Chapter 1
Introduction

Abstract At the turn of the seventeenth century, the Venetian physician Sanctorius Sanctorius (1561–1636) developed instruments to measure and to quantify physiological change. As trivial as quantitative assessment with regard to health issues might seem to us today – in times of fitness trackers and smart watches – it was a highly innovative step at the time. With his instruments, Sanctorius introduced quantitative research into physiology and thus represents an early case of today's self-tracking, or self-quantifying, technology. Until now, no systematic research has been undertaken to investigate Sanctorius and his work from the broader perspective of processes of knowledge transformation in early modern medicine while including the entire range of his activities—intellectual and practical—rather than just a selection. This work aspires to fill that gap. As an introduction to the entire book, this chapter gives an overview of the aims, sources, methodologies and contents of the book.

How many steps have you taken today? How many calories did you burn? Is your smartwatch buzzing again, to remind you to leave your desk and get some exercise? Wearable technology in the form of smart watches or fitness trackers, for example, has become a familiar part of daily life for most of us. According to Meghann Chilcott, member of the Forbes Technology Council, the market value of fitness technology wearables is likely to grow to over $23 billion by 2025.[1] The technology's rise illustrates the importance of quantitative assessment for society today, especially with regard to health issues; and it reveals how deeply integrated such asessment has become in our everyday lives. But of course, this has not always been the case. At the turn of the seventeenth century, when the Venetian physician Sanctorius Sanctorius (1561–1636) stepped into his famous steelyard to measure changes in weight, medicine had not yet been conceived of in quantitative terms. Not numbers, but the physician's *senses* were central to any diagnosis. By

[1] See: https://www.forbes.com/sites/forbestechcouncil/2020/03/09/wearing-it-well-the-next-steps-for-wearable-medical-technology/#76945c308d1a. Accessed 16 June 2020.

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developing several instruments to measure physiological change, Sanctorius introduced into the medical field a form of quantitative research that represents an early iteration of today's self-tracking, or self-quantifying, technology.

Historical accounts of Sanctorius and his work tend to foreground the genius who invented, almost out of the blue, a new medical science that profoundly influenced the modern age. This new science is known as iatrophysics, iatromechanics, or sometimes iatromathematics (from the Greek "iatro," meaning "physician"). These terms by no means denote clear categories, but rather have been quite flexibly applied, retrospectively, to developments in research on medicine and the philosophy of nature. The terms are comparable nevertheless: all of them reflect the importance of quantification in medical research, as well as the field's tendency to utilize numerical values and mechanical factors.[2] Besides these heroic narratives, there are a few critical voices who have emphasized instead Sanctorius's strong adherence to the medical tradition of his day, namely Galenic medicine (Wear 1973, 1981; Farina 1975). Admittedly, these are merely the two ends or extremes of what amounts overall to a more balanced spectrum of views of Sanctorius.[3] Yet, some commentators do conjure an image of an innovator who developed his novel approach *despite* clinging to those traditional concepts frequently dismissed as old-fashioned Galenism. In doing so, they overlook a decisive dimension of the complex process through which Sanctorius generated new knowledge, as I will show in this book.

Until now, no systematic research has been undertaken to investigate Sanctorius and his work from the broader perspective of processes of knowledge transformation in early modern medicine while including the entire range of his activities—intellectual and practical—rather than just a selection. This work aspires to fill that gap. By examining not only those parts of Sanctorius's works that are, or appear to be, innovative, but also his work in its entirety, in the context of its day and in its various facets, I try to shed light on the epistemic processes that led Sanctorius to develop his quantitative approach to physiology. I hope thus to contribute to our understanding of the ways in which knowledge was generated and transformed in a period that was shaped by numerous historical developments of far-reaching significance in science and that is, indeed, often deemed a "scientific revolution." As will be seen, in Sanctorius's undertakings, medicine and technology intersect. It is essential, therefore, that any historical study of his work take into account knowledge and practices in both of these fields and their mutual impact. I do so here, by examining scientific development through the twin lens of the histories of medicine and technology. In doing so, I consider not only the intellectual but also and especially the practical dimensions of Sanctorius's activities. This is a marked departure

[2] Capello 1750, Vedrani 1920, Giordano and Castiglioni 1924, Castiglioni 1931, 1936, Baila 1936, Major 1938, Miessen 1940, Premuda 1947, 1950, Sanctorius and Lebàn 1950: 13–102, Ettari and Procopio 1968, Rothschuh 1968, Mattioli 1985: 253–62, Eknoyan 1999, Lemmer 2015.

