AUTHORSHIP AND TEAMWORK AROUND THE CIMENTO ACADEMY: MATHEMATICS, ANATOMY, EXPERIMENTAL PHILOSOPHY

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1. Introduction

Multiple authorship is largely a twentieth-century phenomenon, yet it has become so common as to be taken almost for granted and induce no surprise. In many areas, especially those associated with big science, the growing complexity of many experimental projects leads almost naturally to extensive authorship lists. The rise of multiple authorship, however, is a more complex phenomenon extending in different forms across a wide disciplinary spectrum in the sciences as well as in the humanities.

In different periods authorship has been associated with a cluster of issues including, but not limited to, social habits and publishing conventions, legal constraints and censorship in various forms, and changing financial arrangements between publishers and authors.[2] Since, until the recent past, single authorship was the norm in the great majority of cases, we are left to wonder

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[2] M. Foucault, "What is an author," in M. Foucault, *The Foucault reader*, ed. P. Rabinow (New York, 1984), 101-20. R. Chartier, *Forms and meanings: texts, performances, and audiences from codex to computer* (Philadelphia, 1995), esp. 25-42; id., *The order of books: readers, authors and libraries in Europe between the fourteenth and eighteenth centuries*, transl. L. G. Cochrane (Stanford, 1994), esp. ch. 2. C. Hesse, *Publishing and cultural politics in revolutionary Paris, 1789-1810* (Berkeley, 1991). *The construction of authorship*, M. Woodmansee and P. Jaszi (eds.), (Durham, 1994), contains many useful articles. A. Johns, "Science and the book in modern cultural historiography', *Studies in History and Philosophy of Science* 29 (1998), 167-194, on 188. D.F. McKenzie, *Bibliography and the sociology of texts* (Cambridge, 1999). H.E. Lowood and R.E. Rider, "Literary technology and typographic culture: The instrument of print in Early Modern Europe," *Perspectives on Science* 2 (1994), 1-37.

whether in previous centuries collaboration was radically less common, or it went unacknowledged, or it was acknowledged in forms unusual to us.

This problem is amplified by the useful but potentially misleading tools we regularly employ, at times uncritically: library catalogues and bibliographies. On the one hand, the success of a cataloguing system depends on standardization, and our researches would rapidly turn into a nightmare without it. On the other hand, standardization hides widely different historical practices and conventions. When we search a library catalogue or a bibliographic tool, we may be led to assume that the fields "author" or "publisher" carry approximately the same meaning for all the entries, when in fact they do not. The issue of agency springs to mind: Was "the author" of the publication in question also the subject who conceived the plan and the one responsible for its contents? What about patrons who may have commissioned the work? And what about the illustrations, just to mention one example which in areas such as natural history or anatomy may be at least as significant as the text? My favorite example is that of classical scholar Otto Brunfels, publisher Johann Schott, and artist Hans Weiditz. The text of *Herbarum vivae Eicones* (Strasbourg: Johann Schott, 1531-6), was due to Brunfels and the illustrations to Weiditz. The latter made the book unquestionably one of the most innovative and influential herbals of all times. Although Brunfels is referred to as the "author," it appears that Schott had the idea of producing a text with superior illustrations by hiring a talented artist, an idea Brunfels disliked. In Renaissance herbals, moreover, texts and illustrations were often based on classical sources and previous publications, bringing to mind terms like "borrowing" and "compilation." Of course, many more aspects of the book production and composition need to be historicized in connection with authorship, such as the role of dedicatory letters, acknowledgements, quotations and name references, indices, and footnotes.[3]

[3] G. Saunders, *Picturing plants* (Berkeley, 1992), 21. A. Grafton, *The footnote: a curious history*, rev. ed. (Cambridge, Mass., 1997). A. Johns, *The nature of the book: print and knowledge in the making* (Chicago, 1998); id., "Natural history as print culture," in N. Jardine, J.A. Secord, E.C. Spary (eds.), *Cultures of natural history* (Cambridge, 1996), 106-24. H.D. Rutkin, "Celestial offerings: Astrological motifs in the dedicatory letters of Kepler's *Astronomia Nova* and Galileo's *Sidereus Nuncius*," in A. Grafton and W. Newman (eds.), *Archimedes* (Cambridge, Mass., 2001), forthcoming.

Problems of authorship, and especially multiple authorship, have accompanied in different forms the history of the sciences from their origins to the present, from the Hippocratic corpus to contemporary codes of publication in scientific journals. Ancient historian Geoffrey Lloyd, for example, argued against a number of mutually conflicting studies trying to identify genuine Hippocratic works, that "the evidence we have allows us in *no* case to be confident that a work is by Hippocrates himself," and that "Hippocratic scholarship is more fruitfully deployed in examining some of the far-reaching implications of questions to do with the nature of these early medical writings, how they were constituted, what their audience was, and how they were used."[4] Lloyd argues that the Hippocratic corpus can be seen as a handbook for healers consisting of treatises which often appear to be composite works with later additions, interpolations, and borrowings, as well as joint authorship. Thus Lloyd argues for a shift of emphasis from the search for "authentic authorship," to a broader notion of authorship based on circumstances of composition and transmission of a text, as well as to intended audience and reception.

At the opposite end of the time spectrum, recent science journals are showing growing concerns about authorship rules: Should all co-authors, for example, have read the entire article?[5] A certain unease can be detected in an article from *Science* (Fig. 1), where a footnote cryptically states that the first four co-authors, out of fifty-two from fourteen different institutions, "contributed equally to this work." Interestingly, the first four are not mentioned alphabetically, and how much they contributed individually and together is left to the readers' imagination.

By realizing the contingent and problematic nature of authorship in our culture, we can avoid projecting our views and conventions on to a time when different conventions and rules applied.

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[4] G.E.R. Lloyd, *Methods and problems in Greek science* (Cambridge, 1991), 194 and 197.

[5] These issues are raised in the important article by M. Biagioli, "The instability of authorship: Credit and responsibility in scientific authorship," *The FASEB Journal* 12 (1998), 3-16, reprinted with a different title, "Aporias of scientific authorship: Credit and responsibility in contemporary biomedicine," *The science studies reader*, M. Biagioli (ed.), (New York, 1999), 12-30. *Id.*: "Rights of rewards? Changing contexts and definitions of scientific authorship," *Journal of College and University Law* 27 (2000), 83-108. See also P. Thagard, *How scientists explain disease* (Princeton, 1999), ch. 11. R.K. Merton, *The sociology of science: Theoretical and empirical investigations* (Chicago, 1973), 546-53.

REPORTS

Functional Characterization of the *S. cerevisiae* Genome by Gene Deletion and Parallel Analysis

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The functions of many open reading frames (ORFs) identified in genome-sequencing projects are unknown. New, whole-genome approaches are required to systematically determine their function. A total of 6925 *Saccharomyces cerevisiae* strains were constructed, by a high-throughput strategy, each with a precise deletion of one of 2026 ORFs (more than one-third of the ORFs in the genome). Of the deleted ORFs, 17 percent were essential for viability in rich medium. The phenotypes of more than 500 deletion strains were assayed in parallel. Of the deletion strains, 40 percent showed quantitative growth defects in either rich or minimal medium.

The budding yeast *S. cerevisiae* serves as an important experimental organism for revealing gene function. In addition to carrying out all the basic functions of eukaryotic cells, up to 30% of positionally-cloned genes implicated in human disease have yeast homologs (*1*). Determining the function of all yeast gene products will be an important step toward understanding their function in metazoans and lays the foundation for a more complete comprehension of cellular processes and pathways.

A powerful way to determine gene function is the phenotypic analysis of mutants missing the gene. Several genome-wide approaches have been proposed including genetic footprinting and random mutagenesis (*2, 3*). While genetic footprinting has the advantage that all genes can be tested for their contribution to fitness under a particular growth condition relatively quickly, it has the disadvantage that the mutant strains cannot be recovered. In addition, testing each additional condition is as time-consuming as the first. Random mutagenesis is relatively rapid, but the subsequent matching of phenotypes to genes is slower. In addition, with random approaches a certain fraction of genes may be missed, even with oversampling. These limitations can be overcome by deleting each gene in the genome in a directed fashion and by marking each yeast gene with a molecular "barcode" that allows the phenotypes of the mutant strains to be assayed in parallel.

The precise deletion of yeast genes can be efficiently accomplished using a polymerase chain reaction (PCR)–mediated gene disruption strategy that exploits the high rate of homologous recombination in yeast (*4*). For this method, short regions of yeast sequence [~50 base pairs (bp)] identical to those found upstream and downstream of a targeted gene are placed at each end of a selectable marker gene through PCR. The resulting PCR product, when introduced into yeast cells, can replace the targeted gene by homologous recombination. For most genes, >95% of the resulting yeast transformants carry the correct deletion (*5*). In addition, this method can be modified so as to introduce two molecular barcodes (UPTAG and DOWNTAG) into the deletion strain. The barcodes or "tags" are unique 20-base oligomer (20-mer) sequences that serve as strain identifiers (*6, 7*). We show that these barcodes allow large numbers of deletion strains to be pooled and analyzed in parallel in competitive growth assays. This direct, simultaneous, competitive assay of fitness increases the sensitivity, accuracy and speed with which growth defects can be detected relative to conventional methods.

