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Abraham Trembley's Strategy of Generosity and the Scope of Celebrity in the Mid-Eighteenth Century

*By Marc J. Ratcliff**

ABSTRACT

Historians of science have long believed that Abraham Trembley's celebrity and impact were attributable chiefly to the incredible regenerative phenomena demonstrated by the polyp, which he discovered in 1744, and to the new experimental method he devised to investigate them. This essay shows that experimental method alone cannot account for Trembley's success and influence; nor are the marvels of the polyp sufficient to explain its scientific and cultural impact. Experimental method was but one element in a new conception of the laboratory that called for both experimental and para-experimental skills whose public availability depended on a new style of communication. The strategy of generosity that led Trembley to dispatch polyps everywhere enabled experimental naturalist laboratories to spread throughout Europe, and the free circulation of living objects for scientific research led practitioners to establish an experimental field distinct from mechanical physics. Scholars reacted to the marvels of the polyp by strengthening the boundaries between the public and academic spheres and, in consequence, opened a space for new standards in both scientific work and the production of celebrity.

... comme l'Auteur de l'Histoire des Polypes, il a passé de plein vol à l'immortalité.
—Julien Offrey de La Mettrie (1751)

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HISTORIANS OF SCIENCE have rightly connected Abraham Trembley's celebrity with his discovery of the regeneration of the polyp (*Hydra*), elaborated in his *Mémoires, pour servir à l'histoire d'un genre de polypes d'eau douce, à bras en forme de cornes* (1744). Born in the Geneva Republic, the son of an officer, Trembley (1710–1784) was educated in theology and philosophy and defended his thesis on the infinitesimal calculus in 1731. In 1732, for economic reasons, he migrated to Holland, and in 1736 he became the tutor of Count William Bentinck's two sons. He started his experiments on the polyp in the castle of Sorgvliet in the summer of 1740. After becoming famous thanks to this research, he was named to the British diplomatic delegation that negotiated the peace of Aix-la-Chapelle, putting an end to the War of the Austrian Succession in 1748. He then traveled in Europe as tutor to the son of Charles Lennox, second duke of Richmond, before returning to Geneva in 1756. Trembley married in 1757; from that time on he dedicated himself to the education of his children, to political activity, and to the writing of books that combined educational, moral, and scientific topics.¹

Historical accounts of Trembley's discovery have underscored his extraordinary skills in investigating regeneration; notably, his experimental method has been scrutinized in the seminal studies of John Baker, Marino Buscaglia, Sylvia Lenhoff and Howard Lenhoff, and Virginia P. Dawson. Some historians have even asserted that his celebrity and influence were due chiefly to his mastery of experimental method, and for this reason they credit him with being the father of biology.² In this essay I will show that Trembley's experimental method, brilliant though it was, was neither the only nor even the main reason for his meteoric success and influence on his contemporaries. First, given the regularity of the regeneration phenomenon in the polyp and Trembley's inspired method for demonstrating it, I claim that a major factor in his success was his strategy of communication, which I will label the "strategy of generosity." Moreover, Trembley's management of the polyp was much as concerned with *para-experimental* features—the conservation, care, and transport of polyps—as with experimental method. Implementing the strategy of generosity led to major changes in naturalists' practices within the laboratory; these changes—which were not only, strictly speaking, experimental—radically transformed the standards operating in the field of experimental natural history.

Another commonplace that circulates among historians is that the marvelous regenerative phenomena the polyp demonstrated were a direct source for the sorts of materialist and vitalist ideas that surfaced during the 1740s. I claim that this is only part of the story.

¹ The epigraph is taken from Julien Offray de La Mettrie, *L'homme machine*, in *Oeuvres Philosophiques*, 2 vols., Vol. 1 (1751; Paris: Fayard, 1987), pp. 63–118, on p. 77. For a comprehensive biography of Trembley see John R. Baker, *Abraham Trembley of Geneva, Scientist and Philosopher (1710–1784)* (London: Arnold, 1952).

² See J. R. Baker, *Abraham Trembley*, pp. 170–187; Marino Buscaglia, "The Rhetoric of Proof and Persuasion Utilized by Abraham Trembley," in *From Trembley's Polyps to New Directions in Research on Hydra*, ed. Howard M. Lenhoff and Paul Tardent (Archives des Sciences, 1985, 38[3]), pp. 305–319; Sylvia G. Lenhoff and H. M. Lenhoff, *Hydra and the Birth of Experimental Biology, 1744* (Pacific Grove, Calif.: Boxwood, 1986), pp. 14, 20 (this provides synthetic charts of the discoveries and procedures); Virginia P. Dawson, "Trembley's Experiment of Turning the Polyp Inside Out and the Influence of Dutch Science," in *From Trembley's Polyps to New Directions in Research on the Hydra*, ed. H. M. Lenhoff and Tardent, pp. 321–334; and Dawson, *Nature's Enigma: The Problem of the Polyp in the Letters of Bonnet, Trembley, and Réaumur* (Philadelphia: American Philosophical Society, 1987) (hereafter cited as **Dawson, Nature's Enigma**), pp. 86–88, 183–184. Trembley is referred to as the father of biology in S. G. Lenhoff and H. M. Lenhoff, *Hydra*, p. 16; see also Joseph Schiller, "Queries, Answers, and Unsolved Problems in Eighteenth-Century Biology," *History of Science*, 1974, 12:184–199, on p. 185.

One cultural outcome of the interest in polyps was a strengthening of the divide between the public and the scholarly spheres—at least in France. Confronted with the marvelous polyp, the scholarly world distanced itself from—and indeed protected itself against—the public enthusiasm for metaphysical discourse. Within the scholarly setting, however, the polyp had considerable influence both on the rules for the communication of the scholar's image and reputation and in shaping a new discipline for experimental naturalists. Far from creating biology as a discipline, a development that occurred a century later, Trembley gave something of its new shape to the modern laboratory, a locus that synthesized experimental and para-experimental practices.³ And indeed, from 1750 onward, a web of laboratories sprang up in Europe, networked by the circulation of papers, letters, instruments, and organisms.

**A MODEL FOR SCIENTIFIC COMMUNICATION: THE SPREAD OF THE POLYP
AND THE CONVERSION OF UNBELIEVERS**

Circulating Polyps

An ongoing problem during the seventeenth century was the transport of small and microscopic living animals. Methods used for conveying larger animals—living, dead, or stuffed for display—had been improved from the Renaissance onward. Quadrupeds—dead and alive—were routinely brought from America, Africa, and Asia, intended for museums and zoological gardens. Nonetheless, transporting dead animals overseas continued to present particular problems of conservation: they were subject to decay and to being gnawed and eaten by other creatures. In the early eighteenth century collectors such as Hans Sloane, the president of the Royal Society, and the French academician René-Antoine Ferchault de Réaumur found ways to send small organisms such as worms and insects from one place to another. Réaumur maintained a network of correspondents from several parts of Europe whom he instructed in the collection and forwarding of insect specimens. In 1730, for instance, he told the marquis de Caumont how to secure live cicadas in bottles for transport.⁴

Dispatching living aquatic creatures, as Trembley did, presented special technical problems because they had to be maintained in their particular natural environment. Simply acquiring such creatures was the first obstacle. Hopeful investigators were largely dependent on sailors for their specimens; few seventeenth-century scholars were able to follow the lead of Paolo Boccone, botanist of the grand duke of Tuscany, who himself went on marine expeditions to gather coral. In his preface to Count Luigi Ferdinando Marsigli's

³ On the polyp as a source for materialist and vitalist ideas see Aram Vartanian, "Trembley's Polyp, La Mettrie, and Eighteenth-Century French Materialism," *Journal of the History of Ideas*, 1950, 11:259–280; Jacques Roger, *Les sciences de la vie au XVII^e et XVIII^e siècle* (1971; Paris: Colin, 1993), p. 749; Dawson, *Nature's Enigma*, pp. 155–156; Giulio Barsanti, "Les phénomènes 'étranges' et 'paradoxaux' aux origines de la première révolution biologique (1740–1810)," in *Vitalisms from Haller to the Cell Theory*, ed. Guido Cimino and François Duchesneau (Florence: Olschki, 1997), pp. 67–82, on pp. 68–70; Barbara Maria Stafford, "Images of Ambiguity, Eighteenth-Century Microscopy, and the Neither/Nor," in *Visions of Empire: Voyages, Botany, and Representations of Nature*, ed. D. P. Miller and P. H. Reill (Cambridge: Cambridge Univ. Press, 1997), pp. 230–257, on pp. 233–235; Catherine Wilson, *The Invisible World: Early Modern Philosophy and the Invention of the Microscope* (Princeton, N.J.: Princeton Univ. Press, 1995), p. 203; and Brian J. Ford, *Single Lens: The Story of the Simple Microscope* (New York: Harper & Row, 1985), pp. 109–111. On the origin of laboratory science see Steven Shapin, "The House of Experiment in Seventeenth-Century England," *Isis*, 1988, 79:373–404.

⁴ René-Antoine Ferchault de Réaumur to Joseph de Seytres, marquis du Caumont, 23 July 1730, Geneva, Bibliothèque Publique et Universitaire (hereafter cited as **BPU**), Fonds Trembley, Box 5, fol. 85v.

Histoire physique de la mer (1725), Hermann Boerhaave detailed the hardships scholars had to brave in order to catch living organisms from the sea.⁵ Other problems presented themselves once the specimens were obtained. Seeking to observe coral in its natural environment, Marsigli immediately put it in a large glass jar filled with seawater, placed the jar in a room at sea temperature, and waited for the coral to spread. This forerunner of the aquarium allowed him to observe the coral undisturbed (see Frontispiece). In December 1706, over the course of several hours, Marsigli observed minute growths coming out of the “branches,” attached to tiny holes; he interpreted these growths as the “flowers” of the coral. Apparently, although Boccone and others had considered it a mineral, coral was a vegetable.⁶ While this view was strongly criticized—and progressively abandoned—throughout Europe between 1742 and the 1780s, the practice of maintaining marine specimens in seawater became a standard that was subsequently improved upon for research in marine zoology.