[3] Del Gaizo 1889, Grmek 1952, 1967, 1975, 1990, Siraisi 1987, Dacome 2001, 2012, Sanctorius and Ongaro 2001: 5–47, Guidone and Zurlini 2002, Maclean 2002, Poma 2012, Bigotti and Taylor 2017, Bigotti 2018, Hollerbach 2018.

from other research to date, which has usually focused on Sanctorius's thinking, not on his making and doing.[4]

To put it in a nutshell, this book aims for a broad-ranging and yet integrative view of Sanctorius and his work that examines both innovation and tradition, as well as their complex interplay within the realms of theory and practice, and their social dimensions. It thus facilitates a reevaluation of Sanctorius's role in the wider process by which medical culture began to be transformed in the early modern period—a process that ultimately led to Galenic medicine being abandoned in favor of a new medical science based on the use of quantification in medical research.

Sources and Methodologies Around 2000 pages, often subdivided into columns, in six books: this is Sanctorius's written output in quantitative terms.[5] With the sole exception of his renowned *De statica medicina*, his work is available only in the Latin original. It is this, perhaps, which has prevented scholars from investigating all of Sanctorius's work. Moreover, three of his six books are lengthy commentaries on early medical works still authoritative in his day: Galen's *Ars medica*, Avicenna's *Canon,* and Hippocrates's *Aphorisms*. The *Commentary on Avicenna* has attracted attention, since it is the sole work in which Sanctorius published illustrations of his instruments. Contrary to the traditional historical approach to Sanctorius, which begins—and often also ends—with the *De statica medicina* and the *Commentary on Avicenna,* his major publications, I set out to find my way through the maze of words in the Venetian physician's lesser-known works—the *Commentary on Galen* and the *Commentary on Hippocrates*.

However, analysis of these medical commentaries involves other challenges besides the great masses of Latin text. As the historian Per-Gunnar Ottosson has pointed out in his study of late medieval commentaries on Galen's *Ars medica*, the topics here are discussed not in their own right, but always in relation to the original work commented upon. Thus, when interpreting the content of the commentaries, there is always the problem of determining whether a statement is merely a set phrase without any special significance, an effort to give objective expression to a medical authority, or an expression of the author's original personal convictions. According to Ottosson, the only way to solve this problem is to consider these texts in a broader historical context and compare them with earlier views; for only so can any significant changes in attitude be ascertained (Ottosson 1984: 65). This is the

[4] Only in recent times have the material dimensions of Sanctorius's undertakings been the subject of historical research. See: Bigotti and Taylor 2017, Hollerbach 2018.

[5] In Sanctorius's books the page numbering is either according to columns, or it is a foliated pagination (with *recto* and *verso* indicating front and back of each numbered folio leaf). For my total page count, I converted the pagination into regular, sequential pagination. With regard to the number of published books, I counted the *Commentary on Galen* that was published in two separate volumes as one book, whereas I counted the *Commentary on Hippocrates* and the *De remediorum inventione* as two separate books, even though they were published together in the same volume. For more information on Sanctorius's publications, see Chap. 2.

method I used when analyzing Sanctorius's two commentaries—contextualizing them in the framework of contemporary Galenic medicine.

But why all this effort? Medical historian Nancy Siraisi has convincingly shown that the study of medical commentaries is worthwhile, revealing their value as historical sources. Rather than being reactionary theoretical writings with little significance for Renaissance medicine, commentaries by academic physicians can offer important insight into the intellectual and scientific culture of the period. In fact, writing commentaries on authoritative texts fell within the mainstream of contemporary intellectual life. Accordingly, Sanctorius's commentaries illustrate his responses to contemporary intellectual currents and reveal how he adopted specific technical or practical innovations into a still largely traditional framework. Given that his commentaries originated in the lectures he gave as a professor of medicine at the University of Padua, they provide a window onto his university medical teaching; although of course they do not necessarily directly mirror his classroom practice. In addition to this, they reveal how much his lectures on authoritative texts reflected his own interests and, too, his encounters with the ideas, activities, and controversies of the intellectual environment in which he produced them (Siraisi 1987: 4–12). This is why I paid particular attention to those two commentaries by Sanctorius that had hitherto been largely overlooked. I was convinced that they were key to understanding Sanctorius's own intentions and to approaching Sanctorius in the light of his own era.

