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Displays of Learning

Studies in Early Modern Art and Science

BY INGA ELMQVIST SÖDERLUND

Edited by Peter Gillgren,
Merit Laine & Mårten Snickare

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Abstract

In the early modern period, the links between aesthetics and the natural sciences were close. Wunderkammern, libraries, and cabinets of experimental philosophy, physics, or mathematics were built and decorated with references to classical and contemporary learning alike, for practical as well as aesthetic reasons. In this book the early modern urge for knowledge, power, and control, and ultimately the relation between art and science, are illuminated and problematized through detailed analyses and specific examples, especially from Sweden.

Buildings, interiors, and objects intended to visualize learning are part of our material heritage. Both as a scholar at Stockholm University and as director of the Stockholm Observatory Museum, Inga Elmqvist Söderlund (1967–2017) was deeply committed to preserving and sharing this heritage.

Keywords

17th century, 18th century, art, material heritage, natural sciences, reception of learning, representation of learning, sites of learning

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Introduction

THIS BOOK DEVELOPS a series of related questions about science and art in the 17th and 18th centuries. Its theme is the material and visual culture of early modern science, and in particular the images, objects, and settings in which astronomy was created and communicated. As the presentation shows, these images and objects were situated in a broad range of scientific, social, literary, and aesthetic practices that all attest to the proximity of science and art, whether in the artful design of a scientific instrument, a scene in an artwork, or a display in which scientific instruments and art were on show side by side. Such displays can be found in idealized pictures of prized collections, but also in the written sources and the original milieux that have survived to this day. Art and science came together in such environments as objects of conspicuous consumption. The specialized theoretical knowledge and craftsmanship needed to create scientific instruments, and works of art alike were transformed into symbolic capital, owned by the person who possessed and displayed the objects.

The book forms a thematic whole, but each chapter has been chosen to give a sense of Inga Elmqvist Söderlund's breadth as a researcher and curator. When she fell ill in the summer of 2015, she was in the middle of a major research project. She had first become interested in the material and visual culture of science, and above all astronomy, when working at the historic Stockholm Observatory Museum, where she was director from 1996 to 2013. She had set about presenting its scientific and cultural heritage to the public using both its permanent collections and innovative exhibitions, complemented by the museum's own publications. As a researcher, she appreciated the importance of the relationship between art and science, an area where she did much to share important findings about early modern Sweden and Europe. In 2010, she defended her Ph.D. thesis *Taking Possession of Astronomy: Frontispieces and Illustrated Title Pages in 17th-Century Books on Astronomy*. She then went on to run two closely related projects: 'Scientific Instruments in 18th-Century Europe: Display, Visual Effect, and Aesthetic Experience' at the History of Science Museum, Oxford (2011–2013); and '18th-Century Astronomical Demonstrations and User Experience' at the Royal Museums, Greenwich (2013). In 2014, she embarked on the 'Vetenskapliga konstföremål samlade i Sverige 1550–1660' ('Scientific Art Objects Collected in Sweden 1550–1660') project at Stockholm University, financed by the Royal Swedish Academy of Letters, History and Antiquities. Elmqvist Söderlund published widely in scholarly journals and anthologies and participated in a large number of conferences, and for her final project she had begun to assemble a network of researchers in Istanbul, Chicago, and Stockholm. Alongside the purely scholarly value of such collaborations, she also valued international activities as an important corrective to the isolationist tendencies that increasingly mark our time.

After Inga Elmqvist Söderlund's death in the summer of 2017, we conceived the idea of completing some of the work she had left unfinished and gathering her most important publications in a book that would reflect something of her range. Her colleagues, friends, and family all supported the idea, and it became apparent it had also been her own wish. The work was undertaken by the editors of the present volume, and the Royal Swedish Academy of Letters, History and Antiquities kindly donated Elmqvist Söderlund's remaining research funding to make it possible. In all our communication with periodicals where her work had been published and with her publishers, the response has been consistently positive.

The ten chapters that comprise the book are grouped according to three themes, of which the first, 'Sites', concerns the rooms and buildings used for scientific collections and practices. The first chapter, compiled and developed by Mårten Snickare from three unpublished conference papers, examines the collections held in the Royal Palace of Stockholm in the reign of Queen Christina, looking at the Treasury, which dated from the early 16th century, and the *Kunstkammer*, founded by the queen in the 1640s. The second chapter discusses early modern libraries as sites for scientific instruments and practices. The third and fourth chapters investigate the settings for the display and demonstration of science in 18th-century Stockholm—the places where the socioeconomic elite made a show of their enthusiasm for science, first in the cabinet of physics in Riddarhuset, and then later in the Stockholm Observatory, run by the Royal Swedish Academy of Sciences. Unlike the other chapters, the essay on the

Observatory is an example of Elmqvist Söderlund's work for a more general audience.

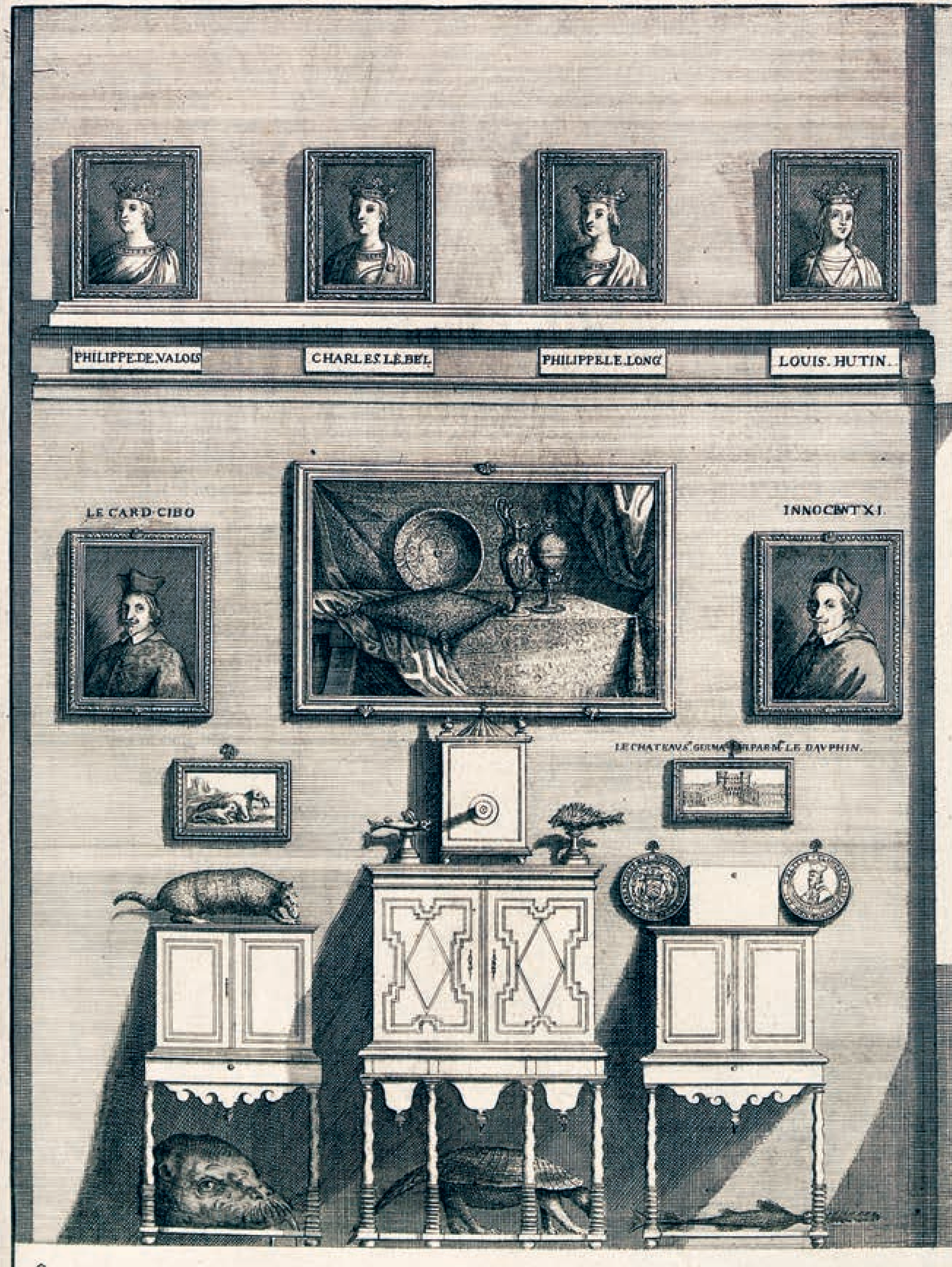
The book's second theme, 'Representations', focuses on the visual culture of astronomy. It opens with the often intricate frontispieces and illustrations created for 17th-century astronomical publications. Such images were the subject of Elmqvist Söderlund's Ph.D., and an abbreviated version of her thesis chapter 'Display: The book as a work of art' is published here as the fifth chapter. Some of the questions she raised in her thesis are developed in the following two texts. Thus in chapter six of this book, she discusses science, instruments, and publications as objects of consumption, demonstrating how frontispieces and illustrations were taken not only as arguments in favour of such consumption, but also as guidelines for how to achieve it. In chapter seven, she concentrates on the multifaceted relationship between classical mythology and astronomy, taking the motif of Hercules the astronomer as her prime example. As in other forms of allegorical art, mythological figures were fundamental to the front matter of many early modern books. At the same time, the brilliant beauty of the actual celestial bodies brought an important dimension to allegorical art, as is considered in chapter eight, which discusses the meaning of the constellations in a ceiling painting done by the court painter David Klöcker Ehrenstrahl for Drottningholm Palace outside Stockholm.

The last theme, 'Reception', consists of two chapters. Chapter nine is an examination of the reception of scientific instruments at the intersection of art and science in the 18th century, compiled and enlarged by Merit Laine from two unpublished conference papers and Elmqvist Söderlund's notes. In the tenth and final chapter, Elmqvist Söderlund broadened her argument to consider the fundamentals of preservation, research, and the accessibility of early modern science in terms of its material heritage, and specifically of books, images, sites, and, of course, scientific instruments for research and demonstrations.

The open-ended character of chapters one and nine is due to the fact that they were left unfinished by Elmqvist Söderlund; in compiling and completing these chapters, we tried to stay true to what could be inferred from the author's conference papers and notes.

Inga Elmqvist Söderlund was sadly denied the possibility to see more of her ideas to fruition. Yet, as her publications demonstrate, she achieved so much, both as a creative scholar and as an enthusiastic director of the Observatory Museum. This book is dedicated to her memory, in the spirit of the words that she chose to sum up her life: *Ars longa, vita brevis*.

Peter Gillgren, Merit Laine & Mårten Snickare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I

SITES

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1 Power, knowledge, and taste in the collections of Queen Christina

A ROYAL PALACE in 17th-century Europe served many purposes.[1] It was a residence for the royal family and the architectural manifestation of royal power and dignity. It contained offices and workspace—and sometimes lodging—for courtiers, officials, artists, artisans, and other professionals who were needed for the royal machinery to work. It was a magnificently furnished stage for grand receptions, official gatherings, and state ceremonies. Last but not least, it housed collections of different kinds: arms and armour, books, manuscripts and archives, scientific instruments, sculptures, paintings and other artworks, memorabilia, jewellery, and rare objects. This chapter will look at the collections at the Royal Palace in Stockholm in the time of Queen Christina—that is, from the 1630s until 1654 when she abdicated, converted to Catholicism, and eventually took up residence in Rome. In particular, it will delve into two collections in the palace: the Treasury, with a history that went back to Gustav Vasa in the early 16th century, and the Kunstkammer, a new col-

1. In 2016, Inga Elmqvist Söderlund was busy exploring the collections at the Royal Palace in Stockholm in the time of Queen Christina. She never got the chance to publish her results, but she presented her preliminary findings and interpretations at a series of conferences. At the Sixteenth Century Society Conference in Bruges in August 2016 she gave a paper discussing the shifting sites of the Treasury and the *Kunstkammer* within the palace, and how these sites interacted with the objects on display in the formation of aesthetic and scientific experiences. In the September of the same year, at the XXXVth Scientific Instrument Symposium in Istanbul, she talked about the presence of objects of Ottoman origin in Christina's collections, but also objects and images referring to the imagined "Turk". A month later, in October, Elmqvist Söderlund took part in a symposium in Uppsala, 'Early Modern Arrangements of Collections and Knowledge', organized by Mattias Ekman. Her paper was a comparative study of the organization and arrangement of objects in the Treasury and the *Kunstkammer* in Christina's time. The present chapter is based on these three papers.

lection established by the queen in the 1640s.[2] These collections overlapped in many ways. Similar objects, and categories of objects, were found in both, and it was not unknown for items to be transferred from one collection to the other. The chapter will explore and discuss similarities and differences between the two collections, concerning content, structure, and function. Which were the distinguishing features of the respective collections? How were they organized and displayed? On what occasions were they activated? The principal aim is to explore and discuss Christina's rationale for instituting an entirely new collection, rather than adding to the ones that already existed. To what kinds of historically and culturally specific needs and desires did the new Kunstkammer at Tre Kronor (The Royal palace) respond?

The Stockholm Palace as a site for collection and display

The history of the palace in Stockholm began in the 13th century when a fortress was erected at the strategically important passage from the Baltic Sea to Lake Mälaren.[3] Over the centuries, the fortress was extended and rebuilt, and by the early 17th century the castle of Tre Kronor had become a permanent residence for the Swedish royal family (*Fig.* 1.1). This was the time when Sweden emerged as a great military power and centrally controlled monarchy, with Stockholm as its undisputed capital. In Christina's day, the building was in a state of flux. Additions were made, rooms redecorated, and collections enlarged and rearranged.[4] An eyewitness account of the constant reorganization of space and transfer of objects is given in a letter from the French librarian and scholar Gabriel Naudé to his colleague Jacques Dupuy in September 1652. Naudé, who had recently arrived in Stockholm to take care of Christina's library, wrote that he and his fellow countryman Raphaël Trichet du Fresne, curator of the queen's Kunstkammer, had to stay at an inn, because the rooms in the palace that had been prepared for them were suddenly being transformed into a gallery for ancient sculptures and other curiosities—in all likelihood, the Kunstkammer. Naudé added that he was busy transferring the queen's library to a new location in the palace, closer to her newly rearranged private rooms.[5]

The rapid growth of the collections in Christina's time was largely due to Sweden's aggressive foreign policy, and its newly acquired military, political,

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2. For the Treasury, see Cederström & Malmborg 1942; Fogelmarck & Cederström 2009. For the Kunstkammer, see Granberg 1929. The Kunstkammer inventory, drawn up in 1652, is published in Granberg 1929, pp. 183–227.
3. For the history of Tre Kronor, see Böttiger *et al.* 1940.
4. Böttiger *et al.* 1940, pp. 244–258, 265–271.
5. Gabriel Naudé to Jacques Dupuy, 26 September 1652, published in a Swedish translation in Bondesson & Hansson 2002.

1.1 Govert Camphuysen, *The Royal Palace, Stockholm*, 1661. Oil on canvas, 44 × 82 cm. Stockholm City Museum, inv. no. SSM 11700 0.

and financial position in Europe. Successful involvement in the Thirty Years War meant an inflow of loot from captured castles and cities on the Continent, culminating in the arrival of priceless paintings, sculptures, books, and other objects from the famous Kunstkammer of Rudolf II in Prague, seized before the Peace of Westphalia in 1648.[6] Intensified diplomatic relations with powers across Europe and beyond left their mark on the royal collections in the form of diplomatic gifts. To that should be added Sweden's colonial enterprises and its increasing involvement in long-distance trade, leading to an influx of rarities, commodities, and natural objects from distant continents.[7]

A number of minor fires in the mid-17th century made repairs and restorations to Tre Kronor necessary.[8] Half a century later, in 1697, the palace was almost completely destroyed by fire.[9] This disastrous event, together with the limited number of archival sources and the fact that the present baroque palace was erected on top of the ruins, sets bounds on our ability to map the exact whereabouts and organization of the collections in Christina's time. To a large degree, we have to be content with assumptions and educated guesses. What we know is that the palace was the home of a number of distinct but interrelated collections. Apart from the Treasury and the Kunstkammer, there was the Armoury—or

6. Granberg 1902; 1929, pp. 89–146.
7. Naum & Nordin 2013; Snickare 2022.
8. Böttiger *et al.* 1940, pp. 244–258.
9. Olsson *et al.* 1940.

actually a number of interconnected armouries—containing arms and armour for the king and his troops, together with banners and standards.[10] Dating from the early 16th century, it was gradually transformed into a kind of museum of royal history. A decisive step in that direction was taken in the early 1630s, when the clothes worn into battle by Gustav II Adolf (Gustavus Adolphus), Christina's father, were put on display in the Armoury "to eternal remembrance".[11] Rather than storing it for potential future use, the bloodstained battle dress was an object to display, dedicated to the memory of the king's fortitude and his martial honour. In the Armoury, it competed for space with state coaches, coronation saddles, funeral caparisons, paraphernalia for royal tournaments, and sabres and daggers from Turkey and Persia. The palace also housed other collections in the borderlands between storage and display, such as the Wardrobe and the Silver Chamber.[12]

The Treasury as monetary reserve and manifestation of royal dignity

Like the Armoury, the Treasury dated back to the reign of Gustav Vasa in the early 16th century. In the 17th century, the Treasury's official name was Räntekammaren or, in French, Chambre des rentes, which suggests that its main function was as a monetary reserve rather than a display space. The public agency in charge of Räntekammaren was Kammarkollegium, an authority established by the king in 1539 to manage tax collection and the audit of public accounts. In 1594 Kammarkollegium was also charged with the safekeeping of the royal regalia (this is still one of its duties).[13] Among its key archival sources are the inventories drawn up by Kammarkollegium officials in the 17th century onwards, and still kept in its archives.[14]

As was the case with the Armoury, the display of objects seems to have become an increasingly important feature of the Treasury over the course of the 17th century. In an early phase, it was the royal regalia that were taken out from the Treasury and put on display on certain occasions. One example is found in a travel journal, published in 1619, describing a Dutch embassy to Stockholm in 1616.[15] The author, the Dutch official Anthonis Goeteeris, carefully described two audiences at Tre Kronor. An engraving, made from a drawing by the author

10. Cederström & Malmborg 1930.
11. The Council minutes of 13 November 1633 state: "Kläderna belangande uti vilka Sal: Kungl. Maj:t blev skuten i Preussen, de skole efter Sal. Kungl. Maj:ts egen befallning här uti Rustkammaren till en evig åminnelse förvarade bliva" (in Cederström & Malmborg 1930, p. xiii).
12. Cederström & Malmborg 1930, p. xvi.
13. Fogelmarck & Cederström 2009, p. 3.
14. Kammarkollegiets arkiv, Stockholm, Handlingar ang. Rikets regalier och dyrbarheter.
15. [Goeteeris] 1619. The text has been published in Swedish as Goeteeris 1917.

1.2 Anonymous artist, *Gustavus Adolphus knighting Dutch ambassadors at the Royal Palace, 1616.* Engraving from [Anthonis Goeteeris], *Journal der Legatie*, 1619.

and included in the book, depicts the second audience, at which the Dutch ambassadors were knighted by Gustav II Adolf (*Fig.* 1.2). The king is seated on his silver throne, in a stately room hung with woven tapestries. One of the ambassadors kneels before him in the act of being knighted, while two other ambassadors stand, waiting their turn. A group of courtiers and officials watch the ceremony from the lower right-hand corner of the image. On a marble table next to the king sit the royal regalia, placed on cushions (blue with gold embroidery, according to the text). The crown and orb are clearly visible in the engraving, and the text also mentions the royal sceptre.[16] As suggested by the engraving and the written description, the objects were not primarily put on display to be admired for their aesthetic qualities, elaborate craftsmanship, and precious materials, but rather as the manifestation of royal power and legitimacy for a defined ritual event at which this power was exercised. Yet equally it could be argued that craftsmanship and precious materials were crucial for the performative effectiveness of the objects as the materialization of royal dignity.[17]

16. Goeteeris 1917, pp. 163–179, engraving at p. 177.
17. Compare Olin 2012.

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Image available only in the printed book

1.3 Christoph Jamnitzer and Jeremias Ritter, *Drinking vessels in the form of terrestrial and celestial globes*, 1620. Partly gilded silver. Presented by the city of Nuremberg to Gustavus Adolphus in 1632. Royal Collections, Stockholm, inv. nos HGK SS 10 & 11. See also page 12

It seems the Treasury gradually became a place to take prominent visitors, as suggested by the diary of Charles Ogier, a French diplomat who visited the collections in May 1635 accompanied by the Swedish noblemen, Sten Båth and Gustaf Horn.[18] In his account of the visit Ogier remarks on the recent growth of the Treasury collection. Before Gustav II Adolf's day, he stated, the Swedish royal treasure was modest, but in recent times important additions had been made, mainly through spoils of war and diplomatic gifts. Ogier observed and described a variety of objects. Some were curiosities, such as the "Troll horn"—according to the myth, won by a Swedish nobleman in single combat with the Devil—and the horn of a unicorn.[19] There was a group of elaborate drinking vessels made of silver, gold, shell, and other precious materials. Ogier noted that some drinking vessels were remarkably large, and that a pair were shaped as globes, one terrestrial and one celestial (*Fig.* 1.3). Another group of objects

18. Ogier's diary was published in Latin in 1656 as *Caroli Ogerii Ephemerides, sive, Iter Danicum, Suecicum, Polonicum: Cum esset in comitatu illustriss. Claudii Memmii Comitis Auauxij, ad septentrionis reges extraordinarij legati. Accedunt Nicolai Borbonii ad eumdem legatum epitolae hactenus ineditae* (Ogier & de Mesmes Avaux 1656); for the account of the visit to the Treasury in the Swedish translation, see Ogier & de Mesmes Avaux 1914, pp. 107–110.

19. The horn described by Ogier was probably the 14th-century silver-plated drinking vessel at Trolle-Ljungby Castle in southern Sweden. Its connection with the Devil may have been Ogier's misunderstanding of the standard myth, which tells of a fight between a Swedish knight and a troll.

1.4 Ludwig Refinger, *Horatius Cocles Holds Back the Army of Porsenna outside Rome*, *c.* 1520–1548. Oil on panel, 161 × 116 cm. Nationalmuseum, Stockholm, inv. no. NM 296.

consisted of paintings, recently plundered by Gustav II Adolf from Würzburg and Munich. Among them, Ogier recognized works by Albrecht Dürer, Lucas Cranach the Elder and the Younger, Hans Burgkmair, and Ludwig Refinger, all of whom he declared to be excellent artists (*Fig.* 1.4, p. 19).[20] Not without bitterness, the Catholic Ogier also observed a group of precious religious objects, stolen from German churches. As he leant forward to kiss one of them, a reliquary in the shape of a crucifix in which a part of the cross of Christ was said to be kept, he heard Båth and Horn laughing at him (*Fig.* 1.5).[21] Here we note there were a variety of gazes in the room: where his Swedish hosts saw war trophies made of precious materials, Ogier saw sacred objects. Even in its new secular display, to Ogier the reliquary was a devotional object that demanded a particular religious response. The royal regalia do not seem to have attracted Ogier's interest; he just mentioned in passing that the Treasury was where they were kept.

Ogier's encounter with the objects in the Treasury thus differed considerably from the Dutch ambassadors' experience some 20 years earlier. Rather than tangible materializations of royal power and dignity, the objects in Ogier's account appear as aesthetic objects and as carriers of histories, primarily histories of their origins and fate. However, many of these histories involved Swedish royalty, first and foremost the warrior King Gustav II Adolf, who had taken the objects as spoils of war or received them as gifts. In that way, royal power was again very much present in Ogier's understanding of the objects.

1.5 *Reliquary in the form of a crucifix*, 11th–15th century. Gilded silver, pearls, gems, enamel, small wooden cross (relic), h. 59 cm. The Swedish History Museum, Stockholm, inv. no. SHM 348.

At the time of Ogier's visit, the Treasury was probably located in a series of smaller rooms on a lower floor at the centre of the palace complex, facing the large courtyard, just below room 19, and possibly rooms 18, 20, and 21, as labelled on a copy from 1660 of Jean de la Vallée's plan (*Fig.* 1.6). Later in the 17th century it was relocated to the north-west corner of the palace (the lower right-

20. Ogier & de Mesmes Avaux 1914, p. 108.
21. Ogier & de Mesmes Avaux 1914, p. 109.

1.6 Jean de la Vallée, *Plan of the top floor of the Tre Kronor Palace*, 1660. Watercolour and ink on paper, 40,8 × 32,6 cm. Nationalmuseum, Stockholm.

hand corner of the plan). This part of the palace was among the least damaged by the fire of 1697, which meant that a relatively large number of the Treasury objects could be rescued.[22] It has not been possible to reconstruct the exact spatial arrangement of the objects in Christina's time, but there is some guidance as regards the Treasury's displays and function to be found in the official inventories, drawn up and signed by prominent members of the royal administration, and kept in the Kammarkollegium archives. Three complete inventories survive from Christina's reign, dated 1630, 1640, and 1653.[23] They do not follow a strict system of classification. Objects of similar kinds are often listed together under one heading, without any notes as to their respective whereabouts in the collection. In other instances, objects that were kept in the same cabinet, chest, or casket are grouped together, irrespective of what they were. Sometimes, objects were grouped by origin, such as, for example, "Tartariske förähringar" ("Tartarian gifts"), or "Efftersksrefne saker äre ifrå Tyskland inkompna A.o. 1632 in Julio" ("The following objects arrived from Germany in July 1632").[24]

The exact number of objects in the Treasury is hard to establish, since one entry often includes a large—sometimes unspecified—number of individual objects. However, the inventories are proof of considerable fluctuations in the size of the collection. In the 1630s there was a significant increase in the number of objects, to a large extent due to the arrival of spoils of war from Gustav II Adolf's German campaigns—as noted by Ogier. A peak was reached in the 1640 inventory, followed by a decrease, partly due to a transfer of objects from the Treasury to the Kunstkammer: for example, most of the looted paintings that arrived in the 1630s, and which appeared in the 1640 inventory, were absent from the inventory of 1653.

All three inventories began by listing precious jewellery, such as hat decorations, pendants, chains, rings, earrings, and bracelets. Age and origin were normally not stated, but materials and weight were carefully specified, together with the number, size, and quality of any pearls or precious stones. In this way the inventories seem to have emphasized the main function of the Treasury as a

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22. Landergren *et al.* 1989, pp. 3–4.
23. Kammarkollegiets arkiv, Handlingar ang. Rikets regalier och dyrbarheter, vol. 1: 'Inventarier upå Åthskillige Juveler och Clenodier [...] Ståckhållm dhen 25 Martij Åhr 1630' (hereafter Inventory 1630); vol. 2: 'Inuentarium opå de Partzeler som woro uthi Cronones RänteCammar, och blefwo inventerade den 2. Junij in til den 11. dito Anno 1640 uthi Cammar Commisariens och Revisions Assessorens, Wälb. Tönne Hindrichsons Langmans så och General Cammarererens Wälb. Mårten Perßons och Rijks Guardinens W. Hans Weilers närwaru' (hereafter Inventory 1640); vol. 1: 'Inventarium Oppå dhe Pertzeler som woro uthi Cronones Räntte Cammar beholdne, och blefwe Inventerade dhen 13 junij Anno 1653 Effter Rijchz och Cammerådz Befallningh, aff Underschrefne' (hereafter Inventory 1653).
24. Inventory 1640, fols. 12, 16.

monetary reserve. This was further underlined by the fact that objects, or groups of objects, might disappear from one inventory to the next. One example was the "340 Orientaliske små rubiner" ("340 small Oriental rubies") in the inventory of 1640, of which only "1 sönderbrutin Orientalisk Rubin" ("one broken Oriental ruby") remained in the 1653 inventory.[25] One plausible explanation is that the value of the rubies had been realized in the interim. The description of the paintings that formed part of Gustav II Adolf's spoils of war gave a similar impression. When they were listed in the 1640 inventory, the precious materials of the frames—"Ebenholtz" (ebony), "förgylte" (gilt)—were carefully recorded, but nothing was said about artists or subject matter.[26] Compare that with Ogier, whose account detailed the artists and their skill, as well as the motifs of individual paintings.

The inventories further listed a number of scientific instruments and other objects related to science and scholarship, such as a gilded brass compass, clocks, and a rune-staff. These objects were not put together in one category, but were found under different headings, depending on their material or their location in a certain cabinet or chest, suggesting that their potential scientific value had no bearing on the organization of the Treasury. One interesting example of an object with scientific connotations was a finger ring that could be opened to form an armillary sphere (*Fig.* 1.7).[27] It had an inscription in French, a quote from Proverbs 22:1, "La renommée est plus desirable que grosse richesse et bonne grace plus que argent y or" ("A good name is rather to be chosen than great riches, and loving favour rather than silver and gold"). This elaborate and intriguing little object connected religion and science. For a modern interpreter it might be tempting to read the inscription as a critique of the material extravagance of the Treasury. Most of all, however, the ring exemplified the overlapping of aesthetics and scientific knowledge so characteristic of the time.

1.7 *Ring that can be opened to form an armillary sphere*, 16th–17th centuries. Gold. The Swedish History Museum, Stockholm, inv. no. SHM 39.

What we can say about the Treasury in Christina's day is that it was a collection in constant flux. Objects were added, moved, and removed. Its function as a monetary reserve was emphasized in the inventories, while the role of certain objects as an embodiment of royal power and dignity was manifest to the Dutch embassy in 1616. Ogier's visit in 1635 suggested other ways to view the Treasury: as a collection of objects that bore witness to wondrous histories, elaborate craftsmanship, and artistry, or as objects of religious devotion.

25. Inventory 1640, fol. 10; Inventory 1653, fol. 2.
26. Inventory 1640, fol. 18.
27. Inventory 1640, fol. 8; Inventory 1653, fol. 1^{v}.

The Kunstkammer as a site for aesthetic pleasure and scholarly knowledge

In the 1640s, at the same time that the Treasury had reached its largest scope, Christina started a new collection in the palace. Archival sources show that the queen herself called her new collection "konstcammer", in that way clearly distinguishing it from the Treasury or "räntecammar'" while at the same time connecting it to the most fashionable display mode on the Continent, the Kunstkammer.[28] It is important to note that the early modern Kunstkammer was not limited to *Kunst*, or art, in the modern sense. Its juxtaposition of antiquities, curiosities, archaeological findings, scientific instruments, artworks, and natural specimens from near and far instead points to a premodern conception of *Kunst* (Latin *ars*) as referring to skill, craft, knowledge, science, and method. The Kunstkammer, in other words, did not make clear distinctions between art and craft or art and science. The German historian Dominik Collet describes a second wave of new Kunstkammer in northern Europe after the end of the Thirty Years War.[29] In the case of Christina's Kunstkammer, it seems there was a particularly strong link to the war and its conclusion in 1648. The inflow of spoils of war in the late 1640s, particularly the haul from Prague that arrived at Tre Kronor in 1649, was an impetus for the creation of the new collection there. This was spelt out in the heading of the inventory of 1652: 'Inventarium Oppå Alle Dhe Rariteter Som Finnas uthi H. K. M:ttz Wår Allernådigste Dronings Konstkammar. Deels ifrån Prag Komne. Deels upkiöpte och deels forährte' ('Inventory of all the rarities there are in Her Majesty our Gracious Queen's Kunstkammer. Partly arrived from Prague, partly purchased, and partly received as gifts').[30]

The exact location of the Kunstkammer in Christina's day is not known. It appears to have been transferred a couple of times before it was installed in the eastern wing in the late 1650s, immediately above the palace archive, or room 37 on the plan (*Fig.* 1.6, p. 21).[31] Its first keeper was Johan Holm, the queen's valet and court tailor, who was raised to the nobility in 1653 as Johan Leijoncrona. It was probably he who drew up the inventory before he was replaced by Raphaël Trichet du Fresne in 1652. The latter was an art connoisseur, best known for having published Leonardo da Vinci's *Trattato della pittura* in 1651—a qualification

28. See Christina's instruction for the curator of the Kunstkammer, quoted in Granberg 1929, p. 110. On the Kunstkammer as the typical display mode in early modern Europe, see Bredekamp 1993. See also Mordhorst 2009.

29. Collet 2007, p. 39.

30. KB, Handskrift (Department of Manuscripts), KB S 4a inventory 1652. Marginal notes indicate which objects came from the Kunstkammer in Prague.