To take full advantage of this approach and to accelerate the pace of progress, an international consortium was organized to generate deletion strains for all annotated yeast genes. Here, we report the construction of precise start-to-stop codon deletion mutants for 2026 ORFs (*8*).

Genes essential for viability in yeast, in particular those encoding proteins lacking human homologs, have been proposed to be the best targets for antifungal drugs. When spores from the 2026 heterozygous strains were germinated on YPD (yeast extract–peptone–dextrose) media at 30°C haploid deletants could not be recovered for 356 ORFs (see www-sequence.stanford.edu/group/yeast_deletion_project/deletions3.html for an exact list) (*9*). Despite the considerable interest in these genes as potential drug targets, only 56% of these ORFs had previously been shown to be essential for viability (*10*). Of the 2026 ORFs analyzed, 1620 were not essential for viability in yeast. For these one additional homozygous and two haploid deletants (Table 1) were also constructed.

A computational Smith-Waterman analysis indicated that 8.5% of the identified nonessential ORFs in the yeast genome have a closely related homolog elsewhere in the ge-

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Fig. 1. A case of multiple authorship from a recent article in *Science*. (Reprinted with permission from *Science*. Copyright 1999 American Association for the Advancement of Science)

Authorship issues appear in different guises and for a range of reasons in medieval times, in the age of the commentaries, as well as in the Renaissance, when patrons, collectors of manuscripts, classical scholars expert in many disciplines, printers, publishers, artists, and instrument makers collaborated in many areas ranging from natural history to the mathematical disciplines. Interesting issues emerged in connection with collaborative enterprises, such as scientific societies and laboratories advocated by Francis Bacon at the beginning of the seventeenth century, and in scientific controversies, when students often acted as their mentors' champions. Authorship issues are also crucial to the history of disciplines such as magic or alchemy, and to all types of secret or dangerous knowledge, where pseudonyms and other forms of concealment abound. Moreover, authorship, or rather the lack thereof, is intertwined with issues of gender and social status. In all these cases the very issues of secret knowledge, gender, and social status provide from the outset explanations for authorship criteria. I am therefore especially interested here in collaborations among scholars of approximately comparable status dealing with mainstream disciplines.[6]

My concern is not with identifying which portions of a text can be attributed to this or that author, nor do I wish to argue that contemporary practices of multiple authorship are "correct" and need to be retrospectively and anachronistically applied to older

[6] S. Shapin, *A social history of truth: civility and science in seventeenth-century England* (Chicago, 1994), ch. 8. R. Sorrenson, "George Graham, visible technician," *British Journal for the History of Science* 32 (1999), 203-21. L. Schiebinger, *The mind has no sex?* (Cambridge, Mass., 1989). Jaszi and Wodmansee (eds.), *The construction of authorship*. P. Long, "Power, patronage, and the authorship of *Ars*," *Isis* 88 (1997), 1-41, provides an interesting challenge to Eisenstein's claims about authorship and the printing press, in E. Eistenstein, *The printing press as an agent of change* (Cambridge, 1979), 121-2, 229-30, 242-3. Important issues relevant to sixteenth-century astronomy are raised in O. Gingerich and R.S. Westman, *The Wittich connection: conflict and priority in late sixteenth-century cosmology* (Philadelphia, 1988), viii. G. Olmi, *L'inventario del mondo* (Bologna, 1992). In controversies, the task of responding to a challenge was often delegated to a junior scholar, as if to imply that the antagonist was not worthy of a direct response. Such cases are very common and would require a special study. In the seventeenth-century controversy on falling bodies, for example, both the Jesuit Giambattista Riccioli and Borelli intervened against Stefano degli Angeli through works authored by their lesser knows followers, Michele Manfredi and Diego Zerilli, respectively. Luigi Guerrini has recently shown that the *Osservazioni intorno alle torpedini fatte da Stefano Lorenzini* (Florence, 1678), were the result of a collaboration with Francesco Redi. L. Guerrini, "Contributo critico alla biografia rediana," in W. Bernardi and L. Guerrini (eds.), *Francesco Redi. Un protagonista della scienze moderna* (Florence, 1999), 47-69.

texts. Rather, I believe that paying attention to issues like teamwork, agency, and changing practices and conventions in authorship and cataloguing will prove crucial for gaining fresh insights into the history of the sciences for two related reasons. First, because they reveal that collaboration was more widespread than title pages may suggest to a modern reader. Secondly, because they reveal a series of collaboration patterns among practitioners of several disciplines at different historical periods. A systematic investigation of these patterns helps us gain a deeper understanding of scientific practices and provides fresh material for a periodization in the history of the sciences.[7]

Before embarking on my investigation, I wish to address the issue of why, if collaboration was not uncommon, multiple authorship hardly occurred in the first few centuries of the printing press. Attempts have been made to link authorship, censorship, and judicial responsibility. Although, to my knowledge, multiple authorship was not explicitly forbidden—in fact, some catalogues of prohibited books were explicitly collaborative enterprises—it is plausible that state and church censorship played an *indirect* role in favoring single authorial responsibility. This conjecture does not rule out the existence of other relevant customs and conventions linked to the individuality of creation and responsibility. It is perhaps significant when at those times and places that censorship rules were comparatively lax, such as in the Low Countries or in Commonwealth England, we do not witness an explosion of multiply authored texts. This suggests that informal customs and conventions may have been more significant than laws and official regulations.[8]

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[7] The classic works here is E. Zilsel, "The sociological roots of science," *The American Journal of Sociology* 47 (1942), 544-62.

[8] On this thesis put forward by Foucault, see Chartier, *The order of books*, 49ff. An excellent account of the history of censorship is P. Grendler, *The Roman Inquisition and the Venetian press* (Princeton, 1977). See the title page of the Venetian *Cathalogus Librorum Haereticorum* (Venice, 1554) in Grendler, *The Roman Inquisition*, 97. Later editions of the *Index Librorum Prohibitorum* were often prepared by a congregation of fathers and issued with papal approval, *cum regulis confectis per Patres a Tridentina Synodo delectos, auctoritate Sanctiss. D.N. Pij IIII, Pont. Max. comprobatus*, Cf. Grendler, *The Roman Inquisition*, 149, 150, and 259. For a comparison between the freedom of the press in the Dutch Republic and Southern Europe see M. Infelise, "La censure dans les pays méditerranéens, 1600-1750," and S. Groenveld, "The Dutch Republic, an island of liberty of the press in 17th-century Europe? The authorities and the book trade," in H. Bots and F. Waquet (eds.), *Commercium litterarium: Forms of communication in the Republic of Letters, 1600-1750*, (Amsterdam, 1994), 261-79; and 281-300.

This essay focuses on a number of publications in mathematics, anatomy, and experimental philosophy produced in Italy in the 1660s at the time of the emergence of the first academy devoted to experimental philosophy, the Cimento Academy. In addition, the presence of an informal group of scholars pursuing anatomical researches alongside the Cimento provides a particularly fertile terrain for the study of teamwork and authorship both in formal and informal collaborations. The aim of my essay cannot possibly be completeness. Rather, I wish to highlight the existence of widely different conventions about authorship even over a brief time-span and among a small community of scholars. Indeed, although this is not at all obvious from the title pages, all publications involved in some fashion one of the leading Italian intellectuals at that time, Giovanni Alfonso Borelli. The first case I examine is an edition and translation of books V-VII of Apollonius's *Conics* and a text attributed to Archimedes, produced by the orientalist Abraham Ecchellensis and Borelli in 1661. The second example consists of three anatomical publications, two by Marcello Malpighi, also dating from 1661, and one by Lorenzo Bellini, from 1662, sharing some analogies but also notable differences with the Apollonius/Archimedes edition. Thirdly, I investigate the 1667 *Saggi di naturali esperienze* of the Cimento Academy, the Academy's collective publication. Here, too, Borelli was not only involved in the experimental activities and discussions surrounding the text production, but was also considered the main intellectual behind the enterprise. Once again, authorship criteria varied from the preceding cases.

2. *The 1661 Apollonius and Archimedes edition*

In 1656 Borelli was called to the chair of mathematics at Pisa University. He had been a student of Benedetto Castelli at Rome and from 1639 was professor of mathematics at the University of Messina. His arrival at Pisa as holder of Galileo's former chair marked a turning point in his career and in intellectual affairs both at Pisa University and at the Tuscan Court, in mathematics and in a whole range of other disciplines, such as anatomy and experimental philosophy. With the support of the Medici, Borelli gained a decisive role within the experimental work at the court of Ferdinand II and his brother Leopold. The latter also became the patron of a different intellectual enterprise.

Some time after his arrival in Tuscany in 1656, Borelli was shown by Leopold an Arabic manuscript at the Laurenziana Library in Florence, which contained a mathematical text identified as Apollonius's *Conics*. Although Borelli did not know Arabic, he had been involved in a previous edition of books I-IV of Apollonius, the only ones known at the time, and was therefore able to recognize some of the geometrical figures. He supposed that the figures following those he could identify belonged to the missing books, V-VIII. His conjecture turned out to be nearly right, for the manuscript contains books V-VII. Another manuscript he found in the same library contained a text attributed to Archimedes, the *Liber assumptorum*.

