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Eye, Mind, Hand. Filippo Pacini's microscopy

Abstract

While Filippo Pacini (1812-1883) remained throughout his life a rather isolated researcher, constantly struggling against obstacles of all kinds – and also hindered by his bad character –, a solemn celebration was held *post mortem* in his honor. At that time his many merits were praised by a good number of distinguished colleagues, and his reputation redeemed. This essay attempts to show how his work as an anatomist and microscopist was always been based on the primacy of the visual, which enabled him to identify specific objects – such as the tactile corpuscles or the cholera vibrio – and to give them essential meaning.

Keywords

Microscopic anatomy, Filippo Pacini, organs of touch, electric fishes, 19th century cholera

“...per giudicare e convenire di una cosa, altro è sentirla raccontare, altro è vederla coi propri occhi (avendo però buona vista, e pratica sufficiente nell'uso degli stromenti ausiliari), onde esaminarla nelle sue diverse contingenze e particolarità, per venire ad una induzione capace di rendere conto della causa che possa averla prodotta...”

Filippo Pacini, *Osservazioni microscopiche e deduzioni patologiche sul cholera asiatico* (Firenze: Tipografia di Federigo Bencini, 1854), p. 25.

1. Posthumous celebration

A couple of years after his death, which occurred on July 9th 1883, a few physicians practicing at the Hospital of Pistoia formed a committee of citizens to honor Filippo Pacini. During the ceremony, a procession moved from the central square of the town, with a musical band playing a symphony specially composed, and all the authorities, local associations, editors or correspondents of a dozen newspapers. A marble bust was inaugurated, while in the town hall a plaque listed the main results achieved by him, as a distinguished anatomist and physician, apostle of microscopy in Italia, discoverer of Pacini's corpuscles, inventor of a method of

artificial respiration, investigator of osmotic processes and of the laws of the cholera process.¹

Quite a number of medical schools, academies, libraries sent their participation, including two Florentine Masonic lodges – Pacini had been part of the Loggia Concordia since 1862, although buried in a Catholic ceremony – and the Società per la cremazione recently founded in Florence. At that time the practice of cremation was part of the lively and multifaceted campaign made in Italy by the hygienic movement.² In succession, there were hagiographic speeches by local notables: one of them pompously reminded that, although natural phenomena do appear to many observers, only to a select few – among whom Pacini had to be placed – they reveal their importance and meaning.³ Another speaker remarked that, despite his relevant findings, he remained throughout his life an isolated researcher, constantly and sadly forced to struggle against obstacles of all kinds: indeed, this was the refrain – solitude

¹ *Onori parentali a Filippo Pacini* (Pistoia: Tip. Cino dei Fratelli Bracali, 1886). The plaque reads:

Onori parentali a Filippo Pacini
Insigne anatomico e medico
Apostolo della microscopia in Italia
Scuopritore dei corpuscoli cutanei
Che si indissero dal suo nome
Inventore di un metodo di respirazione artificiale
Studioso dei fenomeni osmotici e delle leggi regolatrici il processo morboso del colera
asiatico
Vanto
della città natale
della scuola medica fiorentina
del mondo scientifico

The *Dictionary of Scientific Biography* has an entry about Pacini, by Pietro Franceschini, while the only article in English – as far as I know – is by Marina Bentivoglio and Paolo Pacini, “Filippo Pacini: A Determined Observer”, *Brain Research Bulletin*, 1995, 38: 161-165. An exhibition was held in Pistoia (September-October 2012) on the occasion of the bicentenary of his birth, under the scientific responsibility of Donatella Lippi: *Un pioniere della scienza medica a Pistoia. Vita e scoperte di Filippo Pacini (1812-1883)*. I would like to thank her for the help she gave me in finding some images. A rich and largely unexplored mine is the Fondo Pacini owned by the Biblioteca Nazionale Centrale (Florence) and composed by 23 volumes of various kinds of documents: see Aurelio Bianchi, *Relazione e catalogo dei manoscritti di Filippo Pacini* (Roma: presso i principali librai, 1889). Some minor material can also be found in the archive of the Museo Galileo (Florence).

² For a recent and brief overview on the topic see Alessandro Porro et al., “Modernity in medicine and hygiene at the end of the 19th century: the example of cremation”, *Journal of Public Health Research*, 2012, 1: 51-58; some information also in Claudio Pogliano, “L’utopia igienista (1870-1920)”, in *Storia d’Italia. Annali 7. Malattia e medicina*, edited by Franco Della Peruta (Torino: Einaudi, 1984), pp. 623-626.

³ Discorso letto dal Prof. Senatore Francesco Magni, in *Onori parentali a Filippo Pacini* (cit. note 1), pp. 15-16.

and conflict – that echoed throughout the ceremony and established a successful, lasting interpretive pattern.

The star of the event held in Pistoia was Jakob Moleschott, at that time professor of Physiology at the University of Rome and a prominent figure in Italian culture after the unification. In his speech he recalled that, when the Minister of Education Francesco De Sanctis had hired him in 1861 to teach at the University of Turin, Pacini was one of the first colleagues who gave him a prompt and warm welcome. Now, for the occasion, he collected and presented to the town of Pistoia more than twenty tributes sent by distinguished scientists from all over Europa: among them Koelliker, Ludwig, Marey, de Quatrefages, Pasteur, Wundt, Du Bois-Reymond, Retzius.

In his testimony Angelo Mosso, who had inherited Moleschott's chair in Turin, argued that it would have been a splendid epoch for the "Risorgimento" of biology and medicine in Italy, if other people like Pacini had learnt to use the microscope with equal skill, when Giovanni Battista Amici was building the best optical instruments ever existed.⁴ For his part Cesare Lombroso wrote a very short comment that sounds somewhat ambivalent : Pacini's genius was attested by the seal typical of every genius, namely the hatred of the mediocres he had suffered in life, and the fetish adoration after his death.⁵ Wilhelm Krause, professor at the University of Göttingen – who had discovered and described in 1860 the cutaneous thermoreceptors – referred that in his own courses,

Wenn ich an die Lehre von den Nervenendigungen komme, spreche ich zuerst von den Pacini'schen Koerperchen. Dabei erzaehle ich in jeden Semester, dass Pacini als Student, mit einem kleinen nicht-achromatischen Microscop mit Holztubus, wie es auf den Jahrmaerkten verkauft wird, die nach seinem Namen benannten Koerperchen entdeckte; sie sind die Ausgangspunkt unserer ganzen heutigen Lehre von den Endigungen sensibler Nerven geworden. Die Auseinandersetzung pflege ich mit den Worten zu schliessen: 'Sie sehen meine Herren, dass nicht das Instrument, sondern der Beobachter es ist, welche die Entdeckung machen. Nehmen Sie sich in Beispiel daran!'"⁶

Indulging in the rhetoric of the Italian precursor, typical of the nation building then in progress, the Italianized Moleschott put him in a list of illustrious men of science: without Galileo, no Newton; without Cesalpino, neither Harvey or Linnaeus: without Francesco Redi, no Darwin; without Felice Fontana, no Humboldt; and finally, no

⁴ *Onori parentali a Filippo Pacini* (cit. note 1), pp. 161-162.

⁵ "A provare il genio di Pacini non mancò nemmeno quel suggello fatale di tutti i grandi intelletti – che è l'odio dei mediocri in vita – e l'adorazione feticia (*sic*) dopo morte", in *Onori parentali a Filippo Pacini* (cit. note 1), p. 125.

⁶ *Onori parentali a Filippo Pacini* (cit. note 1), pp. 121-122.

Robert Koch without Pacini.⁷ However, he had received little acclaim in life and at home; never inclined to compromise, an inflexible and morally austere character.

It is noteworthy that Pacini left Tuscany only once for a short trip to Turin in 1861, as commissioner of an examination, where he felt embarrassed in front of hotel waiters who did not understand his pure Tuscan language. When the Italian government decided to send a few University professors to Vienna, for a mission aimed at updating their knowledge, Pacini hesitated to accept the invitation to join, because of his family situation that would not allow him to get away from Florence, and therefore was not included in the group. For most of his life he had to take care of two sick sisters – one of them mad and then hospitalized – and of a nephew: a continued commitment that always limited him in many ways.