Marsigli's thesis was challenged by his collaborator Jean-André Peyssonel, who in 1727 sent the Paris academy a paper in which he claimed that the “flowers” of coral were actually small animals.⁷ Réaumur's insistence on evidence to support this conjecture led to one of the first attempts at transporting living coral over a long distance. Men walked more than five hundred miles carrying vessels of seawater, and the coral reached Réaumur “in a decayed condition.” Unable to reproduce Peyssonel's observation, he strongly opposed publication of the paper in the *Mémoires de l'Académie*. Later in the century the controversy over the nature of coral was common knowledge. The anonymous author of a review of John Ellis's *An Essay towards a Natural History of the Corallines* (1755), published in the *Journal Étranger*, acknowledged that the difficulty of observing coral in its natural state was one of the causes of the dispute: “As these productions are very delicate, and the polyps wrinkle as soon as they are exposed to the air, it was not a small effort to find them in their natural condition, in order to examine them with the microscope; which is, perhaps, partly the cause why there have been so many disputes about their true nature.”⁸

In such a context, where almost everything needed for the transport of living aquatic creatures had to be created from scratch, Trembley succeeded in preparing for travel microscopic animals whose “marvelous properties” could hence be made accessible to anyone, anywhere. In the summer of 1740 he discovered in the ponds of Sorgvliet a small

⁵ Hermann Boerhaave, preface, in Luigi Ferdinando Marsigli, *Histoire physique de la mer* (Amsterdam, 1725), pp. 4–6. Boccone traveled to the coasts of Sicily in 1670 and of Holland in 1673. According to biologists, coral is the calcareous skeleton secreted by certain species of marine polyps.

⁶ Marsigli, *Histoire physique de la mer*, pp. 115–116. Marsigli's first “laboratory” was in Cassis, south of Marseilles; see J. R. Baker, *Abraham Trembley* (cit. n. 1), p. 118. For a detailed account based on the manuscript report by Marsigli see Anita McConnell, “The Flowers of Coral: Some Unpublished Conflicts from Montpellier and Paris during the Early Eighteenth Century,” *History and Philosophy of Life Sciences*, 1990, 12:51–66, on p. 57; on the thesis of the mineral coral see pp. 54–55.

⁷ For a detailed account of Peyssonel's discovery and his manuscript *Traité du corail* see McConnell, “Flowers of Coral,” pp. 63–65; Joseph Schiller, *Physiologie et classification* (Paris: Maloine, 1980), pp. 20–22; and J. R. Baker, *Abraham Trembley*, p. 119. A former collaborator of Marsigli, François-Xavier Bon, claimed priority over Peyssonel for the discovery of the animal nature of coral; see McConnell, “Flowers of Coral,” pp. 59–61.

⁸ On the state of the coral when it reached Réaumur see J. R. Baker, *Abraham Trembley*, p. 119. For Réaumur's own views see René Antoine Ferchault de Réaumur, “Observations sur la formation du corail, et des autres productions appellées plantes pierreuses,” *Mémoires de l'Académie Royale des Sciences de Paris*, 1727, pp. 269–281, on pp. 270–271. Réaumur presented his *mémoire* on 9 Aug. 1727, but Peyssonel was not quoted in it; see the *Procès Verbaux de l'Académie des Sciences* for 1727, Vol. 46, fols. 280–287v, Archives de l'Académie des Sciences, Paris. For the review see Anonymous, “Essai sur l'histoire naturelle des corallines,” *Journal Étranger*, Aug. 1755, pp. 72–82, on p. 75. (Here and throughout the essay, translations are my own unless otherwise indicated.)

organism shaped like a tube, which he cut in two in order to determine whether it belonged to the vegetable or the animal kingdom. The strange creature reproduced both parts, the radiating head and the body; two organisms came from one after an artificial cut. Trembley started corresponding with Réaumur about these organisms in late 1740, and on 15 January 1741 he was politely requested to ship some of the curious creatures to Paris: “If you were to have enough of these small bodies to deprive you of several of them, it would perhaps not be impossible for you to enable me to see them, by sending them in a very small bottle filled with water, through the post.”⁹

Trembley sent off the first parcel, containing fifty of the organisms, on 16 February. On 27 February Réaumur received the bottle; the organisms were dead. The Spanish wax used to seal the bottle had deprived them of air, Réaumur said, and he proposed that Trembley try again using only a cork. He also sought Trembley’s permission to read his letter about the first regeneration experiments with these creatures before the Académie des Sciences; this presentation took place over the course of three meetings on 1, 8, and 22 March 1741. On 16 March Trembley sent a fresh sample of fifteen organisms in a larger bottle. Seeking to ensure their survival, he had carried out a test by putting three polyps in a bottle and taking them for a ride of seven leagues, about twenty-five miles. After this “para-experimental simulation” the organisms seemed fine, and so Trembley sent them on the real journey to Paris, which would last between four and seven days. A week later Réaumur received the creatures alive, and that very evening he repeated the experiments carefully described by Trembley. Between 22 and 25 March Réaumur demonstrated regeneration to the “entire academy” and, with it, to “the court and the city.”¹⁰ On 25 March, having consulted Bernard de Jussieu, Réaumur placed these organisms in the animal kingdom and named them “polyp.” Trembley continued to send packages of polyps from The Hague to Paris until 1743. During that period he continued to improve his procedures and to contrive new experiments: he was able to produce a polyp with seven heads, induce a polyp to “swallow” other polyps, graft the halves of two different polyps together, and turn a polyp inside out, an experiment he started in July 1741 and that eventually succeeded in autumn 1742.¹¹

The successful French academic demonstration was repeated in England two years later. Although the president of the Royal Society, Martin Folkes, had been privately informed about the existence and curious characteristics of the polyp by Georges Louis Leclerc de Buffon in July 1741, and the letters of Charles Bentinck and the botanist Johann Friedrich

⁹ Réaumur to Abraham Trembley, 15 Jan. 1741, in *Correspondance inédite entre Réaumur et Abraham Trembley*, ed. Maurice Trembley and Emile Guyénot (Geneva: Georg, 1943) (hereafter cited as *Correspondance*, ed. M. Trembley and Guyénot), p. 17. See also Dawson, *Nature’s Enigma*, pp. 100–110.

¹⁰ For Réaumur’s presentation of Trembley’s results see *Procès Verbaux de l’Académie des Sciences* for 1741, Vol. 60, fols. 76, 80, 88. The simulated journey is described in Trembley to Réaumur, 16 Mar. 1741, in *Correspondance*, ed. M. Trembley and Guyénot, pp. 52–53. Réaumur’s demonstrations from 22 to 25 March are described in Réaumur to Trembley, 25 Mar. 1741, *ibid.*, p. 64. An account of demonstration for “the court and the city” is in Jean-Jacques Dortous de Mairan, “Animaux coupés et partagés en plusieurs parties, et qui se reproduisent tout entiers dans chacune,” *Histoire de l’Académie Royale des Sciences de Paris*, 1741, pp. 33–35, on p. 35. Réaumur used similar sentences in René Antoine Ferchault de Réaumur, *Mémoires pour servir à l’histoire des insectes*, 6 vols., Vol. 6 (Paris, 1742), p. li.

¹¹ On 6 Apr. 1741 Trembley sent twenty polyps to Réaumur. A new batch of polyps failed a year later, arriving dead in June 1742; see Réaumur to Trembley, 23 Aug. 1742, in *Correspondance*, ed. M. Trembley and Guyénot, p. 132. Polyps sent on 8 Aug. 1743 survived: *ibid.*, p. 174. Trembley’s experiments are described in S. G. Lenhoff and H. M. Lenhoff, *Hydra* (cit. n. 2), pp. 14, 20. On turning the polyp inside out see Dawson, “Trembley’s Experiment” (cit. n. 2); and Dawson, *Nature’s Enigma*, pp. 122–127. The success of this experiment is reported in Trembley to Réaumur, 1 Nov. 1742, in *Correspondance*, ed. M. Trembley and Guyénot, pp. 134–135.

Gronovius on the topic had appeared in the *Philosophical Transactions*, the issue was left largely untouched in official English scientific circles until March 1743. But skeptical criticisms, jokes, and ironic remarks were already circulating, especially in Cambridge, about these animals “which, being cut into several pieces, become so many perfect animals.”¹²

Through the medium of William Bentinck, to whom Folkes had applied for confirmation of the reports of the experiments, Trembley sent Folkes polyps that he received on 10 March 1743. The following day Folkes demonstrated the polyps—“before the lens and the microscope”—to twenty Fellows of the Royal Society who came to his home to see them. Meanwhile, he practiced the regeneration experiments described in Trembley's instructions. At a meeting of the Royal Society on 17 March Folkes exhibited the regenerating polyps, and in the course of that week more than 150 people saw them.¹³ On 24 March 1743, two years after Réaumur's demonstration in Paris, Folkes once again demonstrated regeneration before an astonished audience, this time with the assistance of Henry Baker, James Parsons, and the optician John Cuff, who brought “a good microscope.” In March 1743 the *Philosophical Transactions* issued Charles Bonnet's experiments on regenerating worms, which increased the sense of wonderment, if possible, while other fellows—including Bentinck, Richmond, Baker, and Thomas Lord—vouched for the budding and regeneration of polyps.¹⁴

Skeptics and Materialists: The Public Sphere in Question

Folkes's report of the March meeting to Trembley noted that the “unbelievers”—in French, *les incrédules*—were silenced, and skeptical jokes about the “marvelous animal” ceased. Indeed, among the reasons put forward by Réaumur, Trembley, Folkes, Gronovius, and Bentinck for demonstrating the regeneration phenomena with live polyps, the matter of swaying the unbelievers cropped up several times. Réaumur wrote a few pages on the polyp in the preface to the sixth volume of his 1742 *Histoire des insectes*, in order to “have a ready answer to the questions from the unbelievers, which I am flooded with.”¹⁵

Folkes was surprised by how thoroughly the unbelievers' protests were silenced by the

¹² Johann Friedrich Gronovius, “Concerning a Water Insect, Which, Being Cut into Several Pieces, Becomes So Many Perfect Animals,” *Philosophical Transactions of the Royal Society of London*, 1742, 42(466):218–220, on p. 218.