31. In his letter to Dupuy of September 1652, Naudé described an ongoing relocation of ancient sculptures and other curiosities (in Bondesson & Hansson 2002, pp. 16–17).

that would have pleased Christina with her taste for Italian art.[32] He belonged to the circle of French intellectuals recruited by Christina in the early 1650s, which included Gabriel Naudé, the queen's librarian, and Renée Descartes, the most famous philosopher in Europe. In his letter to Jacques Dupuy, referred to above, Naudé told his colleague that the queen's Kunstkammer held the most beautiful things in the world, and that he had joined forces with du Fresne to exhibit its hidden treasures as far as possible.[33] The fact that Naudé called attention to the beauty of the objects, and that he stressed the importance of displaying them, registered the gradually changing ideals of collecting. An earlier indication of these changing ideals was Ogier's response to certain objects in the Swedish Treasury. One could say that Ogier approached the old Treasury as if it were a modern Kunstkammer.

1.8 Adriaen de Vries, *Laocoon and His Sons*, 1623. Bronze, h. 172 cm. Nationalmuseum, Stockholm, inv. no. NMDrhSk 68.

When Christina abdicated and left Sweden, she took important parts of the Kunstkammer with her to Rome, and above all the Italian paintings. The Tre Kronor fire in 1697 dealt another severe blow to the collection, and limits the possibility of reconstructing the spatial organization of objects. The most important source was the inventory that survives in two versions—one Swedish, one French, and both dated 1652.[34] The exact relation between them has not been fully investigated, but it seems that the French is a translation of the Swedish original, probably occasioned by the arrival of du Fresne in 1652. The two versions are alike, but not identical; some of the discrepancies may be due to minor slips in the translation, while others might reflect new acquisitions in the intervening period between the date of the original inventory and the translation. The French translation has marginal notes, probably by du Fresne, stating the provenance of certain objects. "De Prague" is by far the most common. The primary principle of categorization seems to have been the materials, even if it was not carried through systematically. The inventory thus began with 'Les statues de bronze' (bronze sculptures), among which could

32. Granberg 1929, pp. 110–113.
33. Gabriel Naudé to Jacques Dupuy, 26 September 1652, in Bondesson & Hansson 2002, pp. 16–17.
34. KB, Handskrift, KB S 4a, 'Inventarium Oppå Alle Dhe Rariteter Som Finnas uthi H. K. M:ttz Wår Allernådigste Dronings Konstkammar'; KB, Handskrift, KB S 4, 'Inventaire des raretéz qui sont dans le cabinet des antiquitéz de la serenissime reine du Suède', published in Granberg 1929, pp. 182–227.

be found a Laocoon group by Adriaen de Vries, probably from the Wallenstein Palace in Prague (*Fig.* 1.8, p. 25).[35] The bronze sculptures were followed by 'Les statues de marbre' (marble sculptures), 'Les medailles' (medallions), 'Les raretéz d'ivoire' (ivory rarities), 'Les raretéz d'ambre' (amber rarities), 'Les raretéz de coral' (coral rarities), and 'Les raretéz de rocailles' (shell rarities) (*Fig.* 1.9).

Most of these subheadings included both natural specimens and artefacts. A significant number of objects were of a hybrid character, combining unworked natural specimens with elaborately worked additions, ornaments, or settings. One example came under the heading 'Les raretéz d'ivoire': "141. A cup made of an ostrich egg, decorated with silver gilt on a pedestal of ivory and with a lid crowned by an uncut stone."[36] Not only did it combine unworked specimens (the ostrich egg, the stone) with fine craftsmanship (silver gilt); it also brought together materials from different parts of the world. There were also objects in the inventory that left the realm of physical reality behind: a unicorn horn, for example (just like in the Treasury), but also a unicorn skull. The latter part of the inventory included groups of objects that were not primarily defined by their material, but rather by their use or function, such as 'Les horloges' (clocks) and 'Les instrumens mathematiques' (mathematical instruments). The latter was a remarkably large group, consisting of 69 entries (some of them including several objects) and the descriptions not only specified the materials, but also the function of the instruments. The inventory ended with over 700 paintings, of which more than 400 were from Prague. They were divided into two subcategories: 'Les Tableaux' (the paintings) and 'Les Pourtraits' (the portraits), with the first category further subdivided by size. The information about individual paintings is scant, but, unlike the Treasury inventories, included brief descriptions of motif and iconography. Olof Granberg and other scholars have noted the high quality of this large group of paintings.[37] Even though Queen Christina took a considerable number to Rome, there were still enough left in Stockholm to form the core of the Nationalmuseum collection. One example was the Flemish artist Jan Massys' masterpiece *Venus Cythereia* that formed part of the Prague spoils of war (*Fig.* 1.10, p. 29).

Almost all categories of objects in the Kunstkammer were also to be found in the Treasury, and vice versa, although the proportions differed: while jewellery had a central role in the Treasury, sculpture and paintings were one focus of the

1.9 Georg Petel after drawings by Peter Paul Rubens, *Salt cellar*, 1627–1628. Ivory, gilded silver. Royal Collections, Stockholm, inv. no. HGK SS 143. Acquired from Rubens' estate by Queen Christina in 1646.

35. Larsson 1992, p. 98.
36. 'Inventaire des raretéz' in Granberg 1929, p. 192: "141. Une coupe d'un oeuf d'autruche garni d'argent doré, porté sur un piedestal d'iuoire, don't le couuercle est orné d'un rocher". All translations are Elmqvist Söderlund's own unless otherwise stated.
37. Granberg 1929, pp. 94–106.

Kunstkammer. The organization of the two collections, as reflected in the inventories, pointed in different directions. The Treasury inventories emphasized precious materials, monetary value, and the materialization of royal power. Without abandoning these factors, the Kunstkammer inventory also accentuated provenance, iconography, connoisseurship, science, and technology. It revealed an ambition to structure the objects according to a system of knowledge. In that way, Christina's Kunstkammer corresponded to the national ambitions of a young great power, and not only the well-documented scholarly interests of its originator. The close relation between collecting and knowledge was underlined by Gabriel Naudé when he wrote to the philosopher and mathematician Pierre Gassendi to praise Christina's all-embracing erudition:

> Si ie vous dis que son esprit est tout a fait extraordinaire ie ne mentiray point, car elle à tout veu, elle à tout leu, elle sçait tout, & elle en donne de preuues iudicieuses, & avec telle facilité de discours & force de raisonnement [...] Mais ne croyez pas qu'elle soit seulement sçauante en ce quis depende des Liures, car elle l'est pareillement en Peinture, Architecture, Sculpture, Medaille, Antiquitez, & en toute autre chose belle & curieuse ... elle à une Galerie de Statues tant en bronze qu'en marbre, de Medailles, tant d'or, d'argent, que de bronze, en pieces d'iuoire, d'ambre, de coral, de crystal trauaillé, de Miroirs d'acier, d'Horloges, de Tables, de guises, bas-reliefs & autres choses non moins artificielles que naturelles que ie n'en ay iamais veu en Italie de plus riches. Reste les Tableaux desquels elle a aussi une merueilleuse quantité, & ainsi vous voyez *que habet animum apertum ad omnia*.

> I would not lie if I were to tell you that her genius is altogether extraordinary, for she has seen all, read all, and she knows all, and she gives proof of good judgement and great facility of discourse and power of thought. [...] Do not think, however, that her erudition is solely dependent on books, because she is equally learned in painting, architecture, sculpture, medals, antiquities, and in all other things beautiful and curious. ... She has a gallery of statues both bronze and marble, medals of gold, silver, and bronze, pieces of ivory, amber, coral, worked crystal, steel mirrors, clocks and tables, bas reliefs, and other things artificial and natural; I have never seen richer even in Italy. Finally, the paintings, of which she also has a great quantity; you see that her mind is open to all impressions.[38]

Here Naudé seems to have been echoing the empiricist ideals of Francis Bacon, with his emphasis on an all-embracing collection of objects as a necessary basis for the scientific exploration of the world.[39]

38. Gabriel Naudé to Pierre Gassendi, 19 October 1652, in Gassendi 1658, pp. 336–337.
39. Bacon 2012, pp. 595–606.

1.10 Jan Massys, *Venus Cythereia*, 1561. Oil on wood, 130 × 156 cm. Nationalmuseum, Stockholm, inv. no. NM 507.

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The Treasury and the Kunstkammer were not static collections. On the contrary, they were relocated and rearranged all the time. Objects were taken out and put on temporary display for certain occasions, such as the knighting of the Dutch ambassadors in 1616. Additions were made, most significantly the spoils of war from Gustav II Adolf's German campaigns that entered the Treasury in the 1630s, and the Prague spoils of war that came to form a substantial part of Christina's Kunstkammer in the late 1640s. The borders between the two collections were permeable, and objects were transferred from one to the other. The same was true when it came to the reception of the objects in the two collections. We have seen how Ogier approached the Treasury with a Kunstkammer gaze, and there was a clear tendency in the period towards a new awareness of the importance of display. The storehouses that were the Treasury and the Armoury were both reconceived as display spaces. When it came to the Kunstkammer, Naudé described working hard with du Fresne to exhibit its hidden treasures as far as possible.[40]

Let us finally return to the question raised at the beginning, about Christina's rationale for instituting an entirely new collection, rather than building on the ones that already existed. To what kinds of historically and culturally specific needs and desires did the Kunstkammer respond? The differences between the Treasury and the Kunstkammer should not be overstated; they comprised similar kinds of objects, they were located in the same palace, and part of their significance was the display of royal power and glory. There were, however, important distinctions between the two, beyond their names. The Treasury was originally a monetary reserve, and it continued to be so throughout the 17th century. This was indicated by the inventories, which first and foremost recorded the material worth of the objects, and by the fact that the people in charge were Kammarkollegium officials—tax collectors. The second function of the Treasury objects was to materialize and legitimize royal power and dignity, something that was particularly true of the royal regalia. They were signifiers pointing inwards to their royal possessors, and backwards to their dynastic lineage. In that way, the Treasury corresponded to Samuel Quiccheberg's *Inscriptiones* of 1565, sometimes said to have been the first treatise on collecting and museums. In his influential treatise, Quiccheberg stressed that the role of a collection was to visualize and glorify the proprietor and his ancestry.[41]

40. Gabriel Naudé to Jacques Dupuy, 26 September 1652, in Bondesson & Hansson 2002, pp. 16–17.
41. Quiccheberg 2000; 2013.

What then of the Kunstkammer? The Prague spoils of war seem to have played an important role for the establishment of Queen Christina's new collection. However, they did not really explain the Kunstkammer per se. After all, we have seen that the great influx of spoils of war in the 1630s was smoothly incorporated into the existing Treasury. At the most general level, the Kunstkammer answered to the needs of the young great power to match the European standard, not only in terms of warfare but also culturally. The Peace of Westphalia marked the beginning of an intense period in building and collecting art among Swedish royalty and aristocracy. Christina's Kunstkammer should be seen in this context, as an effort to establish a Swedish parallel to the most splendid and fashionable Kunstkammer on the Continent. If the Treasury pointed inwards and backwards, the Kunstkammer pointed outwards, towards its European counterparts, but also towards the expanding world. It was no coincidence that it was established in the heyday of Swedish imperialism and colonialism. With its wealth of artworks from European metropoles and an abundance of materials from distant lands—ivory, coral, shell—Christina's Kunstkammer can be interpreted as a way of proclaiming Sweden's new-found position in Europe and the world. It was about control: of knowledge of a rapidly changing and expanding world, in line with the interrelated European projects of colonialism and empiricism. If the Treasury corresponded to Samuel Quiccheberg's treatise of 1565, the Kunstkammer instead foreshadowed Johan Daniel Major's treatise on Kunstkammer from 1674.[42] Major, sometimes called the founder of museology, situated the Kunstkammer in a global world, pointing to its epistemological value. But the Kunstkammer also responded to a burgeoning aesthetic sensibility, a new emphasis on personal taste, connoisseurship, and the notion of artist as genius. It was no coincidence that Queen Christina recruited a connoisseur and expert on Leonardo da Vinci to be keeper of the Kunstkammer. A letter from Christina to the duke of Bracciano, written in 1652, was an eloquent example of this new attitude. She described her Kunstkammer as "really great and beautiful", and continued:

> There is an infinite range of items, but apart from some thirty or forty Italian originals, I discount them all. There are works by Albrecht Dürer and other German masters whose names I do not know, but who would arouse the profound admiration of everyone apart from myself. But I do declare that I would exchange them all for two Raphaels, and I think that even this would be doing them too much honour.[43]

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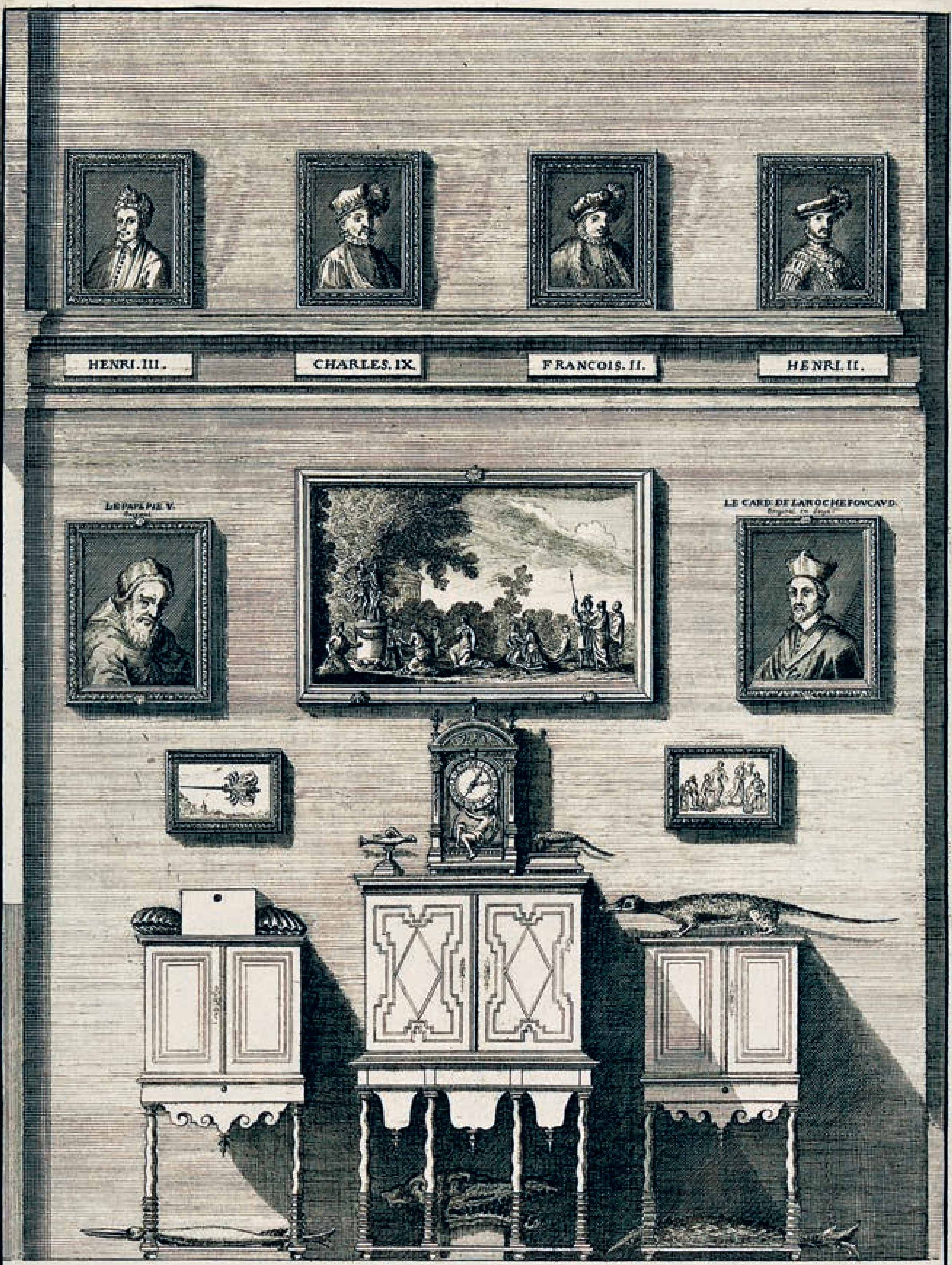
42. Major 1674.
43. Nordenfalk 1966, quote at p. 419. The original has proved elusive and the author has thus had to rely on the English translation.



6 L D F. Ertinger sculp.

2 The library as a site for the collection and display of scientific instruments

Early modern artefacts and *naturalia* were collected, displayed, and used in a variety of sites:[1] in a Kunstkammer, library, gallery, cabinet, or other purpose-built space in a princely residence, monastery, church, university, learned society, academy, or private home, and also at sites of commerce where objects were traded. Each of these sites was shaped by individual choices, but was also influenced by general trends and theoretical concerns. This chapter focuses on the library as a site for collection and display, in particular with reference to scientific instruments. The library is compared to the Kunstkammer, museum, and collection of rarities. The use of scientific instruments in the library space is also discussed.

Anachronic science

Today I believe that most people would agree that a three-dimensional artefact used for scientific observation and experimentation is a scientific instrument. By "scientific instrument" is meant a tool by which science is advanced; by "science", we normally mean the natural sciences, used in the study of the physical world—physics, chemistry, geology, biology, and botany. Science is a branch of knowledge conducted according to objective principles, involving the systematized observation of and experimentation with phenomena, normally at a university or research institute by a professional researcher.[2]

I need to specify this, since "scientific instrument" is an anachronism. What

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1. This essay was first published in Galdy & Heudecker 2014, pp. 151–168. The original paper was made possible by the generous support of the Åke Wiberg foundation, the Museum of the History of Science at Oxford University, and the Royal Museums Greenwich.

2. Allen 2008, p. 790, "natural science", p. 1081, "science", "scientific", "scientist".

is considered science and a scientific object has changed with time.[3] The word science was in use in early modern Europe, but was not as narrow as our modern understanding, since it referred to a more generalized knowledge base. It was not until the mid-19th century that the words "science", "scientist", and "scientific instrument" acquired the approximate meanings we use today.[4] Only some scientific instruments in the museum collections of the present day appear to have been used as research tools in the modern sense. There are a number of artefacts that contain complex information related to the natural sciences, but the primary function of which seems not to have been research at all, but to yield information, to demonstrate theories, or to provide an aesthetic experience and entertain its beholder or user.

For the purpose of this chapter, then, I include such artefacts as the astrolabe and the orrery in my definition of "scientific instrument", regardless of whether they were made for research and science in the modern sense or not. I also use the term "scientific instrument" more broadly to signify a three-dimensional artefact as the means of experiencing, explaining, understanding, and gaining knowledge about nature and natural phenomena. In early modern Europe, the correct terminology would have been more specialized. Inventories and literary sources normally referred to specific disciplines; often the terminology used spoke of philosophical, mathematical, astronomical, or optical instruments. The term instrument was also used in other fields, for example, for musical or surgical instruments.[5] Besides instrument, other labels generally used were machine or apparatus.

Good-quality scientific instruments were often signed by their inventors or makers, indicating the diverse levels of skill to be expected from the maker by different users. The artists who could combine theory with design and craft skills, such as Wenzel Jamnitzer, were especially admired.[6] Scientific instruments are peculiar since they often combine advanced levels of craft with a very complex theoretical content—a complexity that makes them a challenging experience for the user. In many cases, an artefact presupposes a user with a high level of education, and possibly requires a written explanation in order to be understood and used correctly.

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3. Daston 1998.
4. Field 1988; Warner 1990.
5. Zedler 1732–1754, vol. 14, p. 761, "Instrument", "Werck-Zeug".
6. Spenlé 2014.

Collecting and displaying scientific instruments

In early modern Europe, the manufacture and trade in scientific instruments grew as interest grew. Traditional instruments were developed further, and new types were invented. New architectural spaces for research such as the laboratory and observatory emerged as the home for some of these instruments. Curiosity and learning were not limited to particular research facilities, but were evident in the collection and display of numerous artefacts and *naturalia*. Specific sites were set up to cater for this interest, to please, instruct, and shape identities. References to ancient authorities and new scientific discoveries were presented side by side in the various types of collections.

In the standard work in the field, *The Origins of Museums: The Cabinet of Curiosities in Sixteenth- and Seventeenth-Century Europe*, the scientific instrument was placed in the context of general collection and display.[7] The interest in collecting instruments spread throughout Europe, and, accordingly, a number of specialized scholars have more recently contributed to a greater understanding of this field in the anthology *European Collections of Scientific Instruments in Europe, 1550–1750*.[8] One of the more prolific scholars of early modern collections of scientific instruments, Silvio Bedini, has traced the origins of the collection and display of scientific instruments, in particular those related to the physical sciences and technology.[9] He sees a parallel development of the scientific museum and the natural history museum, originating in 16th- and 17th-century collections of art and nature such as those owned by Rudolf II in Prague, by the landgraves of Kassel and electors of Saxony, and by a number of prominent collections in Italy—Ulisse Aldrovandi's museum in Bologna, the Medici museums in Florence, and Athanasius Kircher's museum in Rome, among others.[10] Eventually these encyclopaedic collections went out of fashion. They were split up, and our modern, specialized museums were created in the 19th and 20th centuries.

Between library and Kunstkammer

No doubt, the Kunstkammer contained scientific instruments. A variety of sources testify that the Kunstkammer was indeed a suitable place to keep, display, and use scientific instruments. In his 16th-century treatise on collecting, Samuel Quiccheberg recommended a number of categories to be included in the Kunstkammer. Together with objects related to the founder of the collection, religious artefacts, sculptures, coins, clothes, *naturalia*, paintings, and fur-

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7. Impey & MacGregor 1985.
8. Strano *et al.* 2009.
9. Bedini 1965, p. 1.
10. Bedini 1965, pp. 9–17.

niture, mathematical instruments were listed between musical instruments and writing instruments.[11] Throughout the early modern period, authors stated that scientific instruments were proper objects of a Kunstkammer.[12] Apart from treatises, which recommended what and how to collect, there were many visual representations of Kunstkammer, in which scientific instruments were displayed together with other types of natural and artificial objects (see, for example, *Fig.* 5.6, p. 90). This imaginary Kunstkammer is made up of a great number of panel paintings, sculptures, books, coins, and *naturalia*. Scientific instruments are shown on the floor, next to open books; on tables at which small precious items are being examined; and in a gallery of sculptures and paintings in the background. The painting as a whole is representative of a time in which our modern divisions of art, science, and nature did not apply, and where works of art, scientific instruments, and natural objects were exhibited together.

However, there were others who believed that such things did not belong in a Kunstkammer. In 1587, Gabriel Kaltemarckt wrote a treatise on the formation of art collections as advice for Christian I of Saxony. His main concern was the display of sculpture and painting, but he also wrote that in addition to these categories a Kunstkammer ought rightly to contain "curious items from home and abroad made of metals, stone, wood, herbs", but without specifying what these objects ought to be.[13] Instruments could potentially fall into this category, but Kaltemarckt proclaimed that

> musical, astronomical, and geometrical instruments, as well as those of numismatists, goldsmiths, sculptors, carpenters, woodturners, and grinders ought to be kept separately from the art collection [*Kunst cammer*]. Since these are not themselves pieces of art [*das Werck*], but only the means for producing them, they ought to be allocated special places among the liberal arts near the library.[14]

Instruments here seemed to have been an indeterminate category, neither appropriate for the Kunstkammer, nor for the library, but particularly relevant for the liberal arts. He held that the library and Kunstkammer ought to be kept separate from each other, and, to him at least, it was quite clear what belonged where: "For just as all kinds of good books belong to a library, so all sorts of good paintings and sculptures belong in the art collection [*Kunst cammer*]."[15]

In the popular publication *Der geöffnete Ritter-Platz*, which appeared in several

11. Quiccheberg 2000, pp. 36–78.
12. Jencquel 1727, p. 3.
13. Gutfleisch & Menzhausen 1989, p. 11.
14. Gutfleisch & Menzhausen 1989, p. 31.
15. Gutfleisch & Menzhausen 1989, p. 30.

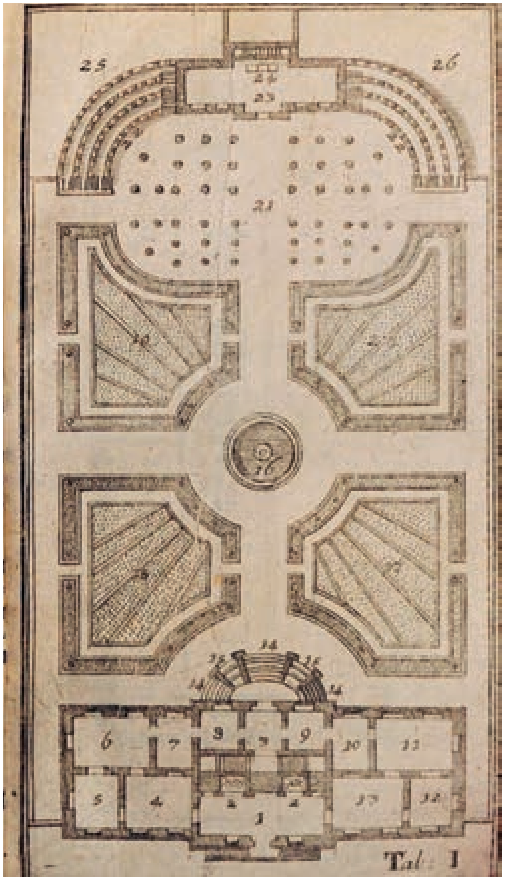
editions from the beginning of the 18th century, ample advice on collection and display was offered.[16] There were sections on all kinds of accomplishments useful to a gentleman, such as riding, hunting, and the construction of fortifications. *Der geöffnete Ritter-Platz* had a section on libraries and another on cabinets of rarities: these two spaces of display were treated as separate entities and, accordingly, their respective principles of collection and display differed too. In the introduction to the section on cabinets of rarities, the author explained that it was important to learn about the sciences and rare things in nature, and not just antiquities, and to care about seeing important things. The traveller was advised to use his time wisely. Once home, it would be embarrassing to reveal his ignorance and not be able to converse about useful and learned matters—which is what would befall the traveller who only visited grand palaces and gardens, and only consulted riding, fencing, and dancing masters. To see other travellers indulge in rich food and drink, or kiss young girls on the hand, would only set a bad example.[17]

Instruments in an ideal Kunstkammer

Der geöffnete Ritter-Platz stated that a collection of rarities should be so disposed that visitors could be received. The author presented an ideal architecture for a collection of rarities owned by a lover of curious things. An illustration showed the supposed floor plan of this imaginary building, composed of three floors with the same floor plan (and room numbering) on every floor (*Fig.* 2.1, p. 38). The visitor would enter the house by a double staircase set between two fountains, and arrive in the first room on the ground floor. The exhibition was organized partly chronologically, but mainly thematically. The author stressed the importance of white walls and little conspicuous décor, lest the visitor should be distracted from the exhibited rarities. In room thirteen resided the guardian of the collection, responsible for showing the visitors around. On the ground floor were antiquities, early Christian artefacts, and objects made of precious materials. There were wooden cabinets with collections of ivory, ebony, silver, mother-of-pearl, lapis lazuli, jewels, old porcelain, and a room for artefacts related to knighthood. On the second floor were foreign rarities and *naturalia*. Turkish, Persian, and Jewish rarities were shown at the start; the *naturalia* required a great deal of space and thus occupied more than half the floor, starting in the

16. Sturm 1700–1707, especially the second and third volumes.
17. Sturm 1700–1707, Vorbericht, vol. 3, 3–3^{v}: "Man soll mehr um die Wissenschafften, Seltenheiten der natur, und *Antiquitäten* auswertiger *Nationen*, und andere sehenswurdige Sachen bekümmert seyn." For the collecting of living plants and animals, see Groom 2014; Kearney 2014; Kirch 2014.

eighth room. Among the *naturalia* were to be found skeletons and embalmed bodies, dried animals, human remains, quadrupeds, fish, birds, shells, minerals, etc. The author located the Kunstkammer on the third floor. The objects displayed there were artefacts of different kinds, starting in the fourth room with sculpture, paintings, and curious things. It continued in room five with all kinds of clocks, continued in room six with crafts, in room seven with works of art by amateur artists and curiosities created by women, while in room eight were models of buildings and machines.



2.1 Anonymous artist, *Ground-plan for an ideal house of collections of rarities owned by a lover of curious things*. Illustration from Hans Leonard Sturm (attr.), *Der geöffnete Ritter-Platz*, vol. 3, 1707.

As the visitor came back to the central part of the building in room three, optical curiosities led over to a different section of the Kunstkammer, in which the curiosities of mathematics and physics were located. In room nine, globes and armillary spheres were to be found; in room ten, other astronomical instruments and rare geometrical instruments as well as arithmetical works of art; in room eleven, curiosities of experimental physics were displayed; in room twelve, geographical rarities; and, finally, a section on chemistry completed the Kunstkammer. The area outside the building was also part of the exhibition, for the garden should be planted with rare and foreign plants. There should be an orangery, terraces, a building for the theatrical display of plants during winter, and a menagery for foreign animals.[18]

With this ideal collection, *Der geöffnete Ritter-Platz* encouraged the notion of a universal collection of encyclopaedic scope. The artefacts and *naturalia* are sorted into their respective categories, and the treatise advises the collector to find representative objects of specific types within each group. The Kunstkammer offered space to objects that would be considered art in our modern sense, such as sculpture and paintings, as well as scientific instruments, although in separate parts of the display. As more and more objects flooded the market, it became increasingly difficult to assemble collections that represented such wide, divergent interests. In the 18th century, in accordance with this widening scope, specialized exhibitions emerged, such as cabinets of coins, geography,

18. Groom 2014, pp. 27–32.

antiquities, paintings, shells, anatomy, and so on.[19] The cabinet of experimental philosophy or physics became particularly relevant for collections of scientific instruments.[20]

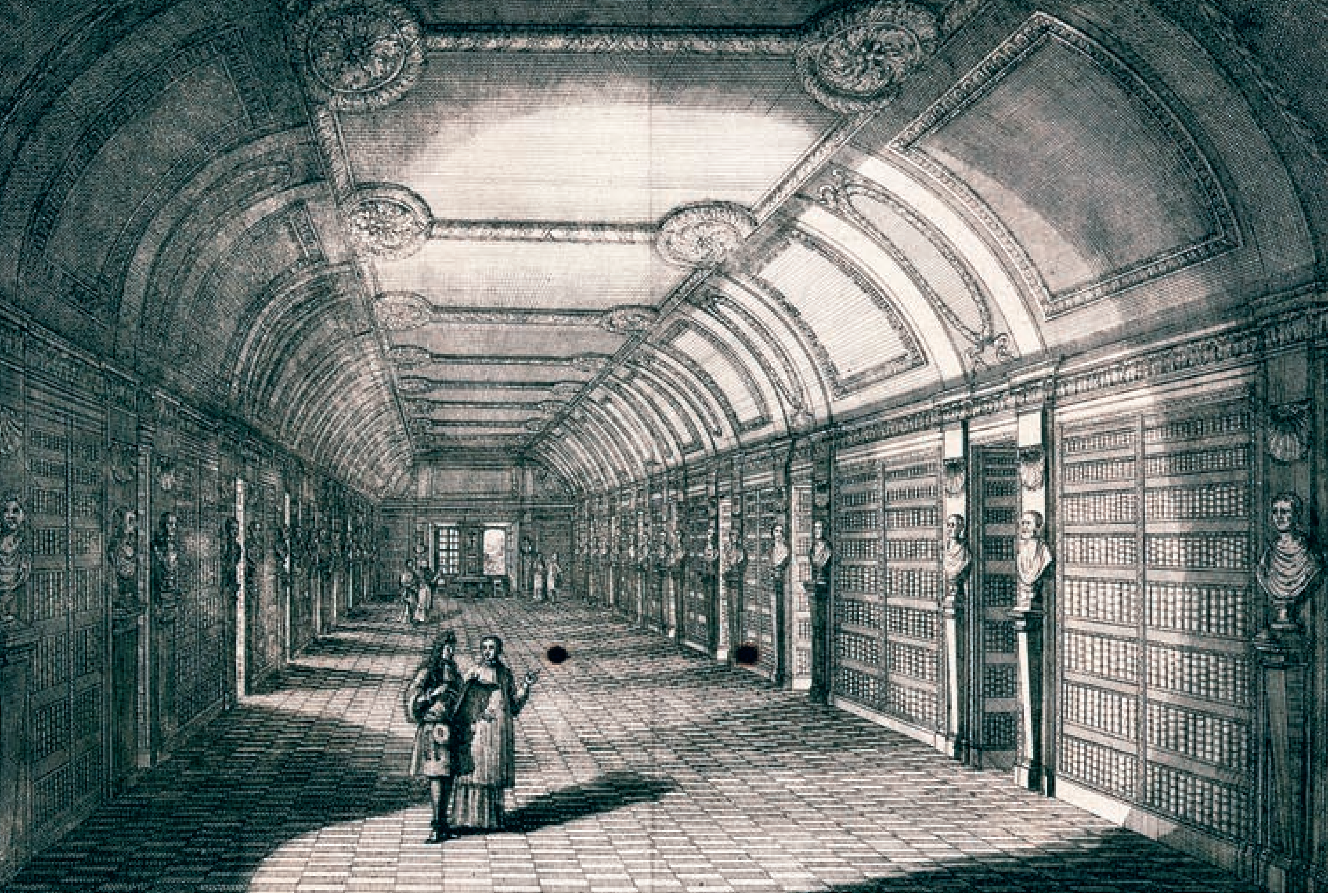
The library as a site of display for artefacts and naturalia

A library is by definition a repository of books, just as its name indicates. Numerous sources testify, however, that early modern libraries contained more than books: *naturalia*, antiquities, sculpture, paintings, coins and medals, and scientific instruments. Collectors all over Europe went to great effort and expense to create exceptional libraries, both in terms of collections and architecture.[21]

Both early modern libraries and museums could trace their origins to the ancient μουσεῖον in Alexandria, understood as a library-cum-collection and research centre. In her 'The museum: Its classical etymology and Renaissance genealogy', Paula Findlen sets out the diverse meanings of the early modern label, "museum". A variety of sites, among them libraries, were set up with the ambition to make them an appropriate space for the muses. Nonetheless, Findlen does not fully differentiate between the definitions of museum and library.[22] Such distinctions seemed difficult even for some early modern writers, since the concepts merged at times.