Borelli's involvement in a previous edition of Apollonius had long been suspected, but has only recently been established with the discovery of the private contract between Borelli and the printer. In 1654 a descendant of the great sixteenth-century mathematician Francesco Maurolico, Paolo, edited *Francisci Maurolyci Messanensis, emendatio, et restitutio conicorum Apollonii Pergaei* (Messina: Typis haeredum Petri Breae, 1654), consisting of the known first four books, and a reconstruction by Francesco Maurolico of books V-VI. The volume opens with a dedicatory letter to the Messina Senate by Paolo Maurolico, dated August 15, 1653, possibly in response to some financial support from the Senate enabling the printing. As we have seen, from 1639 to 1656 Borelli was professor of mathematics at Messina University and by far the most eminent mathematician in the city, if not the whole of Sicily. Historians often expressed incredulity that his name did not figure at all in the edition of Maurolico's reconstruction of Apollonius, since Borelli was in all probability the only person in Messina capable of seeing such an edition through the press. Recently, a revealing document has been retrieved in Borelli's own copy of the sixteenth-century edition of books I-IV of Apollonius by Federico Commandino.[9] It is a slip of paper dated Messina, March 2, 1654, signed by a printer, Niccoló Vattacci, and by Borelli, binding them to a schedule for the production of the book. Vattacci

[9] *Apollonii Pergaei Conicorum libri quattuor. Una cum Pappi Alexandrini lemmatibus, et commentariis Eutocii Ascalonitae. Sereni Antinsensis philosophi libri duo nunc primum in lucem editi. Quae omnia nuper Federicus Commandinus ... illustravit* (Bologna, 1566). See U. Baldini, "Libri appartenuti a Giovanni Alfonso Borelli," in C. Dollo (ed.), *Filosofia e scienze nella Sicilia dei secoli XVI e XVII*, vol. 1 (Catania, 1996), 191-232, at 197, n.16.

was obliged to print three sheets a week, Borelli to correct the proofs and provide text and figures. Thus the historians' suspicion that Borelli was involved seems to be abundantly vindicated, i.e., he appears to have been in charge of preparing the text and figures for publication. However, this editorial work probably enabled him to identify the figures in the Arabic manuscript. We do not know why Borelli's name was omitted from the book, and why later in his life Borelli never claimed that edition as his own. This is not the only case where one encounters some deliberate concealment about aspects of his life and activities.[10]

In the summer of 1658 the Medici princes allowed Borelli to go to Rome in order to work with Abraham Ecchellensis. The Arabic text turned out to be a paraphrase rather than a translation, requiring extensive editorial work. The title page of the resulting edition bears witness to their collaboration, for it mentions not only Apollonius, Archimedes and Abalphatus Asphahanensis, or Abu al-Fatḥ al Iṣfahānī, responsible for the Arabic paraphrase, but also both Ecchellensis and Borelli (Fig. 2).[11]

Interestingly, the book opens with Borelli's dedication to Cosimo III on the occasion of the latter's wedding, followed by a proemium by Abu al-Fatḥ al Iṣfahānī, and then separate prefaces, one by Ecchellensis and one by Borelli. The edition of the *Liber assumptorum* is prefaced by Borelli. Thus, it appears as if any portion of the text outside the translations of Apollonius and Archimedes was signed by either one—and only one—of the editors.

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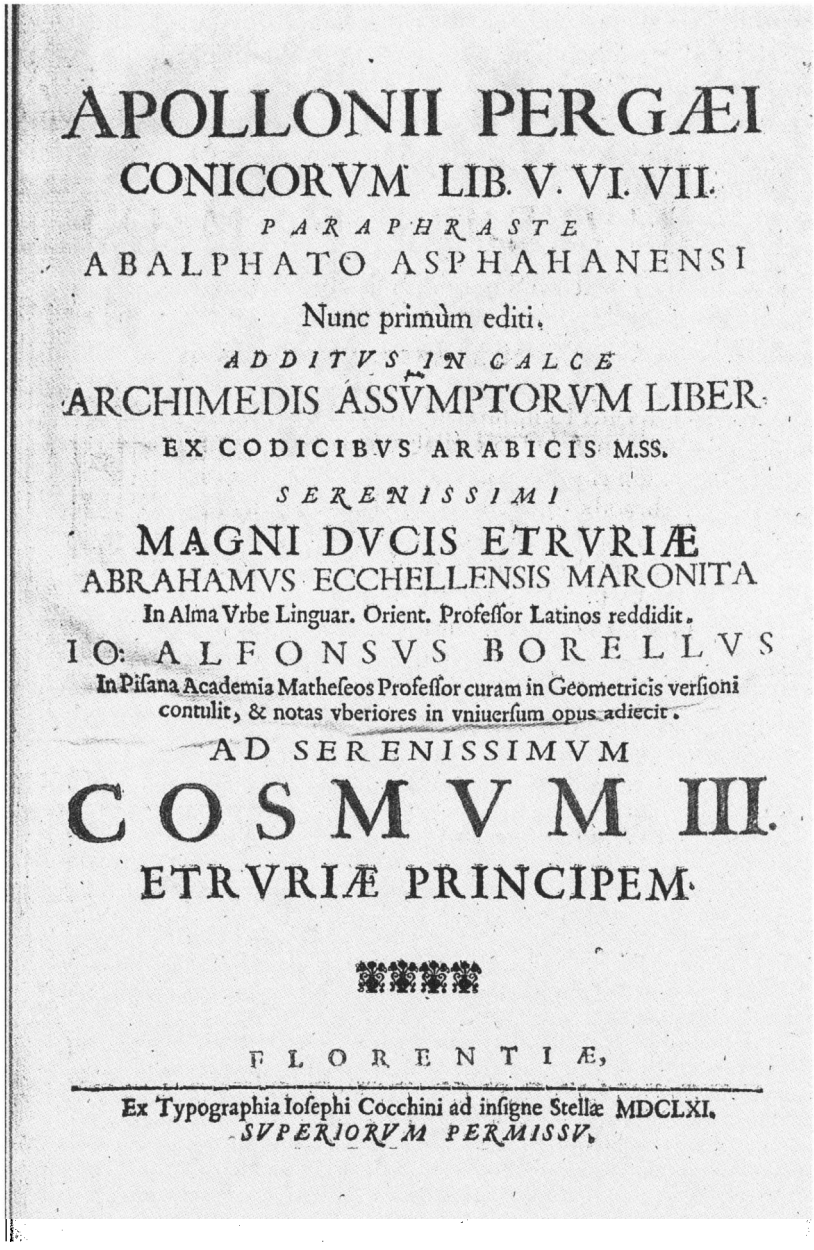
[10] Other cases involve the circumstances of his birth and intellectual links with Tommaso Campanella, for which see the entries "Borelli, Giovanni Alfonso," by U. Baldini; and "Borelli, Filippo," by L. Firpo, in *Dizionario Biografico degli Italiani.* Moreover, Borelli is believed to have been heavily involved in the composition of Pier Maria Mutoli, *Del movimento della cometa apparsa nel mese di dicembre 1664* (Pisa, 1665) and in the edition of S. Rao, *Rime* (Venice, 1672).

[11] A. Fabroni, *Historia Academiae Pisanae,* vol. 3 (Pisa, 1795), 146-51. G. Giovannozzi, "La versione borelliana di Apollonio," *Memorie della Pontificia Accademia Romana dei Nuovi Lincei,* 2 (1916) 1-31; and id., *Lettere inedite di Giovanni Alfonso Borelli al P. Angelo di S. Domenico sulla versione di Apollonio* (Florence, 1916). L. Guerrini, "Matematica ed erudizione. Giovanni Alfonso Borelli e l'edizione fiorentina dei libri V, VI, e VII delle *Coniche* di Apollonio di Perga," *Nuncius* 14 (1999), 505-68. Apollonius, *Conicorum lib. V. VI. VII. Paraphraste Abalphatuo Asphahanensi ... Additus in calce Archimedis Assumptorum Liber ... Abrahamus Ecchellensis Maronita ... Latinos reddidit. Io: Alfonsus Borellus ... curam in Geometricis versioni contulit, & notas uberiores in vniversum opus adiecit* (Florence, 1661). The *Liber assumptorum* has a separate title page: *Archimedis Liber Assumptorum interprete Thebit Ben-Kora exponente Almochtasso ... Abrahamus Ecchellensis Latine vestit. Io: Alfonsus Borellus notis illustravit.*



APOLLONII PERGÆI
CONICORVM LIB. V. VI. VII.
PARAPHRASTE
ABALPHATO ASPHAHANENSI
Nunc primùm editi.
ADDITVS IN CALCE
ARCHIMEDIS ASSVMPTORVM LIBER
EX CODICIBVS ARABICIS M.SS.
SERENISSIMI
MAGNI DVCIS ETRVRIÆ
ABRAHAMVS ECCHELLENSIS MARONITA
In Alma Vrbe Linguar. Orient. Profeſſor Latinos reddidit.
IO: ALFONSVS BORELLVS
In Piſana Academia Matheſeos Profeſſor curam in Geometricis verſioni contulit, & notas vberiores in vniuerſum opus adiecit.
AD SERENISSIMVM
COSMVM III.
ETRVRIÆ PRINCIPEM.
FLORENTIÆ,
Ex Typographia Ioſephi Cocchini ad inſigne Stellæ MDCLXI.
SVPERIORVM PERMISSV.