¹³ The letters of Trembley to Martin Folkes are held in London at the Royal Society (hereafter cited as **MSS Folkes**). The letters from Folkes to Trembley are held by Jacques Trembley in Geneva, who kindly authorized me to use this material (hereafter cited as **MSS Trembley**); a few of these are also included in *Correspondance*, ed. M. Trembley and Guyénot. On Folkes's demonstrations see Folkes to Trembley, 11 Mar. 1743, *ibid.*, pp. 165–166; and Folkes to Trembley, 25 Mar. 1743, **MSS Trembley**, pp. 18–19.

¹⁴ Bonnet observed other organisms that regenerated after cutting—e.g., water worms. See Charles Bonnet, “Of Insects Which Are Multiplied, as It Were, by Cutting or Slips,” *Phil. Trans. Roy. Soc. Lond.*, 1743, 42(470):468–488. The discovery was also published in French in Bonnet, *Traité d'insectologie ou observations sur les pucerons* (Amsterdam: Luzac, 1745). See also William Bentinck, “Abstract of Part of a Letter from the Honourable William Bentinck, Esq., F.R.S., to Martin Folkes, Esq., Pr.R.S., Communicating the Following Paper from Mons. Trembley, of the Hague,” *Phil. Trans. Roy. Soc. Lond.*, 1743, 42(467):ii (the paper that followed was Abraham Trembley, “Observations and Experiments upon the Freshwater Polypus, by Monsieur Trembley, at the Hague,” *ibid.*, pp. iii–xi); Duke of Richmond, “Part of a Letter from His Grace the Duke of Richmond to M. Folkes,” *ibid.*, 1743, 42(470):510–513; Henry Baker, *An Attempt towards a Natural History of the Polyp* (London: Dodsley, 1743); and Thomas Lord, “Concerning Some Worms Whose Parts Live after They Have Been Cut Asunder,” *Phil. Trans. Roy. Soc. Lond.*, 1743, 42(470):522–523.

¹⁵ Folkes to Trembley, 25 Mar. 1743, **MSS Trembley**, p. 16: “c'est avec joie que j'ai été en état de convaincre les plus incrédules”; and Réaumur to Trembley, 25 June 1742, in *Correspondance*, ed. M. Trembley and Guyénot, p. 130.

demonstrations. Trembley regarded Réaumur's and Folkes's notes on the polyp as the best "credentials" he could have received from the acknowledged authorities and the strongest evidence with which he could confront the unbelievers. In Leiden, the doubters had been persuaded by experiments carried out in 1742 by the professor of anatomy Bernhard Siegfried Albinus, the professor of physics Pieter van Musschenbroek, and Trembley's friend Jean Nicolas Sébastien Allamand; their findings were reported by Gronovius in the *Philosophical Transactions*.¹⁶ Moreover, since the summer of 1742 Trembley had embraced the "strategy of generosity" as a systematic solution to the problem of convincing others to trust regeneration. He dispatched polyps and correlative instructions to everyone who asked for them in order to repeat his observations. Meticulous instructions allowed others to reproduce the experiments and enabled Trembley to share his procedural knowledge about *naturalia*, not just the organisms themselves. Yet the regeneration of the polyp was so "marvelous" that it remained difficult to accept, because even in the face of growing numbers of reports of witnessing some people still refused to attend the experimental demonstrations. As late as 1744, Albinus and Hieronymus David Gaub, who had succeeded to Albrecht von Haller's professorship in Leiden, were solicited as witnesses for a repetition of some of Trembley's experiments.¹⁷

By this point, it was possible to distinguish two distinct groups of unbelievers, which I will label the "skeptics" and the "materialist unbelievers." The first accounts of the polyp aroused skepticism among those who did not trust regeneration; Folkes, Réaumur, and Trembley called them unbelievers—*incrédules*.¹⁸ Both on the Continent and in England, scholars sought to "convince the unbelievers" through their experiments on regenerating creatures. These skeptics were not supporters of materialism; rather, they simply did not believe that an animal could regenerate when cut in pieces or that coral was produced by an animal. Yet the marvelous phenomenon not only fueled the jokes of the skeptics but also nourished the views of metaphysical thinkers.¹⁹ These French *philosophes*, materialists, and freethinkers were a second kind of "unbeliever" that showed up during the 1740s. Writing in covert opposition to the political and religious French establishment, they carried out a debate over the material soul in the clandestine literature. Julien Offray de La Mettrie, Pierre-Louis Moreau de Maupertuis, Denis Diderot, Thémiseul ou Paul de Saint-Hyacinthe, and others invoked plastic forces, raised the question of spontaneous generation, and appealed to random combinations of atoms to explain life and soul.²⁰ In general,

¹⁶ Trembley to Réaumur, 11 Jan. 1743, in *Correspondance*, ed. M. Trembley and Guyénot, p. 153; and Trembley to Folkes, 31 May 1743, MSS Folkes, Vol. 4, letters 17, 34. For Gronovius's report see Gronovius, "Concerning a Water Insect" (cit. n. 12), p. 218. On the Leiden scholars see J. R. Baker, *Abraham Trembley* (cit. n. 1), p. 13; and Dawson, *Nature's Enigma*, p. 124.

¹⁷ Trembley was a good friend of Willem Jacob's Gravesande, Albinus, Gaub, and Musschenbroek, whose lectures he probably attended at Leiden between 1733 and 1736. See J. R. Baker, *Abraham Trembley*, p. 13.

¹⁸ According to the *Dictionnaire de l'Académie Française*, 3rd ed., 2 vols. (Paris: Coignard, 1740), "*incrédule*" had two meanings, one of which was especially religious (Vol. 1, p. 856). "*Sceptique*" related only to the Greek "sect of ancient philosophers" (Vol. 2, p. 639).

¹⁹ For efforts to "convince the unbelievers" see Francesco Ginanni, "Lettera intorno alla scoperta degli insetti che si moltiplicano mediante la sezione de' loro corpi," *Raccolta d'Opuscoli Scientifici di Calogera*, 1747, 37:253–304, on p. 255; and John Ellis, *An Essay towards a Natural History of the Corallines* (London, 1755), p. xiv. For the effect of the polyp on metaphysical thinkers see Edward Ruestow, *The Microscope in the Dutch Republic: The Shaping of Discovery* (Cambridge: Cambridge Univ. Press, 1996), p. 273; and S. G. Lenhoff and H. M. Lenhoff, *Hydra* (cit. n. 2), p. 35.

²⁰ Vartanian has highlighted the debate over the material soul in Saint-Hyacinthe's *Recherches philosophiques* (1744), Jacques Perretti's *Lettre philosophique sur les physionomies* (1746), La Mettrie's *L'homme machine* (1747), and other anonymous writings. See Aram Vartanian, *La Mettrie's "L'homme machine": A Study in the Origins of an Idea* (Princeton, N. J.: Princeton Univ. Press, 1960). On the link of materialism with the polyp see

these materialist unbelievers had nothing to do with those who were skeptical about regeneration, although the same word—*incrédules*—was applied to both groups. To distinguish them, one could say that the skeptics, though initially hostile, were satisfied once they were eyewitnesses to the successful experiments; the materialists, on the other hand, welcomed the wonderful properties exhibited by the polyp and were determined to turn them to subversive purposes. Appearing around 1741 in every place touched by rumors about the polyps, the skeptics were convinced before the end of 1743, while the materialist unbelievers surfaced in France from 1744 onward. Though the latter sometimes made use of the polyp to ground their theses, it was by no means the main topic discussed in their writings. Maupertuis, for example, did not develop his views on the soul with reference to the polyp but instead appealed to vital forces. Diderot's entry "Polype" in the *Encyclopédie* is more or less an abstract of Trembley's 1744 *Mémoires* and does not address the problem of the soul at all. And La Mettrie, in writing about the polyp, went no further than repeating Réaumur's and Trembley's epistemological claim. Following Trembley, for whom "these discoveries . . . must of course arouse our mistrust towards . . . general rules," La Mettrie stated that "this discovery teaches us to never conclude generally." The fact that the polyp helped to inspire freethinkers does not mean that scholars expatiated on materialist or metaphysical hypotheses. Not one word of Trembley's published writings referred to plastic forces, soul, or vitalist or materialist issues.²¹

Indeed, some scholars warned their colleagues against raising such topics. In the widely read preface to his 1742 *Mémoires*, Réaumur broached the tricky enigma, "Is the soul divisible?" But he immediately supplied the answer—such a question was not relevant in the scientific realm—and concluded with a strong warning: "Whatever the multiplication of our physical discoveries, we must not hope to become more enlightened as to truths of another type, as to those truths relating to objects that are neither body nor matter."²²

Virginia P. Dawson, "La théologie des insectes dans la pensée de Charles Bonnet," in *Charles Bonnet, savant et philosophe (1720–1793)*, ed. Marino Buscaglia et al. (Geneva: Passé-Présent, 1994), pp. 79–90, on pp. 84–85; and Vartanian, "Trembley's Polyp" (cit. n. 3), p. 253. For more on clandestine literature see Robert Darnton, *The Literary Underground of the Old Regime* (Cambridge, Mass.: Harvard Univ. Press, 1982); Darnton, *The Forbidden Bestsellers of Pre-Revolutionary France* (New York: Norton, 1994); and Geneviève Artigas-Menant and Antony McKenna, eds., *Anonymat et clandestinité aux XVIIe et XVIIIe siècles* (Paris: Presses Univ. Paris-Sorbonne, 1999). On Maupertuis's and Buffon's theories of heredity see Mary Terrall, "Salon, Academy, and Boudoir: Generation and Desire in Maupertuis's Science of Life," *Isis*, 1996, 87:217–229, on pp. 220–225; and Roselyne Rey, "Génération et hérédité au XVIIIe siècle," in *L'ordre des caractères: Aspects de l'hérédité dans l'histoire des sciences de l'homme*, ed. C. Bénichou (Paris: Sciences en Situation, 1992), pp. 7–48, on pp. 18–27. Bonnet would later argue against the unbelievers; see Renato G. Mazzolini and Shirley Roe, eds., *Science against the Unbelievers: The Correspondence of Bonnet and Needham, 1760–1780* (Oxford: Voltaire Foundation, 1986), pp. 62–76.