2. “New organs” discovered

Rather maliciously – given the particular meaning of that term in his lexicon – Lombroso evoked the “genius” of Pacini. He could have added that his genius had been precocious, if it is true that, being the son of a poor cobbler and still an adolescent studying at the Collegio Forteguerra in Pistoia, Pacini had the idea to catch and fix by chemical means images in their lights and shadows. It seems that he made experiments some ten years before Daguerre announced his new technique.⁸ His precocity found a favorable environment at the medical school in Pistoia, an institution that already had a long history marked by the recurrence of good teachers and by a valuable connection with the city hospital, the Ospedale di Santa Maria del Ceppo, founded in the 13th century.⁹ There, a “great vocation for the corpse” grew in him – as an early biographer wrote¹⁰ – and he soon began to spend much time watching dissections and dissecting himself.

⁷ “O non è vero forse che senza Galileo non sarebbe Newton, e senza Cesalpino non sarebbero né Linneo né Harvey, come senza Francesco Redi non avremmo Darwin, né Alessandro von Humboldt senza Fontana, né senza Filippo Pacini Roberto Koch?”, in *Onori parentali a Filippo Pacini* (cit. note 1), p. 91.

⁸ The episode – that confirms the “precursor” *cliché* – is told by Francesco Leoncini, “Un documento inedito su Filippo Pacini”, *Bollettino dell’Accademia Medica Pistoiese “Filippo Pacini”*, 1937, 10: pp. 3-8, p. 6, and by Manuela Maggini Arreghini, *Nel paese di Galileo. Vita di Filippo Pacini* (Poggibonsi: Lalli, 1987), pp. 9-10.

⁹ See Enrico Coturri, *La scuola medico-chirurgica dell’Ospedale del Ceppo* (Pistoia: Società pistoiese di Storia patria, 1983).

¹⁰ “...e senti nascere nell’animo suo gran vocazione per il cadavere”: Angiolo Filippi, *La storia della Scuola Medico-Chirurgica Fiorentina. Opera postuma compilata di sugli appunti e spoglio di documenti del figlio Eduardo* (Siena: Tip. S. Bernardino, 1927), p. 69.

A particular anatomical formation in the human hand fell under his eye towards the end of 1831 – at age 19 – and the following decade was mainly devoted to the best interpretation of what he had seen at the sides of the digital branches of median nerve. There was something that looked like an aggregate of small eggs, visible to the naked eye, but totally ignored by anatomy. Nobody had given attention to those corpuscles, at best considered as lumps of fat; nowhere in the medical textbooks the young Pacini could find any functional explanation of the curious organs which he noticed with a particular emphasis and even suspected to be related to the nervous system.

However, his intuition had to be supported by further observation and experiment. Since no microscope was yet used or available at the medical school in Pistoia, Pacini bought himself a small wooden one, quite rudimentary, on the banks of a fair. It took almost four years to communicate the history of his discovery to the Società medico-fisica of Florence, although without provoking any reaction, even despite the publication of the same report in a journal, where he proposed to call “ganglii del tatto” the new organs.¹¹ As the announcement remained buried in the pages of the *Nuovo Giornale dei Letterati*, Pacini decided to maintain momentary silence in order to better verify his findings and to check their originality: he considered as a social duty of any authors, especially scientific, to consult all the available works before announcing a discovery, in order to avoid embezzlement and plagiarism, although unaware.¹²

So he happened to learn from the *Anatomie descriptive* published in 1834-1836 by Jean Cruveilhier that the same organs had been recently noticed by three young French anatomists¹³, who, however, did not give them any physiological meaning.

¹¹ Filippo Pacini, “Sopra un particolare genere di piccolo Corpi Globulari scoperti nel corpo umano (Relazione alla Società medico-fisica di Firenze, letta nell’Adunanza del 22 novembre 1835)”, *Nuovo Giornale dei Letterati*, 1836, 38: pp. 109-113.

¹² “Io ho sempre riguardato per dovere sociale di uno scrittore, specialmente in fatto di Scienze, il consultare tutte le opere relative che trovinsi almeno a sua disposizione, prima di annunziare una scoperta per propria, onde non porsi nel caso di usurpare, quantunque insaputamente, ciò che appartiene ad altrui, come per non incorrere nella vergognosa taccia di plagiatario (...) io non omisi alcuna ricerca, onde assicurarmi che fino a quell’epoca nessuno avesse pubblicato alcuna cosa in proposito”: see Filippo Pacini, *Nuovi organi scoperti nel corpo umano* (Pistoia: Tipografia Cino, 1840), p. 14.

¹³ “Les rameaux qui fournissent à la face palmaire des doigts présentent une disposition fort remarquable, qui consiste dans la présence de corpuscules grisâtre, gangliformes, d’une forme constante en croissant.” In a note, Cruveilhier informed that “cette disposition a été signalée dans un des dernier concours d’aides de la faculté par MM. Andral, Camus et Lacroix, qui avaient à préparer les nerfs cutanés de la main”: see Jean Cruveilhier, *Anatomie descriptive* (Paris: Bechet jeune, 1836), t. 4, p. 822.

Consequently, in 1840 Pacini claimed to himself the merit of having first and fully recognized them as special organs, and named them “ganglii del tatto” because of their peculiar structure and function, as if they were squeezed by the pressing hand, and so transmitted their humor through the nervous tubules.¹⁴

In the meantime, Pacini took his medical and surgical qualifications at the University of Pisa, where he had moved since 1837. Being the main university town in Toscana, Pisa hosted the first congress of Italian scientists in 1839, a major and successful event – supported by the Grand Duke Leopold II – that would have followed up with eight other meetings in different cities up to 1847.¹⁵ Pacini resolved to communicate his discovery to the section of zoology and comparative anatomy, chaired by the naturalist Prince Carlo Luciano Bonaparte; on October 4th he read a brief memory, “accompagnata da disegni” about the new organs. The proceedings report that he would have also wanted to show them on a corpse and with a microscope, but Bonaparte considered more appropriate to address his demonstration to the section of medicine. As a matter of fact, on October 9th its president, Giacomo Tommasini, informed that the young doctor was going to demonstrate “alcuni nuovi corpicelli organici da lui scoperti lungo i nervi della mano”. A committee of four members was appointed, and their verdict left Pacini quite disappointed: according to them, the existence of those organs was undeniable, but they could also be simple “espansioni tendinee-aponeurotiche”, something inessential and substantially negligible.¹⁶

The recognition that some Italian colleagues had denied him during the first congress of 1839, came to Pacini from abroad in 1843, when Lucca hosted the fifth congress of scientists. Jacob Henle, who at that time taught anatomy in Zurich, had

¹⁴ “E fu appunto per averli riconosciuti quali organi speciali, ch’io proposi denominarli *ganglii del tatto* (...) io aveva fin da principio riconosciuta nei medesimi una specifica e particolare struttura, e prevedute coi nervi del tatto relazioni tali, sicché la loro funzione fosse (...) *originata dalla resistenza che oppone il corpo che si tocca*; quasi che questi organi posti a contrasto con la mano che preme, ed il corpo che resiste, fossero spremuti, e tramandassero per mezzo di canali entro il nevrilema, ed entro i tubuli nervosi quell’umore che essi contengono, onde favorire in qualche modo la funzione del tatto”: Filippo Pacini, *Nuovi organi scoperti nel corpo umano* (cit. note 12), p. 20.

¹⁵ See Maria Pia Casalena, *Per lo Stato, per la Nazione. I congressi degli scienziati in Francia e in Italia, 1830-1914* (Roma: Carocci, 2007); Marco Meriggi, *Prove di comunità. Sui congressi preunitari degli scienziati italiani*, in Francesco Cassata, Claudio Pogliano (a cura di), *Storia d’Italia. Annali 26. Scienze e cultura dell’Italia unita* (Torino: Einaudi, 2011), pp. 7-35; Ernesto Capanna, *Eran Quattrocento. Le Riunioni degli scienziati italiani (1839-1947)* (Bologna: Clueb, 2011).

