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ANIMAL ELECTRICITY IN PARIS: FROM INITIAL SUPPORT, TO ITS DISCREDIT AND EVENTUAL REHABILITATION

Christine Blondel*

Luigi Galvani's experiments, and his thesis on the existence of an animal electricity peculiar to living organisms, gave rise to a great variety of experiments and to divergent interpretations in Italy, Germany and England. What part did the French savants play in the storm raised among European physicists, physiologists and physicians by Galvani's *Commentarius*, a storm which, according to the German physiologist Emil Du Bois-Reymond, could be compared only with the political storm which prevailed in Europe at that time?¹ At first sight the French seem to have had a detached attitude towards the «scientific war» Galvani's and Alessandro Volta's partisans engaged in, to use the expression of Pierre Sue, the first French chronicler of Galvanism.² Several French participants in the research on Galvanism, such as J.F.N. Jadelot or Nicolas Gautherot, themselves spoke of the weakness of the French in this new field.³ Recent historians of Galvanism mention very few French names among the contributors to Galvanism.⁴ To what

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1. Emile Du Bois-Reymond, *Untersuchungen über thierische Elektrizität*, 1 (Berlin, 1848), 50-51.

2. Pierre Sue, *Histoire du galvanisme*, (4 vols., Paris, 1802-1805), 1, 19; the expression is taken up by Sue from Jean-Louis Alibert, *Eloge historique de Louis Galvani* (Paris, an X).

3. J.F.N. Jadelot mentioned only non-French savants in his "Discours préliminaire" to Humboldt's treatise on Galvanism: Alexander von Humboldt, *Expériences sur le galvanisme* (Paris, 1799), x-xii; Gautherot maintained that, concerning Galvanism, France not only laid much behind other learned nations in Europe but even ignored their extensive researches: Nicolas Gautherot, *Recherches sur le galvanisme* (Paris, 1802), 1.

4. Naum Kipnis, in his overview of galvanic studies, mentions only two French over more than thirty contributors to early Galvanism: see Kipnis, "Galvani and the debate on animal electricity", *Annals of science*, 44 (1987), 107-142, on 116-117. Geoffrey Sutton and Eugene Frankel have studied mainly the period after 1800: see Sutton, "The politics of science in early Napoleonic France: the case of the Voltaic pile", *Historical studies in physical sciences*, 11 (1981), 329-366; Frankel, "J.B. Biot and the mathematization of experimental physics in Napoleonic France", *ibid.*, 8 (1977), 47-52; see also Marc Sirol, *Galvani et le galvanisme. L'électricité animale* (Paris, 1939).

extent were the French really absent from the debate? How were foreign works on Galvanism presented and received? Who conducted experiments or proposed interpretations and in what settings? How did the French savants intervene in the various controversies, between 1792 and Volta's so-called "victory" in 1800? Can we distinguish some specific features, and if that is the case, how can we understand them?

Volta's battery has been described as having suppressed all argument, if not all expressed opinion, in favour of animal electricity. Certainly, with Bonaparte's support after his public demonstrations, Volta's triumph shone particularly brightly in Paris, and animal electricity was not in high favour among the leading French physicists. Galvanism, however, attracted a great number of physicians and amateurs, and I shall also be taking a look at their accomplishments.

A succession of commissions and collective reports

A series of various commissions dealt with Galvanism in Paris between 1792 and 1801. As there is some confusion in the literature about these commissions, several of them being called "Commission du Galvanisme", here is a rough description of their respective activities. Galvani's experiments were known in Paris through one of his supporters, the Italian physician Eusebio Valli, who described and performed some of these experiments during the meeting of the *Académie des sciences* on July 11th, 1792. According to its usual procedure for promising or controversial subjects, the *Académie* then appointed a commission to repeat these experiments and report on them.⁵ The three members of the commission, the physicist Charles Coulomb, another physicist, Jean-Baptiste Le Roy, and the famous physician Félix Vicq d'Azyr, secretary of the *Société royale de médecine*, met the very next day in Antoine Francois de Fourcroy's laboratory with Valli and some other academicians. Coulomb was a specialist in the physical aspects of electricity, Le Roy had practised medical electricity in addition to his research into physics and Vicq d'Azir, an eminent physiologist, had written about the utility of medical electricity.⁶ This collective

5. *Registres des Procès-Verbaux des séances de l'Académie royale des Sciences*, Manuscript, July 11 and 21, August 22, 1792. See also Walter Bernardi, "L'électricité animale: les savants italiens et leurs relations avec les milieux français à la fin du XVIIIe siècle", in *Echanges d'influences scientifiques et techniques entre pays européens de 1780 à 1830* (Paris, 1990), 161-170.

6. Jean Torlais, *L'Abbé Nollet. Un physicien au siècle des Lumières* (Paris, 1954), 182-185.

experimentation, apparently able to rely on several of the necessary disciplinary skills, did not lead to any full report at the *Académie*, as had been announced. A mere *Procès-verbal* was read and published by Fourcroy, who had been added to the commission. His medical journal *La médecine éclairée par les sciences physiques*, gave "a pure and simple account of facts," without any interpretation.⁷ The French feature added to Galvani's experiments consisted mainly in the use of a Coulomb's torsion electrometer on a rabbit. The absence of any report may be explained by some uncertainty among the members of the commission, especially about the theoretical interpretation given by Galvani to his experiments. But we should also bear in mind that during the following months, and right up to the dissolution of the *Académie*, in August 1793, the academicians were overwhelmed with other requests directly linked to the political and military situation: a Commission for weights and measures, reports on rifles, cannon, gun powder, oiled taffeta for soldiers coats, etc. not to mention their personal political responsibilities in the midst of the revolutionary upheavals. "When the revolution began - recalled Jean-Baptiste Biot some years later - all minds turned towards politics. Sciences were suddenly abandoned."⁸ However that may be, the first commission of the *Académie* dedicated to Galvanism disappeared almost without a trace. The keen galvanist Valli, however, repeated his experiments both at the *Société royale de médecine* and at Jean-Claude de Lamétherie's laboratory.⁹ De Lamétherie was the editor of one of the main French scientific journals, the *Observations sur la physique*. He too became a convinced galvanist through Valli's lectures and the jerks of his frogs' legs with only one metal, and consequently published a series of nine letters by Valli and one by another Italian galvanist, the physicist Leopoldo Vaccà Berlinghieri.¹⁰ The French accepted Galvani's experiments and if the *Académie's* commission

7. *La médecine éclairée par les sciences physiques ou Journal des découvertes relatives aux différentes parties de l'art de guérir*, rédigé par M. Fourcroy, 4 (1792), 66-73, 164-167.

8. Jean-Baptiste Biot, *Essai sur l'histoire générale des sciences pendant la Révolution française* (Paris, 1803). The *Annales de Chimie* interrupted their publication between 1793 and 1797 and the volume 19-20 (1797) stressed the fact that during that time the scientists had to worry about the defense of the Republic and their public offices (p. iii).

9. Eusebio Valli, "Première Lettre sur l'électricité animale", *Observations et mémoires sur la physique, sur l'histoire naturelle et sur les arts*, (hereafter *Observations sur la physique*), 41 (1792), 62; Valli, "Quatrième Lettre sur l'électricité animale", *ibid.*, p. 192.