²¹ Pierre Louis Moreau de Maupertuis, *Vénus physique* (Paris, 1745), pp. 84–87, 102–105 (for more on vitalism see Cimino and Duchesneau, eds., *Vitalisms from Haller to the Cell Theory* [cit. n. 3]); Denis Diderot, "Polype," in *Encyclopédie; ou, Dictionnaire raisonné des Sciences des Lettres et des Arts*, ed. Diderot and Jean le Rond d'Alembert, 36 vols., Vol. 26 (Geneva: Pellet, 1778), pp. 605–610; and Abraham Trembley, *Mémoires, pour servir à l'histoire d'un genre de polypes d'eau douce, à bras en forme de cornes* (Leiden: Verbeek, 1744). Trembley's argument is on pp. 301–312, and the quotations are on p. 303: "On peut juger par-là combien sont peu sûres ces règles prétendues générales"; and p. 311: "ces découvertes . . . doivent naturellement nous jeter dans une grande défiance à l'égard de ces règles générales." Bonnet discussed exactly the same argument; see Bonnet, *Traité d'insectologie* (cit. n. 14), p. xxxviii: "nous tenir en garde contre les règles générales"; and p. 90: "rien de plus dangereux en physique que ces conclusions trop générales." Cf. La Mettrie, *L'homme machine* (cit. n. 1), p. 100: "cette découverte nous apprend bien à ne jamais rien conclure de général." See also S. G. Lenhoff and H. M. Lenhoff, *Hydra* (cit. n. 2), p. 37: "The *Mémoires* say nothing regarding preformation."

²² Réaumur, *Mémoires pour servir à l'histoire des insectes* (cit. n. 10), Vol. 6, p. lxxvii. Roger, *Sciences de la vie* (cit. n. 3), pp. 396, 639, has cited this passage to show that Réaumur used the soul in order to set up preformationism. But Roger neglected to note the semantic context, for Réaumur drew a clear border between the metaphysical discussion he rejected and scientific investigation. For a similar interpretation see Dawson, *Nature's Enigma*, p. 149.

Clearly, in the view of Réaumur and those who supported his way of thinking, scholars should exclude questions of metaphysics—and particularly ideas about the soul—from their experimental research on regeneration. Drawing a clear line between what the academy considered suitable scientific discussion and the types of discourse that abounded in the clandestine and materialist literature was vital to avoid confusing the spheres. Réaumur was well aware of the risks the French academic community faced if it defied this conventional rule.²³ In Geneva Bonnet was the head of a circle called “the four B’s” whose members discussed metaphysics and exploited the polyp for the purposes of their debates. Yet Bonnet and Trembley obeyed Réaumur’s strictures as to what was appropriate in academic discourse, for they never lingered over these issues in their published writings after 1742 or in their correspondence with Réaumur and Folkes. The appropriation of the polyp for the purposes of clandestine and materialist writers compelled scholars who upheld the French academic standard barring metaphysical speculations to avoid such sensitive issues. Privately drilled by Réaumur, Bonnet anticipated his advice in a paper on aquatic worms written in March 1742 and published a year later in the *Philosophical Transactions*. The issue was raised; inquiring whether the worms had any “kind of soul,” he asked, “How can this principle afterwards appear in every distinct [cut] piece?” Yet he went no further; indeed, in a determined display of self-censorship he brought such considerations to an abrupt close: “This may be; and yet we know but little more of it.” In his didactic *Leçons de physique expérimentale* the abbé Jean-Antoine Nollet—a disciple of Réaumur—embraced precisely the same strategy: he raised the question but refrained from answering it.²⁴ Scientific discourse established and adhered to a strict segregation of scientific from nonscientific topics. Moreover, such examples illustrated how cases of this sort were to be handled: nothing more was to be said regarding metaphysical issues.

The stress on the heuristic field opened up by the “scientific polyp” and the banishment of any discussion regarding its metaphysical properties hardened academic norms and increased the distance between the specialized academic sphere and that in which the “metaphysical polyp” was debated. And while clandestine literature provoked public censure—clandestine books were burnt—self-censorship was at work in the academic milieu. During the 1740s and 1750s, such censorship effectively established the border between the “metaphysical polyp” and the “scientific polyp.” Scholars were to deal with these new boundaries in various ways. Maupertuis, for instance, moved “away from academic territory” in his 1744 discussion of the facts of heredity. He found asylum in the private space of the salon that hosted scholars and *philosophes* and supported such “alternative ways of thinking,” removed from the academy.²⁵

What was at stake was the emergence of a new game, with new rules for the production of both scientific objects and scholarly reputations. Elements necessary for the production of celebrity that emerged under the sway of the polyp included knowing how to use the public sphere, managing the circulation of objects, carrying out research on objects with a metaphysical side, making experiments more spectacular, and playing at the edges of the academic realm. Both academicians and *philosophes* tended to use the public sphere as an opportunity for the production of celebrity—with dramatically different outcomes.

²³ This style was adopted in France. In Prussia, in contrast, the Berlin academy had a section for metaphysics.

²⁴ Dawson, *Nature's Enigma*, pp. 155–156; Bonnet, “Of Insects Which Are Multiplied, as It Were, by Cutting or Slips” (cit. n. 14), p. 480; and Jean-Antoine Nollet, *Leçons de physique expérimentale*, 3rd ed., 6 vols., Vol. 1 (Paris, 1753), p. 151.

²⁵ Terrall, “Salon, Academy, and Boudoir” (cit. n. 20), p. 221.

La Mettrie had to flee Paris; Diderot went to jail in Vincennes. Others explored the blending of metaphysical and scientific styles, as did Buffon and John Turberville Needham in describing their microscopic observations. Though they played a dangerous game, delving deeper into scientific objects with a metaphysical side—organic molecules, transmutating eels—helped them to establish their reputations. Iconographic strategies for depicting the new natural scientific laboratory could also be used to enhance one's reputation; Buffon, following Trembley, took this path (see Figure 1). Yet the independent management of the “scientific polyp” and the “metaphysical polyp”—whether materialist or not—sealed the autonomy of naturalistic experimental practice, conducted in academic privacy. The new form of practice, as initiated by Trembley, evolved through the new strategy of communication and the newly asserted importance of the laboratory.

PARA-EXPERIMENTATION AND SHAPING THE NATURAL EXPERIMENTAL LABORATORY

Sending Living Systems

To succeed in sending his specimens—and for them to do the work he had in mind once they reached their destinations—Trembley focused on both the means of preservation of the animal–environment system during the journey and the instructions for those who were to receive the gifts of his parcels. Looking at the animal–environment system and not at the animal alone was, in itself, a kind of novelty, and such attention characterized para-experimentation. The French mathematician and microscopic research enthusiast Louis Joblot had succeeded in transporting animalcules around Paris and included a design of a suitable phial in his 1718 book *Descriptions et usages de plusieurs nouveaux microscopes* (see Figure 2). However, although his method enabled people to transport microscopic animalcules in plant infusions during the 1710s, there are no reports that it was used after the 1720s. At around the same time, Marsigli was also thinking in terms of an

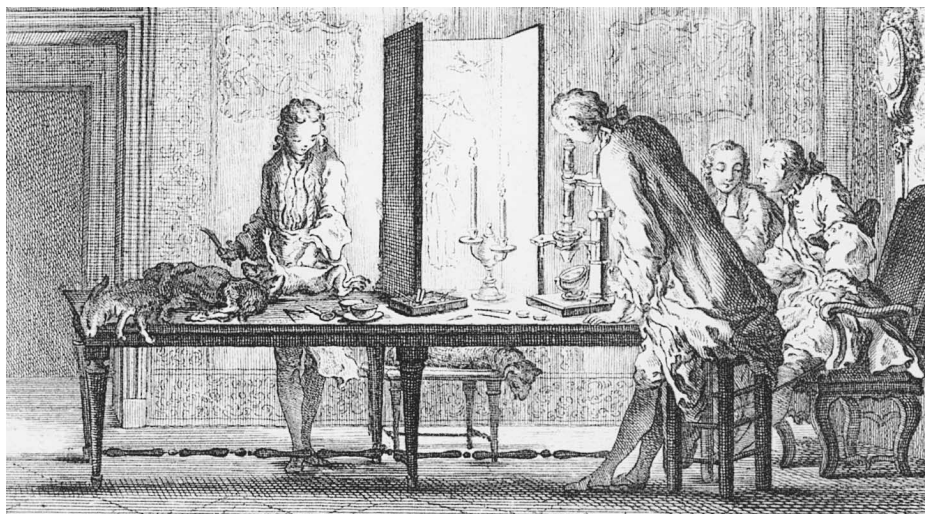


Figure 1. Following the example of Trembley, Buffon also used iconography as a backup to the descriptions of his laboratory. (From Georges Leclerc de Buffon, *Histoire naturelle générale et particulière*, 15 vols., Vol. 2 [Paris: Imprimerie Royale, 1749].)