¹⁶ *Atti della prima riunione degli scienziati italiani tenuta in Pisa nell’ottobre del 1839* (Pisa: Tipografia Nistri, 1840), pp. 181, 233, and 256.

written a letter to Prince Bonaparte, once again one of the leaders of the sociable event. The German anatomist expected that Pacini's discovery, announced in 1839 and published in 1840 under the title *Nuovi organi scoperti nel corpo umano* – also accompanied by three plates (**fig. 1-2: tavole e cera**) – would have changed the theory of the elementary structure of the nervous system.¹⁷ In fact, it happened that his young Swiss prosector Albert Kölliker had not only confirmed the existence of those peculiar corpuscles both in man and in many mammals, but also noted that each strand connecting the corpuscles to the nerves contains a single fiber which penetrates the nerve and runs until its peripheral end. In his letter Henle declared to be highly grateful to the discoverer, and proposed using the term *Corpuscula Pacini* in his honor.¹⁸

For some reason Pacini was not attending the meeting of September 22th, that finally did him justice. One week later, however, he read before the congress a note, first of all to thank Henle and Kölliker for having taken his new organs under the protection of their authority, and to hope for the Italian translation of their memory *Ueber die Pacinischen Körperchen an den Nerven des Menschen und der Säugethiere*, that would be published in Zurich. He gave further information about the intimate structure of the corpuscles and answered some questions posed by the naturalist Paolo Savi, still rather incredulous about their nervous function.¹⁹ A few months later, in March 1844, Pacini received a letter from Lorenz Oken, professor of natural history in Zurich, who informed him (in a rather imperfect Italian) about the publication of the brochure by Henle and Kölliker, which described his corpuscles and would hopefully repair the wrong done to him in Italy.²⁰ It is worth noting that

¹⁷ Filippo Pacini, *Nuovi organi scoperti nel corpo umano* (cit. note 12).

¹⁸ “Prosegue l’Henle a narrare che unitamente allo stesso Kölliker vide il nervo mutar natura poco dopo la sua inserzione nel corpuscolo, divenir cioè piatto e sottile da cilindrico e grosso, perdere i suoi contorni opachi, impallidire. (...) Dichiarando in fine di essere altamente riconoscente della scoperta del Pacini, promette una memoria su tale soggetto, e propone siano denominati *Corpuscula Pacini* quegli organi, ad onore di chi primo li discoperse.”: *Atti della quinta unione degli scienziati italiani tenuta in Lucca nel settembre del MDCCCXLIII* (Lucca: dalla Tipografia Giusti, 1844), p. 389.

¹⁹ *Atti della quinta unione degli scienziati italiani tenuta in Lucca nel settembre del MDCCCXLIII* (cit. note 16), pp. 439-442. See also a brief reference to the episode in Ernesto Capanna, *Eran quattrocento. Le Riunioni degli scienziati italiani 1839-1847* (cit. note 15), pp. 139 and 142.

²⁰ “Ne profitto d’annunziarvi, che le ricerche del Prof. Henle e del Dottor Kölliker sopra la vostra scoperta sono impresse sotto il titolo “Sopra gli corpuscoli pacinichi” 1843 (...) Il Prof. Henle vi manderà questo opuscolo. Mi fa molta gioia, d’aver potuto comunicare l’esposizione vostra nell’adunanza di Pisa al Signor Henle, come anche la memoria vostra, la quale m’avete inviata. Questa scoperta è interessantissima per la terminazione dei nervi et cangierà molto nella teoria fisiologica. Adesso il fatto è posto fuori di contenzione e Voi avete guadagnato la cosa, che fù stata si singolarmente contrariata a Pisa, il forte ordinario delle scoperte straordinarie. Nell’opuscolo di Henle gli corpuscoli sono disegnati sotto il microscopio in mensura grandissima e tagliati per lo

the massive volume with the proceedings of the Lucca congress contains only three figures throughout, two of geological character, the third one (p. 440) representing Pacini's corpuscle magnified under a microscope, with an accurate morphological description (**fig. 3**).

Here and there the careful and cautious observer also leaves room to speculation: Pacini had witnessed and even produced some phenomena of animal magnetism, being aware of the most recent literature in that controversial field. The suspect that the new corpuscles could have something to do with the so called "lucidità magnetica", was engendered by their localization in hands, feet, and epigastric region – all tied with the practices of magnetizers, which were then experiencing a revival in Europe and overseas. Of course it was just a matter of conjectures, and Pacini apologized for having perhaps transcended the limits of experience and facts, pushed by the irresistible tendency to go beyond their sphere, and to find food for his restless mind ("appagare la nostra mente irrequieta").²¹

3. *Microscopy extolled*

From the beginning, the microscope and its visual revelations really lie at the heart of his scientific biography, but also gave him a hard time because of the opposition he encountered in imposing the role of the instrument in the anatomical research. A collection of letters written by Pacini allows to retrace the chronicle of those events: he addressed them to Niccolò Puccini, a wealthy philanthropist, patriot, and patron living in Pistoia, who owned a good microscope built by Giovanni Battista Amici.²² Pacini was allowed to make use of it and even to bring it to Pisa in 1843, at a time when to own such an object was still a rarity. That was the instrument with which Pacini deepened his observations on the corpuscles and at the same time turned to another object, the "intimate texture of the retina", dedicating to Puccini in 1844 a rigorous report about what he had been able to see in the most internal

mezzo; di sorte che la terminazione del nervo è evidente. Spero, che questa opera riparerà in buono stato il torto, che avete trovato in Italia, ed io mi affretto di felicitarvene." (Carlo Maxia, "Tre lettere inedite riferentisi alla scoperta dei corpuscoli del tatto", *Scritti biologici*, 1933, 8: 203-206, p. 204).

²¹ Filippo Pacini, *Nuovi organi scoperti nel corpo umano* (cit. note 12), pp. 48-49.

²² Elena Boretti, Chiara D'Afflito, Carlo Vivoli (eds.), *Niccolò Puccini: un intellettuale pistoiese nell'Europa del primo Ottocento: atti del convegno di studio (Pistoia, 3-4 dicembre 1999)* (Firenze: Edifir, 2001). Pacini's letters are preserved in the Biblioteca Comunale Forteguerriana, Pistoia, and recently published: *Lettere di Filippo Pacini a Niccolò Puccini trascritte in occasione della mostra "Un pioniere della scienza medica a Pistoia. Vita e scoperte di Filippo Pacini (1812-1883)*. Biblioteca Forteguerriana, Pistoia, Fondo Puccini, without typographic indications.

membrane of the eye, through a comparative look at man, vertebrates, cephalopods, and insects. Many anatomists – often great scientists – had previously addressed the issue and Pacini felt obliged to take them into account. Actually his work on the retina took shape as he was examining the cortical substance of the brain, a topic reviewed in the first chapter of his memoir, for some morphological elements were common both to the retina and to the brain.²³ Easily he noticed that there were no substantial differences between the intimate texture of the human and of the vertebrates retina: being built on a same type, composed of the same number of layers, superimposed in the same order. Pacini recommended to observe microscopically the retina between two crystals by subjecting it to a graduated compression, in order to avoid either its break or its chromatic alterations. In that way he could distinguish five layers of different thickness, all together measuring around 0,14 mm. **(fig. 4)**

That same year he turned to the Grand Duke of Tuscany asking him to provide his lectures of Human Anatomy in Pisa – which he had recently started – with an efficient microscope, that he considered essential to teaching. Although not immediately, Leopoldo II gave him a small sum of money (300 scudi) to build a new instrument, that Pacini himself designed in its mechanical part and commissioned to Amici's renowned optical mastery. Fourteen letters, sent by Pacini to Amici between January 1845 and February 1846, give an account of their collaboration, and show how the anatomist was eager to handle the new tool and generous with guidance about construction details.²⁴

Pacini significantly presented the particular mechanism he had designed in a memory of 1845: in order to study well a microscopic object – he wrote – not only the instrument must be equipped with a good lens system, it is also necessary that the object can be maneuvered with great ease, so as to subject it to any possible experimental test during the observation.²⁵ Almost always the observed object suffered alterations because compressed between the two crystals, and all the

²³ Filippo Pacini, *Nuove ricerche microscopiche sulla tessitura intima della retina nell'uomo, nei vertebrati, nei cefalopodi, e negli insetti. Memoria* (Bologna: Tipi Sassi nelle Spaderie, 1844).