10. Valli, "Lettres sur l'électricité animale", *Observations sur la physique*, 41 (1792), 66-71, 72-77, 185-188, 189-192, 193-197, 197-202, 435-437; 42 (1793), 74-75; Leopoldo Vaccà Berlinghieri, "Lettre sur l'électricité animale", *ibid.*, 41 (1792), 314-316.

remained neutral, others were more favourable to his interpretation. All the more so, as Volta's 1792 objections to the hypothesis of an electricity specific to animals and to Galvani's description of muscle and nerve as a sort of Leyden jar, were not published in French journals.

A second commission took over the Galvanism affair at the level of a more modest scientific society, the *Société philomatique de Paris*, in March 1793. Founded in 1788 "to spread scientific news and repeat doubtful or little-known experiments,"¹¹ this society patterned itself on the *Académie*, with its members, associates and correspondents, its commissions performing experiments, its *Bulletin*, etc. and became a surrogate for the *Académie* after its suppression in August 1793. Among the three amateur scientists nominated to the *Société philomatique*'s commission on Galvanism, two (Claude Chappe and Augustin-François Silvestre) had experimented some time earlier on the - then much discussed - influence of electricity on animal and plant life. But the *commissaires* were not used to physiological experimentation. The commission carried out new experiments (animal contractions in vacuum, in oil, etc.), repeated Galvani's experiment on the frogs' contractions with only one metal, and Volta's experiment on the taste excited on the tongue by two different metals and, once more, seemed more favourable to Galvani even if no definite conclusion was stated.¹² Next year, in 1794, the *Société philomatique* proposed a prize for Galvanism, but it was never awarded.¹³

It was Alexander von Humboldt's experiments, described in November 1796 by Guyton de Morveau at the First Class of the *Institut* (the post-revolution version of the *Académie des sciences*), which reawakened the interest of French scientists in Galvanism. Humboldt, unlike Galvani, refused to attribute the animal contractions to electricity and, against Volta's theory of metallic electricity, exhibited various contractions without any metal. The discussion which followed this description of Humboldt's experiments on Galvanism led to the creation of a *Commission du galvanisme* "to examine and verify the phenomena of Galvanism."¹⁴ Three physicians (Jean-Noël Hallé as

11. Notice sur l'institution de la Société Philomatique (s.p., s.d.), 2. On the *Société philomatique* see J. Mandelbaum, "Science and friendship: The Société Philomatique de Paris 1788-1815", *History and technology*, 5 (1988), 179-192.

12. *Bulletin des sciences, par la Société Philomatique de Paris* (hereafter referred to as *Bull. Sc. Soc. Phil.*), (mars 1793), 42-43.

13. Sue, *Histoire du galvanisme* (ref. 2), 1, 95. I did not find any mention of this prize in the *Bull. Sc. Soc. Phil.*

14. About the activities of the first *Commission du galvanisme* see: Institut de France,

rapporteur, P. Pelletan, Sabatier), three chemists (Fourcroy, also a physician, Guyton de Morveau and Nicolas Vauquelin), and two physicists (Coulomb, Jacques-Alexandre Charles) were nominated. The commission, however, showed no sign of life for one and a half years. We know from the subsequent report that it performed a series of experiments directed by Hallé and Fourcroy at the *Ecole de médecine* in April-May 1797.¹⁵ Their viewpoint was physiological, and no experiments used an electrometer. They studied the susceptibility of animals with ligatures of nerves, the influence of the nature of the death (asphyxia, poisoning, etc.) on the sensibility of the animal to Galvanism, etc. But the commission did not publish or even communicate anything about these 1797 experiments. When Humboldt himself came to Paris, a year later in spring 1798, with his frogs, his metals and his instruments, with his experience of about 3000 experiments on more than 4000 animals, the commission felt obliged to resume its work - with Humboldt.¹⁶ The Italian physicist Giambattista Venturi also joined the commission. The long report, published afterwards as a widely diffused book, criticised Galvani's analogy between the frog leg and the Leyden jar, underlined the differences between electric and galvanic phenomena (some substances were conductors for the first and not for the second) and stressed the contractions with only one metal.¹⁷ These experiments were expected to open up a new field in medicine, helping with the diagnosis of death and resuscitation from asphyxia (in a broad sense). With its experimental results, the commission was drawing away from Galvani and nearer to Humboldt. However, it did not explicitly account for this. Indeed the conclusion of the report cast doubts on the identity between the principles of Galvanism and electricity (following Humboldt) and partially invalidated Volta's theory on the role of a metallic electricity in galvanic phenomena. But the *rapporteur* Hallé did not want to go further, and discuss the various systems proposed to explain galvanic contractions. He stood the

Académie des sciences, *Procès-Verbaux des séances de l'Académie* (hereafter referred to as *Procès-Verbaux*), 1 (Hendaye, 1910), 126, 136, 397, 403, 406, 407, 415.

15. *Compte rendu à la Classe des sciences mathématiques et physiques de l'Institut national, des premières expériences faites en floréal et prairial de l'an 5, par la commission nommée pour examiner et vérifier les phénomènes du Galvanisme* (Paris, s.d. [1798]).

16. See Karl Rothschild, "A. von Humboldt et l'histoire de la découverte de l'électricité animale", in *Conférences du Palais de la découverte*, D 72 (Paris, 1960), 2, 14.

17. *Ibid.*, p. 82. On the diffusion of the book and the publishing of extracts in most scientific journals see Sue, *Histoire du galvanisme* (ref. 2), 2, 14.

academic commission above debates, controversies and fashions:

If anyone has to impose on themselves the law of this prudent reserve, it is those who, like ourselves, are responsible for reporting on their researches to a society of men gathered in order to search for the truth, clearing it from both the prestige of enthusiasm and from the illusion of false appearances.¹⁸

After the announcement of Volta's "artificial electrical organ" - i.e. the Voltaic pile - reached Paris in 1800, the first French work on the battery was a memoir read at the *Institut* on August 29th, 1800 by Etienne-Gaspard Robertson, an amateur who performed shows with both the apparitions of ghosts and demonstrations of experimental physics.¹⁹ This memoir, where Robertson insisted on chemical effects inside the pile and described a "galvanometer" with a tube where the electrolysis of water was performed, was committed to five *commissaires*, three out of five physicians and all former members of the 1796 *Commission du galvanisme*.²⁰ The commission was also supposed to verify the phenomena announced in the English papers (quite probably the electrolysis of water). Later on it was asked to examine some memoirs on Galvanism submitted to the *Institut*.²¹ A series of experiments was carried out at the *Ecole de médecine* under the direction of Hallé, who taught there, and where the first Parisian powerful battery was set up, hence the subsequent title of *Commission de l'Ecole de médecine* or *Commission Hallé* for this fourth commission. The only other powerful battery in Paris was set up by a pharmacist, Bertrand Pelletier, member of the *Société libre de médecine*. This testifies that interest in Paris for the battery came in the first place from the medical *milieu*. Indeed the main

18. Ibid., 101 and Jean-Noël Hallé, "Compte rendu à la Classe des sciences mathématiques et physiques de l'Institut national [...]", *Journal de physique*, 47 (1798), 466-468: "Si quelqu'un doit principalement s'imposer la loi de cette prudente réserve, ce sont ceux qui, comme nous, se trouvent chargés de rendre compte de leurs travaux à une société d'hommes réunis pour procéder à la recherche de la vérité, en la débarrassant, et des prestiges de l'enthousiasme et de l'illusion des fausses apparences."

