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THE RHETORIC OF PROOF AND PERSUASION UTILIZED BY ABRAHAM TREMBLEY

BY

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ABSTRACT

Criticism of the rhetorical organization of the fourth *Mémoire* of the *Mémoires, pour servir à l'histoire d'un genre de polypes d'eau douce, à bras en forme de cornes* of A. Trembley (1710-1784) reveals the logical structure of the book and the influence of infinitesimal calculus on early experimental biology.

INTRODUCTION

My interests are in the concepts and methods used by Abraham Trembley during his very short period of intensive scientific activity (from 1740 to 1744) (Eternod, 1909; Baker, 1952; Guyénot, 1957; Geisendorf, 1976; Lenhoff, 1980; Dawson, 1983, 1984; Baker, this volume), and how these concepts and methods were utilized in the organization of Trembley's texts themselves, and especially of the fourth volume of the *Mémoires, pour servir à l'histoire d'un genre de polypes d'eau douce, à bras en forme de cornes* (1744)[1]. This textual organization deals with the transmission of scientific knowledge and how it can convince others but also in some way with the conceptual elaboration of science itself. I will not give much attention to the concrete contents of Trembley's work; these are described in this volume and elsewhere (Guyénot, 1943; Trembley, 1943; Baker, 1952; Lenhoff and Lenhoff, 1984).

Some of Trembley's observations of the 1740-1744 period were of immediate interest (H. Lenhoff and S. Lenhoff, this volume) as belonging to the tradition of natural history. It was also very soon recognized, however, that his discoveries of animal regeneration and of animal grafting (Trembley, 1943; Rostand, 1958; Lenhoff and Lenhoff, 1984) were important not only because they described new properties of animals, but also, and this is fundamental, because they constituted the first systematic

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attempts at experimental biology. Trembley is considered one of the "fathers" of experimental biology who opened the road in the history of biology to the quasi demiurgic activity of modern developmental biology (Buscaglia, 1983). He was the first to create two individuals from one (regeneration) and one from two (grafting). In the second half of the eighteenth century, his discoveries were intensely discussed in scientific academies as well as in cultural "salons" in Paris and London[2]. The polyps, which presented both animal and plant characteristics, were considered strong evidences of "natural continuity", a theory which had a decisive influence on La Mettrie (1709-1751) and on the progress of French evolutionary materialism (Vartanian, 1950, 1953; Dawson, 1983, 1984). It is noteworthy for the historian that such a systematic and coherent work, as we will see, had also such a cultural impact.

TREMBLEY'S PROBLEMATIC

Although the development of science in Geneva from 1700 onward (Montandon, 1975) and the influence of Dutch scientific traditions on Trembley are undoubtedly very important, here I will offer only some observations on the ideas that were fundamental in the origin of Trembley's experimental work, and how they developed, observations that can help us in the understanding of the 1744 *Mémoires*. First of all, it must be noted that most of Trembley's intensive activity as an experimenter took place in a very short period of time (three and a half years) and all his activity as a naturalist in a maximum of nine years. His scientific activity was not at all continuous as was, for example, that of Réaumur (1683-1757) or von Haller (1708-1777). Even his interest in science was not a persistently long one[3] as was that of his friend Charles Bonnet (1720-1793). Trembley was mainly and during all his life an educator and he made the majority of his discoveries while he was a tutor to the two young sons of Count Bentinck in Sorgvliet (see Figure 1 in article by Dawson in this volume).

As a naturalist Trembley must be considered an "amateur éclairé" whose interest in "insects", as he said himself[4], developed after the reading of the famous *Mémoires pour servir à l'histoire des insectes* of Réaumur. His formal education was in mathematics. In 1730, under the direction of J.L. Calandrini (1705-1758), he wrote a thesis on the infinite and the infinitesimal calculus (Figure 1). His knowledge of natural history was limited. In fact when he "discovered" the green polyps (*Hydra viridis*) in Sorgvliet, he was completely unaware that similar organisms had already been described by Leeuwenhoek (1632-1723), an anonymous Englishman and even by B. de Jussieu (1699-1758)[5]. If he had known that polyps were animals, he would probably not have undertaken his famous experiments on regeneration. This lack of knowledge of the early literature explains why he hesitated to attribute an animal or plant nature to his polyps[6]. The original hypothesis of Trembley on hydra was an incorrect one. He postulated that one way to discriminate between their vegetable or animal nature, was

THESES MATHEMATICÆ
DE
INFINITO
ET
CALCULO INFINITESIMALI

Quas,

DEO FAVENTE,

Sub Præſidio

D. D. JOH. LUD. CALANDRINI,

Matheſeos Profeſſoris.

publicè tueri conabitur.