²⁴ Alberto Meschiari, "Microscopi Amici ritrovati. I microscopi di Bettino Ricasoli, Antonio Targioni Tozzetti, Filippo Pacini e corrispondenza", *Atti della "Fondazione Giorgio Ronchi"*, 2002, 57: 1009-1055. No responsive letter is available.

²⁵ "non basta che lo stromento sia dotato di un buon sistema di lenti, bisogna anche che l'oggetto possa essere manovrato con grande facilità, onde sottoporlo a qualunque possibile prova sperimentale *nel tempo stesso che si osserva*." Filippo Pacini, *Sopra un nuovo meccanismo di microscopio specialmente destinato alle ricerche anatomiche e fisiologiche. Memoria* (Bologna: Tipografia Sassi nelle Spaderie, 1845), p. 3. The memory was published by the *Nuovi Annali delle Scienze naturali di Bologna* in November 1845.

expedients hitherto devised to remedy the disadvantage had not proved to be very fruitful. However, by inserting two wedges that would keep the crystal surfaces at the right distance, compression could be prevented. Pacini asserted that, from an experimental point of view, the “porta-oggetti” (*object-holder*) was the most important part in a microscope; therefore it should be made completely independent from the rest, adaptable to any microscope, so that the operator might have more than one object-holder and switch between them depending on his needs. Once described in general the device, Pacini dwelt on the optical apparatus and its supports, explained why it was superior to the previous ones, and included a drawing of the whole instrument with some of its parts highlighted (**fig. 5**).

At the end of his memory, he also wanted to clarify that what mattered above all was the individual ability to use the microscope, which meant – quoting a recent English handbook – to have first of all an *eye* educated to distinguish the genuine appearances from the optical aberrations; then a *mind* capable of detecting possible sources of fallacy, and of understanding the changes which the manipulation, chemical reagents, and other disturbing causes may produce. A third decisive requisite – added by Pacini – consisted in a *hand* trained to perform the most convenient microscopic preparations.²⁶ Joined together, Eye, Mind, and Hand made up the working triangle of the skilled microscopist.

The new instrument was finally at his disposal, but it would give him a very hard time. Pacini had every intention of placing the microscope at the center of research and teaching in anatomy, while most of his colleagues were more or less suspicious, and some of them opposed the innovation because they conceived of anatomy as being limited to a description of organs and structures visible to the naked eye. Not by accident he had to defend microscopic anatomy in a paper of 1847, dedicated to the memory of Felice Fontana, whom he considered “our first anatomic microscopist”, forgotten or poorly appreciated by his compatriots. Pacini emphatically claimed that the microscopic anatomy of the human body was even born in Toscana and not in Germany – as usually believed: a proof of his statement was in Fontana’s *Traité sur le venin de la vipère*, that in 1781 contained also some

²⁶ Filippo Pacini, *Sopra un nuovo meccanismo di microscopio* (cit. note 23), p. 15. Pacini quoted a passage from Robert B. Todd and William Bowman, *The Physiological Anatomy and Physiology of Man* (London: John W. Parker, 1845), vol. I, p. 32. It is highly probable that the microscope illustrated by Pacini’s memory in 1845 is one of those preserved at the Museo Galileo in Florence: see Gerald L’Estrange Turner (ed.), *Museo di Storia della Scienza. Catalogue of microscopes* (Firenze: Giunti, 1991), pp. 108-109.

*Observations sur la structure du corps animal, différentes expériences sur la reproduction des nerfs et la description d'un nouveau canal de l'oeil.*²⁷

For a long time microscopes had been rather unreliable – imperfect, difficult to use, expensive –, and with this circumstance Pacini explained the widespread distrust against them. Only the early 19th century had introduced the achromatic lenses and consequently the reputation of the instrument began to grow, fostered also by the discoveries that led to the cellular theory of Schleiden and Schwann. All over Europe the best anatomists were commendably practicing microscopic anatomy, from which physiology and pathology could derive great profit. The new way of looking at the most minute structures of the organism – he maintained – had also providentially dispersed many hypotheses, dreams and disputes of the past. That is why, probably, there seemed to be around so many and relentless “antimicroscopisti” who were too fond of that past and therefore advanced specious arguments to hinder the spread of microscopic practice.

Against them Pacini’s indomitable temper chose to take a long and harsh battle, perhaps even too harsh as he spent a lot of energy in reply to his opponents. However, the fact of being forced to refute blow by blow their attacks allowed him to elaborate on his positions. “Cet animal est fort méchant, quand on l’attaque, il se défend” is the motto prefixed to the collection of some *Memorie in propria difesa*. In the first of these Pacini defended his own discovery of the “new organs” of touch against criticism raised by Giuseppe Ciantelli, a physician of Pistoia and one of his old classmates. Others had seen the corpuscles before him – this was undeniable – but what actually mattered was the *concept*, that only he had been able to provide, and first: if the object is a new genre and therefore unknown, the act of just seeing it is not enough to claim its discovery. By analogy, the planet Uranus had been *seen* by some astronomers, and mistaken for a fixed star, long before William Herschel *discovered* it by ascertaining its true nature.²⁸ So the priority about the corpuscles was

²⁷ “nostro primo anatomico microscopista (...) il quale con mezzi quanto imperfetti con altrettanta lucidità ed acume scopri ed illustrò le più recondite forme della umana organizzazione, perché obliato o male apprezzato finora specialmente da noi suoi compatriotti.”: *Cosa è ed a che è buona l’anatomia microscopica del corpo umano? Questione vivamente agitata in Toscana, ora un poco dilucidata da Filippo Pacini* (Firenze: Stamperia sulle Logge del Grano, 1847), unnumbered page. As for the the priority claim see the following handwritten text: “Sono ancora pochi anni che la *Microscopia* si riteneva generalmente in Toscana, non essere altro che una *fantastica novità tedesca*, sebben in realtà non fosse che una *gloriosa anticaglia italiana*, resuscitata allora in Germania.” (*Nuovo metodo per eseguire le preparazioni microscopiche da servire alla pubblica istruzione*, in *Fondo Pacini*, vol VII, v, Biblioteca Nazionale Centrale, Firenze).

²⁸ “Ma se l’oggetto è di un genere nuovo e perciò sconosciuto, non basta *vederlo* per dire *io ne ho fatta la scoperta*, perché a buon conto voi non sapete ancora dire in che consiste la vostra scoperta:

undoubtedly and firmly in Pacini's hands, as he had been the first to make known their true and essential structure, their connection with the nerves and the nervous system, their analogy with the electric organ of the torpedo and finally their likely function.²⁹ His strenuous, almost obsessive self-apology was also an opportunity to retell the story of the discovery step by step, each time with further and more minute details. As this was happening, his pride in being the first to have systematically taught the microscopic anatomy in Tuscany became increasingly bombastic.

A second, long, and polemic memory was written against Giuseppe Puccianti, a physician in Pisa, who had denied Pacini's primacy, and this gave him a starting point for a further and fierce invective against the ranks of "antimicroscopisti", "*people without education and without faith, similar to the eunuch who does nothing and harms those who want to do*".³⁰ He dared to argue that if the work so well begun by Felice Fontana had been followed in Italy, German anatomists would be preceded by more than fifty years. An appendix was then devoted to Fontana's anatomical work³¹. By contrast, there was an unfortunate gap of more than ten years, that he had been trying to remedy with his lessons in Pisa: however, to talk in favor of microscopic anatomy was not enough, it was necessary to patiently show and study tissues under the microscope.