19. Etienne-Gaspard Robertson, "Expériences nouvelles sur le fluide galvanique, lues à l'Institut National le 11 fructidor an 8 (29 août 1800)", *Annales de Chimie*, 37 (1801), 132-150. On Robertson's shows see F. Levie, *Etienne-Gaspard Robertson. La vie d'un fantasmagore* (Québec, 1990).

20. The *commissaires* were Hallé, Fourcroy, Sabatier (physicians), Charles and Coulomb. About the activities of this commission see *Procès-Verbaux*, 2 (Hendaye, 1912), 218, 228, 273-274, 280.

21. *Procès-Verbaux*, 2 (Hendaye, 1912), 224 (memoir by Biron), 278 (memoir by Lehot), 293, 328, 357, 369, 398 (memoirs by Gautherot).

purpose of the commission was to test the battery for medicine. In September and December 1800, Hallé reported on these experiments before the *Institut* and his mixed results on paralysis were published in some medical journals.²² But the attraction of the new device was so strong that other members of the *Institut*, among them Pierre-Simon de Laplace, Fourcroy and Vauquelin, went to the *Ecole de médecine* in order to see its wonderful effects: the commotions, sparks, and decomposition of various chemical solutions. To study the battery they used the apparatus with the Coulomb electrometer, which had been so successful for the determination of the law of electrical attraction and repulsion. In so doing, they showed electrical attraction and repulsion at the ends of the battery and studied the influence of the number and surface of the disks on the various effects of the pile.²³ Laplace then encouraged his *protégé* Biot to study these new phenomena. Biot resumed the commission's work on the relationship between the size and the number of the metallic disks in a pile and looked for the influence of oxidation processes inside the pile.²⁴ This last line of research, which was at odds with Volta's interpretation on the exclusive role of bimetallic contacts, would soon be reversed during Volta's stay in Paris.

It is precisely during Volta's stay in Paris in autumn 1801 that the best known Commission on Galvanism was set up. On his arrival on September 27th, Volta had already shown his experiments with his electrometer to Claude Louis Berthollet, Biot, Fourcroy and to the president of the First Class, the mineralogist René-Just Haüy, when he attended the *séance* of the *Institut* on October 3rd.²⁵ Disregarding the fact that five *commissaires* had already been nominated a few weeks before to deal with Galvanism, the president Haüy proposed a new Commission on Galvanism, including Volta and his colleague the chemist Luigi Valentino Brugnatelli. In this large commission of twelve members, physicians were not included (except Hallé), and physicists or mathematicians (Laplace, Monge, Coulomb, Brisson, Charles, Biot,

22. Sue, *Histoire du galvanisme* (ref. 2), 2, 384-394; Hallé, "Observations sur l'effet du Galvanisme dans un cas de paralysie", *Bull. Sc. Soc. Phil.*, 3 (1801), 31.

23. Sue, *Histoire du galvanisme* (ref. 2), 2, 2-13; *Bull. Sc. Soc. Phil.*, 2 (1800), 144, 151, 165-7; 3 (1801), 31; *Notice des travaux de la classe des sciences mathématiques et physiques*, 1 (1800-1810), G. Cuvier, Partie physique, 2ème trimestre de l'an 9, 15-21; reprinted in *Journal de Physique*, 52 (1801), 318-321.

24. Biot, "Sur le mouvement du fluide galvanique", *Journal de physique*, 53 (1801), 264-274.

25. Luigi Valentino Brugnatelli, *Diario del viaggio in Svizzera e in Francia con Alessandro Volta nel 1801*, ed. A.G. Berzolari (Bologna, 1997), 153-165.

and Haüy) outnumbered even chemists (Fourcroy, Vauquelin).²⁶ A few weeks later, after Volta's first lecture and the demonstration of his experiments before the First Class of the *Institut*, Bonaparte (who attended the *séance*) awarded a gold medal to Volta, and asked that experiments on Galvanism be carried out on a grand scale. This work was attributed to the new commission, and was performed mainly by Biot, who was appointed *rapporteur* in place of the physician Hallé. Biot accepted Volta's view on the identity of galvanic and ordinary electricity, as well as his attribution of the new phenomena to the contact between two different metals,²⁷ but criticised the use of his straw electrometer. After some difficulties over coping with the delicate Coulomb balance, the young Biot managed, with the help of the experienced Coulomb, to give a coulombian interpretation of the pile in open circuit.²⁸ The chemists Fourcroy and Vauquelin, Guyton de Morveau, Desormes and Thénard, who were not directly involved in the commission, focused on electrolysis, and according to Vauquelin, "Galvanism, which seemed to be of interest only to physiology, is carried, so to speak, in the field of chemistry."²⁹ In short, the physicists, who controlled the commission, and the chemists outside the commission, went separate ways in their attempts to explore and explain the working and the effects of the battery with each discipline's intellectual and material resources. This 1801 Commission, unlike the previous ones, strengthened the undecided disciplinary boundaries between physicists and chemists. However, although academic chemists and physicists did not agree and did not accept all of Volta's statements, they shared his exclusion of animal electricity from the field of science.

The next commission was again a consequence of a Bonaparte decree. In June 1802, the First Consul proposed two prizes for Galvanism, an annual prize of 3,000 francs and a large prize of 60,000 francs for "the person who, by his experiments and discoveries, will advance electricity

26. *Procès-Verbaux*, 2 (Hendaye, 1912), 410.

27. See Sutton, "The politics of science" and Frankel, "J.B. Biot" (ref. 4).

28. Two years of research elapsed between Biot's "Rapport fait à la classe de sciences mathématiques et physiques de l'Institut national, sur les expériences du citoyen Volta", *Mémoires de l'Institut national des sciences et des arts. Sciences mathématiques et physiques* (1801), 5 (1804), 195-222, where he criticised the use of Volta's electrometer, and his paper in the *Annales de Chimie*, 47 (1803), 5-42 with the results of his experiments with the Coulomb's balance.

29. Nicolas Vauquelin, "Résumé des nouvelles expériences faites sur le galvanisme, par divers physiciens", *Bull. Sc. Soc. Phil.*, 3 (1801), 13.

and Galvanism to a degree comparable to the advances made in these sciences by Franklin and Volta."³⁰ The large prize was never awarded, but the offer encouraged a number of amateurs to turn to Galvanism and electricity. A great many writers, French and otherwise - the young Ampère, Oersted or Ritter, to mention the more famous ones, but also a lot of obscure physicians and amateurs - referred to this incentive at the beginning of their publications during the first decade of the 19th Century.³¹

Among these physicians and amateurs, a good many had not been converted to Volta and Biot's analysis. Moreover, those who thought there was still something worth studying in the relationships between electricity and the living organisms must have felt they had to find another place than the *Institut* to present their research. In 1802 they founded a new society: the *Société galvanique*, presided over by a physician, Jacques Nauche. The society got the membership of several leading scientists (Laplace, Lacépède, Chaptal, Fourcroy), but recruited its active members among physicians (Mauduyt de la Varenne, Guillotin, etc.), some teachers of physics (Izarn), amateur scientists (Gautherot, Robertson), and amateurs *tout court* such as senators (Lucien and Joseph Bonaparte) or officers like the general Massena and politicians such as the Second Consul Cambacérès.³² The membership of several closest to Bonaparte suggests that he was personally interested in the pursuit of this question outside the *Institut*. Bonaparte's role toward Galvanism seems ambiguous. He covered Volta with honours and compelled the *Institut* to do the same, and yet he supported

30. *Procès-Verbaux*, 2 (Hendaye, 1912), 518.