ABRAHAMUS TREMBLEY, GENEVENSIS,
Author & Reſpondens.

Die Veneris, 22 Menſis Septembris, horâ locoque ſolitis.

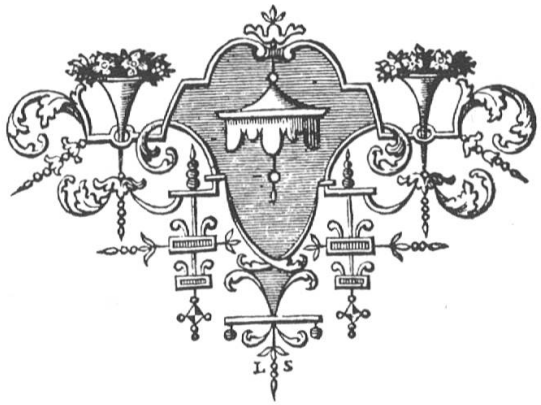

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FIG. 1. — Title page of Trembley's *Mathematical thesis* on the infinitesimal calculus (Geneva, 1730).

to test the polyps' regenerative properties. Budding was a classical attribute of plants. Polyps regenerated but, as Trembley observed them very accurately, he was still convinced that they were animals. His wrong hypothesis changed to a very heuristic one when he recognized that polyps were animals.

In the meantime, Trembley had put into action a strong experimental logic which had its proper necessity. The crucial experiment for plant and animal discrimination changed into the description of new properties of the animal kingdom. His poor knowledge of the literature I believe explains also why he limited himself to concrete and active observations but never elaborated a more general theory like his friend Charles Bonnet or like Buffon (1707-1788). The rather practical tradition of Dutch scientists he met in Leiden (Dawson 1984, this volume) and his reformation mentality probably increased this tendency to a concrete empirical non-theoretical description of nature (Montandon, 1975; Dawson, 1983).

As we shall see, his empirical and experimental scientific project was implicitly organized according to mathematical and geometrical criteria which gave it a systematic organization and a strong logical background.

CONVINCING OTHERS (RHETORICAL APPROACH)

History of science may develop three main lines of research. One deals with the concrete experiments, techniques and results (proof). The second deals with the historical situation (biography, influences, precursors, history of civilization). The third deals more with methods and concepts, with the relation between logic and experiments or observations, and with the structure of the scientific discourse (how the self validity of an experiment is established, how the scientist convinces and persuades others). In science, proof and persuasion are often linked and they may have something to do with the scientific philosophy of the author. As the first and the second approaches were already reported in this symposium, I will restrict myself to the third approach which can perhaps lead us to a better and new understanding of Trembley. Perhaps such an approach may also give us some light on the complexity of science itself.

I will analyse the records of Trembley's writing (books and letters) (Guyénot, 1943; Trembley, 1943; Baker, 1952; Speziali, 1958; Dawson, 1983, 1984) and will follow a semi-subjective method as is used in literary criticism to explain the texts and apply this method to the fourth book of the *Mémoires*.

As scientists we are not prepared to accept the idea that scientific texts are rhetorical ones, constructed according to a persuasive strategy, and not only devoted to the manifestation and communication of scientific truth, but also to convince others that: a) the experiment was done, b) the observation was correct, c) the result was not

misinterpreted. Our reluctance comes probably from the trivial opinion that scientific descriptions are direct conversions of reality, that they are the *Songs of Innocence* of truth.

One of the purposes of the present study is precisely to test if, through only reading one of Trembley's books as a persuasive structure, and without paying too much attention to its concrete contents, it is possible to obtain a new understanding of his rhetoric and logic. The concept of rhetoric is not used here in its strictest and specialized sense. I will not refer to such classical figures of rhetoric as the tropes of Fontanier (1977). But even in its wide interpretation, this concept can help us to find structures which are active in the *Mémoires,* to understand the persuasion strategy and even the experimental logic of Trembley and its mathematical principal origin.

I will consider the fourth *Mémoire* of 1744 more as a rhetorical entity than as a genuine scientific book. Consciously or unconsciously, the persuasive rhetoric may have many aims, the major of them being to convince the scientific community that the work was done (cognitive advantage) and that it was done by somebody (social advantage). This rhetorical approach may be of general interest (psychology of discovery, history of epistemology). I will restrict myself to two aspects: a) How Trembley organized the *Mémoire* in order to convince others clearly and logically that the concrete contents of the book are true, and b) How this organization is partly a consequence of the logical articulations of the experiments themselves.