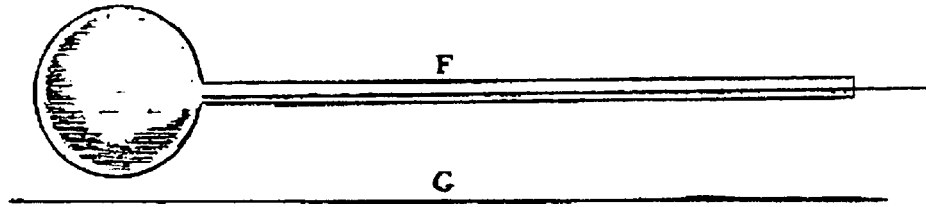


Figure 2. This phial, F, was used to transport animalcules around Paris in the 1710s. It was filled by fitting a little brass thread, G, inside to draw the liquid. Warming the phial with the hand made the liquid run out. (From Louis Joblot, *Descriptions et usages de plusieurs nouveaux microscopes, tant simples que composez* [Paris: Collombat, 1718], Plate 7, pp. 17–18.)

animal–environment system when he placed his coral in a jar filled with seawater. This procedure certainly required attention to the means of conserving such “plants”; but he did not show any interest in sending jars of coral to others. Trembley’s ability to distribute living aquatic systems to the major intellectual centers of Europe was among the conditions vital for his success. In every shipment of polyps there was not just one thing traveling, but always three: the polyps, their environment—which both preserved them and provided the specific food they needed—and instructions for both the conservation of the system and the reproduction of the experiments. These elements were important enough to merit mention in the letter Folkes sent to Trembley on 30 November 1743 to award him the Copley Medal: “We are no less sensible of your great candour, 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 our selves, and see with our own Eyes the Truth of the astonishing Facts, you had before made us acquainted with.”²⁶

Trembley’s “para-experimental simulation” also illustrates that he was every bit as careful and clever in devising a system to transport living polyps as he was in inventing his extraordinary experiments. Very seldom was such attention paid all at once to experiments, para-experiments, and the strategy of communication. Trembley’s scheme for open communication arose from his awareness of all these factors, as he noted in the preface to his 1744 *Mémoires*:

I made it my duty to communicate my discoveries, in proportion as I carried them out. I gave polyps, as much as I could, to those who desired to repeat my experiments; and I explained to them how I managed to perform the experiments. It came hence that the polyps were generally known in a short time, and that, in several places, people were put in a condition to verify a part of my experiments. This is what Mr. Baker in England did last summer as regards a few of them.²⁷

²⁶ Folkes to Trembley, 30 Nov. 1743, MSS Trembley, pp. 91–92. Louis Joblot was one of the seventeenth-century enthusiasts for microscopical research. A professor of geometry at the Paris Académie des Arts, he carried out microscopical studies from 1678 to 1716 and published his results in *Descriptions et usages de plusieurs nouveaux microscopes, tant simples que composez* (Paris: Collombat, 1718). He invented the experimental protocol used to test the spontaneous generation of microorganisms. See Marian Fournier, “The Fabric of Life: The Rise and Decline of Seventeenth-Century Microscopy” (Ph.D. diss., Univ. Twente, 1991), pp. 182–183; and Ruestow, *Microscope in the Dutch Republic* (cit. n. 19), p. 279.

²⁷ Trembley, *Mémoires* (cit. n. 21), pp. v–vi. Henry Baker, F.R.S., who attended the demonstrations at the Royal Society, reproduced all of Trembley’s experiments and hurried to publish his *An Attempts towards a Natural History of the Polype* (1743) before Trembley’s reports appeared. Even though a French translation was

Within a few years, parcels based on lessons learned from the journey of the polyp were circulating throughout Europe. Trembley's system was extended to other microscopic animalcules. A practice reserved for Réaumur and his circle of disciples up until 1742, the shipping of animal–environment systems became standard from 1743 onward. On 2 March 1743 Folkes received polyps from a fellow who lived in the countryside, and on 8 June he received worms that had been cut and were starting to regenerate. In Edinburgh, Colin Mac Laurin received polyps from Folkes. Henry Baker, likewise, solicited microscopic creatures from his countrymen, and from March 1743 onward he received many live animalcules in bottles from his numerous British correspondents. In addition to Count Bentinck—one of Trembley's mentors—Gronovius, and Lieberkuhn in Berlin, many other scholars whose names have not been preserved received polyps from Trembley, who wrote to Folkes in July 1743: "I am entirely taken up with dispatching polyps to one place or another."²⁸

Although these are only a few hints that manifest the existence of the practice, the parcels in fact served as a relay system that, in its continuous expansion, disseminated a standard method for the exchange of small animal–environment systems. Later this procedure—which is para-experimental rather than experimental—was extended to non-aquatic creatures. It enabled more scholars to expand their awareness and studies of many lesser-known species and specimens.²⁹

The ability to send living systems anywhere as a regular para-experimental routine produced major changes in the circulation of scientific objects and strongly affected the practices of scientific demonstration in the natural sciences. Indeed, between 1741 and 1743 the emblematic parade of witnesses summoned to establish a scientific fact—a feature of scientific practice since the seventeenth century—was overwhelmed by networks that could distribute similar evidence anywhere, delocalizing scientific discovery. The increased speed at which information could be shared and the consequent closeness brought about by the parcels containing polyps meant that witnesses were now everywhere.³⁰ Once

issued in 1744, the text was badly received on the Continent and Baker was regarded as a plagiarist. On Baker see Gerard l'E. Turner, "Henry Baker, Founder of the Bakerian Lecture," in *Scientific Instruments and Experimental Philosophy, 1550–1850* (Brookfield, Vt.: Variorum, 1990), pp. 53–79. Brian J. Ford has turned Baker into a hero and almost the discoverer of the polyp; see Ford, *Single Lens* (cit. n. 3), pp. 107–109. For a closer interpretation of Baker's plagiarism based on the sources see S. G. Lenhoff and H. M. Lenhoff, *Hydra* (cit. n. 2), p. 25; J. R. Baker, *Abraham Trembley* (cit. n. 1), pp. 41–42; and *Correspondance*, ed. M. Trembley and Guyénot, pp. 190–191n.

²⁸ Bonnet sent Réaumur many insects and worms, dead and alive, perhaps most notably his regenerating worms in Feb. 1742; see Réaumur to Charles Bonnet, 28 Feb. 1742, BPU: MS Bo 42, fol. 35. On samples sent to Baker see Henry Baker, *Employment for the Microscope* (London: Dodsley, 1753). Gronovius received polyps from Trembley during the summer of 1742, and Lieberkuhn received them in May or June 1743; MSS Trembley, pp. 20, 21. On his being "entirely taken up" with sending polyps to others see Trembley to Martin Folkes, 16 July 1743, MSS Folkes, Vol. 4, letter 66.

²⁹ Both John Ellis and Carl von Linnæus were able to study insects from Mexico that were sent as small animal–environment systems. See John Ellis, "An Account of the Male and Female Cochineal Insects," *Phil. Trans. Roy. Soc. Lond.*, 1762, 52(2):661–667, on p. 662; and Carl von Linnæus, "Von der Schwedische Cochénille," *Abhandlungen der Königlischen Schwedischen Akademie der Wissenschaften*, 1762, 21(1):28–31, on p. 29 (the original paper was published in 1759 in Swedish).

³⁰ On witnessing science see Steven Shapin and Simon Schaffer, *Leviathan and the Air-Pump: Hobbes, Boyle, and the Experimental Life* (Princeton, N.J.: Princeton Univ. Press, 1985), pp. 55–60. Before 1745, the network of those who reproduced regeneration experiments on polyps or other animals was restricted to three major sites: Holland (Trembley, Bentinck, Lyonet, Allamand, Gronovius, Musschenbroek, Gaub, Albinus, Sacrelaire), Paris (Réaumur, Jussieu, Guettard, Brisson, Nollet), and London (Folkes, Baker, Needham, Parsons, Lord, Richmond, Milward, Miles, Beauclerk St. Albans). Manuscript sources show evidence for major and minor branches of the network in Geneva (Bonnet, Jallabert, Calandrini), Marseille (Caumont), La Brède (Montesquieu's son), Nantes (Lignac), Strasbourg (Bazin), Cambridge (Newcome), Edinburgh (Mac Laurin), Norfolk (Arderon), Rome (Mazzoleni), Siena (Ginanni), Pisa (Cerati), and Berlin (Lieberkuhn at the Berlin academy).

the regeneration of the polyp was recognized on the Continent, a network of demonstrations from England to Scotland took only about six months to establish the value of the discovery and acknowledge its author. Up until the 1740s, slow-to-connect local groups of witnesses had vouched for isolated naturalistic facts; acknowledging the regeneration of the polyp, in contrast, was the synchronized reply of a whole European network of witnesses. The celebrity Trembley gained so quickly was a return for the positive impact his work had on natural science. A new, quicker way to tackle natural objects was born; living systems were now accessible to anyone, promoting the experimental naturalists to the rank of those who experimented on the color spectrum.