31. For example: Anton Maria Vassalli-Eandi et al., "Rapport sur les expériences galvaniques faites sur la tête et le tronc de trois hommes", *Journal de physique*, 55 (1802), 286; B.G. Sage, *Recherches et conjectures sur la formation de l'électricité métallique nommée galvanisme* (Paris, 1807), 1; J.H. Pétetin, *Théorie du galvanisme* (Paris, 1803), iv; J.J. Menuret de Chambaud, "Lettres sur le galvanisme", in *Essais sur l'histoire médico-topographique de Paris* (Paris, 1804), 335.

32. On the Society see Sue, *Histoire du galvanisme* (ref. 2), 4, 113-117. According to one of its members, the *Société galvanique* was created because many savants did not share Volta's theory: de Ponton d'Amécourt (le jeune), *Exposé du galvanisme* (Paris, 1803), 10. Among its members figured: the senator M.-F. d'Aboville, A.-J. Abrial (ministre de Justice in 1802), G. Aldini, Alizeau, Baget, Bonnet, Bourru, Cassius, Chompré, Dudaumon, Fabré-Palaprat, N. Gautherot, Godine, J.B.E. Graperon, J.I. Guillotin, J. Izarn, Lacépède, Lagrave, Lamartillière, Laplace, C. Larcher-d'Aubancourt, J. J.C. Legallois, P.H. Nysten, P. Pajot-Laforet, Paroisse, Petit-Radel, A. Pitaro, Ponton d'Amécourt, J.R. Riffault, E.G. Robertson, de Saintot, Struve, J.J. Sue, P. Sue, Thouret, C. Veau-Delaunay, Vosdey. Among its correspondants: Le Bouvier-Desmottiers (Nantes), Curtet (Bruxelles), A.C. Gerboin (Strasbourg), Giulio (Turin), Maréchaux (Wesel), B. Mojon (Gênes), Herman (Berlin), Rossi (Turin), Van Marum, Van Mons, A. Vassalli-Eandi, Winckler.

a society partly devoted to oppose Volta's thesis.³³ Giovanni Aldini, Galvani's nephew who had defended his uncle's thesis since 1792, and had already founded a galvanic society in Bologna, was one of the founding members of the *Société galvanique* during his stay in Paris in 1802.³⁴ Organised, like the *Société philomatique*, on the pattern of the *Institut*, the *Société galvanique* had correspondents in the provinces and abroad, such as the recognised scientists Martinus van Marum and Van Mons. It formed three permanent commissions, one for physical and chemical phenomena, one for physiology and medicine, and a third one for the history of Galvanism. It produced a *Journal du galvanisme* until 1804, publishing the results of galvanic research carried out throughout Europe.³⁵ And unlike the *Institut*, the *Société* owned its private laboratory. Most of its members were sceptical about Volta's theory, as is stressed in the *Avant-propos* of the *Journal*: "Volta's theory will necessarily undergo many changes, as it does not tally with the present state of knowledge and a great number of observations."³⁶ The *Société* supported the diffusion of galvanist theses by the translation of Aldini's and Anton Maria Vassalli-Eandi's memoirs. The physicist Izarn harshly criticised the weaknesses of Volta's fundamental experiment with the electrometer to show the production of electricity by the mere contact between two metals. The amateur Gautherot performed a series of scrupulous experiments to show the role of chemical action in the pile, whereas Biot maintained, after Volta, that chemical action was negligible.³⁷ The *Société galvanique* carried out a great many experiments on the chemical, the physiological and the medical effects of the electric

33. Geoffrey Sutton underlines that the *Institut* was quite reluctant to elect Volta as a foreign associate: Sutton, "The politics of science" (ref. 4), 356-7.

34. A.-G. Ballin, "Notice biographique sur G. Aldini", in *Précis analytique des travaux de l'Académie royale des sciences, belles-lettres et arts de Rouen pendant l'année 1838*, 200-216; on Aldini's defense of Galvanism see Giovanni Aldini, *Essai théorique et expérimental sur le galvanisme, avec une série d'expériences faites en présence des commissaires de l'Institut national de France et en divers amphithéâtres de Londres* (Paris, 1804); on his medical experiments see C. Sleight, "Life, Death and Galvanism", *Studies in the history and philosophy of biology and biomedical sciences*, 29 (1998), 219-248.

35. On the organization of the Society see J. Nauche et R. Tourlet, "Aperçu des travaux de la Société galvanique pendant l'an XI", *Journal du galvanisme, de vaccine, etc. Par une société de physiciens, de chimistes et de médecins*, 2 (1804), 193-211.

36. Tourlet, "Avant-propos", *Journal du galvanisme*, 1 (1803), 10.

37. Cassius, C. Larcher d' Aubancourt and de Saintot, *Précis succinct des principaux phénomènes du galvanisme, suivi de la traduction d'une Commentaire de J. Aldini et de l'extrait d'un ouvrage de Vassali-Eandi* (Paris, 1803); J. Izarn, *Manuel du galvanisme* (Paris, 1804), chapter 2 ("De l'électromètre de Volta"); Gautherot, "Mémoire sur le galvanisme", *Annales de chimie*, 39 (1801), 203-210.

current. While it is true that a couple of its members drifted into "galvanic magic", most of its researches were considered worth noticing by French and foreign scientific journals and even encouraged by the *Institut*.³⁸ It seems that the *Société* vanished in 1809.

So within a decade, almost ten successive commissions were set up by the various Parisian scientific societies to judge Galvanism. Indeed the appointment of commissions was a standard procedure at the *Académie des sciences*. During the revolutionary period, a great variety of various committees, commissions and tribunals were set up in order to place under control virtually every area of society. But Galvanism - with its numerous and long-lived commissions - was particularly subject to scientific tribunals. At the *Académie* and the *Institut*, during the years 1790-1810, it was the only long-term commission about a scientific subject. Whereas in Germany, a great variety of opinions and approaches prevailed, until 1801 Parisian institutions looked for a collective and official judgement.

Moreover - and this is probably not independent of the issue of collective judgement - these commissions insisted on an empirical stance. The 1792 Commission restricted itself to a *Procès-verbal*, "a pure and simple account of facts." The 1796 Commission was set up only in order to "examine and verify the phenomena." Its reporter Hallé put forward "this spirit of doubt and observation which has always been in Paris the rock on which the false theories come to grief" and defended the non-engagement of the commission.³⁹ The commission of the *Société galvanique* had as its explicit aim "to establish the facts." The association in most of these commissions of physicists, chemists and physicians, with their own disciplinary techniques, was supposed to support the strength of experimental conclusions. However, we know that these empirical statements could turn out to be mainly professions of faith. If we assess the conclusions of the successive commissions, we can perceive the impact of the foreign scientists who performed their

38. The *Magasin encyclopédique* in France and the *Philosophical Magazine* in England gave regular reports on the activities of the *Société galvanique*. On the encouragements by the *Institut*, see *Procès-Verbaux*, 3 (Hendaye, 1913), 469 (15 déc 1806), 473 (Laplace spoke on behalf of the Society, 29 déc 1806). The term "galvanic magic" used positively by A. Pitaro, a member of the Society, was brought as an accusation by the most famous 19th Century French populariser, Louis Figuier, who thought probably of some members such as A.C. Gerboin, who defended an organo-electric dowsing rod.