Some early modern treatises recommended equipping a library with collections other than books. Justus Lipsius in his *A Brief Outline of the History of Libraries* (*De bibliothecis syntagma*, 1602) wrote that it was proper to construct a library with precious materials and to adorn it with busts in plaster and metal. He wrote about the ancient library of Alexandria as a role model, noting that it had an adjacent museum.[23] He omitted to write about the inclusion of artefacts and *naturalia* in the library space, and may have believed it was preferable to keep these sections separate from one another—it is known that objects were displayed separately from the rooms of the libraries, as, for example, in the library of Saint Geneviève in Paris. There the visitor had to walk through the main library space to reach a number of smaller cabinets reserved for the collections of artefacts and naturalia. A written account of part of the collections, concentrating on the *naturalia*, antiquities, and coins, has illustrations of what the rooms once looked like (*Figs* 2.2–2.3, p. 40, 41).[24]

19. Jencquel 1727, pp. 3–5.
20. Bennett & Talas 2013.
21. Lehmann 1996; Garberson 1998.
22. Findlen 1989.
23. Lipsius 1967.
24. du Molinet 1692.



2.2 Franc Ertinger, *The main library at Sainte Geneviève*, from Claude du Molinet, *Le cabinet de la bibliothèque de Sainte Geneviève*, 1692.

Other theoreticians advised that artefacts and *naturalia* ought to be displayed within the library space, as pointed out in the section on libraries in *Der geöffnete Ritter-Platz*. The treatise outlined what types of artefacts and *naturalia* were most beautiful and appropriate to collect in the library space. Certain fields of research had fine, suitable accessories: geometry, astronomy, geography, optics, navigation, gnomonics, mechanics, music, and arithmetic could all be represented by a number of listed scientific instruments. Natural history could be represented by diverse types of *naturalia* from all over the world. History was visualized by displays of coins, muniments, and antiquities such as banners, urns, and wax tablets. Colourful maps and pictures of landscapes and cityscapes were suitable to represent geography on the walls. The inclusion of these objects was of central importance, since they acted as reference points for the disciplines discussed in the library books.[25] This is a different view to that expressed in the section on cabinets of rarities. In the library, objects were included primarily for their

25. Sturm 1700–1707, vol. 2, pp. 191–195.

2.3 Franc Ertinger, *A cabinet for collections at Sainte Geneviève*, from Claude du Molinet, *Le cabinet de la bibliothèque de Sainte Geneviève*, 1692. See also page 10 and 32.

thematic connection to the books and by virtue of being illustrative material, but not for their own sake.[26] The objects seem to have served a subordinate role to the books, in contrast to their task in the cabinet of rarities, where they were the essential exhibits. The majority of the text is devoted to which books to collect in each category, and how to arrange books systematically.

The role of beauty and decoration should not be underestimated, though. Vast sums were spent on the construction of impressive and beautiful libraries, but also in order to praise learning and knowledge. Scientific instruments in particular were thought very suitable to indicate learning since they required a knowledgeable user; they were often referred to in the books found in the library. These objects were also very valuable and thus signalled wealth. They helped shape the identity of the owner, and indeed of the library users, since they were not only financially powerful, they were also erudite. In this way, instruments helped enhance the implicit value of the knowledge possessed by the library's owners and users.

Caspar Friedrich Jencquel's book *Museographia* from 1727 (published under the pseudonym of C.F. Neickel) contains useful information about actual collections and the theoretical concerns they raised. Jencquel had visited some collections in person, while his information about others was hearsay. He also described a number of collections no longer in existence. The book contained lists of museums and libraries, advice on how to collect, organize, and display collections, and how to behave when visiting them. There was a degree of fuzziness to his definitions of museum and library, since the list of museums included a number of libraries. He wrote that the reader had to accept this, for libraries often not only displayed beautiful books, but also rare things. Therefore, libraries were included under the repositories of rarities, or, even better, under museums.[27]

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26. Sturm 1700–1707, vol. 2, pp. 193–198.
27. Jencquel 1727, 'Vorrede des Autoris' (*sic*), fol. 3^{v}.

The frontispiece shows Jencquel's ideal museum (*Fig.* 2.4). The illustration shows a room that contains both a systematic collection of books and objects made by man and nature. In the centre of the room a man is seated at a table which is laden with a number of objects: books, a quill, an inkpot, shells, a fish, a small globe, and some additional objects that are difficult to identify. Along the left wall are shelves full of books, each section marked as a library should be, with signs giving the subject matter of the shelf: logic, astronomy, medicine, and physics. The shelves are equipped with a ladder so that the books can be reached; drawers below are reserved for additional objects. At the back of the room is a cabinet for storage. Above, hanging from the ceiling, is a stuffed crocodile. To the right are shelves displaying different body parts. Arms and heads, probably wax models, can be made out. The next shelf holds shells and corals, while the one furthest to the right contains skeletons. The room is also hung with portraits and landscape paintings. It is located in a corner of the building with windows in two directions so that sufficient light is available for work. Jencquel's ideal museum is very similar to a library. He suggested the inclusion of books, for what is a collection of objects without knowledge? He wrote that catalogues were the minimum requisite, but preferably more books relevant for the collection should be included. Several well-known libraries were accordingly included in Jencquel's list of museums: the library at El Escorial, the Bodleian in Oxford, and the imperial library in Vienna.[28]

2.4 Anonymous artist, frontispiece from Caspar Friederich Jencquel, *Museographia oder Anleitung zum rechten Begriff und nützlicher Anlegung der Museorum oder Raritäten-Kammern*, 1727.

Over the years, many early modern libraries have changed, and in the process either lost their holdings of artefacts and *naturalia* or disposed of them to museums. One of the reasons was that books became more numerous and less expensive. Of necessity, the nature and use of working libraries had to change. It appears from inventories drawn up in the course of the 17th century that books lost their status as being very valuable, and were increasingly regarded as household equipment. By 1700 they were usually no longer listed by individual title or description.[29] Soon space became an important issue.

28. Jencquel 1727, pp. 34, 78, 128–129.
29. Mandelbrote 2000.

2.5 Conrad Buno, *August the Younger of Brunswick-Lüneburg in his library*, from Martin Gosky, *Arbustum vel arboretum Augustaeum*, 1650.

A number of libraries survive in their original locations and with their original contents. The library at El Escorial still displays some of the instruments that were ordered for the space at the end of the 16th century. The entire interior is sumptuously decorated. The walls are lined with bookshelves that are still full of tomes. The ceiling and walls are painted with allegorical motifs—indeed, they depict a number of scientific instruments, each scene alluding to the subject discussed in the books placed underneath, explaining the organization of the library. This library space was also intended to display scientific instruments, of which globes and armillary spheres are the most conspicuous.[30]

In addition to sites preserved almost unchanged, ample visual material testifies to the inclusion of scientific instruments in libraries. Numerous illustrations show a globe or a pair of globes, such as the picture of Herzog August the Younger of Brunswick-Lüneburg in his library in 1650 (*Fig.* 2.5). It is also possible to trace the provenance of many scientific instruments today in museum collections back to libraries. One example is the Orrery collection, bequeathed to Christ Church College in Oxford in 1731 by Charles Boyle, 4th Earl of Orrery. The collection had been put together at the turn of the century, and the inventory specified 50 mathematical instruments which were kept in the earl's library in his London townhouse, unfortunately no longer extant. According to

30. Scholz-Hänsel 1987; Van Cleempoel 2009.

the inventory, the instruments were arranged in the library by size. The library consisted of three rooms, and the larger instruments were displayed in two of them, whereas smaller objects were kept in drawers in the main room.[31] Today this collection is on display in the University of Oxford's Museum of the History of Science.

Non-verbal statements and the transmission of knowledge

To represent knowledge about nature using collectibles can be easy. A shell, a plant, or an animal can provide us with visual, tangible material from far-distant places and times. The same is more difficult to achieve with material such as the heavens and the wandering stars, which cannot be brought inside a room, although our knowledge can be made manifest with the help of a model. Adam Olearius in the foreword to his *Gottorffische Kunst-Kammer* acknowledged that Creation is more wonderful than can be described. When words are not enough, non-verbal cues such as models can play a role, since they can visualize and communicate knowledge in a complementary way:

> The wise father or industrious teacher who wishes to teach his children and pupils something of science, will not only inform them with his mouth: but also with his quill he writes and paints all the different kinds of figures and depictions, and through the small thing points to the greater. So does a mathematician and geometer. An astronomer shows on a small handheld celestial globe the nature of the vast heavens with all the visible bodies, where one point indicates a large star. In the same manner, the geographer uses the terrestrial globe to show the whole Earth, with its landscapes, seas, and rivers, where a dot indicates a city, a line a watercourse, and an area the width of a thumb must indicate a wide sea.[32]

Olearius believed that objects were useful to the learning process since they could make nature and knowledge easier to understand. Claude du Molinet in his 1692 description of the collections in the library of Saint Geneviève in Paris also wrote in favour of the usefulness of collections of *naturalia* and artefacts in the library. He claimed that collections contributed to the ornamentation, but that they were also an advantage when learning, that they served the purpose of the *belles-lettres* and were useful for the sciences. Mathematics, astronomy, optics, and geometry, but most of all history, whether natural, ancient, or modern, all benefited from such a juxtaposition.[33]

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31. Gunther 1967, pp. 378–382.
32. Olearius 1674, fol. 1^{v}.
33. du Molinet 1692, Preface, fol. 1; King 2014 shows that collections of *naturalia* could not only be relevant for texts on natural history, but for poetry too. Artefacts can help in cross-references between diverse fields.

Apart from promoting understanding, I would argue that scientific instruments and other objects exhibited in libraries could also have a social function. It is well known that artefacts and *naturalia* were used in demonstrations in learned societies, such as the Royal Society of London, to promote learning. Iordan Avramov has shown that the use of collections at the Royal Society had both social and scientific implications.[34] Some objects and images more than others invited the audience to discuss and interact; some of the scientific instruments, such as the armillary sphere, needed interaction in order to yield the required information. When receiving guests in the library an instrument such as an armillary sphere was probably ideal as a conversation piece. It would have allowed members of the audience to steer and manage conversation in a more liberal order than a text, which has a fixed structure and is more difficult to share unless read aloud. An artefact, like an illustration, can usually be captured in its entirety at a glance; it also allows more than one possibility for the viewer's experience, interpretation, and digression simultaneously.

Accounts of the use of instruments in social interactions indicate that this was one of the intended functions. In the collections of Rijksmuseum Boerhaave is a large Copernican armillary sphere from about 1670.[35] In the early 18th century it was presented to the University of Leiden, where it was exhibited in the university library. At 1.5 metres in diameter its sheer size alone made it conspicuous. The sphere had a clockwork mechanism that could put it in motion, but it is now no longer functioning. An illustration and account of the sphere were added to the 1751 German edition of Bernard Le Bovier de Fontenelle's *Entretiens sur la pluralité des mondes* (*Fig.* 2.6).[36] First published in 1686, the extremely popular book—a flirtatious dialogue between a philosopher and a marquise—took astronomy to be a subject fit for social interaction, and contributed to making natural philosophy fashionable. By including the Leiden sphere, the editor implied that a visit to a library where this kind of artefact was on show was a suitable social activity. The library was presented as the proper site for a discourse about astronomy, not only for scholars, but for ladies too. Numerous editions of the *Entretiens sur la pluralité des mondes* were printed, and it was translated into a range of

2.6 Johann Benjamin Brühl, *The sphaera of Leiden*, from Bernard Le Bovier de Fontenelle, *Herrn Bernhards von Fontenelle … Auserlesene Schriften*, 1751.

34. Avramov 2014.
35. Library Rijksmuseum Boerhaave, Leiden, inv. no. V09619.
36. de Fontenelle 1751. The French title *Entretiens sur la pluralité des mondes* was rendered in the earliest English editions as *A Discovery of New Worlds*.

2.7 Charles Grignion after Samuel Wale, frontispiece from Benjamin Martin, *The Young Gentleman and Lady's Philosophy in a Continued Survey of the Works of Nature and Art by Way of Dialogue*, vol. 1, 1759.

other languages. In its wake came variants on the theme. One example was a conversation about natural philosophy between a brother and sister, written by Benjamin Martin. The frontispiece of the first volume showed the brother and sister seated in a private library, deep in conversation over a globe. The young woman holds a book in her lap, as if to verify details as they went. Next to them is a telescope directed towards the starry sky through the open window, as if it had been recently used by the siblings (*Fig.* 2.7).[37] Here the instruments in the library were shown as objects for social interaction and entertainment, in a frontispiece that suggested that a library was a suitable site for this sort of social activity.

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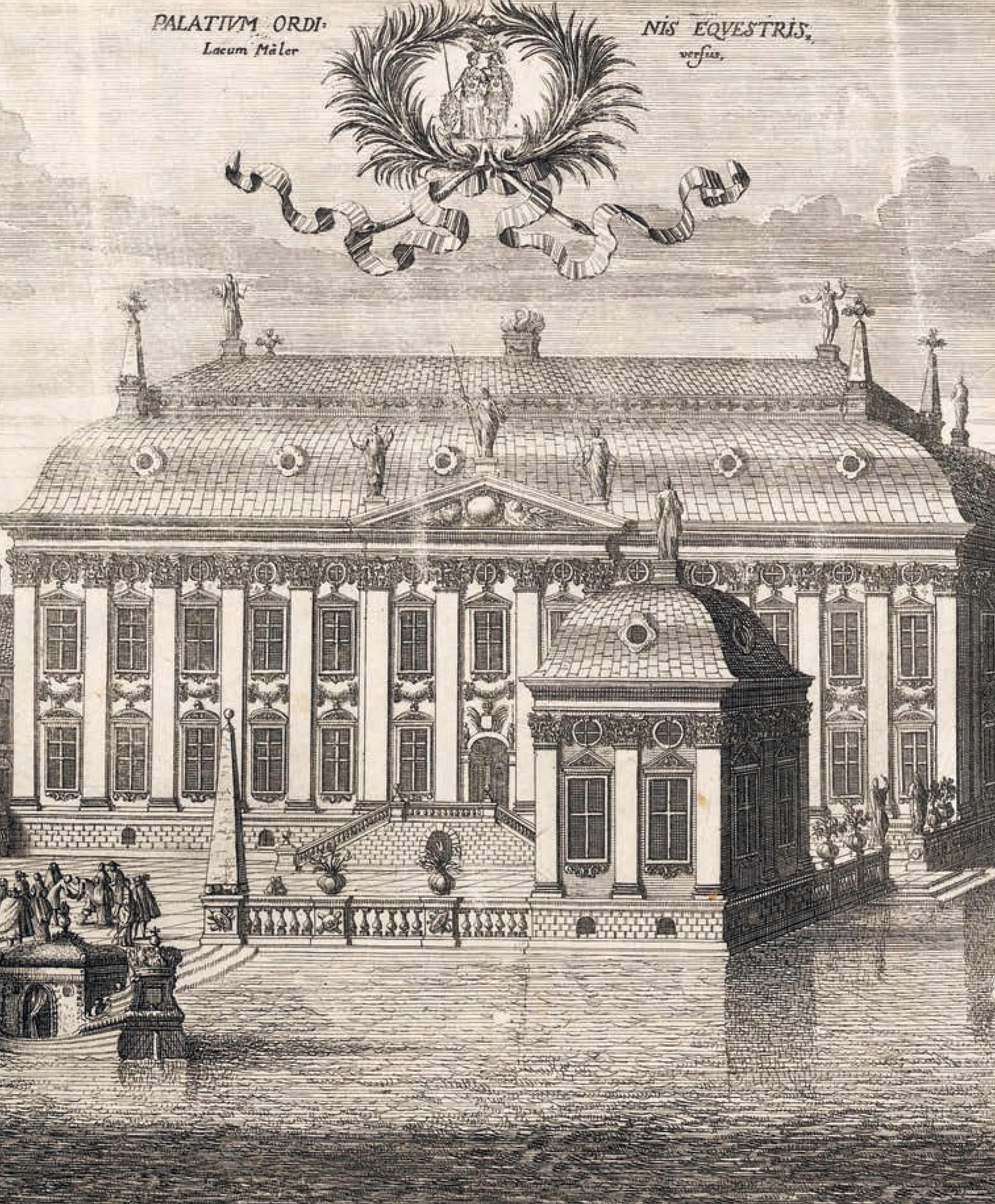
A number of early modern libraries were not only book repositories, but also had extensive collections of artefacts and *naturalia*. At times this type of library was understood as a museum, in accordance with the role model of the ancient library at Alexandria. Theoretical treatises stressed the role of collections in providing encyclopaedic information, with artefacts and *naturalia* contributing to the value of the library holdings. An important role fulfilled by these objects was the decoration of the library space. The display of conspicuous collections contributed to create an impressive, beautiful, intriguing, and inviting space. It helped give a unique identity to the space. It indicated to its owners and users alike that the library not only contained vast amounts of knowledge, but that its objects also denoted financial wealth, since they often represented monetary value. Scientific instruments were particularly appropriate when visualizing learning because of their complex theoretical content, which could be linked to the texts held in the library. The function of the artefacts and *naturalia* consisted in the non-verbal communication of knowledge. Collections offered the means to provide visual, tactile, and spatial information in a complement to the information contained in the books, and thus were useful for the advancement of learning. Finally, the collections also had a social function for instruction and debate, as well as for entertainment. Artefacts and *naturalia* in a library could make it a space for social interaction. Such interaction was in contrast to the traditional perception of the lone scholar, searching single-handedly for knowledge among the library books.

37. Martin 1759.


PALATIVM ORDI-NIS EQVESTRIS,
Lacum Mälor versus,

3 The cabinet of physics at Riddarhuset in Stockholm

Riddarhuset is situated in a central location in the Old Town of Stockholm, and is the House of Nobility, the Swedish equivalent to the United Kingdom's House of Lords.[1] Sweden was ruled by the so-called Ståndsriksdagen, or Diet of the Estates, a parliament made up of four Estates—the Nobility, the Clergy, the Burghers, and the Peasants. Riddarhuset was built to house political meetings and for the administration of the Estate of the Nobility. An imposing building, it was built in the mid-17th century, at a time when Sweden was relishing the successes of its expansive foreign policy. The building is an obvious statement of the importance that the Swedish aristocracy assigned to itself in political terms (*Fig.* 3.1).

During the 18th century in Sweden, the natural sciences became increasingly popular. Riddarhuset became an important site in this development, hosting lectures on various subjects and also musical concerts. With the establishment of a cabinet of physics, it also became the main meeting place for those with an interest in natural philosophy. The possibility of having such a cabinet in Riddarhuset was first raised in the late 1720s.[2] Sebastian Tham, a merchant from Gothenburg, donated funds in 1727. The idea of using Riddarhuset for teaching and lectures was not new, as in the 17th century the premises had housed a school for young noblemen, the Collegium Illustre, although this seems to have been in operation only briefly. The Tham donation was used throughout the 18th century to teach natural philosophy, in the form of lectures and publications. The fund exists today, used by the Royal Swedish Academy of Sciences to invite particularly distinguished lecturers to Sweden.

3.1 Johannes van den Aveelen after Erik Dahlberg, *Riddarhuset*, in *Suecia antiqua et hodierna*, vol. 1, 1667–1715.

1. This essay was first published in Bennett & Talas 2013, pp. 99–118.
2. The main published works on the cabinet are Schück 1942; Lindroth 1967; Beckman 1967–1968; Lindqvist 1984; Grandin 1999.

This chapter will focus on the collections of scientific instruments and the lectures on experimental physics held at Riddarhuset from 1728 on, first by the gentleman scientist Mårten Triewald, then by other scholars, under the aegis of the Royal Swedish Academy of Sciences. It will track the present whereabouts of the surviving instruments as far as is known. It will also briefly describe the other cabinets of physics that were set up in Sweden in the 18th century, in Stockholm, Lund, and Uppsala.

Demonstrations of experimental physics at Riddarhuset

In 1728 the first lectures on experimental physics were given in rooms on the ground floor at Riddarhuset. The committee rooms of the Diet's Secret Committee, which oversaw foreign policy, were normally used for important political meetings of about a hundred people. While it was a good start, it seems not to have been an entirely satisfactory solution, as a few years later in 1734 Triewald set about having the unused eastern part of the second floor refurbished as a "Schola illustris", with space for necessary instruments, machines, and a lecture hall. Permission was granted, and Triewald was able to start his renewed public activities in the Auditorium Illustre in 1739. The rooms have been refurbished since, but a drawing gives an impression of the layout (*Fig.* 3.2). A round auditorium with a stage in the middle and tiers of seats connected by stairs provided the main space for lectures. Outside the auditorium was an iron barrier, behind which was a repository for "machines, models, and instruments". The rooms adjacent to the auditorium were a vestibule and a repository for larger instruments, and a "Laboratorium Mechanicum" or room for experiments. There was also a particular repository for fortification models, and another used for drawing by the young men of Livgardet, the Royal Life Guards. This suggests a degree of co-operation on education for military purposes.

In the same year as Triewald started his activities in the Auditorium Illustre, the Academy of Sciences was founded at Riddarhuset, with Triewald as one of its founders and prime movers, having proposed the Royal Society of London as a model. The Academy was granted use of the rooms for 25 years, but even after that the Academy continued to host lectures and official events in Riddarhuset. Physics was not the only subject of the lectures there: for example, Carl Linnaeus, another founding member of the Academy, gave lectures on botany, zoology, and mineralogy. They were so popular that they outgrew Triewald's room.[3]

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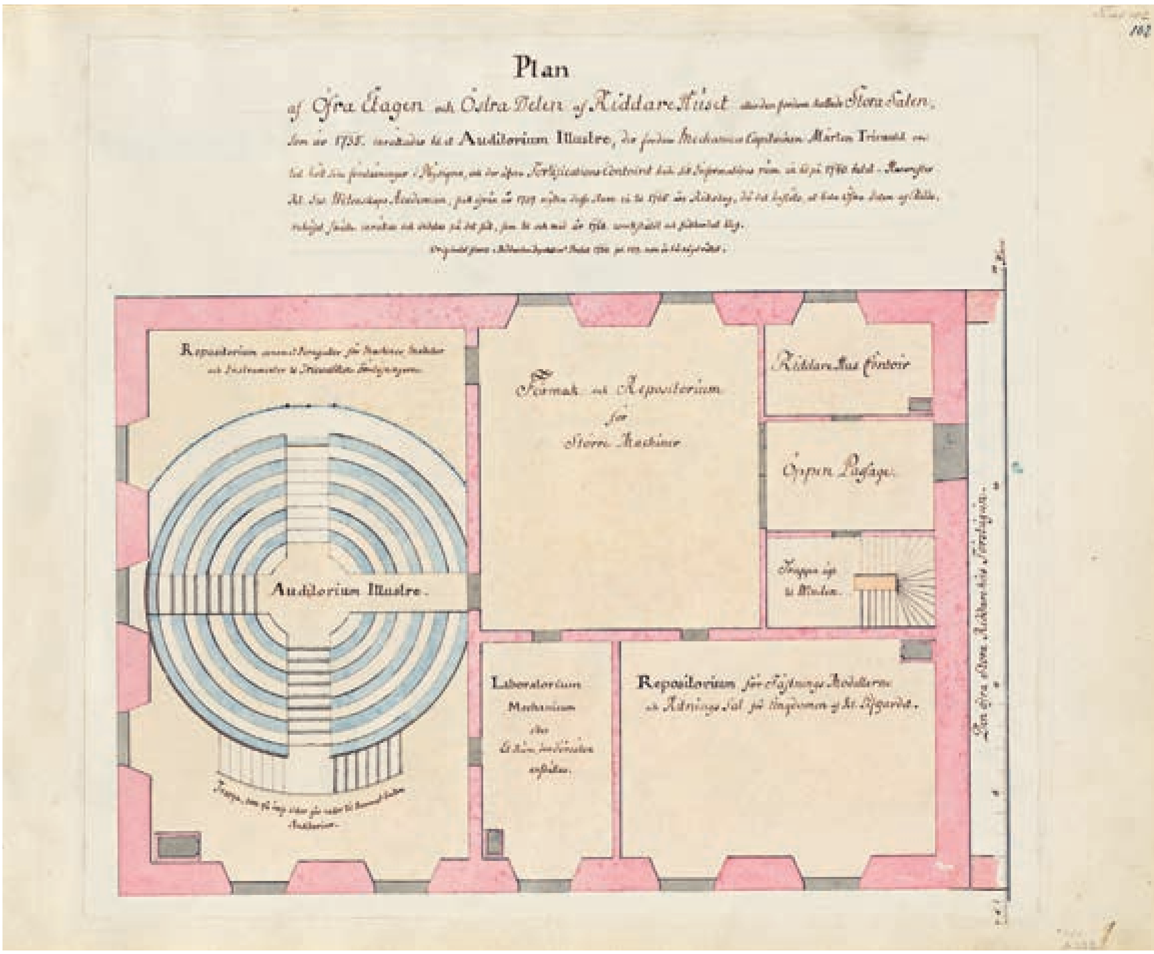
3. Carl Linnaeus to Carl Gustaf Tessin, 22 April 1740, in Ährling 1878–1880, vol. 1, pp. 1–3.



3.2 Anonymous artist, *The Auditorium Illustre and repository of scientific instrument at Riddarhuset*, modified copy of original dated 1738. Pen, ink, and watercolour, 33,5 × 36 cm. The National Library of Sweden, Stockholm, Tilas collection vol. 1, p. 102.

The main audience was initially male, genteel and occasionally in trade; later, as the lecture series became more established, it provided useful training for fortification officers and architects. The first advertisement of Triewald's lectures addressed the audience as "honoured Gentlemen". The list of subscribers for the published lectures had the names of several well-known, wealthy men. The printed lectures also contained illustrations of instruments, each plate with the subscriber's coat of arms, in an implicit reference to the great hall of Riddarhuset, where the coats of arms of all the Swedish nobility are displayed—the inclusion of a coat of arms situated experimental physics as an aristocratic concern.

We cannot exclude female interest, but it is reasonable to assume that the audience was male, and the main target group for the books was male too. In the latter half of the century, though, Johan Carl Wilcke made a point of the appropriateness of including a female audience. He advocated the usefulness and pleasure to be derived from experimental physics by women and children. He particularly pointed out that Émilie du Châtelet was a role model, being not only learned, but also instructing others and writing.[4]

Mårten Triewald

On 8 January 1728, Mårten Triewald gave his first lecture on experimental physics at Riddarhuset. It was the starting point in a series of 28 lectures. It was followed by a second and extended series of 30 lectures that started on 15 October the same year. In 1730 a new series of lectures was advertised, now extended to 32 lectures; with Triewald's permission, they were to be given by his assistant Daniel Menlös.[5]

In a half-length portrait of Triewald attributed to Georg Engelhard Schröder, preserved at the Royal Swedish Academy of Sciences, he is shown pointing at a bird in a bell jar (*Fig.* 3.3). This gesture is at once a reference to his teaching and to his research in pneumatics. He is best known for his contributions to the development of the steam engine as well as his publications on the diving bell, including *Konsten at Lefwa Under Watn* ('The Art of Living Under Water', 1734).[6] When he gave his first lectures he had just come back from Britain, where he had been living for eleven years. In London he had attended lectures on natural philosophy by John Theophilus Desaguliers, and had seen how experiments were performed and demonstration instruments set up in front of an audience. He was impressed by the Royal Society, of which he later became a fellow. Newton, whom he claimed to have met, was the authority to whom he often deferred. Triewald taught in rented rooms in Newcastle, and he lectured on astronomy and natural philosophy in Edinburgh in 1724 and 1725.[7] He noted the widespread interest in natural philosophy, and wrote that philosophy, by which he probably meant experimental natural philosophy, was taught in several towns in the country, and lecturers competed with one another. He bought a set of instruments, so it is fair to assume that he was teaching on a regular basis. He claimed to have bought the set on his own account, with no financial help from home, and later brought it back to Sweden, determined to introduce the new fashion to his home country.[8]

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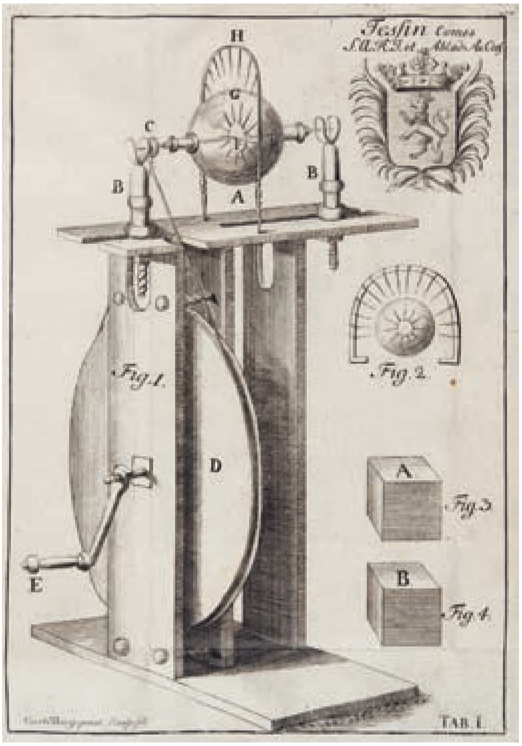
4. Wilcke 1762, p. 18.
5. Schück 1942.
6. Triewald 1734.
7. Cable 1973; Lindqvist 1984, pp. 197 ff.; 1991.
8. Triewald 1735–1736.

3.3 Georg Engelhard Schröder (attr.), *Portrait of Mårten Triewald*, around 1740. Oil on canvas, 81 × 64 cm. Center for History of Science, The Royal Swedish Academy of Sciences.

A printed 16-page *Notification*, signed by Triewald on 2 September 1728, advertised the lectures on mechanics, hydrostatics, aerometry, and optics. It gave a description of the topic of each lecture. Experiments and instruments played a key role in the text, apparently thought to be an appropriate means of promoting the lecture series. From the text it was obvious that the first lectures earlier in the year had gone very well, but that Triewald was marketing the series to gain a larger audience. The lectures were to be held every Tuesday, Thursday, and Saturday at five o'clock sharp, to be paid in advance at a shop in the square outside Riddarhuset, and the receipt was to be presented at the entrance of the lecture room. One could simultaneously sign up and pay for the published version of the lectures, and the illustrations.[9]

A written account of the lectures was published in two volumes (1735–1736). Each is richly illustrated, with 64 plates in all. This edition was reprinted in 1758. Unfortunately, the text covers only half the lectures, as the planned third and fourth volumes were never published. The first lecture begins with very small bodies, the point of departure being Newtonian physics. Some instruments and experiments are mentioned: microscopes, magnets, and a vacuum experiment with mercury. The first plate shows a glass globe friction machine very similar to that constructed by Francis Hauksbee (*Fig.* 3.4, p. 54). Triewald wrote that before using the machine, grey paper or dry wool was rubbed on a glass staff, then gold leaf was thrown into the air so he could show how it could be manoeuvred in the air using the staff. Then he turned to the machine, which had a hollow glass bulb, pierced by an iron rod resting on supports outside the bulb. Within the bulb was a round board to which were attached pieces of woollen yarn. The bulb was turned by a crank connected to the bulb by the yarn. Suspended above the glass bulb was a bow from which hung pieces of yarn. As soon as the experiment was started, the outer strings would stiffen and point towards the middle, and the inner strings would straighten and point outwards like the spokes of a wagon wheel.[10]

9. Triewald 1728.
10. Triewald 1735–1736, vol. 1, pp. 23–25.



Triewald's style of teaching in the vernacular appealed to his audience, but what pleased many also made him enemies. He referred to this in the publication. He wrote that they did not like the lectures to be in Swedish. Triewald complained that a few were not really interested, but were there simply to pass the time. The criticism may also have been aimed at the great number of experiments, which left little time to explain the theory. For example, the *Notification* stated that the fifteenth lecture would have 50 experiments with the air pump.[11] It is possible that he appealed to different senses to hold his audience's attention, and there was a degree of showmanship involved. Certainly, it seems there was a lot happening on stage. He mentioned mixing liqueurs, making drinks with layers of different coloured liquids, and he referred to smell (smoke) and sound (a loud bang when a thermometer broke). The eighth lecture treated the life force of humans and other animals. This was demonstrated using men, one of whom was referred to as particularly strong. In one of the experiments, a man used a sledgehammer to hammer on a piece of iron laid on the chest of another man lying flat on the ground. Triewald wrote that the larger the piece of iron

3.4 Carl Bergquist, *Glass globe friction machine*, from Mårten Triewald, *Mårten Triewalds år 1728 och 1729 håldne föreläsningar …*, vol. 1, 1735.