Fig. 2. The title page of the 1661 Apollonius and Archimedes edition, featuring the names of both Borelli and Ecchellensis.
(Courtesy, The Lilly Library, Indiana University, Bloomington, Indiana)

The awkwardness of two separate addresses to the reader testify to the unusual nature of multiple authorship—or "editorship," in this case. To my knowledge, examples where collaborative work is acknowledged on the title page are exceedingly rare, so that the 1661 Apollonius and Archimedes edition is in no way representative of seventeenth-century or earlier publishing practices, especially in the history of the sciences. The celebrated edition of a condensed translation of Ptolemy's *Almagest* by Georg Peurbach and Joannes Regiomontanus, for example, acknowledges their respective contributions in the heading of the dedication to Cardinal Bessarion, whereas the title page reads *Epitoma Joannis de Monte Regio in Almagestum Ptolomei* (Venice, 1496).[12]

The 1661 edition poses other obvious authorship problems at different levels, and the literature on this Apollonius and Archimedes edition amply documents the extensive network of collaborations and exchanges involved. Moreover, translations are often problematic, but in this case Borelli and Ecchellensis were dealing with a paraphrase in a different language from that used by Apollonius. Further, Borelli knew no Greek and when he was back at Pisa had to rely on help from friends in order to check printed editions and manuscripts. In addition, the name of Archimedes is mentioned in the *Liber assumptorum,* and this seems to rule out his direct authorship.[13] Posthumous editions pose additional authorship problems, especially in the case of ancient texts transmitted through successive stages and in different languages.

[12] Peurbach completed the first six books, Regiomontanus finished the translation, which appeared twenty years after his death corrected for the press by the published Johannes Hamman. A case of multiple authorship acknowledged on the title page is V. Wing and W. Leybourn, *Urania Practica: or practical astronomie* (London, 1649). Elizabethan drama is one of the areas where collaborative authorship occurred routinely and has been widely debated. J.A. Masten, *Textual intercourse: collaboration, authorship, and sexualities in Renaissance drama* (Cambridge, 1997). John Dod and Robert Cleaver collaborated extensively in the field of biblical scholarship and appeared as co-authors in *A plaine and familiar exposition of the eighteenth, nineteenth, and twentieth chapters of the proverbs of Salomon* (London, 1610). They both signed the dedication.

[13] E.J. Dijksterhuis, *Archimedes. With a new bibliographic essay by Wilbur R, Knorr* (Princeton, 1987), 401.

3. Anatomical collaborations

From the late 1650s onward, Borelli's house was used as an anatomical laboratory by a number of scholars with different skills but common interests, including the anatomy professor Claudius Auberius from Lorraine, the microscopic anatomist Marcello Malpighi from Bologna, the Florentine Lorenzo Bellini, who eventually succeeded Auberius, and Carlo Fracassati, a former colleague of Malpighi at Bologna. Relying on Medicean patronage, they could dissect a wide range of animals, including exotic ones, in order to compare their body parts and establish the mechanisms according to which they operated. This work involved collaboration among scholars with complementary forms of expertise, such as anatomical prowess, mechanical ingenuity, technical ability with microscopes and injections, as well as philosophical curiosity. This highly productive form of teamwork poses problems of authorship to modern historians and at times generated priority claims among the actors. Borelli was the senior member of the group and had great ascendancy over his collaborators. In all likelihood a physical handicap prevented him from performing manual tasks, such as dissecting, but he compensated by keeping a close eye on his collaborators. No feature of their publications, from the dedication to pictures, from style of writing to references and allusions to contemporary debates and controversies, escaped his attention. In more than one sense then, from the contacts with Medicean patronage, to seniority and intellectual ascendancy, Borelli's role was not dissimilar to that of the "head of the laboratory."[14]

Between 1656 and 1659 Malpighi held a medical chair at Pisa. During those years he was closely associated with Borelli and they had countless conversations on anatomical and philosophical matters, dissection techniques, and interpretative schemes. In his *Vita*

[14] On the Pisa group see M. Malpighi, *Opere Scelte* (Turin, 1967), L. Belloni (ed.), 9-68. H.B. Adelmann, *Marcello Malpighi and the evolution of embryology*, 5 vols. (Ithaca, 1966), esp. vol. 1. D. Bertoloni Meli, "The new anatomy of Marcello Malpighi" and "The posthumous dispute between Borelli and Malpighi," in D. Bertoloni Meli (ed.), *Marcello Malpighi anatomist and physician* (Florence, 1997), 17-60 and 245-73. Both Borelli and Malpighi claimed to have first discovered the spiral structures of the heart in 1657. See Borelli, *De motu animalium*, 2: prop. 37; M. Malpighi, *Vita a seipso scripta*, in Malphigi, *Opera Posthuma* (London, 1697), 2. H.B. Adelmann (ed.), *The correspondence of Marcello Malpighi*, 5 vols. (Ithaca, 1975), 1: 176, where Borelli states that he had difficulties in writing.

Malpighi acknowledged that Borelli had instructed him in the new and free philosophy. Malpighi was also influenced by the first publication of a member of the Pisa group, namely Auberius's 1658 single-sheet *Textis examinatus*. In 1659 Malpighi left Pisa, and the exchanges with Borelli became epistolar. It was through correspondence that Malpighi announced his discoveries on the structure of the lungs, and Borelli exhorted him to publish, "even if it were only half a sheet," probably an allusion to Auberius's *Textis examinatus*. Moreover, Borelli insisted with Malpighi that he include pictures, because of their persuasive powers.[15] Eventually in 1661 Malpighi, by then back at Bologna, published an *Epistola* on the lungs dedicated to Borelli, including copper-plates showing the first significant findings about the microstructure of an organ and marking a significant date in the history of anatomy. Borelli objected to the dedication, since he argued that it would have been better addressed to the Granduke, and to Malpighi's interpretation of the lungs' operation. Following a typical pattern in his relationships with anatomists, Borelli appreciated their structural findings but felt that he was best placed to provide explanations. Following in part Borelli's advice, Malpighi corrected some points in the first letter and expanded his findings in a second letter, also dedicated to Borelli. Malpighi's dedications are indicative of the debt he felt towards his mentor. In a private letter Borelli had outlined an alternative explanation of pulmonary function based on a botanical analogy. He claimed having seen in Rome a vine and jasmine grafted into a lemon tree trunk. This showed that the respective shapes of their vessels led to diverse particle sequences, very different in sweetness from the juice of the lemon tree. The lung vessels were conceived to work analogously,

[15] The correspondence between Borelli and Malpighi is in Adelmann (ed.), *The correspondence*, vol. 1. Additional materials are listed and published in D. Bertoloni Meli, "Additions to the Correspondence of Marcello Malpighi," in Bertoloni Meli, *Marcello Malpighi*, 279-312. See also id., "The new anatomy." Adelmann (ed.), *The correspondence*, 1: 54-6, at p. 55 (letter of 4 January 1661): "Ne perche le cose sono assai piccole si dovranno stimare difficili a disegnarsi, et intagliarsi, perche Vostra Signoria puó fare le cose in grande protestandosi, che per maggior' chiarezza è necessario alterar' le dimensioni di detti lobuli, o membrane, e loro siti: una cosa simile fece il Cartesio nella sua filosofia, e meteora, il quale con quel suo bello, et artificioso modo di spiegarsi, e dichiararsi ha affascinato non pochi huomini da bene." On Malpighi's figures see J.C. Sournia, *The illustrated history of medicine* (London, 1992), 271. L. Premuda, *Storia dell'iconografia anatomica* ([Saronno], 1993), 269.

namely preparing the correct sequences of the mixture between blood and nutritive juice from the thoracic duct in order to produce body parts. In the mechanistic tradition of the Pisa group, respiration was part of the digestive process, and the role of air was limited to helping the mixing of blood and nutritive juice. This rather charming and ingenious explanation was inserted by Malpighi at the end of his second letter on the lungs, and he attributed it to Borelli. Thus the analysis of the *usus* of respiration in Malpighi's letter was provided by Borelli and reproduced almost *verbatim*. Malpighi added that the structure of the testicle is similar, thus establishing a similarity between the nutrition process and generation. The structure of the testicle, as explained in Auberius's *Textis examinatus*, had become the interpretative framework for understanding the lungs' operations.[16]

In the following year Borelli's nineteen-year-old student Lorenzo Bellini published *De structura et usu renum*, which he dedicated to Prince Cosimo III. This is a pioneering work in the process of uncovering with the help of the microscope the micro-structure of the kidneys and providing a mechanical interpretation of their function. To be more precise, after having argued that the kidneys consist of tiny vessels of suitable size and shape, Bellini stated that he was leaving the explanation of their operations to Borelli, introducing his mentor with the words "Certum, inquit, est," or "It is certain, he states." We witness here a pattern similar to Malpighi's second letter on the lungs, where the anatomist explains the structure and Borelli interprets it. In this case, however, Bellini and Borelli were working together, and this probably allowed the senior scholar an even closer control of the text. According to Borelli, the separation of urine from blood occurs without attraction or sympathy, but only on the basis of the configuration of the renal vessels, which work like a filter.[17]

Bellini's work was reprinted several times, such as in Padua in 1663 (Fig. 3). In the 1664 Strasbourg edition, we find an interesting variation. The title page separates Bellini's and Borelli's contributions, attributing to the former *De structura renum observatio*

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[16] Adelmann (ed.), *The correspondence*, 1: 80-3 (letter by Borelli to Malpighi, 24 March 1661). M. Malpighi, *De pulmonibus* (Bologna, 1661).