39. Hallé, "Séance publique de l'Ecole de Médecine de Paris du 5 brumaire an XI (27 oct 1802)", *Historique des sciences médicales* (1802), 3-24.

experiments in Parisian laboratories, in the flesh, over several weeks, before groups of French scientists who were not personally involved in this subject. In 1792 the galvanist Valli convinced the French scientists about the existence of animal electricity, in 1798 Humboldt cast serious doubts on this animal electricity and turned the balance towards his side, in 1801 the triumphant stay of Volta converted at least the physicists of the *Institut* to his metallic electricity and eventually in 1802 the stay of the galvanist Aldini entailed a revival of animal electricity through the *Société galvanique*. As long as they were outsiders, the French savants found it difficult to justify their assertions of empiricism, when put to the test by convinced partisans of one side or the other. After 1801, when many of the French savants and amateurs committed themselves, these assertions gave way to the defence of definite interpretations.

Research on animal electricity in Paris before the Voltaic pile

In fact French scientists did not get very involved in Galvanism before 1801. In his big 1797 treatise, Humboldt mentioned almost no French contributions. If we look at the French chronicler of Galvanism, Pierre Sue, professor at the *Ecole de médecine*, who devoted more than 1500 (rather disorganised) pages to the subject, the French contributions published before 1800 are very few. Among the physicists who belonged to the galvanic commissions, Coulomb was involved in his own research programme on magnetism and was a long way away from physiological interests. The chemists did not react to Giovanni Fabbioni's paper on the chemical origin of galvanic phenomena published in 1799 in the *Journal de physique*. When the naturalist Geoffroy Saint-Hilaire published his memoir on the various electric fish, some of which he had studied during his Egypt expedition, he did not mention Galvani's and Lazzaro Spallanzani's studies.⁴⁰

Galvani's experiments were known in Paris in an indirect way, since his *Commentarius* seems to have been available in Paris only through Aldini in 1802, at a time when the leading French scientists were no

40. Giovanni Fabbioni, "Sur l'action chimique des différents métaux [...]", *Journal de physique*, 49 (1799), 348-357; Etienne Geoffroy Saint-Hilaire, "Sur l'anatomie comparée des organes électriques de la raie torpille, du gymnote engourdisant et du silure trembleur", *Annales du Muséum national d'histoire naturelle*, 1 (1802), 392-407.

longer interested in it.⁴¹ Volta's work was even less well known. Until 1797, when his *Letters to Gren* were published in the *Annales de chimie*, only a few vague allusions to his experiments and his position concerning the metallic origin of electricity in galvanic phenomena, were scattered in the periodic overviews by de Lamétherie for the *Journal de physique*. Volta did not come to Paris nor sent memoirs or letters.⁴² Certainly the political troubles and wars partly explain this absence, and the loosening of the relations between France and Italy. However, although Galvanism did not give rise to striking research from the leaders of the scientific community, independent research (outside the various galvanic commissions) was carried out either by physicians or by amateurs. Those who repeated and extended Galvani's experiments (apart from the *Académie's* commission and Val-li) were physicians in the Parisian hospitals and at the *Ecole de médecine*.⁴³

Many features made Galvanism attractive to physicians: from a therapeutic standpoint, a long-standing French interest in medical electricity, and the hope of finding a way to distinguish between "apparent" and "real" death; from a physiological standpoint, the perspective of new knowledge about nerve action or the determination of the relations and hierarchy between the heart and the brain.

Medical electricity had a long tradition in France, revived in the 1780s by protagonists offering a variety of professional profiles. The book by abbé Pierre Bertholon on the role of electricity in the human body and in illness had enjoyed considerable success and had been translated into English, German and Italian. It was Bertholon who popularised the expression "animal electricity" which Galvani adopted, quoting Bertholon several times in his 1791 memoir.⁴⁴ But we must also name Mauduyt de la Varenne, Sigaud de la Fond, the future revolutionary Jean-Paul Marat, the abbé Sans, Le Dru, Tressan, etc.⁴⁵ These men, most

41. The catalogue of the library of the *Institut* mentions "very rare book in France".

42. In January 1797 a letter addressed by Monge in Milan, describing Volta's experiments, was read at the *Institut* (*Procès-Verbaux*, 1, 162) and Volta's letters to Gren were (partly) published in *Annales de chimie*, 23 (1797), 276-313; 29 (1799), 91-93.

43. Larrey on an amputated leg, *Bull. Sc. Soc. Phil.*, 1 (mai 1793), 52; Sue, *Histoire du galvanisme* (ref. 2), 1, 69-71.

44. Pierre Bertholon, *De l'électricité du corps humain dans l'état de santé et de maladie* (Paris, 1780, 2nd edn. 1786).

45. Among the main writers on medical electricity one may note: C.N. Le Cat, *Traité de l'existence, de la nature et des propriétés du fluide des nerfs [...] musculaire* (Berlin, 1765); Abbé Sans, *Guérison de la paralysie par l'électricité* (Paris, 1778); F. Masars de Cazelles, *Mémoire sur*

of whom had practised medicine, worked from a therapeutic and often a general, overall perspective (electrification was directed towards general purposes). In contrast to the Italian anatomists, they did not usually carry out physiological experimentation on the relationship between electricity and nerve impulse. Of course, the condemnation of animal magnetism in 1784 and the setting aside of Marat and Nicolas-Philippe Le Dru by the academic community, had cast some discredit on medical electricity.⁴⁶ However, when Galvani's work became known in France, the practice of medical electricity still retained its medical and social significance. And on the eve of the invention of the Voltaic pile, there seemed to be a hope shared by all educated people that Galvanism would be the source of a significant progress in medicine.⁴⁷ Still in 1801, de Lamétherie commented favourably in his *Journal de physique* on a letter from the Italian Vassalli-Eandi describing the use of an electrometer (called «vitalitomètre») on the sick, to study the electrification caused by illness.⁴⁸

Electricity had also raised hopes in medicine as a possible way to distinguish between apparent and real death, or imperfect and absolute death. The article «Death» in the *Encyclopédie* insists on how cautiously absolute death should be proclaimed and shows how strong was the fear of hasty burial in the middle of the 18th century.⁴⁹ The article recounts the stories of a large number of people considered dead, some of them already in the grave, who had come back to life naturally or under various stimuli such as fire or even the scalpel of the anatomist. It was then considered highly desirable to find another absolute criteria of death to replace the beginning of putrefaction. The suggested use of

l'électricité médicale (Paris, 1780); J.-B. Bonnefoy, *De l'application de l'électricité à l'art de guérir* (Lyon, 1782); Nicolas-Philippe Le Dru, *Rapport de MM. Cosnier, Maloet, [...] Sur les avantages reconnus de la nouvelle méthode d'administrer l'électricité dans les maladies nerveuses* (Paris, 1783); P.-J. Mauduyt de la Varenne, *Mémoire sur les différentes manières d'administrer l'électricité* (Paris, 1784); Felix Vicq d'Azir, *Avis sur l'électricité médicale* (Paris, 1781); J.A. Sigaud de la Fond, *Lettre sur l'électricité médicale* (Paris, 1771); L. Tressan, *Essai sur le fluide électrique considéré comme agent universel* (Paris, 1786); Jean-Paul Marat, *Mémoire sur l'électricité médicale* (Paris, 1784); Thourri, *De l'influence de l'électricité sur le corps humain* (Lyon, 1796).