Having practiced microscopy with such a tireless enthusiasm – he bitterly remarked – was more a disgrace than an honor. In fact Pacini imputed to his reform program in teaching – disliked by his superiors – his forced and unwelcome transfer, in 1846-47, from the University of Pisa to the courses taught at the Ospedale

fin qui voi non avreste scoperto che *un pezzo di materia*, della quale l'universo ne ha d'avanzo (...) Il pianeta Urano era stato *veduto* da alcuni astronomi, molto prima che Herschel ne facesse la scoperta: i primi lo avevano preso per una stella fissa (...) avendo egli scoperto il concetto vero di quell'astro, la scoperta ne fu giustamente a lui attribuita."": Filippo Pacini, *Memorie in propria difesa* (Firenze: Stamperia sulle Logge del Grano, 1847-48), pp. 4-5. The four collected memories were first published in the *Gazzetta Toscana delle Scienze Medico-fisiche*.

²⁹ "Io sono stato il primo a far conoscere la vera ed essenziale *struttura* di questi organi, la loro *normalità* negli ordini della organizzazione, la loro *singolare connessione coi nervi*, i loro rapporti col *sistema nervoso cerebro-spinale*, e col *sistema simpatico*, la loro analogia coll'*organo elettrico* delle torpedini e finalmente la loro *presuntiva* funzione."": Filippo Pacini, *Memorie in propria difesa* (cit. note 28), pp. 9-10.

³⁰ "*gente senza istruzione e senza fede, pari all'eunuco che nulla fa e nuoce a chi vuol fare*": Filippo Pacini, *Memorie in propria difesa* (cit. note 28), p. 76.

³¹ Filippo Pacini, *Appendice. Sui lavori di Anatomia microscopica di Felice Fontana*, in *Memorie in propria difesa* (cit. note 28), pp. 121-137. Since the 1760s Fontana had undertaken extensive microscopic investigations in various fields, with original results: see Peter K. Knoefel, *Felice Fontana: Life and Works* (Trento: Società di studi trentini di scienze storiche, 1984).

di Santa Maria Nuova in Florence.³² He did not give up, however, and tried to change his chair of descriptive anatomy in something different, which would include a great deal of microscopy. Furthermore, the so called “Anatomia sublime” – a nonsensical adjective: “Du sublime au ridicule il n’y a pas loin”³³–, which he was supposed to teach, could not offer any help to medicine. His enemies in Florence began to rumor that he knew only the microscopic anatomy, which they deemed unnecessary. Against them, in his inaugural speech of November 3, 1849, he quoted Fontenelle: “on traite volontiers d’inutile ce qu’on ne fait point; c’est une espèce de vengeance.” When, in May 1847, he had delivered the opening address to his course of “Anatomia pittorica”, he honestly confessed his ignorance in that field and his lack of aesthetic sense.³⁴

As a sort of by-product, the discovery of the corpuscles led Pacini to a comparative study of the electric organ in different fishes: his aim was to detect any analogies that could give cues on the functions of the new human organs, still rather obscure. As a matter of fact, the last figure in his *Nuovi organi* of 1840 had already shown a column of the electric organ of the torpedo, a fish to which the naturalist Paolo Savi, professor in Pisa, devoted some *Études anatomiques* in 1844, included in a more than famous book by Carlo Matteucci.³⁵ Pacini decided to examine, also aided by the microscope, two specimens of the Nile electric catfish (*Malapterurus electricus*) received from a friend who worked as *protomedico* in Egypt. Both Etienne Geoffroy Saint-Hilaire and Karl Rudolphi had already described that kind of catfish, but a representation of its electromotor elements was still missing: in his

³² For details about his transfer to Florence, see Alessandro Dini, *Vita e organismo. Le origini della fisiologia sperimentale in Italia* (Firenze: Olschki, 1991), pp. 101-106.

³³ *Discorso inaugurale pronunciato dal Prof. Filippo Pacini il dì 3 Novembre del 1849, per la solenne apertura del tirocinio accademico 1849-50, della Scuola pratica Medico-Chirurgica di complemento e perfezionamento* (Fondo Pacini, vol. I, vii, Biblioteca Nazionale Centrale, Firenze).

³⁴ “Privo affatto di ammaestramenti in questo genere, poiché io non ho giammai ascoltata da alcuno una sola lezione di Anatomia pittorica, io mi vedo obbligato a seguire in parte le traccie (*sic*) di qualche opera di distinto autore, ed a lasciarmi guidare per il resto dal comune ed ordinario buon senso, per il quale io cercherò di mantenere sempre in veduta il fine al quale è destinato il presente insegnamento. Senza alcuna nozione di belle arti, e mancante ancora, al pari del celebre naturalista Buffon, di quel senso estetico che si può risvegliare per la abituale contemplazione delle opere dell’arte, io non so se giungerò per il solo buon senso a pormi in accordo con ciò che si esige per la vostra istruzione o Signori; ma se non altro io spero varrà a soddisfarvi il mio buon volere, il quale sarà sempre pronto ad accettare le sagge riflessioni dei vostri maestri su ciò che la creatrice Arte vostra sublime addimanda alla Scienza della Natura.”: *Prolusione all’anatomia pittorica, 5 maggio 1847* (Fondo Pacini, vol. I, vi, Biblioteca Nazionale Centrale, Firenze).

³⁵ Carlo Matteucci, *Traité des phénomènes électro-physiologiques des animaux, suivis d’études anatomiques sur le système nerveux et sur l’organe électrique de la torpille par Paolo Savi* (Paris: chez Fortin, Masson et C^{ie}, 1844), pp. 273-348. Savi’s text was completed by sixteen figures in three accurate *planches*.

memoir read in Bologna, Pacini produced a figure and clarified the essential difference with regard to other electric fish (such as the torpedo and the gymnotus), consisting in the extension of the electrical functionality to the entire body surface.³⁶ (fig. 6)

At that time and in the specific context, who advocated or practiced microscopic anatomy could easily be suspected of materialism, one of the worst accusations, from which Pacini had to carefully protect himself. In his manuscript documents he reverses the argument of his opponents and argues that, on the contrary, to scrutinize at an intimate level the game of devices that make up the body can even better reveal the providence and omnipotence of a superior mind.³⁷ The stigma of materialism was often associated with the idea that the living world is the product of a transformation, instead of a creation – Darwin was still toiling for his theory, quite afraid to reveal what he had discovered. The tradition of natural theology seemed to be very much in vogue, not only for the British culture. The eight Bridgewater Treatises had been written between 1833 and 1836 by distinguished men of science to celebrate “the Power, Wisdom, and Goodness of God, as manifested in the Creation”. One of them, by the Scottish surgeon and anatomist Charles Bell, had illustrated in great detail *The Hand. Its Mechanism and Vital Endowments as Evincing Design*. On the human hand, Pacini has something significant to say in a handwritten text, with no real trace of some transformist bent: it is the more changeable organ, according to the various uses to which it is intended; the human species has its most perfect mechanism, that degrades when it functionally goes from prehension to quadruped support.³⁸

³⁶ Filippo Pacini, *Sopra l'organo elettrico del siluro elettrico del Nilo comparato a quello della torpedine e del gimnoto e sull'apparecchio di Weber nel siluro comparato a quello dei ciprini. Memoria con una tavola letta all'Accademia delle Scienze dell'Istituto di Bologna li 26 Marzo 1846* (Bologna: Tipografia Sassi nelle Spaderie, 1846). Pacini's microscopic researches on electric fishes are recalled by Stanley Finger and Marco Piccolino, *The Shocking History of Electric Fishes. From Ancient Epochs to the Birth of Modern Neurophysiology* (Oxford-New York: Oxford University Press, 2011), pp. 372 and 407.

³⁷ See the following manuscript note: “Il timore che l'anatomia microscopica, perché si occupa di parti piccolissime possa condurre al materialismo è un timore affatto destituito di fondamento, poiché quando lo avesse, vi condurrebbe assai più presto la chimica che si occupa degli atomi; in confronti dei quali, le parti elementari del corpo umano sono infinitamente e infinitamente più grosse, non essendo piccole che per i nostri occhi. (...) La infinita sapienza e onnipotenza di Dio se è dimostrata dalle opere Sue che ci cadono giornalmente sotto gli occhi, quanto più ampiamente e luminosamente è dimostrato dalla intima compage della nostra organizzazione!” (*Fondo Pacini*, vol. III, C. 196, 1849, Biblioteca Nazionale Centrale, Firenze).