Thanks to the strategy of generosity, the circulation of scientific goods developed into a primary standard for an emergent discipline based on naturalist practices. Though important work had been performed in the second half of the seventeenth century by Francesco Redi and his school—even disproving spontaneous generation—it was not sufficient to draw a clear demarcation between natural-experimental investigations and physics. Nonetheless, a scientific tradition that capitalized on Redi's works began to grow up in Europe, and among its heirs was Réaumur.³¹ One consequence of Trembley's polyp was the establishment of a significant boundary that strengthened the specificity of naturalistic research based on the conservation and travel of living systems—a set of para-experimental practices that remain basic to the life sciences even today. In order to reproduce phenomena, experimental physics relies not on the circulation of *naturalia* but on the proliferation of instruments. Trembley, in contrast, demonstrated that circulating living systems was material to the field of experimental natural history. Just as the “metaphysical polyp” helped to establish the cultural boundary between academic and public life, the “communicative polyp” strengthened the emerging demarcation between experimental physics and the new type of natural history, shaped as a laboratory science. Far from being dependent on the mechanical model, the symbol of which was Newton's *Optics*, the new experimental naturalists found themselves well positioned to challenge mechanism through the exchange of living objects with astonishing characteristics that were not found in the realm of physics. Jacques Roger has contended that the history of the life sciences between 1670 and 1745 was a battle of empirical observation against *a priori* mechanism. But this does not explain why there was such a sudden and widespread explosion in the practice of experimental natural history in Europe during the 1740s. Stimulated by Réaumur, whose role was absolutely crucial, Trembley invented an efficient way to circulate microscopic living systems; he thus brought about an epistemological rupture with regard to the collective system of proof, the speed required for *naturalia* to move from one practitioner to the next, and the demarcation of the field of experimental natural history from that of experimental physics.³² These were the conditions that enabled the laboratory to establish itself as a locus central to naturalistic investigation.

A New Physiognomy of the Laboratory

The perfection of methods for transporting animalcules involved considerable preparation that took place within the laboratory. Refining the techniques for sending polyps and

³¹ Paula Findlen, “Controlling the Experiment: Rhetoric, Court Patronage, and the Experimental Method of Francesco Redi,” *Hist. Sci.*, 1993, 31:35–64, on p. 51; see Ruestow, *Microscope in the Dutch Republic* (cit. n. 19), pp. 203, 279, on Redi's impact on Dutch and British scholars.

³² Roger, *Sciences de la vie* (cit. n. 3), pp. 451–453. On Réaumur's general importance to Trembley and the polyp see Dawson, *Nature's Enigma*, pp. 179–183; Jean Torlais, *Réaumur d'après des documents inédits, un esprit encyclopédique en dehors de “L'Encyclopédie”* (Paris: Blanchard, 1961); and J. R. Baker, *Abraham Trembley* (cit. n. 1), pp. 186–187.

specifying the instructions for their maintenance and experimental investigation required a long time and many para-experiments on feeding and conservation. Trembley's research formed a starting point for para-experimental thought on the conditions required for the preservation and replenishment of small organisms: both Trembley himself and the recipients of his parcels needed enough polyps to perform multiple series of experiments. The attention paid to the problems of conservation of living beings was a constitutive element in the emergence of the experimental naturalistic laboratory during the 1740s. Trembley stated that at any given time he maintained in his laboratory more than 140 labeled jars containing polyps. They needed to be cared for with weekly—sometimes even daily—regularity, and because they were not the object of regular records they have not been noticed by historians of the laboratory, who have mainly been concerned with inscriptions and experimental method. Trembley's lab, and his multiple experiments and para-experiments, was not unique. Bonnet carried out series of experiments on many species of the louse and observed parthenogenesis up to the ninth generation. In September 1743 Count Francesco Ginanni in Siena, who had become familiar with the polyps through Réaumur's 1742 *Mémoires*, tried the regeneration experiments on water worms that were briefly outlined in Réaumur's preface. He cut sixty worms in three parts and put them in as many labeled jars; he then opened one each day to measure the progress of regeneration.³³ It seems, then, that the vignette placed at the top of Trembley's fourth *Mémoire*, containing his most exciting experiments, is a much-cleaned-up depiction of the reality that was his laboratory. The engraving shows him experimenting in the corner of an almost empty room, positioned in front of the window with his two pupils in attendance (see Figure 3). One can count about twenty jars, set on the table and on the window sills; the remaining 120 are nowhere in evidence.

From the 1740s onward, the natural experimental laboratory—with several microscopes at its center, surrounded by a profusion of tools such as glass jars, bottles, labels, scalpels, scissors, needles, watch-glasses, brushes, and candles, with hundreds of minute organism–environment systems, with books and the journal of experiments, sometimes with instruments like a camera obscura, thermometers, an air-pump, and a blowtorch—began to acquire its distinctive modern physiognomy, of riotous life enclosed in a designated space. The many jars containing infusions, plants, insects, worms, batrachians, eggs, and the like exhibited the swarming of nature—but under the control of scientific instruments and subjected to the naturalist's gaze. In particular, Trembley's focus on an abundance of organisms and the variety of these living objects stand in contrast to the traditional features of the physicist's cabinet—especially costly instruments—which were notably absent. Meanwhile, the iconography was also part of the strategy of self-censorship noted earlier. Trembley's *Mémoires* illustrate a filtered, tidied-up laboratory for his readers; his visitors, on the other hand, were privy to the much more extensive “organization” that governed his work there. The laboratory was a private venue, yet one open to enthusiasts, in which instruments and the great number of organisms called for specific para-experimental gestures and practices, repeated on a daily basis, and drove the practitioner to carry out research intended to produce new scientific facts. Historians have studied how contingent social processes affected the production of scientific facts in the laboratory.³⁴ Yet they have

³³ Trembley to Folkes, 21 June 1743, MSS Trembley, p. 48. Ginanni, “Lettera intorno alla scoperta degli insetti che si moltiplicano mediante la sezione de' loro corpi” (cit. n. 19), identified regeneration after forty days; see p. 298.

³⁴ Timothy Lenoir, “Practice, Reason, Context: The Dialogue between Theory and Experiment,” *Science in Context*, 1988, 2(1):3–22, on p. 14; and Frederic L. Holmes, *Lavoisier and the Chemistry of Life: An Exploration of Scientific Creativity* (Madison: Univ. Wisconsin Press, 1985), p. xvi.

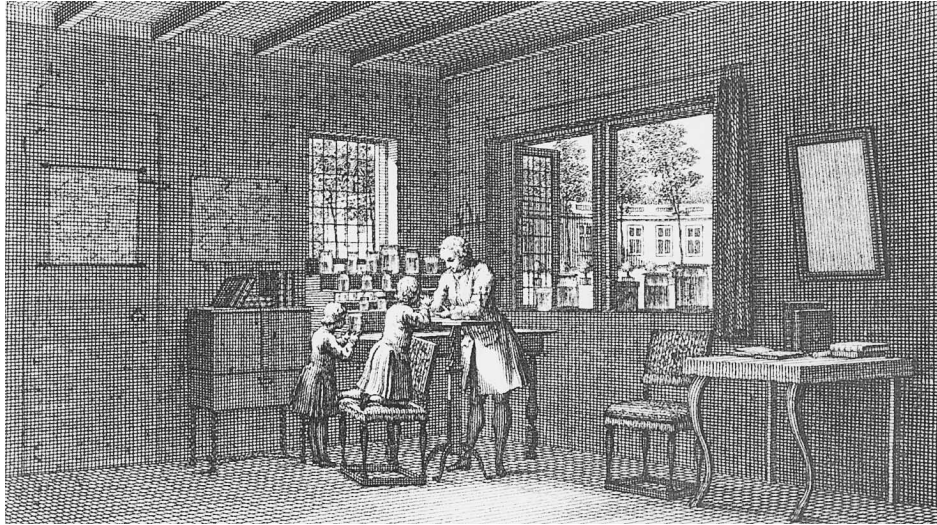


Figure 3. Historians have considered this image to be a reliable depiction of Abraham Trembley's laboratory. Yet his correspondence reveals that his laboratory was in fact filled with many more objects, including up to 140 jars containing his specimens. (From Abraham Trembley, *Mémoires, pour servir à l'histoire d'un genre de polypes d'eau douce, à bras en forme de cornes* [Leiden: Verbeek, 1744].)

not attended to how structuring this contingency required time, particularly for repeating and varying the many series of experiments that shaped the new form of experimental practice. The necessities of this new sort of scientific practice strengthened the relationship between the scholar and the laboratory: performing series of experiments and para-experiments required him to spend more and more time there.

The new form of practice also raised a new challenge. How should an author report on work that encompassed a series of experiments rather than one or a few trials? Abandoning the prolixity of the classic experimental report, Trembley sought to distinguish among the many details his work presented, separating the regular and important phenomena from those that were purely circumstantial. Condensing data through an economy of words became the new tacit rule for reporting on series of experiments, a literary technology Trembley and Bonnet devised to manage their proliferating data. They also used other methods, such as tables that, for example, could concentrate information either on several generations of one louse (see Figure 4) or on the polyp's growth (see Figure 5). Reporting series of experiments demanded an economical approach to writing science and changed the balance between two components of scientific texts, argument and narration.³⁵ The new literary technology was based on the statistical intuition that the repetition of experiments shaped a result that was not merely the sum but the synthesis of all trials. In contrast to

³⁵ On narration and arguments in scientific papers see Frederic L. Holmes, "Argument and Narrative in Scientific Writing," in *The Literary Structure of Scientific Argument*, ed. Peter Dear (Philadelphia: Univ. Pennsylvania Press, 1991), pp. 164–181. On changes in the experimental report in the *Philosophical Transactions* during the eighteenth century see Charles Bazerman, *Shaping Written Knowledge: The Genre and Activity of the Experimental Article in Science* (Madison: Univ. Wisconsin Press, 1988), Ch. 3; for a comparison of the changes in French and English physics see Christian Licoppe, *La formation de la pratique scientifique: Le discours de l'expérience en France et en Angleterre (1630–1820)* (Paris: La Découverte, 1996).