46. Sutton, "Electric medicine and mesmerism", *Isis*, 72 (1981), 375-392.

47. J.-B. Pujoulx, *Paris à la fin du XVIIIe siècle* (Paris, 1801), 115. This book was written a few months before the announcement of the battery.

48. Vassalli-Eandi, "Lettre à J. Buniva sur l'électricité animale", *Journal de Physique*, 51 (1800), 148-149 and Jean-Claude de Lamétherie, "Discours préliminaire", *Journal de Physique*, 52 (1800).

49. J.-J. Menuret de Chambaud, "Mort", in *Encyclopédie ou Discours raisonné des sciences, des arts et des métiers*, 10 (Neuchâtel, 1765), 718-727; on this question see Claudio Milanesi, *Mort apparente, mort imparfaite. Médecine et mentalités au XVIIIe siècle* (Paris, 1991).

the electrical discharge of a Leyden jar had already been made in the 1770s by a French physician who suggested the appointment of "verifiers of death" provided with electrical machines. At the same time, he added, the electrical machine - cheap and often owned by physicians - would allow them to bring round some asphyxiated, drowned or hanged people.⁵⁰ Galvanism renewed the hope of resuscitation with a technique even simpler than the electrical machine. When the *Institut* formed a commission on the problem of "hasty burials," it was the leader of the 1796 galvanic commission, Hallé, who was chosen as commissioner.⁵¹ After the battery was known, Hallé was requested by the government to report on the suggestion, made by the German Creve, to use electric current to distinguish between apparent and real death, and it was decided to construct batteries to resuscitate victims of drowning.⁵² In order to demonstrate the power of modern science in front of the ulemas at the Institute of Egypt, Gaspard Monge and Berthollet performed galvanic experiments on animals, suggesting the possibility of resurrection.⁵³

Galvanism also offered prospects for physicians in the field of physiology. Further advanced in French scientific literature than the controversy between Galvani and Volta's interpretations, was the controversy about the respective roles of the brain and of the heart in the transmission of sensations and of voluntary or involuntary muscular contractions. In one of his letters published in Paris as early as 1793, Valli had written that metals had no action on involuntary muscles and organs, meaning mainly the heart, the stomach and the intestines. Volta and others agreed, but some time later a French physician in Italy sent a letter from Felice Fontana claiming that Galvanism was indeed active on the heart.⁵⁴ Faced with this contradiction, the Parisian physician J.J. Sue tried metals on beheaded animals, whereas Bichat did the same on decapitated humans supplied by the guillotine, in order to see whether life could continue in the heart (and the other organs)

50. P.N. Changeux, "Lettre concernant un agent par lequel on peut s'assurer sans un long délai de la mort véritable des individus attaqués d'asphyxie", *Observations sur la physique*, 10 (1777), 197-200; Changeux, "Lettre contenant la confirmation des avantages de l'électricité dans les asphyxies", *Observations sur la physique*, 15 (1780), 74-76.

51. *Procès-Verbaux*, 1, 505 (26 déc 1798).

52. Sue, *Histoire du galvanisme* (ref. 2), 3, 44.

53. Francois Arago, *Oeuvres complètes*, 2 (Paris, 1854), 541: "Monge".

54. Valli, "Huitième Lettre sur l'électricité animale", *Observations sur la physique*, 41 (1792), 435-437; R.N. Desgenettes, "Lettre à J.C. de La Métherie", *ibid.*, 42 (1793), 238-239.

without the brain, or in the brain without the rest of the body.⁵⁵ According to J.J. Sue, the fact that the sensitivity of the muscles to Galvanism lasted several hours after decapitation, and other facts such as the existence of children without a brain, led to the idea that the guillotine was probably not the painless, almost humanitarian and efficient instrument it was claimed to be.⁵⁶ But according to Xavier Bichat, the heart was not sensitive to Galvanism after death. The controversy remained open. At stake was the seat of vitality, a leading question in physiology. These galvanic experiments led to doubts about the localisation of such a seat of vitality, and suggested that the human body should be considered as an integrated whole, of which the brain and the heart are only a part.

Physiological and medical researches with the Voltaic pile

When the Voltaic pile was presented at the *Institut* in August 1800, it was considered an experiment which was "basically no more than a remarkable increase of the one with two metallic pieces," i.e. Galvani's experiment.⁵⁷ The pile did not seem to involve a break with Galvanism. Actually the various new phenomena produced by the pile - the decomposition of water, the electrical attractions, etc. - were still called "galvanic", although no organic part was involved. We must also remember that *all* the experiments described by Volta, in his 1800 letter to the Royal Society about the pile, belonged to physiology, and that at the end of his paper he made the prediction that "there is much here to occupy the anatomist, the physiologist and the physician."⁵⁸

Indeed it was a physician from the French army in Italy, who had seen Volta speaking before his battery in Italy, who presented the first replication of a Voltaic pile, called a "torpedian apparatus," at the *Institut* in September 1800.⁵⁹ It was to a naturalist - Dieudonné Dolomieu -,

55. See Sue, *Histoire du galvanisme* (ref. 2), 1, 101-108; 2, 216-229; J.J. Sue, "Recherches physiologiques et expérimentales sur la vitalité", *Journal de Physique*, 46 (1798), 226-235.

56. J.J. Sue, *Opinion de J.-J. Sue sur la douleur qui survit à la décollation* (Paris, 1803). On this question see also Gerard Rudolph, "En marge de la Révolution : le Galvanisme", in *Scientifiques et Sociétés pendant la Révolution et l'empire* (Paris, 1990), 357-381 and D. Arasse, *La guillotine et l'imaginaire de la terreur* (Paris, 1987).

57. *Bull. Sc. Soc. Phil.*, 2 (1800), 144.

58. Alessandro Volta, "On the Electricity excited by the mere contact of conducting Substances of different kinds", *Philosophical Transactions of the Royal Society of London*, 90 (1800), 429.

59. *Procès-Verbaux*, 2, 224.

that Volta sent his letter about his portable pile.⁶⁰ And it was at the *Ecole de médecine*, as already mentioned, that the first important Voltaic pile was set up in Paris for the experiments, aimed "at the art of healing," carried out by Hallé, professor at the *Ecole*, for the 1800 Commission of the *Institut*. In particular, Hallé compared the therapeutic effect of the pile to that of the Leyden jar. The *Ecole de médecine* had a tradition in the practice of medical electricity with the six thousand observations made by Le Dru in the 1780s.⁶¹ And this interest of the *Ecole de médecine* in electricity did not vanish afterwards, since in the 1820s the pile of the *Ecole de médecine* was still the most powerful in Paris.