3.5 Carl Bergquist, *Demonstrations of the forces of the human body*, from Mårten Triewald, *Mårten Triewalds år 1728 och 1729 håldne föreläsningar …*, vol. 1, 1735.

11. Triewald 1728, n.p. (fol. 6v).

laid on the man's chest, the less the force of the sledgehammer will be felt. Here Triewald took the opportunity to reveal that travelling strongmen, performing such an act in public, were not extraordinarily resistant to heavy blows with a sledgehammer after all, but it was the large piece of iron that protected the man from the force of the blow.[12] There was not necessarily a direct correlation between what was said and done in the lecture and what appeared in the printed version. For example, the illustrations show naked, muscular men, covered only with a scrap of cloth, engaged in the demonstrations (*Fig.* 3.5). It seems very unlikely that they were so scantily dressed. These illustrations were in fact taken from Desaguliers's book *A Course of Experimental Philosophy*, albeit adapted to the new format and context.[13] It is probable that Triewald had the artists copy instruments and experiments from various sources, and that some instruments were drawn from life. Otherwise it can be assumed that the illustrations give a reasonably accurate idea of the instruments at Triewald's disposal.

The unique challenges of maintaining and showing a cabinet of physics in the middle of a Nordic winter were evident from an account of a curious event which was published in the transactions of the Royal Society. Triewald wrote that coming into the hall with some visitors, he feared that the glass for showing the experiment with the "Cartesian devils" would be in danger of breaking, should the water freeze. This instrument consisted of hollow divers (figures) placed in a jar filled with water, which moved when pressure was applied to a membrane on the surface, sinking to the bottom of the glass. He took the jar down from the shelf, and was pleased to see the water was still liquid. Before he emptied the glass, he wanted to show the experiment to his visitors, but in that very instant, in a matter of seconds, he found all the water changed into ice. He offered no explanation, but invited "that ingenious Gentleman Dr Desaguliers" to provide one.[14] Besides this curious instant freezing, we can wonder at the fact that the rooms were not heated to protect the artefacts or when visitors were expected. In 1732 Triewald sold his collection of 327 instruments to his assistant Daniel Menlös, who took it to Lund University. Triewald acquired a new collection, but its content and fate are not known, and neither is how regularly he lectured. In the commemorative speech after his death, given at Riddarhuset, it was indicated that the instruments were still in the keeping of the Academy. His instruments were probably displayed in Riddarhuset in 1747, and possibly still in 1780.[15]

12. Triewald 1735–1736, vol. 1, pp. 12–14, 31–38, 285–327.
13. Desaguliers 1734–1744, vol. 1, pl. 19.
14. Triewald 1731–1732, pp. 79–80.
15. Laurell 1748, p. 22; Oseen 1939, p. 307.

The cabinet of the Royal Swedish Academy of Sciences

In 1746 it was decided that that the permanent secretary of the Academy of Sciences, Pehr Elvius the Younger, would hold the Tham lectures at Riddarhuset. This decision was in part for financial reasons, as it allowed the secretaryship to be salaried for the first time. The secretary was to give lectures every Wednesday at three o'clock. In the commemorative speech after Elvius's death, it was said that his main teaching model was the "Florentine academy", by which was probably meant the 17th-century Accademia del Cimento. As he did not travel widely, his inspiration must have come from his experience of the universities of Stockholm and Uppsala, and not least from books or from someone who had travelled abroad. Perhaps his teacher and well-travelled cousin Anders Celsius had told him about the wonders of Italy, and the collections of instruments there. In all, Elvius gave 14 lectures. The audience stopped coming and Elvius's lecturing duties were suspended. He still kept the salary though, and his new task was to write and publish an article on the history of science in the transactions of the Academy four times a year. His contemporaries appreciated his writing skills more than his lecturing.[16]

When Elvius died in 1748, he was succeeded by Pehr Wargentin. Lecturing was not something Wargentin prioritized, although its importance was stated repeatedly. Wargentin wrote: "To lecture to the public with quality would take all your time, particularly if you want to do experiments as is stated in the directions [of Sebastian Tham's will] and also what the audience desires."[17] Wargentin emphasized the audience's wish for experiments and instruments, and the absence of an audience was blamed on the lack of appropriate instruments. It is possible that he was not a very captivating lecturer, for soon another solution was sought. His complaints about the lack of instruments were somewhat contradicted by other evidence that instruments were available: for example, the Academy had acquired an air pump and an electricity machine in the 1740s, and in 1755 and 1757 the accounts indicate payments to transport an electrical machine from Riddarhuset to Stockholm Observatory, where Wargentin now lived and researched.[18] At the Observatory he was neighbours with the instrument maker Daniel Ekström, who also contributed to the store of instruments by making a large electrical machine for the Academy, but his untimely death in 1755 put an end to the collaboration between the two.[19]

16. Dalin 1750, pp. 20, 25.
17. Nordenmark 1939, p. 154.
18. RSAS, CfVH: Accounts 1755, no. 38; Accounts 1757, no. 63.
19. Amelin 1999, pp. 74–76.

Johan Carl Wilcke

In 1759, Wargentin managed to persuade the other members of the Academy to employ the young and apparently rather more charismatic Johan Carl Wilcke. The Academy's financial situation had improved and allowed the creation of a Tham lectureship. Wilcke was to lecture twice a week for two months in spring and autumn. This arrangement allowed him time to develop as a researcher, particularly in electricity, developing an electrophorus in 1762, and to work on "specific heat".[20] His salary was on the meagre side; however, and in order to make a decent living, he took a side job as the tutor for a son of the powerful Höpken family. Wilcke managed to revitalize experimental physics in Stockholm by giving a great number of lectures, and under his supervision the collection of instruments grew substantially.

Wilcke had studied at Uppsala, where he had witnessed the use of instruments in Samuel Klingenstierna's demonstrations. Klingenstierna, who translated Pieter van Musschenbroek's *Elementa physicae* into Swedish, had acquired a full set of experimental physics instruments from London. In the foreword to the book, Klingenstierna wrote of the usefulness of instruments in teaching, about how difficult it was to obtain knowledge about nature, and that the "powers are hidden to our senses, as their function is invisible, and must be explained by particular accounts and made visible with the aid of instruments".[21] If Klingenstierna managed to drive home the usefulness of demonstrations when teaching, Wilcke gained further opportunity to learn by travelling abroad. Between 1751 and 1757 Wilcke lived in Germany, where he studied at Rostock and Berlin, undoubtedly becoming acquainted with new teachings and collections, and making friends with, among others, Franz Aepinus. In his texts, Wilcke referred to many contemporary European colleagues as well as printed works, and plainly aspired to bring Stockholm up to date with what was being done on the Continent and in Britain.

Some of Wilcke's lectures and speeches were published. In 1761 he gave a lecture in which he argued for the usefulness of the acquisition of instruments for the demonstration of experimental physics. He emphasized that the teaching of experimental physics had to be engaging, and needed instruments in order to hold the audience's attention.[22] On his death in 1796 the Academy acquired Wilcke's private collection of 287 items, some of which he had used in his lectures at Riddarhuset, although it is not easy to know exactly which instruments were demonstrated when. He had owned a variety of instruments relating to

20. Oseen 1939, pp. 68–276.
21. Klingenstierna 1747, n.p. (fol. 2^v).
22. Wilcke 1762, p. 32.

pneumatics, magnetism, optics, acoustics, and, not least, electricity. There were several electrical machines along with isolator tables that were well-suited for demonstrations—electricity was evidently a key element in the programme. Over 70 artefacts associated with Wilcke are identifiable in the Academy's collections.[23]

The Academy's accounts indicate that more was spent on the lectures on experimental physics once they had employed Wilcke. Several instruments were paid for, but it is not always clear if they were intended for the cabinet of physics, Stockholm Observatory, or something else. In 1759 Anders Smahl, the caretaker at the Observatory, was given a pay rise because he was to assist with the lectures. In 1760, the instrument maker Steinholz's boys were tipped for bringing an air pump to Riddarhuset, and three days later the turner was paid for glass tubes, bladders, gold leaf, and a particular oil for the machine. In 1761 the machines for the lectures were repaired.[24] Unfortunately the air pump mentioned seems to have been lost, as it was replaced in the 1780s or 1790s with one made by Johann Heinrich Hurter of London (*Fig.* 3.6). This was labelled no. 1 in the Academy's inventory of 1798, and is thus often wrongly referred to as the first instrument in the collection. In fact, the first proper demonstration instrument had been given to the Academy by one of its members, Jacob Faggot, probably in the early 1740s.[25] In this case it seems it was the function of the object and not the provenance that was relevant in the inventory. This shows how important it is to look at artefacts critically to evaluate whether the provenance given in inventories is credible, and whether items have been replaced or not.

Some identified artefacts are very small and would not be effective for a large audience seated far from the lecturer. For example, two small electric dolls, Harlequin and Columbine, fashionably clothed and brightly coloured, are only 11 centimetres tall. Their dancing floor is a brass disc, the insulating foot now missing (*Fig.* 3.7). To be able to enjoy their jerking electric dance, the viewer would need to be close to the performance.

23. Pipping 1977, pp. 84 ff.
24. RSAS, CfVH: Accounts 1759, no. 172, 8 May & 31 October; Accounts 1760, nos 229, 245–246, sec. II no. 65; Accounts 1761, nos 112, 161.
25. Pipping 1977, p. 177.

3.7 Anonymous maker, *Harlequin and Columbine as electrical dolls*, 18th century. From Johan Carl Wilcke's collection. Center for History of Science, The Royal Swedish Academy of Sciences.

In 1764 Wilcke was reimbursed for moving instruments to the Academy's house on Helgeandsholmen (the Old Bank), after which the collection had an itinerant existence for some years. In 1767 Wilcke was granted an allowance in order to rent other rooms for his lectures. In 1771 the instruments were moved to the Academy's new headquarters in Greve Pehrs Hus, and the rooms were decorated and shelves put up.[26] But soon the Academy was to move again, as a new building in Stora Nygatan was bought in 1779. In 1780 Wilcke confirmed that the Academy was in possession of a good collection, but there was no appropriate place to keep it.[27] Eventually rooms were arranged on the third floor of the Stora Nygatan house. Instruments lined the walls and the globes stood in the middle of the floor, to the extent that by the end of his life, Wilcke complained it was nothing but storage: there was hardly any space for experiments. At that point he had pursued his career in the Academy and acquired the shared post of permanent secretary; other duties had taken him away from physics. Yet even though Wilcke no longer lectured, the collection was still used; for example, in 1794 Baron von Gedda borrowed instruments to teach the young king up at Stockholm Palace.[28]

3.6 Johann Heinrich Hurter, *Air pump*, c. 1780–1790. Center for History of Science, The Royal Swedish Academy of Sciences.

26. RSAS, CfVH: Accounts 1764, no. 66; Accounts 1771, no. 265; Accounts 1772, nos 100, 146; Minutes 18 February 1767.
27. Oseen 1939, pp. 307 ff.
28. Lindroth 1967, vol. 2, pp. 364 ff.

In the 19th century the Academy moved again, this time to Drottninggatan, and then in the early 20th century it moved to its present location in Frescati on the outskirts. The instruments went too, at least those that had not been dispersed, discarded, or neglected as they fell out of fashion. In the last move, the physicist Vilhelm Carlheim-Gyllensköld recognized the historical value of the collections and started to trace the history of the objects. Much of the work of cataloguing the collections was done by Gunnar Pipping, but there is still great potential to discover new information in the extensive archives—and not least from the instruments themselves.

Collections of scientific instruments in 18th-century Sweden

There were three main cabinets of experimental philosophy in Sweden in the 18th century. The first, the focus of this chapter, was in Riddarhuset in Stockholm; and the other two were kept at the universities of Lund and Uppsala. There were also other collections which provide a frame of reference, from which the lecturers at Riddarhuset at times could borrow or trade artefacts.

University research and teaching required instruments, but many were the private property of the individual professors. As noted, Lund University had acquired Mårten Triewald's first collection. Triewald's assistant Daniel Menlös had become a lecturer in his own right, and in 1732 he was appointed professor of mathematics at Lund University—on condition that he acquire Triewald's collection of instruments at his own expense and donate it to the university. Menlös drew up an inventory of 327 items to be donated. The collection was packed into 30 boxes in Riddarhuset and then shipped south from Stockholm to Lund. It was placed in Kungshuset (just north of the cathedral) where an auditorium was constructed. Today about 70 of Triewald's original items survive; they belong to the Lund Department of Physics, but are deposited at Malmö Technology & Maritime Museum. In the inventory from 1732, the artefacts are listed with their material, design, and what the experiment demonstrated. References were made to pages and plates in books by Willem Jacob 's Gravesande, Francis Hauksbee, Christian Wolff, Christian Gottlieb Hertel, and Jacob Leupold. In only a few cases were the names of the instrument makers specified (Hauksbee, Barclay, and one Swedish instrument maker, Johan Herbst in Stockholm). The list also specified an air pump made by Otto von Guericke, which, except for a few parts exchanged in the 18th century, appears to be the original. It seems that the instrument can be traced from owner to owner from 1663.[29] A manuscript with careful drawings of the pump

29. Tandberg 1920; 1922; Larsson 1984.

and other instruments from the collection, as well as descriptions of lectures, has survived.[30]

At Uppsala, experimental physics had been promoted by Andreas Drossander, who acquired many instruments for his demonstrations at the end of the 17th century. In 1738, on the initiative of the professor of geometry Samuel Klingenstierna, the university ordered a set from London. As yet there was no permanent accommodation, so he used rooms in the university hospital. Later, in 1761, the professor of physics Samuel Duraeus bought instruments from Pieter van Musschenbroek's private estate at an auction in Leiden to extend the collection. He also moved the collection to his home. In 1788 it went to the astronomical observatory, and in 1790, under the professorship of Zacharias Nordmark, to the main university building.[31] The remaining collection is kept in the Gustavianum (Uppsala University Museum), but some instruments may still be held by other university departments.[32]

Collections of scientific instruments were also found at the observatories in Stockholm, Lund, and Uppsala, along with smaller ones such as at Skara. Even if Stockholm Observatory was originally planned to accommodate physical experiments, it should be pointed out that there is as yet no evidence that a cabinet of experimental physics was kept there; however, until Wilcke was employed in 1759, it was the duty of the astronomer at Stockholm Observatory to teach experimental physics at Riddarhuset, on account of his salary being financed by the Tham donation.

In Stockholm, the general public was allowed access to the Laboratorium Mechanicum, later renamed the Royal Cabinet of Models, that had been assembled by Christoph Polhem. It was properly a collection of models, but according to the inventory it also contained some scientific instruments. The collection was first displayed in Kungsholmen, moved to different locations, and between 1757 and 1802 was on display in the Wrangel Palace, not far from Riddarhuset. Triewald borrowed instruments and models from this collection for his teaching. Today the collection of models is preserved at the National Museum of Science and Technology in Stockholm. In the capital, physics demonstrations were also given at the Collegium Medicum and the Board of Mines.

When Wilcke argued for the acquisition of new instruments in 1761, he was articulate about defining the space allotted for a proper collection of physics

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30. UUB A 200, Daniel Menlös & Niclas Schenmark, *Collegium curiosum & experimentale*, 1743.
31. Sandström 1983–1984; Andersson 2006.
32. At present there is a project to care for and make inventories of the collections of all the departments of Uppsala University in order to get to grips with the university's collections. Eventually it will be possible to search for artefacts from all departments.

instruments. He wrote that "Astronomy lives in its costly observatories, chemistry in its well-established laboratories, botany and natural history in royal palaces and their gardens, so great that there is hardly their like, mechanics has its model-chambers, medicine is nurtured with the most tender care."[33] Only physics needed to be revitalized: not only should new instruments be bought and displayed in a suitable cabinet, but the space should also allow handling and experiments. In the same lecture, Wilcke lamented the lack of cabinets of physics for public use and teaching, and that access to good-quality instruments was too often dependent on private collectors, and that these collections were often dispersed after their owners' deaths. He took the opportunity to argue for the establishment of a new and more appropriate cabinet of physics in Stockholm, funded by a goverment body.[34]

There were royal collections, but it is not known to what degree commoners were given access. At the end of the 17th century, some instruments were on display in the Royal Library in Tre Kronor, only a few could be saved from the devastating fire in 1697.[35] The royal collections still have a few spectacular items from the sack of Prague, but scientific instruments from the royal collections are now also preserved in two different museums: Livrustkammaren (the Royal Armoury) and Nordiska Museet. In the mid-18th century, King Adolf Fredrik, who was very interested in the natural sciences and also in handicrafts, had a mathematical cabinet. After his death in 1771 the instruments were auctioned off, and 20—many of them made by Daniel Ekström—were presented to the Royal Swedish Academy of Sciences, where they are to this day.[36] Other than the royal collections, few notable private collections of scientific instruments existed before the 18th century, the best-known being the collection at Skokloster Castle. Knowledge of private 18th-century scientific collecting in Sweden is thin, however.

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In the 18th century, interest in experimental natural philosophy boomed in Sweden. This was driven by the popular lectures by Triewald and Wilcke at Riddarhuset in Stockholm, but also by teaching at Sweden's two universities, Uppsala and Lund. The lectures were part of a European trend, and while some Swedish lecturers gained knowledge and experience by travelling in Northern

33. Wilcke 1762, p. 37.
34. Wilcke 1762, p. 37.
35. Granberg 1921.
36. RSAS, CfVH: Minutes, 5 February 1772.

Europe and Britain, the many publications in the field were valuable for others who were less mobile. Wilcke claimed that demonstrations of experiments and instruments would draw larger audiences to natural philosophy. He admitted that this would not always provide the audience with profound knowledge, but it could attract the young and stimulate curiosity in those who had never thought about the subject. To awaken just ten such people to natural philosophy was for him worth more than the cost of the most precious collection of instruments.[37] With such aspirations, the teaching of natural experimental philosophy would be both pleasant and useful.

37. Wilcke 1762, pp. 33 ff.

4 Three centuries of science and culture at the Stockholm Observatory

In 1753 things were looking bright for astronomy in Sweden.[1] Stockholm, the capital, had something entirely new: an astronomical observatory. It became not only a centre of scientific research, but also a meeting place for leading cultural figures. The building is the oldest astronomical observatory in Sweden still in use, and today offers amateurs the opportunity to make observations in fine historic surroundings.

Earlier observatories

Astronomy was one of the seven liberal arts that had been taught at European universities since the Middle Ages.[2] The Church also had a long tradition, because, crucially, the dates of its high days and holidays were determined astronomically. The most famous observatory in Scandinavia in the 16th century was not associated with an institution, however; it was the work of a private person. Tycho Brahe built an impressive facility on the island of Ven, in the sound between Denmark and what is now Sweden. The main building, Uraniborg, was not only his private residence, but had towers with shuttered domes for astronomical instruments and an alchemical laboratory in the basement. It transpired that the instruments were not sufficiently steady so high up in the building, so he added Stjerneborg, a separate underground observatory. It had space for large astronomical instruments, and it was here the careful observations were made that were the basis of a new understanding of the solar system

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1. This essay was first published as 'Vetenskap och kultur på Observatoriekullen under 250 år', in Bergström & Elmqvist Söderlund 2003, pp. 37–59.
2. The seven liberal arts were rhetoric, logic, and grammar (the *trivium*), with arithmetic, astronomy, music, and geometry (the *quadrivium*).

in the 17th century. The buildings on Ven were razed shortly after Tycho left the island.

In the 1640s, Benedictus Christierni Hedraeus, an astronomer from Uppsala, studied in the Netherlands. Using what he learnt there, he described how different instruments could be used, and argued that an observatory be built in Sweden.[3] He advocated a tower, built in a high, open place—a common recommendation at the time. He started building an observatory in his own home in Uppsala, but it seems it was left unfinished at his death in 1659. Magnus Celsius and Anders Spole also built observatories adjacent to their homes in Uppsala, but these do not survive. At the new university founded in southern Sweden, Lund, Spole set up an observatory on the roof of his own house, designed so that it could open on all sides. It was finished in 1672, but the building was destroyed in the Battle of Lund four years later, after which the observatory was moved to Lundagårdshuset close to the cathedral, although it was not fully installed until the mid-18th century.[4]

In the 1730s, a new observatory was built in Svartbäcksgatan in Uppsala (*Fig.* 4.1). The building still stands, but the observation tower has been demolished. Contemporary engravings give a sense of what it would have been like. Anders Celsius was responsible, after a fact-finding mission to the main observatories in Germany, Italy, France, and Britain. The architect Carl Hårleman was engaged. Soon after Celsius' death, there were complaints about the poor observation conditions in Uppsala. The vibrations from passing traffic were causing considerable problems, nor was the horizon free, because the observatory was in the middle of the city. Thus, despite considerable efforts and the support of several prominent astronomers, there was no decent observatory in Sweden in the 1740s.

The Academy's observatory

The inaugural meeting of the Royal Swedish Academy of Sciences was held in Riddarhuset (the House of Nobility) in Stockholm in 1739 (*Fig.* 3.1, p. 48). Created to promote knowledge of mathematics, science, economics, commerce, applied science, and manufacturing, its founders were Jonas Alströmer, Anders Johan von Höpken, Sten Carl Bielke, Carl Linnaeus, Mårten Triewald, and Carl Wilhelm Cederhielm. At first it borrowed rooms in Riddarhuset for its meetings and collections (which included natural history). Its members gave scientific lectures there. However, as it grew, the Academy needed more space.[5]

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3. Hedraeus 1643.
4. Nordenmark 1959; Kristenson 1990, pp. 139 ff.
5. For the Academy, see Lindroth 1967.

4.1 Fredrik Akrel, *Anders Celsius' observatory in Uppsala*, from Johan Benedikt Busser, *Utkast till beskrifning om Upsala*, 1769.

The driving force behind the construction of an observatory in Stockholm was the astronomer Per Elvius the Younger, the Academy's permanent secretary. He secured funding by obtaining the Swedish monopoly on almanacs for the Academy, and he chose the site himself. It was significant that the Academy took it upon itself to build an observatory, instead of leaving it to one of the universities, although it was not that uncommon for academies and similar institutions to do so (as was the case with the Académie des sciences in Paris and the Sozietät der Wissenschaften in Berlin). The Academy now planned its own astronomical observatory, which would cover a wide range of other functions. In the mid-18th century, the ideal observatory was described as a building in

4.2 Jean Eric Rehn, vignette for *Kongl. Vetenskapsacademiens handlingar*, 1751.

an elevated position with a free horizon, and space for instruments and experiments. Even better if it were to have space for instrument making, meeting rooms, laboratories, a library, and scientific collections.[6]

The City of Stockholm provided the site, which offered an unobstructed view of the sky and good observation conditions. The city architect, Johan Eberhard Carlberg, designed an observatory building; however, since the Academy counted among its members the leading architect Carl Hårleman, the commission was given to him. Elvius and Hårleman were good friends. Hårleman had been the Academy's president and was interested in scientific questions. The foundation stone was laid at a ceremony on 26 May 1748. The observatory was built relatively quickly thanks to an interest-free loan from Claes Grill, a wealthy Stockholm merchant. Some of the building material (sandstone, brick, wrought iron, plaster, and timber) was obtained free of charge from the Stockholm Palace construction site, where Hårleman was working at the same time[7] (*Fig.* 4.2).

The Stockholm Observatory faced south, so that observations could be made along the meridian. On the ground floor was the observation room, a round, central hall with tall windows; an imposingly grand space intended for astronomical observations (*Fig.* 10.1, p. 160). What Hårleman designed was a temple to science. Originally, all observations were taken on the ground floor, and it was only after the Observatory was rebuilt that one of the instruments was moved up a level. Around the observation room were offices, a meridian room, a library and archive, and a natural history cabinet. The two floors above were

6. Donnelly 1973, pp. 29–30.
7. Alm 1930.

residential. Above it all was a roof lantern, topped by a gilded star. In the basement was the instrument maker Daniel Ekström's workshop and the bakehouse.

Hårleman's approach proved to be innovative to observatory architecture. In the past, the accommodation had been put at the bottom of the building and the observations were taken higher up, in a tower, which risked rendering the instruments unsteady. Hårleman did the opposite. Perhaps his experience in Uppsala and the problems there prompted a rethink. It helped that in Stockholm he did not have to take into account existing buildings on the site, and was able to construct an ideal observatory from scratch. In the later 18th century high observation towers fell out of fashion, and it is likely that the Stockholm Observatory showed the way for several observatories in other countries.

In 1752 the Stockholm Observatory was finished, but because of Hårleman's death in early 1753 its inauguration had to be postponed. Similarly, Elvius did not live to see what he had started. When the time did come for the inauguration, the Academy marked the occasion with a magnificent ceremony. Elvius' successor as secretary was Pehr Wargentin, and it was he who would be the first director of the Observatory. It might be thought that Wargentin somewhat undeservedly was given the credit for Elvius' work; however, Wargentin's efforts for the Academy would be of lasting significance, for as its permanent secretary for 34 years he shouldered a heavy workload, and thus in addition to the scientific work of the Observatory, he managed most of the Academy's business.

Sweden's calendar

It was at the Stockholm Observatory that the Swedish calendar was drawn up. The year the Observatory opened was also the year when the Gregorian calendar—the New Style calendar—was introduced in Sweden, and the country finally fell into line with the rest of Europe. It meant deleting eleven days in February from the calendar. For several centuries there had been controversy about the length of the year. The issue was that the Julian calendar, named for Julius Caesar and used since ancient times, no longer matched the solar year (otherwise known as the tropical year)—the calendar year was too long. The Julian calendar assumed that a year was 365.25 days, when a solar year is in fact approximately 365.24219 days. The uneven number of days is adjusted using leap days. In the Julian calendar a leap day is added every four years regardless, but the Gregorian calendar drops the leap days in century years not divisible by 400, which brings it very close to the solar year. The differences may seem insignificant, but in the long run the calendar year will drift out of synch with the seasons.

Protestant Sweden could not at first accept the New Style calendar, dismissing it as a Catholic invention because it was introduced by Pope Gregory XIII. Between 1740 and 1753 Sweden had its own solution, the so-called Celsian calendar. Almost all of Europe had switched to the Gregorian calendar. Denmark and the German Protestant territories had already adopted it in 1700, and Great Britain followed suit in 1752, the year before Sweden.[8]

The Academy's monopoly on almanacs—printed calendars—was as good as a prerequisite for the implementation of calendar reform, because it put a serious organization in charge of publication. Previously, there had been years when the various Swedish almanacs had not agreed on holidays, name days, gospel lessons, and market days, or had given the wrong dates for astronomical events such as solar eclipses. Wargentin was commissioned to submit the Academy's proposal on how to manage the transition to the New Style calendar. There were many factors to consider: when to celebrate religious holidays, market days, and when farmers should sow crops. Initially, both New Style and Old Style dates were often given together, or the intended style was indicated after a date. In the end, the transition in Sweden seems to have been undramatic. The almanac for 1753 recommended a transitional phase whereby any event that would have been held on an Old Style date that was cut should instead take place on the same day, but with its New Style date. The Swedish newspapers from February and March 1753 did not report anything out of the ordinary, and merely noted in passing that the change had taken place. The almanac was very popular and sold in large numbers with print runs of over 100,000 copies. The Academy took the opportunity to add educational essays, which thus were widely circulated.

The business of the Observatory

One of the reasons why a fully equipped observatory was deemed essential was the imminent transits of Venus in 1761 and 1769. These occasions saw astronomers collaborate internationally to take observations from as many sites as possible. Academies and learned societies dispatched expeditions around the world. For Sweden to organize its own observations was a sign that the country had reached a certain standard of research. At first, though, there was very little equipment at the new Stockholm Observatory. Wargentin complained in his diary that he had no observational instruments to speak of. All that was available was older equipment that had been given to the Academy. Daniel Ekström's workshop produced first-class instruments, but the orders were left incomplete

8. Nordenmark 1959, pp. 214 ff.

on his death only two years after the Observatory opened. Ekström's successors were not thought sufficiently skilled, so the Academy turned to London and the most skilled instrument makers of the day. A quadrant, bought through an agent from the instrument maker John Bird, proved the single most expensive purchase. Later, a transit instrument, or small telescope, was also ordered from the same instrument maker. As part of the preparations for the transits of Venus, the Swedish lens maker Carl Lehnberg was commissioned to grind lenses.[9]

There would be a long hiatus after the transits of Venus before any further new instruments were acquired. In 1788, when Henrik Nicander was director of the Observatory, a reflector telescope was commissioned from the outstanding maker William Herschel in England. However, a Swedish instrument maker was chosen to assemble the telescope, and delays meant it was several years before the instrument could be used.[10] In the 19th century, many users complained that the instruments were outdated. However, several of them were primarily theoretical astronomers, who worked with statistics and mathematics. Geodesy and topography were also subjects that interested the successive directors, Jöns Svanberg, Simon Anders Cronstrand, and Nils Haqvin Selander. Several geographical instruments for use by expeditions were also acquired.

The natural history collection

For the first 18 years of the Observatory's existence (1753–1771) it was home to the Academy's natural history collection (*Figs* 4.3 & 4.4, p. 72). Previously, it had been stored in Riddarhuset and scattered around members' homes, which proved problematic given that house fires were not uncommon, not to mention disputes when members died. The collection seems not to have extended to large stuffed animals, but there were gastropod and mollusc shells, minerals, butterflies, birds, and fish. Numerous exotica and ethnographica came from the East Indies and other parts of the world, and physicians sent in specimens. The Academy also received a variety of gifts, some were curios, such as lemons that had grown together, or a mummified baby. Perhaps the most bizarre item was an embalmed thumb. According to a written note, it was thought to come from a sea troll, who one night got hold of the gunwale of a farmer's boat and began to drag it down, whereupon the farmer chopped off its thumb.

One problem for the collection was pests. The correspondence between Wargentin and Linnaeus reveals that they both had the same problem with one particular type of beetle. Since the collection at that point had no particular

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9. Amelin 1999, p. 165.
10. Amelin 1999, pp. 148 ff.


4.3 & 4.4 The cabinet of natural history at the Observatory in Stockholm was reconstructed in 2006–2007 on the initiative of Inga Elmqvist Söderlund. Based on her research of inventories and other sources, the interior was designed by Anders Wirén and filled with specimens from the collections of the Royal Swedish Academy of Sciences/Center for History of Science, Stockholm University Library, The Museum of Ethnography (Stockholm), and the Swedish Museum of Natural History, where Erik Åhlander was especially helpful.

historical interest, old and damaged specimens were often replaced, which is why so few of the original animals survive. It went on to become a core collection of the Swedish Museum of Natural History, first in the Westman Palace five minutes' walk from the Observatory, and then from 1916 in Frescati on the northern outskirts of the city.[11]

Measurements and determining time

Time was a pressing concern at any observatory: astronomers had to know with certainty when their observations had been made. Wargentin's diary shows just how careful he was to set the clocks every day. He worried about how cleaning and temperature might affect the period of the pendulum in each clock, and whether the pendulums should be lengthened or shortened. A number of clocks at the Observatory were made by the Stockholm watchmakers Gustaf Nylander and Petter Ernst. In the 19th century, even more precise chronometers were ordered from Molyneux & Cope in London and Kessels in Altona, Hamburg. They had many of the recent innovations designed to ensure they were as accurate as possible.