Rhetorical analysis shows that the fourth book of the *Mémoires* is composed of elements which are organized in recurrent structures. Each chapter is made of the following sections:

a) a definition of the type of experiment (animal sectioning, animal grafting, transverse and longitudinal sections).

b) an accurate description of the surgical techniques.

c) a precise description of post experimental phenomena.

d) a description of the results (success or failure).

The last two sections (c and d) are closely linked, the descriptions being more objective (c) and the results more oriented to a logical conclusion (response to the hypothesis) (d).

e) a portion of his experimental diary (its place varying according to the chapter).

All these sections contribute to the strategy of persuasion. Trembley neither limits himself to the clear explanation of the logic of his purpose (a) nor to the pure description of the results (d). But he added to (a) and (d) three other types of persuasion.

1) He increases the complexity of the concrete results (d) by varying the point of view of his observations. 2) He gives more reality for the reader to the experiment by

specifying existential parameters of the experiments as the actual narrator's life(e), i.e. when, where, by whom the experiment was done[7]. The work of the psychosociological school of Ghiglione who developed the concept of "communication contact" (Ghiglione and Nooyen 1981, Bromberg 1981) has shown the grammatical importance of such references in persuasion processes. 3) Last but not least, the results, to be sure and validated, need the testimony of other people. In the *Mémoire,* the presence of other naturalists while the experiments were being done is always pointed out. The description of the techniques (b) makes it possible for others to repeat the experiments. So the text takes the rhetorical advantage of coming from the eye-witness of the experiment hic et nunc and in the future[8].

Like other scientific texts, old and modern, the *Mémoires* are not only organized according to the actual concrete facts but with special aims. The words, phrases and chapters are chosen in order to stress specific points of scientific information and to obtain specific effects on the reader. Concerning the fourth volume of the *Mémoires,* we can now distinguish two levels of rhetorical organization. They are of different importance and can be differentiated according to the aims of Trembley himself. The same purposes are often present in modern scientific papers (Besançon, 1980). They are the following: i) To enhance the persuasive value of the book and to give legitimacy to it (e.g. by references to scientific authorities and witnesses). ii) To convince the reader that what is written in the book is the truth. iii) To establish Trembley's own authorship for his experiments. Baker's publication (1743) had introduced some ambiguity that was solved almost completely by the tardy publication of the *Mémoires*[9].

From a very general point of view, the *Mémoires* are organized in a way (succession of the chapters, logical links between the parts) that induces the reader to read it as an organic totality composed of logical series of surgical operations. This quality of composition and of style is perhaps one of the reasons for the great success of this book during the eighteenth century. There is a theatrical narrating of the discovery. The fourth *Mémoire* presents an emotional cognitive intensity (intensity which is made of alternating of personal and impersonal parts) which does not corrupt the objectivity of the observations.

We can conclude here by saying that implicit rhetorical requirements are not without consequence for the organization of Trembley's research. Some experiments were done not only to convince the scientific community but also Trembley himself. So rhetorical elements are not only to be found in the style of the *Mémoire* but in its logical organization also. Rhetoric has to do with knowledge (Vonèche, 1977).

EXPERIMENTAL LOGIC OF THE FOURTH *MÉMOIRE*

It has already been pointed out that the fourth *Mémoire* of 1744 has a very strong logic (Lenhoff and Lenhoff, 1984). We can try here a further and deeper analysis in