[17] L. Bellini, *Exercitatio anatomica de structura et usu renum* (Florence, 1662). The original Latin with Italian translation is in F. Grondona, "L'esercitazione anatomica di Lorenzo Bellini sulla struttura e funzione dei reni," *Physis* 5 (1963), 423-63, at 455.

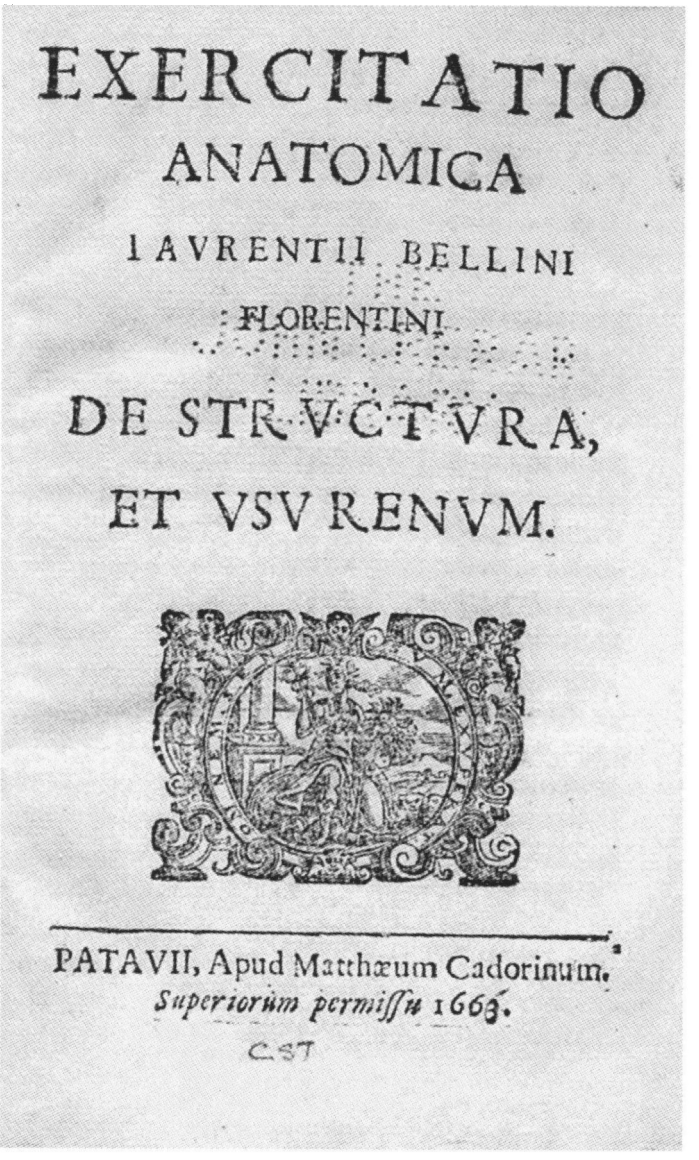
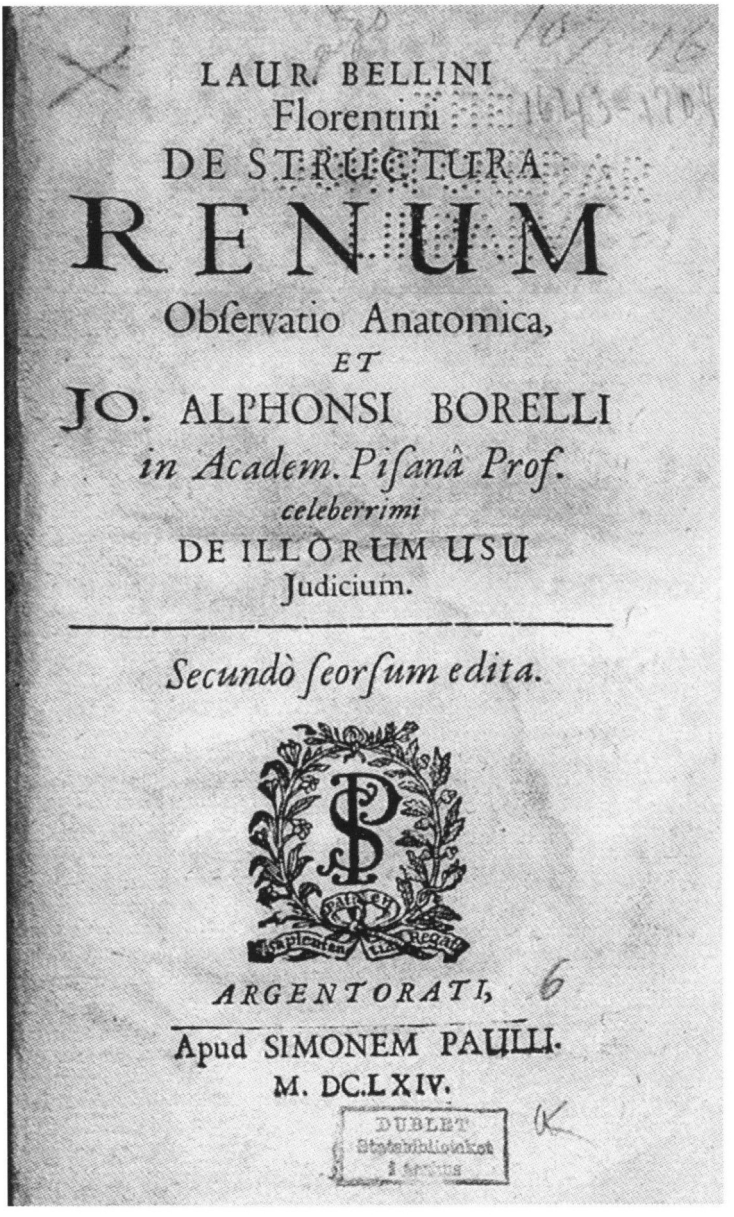


Fig. 3.

Figs. 3 & 4. Changing authorship conventions in two editions of Bellini's (and Borelli's) work of 1663 and 1664.
(Department of Special Collections, The University of Chicago Library)



LAUR. BELLINI
Florentini
DE STRUCTURA
RENUM
Obſervatio Anatomica,
ET
JO. ALPHONSI BORELLI
in Academ. Piſanâ Prof.
celeberrimi
DE ILLORUM USU
Judicium.

Secundò ſeorſum edita.

ARGENTORATI,
Apud SIMONEM PAULLI.
M. DC.LXIV.

Fig. 4. Legend see previous page.

anatomica, and to the latter *De renum usu judicium* (Fig. 4), which starts with the words "Certum est," where "inquit" or "he states" of Bellini's original edition has been omitted. These two works are the first and final part, respectively, of Bellini's *De structura et usu renum*. In the 1730s the *Bibliotheca scriptorum medicorum* by Jean Jacques Manget relied on the Strasbourg edition and attributed a *Judicium*, or opinion, on renal function to Borelli. Manget referred also to the 1665 Amsterdam edition in the same fashion, despite the fact that there Borelli's name does not appear on the title page. Thus a later edition with a different title page separating the contributions of Bellini and Borelli raised the latter to the status of author of a separate treatise. The phenomenon of subsequent editions adopting different authorship conventions is interesting in many respects and deserves careful handling. For the sake of standardization, library catalogues at times select the authorship information from one convenient edition and then apply it to all editions.[18]

Both in the 1661 Apollonius/Archimedes edition and in the 1661 and 1662 texts on the lungs and kidneys, the role of the two contributors could be separated: Ecchellensis dealt with the translation and Borelli with mathematics; Malpighi and Bellini dealt with the dissection or *structura* and Borelli with the lungs' and kidneys' function. However, authorship conventions varied. Borelli's practices appear to be diametrically opposed to those of our research laboratories, where directors often appear as co-authors of all publications coming from their institutions. In his *magnum opus*, however, *De motu animalium* (Rome, 1680-1), Borelli relied on years of collective work with the group of his medical friends.

Among Italian intellectual circles, and especially at Pisa University, Borelli was considered a leader of the neoterics, or of the philosophers opposed to scholasticism and actively defending broadly corpuscular and mechanistic views inspired by Galileo and Gassendi. Within this context, authorship was used as a negotiable commodity with the aim of promoting younger scholars and a new worldview. Later anatomical publications by Malpighi, Bellini, and

[18] *Laur. Bellini Florentini De structura renum observatio anatomica. Et Jo. Alphonsi Borelli ... De illorum usu judicium* (Strasbourg, 1664). On p. 24 we read that Borelli's work has been extracted from Bellini's. Borelli's work is at pp. 25-9. The Amsterdam edition cited below was published in 1665 "Sumptibus Andreae Frisii." J.J. Manget, *Bibliotheca scriptorum medicorum* (Geneva, 1731), 4 vols., 1: 366.

Fracassati on the tongue and taste also show signs of collaboration orchestrated by Borelli. Not suprisingly, the latter was able to find university positions for Bellini at Pisa, Malpighi at Messina, and later Fracassati at Pisa and Messina. In a letter to Malpighi, Borelli claimed that his enemies

> have formed a sect trying to persecute these Doctors pupils of mine, and have not forgotten to insinuate that the reason for their getting together was that I want to be the reformer of this Studio, by choosing Lectors belonging to my faction.[19]

Borelli was a "political" mind, one with a clear perception of the intellectual struggle then unfolding and with a vision of what he wished to achieve. This is one of the reasons why authorship conventions in his case are particularly interesting.