³⁸ “La mano è la parte che più si modifica per i diversi usi ai quali è destinata: dotata del meccanismo il più perfetto nell'Uomo, si degrada a misura che d'organo di preensione si fa organo

In the following years Pacini worked to classify his anatomical preparations and to compile a “methodical catalogue” ordered by subjects, open to subsequent additions: a card would report the title and author of the single preparation. A new collection of them, called Museo micrografico, was finally set up in view of the Esposizione Nazionale held in Florence shortly after the proclamation of the Kingdom of Italy, and was awarded a gold medal. The Latin double inscription on the oval plaque made for that public occasion is highly significant, in its second part being a quotation from Pliny’s *Naturalis Historia*. (fig. 7)

Pacini had in mind to put together an archive of anatomical and microscopic photographs, taken through a photographic microscope invented by himself. Nevertheless, in order to achieve the project, he needed to hire a photographer who would produce a visual documentation so rich as to be systematically distributed in all the medical schools of Italy. He also sent an unsuccessful request to the Ministry to get official and financial support for his initiative.

4. *Seeing Cholera vibrios*

Exactly as in the first part of Pacini’s career the corpuscles of touch represented the focus of his attention and the cause of his controversies, during the second part another meaningful visual object took over and dominated his activities for a quarter of a century. To this particular object he also owes his posthumous fame of “precursor”, a reputation grown over a period – the last decades of the 19th century – in which the Italian nation was being built, and the search for scientific precursors was just one of the many devices of that construction. In Pacini’s case, the ceremony held in 1883 marked the public recognition of that kind of assignment.

In 1849 John Snow, member of the Royal College of Surgeons of England, had published a small pamphlet *On the Mode of Communication of Cholera*, where he proposed that the “Cholera Poison” reproduced in the human body and was spread through the contamination of food or water. His theory was opposed to the more commonly accepted miasmatic idea that the disease was transmitted through inhalation of contaminated vapors. Although awarded for this work, at that time he had no way to prove his theory. However, for the third time since the beginning of the century, in 1854 cholera struck England, Europe, and America, and Snow was

di sostegno quadrupede, e già negli inferiori Quadrumani comincia a farsi rudimentale per il suo pollice, che, per la facoltà di opporsi alle altre dita, costituisce nei primi Quadrumani, e molto più nell’Uomo, il fondamento della perfezione di quella.”: *Temî di Anatomia Comparata della Classe dei Mammiferi (Fondo Pacini, vol I, iv-v, Biblioteca Nazionale Centrale, Firenze)*.

able to legitimate his argument, then publishing a second edition, “much enlarged”, of his previous work, with new evidences on the nature of the disease.³⁹ The new outbreak centers, figuratively and literally, on the Broad Street pump in London, which was public, free and previously considered a safe source of drinking water, from a well beneath Golden Square – home to some of London’s poorest and most overcrowded people. In the last week of August 1854, many residents of Golden Square suddenly took sick and began dying. Their symptoms included upset stomach, vomiting, gut cramps, diarrhea and racking thirst. Whatever the cause, it was fast — fast to kill and fast in spreading to new victims. Hundreds of residents had been seized by the disease within a few hours, in many cases entire families. Snow examined water samples under a microscope. He studied the weekly statistics on cholera death throughout London, looking for geographical patterns, and he was able to draw a map that showed the correlation between cholera cases and walking distance to the Broad Street pump. One week after the outbreak began, having heard Snow’s arguments, the local Board of Governors ordered the shutdown of the Broad Street pump, and soon afterward the epidemic came to an end. Snow himself was sure that cholera is caused by by the morbid poison entering the alimentary canal, but he never managed to see or identify exactly what it was, in the water, making people sick:

It would seem that the cholera poison, when reproduced in sufficient quantity, acts as an irritant on the surface of the stomach and intestine, *or*, what is still more probable, it withdraws fluid from the blood circulating in the capillaries (...) For the morbid matter of cholera having the property of reproducing its own kind, must necessarily have some sort of structure, most likely that of a cell. It is no objection to this view that the structure of the cholera poison cannot be recognised by the microscope, for the matter of smallpox and of chancre can only be recognised by their effects, and not by their physical properties.⁴⁰

Of course the return of the epidemic provoked a flood of medical discourse everywhere. As for continental Europe, throughout the century the Italian peninsula was one of the areas most affected by the periodic raging of the disease that came from the East.⁴¹

Narrowing the focus, in Tuscany cholera spread by sea from Genoa to Livorno and the rest of the region in the spring of 1854. The following year a resurgence of

³⁹ John Snow, *On the Mode of Communication of Cholera* (London: John Churchill, 1855); in particular, see Steven B. Johnson, *The Ghost Map: The Story of London's Most Terrifying Epidemic and How It Changed Science, Cities, and the Modern World* (New York: Riverhead Books, 2006).

⁴⁰ John Snow, *On the Mode of Communication of Cholera* (cit. note 37), p. 15.

⁴¹ See Anna Lucia Forti Messina, *L'Italia dell'Ottocento di fronte al colera*, in Franco Della Peruta (ed.), *Storia d'Italia Annali 7 Malattia e medicina* (Torino: Einaudi, 1984), pp. 429-494.

the disease, which seemed to have died down in winter, raged in the Florence district and led to the deaths of many thousand of people. The improvement of communications, due to the opening of the railway and the renewal of the road network promoted by the Grand Duke Leopoldo II, favored the journey of the pathogen. Since 1835, Pietro Betti – professor of physiology and pathology at the medical school in Florence – had worked hard to understand the characteristics of the various infections that had occurred over time and to limit the damages they produced.⁴² In 1851 he was appointed delegate of the Grand Duchy at the First International Sanitary Conference held in Paris – which failed to agree on quarantine regulations – and again in 1854 he took charge of the direction of all the Tuscan *lazzaretti*, eventually publishing in a few volumes the massive results of his twenty-year observations.⁴³

During the deadly epidemic that afflicted Florence in 1854, Pacini made careful investigations on the etiology of the disease, and reported his findings at the Società Medico-Fisica. He opened the published text with a quotation of the statistician Alexandre Moreau de Jonnés who in 1831 had extensively written on cholera, at that time already complaining that nobody was yet applying the microscope to the study of the body parts affected by the disease, although this seemed a promising way to get important information.⁴⁴

⁴² Pietro Betti, *Metodo per purificare gli individui e disinfettare le stanze e le robe che hanno servito al ricovero o all'uso delle persone state affette dal cholera-morbus* (Firenze: Ciardetti 1835); *Cenni sul modo di preservarsi dal cholera e per amministrare o primi e più pronti soccorsi a chi ne cadesse malato* (Firenze: Ciardetti, 1835).

⁴³ Pietro Betti, *Sul colera asiatico che contristò la Toscana nelli anni 1835-36-37-49. Considerazioni mediche* (Firenze: Tipografia delle Murate, 1856); *Documenti annessi alle considerazioni sul colera asiatico che contristò la Toscana nelli anni 1835-36-37-49* (Firenze: Tipografia delle Murate, 1857); *Prima appendice alle considerazioni sul colera asiatico che contristò la Toscana nelli anni 1835-36-37-49 comprendente la invasione colerica del 1854* (Firenze: Tipografia delle Murate, 1857); *Seconda appendice alle considerazioni sul colera asiatico che contristò la Toscana nelli anni 1835-36-37-49 comprendente la invasione colerica del 1855* (Firenze: Tipografia delle Murate, 1858, 2 volumes).