To set a clock, one needed good measuring instruments. Bird's quadrant was used until the 1820s, by which time it was some 60 years old and it was felt that more modern instruments were needed. In the 19th century, many of the skilled optical instrument makers were based in Germany. Reichenbach and Ertel in Munich were thus approached for a new transit instrument and a meridian circle.[12] When the new meridian room in the Observatory was brought into use, the Stockholm meridian was moved 18 metres west so that it ran through the room. The room was given improved foundations so the instruments would stand steady—the old meridian room had had problems with the floor being unstable. Next to the meridian room was a clock room, furnished with new clocks and furniture. The architect Carl Christoffer Gjörwell was responsible for the refurbishment. The rooms (since restored) show that a great deal of effort went into creating an imposing setting.

Until 1878, local Stockholm time was determined at the Observatory. In 1879, however, national time was introduced—the whole country would have the same time. Now that trains were able to travel quickly from one place to another, there was a need for a single standard time for everyone. In a compromise between Stockholm and Gothenburg, Sweden's meridian was moved to midway between the cities, defined as the mean solar time of a meridian three

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11. Löwegren 1952; Törnblom 1999.
12. Pipping 1977, pp. 96–97.

degrees or 12 minutes west of the Stockholm Observatory. However, time was determined in Stockholm and time signals were telegraphed out.

Life in the Observatory

The first people to move into the Observatory were Pehr Wargentin, Daniel Ekström, and Anders Smahl the caretaker. According to the population registers, the assistants and apprentice instrument makers in Ekström's workshop also lived there, as did domestic staff—maids and a boy.[13] In 1756, Wargentin married Christina Magdalena Raab, Hårleman's niece. They had three daughters, one of whom, Christina Juliana, kept a meteorological diary which survives, just one indication of the extent to which the whole family was involved in scientific work. Internationally, there were many similar examples of wives, sisters, and daughters who joined in to work in astronomy.[14]

The Observatory was frequented by Stockholm's scientific and cultural circles. In the mid-19th century when Nils Haqvin Selander was director, there were suppers and evening gatherings most days. Jacob Berzelius, Archbishop Carl Fredrik af Wingård, and Baron Fabian Wrede were welcome guests.[15] When director Hugo Gyldén and his wife Thérése lived in the Observatory later in the century, their dinners were also popular events. Their circle included the mathematician Gösta Mittag-Leffler, the authors Viktor Rydberg and Ellen Key, the educational reformer Anna Whitlock, and the mathematician Sofya Kovalevskaya (Europe's first female professor), whose little daughter was taken in by the Gyldéns after Kovalevskaya's untimely death. Thérése was active in the suffrage movement and Hugo in public education.[16] Hugo also inspired the young Hjalmar Branting, a future prime minister of Sweden, to become an astronomer. For a while, Branting lived and worked as an assistant at the Observatory. However, he did not complete his studies, which he abandoned in order to concentrate on his political interests.[17]

This busy social life continued at the Observatory well into its new incarnation as the Department of Geography in the 20th century; it was particularly lively in Hans W:son Ahlmann's time in the 1930s and 1940s. The Observatory was a home until the 1980s, when the technician Sigvard Blom and his family moved out of the caretaker's residence on the ground floor.

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13. Stockholms stadsmuseum 1986, pp. 301 ff.
14. Famous examples are Tycho Brahe's sister Sophie, Johannes Hevelius' wife Elisabetha, and William Herschel's sister Caroline.
15. Selander & Selander 1920, pp. 51–71.
16. Scheutz 2001, pp. 261–262.
17. Meurling 1975, p. 51; Jönsson & Lindblom 1995, pp. 193, 215–216, 334 ff. I wish to thank Bertil Jansson for the information about Hjalmar Branting and the Observatory.

Public interest

Special astronomical events have always attracted crowds to the Observatory. For the transits of Venus in 1761 and 1769, Observatory Hill was packed with interested Stockholmers.

The astronomers hoped to use the results of their observations to determine the solar parallax (the distance between the earth and the sun). All astronomers in Sweden were involved. The Academy sent out instruments to all those who needed them. The Observatory Hill quickly filled up with curious visitors. There were distinguished guests—Queen Lovisa Ulrika, Crown Prince Gustav, the Council of the Realm, and foreign ambassadors. Wargentin wrote in his diary that you could hardly hear poor Dr Gadolin, who had the job of announcing the time in seconds and minutes.

Eclipses and comets were equally popular. Stockholmers were not immune to the general alarm that accompanied these dramatic events. When Donati's Comet appeared in all its glory in 1858, people gathered every night, anxious, terrified even. People crowded into the observation room to see the comet. Sven Roos, who was the caretaker mid-century, had an eye to the main chance. He realized he could turn a quick penny by arranging viewings. Interest in the comet lasted long after it had gone—so Roos took a monocular and attached some blackened glass on which he scratched a comet, and continued to show it to daytime visitors. This continued until he was found out by Professor Selander, who was the director of the Observatory at the time.[18]

It was not only astronomy that caught the public imagination. In the 18th century, spectacular public demonstrations of physical phenomena and inventions were part of science, and fuelled increasing public interest. Early in the Academy's history, one of its founders, Mårten Triewald, had given public lectures in Riddarhuset, following the example of the Royal Society in London. The House of Nobility was also largely responsible for the Tham donation to promote the education of younger sons of the aristocracy. The Academy was quick to hive off some of the funds, in return for its permanent secretary giving public lectures. Pehr Elvius the Younger gave a number of such lectures, but Wargentin does not seem to have been particularly keen to do so. Once the Observatory's debts were cleared, the Academy could instead employ its own Tham lecturer, the experimental physicist Johan Carl Wilcke. Wilcke had a collection of instruments with which to give demonstrations, a large number of which still survive in the Academy's physics collection.[19] The Observatory itself arranged demon-

18. Selander & Selander 1920, pp. 39–40.
19. Florén 1999, pp. 94 ff.; Lindroth 1967, vol. 2, pp. 456 ff.; Oseen 1939, pp. 60 ff.

4.5 Anonymous artist, *The balloon ascent at the Observatory in 1784*. Engraving. Center for History of Science, The Royal Swedish Academy of Sciences.

strations for an interested public. A balloon ascent was organized in 1784, only a year after the Montgolfier brothers in France had for the first time untied an "aerostatic machine", as it was called, and risen into the sky (*Fig.* 4.5). Among the crowds of spectators in Stockholm were Gustav III and his court. A balloon made from taffeta was filled with hydrogen generated by iron filings, water, and sulphuric acid, and a cat was placed in the basket. A rocket signal was fired and Queen Sofia Magdalena cut the cable, and the balloon rose into the sky with the cat on board. The remains of the balloon were later found on Värmdön, a large island to the east of Stockholm, but there was no sign of the cat. The event was recorded in a contemporary engraving.[20]

Renewal and conservation

By the mid-19th century, the instruments and the Observatory itself were thought hopelessly outdated. New observatories had been built in the university cities of Lund and Uppsala. In Hugo Gyldén's time, therefore, there was an extensive programme of modernization. In 1875 work began on an extension on the north side of the building, which guaranteed more space, and the observation tower made way for a modern refractor from A. Repsold & Söhne in Ham-

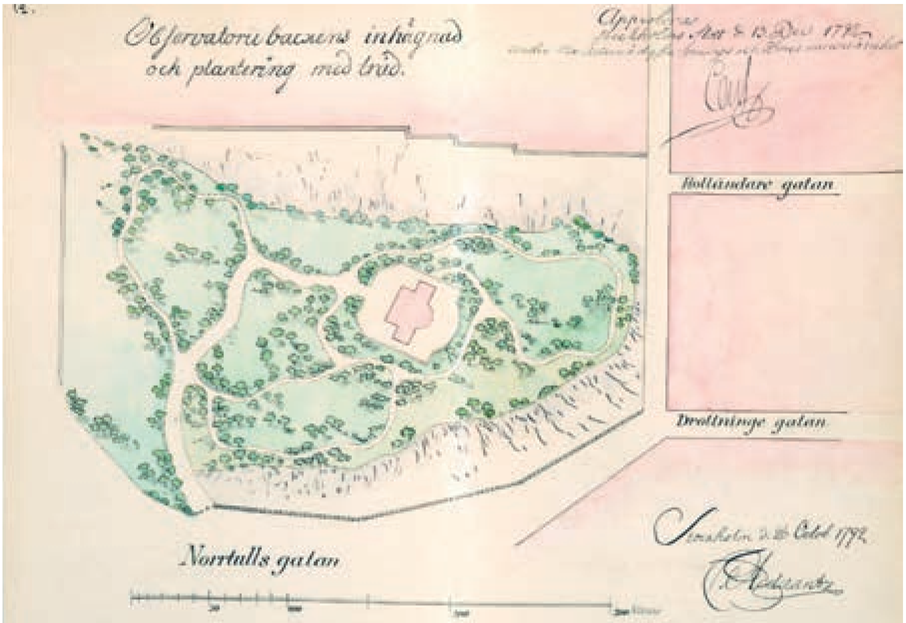
20. Lindroth 1967, vol. 2, pp. 266 ff.; Oseen 1939, p. 269.

4.6 The Observatory in 2011, Stockholm. Designed by Carl Hårleman, inaugurated in 1753; modified from 1875.

burg. This meant the removal of the 18th-century lantern and a radical change in silhouette. A pillar (later removed) was added so that the heavy instrument would stand firm. The design fell to the royal architect Johan Erik Söderlund; however, he died while work was still underway, and was replaced by his successor as royal architect, Hjalmar Gottfrid Sandels, and later by Frans Gustaf Abraham Dahl (*Fig.* 4.6).[21] Modern photographic equipment was acquired for the new instrument. For astronomers this meant long, cold nights monitoring the exposure of the photographic plates—not exactly pleasant working conditions.[22]

The last major instrument acquired in the astronomers' time was a reflecting telescope with a spectrograph made by Carl Zeiss, bought in preparation for the solar eclipse in northern Sweden in 1914, and then set up in the Observatory.

21. Alm 1930, pp. 170 ff.; Petander 2000.
22. For a description of the method, see Carlsson & Holmberg 1995.



4.7 Carl Fredrik Adelcrantz, *Design for the Observatory park*, 1790s. Pen, ink, and watercolour. Center for History of Science, The Royal Swedish Academy of Sciences.

One person who would be very important for the preservation of the scientific instruments had in fact had to leave the Observatory in Karl Bohlin's time at the turn of the 20th century—Vilhelm Carlheim-Gyllensköld. As a young man he had worked as an assistant at the Observatory, but when his former student friend Bohlin succeeded Gyldén, Carlheim-Gyllensköld lost his job. Instead he went on to found the Museum of the History of Exact Sciences, and made huge efforts to save many objects of historic significance. Ultimately the museum would never open to the public, but one of his suggested premises was the Observatory.[23] Today, the Center for History of Science is responsible for the historical objects, which comprise the foremost collection of scientific instruments in Scandinavia.

The Observatory Park

Originally, Hårleman had planned for several approaches to the Observatory. These drives were never completed, however. It is not clear what the area around the Observatory was like at first, but from surviving notes it is known, for example, that Wargentin had a herb garden. In 1767, the Academy decided to build a gazebo there.[24] Again, in the 1790s the whole of Observatory Hill was

23. Carlsson 1994.
24. Nordenmark 1939, p. 148.

refashioned to a design by Carl Fredrik Adelcrantz (*Fig.* 4.7). English parks were then all the rage, and winding park roads were constructed. These are most of the park roads that survive today. Initially, Observatory Hill was not fenced off, but the astronomers complained they were being disturbed by people enjoying themselves. Worse, people were using the hill as a gravel pit and removed sand, and the concern was that it would leave the Observatory unsteady on its foundations. Eventually, permission was given to fence in the Observatory. The park remained a popular destination for day trips, though. Queen Josephine often arrived by carriage in order to take walks. It was not until 1929 that the park was officially opened to the public.

Stockholm was growing, and observation conditions were deteriorating at the Observatory. Light and air pollution made work difficult, as did traffic vibration. Under the leadership of Bertil Lindblad, a new observatory was planned in Saltsjöbaden, south-east of Stockholm, which was inaugurated in 1931. Knut and Alice Wallenberg, the main donors, wanted the new observatory to be called the Stockholm Observatory too: a source of no little confusion since there were now two observatories with the same name. Meanwhile, the old Observatory was taken over by the University of Stockholm's geography department. Thus the building continued to be used for applied science, and with it the geodetic tradition begun by the 19th-century astronomers. In the 1930s, it was modernized so it was better suited to its new function, with the additions of features such as a lecture room. The area has been called Stockholm's Latin Quarter. Nearby were other University of Stockholm buildings, the KTH Royal Institute of Technology, the Stockholm School of Economics, the Department of Pharmacology, Stockholm City Library, and student unions.

In the 1980s, the geographers moved on to brand-new, purpose-built premises in Frescati. From the time that the astronomers had left the Observatory it had been the property of the City of Stockholm, and its property management office now decided to sell up. The plan was for the building to be converted into a mosque. Following protests by a number of committed campaigners, the Stiftelsen Observatoriekullen (the Observatory Hill Foundation) was founded, and the building was saved for the nation and turned into a museum.[25] At this point the building was owned by the Royal Swedish Academy of Sciences, and it worked on the assumption that the building would continue to be a focus for Stockholm's scientific and cultural life.[26]

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25. Helmfrid 2000.

26. In 2013 the Royal Swedish Academy of Sciences decided to close the museum for financial reasons. In 2018 the City of Stockholm took over the building with a view to reopening the museum.

II

REPRESENTATIONS

Delphinus
Aquila
PISCIS
ÆQVINOC
Cetus
CIRCVLVS
AQVARIVS
SAGITTARIUS
Piscis Aust.
Phœnix
Grus
Indus
Toucan
Hydrus
Pavo
Corona Aust.
COGNITA
Apis Indica

5 Astronomical books as works of art

WHICH FEATURES OF a book make it ideal for display, discussion, and admiration in a library or some other collection such as a Kunstkammer?[1] What features make it comparable to other works of art in those places? Illustrations are certainly essential, even if the qualities of the text alone make a book an ideal subject of admiration, rumour, and even reverence. Beauty, exquisite workmanship, execution, or exactitude can be decisive. Both conformity to and deviation from the norm, particularity or specifically remarkable qualities might be important. The frontispiece was one vehicle by which authors and printers could shape a book's identity.

The luxury of books

Before the advent of printing, books, especially illuminated ones, had been extremely expensive. It has often been remarked that the first printed books had several affinities to manuscripts, and were deliberately made to look like them.[2] In the 17th century, many more books than before flooded the market, but they were still expensive.[3] Devotional books, even if printed, were still decorated with the utmost care, as can be seen from the binding of a Swedish book of prayers which may have belonged to Queen Hedvig Eleonora (*Fig.* 5.1, p. 84).

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1. This essay is an abridged version of 'The book as a work of art: The role of the frontispiece', from Elmqvist Söderlund's doctoral thesis *Taking Possession of Astronomy: Frontispieces and Illustrated Title Pages in 17th-Century Books on Astronomy* (Royal Swedish Academy of Sciences; Stockholm, 2010), pp. 313–331.
2. Jardine 1996, pp. 137 ff.
3. Mandelbrote (2000, p. 30) notes that, over the course of the 17th century, books were regarded increasingly as household equipment, and by 1700 were no longer listed by individual title or description in inventories.

5.1 Anonymous maker, *Embroidered bookbinding* for Johannes Habermann, *Christelige böner*, 1669 (octavo). Silk, silver, gold. The National Library of Sweden, Stockholm.

The volume is covered with silk, with embroidery of flowers in several beautiful colours including gold and silver thread.[4] It is obvious from its craftsmanship that this binding was suitable for display, and may possibly have served as a fashionable female accessory. Other books were bound in velvet or leather with silver clasps, or otherwise adapted to suit the owner's tastes.

With lower prices, more people could acquire more books. Publishers, printers, and agents were able to create markets for different target groups by fashioning books for different price groups. Books now came in different sizes, with different paper quality, with or without illustrations, or with illustrations of varying quality.[5] The most luxurious books were coloured, richly illustrated, and sumptuously bound. Astronomical subjects were also represented in many of the most beautiful manuscripts. The traditional production of sumptuous astronomical books continued unabated, and there was a market demand for large, handsomely produced works. It is fair to assume that any reasonably comprehensive library would have contained some astronomy books.

The advantage of a printed book was that it promised exactly the same textual content as the template; no scribe would have distorted the text. In this sense, the reader of a printed book could be certain of having access to the same infor-

4. Rudbeck 1925, pp. 68 ff.
5. For examples of prices and how they were quoted, see Judson & Van de Velde 1977–1978, vol. 2, pp. 431 ff.

5.2 Melchior Haffner, page from Georg Hieronymus Welsch, *Commentarius in Ruzname Naurus, sive Tabulae aequinoctiales novi Persarum & Turcarum anni*, 1676.

mation as anyone else who had the same title. It now also became possible to put works on the market which had hitherto only been available in a single manuscript. Some printed books imitated the manuscript from which they were copied in appearance too. In that sense, it was not only the text that was multiplied, but also the design. One example is a *ruzname* (calendar) in Persian with comments in Ottoman Turkish, engraved by Melchior Haffner and published by Georg Hieronymus Welsch in *Commentarius in Ruzname Naurus* (1676, *Fig.* 5.2). Even so, the book lacks the particularity of the manuscript original. Hand-colouring, the quality of the paper, the choice of illustrations: they offered the possibility to customize a copy and make it more magnificent, and also more particular.[6] A personal dedication by the author, or perhaps colouring in his own hand, featured in some presentation copies. In that sense, a few owners could have a very personal volume, which no one else could have in their library. Such a volume would be particularly suitable for display in a large library. But large libraries were also expected to hold copies of standard works in an assemblage of encyclopaedic knowledge. They were expected to hold books in a variety of genres. And not only books. A library was expected to have collections of *naturalia* and man-made objects.

Where would such books be displayed? A library, *studiolo*, curiosity cabinet, or Kunstkammer would have been the ideal place.[7] There were a few particularly sumptuous library settings, for example, the library of El Escorial outside Madrid and Biblioteca Marciana in Venice. Astronomical motifs feature conspicu-

6. Lengnich 1780, p. 102 describes a copy of Hevelius 1673 that had a portrait of Louis XIV signed by the inventor Nicolas Mignard and the engraver Peter van Schuppen. Whereas all the other artists who signed illustrations in this book were connected with Danzig, these two artists cannot be tied to the place where it was printed. Lengnich assumed the copy was intended as a presentation copy for Louis XIV. None of the copies I have consulted contained this illustration, so I presume its inclusion indicates it was a non-standard edition. The portraits, probably already existing ones, were bought separately to be bound in special volumes only. This is possibly the same copy as the one held by the library of the Polish Academy of Sciences in Danzig.
7. Jardine 1996, pp. 183 ff.

ously in both libraries, making it clear that astronomy occupied a self-evident place within the library. The Salone Sansoviniano in Biblioteca Marciana, for example, was decorated by a number of the most prominent artists in Venice in the 16th and 17th centuries (*Fig.* 5.3). Its walls are lined with paintings of ancient philosophers with books and scientific instruments, not unlike the philosophers depicted in frontispieces. Its ceiling is decorated with motifs of virtues and the different disciplines. The tondo of *The Nile, Atlas, Geometry, and Astrology* (1635) was painted by Alessandro Varotari (Il Padovanino). In the middle is a woman exposing her chest and holding up an armillary sphere. Beside her is Atlas carrying the heavenly sphere, a number of putti—one of them holding a sector—and an old man, a crocodile, and a pyramid, the latter representing the Nile and the long history of astronomy. The motif addresses astronomy in a fashion similar to frontispiece imagery: the inclusion of scientific instruments, references to ancient history, nudes, female personifications, and putti. It is not unlikely that libraries such as these were expected to display books that would in some sense complement the painted motifs on their walls and ceilings.

5.4 Ghent–Bruges school in the style of Simon Bening and Gerard Horenbout, *St Luke*, *c.* 1500–1525. The National Library of Sweden, Stockholm, Ms A 227 fol. 60 v.

Many libraries had shelves for display. Libraries that had few books could store them on shelves where each volume was on display, on smaller shelves or in chests.[8] The National Library of Sweden possesses an illuminated manuscript from the early 16th century in the style of the Ghent–Bruges school that has an illustration of St Luke the Evangelist in a small scriptorium (*Fig.* 5.4). The scriptorium also holds a small library of books. Each of the books is a treasure, beautifully bound in bright colours, set out on sloped shelves. Many early libraries had only a few books, where each book was treasured: the two shelves of books

5.3 Interior view of the Gold Salon by Sansovino, Biblioteca Marciana (St Mark's Library), Venice, Italy. Architect Jacopo Sansovino, 1537–1588.

8. Adriani 1935, pp. 39 ff.

in the illustration of the great mural quadrant in Tycho Brahe's Uraniborg—in Tycho's *Astronomiae instauratae mechanica* (1598) and later reproductions—show such a scientific library (*Fig.* 5.5). Each of the books is carefully rendered in beautiful bindings and neatly placed on the shelf. The explanation accompanying the picture pointed out that this was only part of the library, but it is reasonable to assume that Tycho's library was rather limited, given that books were so very expensive. A smaller scene also shows the interior of Uraniborg, where learned men at two tables pore over books, deep in discussion. At such moments, pictures would have been a useful point of departure in scholarly debate and the reason why they were displayed. Naturally, though, there were larger collections, and collections that were more general in character. The interior of the library of Duke August the Younger of Brunswick-Lüneburg, engraved by Conrad Buno in 1650, shows a larger library with shelves along the walls, as was becoming increasingly usual in the 17th century when books were available in larger numbers. The library has tables for reading and display as well as the customary globes (*Fig.* 2.6, p. 45).

Both inventory lists and paintings testify that books were included in Kunstkammer. The inventory of the Kunstkammer of Rudolf II from 1607–1611 lists several chests of books, some of them astronomical.[9] There are also examples of paintings and drawings depicting Kunstkammer where books with illustrations are admired together with other objects of art: paintings, sculptures, coins, antiquities, *naturalia*, rarities, and exotic objects together with scientific instruments.[10] One example is the painting by Willem van Haecht, *De kunstkamer van Cornelis van der Geest* (*The Picture Gallery of Cornelis van der Geest*, *Fig.* 5.6, p. 90).[11] It shows a magnificent cabinet, or room, crammed with paintings and full of admiring visitors conversing in small groups, the most prominent being Archduke Albert and Archduchess Isabella. The objects on display include scientific instruments as well as books and engravings. The kind of books which would have had a natural place in such a cabinet would be collections of en-

9. Bauer & Haupt 1976, pp. 130 ff. Together with manuscripts and drawings, the inventory also mentions some printed astronomical books, for example, no. 2610 'Joan Anthonii Magini tabule primi mobilis, in rot leder, vergultt'; no. 2629 'Astronomia Joan Baveri'; and no. 2717 'Drei bücher, die 2 geschrieben von der hand, das dritte gedruckht, Auth: Tichonis Brahe, sein alle drey in gulden stuckh gebuden mit seiden nestell und guldenen stefften'. Note that any special binding was listed.

10. Other examples are Frans Francken the Younger, *A Picture Gallery* (*c.* 1620–1630), The Royal Collection, Her Majesty Queen Elizabeth II; Jan Brueghel the Elder & Hieronymus II Francken, *The Archdukes Albert and Isabella Visiting the Collection of Pierre Roose* (*c.* 1621–1623), Walters Art Museum, Baltimore, Acc. no. 37.2010; and attributed to Hieronymus Francken II, *Cabinet d'amateur* (1621), Musées royaux des Beaux-Arts de Belgique, no. 2620.

11. Rubenshuis, Antwerp. See Muller 2004, pp. 63 ff.

5.5 Willem Blaeu after Tycho Brahe, *The mural quadrant at Uraniborg on Hven*, from Joan Blaeu, *Atlas maior*, part 1, 1662.

5.6 Willem van Haecht, *The Picture Gallery of Cornelis van der Geest*, 1628. Oil on panel, 99 × 129,5 cm. Rubenshuis, Antwerp, inv. no. RH.S. 171.

gravings rather than "scientific" books, which were more likely to be placed in a library. In this painting, there is however a group of men busy with a globe in the bottom right-hand corner: one man holds a pair of compasses and seems to be measuring a distance on the globe, while the others look on and gesture as if discussing some issue related to the globe. In front of them several brass instruments have been laid out on the floor along with a book. This suggests that the use of books in conjunction with instruments was expected in a Kunstkammer. Displayed in such a setting, a picture could usefully serve as a prompt for learned disquisition. The frontispiece of a book, together with its other illustrations, would also work very well in this situation.

Quite a few astronomical frontispieces and illustrated title pages themselves also testify to the use of books and illustrations in a discussion.[12] In the frontispiece of Jacob Bartsch's *Planisphaerium stellatum* (1661), a conversation is taking place, not in a Kunstkammer but at a table placed outdoors (*Fig.* 5.7). It depicts a group of men, among them the artist Albrecht Dürer easily identifiable to

5.7 Mathias van Somer, frontispiece from Jacob Bartsch, *Planisphaerium stellatum*, 1661.

12. Kepler 1969; Hevelius 1673.

the left. He is one of the great men of Nuremburg, which is also depicted in the background. In the book the great men of Nuremburg are also presented together with astronomical matters. They seem to be involved in a conversation about objects and books placed on and below the table. That astronomical books could also be part of such a conversation is made apparent from the open book next to the armillary sphere in the left foreground. The open page of the book shows diagrams reminiscent of a book on astronomy. The place where books on astronomy would be displayed, discussed, and used was obviously not only the sumptuous library or Kunstkammer of princes, but also in more modest collections, observatories, and private houses. There it could be appropriate to discuss astronomical matters together with the other arts.

In the *Historische Bilder-Bibel* of 1702 by Johann Ulrich Kraus, the immense riches of the imagined Nebuchadnezzar's palace include interiors with astronomical instruments and books (*Fig.* 5.8). The central scene is inscribed within a graduated circle with a handle, which looks like the rim of an astrolabe. The scene itself shows the king on his throne in the background, astronomers in discussion in the foreground with instruments, and in front of them an open book of illustrations of a wind-rose and a planetary system, while on the wall hangs a chart of the constellations. These objects are here associated with both the astronomers and the monarch, suggesting that the objects were used together. Instruments and illustrations are placed in a scene where a learned discussion is taking place. I would argue that the picture is an idealized Kunstkammer, complete with typical objects and activities. Here, books and illustrations often seem to form the backdrop as well as a necessary accessory for learned scientific activity.

5.8 Johann Ulrich Kraus, possibly with the co-operation of Johanna Sibylla Kraus (née Kuesel) and Maria Phillipina Kuesel, *The palace of Nebuchadnezzar*, from *Historische Bilder-Bibel*, 1702.

Even where scientific instruments and books were presented alongside other kinds of works of art and nature in depictions of Kunstkammer, there were some who wished to single out the "scientific" objects and their particularities. In his treatise on Kunstkammer, Gabriel Kaltemarckt stated that scientific and other instruments should be separated from the art collection: "Since these are not themselves pieces of art but only the means

5.9 Niccolò Tornioli, *The Astronomers*, *c.* 1640. Oil on canvas, 148 × 218 cm. Galleria Spada, Rome, inv. no. 267.

for producing them, they ought to be allocated special places among the liberal arts near the library."[13] This begs the question of what Kaltemarckt and his contemporaries considered to be "pieces of art", as opposed to the "liberal arts".[14] It is notable that he wanted the art to be close to the library and the books. Some extensive collections had a special room for mathematical devices, as was the case in the Stanzino delle Matematiche (sometimes the Stanza dell'Architettura militare) in the Uffizi at the end of the 16th century, or later in the Kunstkammer

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13. Gutfleisch & Menzhausen 1989, p. 31 (trans. Gutfleisch); cf. above chapter 2.

14. Gutfleisch & Menzhausen (1989, p. 6) write that scientific instruments are grouped by Kaltemarckt together with tools and the applied arts. Kaltemarckt categorized them with the more traditional tools of the applied arts (as would be expected of sculptors' chisels or woodturners' lathes), but he also wrote that they should be placed with the liberal arts close to the library, which seems to indicate not only the practical but also the intellectual activities associated with the instruments. Kaltemarckt's main concern seems to be what we would label "the fine arts", preferably works by named painters, sculptors, and engravers, but he acknowledges other types of objects within this kind of collection (Gutfleisch & Menzhausen 1989, p. 11). His wish to move the tools and scientific instruments may have been a criticism of the thousands of objects of this kind in the then-collection in Dresden. The tools Kaltemarckt referred to could be exquisitely decorated with intarsia, ivory, or precious metals. I wish to thank Michael Korey for pointing this out to me.

in the Royal Palace in Copenhagen, as specified in an inventory of 1674.[15] Like other mirabilia in those collections, a few scientific instruments were depicted and thought to merit lengthy descriptions. These kinds of objects were both part of the context of the Kunstkammer, but nevertheless particular by dint of being mathematical or astronomical (or both). The distinction between our current concepts of "technical" or "scientific" and "work of art" obviously did not apply.[16]

In the foreword to *Sidereus nuncius*, Galilei compared the works of the astronomer to monuments such as statues, columns, pyramids, and even cities:

> images sculpted in marble or cast in bronze are passed down for the memory of posterity; because of this, statues, pedestrian as well as equestrian, are erected; because of this, too, the cost of columns and pyramids, as the poet says, rises to the stars; and because of this, finally, cities are built distinguished by the names of those who grateful posterity thought should be commended to eternity. For such is the condition of the human mind that unless continuously struck by images of things rushing into it from the outside, all memories easily escape from it.[17]

Yet Galilei continued by asserting that these kinds of monuments tend to decay under the effect of time, and that the dedication to the stars of Jupiter is a superior act, as the stars cannot be worn down by time. He placed astronomical discoveries in the same class of courtly gifts as works of art or poetry.

A scene with astronomers, books, and instruments is depicted in Niccolò Tornioli's *The Astronomers* (*c.* 1640) in the Galleria Spada in Rome (*Fig.* 5.9, p. 93). It was a bequest by Virgilio Spada, an important collector who was interested in the arts and sciences. The scene is of a gathering of men of various ages in agitated discussion around Urania, the muse of astronomy. The men may well be specific ancient philosophers, but to the right is a young man in contemporary dress. He is guided by Urania with a set square and a pair of compasses to observe the celestial globe with a telescope. Instead of looking up at the sky, as would be usual for astronomical observations with a telescope, he is looking down at a celestial globe. This is an idealization of how astronomical objects in a Kunstkammer collection could be used—to inspire argument, to teach the young—but here with a mixture of figures of contemporaneity, history, and fiction. The books with their ideal scenes seem to have come to life.

Star atlases were the prime examples of books which were pleasing to the eye and useful for astronomers. Their star charts were often printed in the larg-

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15. Available at http://www.kunstkammer.dk.
16. The difficulty of using such understandings of these concepts is discussed by Valter 2004.
17. Galilei 1989, fol. 2r.

5.10 Frederik Hendrik van den Hove, frontispiece from Andreas Cellarius, *Harmonia macrocosmica*, 1660.

est possible formats and in exquisite detail, perfect for display and learned digressions alike. The National Library in Stockholm possesses an extremely fine hand-coloured copy of Andreas Cellarius' *Harmonia macrocosmica* (1660, *Fig.* 5.10, p. 95). The book is large and contains 29 plates, each done with exceptional skill, depicting the constellations and various astronomical theories. But they also depict idealized gardens and ancient cities, populated by famous historical figures or stereotypes in exotic and exuberant garments or mythological guise, learned female personifications, some with bared bosoms, and frolicking putti. The frontispiece is a parallel to Tornioli's painting (*Fig.* 5.9, p. 93) with its inclusion of scientific instruments and books, and its juxtaposition of Urania and ancient philosophers with contemporary figures. The author is present in the background, indicating his heliocentric theory with a long pointer.[18] In this, like so many pictures, all is learned, pleasant, and pleasing, with expensive books and scientific instruments.

5.11 Francesco Stringa, detail of frontispiece from Cornelio Malvasia, *Ephemerides novissimae motuum coelestium*, 1662.

Other books with profuse illustrations such as Hevelius' *Machinae coelestis* (1673) could offer a virtual tour of an ideal observatory, open for dreams of unlimited consumption. Hevelius not only produced and traded in books, he was also an instrument maker and dealer. It is even possible that prospective customers used his books and their illustrations to consider what to order from him. His books could in that sense be seen as a marketing ploy. It is unusual to find as many illustrations as in Hevelius' books: often the frontispiece or title page provided a volume's only illustration. Even such illustrations could be very beautiful and would have worked in a display situation. Some of the smaller books have fold-out plates of important astronomical events, especially comets. Here the illustrations had the function of documenting a specific event, perhaps a spectacular one, which had been witnessed and was thought worthy of remembrance. In a smaller library this image together with the frontispiece would have served well on display.

18. van Gent 2006; for Copernicanism in the Dutch Republic, see Vermij 2002.