Despite Borelli's leading role and the peculiar arrangements and history of Malpighi's and Bellini's publications, one should not assume that collaboration in different formats was unusual in the seventeenth century. Lack of multiple authorship does not mean lack of extensive teamwork, because teamwork was acknowledged in different ways. As readers unfamiliar with those codes of acknowledgement, we must pay close scrutiny to them and be aware that relevant references can be located among printed and unprinted sources.

This strategy will prove highly rewarding and provide novel perspectives on the history of the sciences. I wish to instantiate my claim by briefly surveying examples of teamwork parallel to those explored in this section. At Padua around 1600, it appears that Galileo and his personal physician, the anatomist Gerolamo Fabrizi of Acquapendente, collaborated in the investigation of animal motion. Descartes had extensive anatomical interests and had fruitful exchanges with medical men such as Henricus Regius. In London too we witness the collaboration between the curator of experiments at the Royal Society, Robert Hooke, and Richard

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[19] Adelmann (ed.), *The correspondence*, 1: 122-3: "Quali han' fatto una setta procurando di perseguitare questi Dottori miei scolari, e non hanno anco lasciato d'insinuare che la cagione di tal' loro unione, é stata perché io voglio fare il riformatore di questo studio, mettendovi lettori di mia fazzione." Borelli continues: "il che si intende da duc filosofi mei allievi, et anche per il Sig^{r} Fracassati e per il Puccini che ha fatto Notomia quest'anno, ma da tanti loro sforzi ne hanno solamente cavato mortificazioni e bravate solenni dai Principi." On his control of Messina University see my "The neoterics and political power in Spanish Italy: Giovanni Alfonso Borelli and his circle," *History of Science* 34 (1996), 57-89. See also Adelmann, *Marcello Malpighi*, 1: 240ff.

Lower in the investigation of respiration, a collaboration acknowledged by Lower in print in his *Tractatus de corde* of 1669. Hooke was also acknowledged in Nehemiah Grew's treatise on plants, for the help he had offered in microscopy. Another great anatomical work of the period, the 1664 *Tractatus de cerebro* by Thomas Willis, resulted from the collaboration with Edmund King and the architect and mathematician Christopher Wren, who drew the pictures for the book. This list can easily be extended to the circle of iatromathematicians around Newton, which included Archibald Pitcairn and George Cheyne. In all these collaborations, philosopher-mathematicians (Galileo, Descartes, Borelli, Hooke, Wren, Newton) inspired and/or were inspired by anatomists and physicians, so that many of their works bear the fruits of collaborative efforts.[20]

Current seventeenth-century historiography is divided between historians of the physico-mathematical and medico-anatomical disciplines and thus into separate and not easily reconcilable accounts. The former generally focus on novelties, such as the rise of the experimental philosophy, the new emphasis of matters of

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[20] U. Baldini, "Animal motion before Borelli, 1600-1680," in Bertoloni Meli (ed.), *Marcello Malpighi anatomist and physician*, 193-246, at 203-4. R.G. Frank, *Harvey and the Oxford physiologists: A study of scientific ideas* (Berkeley, 1980). G.A. Lindeboom, *Descartes and medicine* (Amsterdam, 1979). A. Bitbol-Hespériès, *Le principe de vie chez Descartes* (Paris, 1990). A. Guerrini, "Isaac Newton, George Cheyne and the 'Principia medicinae'," in R. French and A. Wear, (eds.), *The medical revolution of the seventeenth century* (Cambridge, 1989), 222-245. H.J. Cook, "The new philosophy and medicine in 17th-century England," in D.C. Lindberg and R.S. Westman (eds.), *Reappraisals of the scientific revolution* (Cambridge, 1990), 397-436; id. "Physick and natural history in seventeenth-century England," in P. Barker and R. Ariew (eds.), *Revolution and continuity. Essays in the history and philosophy of early modern science* (Washington D.C., 1991), 63-80; id. "The new philosophy in the Low Countries," in R. Porter and M. Teich, eds, *The Scientific Revolution in national context* (Cambridge, 1992), 114-49; id., "Physicians and natural history," in Jardine, Secord, Spary (eds.), *Cultures of natural history*, 91-105. N. Howard, "Beyond Artificial Wings: Hooke's Role in the History of Anatomy" (unpublished manuscript). It would be easy to extend this list by adding a host of collaborative enterprises among physicians and experimental philosophers in the seventeenth century. See for instance M. Hunter, "Boyle versus the Galenists: a suppressed critique of seventeenth-century medical practice and its significance," *Medical History* 41 (1997), 322-61. Back in Italy, around 1700 we find a remarkable group of scholars, such as Geminiano Montanari, Bernardino Ramazzini, Domenico Guglielmini, and Pier Antonio Michelotti, with both strong medical and mathematical interests, especially in the science of waters. In their cases, their careers and intellectual formations testify to the important role of an approach spanning the disciplinary divide. See C.S. Maffioli, *Out of Galileo. The science of waters 1628-1718* (Rotterdam, 1994).

fact, and the mechanization of the world picture. Such themes are noticeably less prominent among the latter, especially with regard to the study and cure of disease. Yet, paying attention to circumstances of composition and collaboration among historical actors reveals an extensive exchange and sharing of practices and forms of expertise among practitioners from different disciplines. From this perspective, a fresh look at the history of the sciences and of medicine in the seventeenth century, following the historical actors' allegiances and collaborations, promises to offer fresh insights into an area still dominated by disciplinary history. For example, how did the mechanical philosophy affect seventeenth-century notions of organism, disease, and therapy? Can we trace any links between the rise of the experimental philosophy and medical practice? What can we learn by comparing anatomical experiments and physico-mathematical ones?

4. The Cimento Academy and its Saggi

In areas ranging from humanist Biblical scholarship, especially polyglot Bibles, to the edition of maps and atlases, teamwork was at the core of the publishing enterprise.[21] Publications by corporate bodies, such as medical colleges, societies, or academies, pose interesting problems of authorship. At times the institution itself appeared as the author of a publication, such as medical colleges authoring *Antidotaria*, or lists of officially accepted medicines with instructions on how to prepare them. If there was one identifiable author, his name—usually male—often appeared on the title page. Multiple contributors or authors, however, could have their names mentioned in a preface or altogether omitted. At times, it was also problematic for an individual author to mention affiliation to a corporate body, since it was not clear whether his publication had the body's approval. Occasionally, it was problematic for a member to publish at all even under his own name without the approval of the corporate body.[22]

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[21] P.G. Hoftijzer, "Between Mercury and Minerva: Dutch printing offices and bookshops as intermediaries in seventeenth-century scholarly communication," in Bots and Waquet (eds.), *Commercium litterarium*, 119-29, at 124. A. Grafton, with A. Shelford and N. Siraisi, *New worlds, ancient texts* (Cambridge, Mass., 1992), 30.

[22] Examples of collective publications by Colleges of Physicians are *Antidotarium Bononiense a Collegio Medicorum novissime restitutum anno jubilaei MDCCL*

Giandomenico Cassini's works on the satellites of Saturn instantiate many of these cases. In 1671 and 1672 he discovered two new satellites and in the following year dedicated a small pamphlet to Louis XIV, entitled *Découverte de deux nouvelles planètes autour de Saturne* (Paris: Chez Sebastien Mabre-Cramoisy, Imprimeur du Roy, 1673). Cassini's name does not appear on the title page, but his authorship is clearly established in the dedication to the king, which he signed and where he stated that the sum of the numbers of planets (six) and satellites (eight) was XIV. It is also significant, of course, that the pamphlet was published by the royal printer. In 1677 Cassini published an article on the same subject in the *Journal des Sçavans* where his name appears in the title, "Histoire de la découverte de deux Planetes autour de Saturn, faite à l'Observatoire Royale, par M. Cassini." In 1684 he discovered two more satellites and in 1686 published an article in the *Journal des Sçavans* with an interesting addition in the title concerning his position as member of the *Académie Royal des Sciences*, "Nouvelle découverte de deux Satellites de Saturne les plus proches, faite à l'Observatoire Royale, par M. Cassini, de l'Acad. R. des Sciences."[23] At the end of his article, Cassini named the satellites of Saturn "Sidera Lodoicea," in honor of his patron. The royal mint, probably acknowledging the heavenly gift, issued a medal celebrating the event as one of the most notable of Louis XIV's reign. Although Cassini's name appears neither on the medal, nor in the relevant caption in the publication by the *Académie Royal des Medailles et des Inscriptions*, he figured in different authorial forms in all the relevant publications.[24]

(Bologna, 1750); and *Pharmacopoeia Londinensis. Opera Medicorum Collegij Londinensis* (London, 1618). Both went through several editions, some of which are attributed to individual authors. Often these texts had a legal status and were used for controlling apothecaries. For the Society of Jesus an internal censorship secured that each work published by a member of the Society complied with the Society's rules. U. Baldini, "Una fonte poco utilizzata per la storia intellettuale: Le 'censurae librorum' e 'opiniunum' nell'antica Compagnia di Gesú," *Annali dell'Istituto Storico Italo-Germanico. Trento* 11 (1985), 19-67. The *Académie Royal des Sciences* refused Samuel Cottereau Duclos permission to publish his work *Dissertation sur les principes des mixyes naturels, faite en l'an 1677*. Duclos revised it and published it with the Elzeviers in Amsterdam in 1680. A. Stroup, *A company of scientists: botany, patronage, and community at the seventeenth-century Parisian Royal Academy of Science*, (Berkeley, 1990), 206 and 345. See also R. Briggs, "The Académie Royale des Sciences and the Pursuit of Utility," *Past & Present* 131 (1991), 38-88.