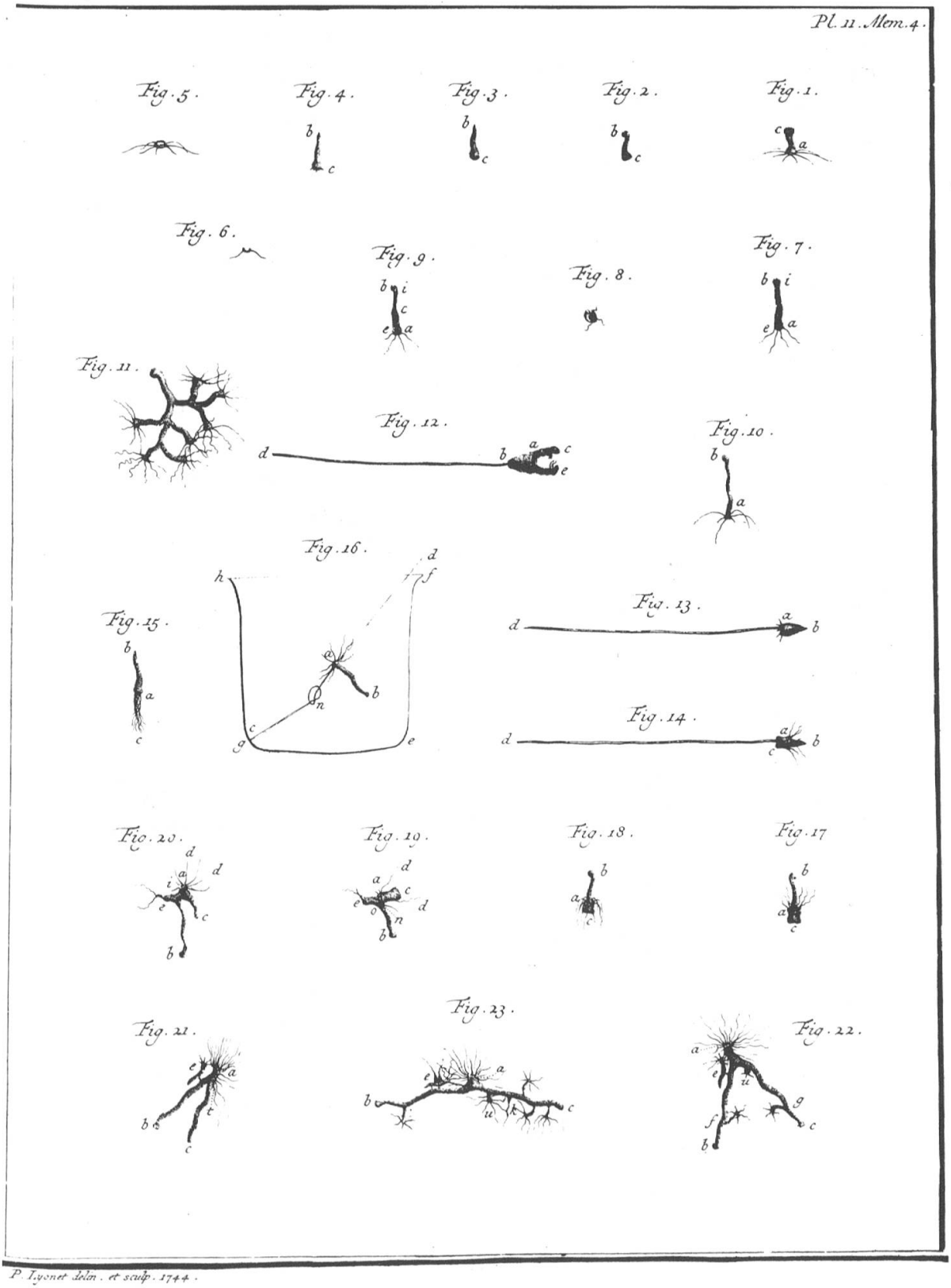

FIG. 2. — Plate XI from the Leiden edition of the fourth *Mémoire* of Trembley. The plate shows transverse and longitudinal sections of the polyps, the corresponding regenerating fragments and inverted polyps. (Figs. 1-6 are transverse sections; Figs. 7-10 are longitudinal sections; Fig. 11 shows a hydra with seven heads; Figs. 12-22 deal with experiments on inverting polyps and the fate of the inverted animals).