TABLE des jours & heures auxquels sont nés, depuis le 18. Juillet jusqu'au 7. Août inclusivement, les Pucerons qu'a enfantés la Puceronne de la première Génération, renfermée le 9. Juillet à une heure après-midi.

Jours de Juillct.	Nombre des Pucer. nés dans chaque j.	Nombre des Pucerons nés chaque matin, & les heures de leur naissance.	Nombre des Pucerons nés chaque après-midi, & les heures de leur naissance.
18.	4. Puc.	A 11. h. 2. P. ††	A 5. h. 1. P. * 6. $\frac{1}{2}$ 1. P.
19.	3. Puc.	A 5. h. 2. P. *	A 3. h. $\frac{1}{2}$. . . 1. P.
20.	3. Puc.	A 6. h. $\frac{1}{4}$. . . 1. P. 10. $\frac{1}{4}$. . . 1. P.	A 3. h. $\frac{1}{4}$. . . 1. P.
21.	5. Puc.	A 4. h. 1. P. † 6. $\frac{3}{4}$ 1. P. * 11. 1. P. *	A 5. h. $\frac{1}{2}$. . . 1. P. 6. $\frac{1}{2}$ 1. P.
22.	1. Puc. 0. P.	A 3. h. $\frac{1}{4}$. . . 1. P.
23.	4. Puc.	A 4. h. 1. P. * 6. $\frac{1}{2}$ 1. P. (1) 8. $\frac{1}{2}$ 1. P.	A 5. h. $\frac{1}{2}$. . . 1. P.
24.	2. Puc.	A 8. h. $\frac{1}{2}$. . . 1. P.	A 4. h. $\frac{3}{4}$. . . 1. P.
25.	3. Puc.	A 4. h. 1. P. 5. $\frac{1}{2}$ 1. P.	A 4. h. 1. P.
26.	5. Puc.	Dep. 7. h. jusqu'à 9. absent. A 9. h. 2. P. * 1. P.	A midi $\frac{1}{2}$. . . 1. P. 9. 1. P.
27.	5. Puc.	A 6. h. $\frac{1}{2}$. . . 1. P. 9. 1. P. 10. $\frac{1}{4}$. . . 1. P.	A 5. h. $\frac{1}{2}$. . . 1. P. 9. 1. P.

(1) Celui-ci est venu au jour la tête la première & le ventre tourné vers le bas.

Figure 4. In his study of parthenogenesis in the louse, Bonnet used tables to condense the information on all parthenogenetic births coming from a single louse. (From Charles Bonnet, *Traité d'insectologie ou observations sur les pucerons* [Amsterdam: Luzac, 1745].)

Jeunes Polypes.	Jour, auquel ils ont commencé à pouffer.	Jour de leur féparation d'avec leur mere.
Le 1 ^{er} . jeune a commencé à pouffer le	Juillet.	Juillet.
2 jeune.	9	Il s'est féparé le 13
3	11	15
4	12	17
5	13	17
6	13	22
7	16	22
8	17	23
9	18	24
10	22	25
11	22	26
12	23	26
	25	27

Figure 5. In this table, Trembley recorded the number of young polyps (left column) that budded on particular days during the month of July (center column) and the day on which each young bud separated from the mother (right column). (From Abraham Trembley, *Mémoires, pour servir à l'histoire d'un genre de polypes d'eau douce, à bras en forme de cornes* [Leiden: Verbeek, 1744].)

the detailed accounts in the standard experimental report, the naturalistic texts of the early 1740s initiated a much less wordy method of reporting experiments and observations that would become widespread by the second half of the century. For instance, after quoting series of experiments by Horace-Bénédict de Saussure, Otto-Friedrich Müller, and Johann August Ephraim Goeze, Wilhelm Friedrich von Gleichen in Nuremberg promised to avoid a “boring prolixity” when reporting on his fifteen years of work. Even Bonnet recalled, in a 1776 letter to Henri-Louis Duhamel du Monceau, that earlier in his career he had been influenced by Réaumur’s verbosity. The works of the latter, he said, “were contagious. They influenced my first works. I devoted myself completely to details.”³⁶

³⁶ On verbosity and the circumstantial details included in Boyle’s experimental reports see Shapin and Schaffer, *Leviathan and the Air-Pump* (cit. n. 30), pp. 63–65. The experiments discussed by Saussure, Müller, and Goeze were on the division of infusoria. See Henry Harris, *The Birth of the Cell* (New Haven, Conn./London: Yale Univ. Press, 1999), pp. 56–59; and Marc J. Ratcliff, “Temporality, Sequential Iconography, and Linearity in Figures: The Impact of the Discovery of Division in Infusoria,” *Hist. Phil. Life Sci.*, 1999, 21(2):255–292, on pp. 271–273. For von Gleichen’s remark see Wilhelm Friedrich von Gleichen, *Abhandlung über die Saamen- und Infusionsthierchen, und über die Erzeugung, nebst mikroskopischen Beobachtungen des Saamens der Thiere, und verschiedener Infusionen* (Nürnberg, 1778), p. 67; for Bonnet’s recollection see Bonnet to Duhamel de Monceau, 22 Jan. 1776, BPU: MS Bo 74, fol. 239vo.

Gleichen's and Bonnet's complaints about verbosity reflected an interest not only in an increased economy of words in reporting experiments but in a more synthesized approach to the narrative as well. Trembley's writing, especially, turned the cluster of details gleaned from his long-term research into an organized narrative pointing toward a particular kind of outcome: a scientific law. As the amount of data related to a phenomenon increased, the mass of words describing it diminished, launching a new approach to the relationship between scientific writing and the management of experimental phenomena. The practice of conducting experiments in series set a standard that stood comparison with the experimental procedures detailed by Newton in the *Optics*. From 1750 onward, dozens of scholars, experimental naturalists, and users of the microscope followed and improved the standard, among them Duhamel, Ginanni, Haller, della Torre, Parsons, Ellis, Hill, Hunter, Targioni-Tozzetti, Schaeffer, Hewson, Müller, Wolff, Spallanzani, Adanson, Wrisberg, Saussure, Fontana, Gleichen, Corti, and Cavolini. Both shaping and, gradually, shaped by the new style of writing, embodied in the many practices exemplified by Trembley, and stamped with the exclusive seal of para-experimentation, the laboratory of the natural experimentalist came into focus as a unique environment, very different from the museum, the cabinet of marvels, the chamber of physics, the workshop, the chemist's laboratory, the botanical garden, or the zoo.

THE EUROPEAN SPREAD OF THE POLYP AND TREMBLEY'S CELEBRITY

The strategy of generosity, by placing the enhanced laboratory at the heart of the naturalist experimental network, achieved particular effects on scientific communication and practice. By reducing geographical distance, it promoted a wider spread of scientific communication and diminished the need for costly trips to verify something with one's own eyes. It helped to share the microscope, to standardize the vision, allowing many people to see essentially the same things. There is virtually no important essay or book dealing with natural science and microscopes in the second half of the century that did not refer to Trembley as a standard for the field. From 1741 onward, there is evidence that the polyp was a European topic that superseded every other scientific and political issue—even as Europe was getting involved in the War of the Austrian Succession. As early as August 1741, Réaumur wrote to Trembley that “never did an insect cause so much uproar as do the polyps and like insects.”³⁷

In 1742 several Italian correspondents of Réaumur, including Father Alessandro Mazzoleni in Rome and Count Francesco Ginanni (1716–1766) in Sienna, repeated experiments demonstrating the regeneration of worms that were inspired by the polyp. Scholarly England was enthralled throughout 1743; as the editor of *Bibliothèque Britannique* wrote that autumn: “The marvelous properties of the new Polyp . . . have become the object of such a curiosity and research of some of the members of the Royal Society, that Mr. Cromwell Mortimer, Secretary of this illustrious assembly, has but given in the n° 467 of the Transactions pieces which only relate to it.”³⁸

Swedish scientists became familiar with the polyp a few years later. At the Swedish academy the anonymous “A. B.”—Abraham Baeck—began a 1746 paper with these

³⁷ Réaumur to Trembley, 30 Aug. 1741, in *Correspondance*, ed. M. Trembley and Guyénot, p. 106.

³⁸ Réaumur, *Mémoires pour servir à l'histoire des insectes* (cit. n. 10), p. lj (on Mazzolini); Ginanni, “Lettera intorno alla scoperta degli insetti che si moltiplicano mediante la sezione de' loro corpi” (cit. n. 19), p. 255; and Anonymous, [report of *Phil. Trans.*, 42(467)], *Bibliothèque Britannique*, 1743, 22(1):159.

words: “Apart from electricity, naturalists did not deal with anything this year other than the polyp.” In 1746 Carl Linnaeus coined the term *Hydra* to designate the genus of the polyps. Between 1747 and 1754, three more articles on the topic were published in the journal of the Swedish academy, *Kongliga Svenska Vetenskaps Akademiens Handlingar*. In 1747 the major Swedish entomologist Carl de Geer wrote a paper on the water insect *Monoculus* in which he discussed issues related to the polyp. In the 1750s pupils of Linnaeus such as Peter Löfling and Martin Kähler introduced the debate over coral in the academy, in the course of which Löfling discussed the polyp’s regenerative capacities and Kähler described a new species of polyp. In Berlin, as already noted, Lieberkuhn had demonstrated the phenomena associated with the polyp around 1743, but the main research on polyps in Germany was undertaken during the 1750s by Jacob Christian Schaeffer and August Johann Roesel von Roesenhoef. In the second half of the century, the polyp was recalled as a heuristic phenomenon that had had epistemological consequences for research and in the creation of new fields. Some scholars even added a political twist: “the discovery of the polyps and of reproduction by cutting is so important in Physics [*Physique*] that nations fought over the honor of having made it.” Up to the time of the French Revolution, people recalled the debut of Trembley’s polyp as an extraordinary event that had overturned many aspects of European scientific, cultural, and public life. Jean-Etienne Guettard, for instance, acknowledged its impact at many levels of elite culture, highlighting “this discovery that caused such a major revolution in the habits of many naturalists, and even of metaphysicians, moralists and physicists.”³⁹