In order to navigate the masses of text, I worked with digitized versions of the first editions of Sanctorius's books, which were embedded in a digital annotator along with searchable transcripts of the original texts. While reading, I annotated text passages, highlighted the works, people, and locations cited, and defined certain keywords, such as "quantity" (*quantitas*), for example, as I show in Appendix I. This helped me get an overview of the contents and find my way through the many pages while writing up this research.

I complemented my analysis of Sanctorius's publications by research in the libraries and archives of Padua and Venice, the two cities where Sanctorius mainly lived and worked. This shed light on his biography as well as on his social and institutional setting: the milieu in which he moved.

Besides Sanctorius's writings, I focus in the book on the material aspects of his research. This accords with the greater attention placed by historians of science, in recent decades, on those practical and material dimensions of research endeavors that shape the processes of knowledge transformation.[6] In adopting this material culture approach, I gave particular consideration to the practical features of his projects, above all his instruments and their possible use. In order to further approximate Sanctorius's medical practice and thereby trace the mechanical and practical knowledge involved in his undertakings, I used the replication method.[7] Namely, as

[6] E.g., Cowan 1993, Pickering 1995, Heering 2008, Smith 2009, Breidbach et al. 2010, Anderson et al. 2013, Rabier 2013, Smith et al. 2014, Valleriani 2017, Leong 2018.

[7] For more details on how I applied the replication method to Sanctorius's weighing procedures, see Sect. 7.5.2.

part of the research undertaken for this book, I reconstructed his most famous instrument, the Sanctorian weighing chair, and sought to replicate his weighing procedures, so as to investigate the design, operation, use, and purpose of the instrument.

Plan of the Book The book is divided into eight chapters. After the introduction chapter, Chapter 2 opens with a biographical account of Sanctorius that situates him in his social, institutional, and professional context. It critically evaluates the existing biographies of the Venetian physician and complements them with my own research into the primary sources. Episodes of Sanctorius's life that have hitherto received little or no attention are discussed in more detail. This opens up a new perspective on the life and work of Sanctorius, setting the stage for the more comprehensive review of his work to be found in the following chapters.

Chapter 3, "Sanctorius's Galenism," deals with Sanctorius's intellectual background and places his book *De statica medicina* within the framework of contemporary Galenic medicine. Usually celebrated for its innovative, quantitative approach to medicine, the *De statica* is mostly read in isolation from the Galenic tradition. However, as I will show, an analysis of this context is crucial to understanding how Sanctorius developed his novel ideas and revised the then prevailing medical knowledge. Of particular importance in this regard are the dietetic doctrine of the "six non-natural things" and the concept of insensible perspiration, an invisible excretion of the human body. Potential links between Sanctorius's notions and the doctrine of the ancient medical school of the Methodists and corpuscular ideas are likewise scrutinized. The chapter concludes with an analysis of the *De statica medicina* itself, focusing on the conceptual backdrop against which Sanctorius developed the weighing procedures he presented in the book. References to Sanctorius's other publications help situate his ideas in the broader framework of his endeavors overall, and thus contribute to an understanding of the theoretical context from which the *De statica medicina* emerged.

Turning from the conceptual to the practical and material resources for Sanctorius's undertakings, Chap. 4, "Sanctorius's Work in its Practical Context," highlights the practical context of the *De statica medicina* and explores Sanctorius's use of instrumentation. Investigation of the form and style of the *De statica medicina* and its relation to the literary genre of *Regimina sanitatis*—a medieval tradition of rules of health—allows important conclusions to be drawn about how Sanctorius shared his practical experience, as well as about his intended audience, and more generally, the purpose of the publication. It offers insight into the way in which Sanctorius connected theory and practice. To complement established research on Sanctorius, the analysis here of his use of instrumentation focuses, not on the measuring instruments but rather on the various other, lesser-known devices that he developed, which range from surgical devices, to a special sickbed, to cupping glasses. The actual measuring instruments are treated in a later chapter. Here, I also examine the relation of these other devices both to Sanctorius's medical practice and his teaching activities at the University of Padua. Even though—or precisely because—they were not part of his quantitative approach to physiology, studying them helps complement the picture of Sanctorius as a practicing physician.