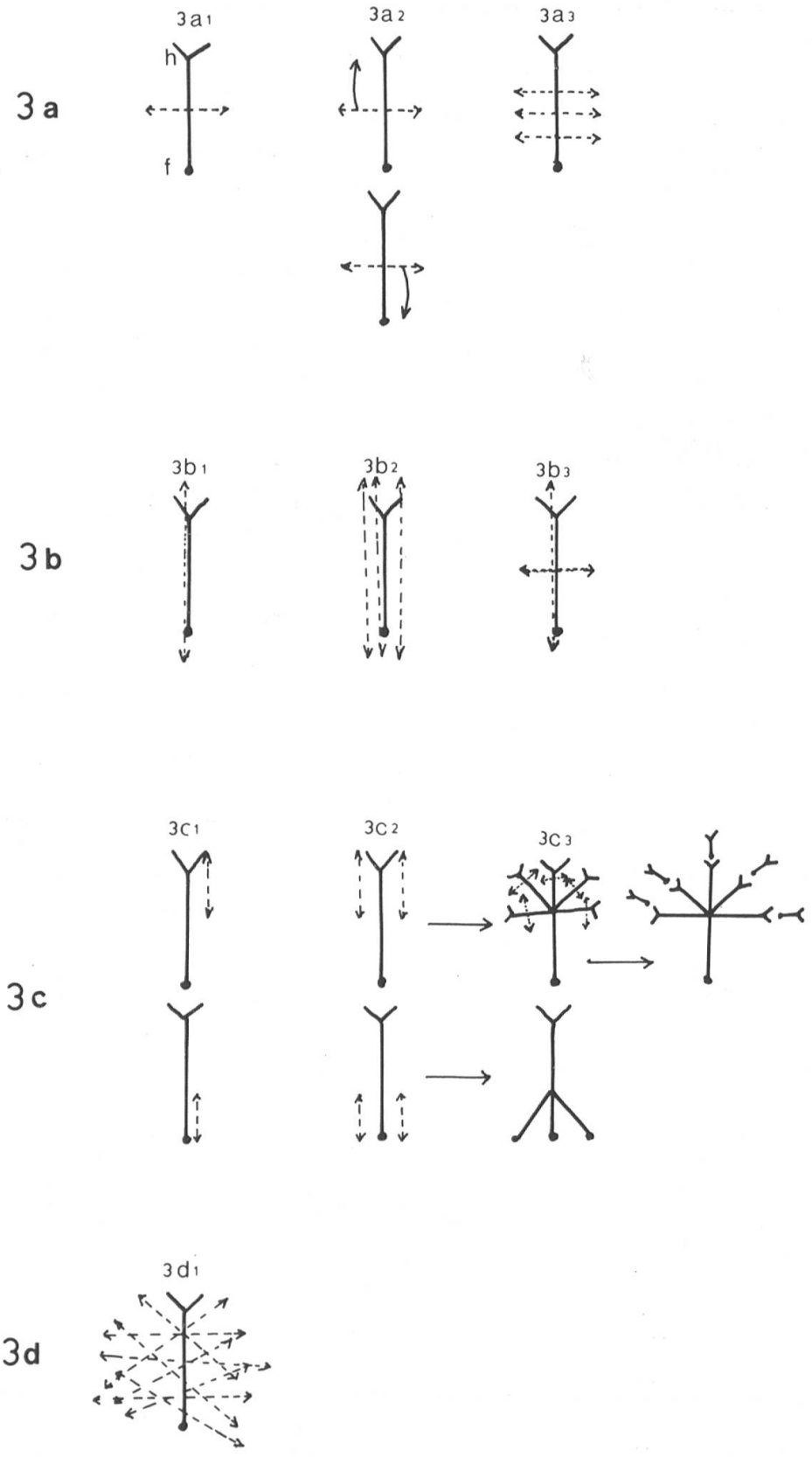

FIG. 3. — Formal interpretation of the four principal series of cutting of hydra in the *Mémoires* of 1744 (dashed lines represent the sites at which the sections were made, h, the head, f, the foot).

order to find order and regularities. We can make two very important and specific observations and one that is more general and straightforward. The more general one is the frequent to and fro between concepts and objects. The concepts give a view of the object, but the object itself may also be at the origin of conceptual changes. As we have already stated, the first goal of these surgical experiments was to discriminate plants from animals, but the observation of the polyps completely changed the significance of the hypothesis with the experimental consequences we know. The more specific things we find in this book concern the experimental logic itself and how it is explained. First of all this logic is a very formal one but it is never made explicit and remains deeply embedded in descriptive details. Nevertheless, logic is the structural axis of the fourth *Mémoire.*

In the *Mémoires* polyps are described as living active organisms (movement, nutrition, localization), and the same is true in the descriptions of post-experimental phenomena. But in the elaboration of experimental logic of the fourth *Mémoire,* the polyps are more or less implicitly reduced to geometrical solids (longitudinal with antero-posterior polarity) (see Figure 2 and 3). It follows that the experimental propositions of Trembley are a distribution of regular geometrical cutting experiments:

1. transverse sections (Figure 3a).
2. longitudinal sections (Figure 3b).
3. longitudinal and transverse sections which are the results of the composition of 1 and 2.