The regeneration of the polyp was probably the first of the enduring microscopical discoveries to achieve rapid, unanimous acceptance across Europe. Para-experimental advances such as the improvement in shipping methods enabled scholars to exchange specimens with greater ease and respond to new developments more quickly. The consequences of Trembley’s strategy of generosity, outlined at the beginning of this section, help to distinguish it from what has come to be recognized as the “modesty of the experimenter.” According to Steven Shapin and Simon Schaffer, modesty is bound to the experimental narrative; it is a quality endorsed by the experimenter. As a matter of fact, the French and British academicians also noted Trembley’s modesty.⁴⁰ Yet modesty was not the only component of Trembley’s attitude in sending out his parcels. His openness in distributing polyps everywhere was strategic, because he wanted a new scientific field to grow from his work. But his generosity also had a price: the risk that other scholars would take

³⁹ A. B., “Kurze Nachricht von Wasserpolypen, auf Veranlassung derer, die um Stockholm gefunden worden,” *Abhandlung. Konigl. Schwed. Akad. Wiss.*, 1752, 8:203–220, on p. 203; and Jean-Etienne Guettard, *Mémoires sur différentes parties des sciences et des arts*, 5 vols., Vol. 2 (Paris: Prault, 1770), p. 515, Vol. 4 (Paris: Prault, 1783), p. 125. A pupil of Réaumur, Guettard shared the discovery of the polypary nature of the coral with Jussieu. The court botanist of the Palatine Elector, Nathaniel-Joseph Necker, wrote that “no animal inspired more research among physicists [*physiciens*—i.e., experimentalists] than the polyp”: Necker, *Physiologie des corps organisés* (Paris: Bouillon, 1775), p. 43. In Florence, Felice Fontana recalled that “we needed a Trembley and a Bonnet to disillusion us from general axioms, and from the idea of a necessary law common to the generation of every animal”: Fontana, *Traité sur le venin de la vipère, sur les poisons américains et sur le laurier-cerise* (Florence, 1781), p. 87. In Hannover, Johann Friedrich Blumenbach acknowledged the importance of Trembley for the creation of marine zoology: Blumenbach, “Von den Federbusch-Polypen in den Göttingischen Gewässern,” *Göttingische Magazin*, 1780, 1:117–127, on pp. 119–122. Moreover, Blumenbach used the polyp as the basic model for his concept of *Bildungstriebe*; see Timothy Lenoir, *The Strategy of Life: Teleology and Mechanics in Nineteenth-Century German Biology* (Dordrecht: Reidel, 1982), p. 20.

⁴⁰ Shapin and Schaffer, *Leviathan and the Air-Pump* (cit. n. 30), pp. 65–69. On Trembley’s modesty see Réaumur to Trembley, 25 Mar. 1741, in *Correspondance*, ed. M. Trembley and Guyénot, p. 64: “la sage retenue qui paraît dans toutes [vos observations], plut beaucoup [aux académiciens].”

unwarranted credit for his experiments—as Henry Baker indeed did. Thus Trembley's strategy of open communication led, ultimately, to the construction of new objects for natural investigation, such as the cryptogams in vegetable anatomy and physiology and elements of marine zoology.⁴¹ Thanks to the public and private demonstrations of regeneration, experiments on the polyps were reproduced and seen by hundreds of people. In contrast to many other discoveries, which were kept secret until their public announcement in some suitable scholarly setting, everyone knew about the polyp and its discoverer was famous long before his major work was issued. Trembley delayed publishing his definitive book because he aspired to bring it to perfection, and he continued to invent new experiments and produce new facts in pursuit of that goal. Réaumur, Folkes, and others badgered him to publish a full account of his work. In a letter dated 14 December 1742 Réaumur complained about Trembley's seemingly endless series of experiments and discoveries: "I'm beginning to wish you would stop making discoveries on polyps, until you have published all those you have already made."⁴²

CONCLUSION

Trembley's attitudes and behavior resulted in a new model both for scientific work and for the production of celebrity. Paula Findlen and Mario Biagioli have shown that gift giving and patronage were constitutive elements of early modern science. While Trembley freely gave his polyps to others, his management of the parcels departed from the established culture of gift giving and patronage. Traditional gift giving demanded an exchange of benefits, as the recipient enjoyed enhanced prestige and the giver was rewarded with patronage. Trembley's strategy of generosity allowed him both to share his knowledge freely and to control the fate of the "gifts" he sent. Trembley's polyps were actually heuristic gifts, elements of both an experimental and a para-experimental style and setting. Trembley wanted the networks of natural historians to assimilate his astonishing discoveries even if his offerings were appropriated and his findings plagiarized—a risk the traditional gift giver never encountered. He was an unknown outsider who did not seek honors or a position, and although he was in touch with the highest scholarly authorities of his time, he in fact declined Réaumur's proposal for his election as a correspondent to the Académie Royale des Sciences in July 1741.⁴³ If patronage and private donations still served to establish reputations, Trembley's strategy of generosity helped to create a new sort of heuristic gift. Thus I dare say that, in the polyp story, issues of patronage were subordinated to the strategy of generosity, which steered the organization of the discovery.

⁴¹ See the naturalistic works published in the *Philosophical Transactions* and in London between 1743 and 1746 by Richard Badcock, Henry Baker, Henry Miles, John Turberville Needham, James Parsons, Roger Pickering, and William Watson. For marine zoology see Bernard de Jussieu, "Examen de quelques productions marines qui ont été mises au nombre des plantes, et qui sont l'ouvrage d'une sorte d'insecte de mer," *Mém. Acad. Roy. Sci. Paris*, 1742, pp. 290–302.

⁴² Réaumur to Trembley, 14 Dec. 1742, in *Correspondance*, ed. M. Trembley and Guyénot, p. 151. Dawson, *Nature's Enigma*, p. 120, relates Trembley's delay to "his determination to understand the polyp's structure."

⁴³ Trembley to Réaumur, 20 July 1741, in *Correspondance*, ed. M. Trembley and Guyénot, pp. 90–91. On patronage in Europe from the Renaissance to the *ancien régime* see Bruce T. Moran, ed., *Patronage and Institutions: Science, Technology, and Medicine at the European Court, 1500–1750* (Rochester, N.Y./Woodbridge, Suffolk: Boydell, 1991). On gift giving and patronage see Paula Findlen, "The Economy of Scientific Exchange in Early Modern Italy," *ibid.*, pp. 5–24; on Galileo see Mario Biagioli, *Galileo, Courtier: The Practice of Science in the Culture of Absolutism* (Chicago: Univ. Chicago Press, 1994). For a critical look at the interpretation of patronage that sees it as a prestige-enhancing strategy see Roland Mousnier and Jean Mesnard, eds., *L'âge d'or du mécénat* (Paris: Éditions CNRS, 1985). Rivalries between state and private patronage for a provincial academy are analyzed in David Lux, *Patronage and Royal Science in Seventeenth-Century France* (Ithaca, N.Y./London: Cornell Univ. Press, 1989).

Trembley's unquestionably astounding experimental skills were but one element in a new constellation of methods and practices that called for para-experimental creativity and depended on free distribution. The circulating polyps helped to establish new criteria of speed and accuracy for scientific communication, enticing a European public to act as witnesses for a new sort of experimental practice that took place in the reshaped laboratory. From the 1740s onward, Newtonian mechanicism ceased to be the dominant mode of natural experimental investigation. The experimental naturalists now followed new standards, embodied in series of experiments that incorporated para-experimental features and were synthesized in more compressed written reports. In quest of natural laws, Trembley had shown how to say fewer things about more phenomena and supplied his fellow practitioners with both examples and criteria that enhanced their explanations of nature. In a 1745 letter to Joseph de Seytres, marquis of Caumont, Réaumur wrote that he had "only glanced at a nature, which Mr. Trembley has probed in depth." Alarmed by the materialist approach to the polyp and the public censure it triggered, Réaumur also updated the rules for censorship in the academic realm; in turn, the self-censorship of French academicians whose investigations had metaphysical implications was strengthened and echoed in the public sphere. Experimental practitioners later applied such self-censorship to their own laboratory work.⁴⁴ In sum, academic natural history secured a new methodology, demarcated an experimental discipline with a new scientific object, and reinforced the relationship between the scholar and the laboratory, meanwhile shaping new patterns for scholarly careers that could also bring public celebrity. New rules for the production of science and celebrity framed a space for the negotiation of both scientific work and reputation, through which, from the 1740s to the time of the French Revolution, many scientific careers were to take shape.

⁴⁴ Réaumur to Caumont, Paris, 5 Jan. 1745, BPU: Fonds Trembley, Box 5, fol. 119v: "je n'ai qu'effleuré une nature que Mr Trembley a approfondie." On two kinds of self-censorship in Haller and Spallanzani see Maria Teresa Monti, "Forme della scrittura e forma della comunicazione: Dai *Mémoires* di Haller al *Prodromo* di Spallanzani," in *Forme della comunicazione scientifica*, ed. P. Galuzzi, G. Micheli, and M. T. Monti (Milano: Franco Angeli, 1998), pp. 277–311. On self-censorship in the nineteenth century see Gerald L. Geison, *The Private Science of Louis Pasteur* (Princeton, N.J.: Princeton Univ. Press, 1995).