Moreover, it provides glimpses of the social context in which he developed and used his instruments and of how he used his head and hands in medicine. Finally, the findings of this chapter allow the *De statica medicina* to be situated anew within the broader practical context of Sanctorius's undertakings.

The central theme of Chap. 5, "Quantification in Galenic Medicine," is to identify and explore different forms of quantification in the medical tradition, on which Sanctorius may possibly have drawn for his quantitative approach to physiology. Firstly, I address theories and practices connected to dietetics and pharmacology, as well as the Galenic concept of a latitude of health that assumed certain graduations in a person's state of health. Secondly, I reconsider how the work of Sanctorius relates to that of two earlier authors who are commonly associated with him and his static medicine: the Alexandrian physician Erasistratus (third century BCE) and the German Catholic cardinal and scholar Nicolaus Cusanus (1401–1464). Both were proponents of early quantitative approaches to medical problems, which is why their undertakings have been often related to Sanctorius and his use of quantitative measurements. Thirdly, I outline instances of quantitative physiological reasoning in Galen's work, as well as in that of Renaissance scholars, and I analyze their possible connection to Sanctorius.

Before considering Sanctorius's measuring instruments in more detail, I examine more generally, in Chap. 6, "Quantification and Certainty," the context in which Sanctorius presented these devices in his works. Unlike previous studies of Sanctorius's measuring instruments, which often focused on the *Commentary on Avicenna*, this being the only work in which Sanctorius included illustrations of his instruments, I analyze the measuring instruments in the light of all of Sanctorius's publications. Furthermore, I scrutinize how the various instruments are related to one another and discuss Sanctorius's possible complementary use of them. Of particular interest in this context is the role of the *De statica medicina*, it having become exemplary of Sanctorius's quantitative approach to physiology. These considerations serve as an introduction to my in-depth study of Sanctorius's measuring instruments in Chap. 7; and they reveal the agenda behind his inventions and efforts at quantification—namely, to enhance the degree of certainty in medicine—particularly given that the conjectural character of medicine and thus of its certainty were much debated issues in the medical works of his day. While there is not a shadow of a doubt that Sanctorius departed from traditional views by introducing new quantitative procedures into medicine, investigation of the roles that he assigned, on the one hand, to logical reasoning and, on the other, to experience, empirical knowledge, and his new methods of quantification draws a more complex picture of the combination of theory and practice in all of his work.

As its title, "Measuring Instruments," suggests, Chap. 7 deals with Sanctorius's most famous devices—*pulsilogia*, thermoscopes, hygrometers, and balances—which he developed to measure physiological changes. Having attracted considerable scholarly attention over the centuries, they underpin the narrative that identifies Sanctorius as a great innovator and as the founder of a new medical science, whose integral components were mechanization, measurement, and numerical values. The findings of the foregoing chapters allow us now to move beyond these selective

accounts of Sanctorius and his work and to take a closer look at, and reevaluate, his celebrated measuring instruments and their use. I explore their design and operation, the contexts in which they emerged, how Sanctorius possibly used them, and what exactly they measured for what purpose. Furthermore, I analyze the hitherto largely ignored two steelyards that Sanctorius devised to gauge climatic conditions, and thereby cover the entire range of his measuring procedures. Moreover, I present the results of the reconstruction of the Sanctorian weighing chair and of the replication of his experimental practice, showing how this approach opened up new perspectives on Sanctorius's work, his doctrine of static medicine, and the operation and purpose of his weighing chair.

The book concludes with a reflection on the epistemic processes that made the use of quantification and measurements in medicine at all *conceivable* to Sanctorius and which might also explain how these methods *made sense* to him in ways that they had not before. To this end, in "Sanctorius Revisited," Chap. 8, I bring into focus the relation between the categories of innovation and tradition in Sanctorius's work, as well as the interplay of the realms of theory and practice, so as to unify the main results of my research. Then, based on my analysis of the measuring instruments in Chap. 7, I reflect on what *quantifying health* meant to Sanctorius. Finally, I briefly outline how his measuring instruments were received. Building on the historical analyses of the previous chapters, I present a new and revised view of the Venetian physician, Sanctorius, which hopefully contributes to a better understanding not only of his own work but also, more generally, of how knowledge was transformed in the early modern period.

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