Inside each geometrical procedure, Trembley introduced a tendency to go to the limits. Transversely cut polyps regenerate, but Trembley questioned how many sections can be made, and the same is true for longitudinal sections and for simultaneous transverse and longitudinal sections. As we will see later, this tendency to reach the limits of cutting organisms into pieces reveals the influence of Leibniz's infinitesimal calculus.

Having the preceding elements in mind, we are now able to read and interpret the fourth book of the *Mémoires.*

The *first experiment* is the transverse section of polyps (Figure 2 and 3a1). The result is, of course, the most significant of all Trembley's work. The two half polyps regenerate two complete neo-polyps. As this result was a very astonishing one, Trembley added to the initial observation complementary ones, all of them showing that the new polyps are complete living organisms (they walk, swim, eat, reproduce themselves and even live two years). Then the experimenter makes a generalization from this puzzling result (going to the limit).

The *first generalization* (Figure 3a2) concerns the level of the unique cutting on the antero-posterior axis. The anterior and posterior limits (near the foot and near the head) are more accurately described.

The *second generalization* introduces a new passing to the limit through multiplication by cutting. From one polyp, Trembley created a maximum of four new polyps (Figure 3a3).

The *third generalization* introduces a time delay in the second one. If the cutting were successive in time Trembley obtained up to fifty polyps.

In the *second series* the solid (polyp) is cut into longitudinal sections (Figure 3b).

The *first generalization* of this second operation introduces the multiplication of longitudinal cuttings (Figure 3b2).

The *second generalization* is a composite of the first series (transverse cutting) with the second series (longitudinal cutting) (Figure 3b3).

The *third generalization* of the second operation introduces a time delay between longitudinal and transverse cuttings. This experiment gave twelve new polyps.

The *third operation series* is similar, at the beginning, to the second one (longitudinal cutting) but in this series only the anterior or the posterior extremity of the polyp is cut (Figure 3c).

The development and generalization of this operation's series is similar to those (series one, series two) previously described. It gave many-headed polyps with many feet[10].

Trembley introduced a time delay in this series and then combined it with the first one (transverse cutting). We have here a rather complex distribution of the preceding geometrical logics of operation. The seven polyps obtained in the first phase of the experiment were compared by Trembley to the famous "Hydre de Lerne". But Trembley's hydra did not only regenerate its seven cut heads, the heads themselves developed into complete living organisms (Figure 3c3).

After this result, and before he closed the logical series of cutting, Trembley changed from formal rational operations to a somehow emotional and irrational one, as if irrationality could enhance the demonstration of regenerative properties in polyps (Figure 3d). In this attempt he submitted polyps to non directional lacerations[11] with the result that each of the fragments regenerated a new living hydra.

There is no room here to go further in the complete description of this experimental logic. Let me just introduce two more series.

One is a very logical consequence of all the preceding ones, changing substraction to addition. If it is possible to cut polyps into pieces it must be also possible to reconstruct them by grafting (Lenhoff and Lenhoff, 1984). Therefore Trembley went to animal grafting.

1. one series was the association of anterior with posterior parts of polyps. It corresponds with the first series of cutting.
2. another series was the lateral association of two polyps. It corresponds to the second series of cutting.

The second series of experiments is based on a more complex geometrical understanding of the polyps. Polyps are not only simple solids but they are empty cylinders. As such they can be evaginated (the inside becoming the outside). It is also possible to introduce one polyp into another.

The influence of mathematics on Trembley's experiments was discussed by his nephew[12] who emphasized his experimental rigor. My purpose here is more precise. The similarities between the infinitesimal calculus and the logical series of Trembley's experiments are strong enough as to suggest the influence of the former on the latter. Such an influence cannot be definitely established because, till now, we do not have any direct and explicit evidence of it[13]. Nevertheless similarities can be found between the *Mémoires* and the *Theses Mathematicae.* Some analogies are general. The infinitesimal calculus uses series of number fractions and is characterized by passing to the limits. This corresponds to the logic of division in polyps (cutting). Another analogy concerns the notion of part. There are also striking homologies between the displacement of the tangent's ordinate along the X axis in Leibniz's calculus (Leibniz, 1684) in its description of the algorithm and the displacement and multiplication of the cuttings along the antero-posterior axis of the polyps. These similarities are confirmed by the analogy existing between words and even phrases of the *Theses* and of the *Mémoires.* The analogies may be strong or loose, they are never complete. The objects of the descriptions are not the same (numbers or polyps) but nevertheless they actually exist. They affect:

* division and parting[14].
* division and causal sequence[15].
* geometrical abstraction[16].
* ordinated series[17].
* modification of the object[18].
* limits[19].

