_%28naturalist%29#/media/File:Henry_Baker_(naturalist).jpg

An attempt towards a natural history of the polype, in a letter to Martin Folkes, 1743, cover. https://www.biodiversitylibrary.org/item/37428#page/7/mode/1up

Slide 43 Mémoires pour servir à l'histoire d'un genre de polypes d'eau douce, à bras en forme de cornes, 1744, cover. https://www.biodiversitylibrary.org/item/130183#page/7/mode/1up