Out of physiological interest, the action of the electric current was tried out on every animal and human organ. The controversy about the sensitivity of the heart to Galvanism, still denied by Aldini, was considered to be solved by the physician Pierre-Hubert Nysten, who managed to stimulate the heart of a guillotined man in a grave, with his pile, several hours after his death.⁶² All the physiological liquids were submitted to the pile and the fibrine of blood exhibited regular contractions.⁶³ To sustain the galvanic interpretation of the pile, the physician Lagrave built up a pile with slices of muscle and slices of brain. From 50 couples onwards, he felt an acid taste when joining the two ends of this "organic pile" with metallic wires.⁶⁴ Those experimenters who had not been convinced by Volta's theory - "the conversion was not general" said one of them - received the support and the encouragement of Aldini during his stay in Paris in 1802. Aldini performed experiments on various large animals at the veterinary school and showed again the fundamental experiments on contractions without metal.⁶⁵ Although his book on Galvanism was published in French, in Paris, and dedicated to Napoléon, the *Institut* was rather

60. Lettre de Volta à Dolomieu, July 2, 1801, Archives de l'Académie des sciences, Dossier Volta; *Bull. Sc. Soc. Phil.*, 3 (1801), 48.

61. Izarn, *Manuel du galvanisme* (ref. 37), xii.

62. Pierre-Hubert Nysten, *Nouvelles expériences galvaniques faites sur les organes musculaires de l'homme et des animaux à sang rouge* (Paris, 1802).

63. Sue, *Histoire du galvanisme* (ref. 2), 3, 271; G.-F. Circaud, "Influence galvanique sur la fibrine du sang", in J.J. Sue, *Recherches physiologiques et expérimentales sur la vitalité et le galvanisme* (3rd edn., 1803), 83 and *Journal de Physique*, 55 (1802), 402-403, 468-70; C. Larcher-d'Aubancourt et al., "Observations chimiques [...] sur différents liquides animaux soumis à l'action galvanique", *Annales de chimie*, 45 (1803), 193-205.

64. Lagrave, "Expériences tendantes à prouver que les lois du galvanisme semblent différer de celles de l'électricité", *Journal de Physique*, 56 (1803), 233-236.

65. Nysten, *Nouvelles expériences galvaniques* (ref. 62); Aldini, *Essai sur le galvanisme* (ref. 34).

contemptuous of his results. According to Biot and Hallé's report, Aldini's experiments were easily explained by Volta's theory, the contact between two heterogeneous substances creating the same effect, only weaker, as the contact between two metals. Biot and Hallé even expressed scepticism about the electrical nature of the contraction produced by the contact between a nerve and a muscle.⁶⁶

Other physicians, especially the members of the *Société galvanique* who followed the German physicians, tried the pile out on blind, deaf, drowned, paralytic and mad people, etc.⁶⁷ One of them even died by experimenting on himself.⁶⁸ They drew cautious conclusions when faced with what they called the German "collective fever." The discredit raised by alleged miraculous cures and by some endeavours to unite Galvanism and volcanism, earthquakes, the dowsing rod and even animal magnetism, reflected badly on physiological research into the relations between electricity and physiology. However, when a physico-mathematician like Biot alluded to Galvanism in his historical sketch of the sciences during the revolution, he did not mention the pile but the link "to the most important phenomena of death and life."⁶⁹ And when Napoléon had the decomposition of an alkali by the pile repeated at the Tuileries, in the company of Monge, Berthollet and Chaptal, he is said to have commented: "Here is the image of life: the spinal column is the pile, the liver is the negative pole, the bladder is the positive pole."⁷⁰ Finally, the vague assumption of a link between Galvanism and vital process remained strongly in the cultural background, even for those who thought they had reduced Galvanism to physics.

66. *Procès-Verbaux*, 2, 579-581; "Extrait d'un mémoire du c. Aldini sur le galvanisme", *Bull. Sc. Soc. Phil.*, 3 (1802), 157.

67. Sue, *Histoire du galvanisme* (ref. 2), 2, 384-394, 438; 3, 45-49, 58-66, 71-78; 4, 216-223; *Journal du galvanisme*, 1 (1803), 66, 126, 204, 207; *Journal de Physique*, 56 (1802), 159-60; Biot and Hallé, "Rapport sur le Mémoire de M. Aldini concernant le galvanisme", in *Procès-Verbaux*, 2, 580-1; J.B. Thillaye, *Essai sur l'emploi médical de l'électricité et du galvanisme* (Paris, 1803); J.J. Sue, *Recherches physiologiques et expérimentales* (ref. 63), 82; Sirol, *Galvani et le galvanisme* (ref. 4), 200-208.

68. According to Le Bouvier-Desmortiers, *Examen des principaux systèmes sur la nature du fluide électrique et sur son action dans les corps organisés et vivants* (Paris, 1813), 325, Gautherot died through applying the current of the battery on himself.

69. Biot, *Essai sur l'histoire générale des sciences* (ref. 8), 19.

70. Antoine-César Becquerel, *Traité expérimental de l'électricité et du magnétisme*, 1 (Paris, 1834), 108.

From discredit to rehabilitation

Biot - together with the French physicists - considered that his experimental work definitely supported Volta's interpretation and gave the *coup de grâce* to animal electricity. His *Notice on the present state of knowledge about galvanism*, read at the *Institut* in June 1803, began with these words: "One will perhaps be surprised that I am still going to speak about Galvanism."⁷¹ At the same time, the historian Pierre Sue was still more radical: "One has been much engaged in Galvanism. Soon no doubt, one will speak no more about it." Galvanism, Sue went on, like Mesmerism, Perkinism (a way of curing by the application of metallic rods) and so many other inventions which quacks managed to make money with, will fall into oblivion unless it provides resources against diseases.⁷²

Discredit of the medical outcome of animal electricity also touched its author Galvani. His first *éloge* by the physician Jean-Louis Alibert praised at length his experimental abilities as an anatomist, his religious feelings, his teaching, etc. But what subsequent historians would retain from Alibert was the stress on the part played by chance in Galvani's discoveries, especially the legend of the frog soup prepared for his sick wife. Moreover, Alibert cast doubts on Galvani's knowledge of electricity. The first frogs' contractions described by Galvani - on his table an electrical machine was put "by chance" - could easily have been explained by the current theory of electricity (electrical influences) and should not have astonished a keen observer. Alibert repeatedly criticised the conclusions Galvani had drawn from his experiments and denigrated his theoretical conclusions about the existence of an animal electricity: "As Galvani proceeded from false principles, it was not long before his theory collapsed."⁷³ Indeed Alibert had been involved in the debate. He had conducted experiments with the German physicist Pfaff, a determined opponent of animal electricity, and had adopted his conclusions.⁷⁴ However, the legend about the frog soup and Galvani's ignorance in electricity were revived by Francois Arago and subsequent historians of physics. The doubts expressed by the *Société galvanique*

71. Sue, *Histoire du galvanisme* (ref. 2), 4, 142.

72. *Ibid.*, 149; 2, 440, 372.

73. Jean-Louis Alibert, *Eloge historique de Louis Galvani* (Paris, an X); republished in *Eloges historiques composés pour la Société de médecine de Paris*, 4 (Paris, 1806), 187-338. This book was already published during Volta's stay in Paris in Oct-Dec 1801.