This represents a second point of contact between the polyps and Leibnizian ideas. Indeed another influence of Leibniz on natural history has already been described. It was shown that the concept of "scale of nature" advanced by John Locke (1632-1704) and generalized in the Leibnizian "law of continuity" greatly influenced Charles Bonnet (1720-1793) when he devised his tentative "échelle des êtres", a theory that helped the elaboration of evolutionary ideas (Barthélemy-Madaule, 1978). The regenerating polyps of Trembley played a central role in this model transfer because they represented the connecting links between the forms of vegetative and animal life (Vartanian, 1950, 1953; Roger, 1963, 1969; Dawson, 1983, 1984; Josephson, this volume).

In the case of the *Mémoires* the transfer of concepts from mathematics to biology does not introduce a new theory of biology, as for example in Descartes, but leads to a new pragmatic experimental biology.

The *Theses Mathematicae* (Figure 1) offer wonderful evidence of persuasion's rhetoric. Indeed it was dedicated to people that represented the main powers in Geneva (political, military, religious and familial). Such an initial dedication[20] may be considered a search for legitimacy (Latour et Fabri, 1977).

CONCLUSIONS

The rhetorical approach of Trembley's work shows that the fourth book of the *Mémoires* of 1744 has a strong persuasive organization. This organization is present in all the chapters which are composed of similar sub-chapter structures. It is also present at the level of the logical succession of regeneration and grafting experiments. This logic is the actual axis of the fourth book. It is organized around the geometrical properties of the polyps and is made of successive series of surgical intervents. The logic of the experiments and of the series that are derived from them is so strong as to induce the reader to consider the book as an organized totality to be read at once. Very soon these experiments were recognized to be correct as presented by Trembley[21].

The series of cutting experiments reveals an influence of the infinitesimal calculus of Leibniz which was precisely the subject of Trembley's thesis in 1730. This illustrates one of the conceptual transfers between mathematics and natural history. Here mathematics had an influence on the experimental method in biology and not, as in Descartes, on the theory of biology.

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NOTES

1. The experiments are described in the correspondence with Réaumur and Bonnet, in the Préface to the *Mémoires* and in the fourth *Mémoire* ("opérations faites sur les polypes et le succès qu'elles ont eu") (see Figure 1 of Dawson, this volume). The *Mémoires* of A. Trembley were published in 1744. The best edition and the only one authorized by Trembley was published by Verbeek in Leiden. Another was published without Trembley's permission by Durand in Paris. The Paris edition was of poor quality but as it received the "privilège du Roi" it was the only one that was on sale in France. It was highly successful and had a strong influence despite the relatively poor quality of its printing.

   In the present paper the cited pages refer to the Leiden edition.

2. Letters 496 and 222 in Sonntag, 1983.

3. "J'ai pensé plusieurs fois à me remettre à faire quelques observations, mais je n'ai jamais pu en trouver le loisir, à peine ai-je le temps de faire quelques lectures" (Letter of January the 25th, 1752, British Museum Mss. Egerton, cited by Guyénot, 1943, p. 357).

4. *Mémoire* I, p. 3.

5. *Mémoire* I, pp. 5 and 6.

6. * "J'eus le bonheur de ne pas rejetter cette idée. Je dis que j'eus le bonheur de ne pas rejetter cette idée, parce que, quoiqu'elle fût la moins naturelle, elle me fit penser à couper des polypes. Je jugeai que, si les deux parties d'un même polype vivoient après avoir été séparées, et devenoient chacune un Polype parfait, il serait évident que ces corps organisés étoient des plantes" (*Mémoire,* I, p. 13).

   * "Si M. Trembley avoit cédé aux premieres apparences que lui présentoient les divers mouvements des bras des polypes, s'il en eût conclu, sans hésiter, que les polypes étoient de vrais animaux, sa conclusion auroit été juste, quoique précipitée; mais cette vérité prématurée nous auroit privé de la partie la plus curieuse de l'histoire des polypes. M. Trembley n'auroit point essayé de les couper pour savoir s'il reviendroient de boutures, parce qu'il n'imaginoit pas que cette propriété put appartenir à des animaux, et la théorie des reproductions animales seroit restée dans l'enfance" (J. Trembley. *Mémoire historique sur la vie et les écrits de M. Abraham Trembley.* Genève 1787, p. 23).