[23] Cassini's publications appeared on pages 88-92 (1677) and 139-54 (1686).

[24] The publication by the *Académie royale des medailles & des inscriptions*, namely *Medailles sur les principaux événements du regne de Louis le Grand, avec des explications*

In this section I am going to focus on some themes associated with the *Saggi di naturali esperienze* (Firenze: Giuseppe Cocchini, 1667), the only collective publication of the Cimento Academy. The traditional dates of the Academy are 1657-1667, the latter being more meaningful than the former because the academy was never formally established. The Medici Princes had a long-standing interest in experimental philosophy, but a register of the experiments started only in 1657. The academy died in 1667, when three of its core members, Borelli, Antonio Oliva, and Carlo Renaldini, left Tuscany and its patron, Leopold, was made a Cardinal. In addition to not being formally established, membership was not officially sanctioned and in many cases it changed drastically when some participants were sent out of Tuscany, often on diplomatic service. Despite this state of flux, throughout its history membership included university professors such as Renaldini and Alessandro Marsili, who taught philosophy at Pisa, and Borelli, as well as courtiers and aristocrats, such as Count Lorenzo Magalotti, Alessandro Segni, and court employees such as Vincenzo Viviani. The intellectual composition of the academy too was mixed: members such as Borelli were declared and radical neoterics, while others took the role of the defenders of Aristotelianism, such as Renaldini, and still others occupied a moderate intermediate position. This intellectual composition insured that the Academy was considered *super partes*.[25]

It is instructive to draw a comparison with another of Prince Leopold's activities, that of collecting drawings. Together with celebrating Medicean patronage of the sciences and of Galileo, or of Tuscany as the birthplace of the Italian language with Dante and Boccaccio, the Medici were celebrating Tuscany as the place

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historiques (Paris, 1702), is of course itself of interest in the present context. I.B. Cohen, "G.D. Cassini and the number of planets: An example of seventeenth-century astro-numerological patronage," in T.H. Levere and W.R. Shea (eds.), *Nature, experiment, and the sciences* (Dordrecht, 1990), 199-205. M. Biagioli, "M. Biagioli, "Etiquette, interdependence, and sociability in seventeenth-century science," *Critical Inquiry* 22 (1996), 193-238, at 221. I found no evidence suggesting that Cassini was involved in issuing the medal or in the related caption. One can only wonder what Huygens thought of Cassini's dedication, since the first satellite of Saturn had been discovered by the Dutch mathematician.

[25] Classic studies on the Cimento are W.E.K. Middleton, *The experimenters. A study of the Accademia del Cimento* (Baltimore, 1971). P. Galluzzi, "L'Accademia del Cimento: 'gusti' del Principe, filosofia e ideologia dell'esperimento," *Quaderni Storici* 16 (1981), 788-844.

where the arts were reborn in the works of Cimabue and Giotto. Leopold's collection of drawings fits into this framework and is organized chronologically and according to regional schools. Both for financial reasons at the time of the acquisition, and for historical reasons within the collection, it was crucial to have the correct attribution of the drawing to a master and school. The attribution procedure, a notoriously arduous task in the case of drawings, was humorously called a "baptism." Such baptisms involved processes which displayed interesting analogies to, but also differences from, the meetings of the Cimento Academy. Of necessity, there was no fixed membership in the committee or *consulta* making the attribution, because drawings could appear on the market everywhere in Italy, and Leopold had to rely quickly on any competent person at hand. When he could, he participated himself, as he tried to do with the final stages of the experiments of the Cimento Academy, but when he could not, he relied on his agents and official or unofficial ambassadors *in loco*. He did not rely on experts working in isolation, however, but rather on a team of them. He favored a combination of nobles and artists or art historians, much like at the Cimento, where he relied on nobles and university professors. Among the nobles active at Bologna, for example, were Count Annibale Ranuzzi and Marquis Ferdinando Cospi. The artists and art historians included Ciro Ferri and Giovanni Battista Natali in Rome, Justus Sustermans and Filippo Baldinucci in Florence. Possibly nobles were seen as sufficiently detached and impartial, whilst artists and "professionals" provided technical expertise. Thus, in both cases teamwork among a changeable group of members selected in accordance with pondered criteria and guidelines, produced reliable knowledge about art and nature, worthy of entering Leopold's collection of drawings or experiments. In both cases, Leopold was a key actor in the form of a refined and intelligent patron. Similar considerations apply to the operations of the *Accademia della Crusca* and Leopold's participation to its activities.[26]

[26] For Leopold's art collections I rely on E.L. Goldberg, *Patterns in late Medici art patronage* (Princeton, 1983), 28ff.; id., *After Vasari: history, art, and patronage in late Medici Florence* (Princeton, 1988). The *Accademia della Crusca* was also a collective body formed by aristocrats and linguistic experts, but it was obviously not Leopold's creation, since it was established in 1583 while Leopold became a member only in 1641. Leopold's activities as "cruscante" are also of considerable interest. S. Parodi, *Quattro secoli di Crusca. 1583-1983* (Florence, 1983), ch. 2, at 59 and 66. On Leopold's intellectual profile see A. Mirto, *La biblioteca del Cardinal Leopoldo de' Medici* (Florence, 1990), esp. 33-47.

From the minutes of the meetings of the Cimento, we gain a precious perspective on the activities of individual members, on the academy's agenda, and on the internal discussions, three aspects conspicuously absent from the final published product. The title page (Fig. 5) indicates that the *Esperienze* had been performed under the protection of Prince Leopold and described by the secretary. The name of the secretary, Lorenzo Magalotti, does not appear either on the title page or in the book, nor does that of any other academician.[27] Ferdinand II is mentioned in the dedication, but Prince Leopold's is the only name of those involved in the project to be mentioned on the title page, thus appearing in a somewhat peculiar authorial form, in the sense of agent or originator, or perhaps more accurately, as patron or guarantor.[28] Further, the Cimento Academy appears more like a venue than as an agent, as exemplified by the usage in the title of "nella Accademia" or "at the Academy" as opposed to "dalla Accademia" or "by the Academy." One could argue that Magalotti was portrayed as the author of the text and in legal terms, had the *Saggi* had problems with the censorship like Galileo's *Dialogo*, it would have been Magalotti to be tried by the Holy Office. On the other hand, the title page states that the academy's secretary had only "described" the experiments performed, more like someone taking minutes at a meeting than like an author. These remarks pose the problem of intellectual authorship for this work, which is attributed in library catalogues and bibliographies at times to the Academy as a whole and at times to Magalotti. His name appears in square brackets in the card catalogue at the University Library, Cambridge, in accordance with Anglo-American cataloguing rules.[29]

Tentatively one may argue that the word "naturali" in the title was meant to suggest that Nature was the author and was speaking in the book. This view is supported by the frequent usage of the impersonal in the description of the experiments, as if to suggest

[27] The name of Lorenzo Magalotti, however, appeared on the title page of the Venice edition of 1761. G. Abetti and P. Pagnini (eds.), *Le opere dei discepoli di Galileo Galilei*, vol. 1 (Florence, 1942).

[28] M. Biagioli, "Scientific Revolution, social bricolage and etiquette," in Porter and Teich (eds.), *The Scientific Revolution*, 11-54. J. Tribby, "Of conversational dispositions and the *Saggi's* proem," in E. Cropper, Giovanna Perini, F. Solinas (eds.), *Documentary culture. Florence and Rome from Grand-Duke Ferdinand I to Pope Alexander VII* (Baltimore, 1992), 379-90.

[29] See *Anglo-American cataloguing rules. Second edition, 1998 revision* (Ottawa, London, Chicago, 1998), 24, and *s.v.* "Authorship" and "Statements of responsibility."