74. *Ibid.*, 250, 276.

about this legend could not undermine Arago's prestige and authority as perpetual secretary of the First Class of the *Institut*.⁷⁵

When, around the 1840s, the hypothesis of animal electricity was restored to life by physiologists - mainly Carlo Matteucci and Emil Du Bois-Reymond - the perception of Galvani's work changed again. Galvani's scientific papers and some manuscripts were published with a laudatory introduction by the Italian physicist Silvestro Gherardi. Relying on these texts, Matteucci stated that Alibert, and all the historians who had repeated his allegations, should no longer be trusted. The new version was that Galvani knew the theory of electrical influences very well and had been working on frog physiology for years when he published his *Commentarius*. A new biography of Galvani was published in the main French scientific journal, the *Annales de chimie et de physique*.⁷⁶ There, physicists and chemists learned that Galvani had been driven by a long-term research programme on the relations between nervous excitability and electricity and that he had classified the various metals according to their galvanic action before Volta. Even his analogy between the muscle/nerve entity and the Leyden jar, so much criticised in his time, was said to be confirmed by the latest discoveries in electrophysiology. Where before, Galvani had been known as an ingenious dreamer, or rather had been completely unrecognised, henceforth, stated his new biographer Gavarret, he should be praised not only for his experimental skills but also for his theoretical intuitions. This new vision of Galvani's achievement prompted Antoine-César Becquerel, one of the leading French physicists of the middle of the century, to change his presentation of Galvani between the 1834 and 1858 editions of his history of electricity.⁷⁷

The great populariser of "Les merveilles de la science," Louis Figuier, afterwards gave a very positive image of Galvani in the middle of the century.⁷⁸ He denounced the frog soup as "a ridiculous anecdote," praised Galvani's *Commentarius* as "a remarkable work of clarity,

75. Arago, *Oeuvres complètes* (ref. 53), 1, 212: "Volta".

76. Carlo Matteucci, *Traité des phénomènes électro-physiologiques des animaux* (Paris, 1844), 5-7; J. Gavarret, "Etude sur les recherches électro-physiologiques de Galvani", *Annales de Chimie et de Physique*, 25 (1849), 58-82.

77. Becquerel, *Traité expérimental* (ref. 70), 1, 83; Becquerel, *Résumé de l'histoire de l'électricité et du magnétisme* (Paris, 1858), 29.

78. Louis Figuier, "La pile de Volta" in *Exposition et histoire des principales découvertes scientifiques modernes* (Paris, 1852), 5th edn. (Paris, 1858), 280-322; republished in *Les merveilles de la science*.

precision, method and style" (supposedly specifically French qualities) and asserted that it had been a great mistake to belittle Galvani's genius beside Volta's. On the contrary Figuiet underlined the weaknesses of Volta's reasoning, and the inaccuracy of his fundamental experiment on the electricity excited by the mere contact between two metals. In his famous 1800 paper, Figuiet added, Volta had described only experiments which can "strike the eyes of a vulgar experimenter." Moreover, Volta noticed neither the chemical effects, nor the quick lowering of the battery, nor the decomposition of water, nor the fact that the polarity did not depend on the extreme plates. And Figuiet concluded by encouraging scientists to study the electrical nature of nerve impulse.

Galvani even became a potential hero for a play. The writer-engineer Antoine Andraud, one of the pioneers of scientific theatre, tried to dramatise electricity. Galvani allowed him - in the same play - to link two main facts of the end of the 18th century: Galvanism and the conquest of Italy by Bonaparte.⁷⁹ In studying this episode, Andraud discovered that "science, far from being irrelevant to politics, should, on the contrary, be intimately linked to it." In the play, while Galvani is looking for the secrets of life in the electricity within bodies, his son is at the head of a conspiracy against Austria. When his son is killed, Galvani restores him to life with an electrical discharge, allowing him just enough time to accuse his murderer. But the same discharge strikes down the young lady his son was in love with. Although Galvani's character is ambiguous (he also shares characteristics with the hero of *Frankenstein*), the play shows that Galvani was well-known through Figuiet to the Parisian audience.

Conclusion

The attitude of French *savants* towards research on Galvanism reveals clearly that they considered it their function to register and check up on European scientific production. Whether they were driven by their belief of being in the forefront of scientific production, by the organisational structure of the Academy, by the cultural framework of the revolutionary committees or by Bonaparte's ambition, they claimed

79. Antoine Andraud, *Théâtre scientifique. Electricité. Galvani. Drame en cinq actes suivi de notes scientifiques* (Paris, 1854), vii; on this play see D. Raichvarg, *Science et spectacle. Figures d'une rencontre* (Nice, 1993), 94-95, 154-155.

to pass judgement on science wherever it came from, even if they had not personally worked in the field in question. This claim aroused the criticisms of foreign scientists. Thus for the German Ludwig Wilhelm Gilbert, editor of the *Annalen der Physik*, "those (members of the *Académie*) appropriated, in a way, the right to maintain or to reform the physical sciences and their principles."⁸⁰ As we have noted, however, French scientists were far from insensitive to the strength of conviction of successive foreign visitors - Valli, Humboldt, Volta or Aldini - who personally performed experiments and defended their interpretations in Paris laboratories and before the Academy. The about-faces of de Lamétherie, the editor of the *Journal de physique*, are especially remarkable.⁸¹ As long as they were not personally committed to one camp or another, the French more or less followed the interpretation of the last performer.

Another striking characteristic of French scientists is their trust in collective research. In England, in Germany and perhaps to a lesser extent in Italy, scientists carried out their research from individualist and competing viewpoints. Most of the experiments on Galvanism in Paris, as we have seen, were carried out by several men together, often physicists, chemists and physicians at once, whether in the academic commissions, at the *Ecole de médecine* or at the *Société galvanique*. Of course Galvanism seemed especially to require such an pluridisciplinary approach, because of its relations with electricity, with chemical decomposition and with physiological phenomena. But we know that collective analysis was a standard practice at the Academy and that it framed the practice of other scientific societies. One could think that in this respect, Galvanism would have led to a common ground for emergent scientific disciplines. In fact it seems, on the contrary, that it led to a hardening of boundaries between disciplines. This contrasts with Germany where, according to Henrik Steffens, with Galvanism "isolated theories faltered [...], theories of chemistry, electricity and magnetism which would be separated from each other and closed in themselves began to lose all meaning."⁸²

80. Ludwig Wilhelm Gilbert, «Lettre à la classe des sciences mathématiques et physiques sur divers objets de physique et de chimie», *Annales de Chimie et de Physique*, 69 (1809), 266.

81. *Observations sur la physique*, 42 (1793), 12, 293; *Journal de physique*, 46 (1798), 468, 37-4; 48 (1799), 18-20; 54 (1802), 15-25; 56 (1802), 27.

82. Quoted in Stuart Strickland, "Galvanic disciplines: the boundaries, objects and identities of experimental science in the era of Romanticism", *History of science*, 33 (1995), 450.

A last point I would underline concerns the strength and the consequences of the break between amateurs and the members of the Parisian academic community. As long as attention is focused mainly on the leading scientists, who played a part only after 1801, the battery seems to represent a great break in the history of Galvanism. Seen from the point of view of physicians and amateurs, this discontinuity almost vanishes. From a cognitive standpoint, the battery was for them nothing more than a multiplication of galvanic effects, and from a practical standpoint the questions posed by its physiological actions (the difference between apparent and real death or the role of the heart in the organism) were the same as those posed by the galvanic or even ordinary electrical stimuli. Galvanic phenomena were accessible to many amateurs, and some, such as Gautherot in his work on the chemical origin of the electric current in the pile, made quite valuable contributions to knowledge of them, but the break between amateurs and academics made these contributions almost forgotten in subsequent history.