⁴⁴ Alexandre Moreau de Jonnés, *Rapport au Conseil Supérieur de Santé sur le choléra-morbus pestilentiel : les caractères et phénomènes pathologiques de cette maladie, les moyens curatifs et hygiéniques qu'on lui oppose, sa mortalité, son mode de propagation et ses irruptions dans l'Indoustan, l'Asie orientale, l'archipel indien, l'Arabie, la Syrie, la Perse, l'Empire Russe et la Pologne / par Alexandre Moreau de Jonnés* (Turin : chez les frères Reycend et Comp. libraires de S.M., 1831). Pacini quoted the following passage from the Italian translation: “Non è a nostra notizia che in verun paese siansi sottoposte a delle ricerche chimiche le parti che sono la sede della malattia, né che si sieno esaminate accuratamente coll’ajuto del *Microscopio*. Dei motivi che non possiamo addurre qui, ci danno luogo di credere che si otterrebbero *da quest’ultimo mezzo di esplorazione delle notizie importanti*; né staremmo in dubbio di raccomandarlo, se non esponesse al maggior pericolo gli uomini abili e pronti a sacrificarsi, che soli sono capaci di adoprarlo con

Pacini's observations were conducted on only four cases of cholera, a very limited sample. However, he described in great detail what he had observed and tried to shed light on an extremely puzzling etiopathogenesis. Among many other things, he found in the intestinal fluid of his fourth case a great amount of "vibrioni" that might have the quality of "contagio del cholera". Only an organized living being could produce lesions of traumatic character as those found in autopsies of the bodies of cholera patients. It was just a hypothesis, but for Pacini the vibrio existed, was visible (and also drawable) thanks to the microscope, not at all hypothetical even though one still needed to prove that it was the real cause of the disease.⁴⁵ His hypothesis became a sort of research program, pursued for a quarter of a century, as his last writing on the topic came out in 1879.⁴⁶ (**fig. 8-9 disegno e vetrino colera**).

To the "dear memory" of Pietro Betti – who had lavished so much in challenging cholera for decades – Pacini dedicated in 1865 a long memoir on its "specific cause", pathological process and consequent therapeutic indication. Italy had been unified since a few years when a new epidemic broke out, coming from Egypt across the Mediterranean Sea and reaching the ports of Southern Europe. The disease spread rapidly in June 1865 from Genoa, Naples, Ancona and Bari, so that as many as 35 out of the 53 Italian provinces were affected. This first *poussée* ran out in 1866, but the following year there was a recurrence that only ended in January 1868. During the entire period the epidemic killed 160,000 people, put an awful strain on

buon'esito.": Filippo Pacini, *Osservazioni microscopiche e deduzioni patologiche sul cholera asiatico. Memoria letta alla Società medico-fisica di Firenze nella seduta del 10 Dicembre 1854* (Firenze: Tip. Federico Bencini, 1854), p. 3.

⁴⁵ "Finalmente noterò che nel fluido intestinale trovai ancora una grandissima quantità di *vibrioni*; i quali, attesa la loro estrema tenuità, possono facilmente passare inosservati, quando siano dispersi in una certa quantità di fluido. (...) Sebbene nei primi tre casi di cholera non facessi molta attenzione a questi vibrioni, giacché è molto frequente il trovarne di diverse specie nei fluidi animali escrementizii, principalmente presso le aperture naturali del corpo, pure nel quarto caso rimasi veramente sorpreso, per la immensa quantità che ve ne trovai, invischiati principalmente nei fiocchi di mucco con molte cellule epiteliali distaccate. Disgregando un poco, sotto il microscopio, queste agglomerazioni di cellule e di mucco, si vedevano sortire miriadi di vibrioni, i quali spargendosi nel fluido ambiente, ben presto perdevansi di vista fra le altre particelle natanti. (...) Noi non ci dissimuliamo però, che per potere attribuire a questi vibrioni la qualità di *contagio del cholera*, farebbe d'uopo riconoscere in loro una specie insolita, e costantemente concomitante questa malattia; (...) Non è senza un fine d'altronde che io pongo la ipotesi appunto di questo vibrione (il quale per lo meno esiste, si vede, e non è ipotetico, se non risulta ancora veramente che sia il *vibrio cholera*), poiché anche le ipotesi sono pur troppo necessarie, onde stabilire una norma ed un piano razionale di ricerche." : Filippo Pacini, *Osservazioni microscopiche e deduzioni patologiche sul cholera asiatico. Memoria letta alla Società medico-fisica di Firenze nella seduta del 10 Dicembre 1854* (Firenze: Tip. Federico Bencini, 1854), pp. 11-12, 25-26.

⁴⁶ For more information (although with apologetic intent) see Pietro Franceschini, "Filippo Pacini e il colera", *Physis*, 1971, 13: 325-332; Id., "La scoperta del bacillo del colera: Firenze 29 agosto 1854", *Physis*, 1976, 18: 349-365.

the liberal State under construction, and revealed deep economic, social, and cultural imbalances. The cultural elite, inspired by values of scientific secularism, had to face the strong persistence of popular attitudes that tended to combine disease, magic and religion. Modernity was still a distant goal to be achieved by the new Kingdom of Italy.⁴⁷

That is the background of Pacini's memoir, which intended to help "dispel the darkness" of a disease defined paradoxical because of its contradictory manifestations. In 1865 he was quite sure that it had a special cause, susceptible to multiply in the human body, and to be transported from body to body by air or water: a contagious disease produced by a *sui generis* principle, parasitically capable of replication in the appropriate environment. Showing, as usual, good knowledge of the rich international literature that had recently grown, Pacini added his own observations and deductions. According to him, the pathological condition of cholera consisted mainly in the destruction of the gastro-intestinal epithelium, caused by the morbid principle, and understandably followed by a severe loss of water in blood for lack of absorption. Therefore blood becomes more thick and viscous, the speed of its circulation decreases, and a whole series of harsh disturbances follows.⁴⁸

In his 1865 memoir Pacini does not refrain from polemics against Maurizio Bufalini (and his school), who had denied the contagious nature of cholera, the existence of a single simple cause, and instead called into question the influence of the weather, air pollution caused by vapors of organic decay, exhalations of marshes and swamps. In 1858 Pietro Betti had accused Bufalini of having failed to fulfill his duties as a clinician during the epidemics of 1855, leaving Florence in the midst of its rage: defending himself, Bufalini excluded the possibility that chemistry and microscopy could really illuminate the disease.⁴⁹ Moreover, from his point of view,

⁴⁷ About the long epidemic of 1865-1868, see Eugenia Tognotti, *Il mostro asiatico. Storia del colera in Italia* (Bari: Laterza, 2000), pp. 221-244.

⁴⁸ Filippo Pacini, *Sulla causa specifica del colera asiatico, il suo processo patologico e la indicazione curative che ne risulta. Memoria* (Firenze: Tipografia di Giuseppe Mariani, 1865). The memoir was translated in French by Eugène-Dorothée Janssens: *Du Choléra asiatique au point de vue de sa cause spécifique, de ses conditions pathologiques et de ses indications thérapeutiques* (Bruxelles: H. Manceau, 1865). By the way, Pacini sent his writings on cholera widely throughout Italy and Europe, as shown by his detailed *Spedizioni di memorie* (Fondo Pacini, vol. XXI, vi, Biblioteca Nazionale Centrale, Firenze).

⁴⁹ Maurizio Bufalini, *Pensieri intorno alla colera e alle malattie epidemiche e contagiose* (1835), in *Opere* (Firenze: Gabinetto di G. P. Vieusseux, 1844-45), vol. I, parte II, pp. 171-194; Id., *Sulle cagioni predisponenti ed occasionali della coléra e sulle indicazioni e controindicazioni che ne derivano per la cura*, Firenze, Tipografia di Federigo Bencini, 1855; Pietro Betti, *Seconda appendice alle considerazioni sul colera asiatico che contristò la Toscana nelli anni 1835-36-37-49 comprendente la invasione colerica del 1855* (cit. note 41), vol. I, pp. 346-347 and vol. II, pp. 658-

microscopic observations tended to be “idle curiosity”: Pacini felt provoked and reacted accusing Bufalini to ignore the true nature of the experimental method. By that time his relationships with the medical establishment in Tuscany – which had never been good – began to further deteriorate.⁵⁰

Cholera was even approached by Pacini with an original mathematical theory, using the calculus to find the law of a pathological process which he essentially considered a “quantitative disorder”. About twenty kinds of values – for instance, the absorptive surface of the gastrointestinal tract, the water lost from the blood during the process, the excreta, and so on – were transformed by him in symbols and then inserted into equations that would allow to predict the subsequent phases of the disease and to intervene therapeutically in the most appropriate way. It is certainly remarkable that shortly after the mid-19th century a medical doctor had such a firm understanding of mathematics and that he gave so much importance to its application to the biomedical field, convinced that he could make a law not unlike that of Galileo's falling bodies.⁵¹

His mathematical approach led also Pacini to put in evidence a particular phenomenon hitherto overlooked by clinicians, that is, the apparent death that represents the last stage of the disease process of Asiatic cholera. After the premonitory diarrhea, there is the so-called “stadio linforragico”, with abundant dejections, followed by the “stadio algido”, the apparent death which precedes the actual one, when the speed of blood circulation becomes insufficient to maintain the manifest life. It can last from an hour to several hours, so that it gives time either to bury people still alive, or to resurrect dead ones. Many alleged corpses of cholera

666; Maurizio Bufalini, “Rettificazione di un racconto del Sig. Consultore Pietro Betti”, *Lo Sperimentale*, 1858, 2: 489.