Finally, concerning the design of the frontispieces themselves, there is evidence in the way their motifs are framed just like pictures that they should be seen as parallels to paintings. Take Francesco Stringa's frontispiece (*Fig.* 5.11) for Cornelio Malvasia's *Ephemerides* (1662): the central motif, a woman painting while observing the planet Jupiter, is surrounded by a frame as if it were a picture hanging on a gallery wall. Another common design is an architectural structure that makes the motif into a monument, such as Matthias Scheits's title page for Lubieniecki's *Theatrum cometicum* (1667).

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Marc Fumaroli writes about the design of 16th- and 17th-century books as beautiful objects of literary and artistic value. In his description, a book is something that contains precious or even sacred "objects" to be treasured. He compares opening a book and going through the first few pages to entering an imposing building, the design and art of which is meant to evoke a feeling of awe and expectation in the spectator. The frontispiece is the threshold to this ephemeral architectural structure, offering a glimpse of the book beyond; or it is the proscenium arch in a theatre, the curtain raised to reveal the content.[19] Fumaroli points out the affinities that this book design has with an epitaph, and with pictures used in religious processions.[20] As I have shown, not all frontispieces are inscribed within an architectural frame or show pictures within pictures, and motifs can be presented plainly in a square, delineated frame without any ornamentation. In such cases, the sheer beauty of the execution or other qualities such as the motif or the outstanding story attached to it make it eye-catching as well as an intellectual challenge. Frontispieces could arguably be collectable in their own right.[21] They should certainly be considered a distinct genre, even as they share several properties with other arts of the 17th century.

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19. Fumaroli 1998; see also Elmqvist Söderlund 2010, illustrations 43, 46, 76, 77, 78, 79, 87, 110.
20. Fumaroli 1998, pp. 421–422.
21. Corbett & Lightbown 1979, p. 2; Remmert 2005.


TABULÆ
RUDOLPHI
ASTRONO-
MICÆ
COPER-
NICUS.
TYCHO
BRAHE.
HIPP.
ARCH
ÆVS.
PTOLE
MÆVS.
MYSTER.COSMO.
ASTR.P.OPTICA
COM.MARTIS.

6 The display of scientific instruments in astronomical frontispieces

This chapter explores how the illustrations in 17th-century astronomical books address consumption.[1] It asks how scientific instruments were displayed in frontispieces and illustrated title pages. Any illustrations on the first pages of a book existed to advertise the contents. This was where authors and printers could communicate to the readers why they should buy, read, and continue to use the book. I am particularly interested in the settings in which instruments were displayed, in the human actions with which they were connected, and in how these images were referred to in the text, particularly as concerns consumption.

Frontispieces and illustrated title pages

Having studied the motifs of a great number of 17th-century astronomical frontispieces and illustrated title pages that were designed specifically for their volumes, I have analysed 291 motifs comprising astronomy in a wider sense. Second to astronomical phenomena, scientific instruments were the most common theme of the books in my sample—62 per cent had one or several astronomical instruments. Narrow that to only books that have a frontispiece or illustrated title page where the illustration has a more prominent role (occupying a whole page), and the proportion of illustrations that include instruments is as high as 86 per cent.[2] Besides instruments, the other main consumer product on display is books. Scientific instruments as such seem to have been a specific attribute of astronomy. Astronomical instruments, meanwhile, could also be used to sig-

1. This essay was first published in Ackermann *et al.* 2014, pp. 199–215.
2. Elmqvist Söderlund 2010, p. 122.

nify the mathematical sciences in general, a fact borne out by contemporary theoretical works. For example, in a book on the theory of emblems, the Jesuit Claude-François Menestrier advised that the appropriate attributes for depicting mathematics were globes, spheres, astrolabes, proportional circles, and telescopes.[3] That was general advice for those who wanted to invent emblems, but in the case of most astronomical books, the instruments depicted are specific to the content of the text.

Scientific instruments and books were often sold together in shops or by the same agents. Many authors of astronomical books were also suppliers of instruments. The books provided an opportunity to market instruments, and even those that were only imagined and not yet actually constructed. As noted above, instruments and books were often collected, displayed, and used at the same sites, such as in the library or the Kunstkammer. This strong relationship between books and scientific instruments was also visualized in the many printer's emblems that depict scientific instruments (armillary spheres, compasses, globes, etc.). One such famous emblem was the one used in a number of variations by the Blaeu family of printers and mapmakers (*Fig.* 6.1). It depicts an armillary sphere, with a personification of Saturn or Time to the left, with his scythe and hour glass, and to the right Hercules slaying the Hydra with a club—both obvious references to antiquity. Below the text the phrase *Indefessus agendo* (indefatigable action) alludes to industriousness. This well-known printer's mark communicated to readers that this was a book made by an established printing house, and advertised a certain recognizable quality. As this particular emblem was used for a number of titles, it was not a comment on anything specific to the book. This use of distinctive images was not unlike the modern branding of consumer goods.

6.1 Joan Blaeu's printer's emblem, from Joan Blaeu, *Atlas maior*, vol. 1, 1667 (French edition).

3. Menestrier 1662, p. 68.

6.2 Johann Georg Waldreich after Johann Heinrich Schoenfeld, frontispiece from Georg Hieronymus Welsch, *Commentarius in Ruzname Naurus sive tabulae aequinoctiales novi Persarum & Turcarum anni*, 1676.

Some frontispieces that were individually designed use similar motifs. A central armillary sphere with a man on each side forms the frontispiece of Georg Welsch's *Commentarius in Ruzname Naurus* (*Fig.* 6.2).[4] In this case the Oriental dress and other details allude to the Persian and Ottoman texts published and commented on by Welsch in the book. The inscriptions on the pedestal are accordingly in Persian and Ottoman Turkish. The conspicuous central position of the armillary sphere and its elevation on a pedestal stresses the preciousness and singularity of the artefact. The reader's attention is directed to the armillary sphere by a number of pointers in the image. From above, the hand of God indicates where the reader should look. The lines of the design guide the eye: the pointer of the man on the left forms a line leading to the armillary sphere; the man on the right the same, and his gaze too. The man on the left holds a globe, his pointer thus indicating not only the armillary sphere, but also the passing of time by indicating one of the signs of the Zodiac (Aries) on his globe; the man on the right is taking the altitude with a quadrant. The three types of instruments—the armillary sphere, the globe, and the quadrant—were not only needed for chronology, they were coveted collectors' items, here with allusions to their exoticism, which was something especially appreciated by collectors. There are numerous examples of frontispieces that show instruments being admired or venerated, placed high on a pedestal, garlanded with flowers, or encircled by putti. The sites where the instruments were placed were often rooms with a great many other artefacts indicating a larger collection, possibly a library or study, and sometimes outside, a balcony or a garden being a suitable site to stage instruments in order to display the refined taste and education of the owner.

Conspicuous consumption

The commercial aspects of early modern collecting and science seems to be a fruitful perspective, and a number of researchers have pursued the questions of commerce and consumption in the studies of material culture. Lisa Jardine

4. Welsch 1676.

has charted the consumption of both physical goods and knowledge in Renaissance Europe.[5] For a somewhat later period, relevant here, Linda Levy Peck has investigated consumption and the demand for luxury goods in 17th-century England. She highlights a number of fields of consumption, such as personal accessories, textiles, and paintings, making the point that both scientific knowledge and scientific artefacts were in demand as part of conspicuous consumption.[6] The collecting of scientific artefacts was generally a field for men, but as a recent study shows, it could be pursued as a princely virtue by women too.[7] Adam Mosley shows in his study of Tycho Brahe and his network that commercial factors were relevant to astronomers in late 16th-century Europe.[8] It appears that knowledge, scientific artefacts, and books, at least at the higher end, were intended for a European rather that a local audience. This was particularly the case for books published in Latin. Giles Mandelbrote identifies a few groups of consumers of books, scientific instruments, and natural curiosities in Europe, noting that it was not only the learned who bought these things, but also interested amateurs and scientific virtuosi, who used them to self-fashion and present themselves to others.[9]

6.3 Adriaen van de Venne (attr.), title page from Philips van Lansbergen, *In quadrantem tum astronomicum tum geometricum nec non in astrolabium introductio*, 1635.

If we accept that commercial interests were as relevant to the production of knowledge as to scientific artefacts, it is not unreasonable to expect to find evidence of this in the various media. One available means is book illustrations, where products could be staged in ways to promote consumption. Thus the illustrated title page of Philips van Lansbergen's *In quadrantem* shows instruments as fashionable accessories (*Fig.* 6.3).[10] Two young men are depicted using

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5. Jardine 1996.
6. Peck 2005, pp. 311–345.
7. Skogh 2013, pp. 225 ff.
8. Mosley 2007, pp. 209–288.
9. Mandelbrote 2000, p. 336.
10. van Lansbergen 1635.

quadrants knowledgeably. The one in front is taking the altitude of the sun, and the man behind is measuring the Lange Jan church tower in Middelburg in the background. The man in front seems to be showing off his fashionable clothes, with his plumed hat, ribboned shoe, and knee roses positioned so they are shown off to best advantage. Further instruments are depicted: a quadrant is set on the ground and an astrolabe is depicted in the top left-hand corner. In common with modern advertisements or product placements, the two instruments are shown in such a way that their identifying features are clearly visible. Indeed, in order to do so the perspective of the quadrant on the ground has been distorted, and it appears to be depicted from a very odd angle so it can be seen from the side. Here objects are no longer impersonal commodities; they are staged to feature at a particular moment in an ideal man's life. The image shows how, with the right possessions, practical astronomy could be done elegantly. Astronomy is depicted as a delightful pastime, as conspicuous leisure, in the tradition of the liberal arts, when they were the leisure pursuits of those free from the need to do physical labour in order to survive. The quadrant and astrolabe are here presented as the means with which the user could fashion himself, displaying his learning and taste with appropriate attributes and actions.

The concept of conspicuous consumption was coined by the economist Thorstein Veblen in his 1899 book *Theory of the Leisure Class*. He pursued the relationship between consumption and the definition of social identity and hierarchy. The book was a product of its time, and Veblen used theories of social evolution which now feel outdated, but nevertheless he was on to something that is still current as a grid of interpretation: consumption and its relationship to social identity. Veblen suggested that actions carry significant social meaning, in that conspicuous consumption gratifies the consumer with a symbolic gain.[11] The concepts of "conspicuous consumption" and "conspicuous leisure" have since inspired numerous important studies.

The extent to which it is possible to shape your own identity and to which it is given is an open question. In an anthropological sense, identity is partly given —that is, inherent—and partly defined by outer circumstances. In repeating certain behaviours, repeatedly showing yourself from the same side, it is possible to enforce your identity and to become more like your ideal (or desired) self. This is the differentiated identity: the identity that is less stable, which can be acquired. To own a certain style can be experienced as positive, to have good knowledge about yourself, to be consistent. Shaping your own identity can comprise everything from how you express yourself, your clothes, hairstyle, and the objects

11. Veblen 1899, pp. 68 ff.

you acquire, but also the acquisition of knowledge. Pierre Bourdieu believed that the tastes that influence such consumption are socially conditioned, and can be used as strategies to display belonging to or separation from various social groups and classes.[12] Stephen Greenblatt uses the term "self-fashioning" in his study of 16th-century England through its literary works, where he sees human identity as the result of both social and individual shaping.[13] The particular role of artefacts was further explored in his book *Marvelous Possessions*.[14]

It is not reasonable to address consumption without mentioning expenditure. The acquisition of artefacts was linked to financial wealth and power. Artefacts could be produced by the transformation of materials, by being bought, exchanged, presented as gifts, inherited, or taken as spoils of war; and in whatever form they were acquired, they represented monetary value. Many scientific instruments were expensive, particularly if beautifully crafted or if made from precious materials. Cheaper versions could be produced by printing templates on paper, where the buyer himself could colour, cut out, and paste the sheet onto a piece of wood. Prices varied over time. Telescopes were very expensive at the beginning of the 17th century, but they gradually became cheaper. In Augsburg around 1650 a large telescope cost about as much as two good horses.[15]

A few frontispieces depict literal monetary value in the shape of coins. A treasure chest filled with coins can be seen in the frontispiece of Mario Bettini's *Aerarium philosophiae mathematicae* (1648, *Fig.* 6.4).[16] In the illustration, a young, well-dressed man has removed his hat, slightly bowed his head, and is gesturing towards a chest filled with coins. In front of the chest stands an elderly Jesuit, one hand pointing to the mathematical garden and the palace's wonders behind, the other hand gesturing towards the chest of coins as if collecting payment. As part of the architectural backdrop on the left there are mathematical sculptures in female form, carrying a number of instruments and models. The sculpture at the front left is carrying lenses, through which rays of light are refracted. In the loggia and the garden a number of young men seem to be enjoying the mathematical entertainments, making and discussing instruments, accompanied by music. The garden is a place of beauty and intellectual challenge where the men can view, make, use, and discuss instruments in a leisurely and pleasant fashion. It presents an ideal place for intellectual exchange and the enjoyment of conspicuous leisure.

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12. Bourdieu 1984, pp. xxiv–xxx.
13. Greenblatt 1980.
14. Greenblatt 1991.
15. Keil 2003, p. 94.
16. Bettini 1648.

6.4 Franceso Curti, frontispiece from Mario Bettini, *Aerarium philosophiae mathematicae*, 1648.

6.5 Georg Celer, frontispiece from Johannes Kepler, *Tabulae Rudolphinae*, 1627. See also page 98.

The famous frontispiece of Kepler's *Tabulae Rudolphinae* (1627) has the Habsburg eagle scattering coins over a temple to astronomy (*Fig.* 6.5).[17] The eagle is seen hovering over the temple with a coin in its beak, and coins are raining down over the legendary men disputing astronomy: Ptolemy, Hipparchus, Tycho Brahe, Copernicus, an unnamed Babylonian astronomer, Aratus, invisible behind a column, Kepler, seated at a desk to the left, and the printers to the right. The central argument is between Tycho and Copernicus on the geoheliocentric and heliocentric models. The frontispiece is accompanied by a long poem in hexameter, the *Idyllion*, inserted after the title page, written by the Latinist Johannes Hebenstreit. The poem permits us to decipher some of the enigmatic features of the image. I will not refer to all its details as this has already been done elsewhere;[18] here it will suffice to highlight the instruments as they are presented in a conspicuous display.[19] On top of the temple a number

17. Kepler 1969.
18. See the discussion of the frontispiece in chapter 7, p. 122.
19. Hammer 1969, pp. 22*–27*; Arnulf 2000–2001; Gattei 2009; Elmqvist Söderlund 2010, pp. 209–211.

of goddesses, Urania and her servants, are carrying instruments as attributes. To the left, instead of the Sun, the head of the goddess Physica Lucis emanates rays, and she grasps at a sphere which can demonstrate the principles of the spherical Moon. Next is Optica, holding a telescope, presented as superior to anything that antiquity could produce. To her right is Logarithmica with two rods, one double the length of the other. To her right is Doctrina Triangulorum with a set square and a pair of compasses; further to the right, Stathmica holds a balance. The goddess furthest to the right is Magnetica, with a lodestone and magnetic needle. Below in the temple, its architecture denoting the progression of astronomy, are a number of instruments on display: an armillary sphere, a celestial globe, a cross-staff, parallactic rulers, a quadrant, a sextant, an astrolabe, and a dial for the Metonic cycle. The instruments are generally displayed next to the astronomer who used that kind of instrument, except for the Babylonian astronomer, who does not have access to any instruments except his fingers with which he takes the altitude. The image is a mixture of modern, ancient, and exotic. It shows what instruments would be proper to collect, and what subjects would be fitting to converse about. The *Idyllion* mentions the instruments several times, especially those associated with Tycho Brahe, directing attention to how the instruments are displayed. "Do you see how Tycho's instruments, cast from golden metal, shine as eternal monuments?"[20] Famous throughout Europe, not least because of the descriptions and illustrations in Tycho's *Astronomiae instauratae mechanica*, they were admired for their scientific value, their beauty and, not least, their cost.[21]

Johannes Hevelius used Tycho's book on instruments as a model for his own *Machinae coelestis*. Filled with descriptions and attractive illustrations of various types of instruments, in the introduction Hevelius wrote that the student of astronomy should not be deterred by "fear of the expense".[22] Not everyone could build and equip an observatory; the costs required a prince, a great patron, who could support the endeavour.[23] Hevelius was himself very successful in attracting a great deal of support from patrons. And certainly, exclusive books of this kind, dedicated to princes, situated astronomy as a princely pursuit, as was shown in both the texts and the illustrations. Needless to say, books were an excellent opportunity to market the knowledge, services, and products that an astronomer could supply to prospective clients.

A great number of frontispieces depict imaginary spaces, as in Kepler's tem-

20. Kepler 1627, quotation from Kepler 1969, p. 17; see also Elmqvist Söderlund 2010, p. 371.
21. Brahe 1598.
22. Hevelius 1673, p. 22; for a translation by Peter Sjökvist, see Elmqvist Söderlund 2010, p. 376.
23. Hevelius 1673, p. 419.

ple to astronomy. The illustrations show worlds that are idealized, spaces for dreams, myth, imagination, grandeur, and the exotic. These concepts have been linked to modern mass consumption. In advertisements and the display of merchandise, dream worlds can be created. The mythical land of plenty is created in the consumer's mind.[24] Advertisers try to create a medium with which to make a link, a mental association, between the consumer goods and romance. Colin Campbell identifies values that are often alluded to in modern advertising as "remote from everyday experience, 'imaginative', or suggestive of 'grandeur' or 'passion'", and that "the pictures and stories used are often typically 'romantic' in the broader sense of being exotic, imaginative, idealized; whilst the very purpose of advertisements, of course, is to induce us to buy the products which are featured: in other words to consume."[25] I would argue that it is these concepts, found in modern consumer advertising, which also appeared in frontispieces in relation to scientific instruments. There is however one major difference, which is valid for a significant proportion of the frontispieces—the amount of time and effort expected of the reader in order to make sense of the visual programme. Many frontispieces require engaged, intense, and prolonged consideration, which is very different to the superficial gaze presupposed by modern product placement.

6.6 Jeremias Falck after Adolf Boy, frontispiece from Johannes Hevelius, *Machinae coelestis pars prior*, vol. 1, 1673.

Enigmatic emblems and images replete with associations to ancient learning were widely fashionable in the 17th century. In an astronomical context they identified books as thoroughly erudite. Compared to any other illustrations, frontispieces tend to contain more abstract concepts. Most illustrations are not signed, and often the artists remain unknown. Often a team would be involved, with the more famous artist designing the frontispiece and the illustrations accompanying the text left to the rest. Hevelius' *Machinae coelestis* is a case in point. The artist Adolf Boy and the engraver Jeremias Falck were commissioned for the frontispiece (*Fig.* 6.6). The other artists who signed the numerous

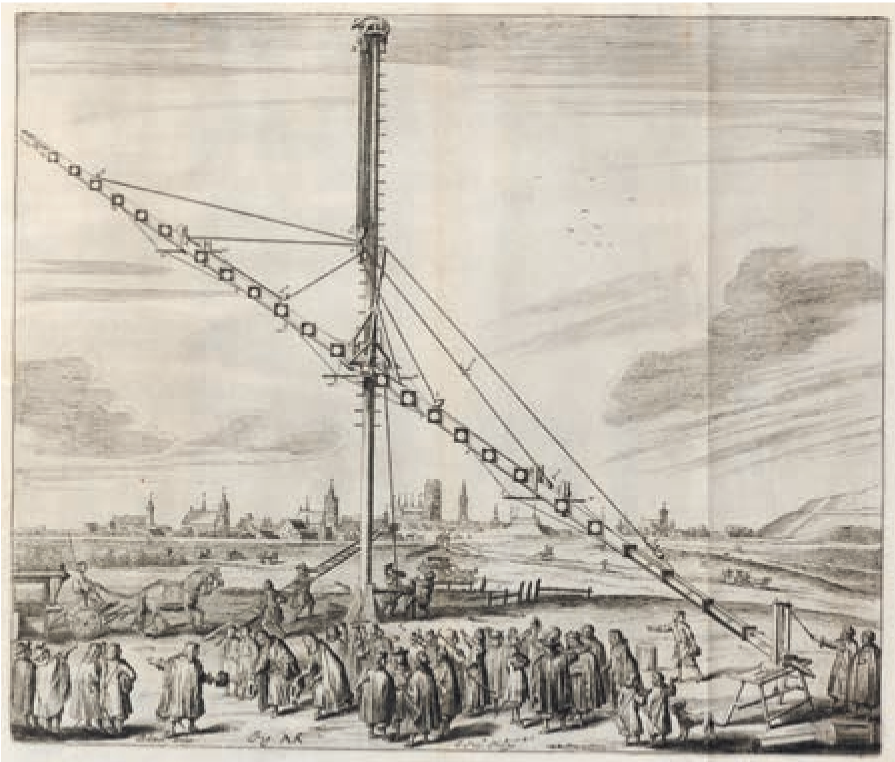
24. Williams 1982, pp. 211–384.
25. Campbell 1987, pp. 1–2.

illustrations were all accomplished, but less famous and skilled than Boy and Falck. Boy combined emblems, allegories, and realistic depictions of scientific instruments in a visually coherent expression of the learned text; Falck had the expertise necessary to do justice to Boy's complicated design. The frontispiece was explained in the foreword, noting many of the details which have profound meanings for the contents of the book, and the ideal qualities of the astronomer, which presupposes a thoughtful reader.[26] For example, each detail on the obelisk is explained, beginning, "The first emblem, going upwards, shows the skull of a man, with the inscription *Acutissimo* [with very sharp head] as if to say: a true astronomer should have a very bright intellect and a very sublime mind, in order to discern abstruse circumstances without difficulty, to explore them completely, and to penetrate them."[27] The physical and mental qualities of the astronomer are described, along with the attributes of an armillary sphere, a sextant, a celestial globe, and the books on display. The astronomers (Hipparchus, Ptolemy, Copernicus, and Tycho) are shown as actors on a stage. In fact, a Roman theatre is shown in the background. The theatrical impression is strengthened by the carriage descending from on high with the personifications at the astronomer's disposal. The message is quite clear: instruments and books are necessary for a proper astronomer, and knowledge is necessary in order to participate in a learned conversation.

This use of emblems and hieroglyphs with profound meanings is often specific to the frontispiece. Other illustrations could have a more decorative or explanatory function. One of the vignettes which adorns the dedication to Louis XIV in *Machinae coelestis* is more ornamental (*Fig.* 6.7). An assemblage of instru-

6.7 Johann Bensheimer after Andreas Stech, vignette from Johannes Hevelius, *Machinae coelestis pars prior*, vol. 1, 1673.

26. See Elmqvist Söderlund 2010, pp. 156, 177 ff., 293 ff., 301 ff., 376 ff.
27. Hevelius 1673, p. 21; for a translation by Peter Sjökvist, see Elmqvist Söderlund 2010, p. 376.



6.8 Isaac Saal after Andreas Stech, illustration from Johannes Hevelius, *Machinae coelestis pars prior*, vol. 1, 1673.

ments and putti, the placement of the artefacts gives an impression of profusion, of riches fit for a king, inviting the reader to admire the beauty of the objects. The instruments on display all have bearing on the book—quadrants, sextants, telescopes, and a globe—but the illustration does not warrant as extensive an explanation by the author as the emblematic frontispiece. Further into the book there are a great many illustrations of instruments and their uses, yet they too do not have the emblematic quality of the frontispiece. Hevelius' arsenal of instruments, as well as his home and observatory, are laid out in detail. One of the illustrations shows how Hevelius has set up a great telescope outside the city of Danzig (*Fig.* 6.8). It appears to document a real event, described in the book, even though the scene has likely been improved on by the artist. It shows how the display of such a telescope could draw large crowds, including prominent figures: telescopes were useful artefacts not only in promoting knowledge but in social interaction too. Keeping and displaying instruments could be a useful political tool.[28] In this case, the sheer size of the instrument was likely to

28. Kaufmann 1978.

arouse interest. It was perhaps befitting the grandeur of the heavens that such a huge machine was needed to capture their vastness. Hevelius' book is a treasure trove, illustrating the instruments and their uses in unusual detail, each category in its own distinct fashion.

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Frontispieces and illustrated title pages contributed to shape the identity of astronomy by suggesting that astronomical instruments were appropriate attributes for a person who wished to be associated with the field. Books and astronomical instruments were consumer goods that were prominently displayed in astronomical frontispieces in the 17th century. The settings in which these products were staged were occasionally identifiable, but more often they were idealized spaces such as imaginary palaces or gardens—depictions of an enhanced reality, a pleasant dream world. In the illustrations, consumer products are displayed with their distinguishing features in attractive arrangements or with beautiful people in ideal poses in ideal places, sometimes with exotic details. In *Theory of the Leisure Class*, Veblen wrote that the wealthy should not consume indiscriminately: "In order to avoid stultification he must also cultivate his tastes, for it now becomes incumbent on him to discriminate with some nicety between the noble and the ignoble."[29] This understanding of the relationship between taste, consumption, and social identity can be useful when interpretating the early modern display of scientific instruments. Instruments had the potential to provide the user with symbolic gratification. The study of the liberal arts, of which astronomy was one, was a noble occupation open only to those free from the need to do heavy manual labour. Books could provide the wealthy with the means to become cultivated. Book illustrations showed them how to collect, use, display, and talk about instruments, as well as create suitable settings for them. For the man of lesser means the illustrations were the stuff of dreams. Collecting books on astronomy could be a substitute for collecting the instruments themselves. And books could be acquired at a lower price, in which the limits were not financial but simply the imagination of the beholder.

29. Veblen 1899, p. 74.


ΟΥΔΕΙΣ ΕΙΣΙΤΩ
ΑΓΕΩΜΕΤΡΗΤΟΣ
AETERNITATI.
IOANNIS BAYERI
RHAINANI I.C.
VRANO-
METRIA,
OMNIVM ASTERISMORVM
CONTINENS SCHEMATA,
NOVA METHODO
DELINEATA,
AEREIS LAMINIS EXPRESSA.
MDCIII.
ATLANTI
VETVSTISS.
ASTRONOM.
MAGISTRO.
HERCVLI
VETVSTISS.
ASTRONOM.
DISCIPVLO.

7 Hercules as an astronomer

Hercules was one of the more popular ancient heroes in early modern European art. Palace decorations, paintings, engravings, book illustrations, sculptures, and other forms of art celebrated his endeavours. His life, like that of other ancient heroes, was used as inspiration, recounted as a story of an exemplary life. It could be used by early modern man to serve as a role model, as a guide to leading a more virtuous life, or as inspiration to work harder in order to achieve greatness. The tragic account of Hercules is of a man who, in a fit of madness, killed his own children and, to atone for this crime, undertook the twelve labours of Hercules, the famous tasks for which he is mainly known. The learned and intellectual Hercules was also held up as an example, and the comparison of the astronomer to Hercules and his work to a Herculean effort was not unusual.[1] This chapter explores how Hercules was referred to in astronomical books in 17th-century Europe, particularly in imagery, dedications, and related texts, and how the mythical Hercules was seen as an appropriate intellectual ideal—an exemplary astronomer.

Inspiration from classical heroic deeds

In modern popular culture, for example, in films in recent decades, Hercules' immense physical strength is emphasized, whereas his supposed intellectual endeavours are not explored. He has, in our understanding, become the opposite of an intellectual, and anything but a man of literary culture. Perhaps this is because it is thought unlikely for a man to be able to cultivate both excessive physical strength and excessive learning. To build muscle takes time, and so

7.1 Alexander Mair, title page from Johannes Bayer, *Uranometria*, 1603.

1. This essay was first published in Campion & Sinclair 2014, pp. 139–150.

does intellectual development. According to modern standards, the muscular bodybuilder is hardly a likely personification of an academic or philosophically minded personality, let alone a trustworthy one. The assumption is that someone engrossed in books in a library, observing with a telescope, or doing complicated calculations is less likely to succeed as a bodybuilder. The hero of Disney's film *Hercules* (1997) is determined, strong, and fair-minded, and even if the film briefly refers to celestial matters (planetary alignments and constellations), the character of Hercules is not typical astronomer–mathematician–philosopher material. He wins in the end only because of his extraordinary strength and good heart. Disney's Hercules has little in common with the Hercules referred to in early modern astronomy books.

This is not to say that the image of the muscular, violent Hercules did not exist in early modern Europe, because there are numerous examples of artworks that depict Hercules in the throes of heroic violence, displaying his enormous physical strength. There seem to have been different conceptions of Hercules at this time: on the one hand, a man of massive muscles, quick to violence; on the other, a courtly and intellectual figure—the image also connected to the ideal astronomer. In this chapter I pursue the relationship between physical strength, moral strength, and learning. I have chosen to look at the front matter in 17th-century books on astronomy. In forewords, dedications, poems, introductions, title pages, and illustrations we find important information about to whom the book was addressed and how it was intended to be read. The front matter can be seen as the entrance to the book. The images used for the frontispieces or illustrated title pages can be seen as a parallel to the front entrance to a building, where the façade is meant to externally represent the contents and provide an appropriate exterior.[2] The name of Hercules was often mentioned in early modern dedications and forewords, particularly when authors praised their princely dedicatees, but also in reference to astronomers themselves.

Hercules, student of astronomy

On Alexander Mair's illustrated title page of Johannes Bayer's atlas of the constellations, *Uranometria* (1603), Hercules appears as a student of astronomy (*Fig.* 7.1, p. 112). A number of ancient figures are placed on an architectural structure. There is Apollo, the Sun and the dragon killer (the dragon is beneath his foot, along with his lyre and bow) and to the right is Artemis (Luna or Diana) with her bow and arrows and a hunting dog, clad in a dress scattered with stars, and with the moon on her brow. Here they simultaneously represent

2. For front matter in general, see Genette 2001; for illustrations, see Elmqvist Söderlund 2010.

sister and brother, sun and moon, day and night. In the middle is a crowned woman representing Eternity, holding a palm branch, in a coach drawn by a lion and a lioness. Below is a view of the German city of Augsburg, and just above it Capricorn, most likely a reference to Augustus, the Roman emperor who gave the city its name. There is also Atlas, an old, bearded, turbaned man in ancient garb, with an astrolabe and a pair of compasses. And to the right, with his traditional attributes, is Hercules.

Uranometria was a successful book and ran to several editions in different formats, both with and without illustrations. It gives almost 2,000 positions of stars. Bayer used Tycho Brahe's observations and other new observations—for example, of the southern skies—and introduced a system of classification with Greek and Latin letters, stated in order of apparent brightness. The lore and history of each constellation is also given, with numerous references to texts and artefacts. This was the kind of information with which an astronomer was expected to be familiar, particularly the ancient literary sources. The book had detailed plates with illustrations of the constellations, also by Alexander Mair, which contributed to its popularity. Each constellation was shown in a grid with co-ordinates that make it possible to read the position of the star.

As Hercules was also a constellation, it might be thought that it was to Hercules that the title page alluded. However, tradition dictates that the constellation

7.2 *The constellation of Hercules*, plate from Johannes Bayer, *Uranometria*, 1603.

of Hercules—as depicted in a large plate in *Uranometria*—is always shown as a kneeling figure, *Engonasin* (*Fig.* 7.2, p. 115). On the title page Hercules is depicted in a very different stance. He is still easily recognizable because of his standard attributes: the lion's skin and the knobbly club, standing carrying the globe of the heavens. This last is a reference to the episode when Hercules tricked Atlas to aid him in one of his labours, fetching the Apples of the Hesperides. But in this image there are no apples. Here the carrying of the globe has another meaning. Many myths about Hercules had sprung up over the centuries, and there were variants praising his different virtues.[3] In some versions he became a student of astronomy. According to one variant on the myth of Atlas, Hercules was a prince who knew astronomy and astrology. He discovered the nature of the sphere, hence the myth that he carried the heavens, while carrying the globe, a heavy burden, could also denote both the responsibility of the astronomer and the fact it was difficult to learn the arts of astronomy and geometry. In one version, Hercules saved Atlas's daughters from pirates, and, as thanks, was taught astronomy. During the Renaissance this story was elaborated on in the *Recueil des histoires de Troyes* by Raoul le Fèvre (1464–1469), from which a particular romance was later published separately. It told of Hercules visiting King Atlas near Libya. Hercules was taught all the sciences, and because he learned so quickly he was soon the most accomplished philosopher–astronomer in the world. After many adventures they travelled together to Athens, where Hercules excelled in astronomy.[4] The frontispiece inscriptions ensure Atlas and Hercules would be recognized and associated with this particular storyline: "Hercvli vetvstiss[imo] astronom[iae] discipvlo" ("To Hercules, the most ancient student of astronomy"); and "Atlanti vetvstiss[imo] astronom[iae] magistro" ("To Atlas, the most ancient teacher of astronomy").