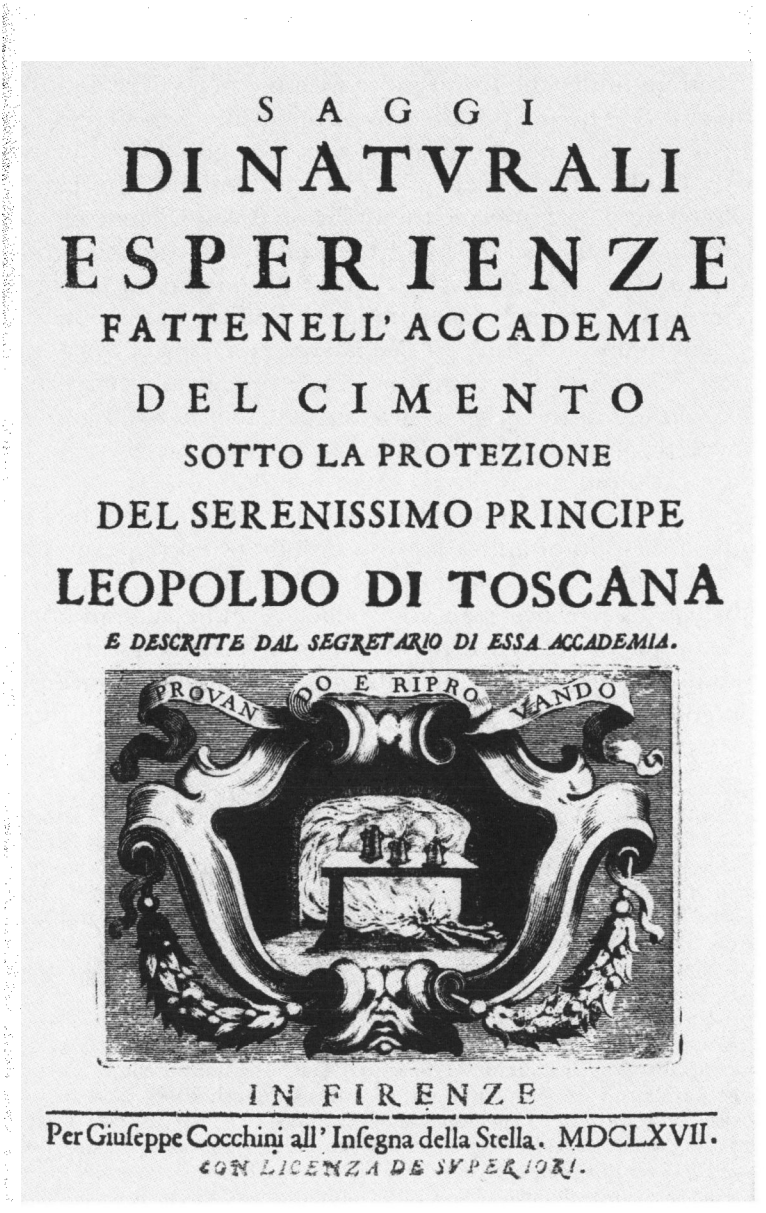

Fig. 5. The authorless title page of the *Saggi di naturali esperienze fatte nell'Accademia del Cimento* (1667)
(Author's collection)

that human intervention was of secondary importance compared to Nature's agency. This interpretation is further strengthened by the quatrain under the frontispiece with the portrait of Granduke Ferdinand II. The text, drafted by Leopold himself, suggests that whereas the heavens had disclosed to the "great royal genius," namely Galileo, the secrets of the highest sphere, the earth in emulation was now removing the veil from unknown marvels. Thus Nature, first in the heavens and then on earth, was the protagonist of the investigations carried out under Medicean patronage. This image was strikingly taken up in the English translation of the *Saggi*, where the *Accademia del Cimento* offers a copy of the *Saggi* to the Royal Society, while Nature daringly reveals her marvels and, while pointing to the *Saggi* as if to suggest that her veil had been removed through that book, looks on at a grim-faced Aristotle as if to say "You did not make it" (Figs. 6 and 7).[30]

Since the Cimento Academy included many members in a state of flux, a division of authorial responsibilities on the example of the 1661 edition of Apollonius and Archimedes would have been unfeasible. As we have seen above, lack of individual authorship was common in collective publications by academies and other corporate bodies and can plausibly be explained by conventions about collaborative works.[31] Moreover, in the case of the Cimento one may attach an epistemological meaning to the *Saggi* as well.

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[30] For the attribution of the quatrain to Leopold, see Middleton, *The experimenters*, 77. The quatrain reads: "Se al gran genio real scoperse il cielo / Gli arcani intatti dell'eccelsa sfera / Oggi la terra emulatrice altera / Toglie ad ignote maraviglie il velo." The reference to the highest sphere seems a direct allusion not to the Medicean planets but to Galileo's Copernicanism. For the problematic posthumous celebrations of Galileo see P. Galluzzi, "The sepulchres of Galileo: The 'living' remains of a hero of science," in P. Machamer (ed.), *The Cambridge Companion to Galileo* (Cambridge, 1998), 417-47.

[31] It is reasonable to argue that Leopold's closeness to his academicians, and more generally the ruler's closeness to his scholars, was a factor in erasing their authorship. Biagioli, "Etiquette," 215, argues that "The authorship of the academicians was erased (or 'insulated' until it was extinguished) because they were too close to the prince." This model is applied also to other cases. As I have argued in my "Shadows and Deceptions: from Borelli's *Theoricae* to the *Saggi* of the Cimento," *The British Journal for the History of Science* 31 (1998), 383-402, however, the Medici were heavily involved in other publications as well, such as *Theoricae Mediceorum Planetarum* (Florence, 1666), to the point of publishing it at their own press (Ex Typographia S[erenissimi] M[agni] D[ucis]), with the name of Giovanni Alfonso Borelli figuring prominently on the title page as the author. This instance suggests that the rulers' closeness to the author(s) may not have been as crucial a factor as the collaborative nature of the publication. Compare also the case of Cassini's *publications*, above.

Fig. 6. Frontispiece of the *Saggi* with Leopold's quatrain (Author's collection)

Fig. 7. Frontispiece of the English edition of the *Saggi*, where a grim-faced Aristotle admires Nature uncovering her beauties.
(Courtesy, The Lilly Library, Indiana University, Bloomington, Indiana)

The issues of authorship and acknowledgement are historically and legally different and should be treated separately. The lack of acknowledgements to any individual member is more complex and requires a different explanation. The dedication to Ferdinand II, dated July 14, 1667—his birthday—is signed collectively by the academicians, and then singly by the secretary in the usual "academic" form as "il Saggiato Segretario," without individual names. This suggests a deliberate plan, though exactly which one is not clear. In a revealing letter of 1662, however, Magalotti accused Borelli of trying to appropriate for himself some of the Cimento experiments, against the rule of considering all the academy's activities as collective, and this clearly suggests that the academy was meant to operate as a collective body, like the *Accademia della Crusca*.[32]

With respect to mentioning contributors to the *Saggi*, one could argue that this text was serving a plurality of purposes, one of them being linguistic. The image of Tuscany as the birthplace of the Italian language was eagerly cultivated by the Medici through their patronage of the *Accademia della Crusca*, and the fact that the *Saggi* was written in Italian was possibly as significant as its philosophical contents. Great efforts were devoted to language, and several experts were consulted, in Florence as well as elsewhere, such as the "cruscante" Cardinal Sforza Pallavicino at Rome. None of them was mentioned in the text, although presumably they would have received copies of the work. Had a list of acknowledgements been included, it is difficult to see where it could have stopped, given that language issues were as important to the Medici as philosophical matters. Moreover, a list of acknowledgements would inevitably have aroused controversies and jealousy among the included and the excluded.

Not surprisingly, some of the academicians were unhappy with

[32] S. Fermi, *Lorenzo Magalotti, scienziato e letterato, 1637-1712* (Piacenza, 1903), 83. Interesting variations can be noticed in the corporate publications by the *Académie Royal des Sciences*. In some cases the preface identified each contributor, such as D. Dodart (ed.) [mentioned as having "dressez" the work], *Memoires pour servir a l'histoire des plantes*(Paris, 1676). In other volumes the preface identified the work as a collective production of the Academy as a whole without mentioning individual contributors, such as the *Memoires pour servir a l'histoire naturelle des* animaux, 2 vols., (Paris, 1671-6). Subsequent editions altered the original authorship conventions. See Stroup, *A company of scientists*, 207. R. Hahn, *The anatomy of a scientific institution: The Paris Academy of Sciences, 1666-1803* (Berkeley, 1971), 26. To my knowledge, the English Royal Society produced no corporate publications.

the outcome of the *Saggi* of the Cimento Academy, both because of its sanitized nature and lack of a strong philosophical stance, and because their own names were omitted. As a result of its composite nature and internal diatribes, the *Saggi* resulted in a compromise where experiments were often presented somewhat cryptically without interpretation. Borelli was certainly one of those who would have liked an acknowledgement of his own activities. Unlike the cases with Malpighi and Bellini, he was not in control of the *Saggi* of the Cimento, where the omission of his name from the title page and book itself was not a part of his academic plans.

In 1667, on his way back to Messina, Borelli stopped in Naples and was elected a member of the Investiganti Academy, a group of intellectuals openly defending neoteric positions. At this Academy he replicated several of the Cimento experiments, and in 1670 he published a work, *De motionibus naturalibus a gravitate pendentibus*, dedicated to the patron of the Investiganti, Andrea Concublet. In his work Borelli identified himself as the author of several Cimento experiments and interpreted them according to his explicitly anti-Aristotelian philosophy. Thus the "same" experiments performed at different academies could be presented under different authorship conventions and philosophical interpretation, to the delight, no doubt, of Prince Leopold.[33]

The examples discussed in this essay cover a small portion of the problems related to authorship and collaborative works in the seventeenth century. Even such a focused investigation, however, suggests both that collaboration was more widespread than we have recognized and that authorship criteria varied considerably depending on a wide range of factors. I hope that the publications examined above and the case of Borelli will prove useful in stimulating further reflections on these themes.

SUMMARY

Multiple authorship is so common and pervasive in our world that it is tempting to take it for granted. Prior to the twentieth century, however, multiple authorship was exceedingly rare. This essay addresses the issue of whether in the past

[33] G.A. Borelli, *De motionibus naturalibus a gravitate pendentibus* (Regio Giulio, 1670), ch. 5, props. 105 and 120. M.H. Fisch, "The Academy of the Investigators," in E. Ashworth Underwood (ed.), *Science, medicine and history*, 2 vols. (Oxford, 1953), 1: 521-63. M. Torrini, "L'Accademia degli Investiganti: Napoli 1663-1670," *Quaderni Storici* 48 (1981), 845-883.