⁵⁰ Filippo Pacini, “Saggio fisiologico della parte fisica del processo di nutrizione, per servire di fondamento alle dottrine patologiche di diverse malattie, seguito da una memoria speciale sul colera asiatico”, *Il tempo*, 1859, 2: 1-15, 179-191, 246-260, 414-449. On the relationships between the two physicians, whom a quarter of century divided by birth, and their conflicting theories, see Alessandro Dini, *Teorie medico-patologiche a confronto: Maurizio Bufalini e Filippo Pacini*, in Giuliano Pancaldi (ed.), *Maurizio Bufalini. Medicina, scienza e filosofia. Atti del Convegno Cesena 13-14 novembre 1987* (Bologna: Clueb, 1987), pp. 137-152.

⁵¹ Filippo Pacini, *Della natura del colera asiatico: sua teoria matematica e sua comparazione col colera europeo e con altri profluvj intestinali* (Firenze: Tip. Uccelli e Zolfanelli, 1866); Id., “Del processo morboso del colera asiatico, del suo stadio di morte apparente e della legge matematica da cui è regolato”, *Lo Sperimentale*, 1879, 43: 355-366, 573-597. On this particular aspect see Gustavo Barbensi, “Il pensiero scientifico di Filippo Pacini medico e matematico”, *Rivista di Storia delle Scienze Mediche e Naturali*, 1940, 31: 101-118, 139-159; Vincenzo Pedicino, “Una memoria di Filippo Pacini sulla legge matematica che regola il processo morboso del colera asiatico”, in *Società italiana di storia della medicina. Atti del 20° Congresso nazionale di storia della medicina* (Roma: Arti grafiche E. Cossidente, 1964), pp. 60-64.

patients, in fact, can move their limbs and regain the animal heat, as soon as the oozing intestinal process stops. Pacini went so far as to formulate the equation of the duration of the apparent death, and recommended to treat corpses as real corpses only when they showed unequivocal evidence of putrefaction, the only sure sign of death.⁵²

His interest in the phenomenon of apparent death – much discussed at the time, as testified *inter alia* by a famous book of Gustave Le Bon⁵³ – opened the way to develop a new method of artificial respiration consisting in putting the apparent dead on an inclined plane and in pulling vigorously the upper arms at the armpit. The movement is thus transmitted by means of the clavicles to the sternum which in turn elevates the corresponding ribs: air enters immediately through the larynx into the lungs producing an inhalation and an exhalation next. Pacini ensured that the act of repeating fifteen times per minute these movements could revive an asphyxiated individual. Beyond introducing the breathable air in the lungs, the respiratory maneuvers had the effect of reactivating the movement of blood.⁵⁴

The last act of the cholera affair came in 1879, when King Umberto I instituted a rather rich prize for life sciences at the Accademia dei Lincei, and Pacini decided to compete by sending his work on the epidemic disease. Approaching 70, he felt the need to be finally compensated for all the disappointments and he hoped also for an improvement in its finances, strained by family costs. The commission met only in 1881, composed by Francesco Todaro, Corrado Tommasi Crudeli, Aliprandò Moriggia – the first two were former pupils of him – and presided by Hermann Helmholtz, who played however a quite secondary role in the affair. After a long and bumpy process, Pacini was finally excluded on the grounds that his writings were prior to 1878, and only adapted for the Lincei competition. So that his last years were plagued by bitterness and controversy, as he did not refrain from arguing pungently against colleagues who in his view were grimly denying his merits. There is something of the persecution complex in his repeated attacks to the Accademia dei Lincei and his president Quintino Sella.⁵⁵ The whole, sad story confirmed him in the

⁵² Filippo Pacini, *Sull'ultimo stadio del colera asiatico o stadio di morte apparente dei colerosi e sul modo di farli risorgere. Memoria* (Firenze: Tipografia italiana N. Martini, 1871).

⁵³ Gustave Le Bon, *De la mort apparente et des inhumations prématurées* (Paris: Adrien Delahaye, 1866); Jan Bondeson, *Buried Alive. The Terrifying History of Our Most Primal Fear* (New York: W.W. Norton & Co., 2001).

⁵⁴ Filippo Pacini, *Del mio metodo di respirazione artificiale nella asfissia e nella sincope, con nove casi di resurrezione e risposta ad alcune obiezioni sperimentali del prof. Maurizio Schiff* (Firenze: Tipografia Cenniniana, 1876).

⁵⁵ Filippo Pacini, *Sul concorso al premio di 10.000 lire istituito da S. M. Re Umberto per le scienze biologiche presso la R. Accademia dei Lincei in Roma. Lettere* (Firenze: Tipografia della Gazzetta

belief, often expressed on several occasions, that the ‘new’ Italy was the country of paradoxes: on the one hand the most numerous and ancient libraries – a quite precious heritage, – on the other hand 17 or 18 millions illiterate, almost 80% of the population.

Ironically, Pacini died on 9 July 1883, a few weeks before Robert Koch’s mission sailed for Egypt, where the German team started to identify the cholera vibrio. On 7 January 1884, Koch announced in a dispatch from India that he had successfully isolated the bacillus in pure culture, and one month later he named it “Komma Bacillus”, while in July he gave a speech at the Kaiserliche Gesundheitsamt (Berlin), promptly translated in Italian.⁵⁶ By applying his rigorous postulates, Koch – unaware of Pacini’s discovery – was further able to prove that the microorganism is the sole cause of the disease. Many decades after, in 1965, the International Committee on Bacteriological Nomenclature decided to adopt “Vibrio cholera Pacini 1854” as its correct name.⁵⁷

d’Italia, 1881); Id., *Sul concorso al Premio reale per le scienze nella R. Accademia dei Lincei: avvertenze per uso della predetta Accademia* (Livorno: Tip. Aldina, 1882); Id., *La Reale Accademia dei Lincei ed il colera asiatico nel Concorso al Premio Reale del 1879 per le scienze biologiche. Riflessioni morali* (Firenze: Tipografia Cooperativa, 1883). The award was divided between Angelo Mosso (*Intorno alla circolazione del sangue nel cervello dell’uomo*) and Salvatore Trinchese (*I primi momenti della evoluzione nei molluschi*).

⁵⁶ Roberto Koch, *Il colera. Conferenza* (Milano: Treves, 1884). For the original text see “Conferenz zur Erörterung der Cholerafrage am 26. Juli 1884,” in *Berliner Klinische Wochenschrift*, 1884, 21: 478-483, 493-503.

⁵⁷ “Conservation of *Vibrio* Pacini 1854 as a bacterial generic name, conservation of *Vibrio cholerae* Pacini 1854 as the nomenclatural type species of the bacterial genus *Vibrio*, and designation of neotype strain of *Vibrio cholerae* Pacini”, Judicial commission, International Committee on Bacteriological Nomenclature. Opinion, *International Bulletin of Bacteriological Nomenclature and Taxonomy*, 1965: 15, pp. 185-186. For a brief survey see Norman Howard-Jones, “Robert Koch and the cholera vibrio: a centenary”, *British Medical Journal*, 1984: 288, pp. 379-381.