To further strengthen the connection to the ancient Athenian philosophers, there is also a Greek inscription in the title page, "ΟΥΔΕΙΣ ΕΙΣΙΤΩ ΑΓΕΩΜΕΤΡΗΤΟΣ" ("Let no one enter here who is ignorant of geometry"). This was allegedly written over the entrance to Plato's Academy. It confirmed that astronomy was dependent on geometry and mathematics, and also defined the readership of the book.[5] A variant of the same phrase featured on the title page of Copernicus' *De revolutionibus* (1543). It is of course possible that the inclusion of the inscription was a nod to Copernicus, but it was more likely a

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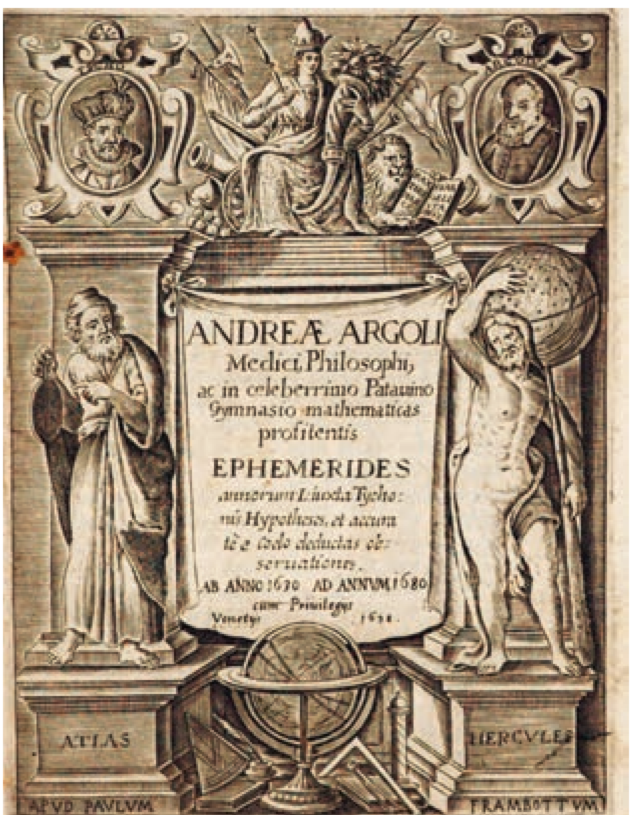
3. Jung 1966. I owe a special debt of thanks to Prof. Hans Helander for his valuable comments; see also Remmert 2005; further references in Zedler 1732–1754, vol. 2, col. 2046 ff., "Atlas", & vol. 12, col. 1644 ff., "Hercules".

4. Jung 1966, pp. 16, 21, 23.

5. For this frontispiece, see Ashworth 1986, p. 180; Remmert 2005.

general indication that the book embodied the heritage of ancient learning.[6] Geometry, together with classical languages, was knowledge the reader was supposed to master. Considering the many illustrations of the book, it can be expected that many of its users would not have belonged to the learned elite, however. The inscription can also be seen as a kind of declaration of content, and seems to promise the reader that, in reading the book, he will gain some connection to the learned legacy of the past.

The motif of Hercules and Atlas was a frontispiece standard. Another version of it was the frontispiece to Andrea Argoli's *Ephemerides* (1648, *Fig.* 7.3). Here Atlas and Hercules carry the globe of the heavens together. They present the globe in such a manner that Urania is shown demonstrating the use of compasses on it. There was no obvious conflict or trickery in this picture, like the main myth of Atlas and Hercules. Here the apples of the Hesperides have become a metaphor for learning the geometry of the sphere and astronomy. In this scene, teaching and learning have become an enjoyable pastime where all three players seem to enjoy the fruits of knowledge. In baring parts of her body, Urania is showing some of her secrets, similar to the personification of Truth, who is normally depicted naked. Urania is accompanied by a small putto and an armillary sphere, possibly intended to echo the goddess of love, Venus, here indicating celestial love.



7.3 Giovanni Georgi after Francesco Ruschi, frontispiece from Andrea Argoli, *Ephemerides*, 1648.

How widespread was this notion of Atlas and Hercules as astronomers in the early modern period? In astronomical texts their names often occurred, particularly in dedications and in praise of dedicatees. Atlas, however, was far more common, at least in front-matter imagery in astronomical books.[7] One beautiful example of Atlas in a frontispiece is found in the small book by Jakob Bernoulli, *Dissertatio*

6. Edward Rosen in Copernicus 1978, vol. 2, p. xv; Elmqvist Söderlund 2010, pp. 298–299.
7. Mosley (2007) considers Atlas's meaning for astronomers and astronomy in the early modern period.

de gravitate aeteris (1683, *Fig.* 7.4). He is depicted as a lonely colossus, bent and weary under the heavy burden of the vault of heaven. He is standing on the rounded Earth on some rocks which represent the Atlas Mountains in Africa. The sun is just rising, allowing us to see his figure, but Atlas seems not to stir. Here the burden of the heavens and of learning is everlasting, difficult to bear, just like the responsibilities of a learned man. In this image, in comparison to the example in Argoli's frontispiece, the learning of the heavens is not light and pleasant, even if it is breathtaking. The burden of the learned man is exemplified by the character of the learned Hercules or Atlas.

7.4 Frontispiece from Jakob Bernoulli, *Dissertatio de gravitate aeteris*, 1683.

Many astronomical books in the 17th century began by recounting the ancient history of the subject, often as far back as biblical or mythical time. Placing the subject in its historical context and extolling its relevance to the most ancient known humans was part of how astronomy was presented. An interesting list of astronomers is given in Edward Sherburne's *The Sphere of Marcus Manilius Made an English Poem: With Annotations and an Astronomical Appendix* (1675). Sherburne was an English poet and translated the astronomical and astrological poem "*Astronomica*" by the Roman poet Marcus Manilius from the 1st century AD into English. This book contained more than just a translation, though. It was also an extensive account of contemporary astronomy. One of the chapters has the list, 'A catalogue of the most eminent astronomers, ancient and modern'.[8] While it listed both Hercules and Atlas, it began with Adam, and continued in chronological order with Seth. Along with the likes of Ptolemy were Abraham, Moses, Solomon, Julius Caesar, Ovid, and many more. Atlas was mentioned briefly as king of Mauretania and inventor of the sphere, and hence was said to have carried the heavens on his shoulders. The version where Atlas was Hercules' teacher was not mentioned by Sherburne. He had him as "HERCULES, called μυσαγέτης, or *Musarum ductor*, to distinguish him from the other *Hercules*, was so well learned in the Doctrine of the Sphere, that he is therefore feigned to have eased *Atlas* of his burden; whence *Ovid, Hercule supposito Sydera fulsit Atlas*."[9] Hercules was specified as the leader of the muses, as peaceful Hercules, leader in the arts and sciences. The text specified

8. Sherburne 1675.
9. 'A catalogue of the most eminent astronomers, ancient and modern', in Sherburne 1675, p. 8.

that this Hercules was distinct from the other one. Here is a notion, with which some historians disagree, that the ancient myths could not possibly concern one and the same person. It is also specified that Hercules excelled at geometry, and Sherburne related the episode in which Hercules relieved Atlas of the burden of the celestial sphere. The quote at the end was taken from Ovid's *Heroides*, Deianeira's letter to Hercules, and alluded to the moment when Hercules carried the heavens on his shoulders.

This many-faced Hercules made for a very useful figure who fitted into many early modern situations. One of those contexts was astronomy, for whether a famous ancient hero or a student of astronomy, he could be held up as an example with which to explore the subject. Potentially, the student of astronomy could feel inspired to similar heroic efforts, that his study was not in vain but meaningful. The labour of those who studied astronomy was part of a virtuous and heroic example of an exemplary ancient life.

Hercules at the crossroads

A popular motif in early modern literature and art was Hercules at the crossroads.[10] Based on ancient sources, it refers to Hercules as a young man, who encounters two fair women at a crossroads, one of them promising a life of virtue, the other vice. In art, the motif usually shows Hercules seated in the middle, tormented by his difficult choice, flanked by two beautiful women, one of them modest and the other voluptuous. Whereas Virtue does not conceal the fact that her way is both arduous and long, Vice promises a short road of enjoyment and pleasure. In the end Hercules is convinced by Virtue's arguments.

I have not found this episode depicted in the front matter of astronomical books of the 17th century, but it was referred to in the books in connection to the great philosophical issue of whether or not the sun moves. The theme of the frontispiece of Giovanni Battista Riccioli's *Almagestum novum* …, printed in Bologna in 1651, is the order of the solar system (*Fig.* 7.5, p. 120).[11] This book was a general overview of astronomy at the time and seems to have been successful, given that a second edition was printed just two years later. Its intriguing frontispiece addresses issues dealt with by the author, and has quotes from the Bible and other ancient sources, such as from Ovid, along with a number of figures. The scene is a landscape: to the left is Argus, the giant whose body is covered with eyes, which could be seen as a metaphor of the heavens; to the right, Astraea, the pure and celestial virgin, who holds a weighing scale with

10. Panofsky 1930; Harms 1970.
11. For more frontispieces on this theme, see Remmert 2005.


Dies diei eructat verbum
Numero
Mensura
Pondere
Et Nox nocti indicat scientiam
Videbo Caelos tuos, opera digitorum tuorum
Non inclinabitur in saeculum saeculi
Ponderibus librata suis
Fr. Curtius Bon. Incid.

two systems, one heliocentric, the other geoheliocentric. The latter is plainly the author's own variant of the Tychonic system. At her foot is the ancient geocentric system. Above them, centrally placed, is the hand of God, and on either side are putti carrying the celestial bodies: to the left, the sun with the bodies circling it; to the right, the night with the celestial bodies circling the Earth (according to the author). Ptolemy, lying down, rests one hand on the Grimaldi coat of arms, and his other arm on a shield.

The title of the book, 'The New Almagest', is an allusion to Ptolemy's *Almagest* and a tribute to the legacy of classical astronomy. Riccioli partially explained the frontispiece in his two dedications at the start of the first and second volumes, dedicated individually to two different members of the Grimaldi family. He thus said of Argus, whom the frontispiece shows oddly holding a telescope directed towards an eye on his knee, that "There Argus with all his eyes, no with the entire eye, moves the telescope rather to his knee (genu) than to the eye of his cheek (genae) not so much sees the outstanding work of God's fingers, as he reveres them while being about to kneel."[12] Astraea, weighing up the systems, notices a "Well-designed levity in the mobility of the world, and in the immobility an inclining judgement. She finds that saying from David very likely, which once had resounded from heaven into her own ears: *it should not be removed forever*." Riccioli points out in the text that whether the earth is moving or not is a matter of judgement, and that the Bible should be considered. He refers to the controversy as an analogy to Hercules at the crossroads, and the act of choosing a system as a matter of virtue: "But now it was suitable that the system of the world, and the entire burden of this controversy, was preserved by the authority of this prince, who would sustain Hercules' lot with hereditary justice."[13] The prince referred to is one of the Grimaldi dedicatees, and the reference to Hercules has various indications. Hercules represents at once the ancient hero and the deceased father of the dedicatee. The prince–dedicatee is placed at the crossroads, like Hercules, and his choice is between the two systems. This was one of the challenges the early modern astronomer–philosopher would face. Just like the tormented Hercules at the crossroads, the prince–astronomer would have to make up his mind on this complicated issue. The frontispiece to Riccioli's book shows the virtuous woman Astraea acting as Virtue herself, not unlike the constellation Virgo, aiding the reader to judge in favour of the virtuous geoheliocentric model.

The fact that the frontispiece was explained in the dedications, and that Ric-

7.5 Frontispiece from Giovanni Battista Riccioli, *Almagestum novum,* 1651.

12. Riccioli 1651, vol. 2, n.p., Dedication to Honoratio II. For a translation by Peter Sjöqvist, see Elmqvist Söderlund 2010, p. 380.
13. Elmqvist Söderlund 2010, p. 380. The biblical quote from David is from Psalms 104:5.

cioli asked the prince to "turn one and another page for a while, and study the picture that is at the front of the work", indicates that he intended that the reader should look thoroughly at the frontispiece and take the time to ponder its meaning.[14] There is an indeterminacy to the picture, with its many layers of meaning and many possible threads open to interpretation and learned digression. Riccioli's own text is not explicit about all the details or the possible allusions in the references, which is part of its appeal. The picture and accompanying text make it clear that learning astronomy called for far more than knowledge of celestial matters, but also of the ancients and theology, and not least moral development, which would enable one to judge philosophical matters.

The Labours of Hercules

The front matter of Johannes Kepler's *Tabulae Rudolphinae* (1627) used the labours of Hercules as an analogy for the immense effort involved in producing an astronomical work. The eponymous tables contained the information from Tycho Brahe's observations of the stars and planets—something Kepler had been struggling with for years. The book was the result of countless hours of hard labour. The very interesting frontispiece has an intricate pictorial programme depicting a temple to astronomy in which a number of astronomers of different eras are gathered for a philosophical discussion (*Fig.* 6.5 , p. 106). Tycho and Copernicus, at the front, are engaged in a dispute about whether the sun is moving or not. Tycho points to the ceiling where his geoheliocentric system is inscribed, saying "Quid Si Sic" ("If it were so"). Around the base of the temple are framed scenes depicting events related to the production of the book, the middle motif being a map of the island of "Vhen", where Tycho had his observatory. On top of the temple are the female figures of Urania and her servants Magnetica, Stathmica, Doctrina triangulorum, Logarithmica, Optica, and Physica lucis.[15]

Hercules is not part of the pictorial programme, but the *Idyllion*, the explanatory poem by Johannes Hebenstreit, mentions the Labours of Hercules in relation to Kepler. Kepler is shown to the left on the base of the temple, seated at a table on which is placed a structure representing his work, and a miniature model of the top of the temple with the female figures. In front of him his most important works are listed. His life's accomplishments are presented in this scene. In the poem it is as if Kepler could watch the play enacted above his head in the temple: "He sits, weighing the disputes of the discussant men in a careful

14. Elmqvist Söderlund 2010, p. 380.
15. For a complete description of the frontispiece, see Kepler 1969, pp. 15–26; for a translation into English, see Elmqvist Söderlund 2010, pp. 370–375; for the extensive literature on the frontispiece, see Gattei 2009; Elmqvist Söderlund 2010.

examination. But he feels closer to the seat of learning of Prussia [Copernicus] and carefully listens to their argument, and he grazes on the connected warps of the continuous night, inflaming them with his intellect. What he himself has done, as an equal to labouring Hercules, as long as the work was still advancing, the walls and the books relate, and above all the tablets themselves."[16] Kepler's heliocentric preferences shine through, and here at the summit of his life he is portrayed as a knowledgeable judge of this difficult philosophical issue.

There are no similarities between Kepler's physical appearance and that of muscle-bound Hercules. Their resemblance lay in the immense effort and strength demanded to finish the work. Kepler's lean body is marked by long hours of calculations and writing. The battles he had fought were not against physical monsters, but false theses and academic adversaries. The writing desk is the proper place for the astronomer–mathematician to accomplish his labours. Considering that the poem compared Kepler's work to the Labours of Hercules, it might seem surprising that his position in the frontispiece is not prominent, but rather to one side at the base of the temple. However, for the design of the frontispiece, Kepler had to take into consideration Tycho Brahe's heirs, who had several objections to the original design. In fact, they were very conscious of how Tycho would appear, in minute detail, including his clothes.[17] It is just possible this detail went unnoticed, however, as Copernicus was not mentioned by name, however obvious the allusion to the Prussian man. However inferior his position in the frontispiece, according to the poem it was Kepler who, after his labours, was in a position to judge the dispute between Tycho and Copernicus. His judgement, after carefully examining all the arguments, was inclined towards Copernicus' system.

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In the frontispiece of Kepler's *Tabulae Rudolphinae*, the work of the astronomer is considered as arduous as the incredible Labours of Hercules, not in terms of the ancient hero's physical strength, but in the immense mental effort required and the difficult choices that face the astronomer. Kepler, the successful student of astronomy, has by a Herculean effort reached a conclusion and made his decision at the crossroads. He has shown not physical strength, but exceptional steadfastness and virtue. In this way, Hercules was an appropriate intellectual ideal for an early modern astronomer.

16. Elmqvist Söderlund 2010, p. 374.
17. Hammer 1969, pt viii.

8 Royal constellations at Drottningholm Palace

THIS CHAPTER EXPLORES the relationship between astronomical phenomena and the ceiling painting *The Glorious Deeds of Swedish Kings*, and why motifs related to the stars and heavens were considered so suitable in court contexts in early modern Europe. *The Glorious Deeds* was executed in the 1690s by the Swedish court painter David Klöcker Ehrenstrahl for Drottningholm Palace near Stockholm.[1] The central theme of the painting is how "Reputation" carries news of the valour and renown of the Swedish kings to the stars.

Ehrenstrahl at Drottningholm

Drottningholm Palace was built for Hedvig Eleonora of Holstein-Gottorp, queen dowager of Sweden.[2] Construction began in 1662. The decoration of the palace celebrates the queen dowager, her late husband Karl X, her son Karl XI, and grandson Crown Prince Karl (later Karl XII), and many of its motifs are connected to their dynastic claims. Sweden had extended its borders through wars of aggression. Its newfound self-confidence and territorial gains were manifested in buildings and works of art intended to compete with the great palaces of Europe. Among the many allegories created for Drottningholm by the court painter David Klöcker Ehrenstrahl were a set of seven large paintings intended for the antechamber in Hedvig Eleonora's state apartments, though by 1709 they were in their final place in her audience chamber, now known as Ehrenstrahlsalongen or the Ehrenstrahl Drawing Room. The paintings include a celebration of Hedvig Eleonora as queen mother and regent, but the main

1. This essay was first published in Corsini 2011, pp. 197–204.
2. For Drottningholm Palace, see Alm & Millhagen 2004 and references.

theme is the life of her son Karl XI and the continuity of the ruling Pfalz dynasty.[3] The ceiling painting, *The Glorious Deeds of Swedish Kings*, deals with continuity, claims of power, and Swedish history in a more general manner (*Fig.* 8.1).

Ehrenstrahl described his work in a book with the confident title *Die vornehmste Schildereyen, welche in denen Pallästen des Königreiches Schweden zu sehen sind inventiret, verfertiget und beschrieben von David Klöcker Ehrenstrahl* (1694, 'The most superior paintings to be seen in the palaces of the kingdom of Sweden, invented, executed and described by David Klöcker Ehrenstrahl'). It explains the often complex iconography of his paintings in detail, which makes it possible to identify the intended iconographic programme of the Drottingholm ceiling painting with certainty. In the centre of the ceiling of the audience chamber were allegorical representations of Virtus, Gloria, and Fortitude, holding a shield inscribed "GC'" which stands for several notable Swedish kings of the 16th and 17th centuries: Gustav I, Gustav II Adolf, Karl X, and Karl XI, and also the crown prince, the future Karl XII. Immortality crowns the shield with a ring of stars, signifying eternity, while Fame blows her trumpet. A number of putti are in attendance. Centrally, below the shield, is a large lion—the Lion of the North according to Ehrenstrahl. It is possible that he was alluding to the constellation Leo, but no stars are painted to indicate it. Surrounding the main figures are a number of constellations, marked with white spots to indicate the individual stars: Ursa Minor, Draco, Ursa Major, Corona Borealis, Hercules, Pegasus, Lyra, Aquila, Cygnus, Perseus, Andromeda, and Via Lactea, as well as Stella Polaris and the fixed stars. In his description, Ehrenstrahl underlined some specifically Swedish and northern details: the Swedish kings, the Lion of the North, and, in the sky above the kingdom of Sweden, the fixed stars, busy admiring the scene. It should be noted that the chosen constellations were associated with valour and heroic deeds, and were visible from Sweden.

Celestial themes in princely interiors

A set of tapestries in the Royal Palace in Stockholm had motifs related to celestial phenomena in allegorical form, but there were many other possible sources of inspiration for the Drottningholm motifs and composition (*Fig.* 1.2, p. 17).[4] Constellations and planetary deities were an established convention in European palace decoration. Ehrenstrahl travelled throughout Europe and was able to

3. For a recent reinterpretation of the meaning and display of the paintings now in Ehrenstrahl-salongen, see Laine 2015, which also explains the discrepancies between Ehrenstrahl's description of the interior and some of the paintings in the series, though these do not affect Inga Elmqvist Söderlund's interpretation of the ceiling painting.
4. Gillgren 2009, pp. 56 ff.

8.1 David Klöcker Ehrenstrahl, *The Glorious Deeds of Swedish Kings*, *c.* 1694. Oil on canvas, 593 × 344 cm. Nationalmuseum, Stockholm, inv. no. NM-Drh 131. See also page 124.

see a great number of paintings; others he knew from the verbal descriptions, drawings, and engravings that made works of art known even in remote parts of Europe. He was educated in Germany, and in his youth he went to the Netherlands, but later found employment in Sweden. In 1654 he travelled through Germany to Italy, where he stayed in Venice and later Rome until 1660. His return journey went via Florence, Marseilles, Paris, and London, and he arrived in Sweden the following year. He was appointed court painter to Hedvig Eleonora, and was ennobled in 1674. He was commissioned to decorate several interiors at Drottningholm.[5]

There is a group of painted ceilings from the 16th and 17th centuries that may have been influential for the ceiling discussed here. In the latter half of the 16th century, the Sala Bologna in the Vatican and the Sala del Mappamondo in the Palazzo Farnese in Caprarola (north of Rome) were given large, impressive ceilings painted as maps of the heavens.[6] In Schloss Ambras at Innsbruck, the Rüstkammer or Armoury has a ceiling with the constellations.[7] Placed high up in the room, such ceilings can be seen as metaphors of the heavens. Large rooms such as these had ceremonial purposes, and were used as audience chambers or dining rooms. At Caprarola, the constellations are depicted together with the *imprese* and heraldry of the Farnese family.

Besides what were essentially large maps of the constellations, there were painted ceilings that showed a few constellations and the zodiac. In around 1500 such rooms were created in Rome, in the Appartamento Borgia in the Vatican and in the Sala Galatea in Villa Farnesina.[8] A succession of rooms named after the planets was created by the most famous artists in notable palaces, such as the Palazzo Vecchio in Florence (by Pietro da Cortona) and Versailles (by Charles le Brun) in the 17th century.[9] It seems reasonable to assume that the planets and constellations were chosen for these environments for their representative function and meaning, rather than as scientific explanations. I would argue they

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5. For Ehrenstrahl, see Nisser 1948; Liljegren 1958; Ångström-Grandien 1997, pp. 396–415.
6. The Sala Bologna was the work of Giovanni Antonio Vanosino da Varese, 1575, see Hess 1967; Lippincott 1990, p. 206; Partridge 1995, pp. 420 ff.; Pietrangeli 1996, pp. 277 ff. The Sala del Mappamondo was devised by Fulvio Orsini and Orazio Trigini de' Marii, and possibly by Cardinal Farnese himself, and executed by Giovanni Antonio Vanosino da Varese, Giovanni de' Vecchi, and Raffaellino da Reggio, *c.* 1574, see Warner 1971; Lippincott 1990; Robertson 1992, pp. 118 ff., 227 ff.; Partridge 1995.
7. The ceiling in Schloss Ambras was executed by Giovanni Battista Fontana before 1586; it was later moved within the castle.
8. Quinlan-McGrath 1984; Lippincott 1990; 1991; Poeschel 1999; see also examples in Lehmann 1945; Gombrich 1950.
9. The planetary rooms in Palazzo Pitti were completed between 1641 and 1665, and in the Palace of Versailles between 1671 and 1681; see Campbell 1977, pp. 63 ff., 177 ff.; Sabatier 1999, pp. 107 ff.

8.2 Andrea Sacchi, *Allegory of Divine Wisdom*, 1629–1631. Fresco. Palazzo Barberini, Rome.

should not be read as advocating a particular planetary system, whether the geocentric or the heliocentric. Celestial themes in ceremonial interiors were in fashion all over Europe, and painted ceilings were especially valued as works of art.[10]

Recent astronomical discoveries could also be used as motifs in large-scale paintings. The Galilean moons in allegorical form can be found in the ceiling of the Galleria Grande in Palazzo Medici Riccardi in Florence, in a painting after a design by Alessandro Segni, executed by Luca Giordano in the 1680s.[11] The Medici princes are depicted with stars on their brows, as personifications of celestial phenomena. It is uncertain whether this painting was seen by Ehrenstrahl, but the architect Nicodemus Tessin the Younger saw it in 1687 and thought it was important enough to describe in his treatise on interior decoration.[12]

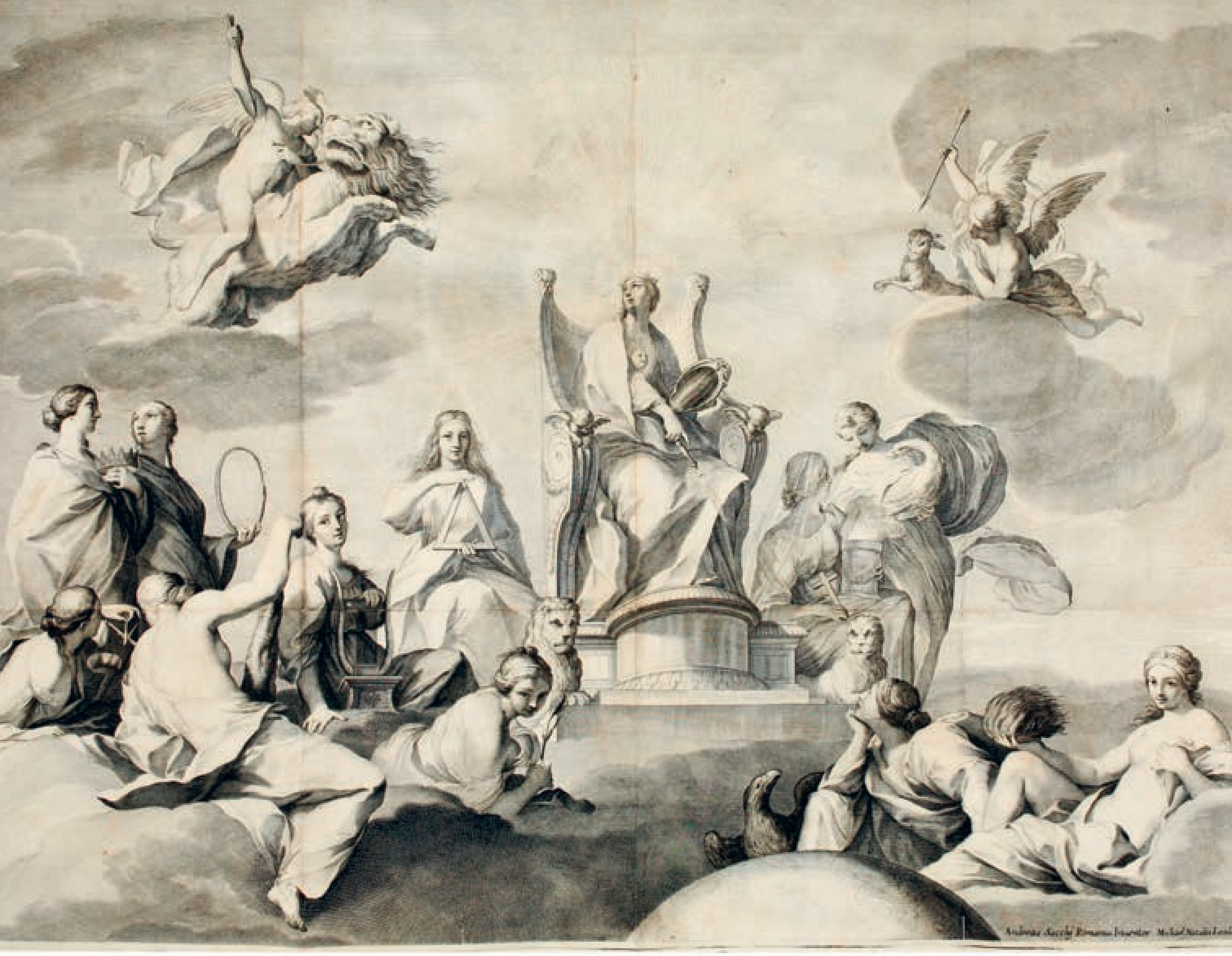
It is known that Ehrenstrahl visited the Palazzo Barberini in Rome and was influenced by Pietro da Cortona's painting. However, in the same palace there is another painting which I believe influenced the ceiling at Drottningholm: *Al-*

10. For the status of the painted ceiling, see Frangenberg 2003; for the painted ceiling as general metaphor for the heavens, see Lehmann 1945.
11. Büttner 1972, pp. 61 ff.
12. Waddy 2002, p. 189; for the painting, see Büttner 1972, pp. 37 ff.

legoria della Divina Sapienza (1629–1631, 'Allegory of Divine Wisdom') by Andrea Sacchi (*Fig.* 8.2, p. 129). This painting depicts several constellations—and they were clearly to be taken as constellations, because points for the locations of stars are explicitly marked in the painting. The placing of the figures in relation to one another cannot be matched to any chart, but they are positioned according to their symbolic value. Thus *Divina providentia* is seated on a throne with lions on each side of her and a Sun on her bosom. She holds a mirror signifying purity and wisdom.[13] To her right is a woman with a cross (Crux) and an altar (Ara), symbolizing faith or sanctity; above to the right on a cloud is a personification of the Fear of God with a hare (Lepus); below to the left, Clearsightedness or Perspicacity with an eagle (Aquila), Purity with a swan (Cygnus), and Beauty holding a votive offering of hair (Coma Berenices). Above, to the left of *Divina providentia*, is Love riding a lion (Leo) and below him Divinity with a triangle (Triangulum), Beneficence or Generosity with a sceptre (Spica or Virgo), Sweetness or Harmony with a lyre (Lyra), Fortitude with the club of Hercules (Hercules), Eternity with a ring (Serpens or Ophiuchus), Justice with her scales (Libra), and Nobility with a crown of stars (Corona Borealis). Each is depicted according to the traditional representations of certain virtues, and at the same time as recognizable constellations. Crucially, the constellations are not portrayed as they would be in a conventional star chart, but as allegorical figures identified by their attributes: for example, the constellation Hercules, which normally is shown as the Kneeler—a kneeling man—is replaced by a woman carrying his club. The figures seem animated, moving on the clouds as if the heavens were inhabited by living creatures.

Below the virtues is a globe where Africa is the most prominent continent, dwarfing Europe. This painting with its religious undertones has been read as referring to the Wisdom of Solomon, to the glorification of the Barberini family. The throne in the painting is decorated with the Barberini bees, while Wisdom directs her light over Italy, closest to her throne. It is remarkable that Africa has such a prominent place, and that some of the constellations, such as Crux and Ara, are only visible from southern locations. This painting has also been taken to show a predisposition for the heliocentric world-view. Naturally, such readings were possible in the 17th century, but it should be remembered that the most important function of this kind of painting was to represent the family for whom it was made. Controversial or heretical views were not material for public spaces, or at least not obviously, and there is as yet no satisfactory explanation

13. The spotless mirror may be a metaphor for the Moon and a reference to the controversy over the surface of the Moon. See Lechner 1976; Lavin 1985 and references; Scott 1991; for the possible function of the room, see Waddy 1990.



8.3 Michael Natalis after Andrea Sacchi, *Allegory of Divine Wisdom* (detail), from Girolamo Teti, *Aedes Barberinae ad Quirinalem*, 1642.

why there would be such a statement in an official room. And it was recognized to be important. Small paintings of the ceiling were given as gifts to prominent guests, and it was reproduced in Girolamo Teti's *Aedes Barberinae ad Quirinalem* (1642), which indicates how important the decoration of this room was considered to be (*Fig.* 8.3). The engraving in Teti's book differs from the original in that the stars in the constellations are not included, and only a part of the terrestrial globe is visible.[14]

A comparison of Sacchi's and Ehrenstrahl's ceilings shows the same kind of inhabited heavens, in which the constellations, depicted as living beings, celebrate a particular family. At the same time there are considerable differences.

14. Frangenberg 2003.

8.4 David Klöcker Ehrenstrahl, *Self-Portrait*, 1691. Oil on canvas, 178 × 145.5 cm. Nationalmuseum, Stockholm, inv. no. NM 949.

Ehrenstrahl did not start with biblical references, nor did he include constellations with obvious religious connotations such as Crux and Ara, or indeed Lepus, who could be associated with the lowly feeling of fear. In Palazzo Barberini, several constellations visible only from southern locations were included, whereas in Ehrenstrahl's painting there were only constellations visible from Sweden—positioned more or less as they would be on a star chart. It can be concluded that Ehrenstrahl used the general language of European allegory and the established connotations between royalty, power, nobility, strength, valour, and celestial phenomena. On his travels through Europe, Ehrenstrahl would have seen many painted ceilings and formed an opinion on the design and decoration of princely palaces. But he transformed what he had seen into an independent invention, with an expression and meaning adapted to the Swedish context of the time. He set out the valour of the Swedish kings for the constellations to admire. The right with which Dowager Queen Hedvig Eleonora and her descendants exercised their power was approved even by the stars. Who could then doubt it?