7. *Mémoire* I, p. 2; *Mémoire* IV, p,. 231.
   "Je m'empressai à faire cette Expérience en présence de bons juges" (Mémoire IV, p. 264).

8. * "Les faits... demandent, pour être admis, les preuves les plus évidentes" (*Mémoire* I, p.2).

   * "Il ne suffit donc pas de dire qu'on a vu telle chose. Ce n'est rien dire, si en même tems on n'indique comment on l'a vue" (*Mémoire* I, p.2)

   * "Ils ont besoin de plus d'un témoins oculaire pour être cru" (*Mémoire* I, p. 2).

   * "Tous ceux qui, de mon sçu, ont répété mes Expériences, ont eu le même succès que moi" (*Mémoire* I, p. 4).

   * "On peut juger ce qui est rapporté par d'autres. Il est nécessaire de savoir que les observations ont été faites de la façon dont vous pensez qu'elles le doivent, et si l'auteur expose clairement ce qu'il a vu" (*Instructions d'un père à ses enfants, sur la nature et sur la religion,* 1775).

   * "Remarqués, qu'il (Buffon) ne dit point comment il s'est assuré de tout cela. Il le donne simplement comme un fait, et il est permis de douter des faits de cet éloquent écrivain" (Letter from Bonnet to von Haller, Sonntag, 1983).

9. Trembley's authorship was contested even by his friend Pierre Lyonet (1706-1789) as shown in a letter of Charles Bonnet: "Il est si prodigieusement altéré de gloire, qu'il osoit bien insinuer à Mr. Trembley lui-même qu'il avait vû avant lui la multiplication des Animaux par bouture" (Letter from Bonnet to von Haller. June the 22nd, 1764. Sonntag, 1983, p. 382).

10. "J'ai vu marcher des Hydres à plusieurs têtes et des Hydres à plusieurs queues" (*Mémoire* IV, p. 247).

11. "Je donne des coups de ciseaux à la peau de tous côtés et en tout sens"... "On s'imagine bien dans quel état est après cela le Polype" (*Mémoire* IV, p. 247).

12. "M. Trembley avoit fait des progrès réels dans l'étude des mathématiques; et sans doute cette étude avoit contribué plus que tout autre chose, à lui inspirer le goût de cette logique sévere, de cette analyse simple et lumineuse qui brille dans ses ouvrages d'histoire naturelle" (J. Trembley, *Mémoire historique sur la vie et les écrits de M. Abraham Trembley,* Genève, 1787, p. 7).

13. It would be very interesting to read the exercise book of the pupils of Trembley which may still be in Sorgvliet.

14. * "numerus partium in infinitum divisibilium" (*Theses Math.* p. 5).

    * "si vero partes illae sint ulteriores divisibiles" (*Theses Math.* p. 15).

15. * "tempus vero est successivum, habetque partes, ergo duratio debet esse successivo et habere partes" (*Theses Math.* p. 14).

16. * "corpus idem, potest esse quadratum rotundum, triangulare" (*Theses Math.* p. 14).

17. * "quid sunt series infinitae" (*Theses Math.* p. 19).

    * "series quae infinitae vocantur" (*Theses math.* p. 19).

    * "liquet autem tempus nihil esse nisi ordinem" (*Theses Math.* p. 14).

18. * "tempus itaque nullam est, nisi quando existunt res mutabiles" (*Theses math.* p. 14).

19. * "quid sint fines" (*Theses Math.* p. 6).

    * "ut ulterius dividi non possit" (*Theses Math.* p. 15).

    * "ea quae ad Maxima et Minima pertinent" (*Theses Math.* p. 25).

    * "ut liquebit, dum de Maximum et Minimum dicimus" (*Theses Math.* p. 19).

20. "Francisco Pictet, consuli prudentissimo, illustrissimo"

    "Carolo Lullin, exconsuli meritissimo, et machinarum bellicarum praefecto supremo"

    "Michaeli Leger, Ecclesiae pastori vigilantissimo dignissimo"

    "Joh. Jacobo Trembley, Reipublicae procuratori integerrimo, cultissimo" (*Theses Math.* p. 1).

21. "Il est d'un philosophe de douter, jusqu'à ce que l'expérience ait parlé; mais quand elle a parlé aussi bien qu'elle l'a fait par la bouche de M^{r} Trembley, le doute n'est plus qu'un écart de la raison" (Letter from Bonnet to von Haller. February the 6th, 1759. Sonntag, 1983).

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