Ehrenstrahl's thoughts on painting were illustrated in his self-portrait from 1691, intended to be exhibited at Drottningholm (*Fig.* 8.4). Two female allegorical figures represent the practical and intellectual aspects of painting. According to Ehrenstrahl's description in the *Vornehmste Schildereyen*, he consulted Intellect as if asking her what to paint, and she responded with the words written on the paper she holds, "Immortales pinge Majestatum laudes" ("Paint the immortal reputation of their Majesties"). Ehrenstrahl thus emphasized the high value he placed on paintings such as *The Glorious Deeds of Swedish Kings*. Astronomical motifs were particularly useful for this kind of painting. Astronomical phenomena and the heavens had positive connotations which could be used to glorify the subject of the painting—the reason they were also ideal for emblems, impresas, and devices. The French Jesuit Claude-François Menestrier in his *La philosophie des images* (1682) singled out celestial phenomena as useful for heraldry and devices, and presented a great number related to the Sun, Moon, and stars.[15] According to Menestrier, it was preferable to use motifs that were beautiful and agreeable to look at. Stars, peacocks, eagles, palms, pomegranates, lions, roses, and lilies were to his liking, but not snakes, swine, trefoils, or thistles (in that order).[16]

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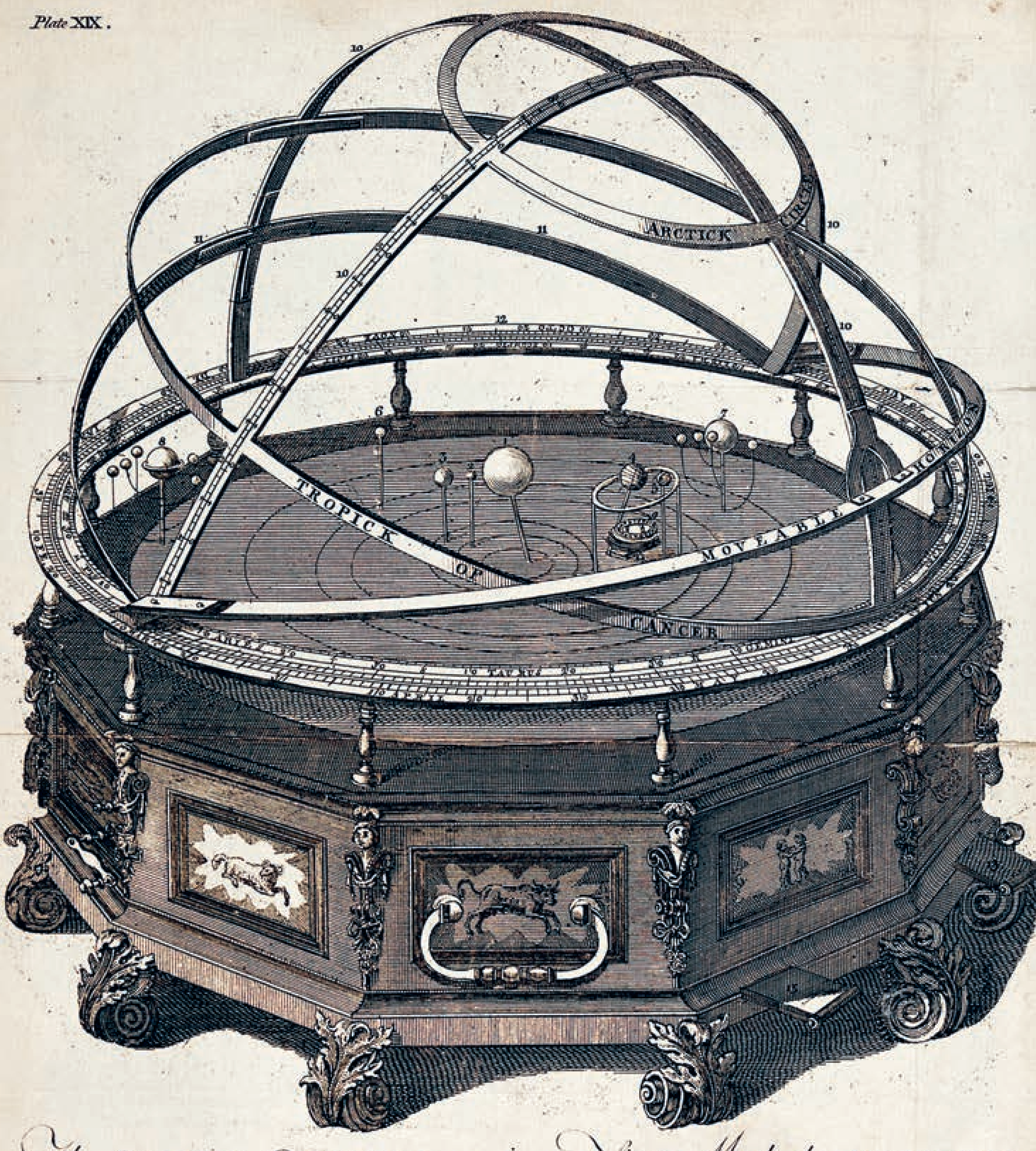
Astronomy's "high" and noble connotations, in particular taken together with aesthetic considerations, made it a subject suitable in a court context. The presumed proximity to God and Heaven added further positive values. In Ehrenstrahl's painting *The Glorious Deeds of Swedish Kings*, he depicted the constellations as if they were living beings, able to follow events on Earth. Ehrenstrahl used pictorial conventions of several European sources, but transformed the visual language into one of his own.

15. Menestrier 1682; the first part was dedicated exclusively to the heavens and stars.
16. Menestrier 1662, p. 57.

Plate XIX.



The GRAND ORRERY *as it was first Made by* M.r Rowley.

III

RECEPTION

9 Is this orrery a work of art?

> This most beautiful System of the Sun, Planets, and Comets, could only proceed from the counsel and dominion of an intelligent and powerful being.
>
> Isaac Newton, *The Mathematical Principles of Natural Philosophy*[1]

THE COLLECTION AND DISPLAY of technically and aesthetically complex scientific instruments have been considered manifestations of power and prestige, and a form of conspicuous consumption.[2] Such interpretations are often valid, but the intention here is different, for the aim of this chapter is to investigate the experiences caused by looking at or using mechanical astronomical instruments in the long 18th century. Many images and descriptions of astronomical activities from this period, whether observations or demonstrations, indicate that there was an interaction between several participants. This interaction was an important aspect of science as part of 18th-century culture in several spheres of society, but will not be considered here.[3] Instead, the focus is the individual when confronted with astronomical demonstration instruments and the knowledge they imparted. The nature of the experiences occasioned by such confrontations and how they were evaluated and interpreted will be sought for in actual instruments and in images and texts

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1. From the 'General Scholium', added to the second edition of Newton's *Principia mathematica*, published in 1713. The quotation is from the English translation of 1729, p. 388.

2. Kaufmann 1978; Walters 1997, pp. 121–124, 125, 137, 142–143.

This chapter is a synthesis of the paper 'Is This Orrery a Piece of Sculpture?' presented at *Moving in Three Dimensions: Conference on Sculpture and Change*, Courtauld Institute, London, 11–12 May 2012, and the seminar 'Orreries, Armillary Spheres, and the Pleasures which Entertain our Reason' held during Inga Elmqvist Söderlund's guest fellowship in Oxford. The paper, seminar, and some fragmentary texts are results of her research at the Museum of Science History in Oxford and as Sackler Research Fellow at the Maritime Museums, Greenwich, on the design of scientific instruments and reception aesthetics in the 18th century. Merit Laine has pieced together and to a certain extent enlarged on various stages of Inga Elmqvist Söderlund's research, with some additional literature.

3. See, for example, Altick 1978; Walters 1992; Schaffer 1993; Chabaud 1996; Walters 1997; Heilbron 2000, pp. 2–3; Bensaude-Vincent & Blondel 2008; Saule 2010.

about instruments, astronomy, science, and art. Of the arts, special attention will be given to sculpture, as this category shares the three-dimensionality of astronomical instruments.

No attempt has been made at a full inventory of possible sources for the discussion in this chapter; rather, a few key instances have been chosen. These are the Earl of Orrery's orrery, the French clockwork demonstration instrument known as the *Pendule de la création du monde*, and the orrery depicted in Joseph Wright of Derby's painting *A Philosopher Giving that Lecture on an Orrery, in which a Lamp is put in the Place of the Sun*. Of the writings on art and art theory, the focus is on Charles Batteux's treatise *Les Beaux-Arts réduits à un même principe* (1746) and on the sculptor Étienne-Maurice Falconet's contribution to the sculpture entry in the *Éncyclopédie* (1765).[4] Edmund Burke's *A Philosophical Enquiry into the Origin of our Ideas of the Sublime and Beautiful* (1759 [1757]) is also highly relevant.[5] The texts on science, instruments, and astronomy quoted are for the most part introductions and lectures intended for the layman, and include Bernard Le Bovier de Fontenelle's *Entretiens sur la pluralité des mondes* (1686), which was reprinted several times in the 18th century, Joseph Harris's guide to the use of globes and orreries (1731), and Jean-Antoine Nollet's lectures on experimental physics (1743–1764).[6] Of present-day aesthetic theory, Richard Lind's analysis of the "aesthetic statement" (1993) has proved very useful.[7] The properties he ascribes to such aesthetic statements are in many ways similar to the properties of the astronomical demonstration instruments of the 18th century, and likewise their reception.

Orrery's orrery and other astronomical demonstration instruments

In the early 18th century, many London makers of the fashionable "philosophical instruments" were to be found around Fleet Street and St Dunstan's Church. One of them was John Rowley, who had his shop in Johnson's Court at the sign of the Globe.[8] Rowley was "Master of Mechanicks" to George I, and his instruments, which date from the period 1698–1720, are considered remarkable for their variety and excellent workmanship.[9] Among Rowley's patrons was Charles Boyle, 4th Earl of Orrery, who was particularly interested in mathematics and astronomy, and collected instruments related to these fields. One of

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4. Batteux 1746; Falconet 1765, pp. 834–837; 2003; Batteux 2015.
5. Burke 1887.
6. Harris 1731; Nollet 1743–1764; de Fontenelle 1852.
7. Lind 1993.
8. Taylor & Simms Wilson n.d., p. 3.
9. Taylor & Simms Wilson n.d., p. 6.

Image available only in the printed book

9.1 John Rowley, *Orrery*, 1712–1713. Brass, glass, ivory, steel, wood, *c.* 50 × 90 cm. Science Museum, London, inv. no. 1952-73.

the Rowley pieces from his collection is an astronomical demonstration model representing the motion of the earth/moon system around the sun. It rests on a drum containing a mechanism that powers the model by means of a crank, and thus requires the viewer's interaction to yield all the information it holds (*Fig.* 9.1). The revolving top is decorated with white stars on a blue background, and the side of the drum has a blue and gold chinoiserie design. An engraved brass ring resting on twelve brass balusters represents the zodiac or calendar, and a pointer shows the sun's position in the zodiac. Of the rotating parts, the sun is made of brass and the earth–moon system of ivory. The latter moves along the outer rim to show the yearly motion of the earth. The earth is carved with meridians and map-like features, while the moon is half white, half black to illustrate its phases.

This beautiful and much-admired object was known as 'The Orrery', and that eventually became the usual name for this type of object in English, while the established international term was tellurium or planetarium.[10] Rowley's tellurium was not the first; similar models had already been constructed by his neighbour, the clockmaker George Graham.[11] Telluria were also combined with armillary spheres, a type of model of the heavens known since antiquity

10. Millburn 1992, p. 7.
11. For the evolution of astronomical models, see King & Millburn 1978; Warner 1990.

9.4 Claude-Siméon Passemant, Louis Dauthiau, Jean-Jacques Caffieri and Philippe Caffieri, *Astronomical clock*, called the *Pendule Passemant*, completed 1753. Gilded bronze, glass, 206 × 83 × 53 cm. Musée national des châteaux de Versailles et de Trianon, inv. no. VMB 1037.

9.2 Richard Glynne, *Armillary orrery*, *c.* 1710–1730. Brass and ivory, h. 108 cm. History of Science Museum, Oxford, inv. no. 57605.

(*Fig.* 9.2). So-called grand orreries, consisting of orreries surmounted by armillary hemispheres, were a further variation.

Mechanical astronomical demonstration instruments are described by several ancient writers, who often attributed their invention to Archimedes.[12] In the 18th century, people thus thought of such objects as a classical legacy. Impressive pieces from more recent history were to be found in court collections, for example, armillary spheres driven by clockwork such as the *Sphaera Copernicana* made for Friedrich III of Holstein-Gottorp and completed in 1657 (*Fig.* 9.3, p. 142). Largely constructed by the court mathematician and librarian Adam Olearius, it reproduced the movements of the planets in real time. Even more spectacular was Friedrich III's large hollow celestial sphere, which people could step inside to see a painted representation of the heavens revolve around them. An 18th-century mechanical demonstration instrument in the courtly tradition is the *Pendule Passemant*, constructed by Claude-Siméon Passemant, "ingénieur-méchanicien du Roi", who spent 20 years calculating the mechanism (*Fig.* 9.4).[13] Crowned by a glass globe containing an orrery within an armillary sphere, it shows the movements of the heavens in real time, and its clockwork mechanism also moves a clock, a calendar, and a disc demonstrating the phases of the moon.

Scientific instruments could be unadorned, but the examples preserved in collections today were often designed to impress, and beautifully executed. In many cases, they had little to do with experiments and research, having been made for demonstration, teaching, and other functions such as display, play, or recreation. Such instruments often have a high degree of complexity, and their interpretation requires a certain intellectual effort; some of them also have an element of surprise, and, like Orrery's orrery, invite interaction.

12. See, for example, Wright n.d.
13. King & Millburn 1978, p. 285.

Design, art, and imitation

To a certain extent, scientific instruments correspond to the definition and function of sculpture given in the *Encyclopédie*: to imitate, through design and solid matter, the palpable objects of nature.[14] In the *Encyclopédie*, design indicates the conception of the work of art through the engagement of the creative, intellectual, and theoretical skills of the artist. In the case of astronomical instruments, these skills may be said to correspond to the knowledge needed to compute and construct the mechanism and to design the visualization of the astronomical information, while the instrument's material properties correspond to the "solid matter" mentioned in the *Encyclopédie*.

The acts of drawing and of giving shape to matter can be compared to the "statement of authorship", which Richard Lind posits is a necessary condition for a work of art: "Every artwork, it seems to me, carries the signs of authorship, the implicit declaration that the item in question has been intentionally produced. Because of the manner in which he or she plans, prepares, constructs, or exhibits an artwork, the artist necessarily communicates to the appropriate audience 'I created this'".[15] Early modern scientific instruments were nearly always collective creations, but they nevertheless were statements of authorship, above all of the intellectual effort behind their construction, and also of the skill required for its materialization, and, where relevant, of the aesthetic qualities of its outward form.

In Charles Batteux's treatise *Les Beaux-Arts réduits à un même principe* (1746) the arts are divided into three categories.[16] The first is the mechanical arts, which provide the necessities of life, the second group is the beaux arts, which exist to give pleasure, and the third group is a combination of the first two—they originate in necessity, but are perfected by taste. Beautifully made scientific instruments used in research can be said to fall into this last category, as they were necessary for the obtainment of scientific results but were also made to please the eye. Demonstration instruments, though, cannot be said to have been necessities, for their function was similar to that of the beaux arts as defined by Batteux (and many others), which is to please and instruct.

The imitation of nature was of fundamental importance in 18th-century art theory, and was the "single principle" referred to in the title of Batteux's treatise, with the idea that the artist should selectively seek *la belle nature* and then unite its parts into a new whole, more perfect than anything could ever be in

9.3 Adam Olearius, Andreas Bösch, Hans Schlemmer and Otto Koch, *Sphaera Copernicana*, completed 1657. Brass, wood, partly painted silver, 224 x 143 cm. Museum of National History, Frederiksborg, Hillerød, inv. no. B 17.

14. Falconet 1765, p. 834; 2003, n.p.
15. Lind 1993, p. 4.
16. Batteux 1746, pp. 5–6.

nature, yet still not unnatural.[17] Falconet's text on sculpture expressed similar classicist views, and both authors allowed for an element of speculative imitation—an artist might create things that are possible and believable according to the principles of nature.[18]

Though they were not the result of one artist's study, but of the accumulated observation and calculation of many generations, astronomical demonstration instruments can nevertheless be described as imitations of nature. Joseph Harris, for example, defined the orrery as an astronomical machine, made to represent the motions of the planets "as they really are in Nature".[19] The choice of materials and decoration for the more costly demonstration instruments often seems to have been motivated by a wish to give to what were very abstract constructions some semblance of the night sky as it appears to the human eye and imagination. Often, the sun is of polished brass, the moon is silvery, the base is blue and studded with stars, and the earth inscribed with the topography of land and water. Rather than imitations, such details are perhaps best described as allusions; as invitations to the viewer to call to mind and "see" the night sky or the earth as it might appear from another planet. Astronomical demonstration instruments thus not only show what we know of the heavens, but also recall our visual experience, as exemplified by de Fontenelle's description of the night sky and the stars: "elles étaient toutes d'un or pur et éclatant, et qui était encore relevé par le fond bleu où elles sont attachées" ("every orb appeared a mass of pure gold, rendered more brilliant by the rich blue of the sky").[20]

Though they demonstrate many aspects of astronomical knowledge, armillary spheres and orreries are nevertheless not exact representations of that knowledge. For example, it would be impossible to reproduce all the variations of the movements of the planets in such instruments, so these movements and other properties of celestial bodies are regulated approximations—idealizations, but made of necessity, not of artistic choice. However, such an idealization might still be experienced in a similar manner as idealized nature in art. In other words, an orrery or armillary sphere representing the eternal movements of the planets, with day following night, the march of the seasons, and the eclipses of the sun and moon as a harmonious, predictable, smoothly working clockwork, might be interpreted as an imitation of the essence as well as the entirety of *la*

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17. Batteux 1746, pp. viii–x, 8–9, 11–16, 74; in his translation, Young gives *belle nature* in French (Batteux 2015, pp. lxxx *et passim*); see Charles M. Young, 'Introduction', in Batteux 2015, pp. xv–lxxx, xix–xxii.
18. Falconet 1765, pp. 834–837; 2003, n.p.
19. Harris 1731, p. 152.
20. de Fontenelle 1803, p. 4; 1852, p. 39.

belle nature. For, according to Batteux, the limits of nature as an object for artistic study are as wide as those of the universe.[21] The fact that the Newtonian universe could serve as a metaphor for an ideal order was demonstrated by John Theophilus Desaguliers's dedication of his poem *The Newtonian System of the World, the Best Model of Government*:

> […] how is the Mind charm'd with the Beauty of the System? What Traces of Divine Wisdom do we see in the most regular Attraction of universal *Gravity*, (or Attraction) whose Power is diffus'd from the Sun to the very Centers of all the Planets and Comets, and acts upon the most distant of those Bodies, in as mathematical a Manner as it does upon the nearest?[22]

Astronomical demonstration instruments also seem to correspond to Batteux's answer to his own rhetorical question on the function of art: "C'est de transporter les traits qui sont dans la Nature, & de les présenter dans des objets à qui ils ne sont point naturels. C'est ainsi que le ciseau du statuaire montre un héros dans un bloc de marbre." ("It is to transport features that exist in nature and present them in objects to which they are not natural. In this way the chisel of the sculptor depicts a hero in a block of marble.")[23] To use Batteux's words, an orrery or sphere can "transport" the heavens—as a hero is transported into a block of marble, so the solar system is transported into a mechanism of wood and metal. But if we can experience the hero and his virtue from his marble likeness, as Falconet suggests in his discussion of sculpture, can we also experience something of real space when looking at an orrery?[24] Unless this is possible, it seems that instruments remain demonstrations of the solar system rather than imitations. For them to represent or imitate space, as idea and visible reality, as a sculpture does a hero, the beholder must be encouraged to use his or her imagination and willingly suspend disbelief.

Astronomical demonstration instruments thus seem to fit into Batteux's second category of art, but his further distinction between science and the beaux arts complicates matters. According to Batteux the object of science is truth,

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21. Batteux 1746, p. 12; 2015, p. 6.
22. Desaguliers 1728, dedication to Archibald Campbell, 1st Earl of Ilay, 3rd Duke of Argyll.
23. Batteux 1746, pp. 11–16; cit. p. 13. Young (Batteux 2015, p. 6) translates this passage as "It is to capture the properties of nature and represent them in an artefact. In this way the chisel of the sculptor depicts a hero in a block of marble." Batteux's phrasing conveys more clearly the fundamental, material difference between the original, natural phenomenon and its imitation in art. At the same time, "transport" indicates that something of the essence of the original is indeed embodied in the artwork. A more literal translation is the one used here: "It is to transport features that exist in nature and present them in objects to which they are not natural." The editors are grateful to Marie-Christine Skuncke for her generous and helpful comments on Batteux in translation.
24. Falconet 1765, p. 834; 2003, n.p.

but, he says, art is not truth but verisimilitude; it is a lie that has all the characteristics of truth.[25] Confronted with this statement, astronomical demonstration instruments become paradoxes. It could be argued that they are the exact opposite to art, being truths about nature while not looking like it (they have no real visual similarity to the night sky as seen by the human eye), but they might be said to be art, because while they seem like the truth as we know it to be, they are in fact idealized imitations.

Art and science inhabit different categories, according to Batteux. Truth is the object of science, goodness and beauty, the object of art.[26] To exercise understanding (the faculty required to distinguish truth from falsehood in science) is to see objects in their essentials, independent of ourselves; to exercise taste (the faculty for appreciating and judging the beaux arts) is to see objects as they are related to us.[27] Or as Batteux puts it, "La connoissance est une lumière répandue dans notre âme: le sentiment est un mouvement qui l'agite. L'une éclaire: l'autre échauffe" ("Knowledge is a light spreading in our minds. Sentiment is a passion that agitates it. The one illuminates, the other heats").[28] Falconet, too, described the experience of the spectator, in his case exemplified by Caesar, who on beholding a statue of Alexander burst into tears and addressed it in person.[29] Such sculptures were the most durable depositories of human virtue, and, from a moral point of view, the worthiest goal of sculpture was to immortalize the memory of illustrious men and provide models of virtue.[30] It was thus no coincidence that Batteux exemplified the function of art with a marble block transformed into a hero. The highest form of imitation was not that of the outward forms of *la belle nature*, but of an inspiring virtue, visualized in the human body and human action.

Despite their often decorative appearance, astronomical instruments functionally belong to science, and would not have been classified as sculpture by Batteux. There is no indication that anyone thought of astronomical demonstration instruments as sculptures (while they might have admitted that their

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25. Batteux 1746, pp. 14–16; 2015, pp. 6–7.

26. Batteux 1746, p. 56; 2015, p. 30. Young (Batteux 2015, pp. xxxviii–xliii) argues that Batteux sees art as a source of knowledge (aesthetic cognitivism), particularly about human nature, emotion, and ethics. This might seem to contradict Batteux's strict division between science and the beaux arts, but the nature of the knowledge offered by the arts is different from the absolute, factual truths of science. More importantly in this context, while art may provide a certain kind of knowledge, there is no indication in his text that scientific truths can provide aesthetic pleasure or emotional experiences.

27. Batteux 1746, p. 56; 2015, p. 30.

28. Batteux 1746, p. 58; 2015, p. 30.

29. Falconet 1765, p. 834; 2003, n.p.

30. Falconet 1765, p. 834; 2003, n.p.

decorative features had sculptural or artistic qualities).[31] However, Batteux's definitions were largely based on the perceptions and experiences he ascribed to individuals who occupy themselves with art or science—but were these perceptions and experiences really as different and separate as he supposed? If not, perhaps orreries and armillary spheres, though not classified as sculpture, may have been experienced in a similar manner?

Pleasure and awe, art and science—and the cosmos

Batteux sees imitation as one of the main reasons for the pleasure that the beaux arts afford, for the mind is exercised when comparing, say, the model with the portrait, and the process of making this judgement is all the more pleasant, as the mind is aware of its own penetration and intelligence.[32] (Not that a comparison of portrait and model should be understood as a mere comparison of physical likeness; rather it is a recognition of the known facts of the model's life and character in the artist's representation. This kind of imitation is what "transporting a hero into a block of marble" really means.) Batteux's analysis of the process comes close to Richard Lind's explanation of why objects catch and hold our interest: "at the basic level is our fundamental inborn need to make sense of our world through discrimination—call it *perceptual* interest", and "At the *meta* level is the 'learned' interest in enjoying that process—call it *aesthetic* interest".[33] A model such as an orrery cannot be compared to a visual original, but the intellectual processes and experiences of an attentive audience at a demonstration are surely similar? The audience compares the facts explained by the demonstrator to what they see before them and are pleased by their own understanding.

In *Entretiens sur la pluralité des mondes*, de Fontenelle popularized the astronomical discoveries of the 17th century in the form of imaginary conversations on astronomy between a philosopher and a marquise (*Fig.* 9.5, p. 148). In the

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31. In Zedler's *Universal-Lexicon*, Seth (the third son of Adam and Eve) is said to be one of the first practitioners of sculpture, as he engraved the secrets of astronomy on two pillars of brick and stone, but later scientific objects are not included in the category of sculpture (1732–1754, vol. 3, p. 977, "Bildhauer-Kunst".

32. Batteux 1746, p. 17; 2015, pp. 7–8. Batteux's wording is "L'esprit s'excerce dans la comparaison du modèle avec le portrait", which Young translates as "the mind engages in comparison of the original and the copy". However, the original phrase can also be interpreted as an example, where the mental process Batteux wishes to explain is illustrated by the comparison of portrait and model. Eighteenth-century portrait theory accords perfectly with his reasoning. The comparison of models (living as well as historical) with portraits was an activity with which his readers would have been familiar, and as the human being as a model for a work of art included not only his or her external form, but also all known facts about the individual's life and character, the comparison would be a more challenging and ultimately pleasurable experience than, for example, the comparison between a painted bowl and a real one; see Laine 2006, pp. 36–40.

33. Lind 1993, p. 7.

introduction, the author admits that understanding the subject of his book requires a little effort, and compares it to the application needed to make sense of a work of fiction, if one wants to follow the plot and fully appreciate all its beauties. The effort is rewarding, as the subject matter satisfies the mind and at the same time charms the imagination.[34] The words pleasure and pleasant recur several times in the conversations, and the marquise assures the philosopher that she is capable of pleasures that appeal only to the mind.[35]

9.5 Anonymous artist, frontispiece from Bernard le Bovier de Fontenelle, *Entretiens sur la pluralité des mondes*, 1719 [1686].

A comparison between scientific studies and literary experience can also be found in a lecture given by the Swedish physicist Johan Carl Wilcke on the utility, pleasantness, and encouragement of the natural sciences.[36] Wilcke likened the student's increasing understanding of nature to that of the theatre-goer's increasing understanding of a play. Wilcke and de Fontenelle thus compared the comprehension of nature to the comprehension of a literary plot, and both processes were seen as sources of pleasure to the mind, as the marquise might have put it. A serious study of nature, and the pleasure derived from understanding it, seems very close to the perfect and solid pleasure Batteux demands from poetry, which he defines as one of the beaux arts.[37] Both science and art, then, are tools for the cultivation of the mind, the *cultura animi*. The arguments of de Fontenelle, Wilcke, and many others make it clear that this elevated pleasure is not the consequence of the truth per se—the sole object of science according to Batteux—but of the effect the comprehension and reception of truth has on the mind.

In the 18th century, the infinity of space and the heliocentric world-view had been contested until comparatively recently. It seems probable that this intensified people's experience of space as unending—its infinity was not only a fact, but a discovery. In his sixth lecture on experimental physics, the French priest, physicist, and instrument-maker Jean-Antoine Nollet reflected on the beauty and infinity of space:

34. de Fontenelle 1803, pp. xiii–xiv; 1852, p. 35. Further on, de Fontenelle (1803, pp. 8–10) compares nature to the plot, scenery, and machinery of a theatrical performance.
35. de Fontenelle 1803, p. 7; 1852, p. 41: "Croyez vous qu'on soit incapable des plaisirs qui ne sont que dans la raison?".
36. Wilcke 1762, pp. 11–15.
37. Batteux 1746, p. 150; 2015, p. 77.

> Rien assurément n'est plus digne de notre curiosité que ce brillant spectacle, que la nature fait éclater nuit & jour à nos yeux; il est si beau, il est si magnifique, & le globe que nous habitons en est une si petite partie, qu'en y réfléchissant, un homme modeste n'oseroit croire qu'un si grand appareil ait été fait uniquement pour lui & pour ceux de son espece.
>
> Nothing is more worthy of our curiosity than this brilliant spectacle that nature reveals day and night to our eyes: it is so beautiful, so magnificent, and the globe we live on is such a small part, and when one considers the small globe where we live, a modest man does not dare to believe that such a great apparatus was made uniquely for him and his kind.[38]

A consequence of the new astronomical discoveries was thus the realization that other planets and other solar systems might be inhabited.[39] Joseph Harris also introduces the subject of life in space, and concludes that God must have created the bright stars for a reason, and that reason probably was to give light to other inhabited worlds, ad infinitum. "What a magnificent Idea must this raise in us of the Divine Being! Who is everywhere, and at all Times present, displaying his Divine Power, Wisdom and Goodness amongst all his Creatures."[40] Such thoughts were expressed by many writers, and are summed up in the title of William Derham's *Astro-Theology: Or a Demonstration of the Being and Attributes of God from a Survey of the Heavens* (1714).[41]

Writers such as Nollet, Harris, Wilcke, and others who celebrated scientific discoveries in physico-theological terms very obviously saw space not only as it was, but in relation to themselves. Their souls were not only illuminated, but moved and "warmed", to repeat Batteux's definition of the differences between the beaux arts and science. Nollet stated in the introduction to his lectures that the further one advances in the study of nature, the more one perceives God's infinite power and profound wisdom, and that the marvels so seen speak to the heart as well as the mind.[42] Nollet's and Harris's reflections on space express emotions that are the result of an intellectual process of understanding, but, unlike de Fontenelle, they felt awe rather than pleasure.

These emotions recall the discussion in Edmund Burke's *A Philosophical Enquiry into the Origin of our Ideas of the Sublime and Beautiful* (1759) of the astonishment, admiration, reverence, and respect caused by the sublime.[43] For him, fear

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38. Nollet 1764, vol. 6, p. 2, leçon xviii.
39. Crowe 1999 gives an introduction to the subject from antiquity onwards.
40. Harris 1731, p. 34.
41. See Jones 1966, pp. 1–32, 79–159 *et passim*.
42. Nollet 1743, vol. 1, p. xli.
43. Burke 1887, pt ii, sections i–iv.

was the fundamental cause of the sublime experience, but it is a fear that can cause delight, and he gives the starry heavens as an example of sublime magnificence. Infinity, obscurity, grandeur, vastness, and the notion of an all-powerful God were acknowledged causes of the sublime experience and are present in the texts quoted above—obscurity especially in an intellectual sense, as a lack of knowledge.[44] Understanding that space is infinite and may contain an infinite number of worlds meant understanding that human knowledge is limited and will remain so: "the ideas of eternity, and infinity, are among the most affecting we have: and yet perhaps there is nothing of which we really understand so little, as of infinity and eternity".[45] In this reasoning, the properties of astronomical demonstration instruments are in some ways incompatible with the sublime. As idealized imitations of the solar system, they do not convey space as infinite and obscure, but on the contrary give a clear idea of it, and "clearness" is—according to Burke—the enemy of all enthusiasm.[46] Instruments do not necessarily have any aesthetic properties, for neither clearness, proportion, perfection, nor utility define objects aesthetically:

> When we examine the structure of a watch, when we come to know thoroughly the very use of every part of it, satisfied as we are with the fitness of the whole, we are far enough from perceiving anything like beauty in the watch-work itself, but let us look on the case, the labour of some curious artist in engraving, with little or no idea of use, we shall have a much livelier idea of beauty than we ever could have had from the watch itself, though the masterpiece of Graham.[47]

Beautiful objects are delicate, comparatively small, their surfaces are smooth, their form and colour softly graduating.[48] (It should be noted that Nollet's "beau" is clearly different from Burke's "beauty".) Some large armillary spheres and orreries may give the impression of magnificence, but compared to what they represent, all astronomical demonstration instruments with aesthetic qualities must be considered beautiful rather than sublime. Beauty, as distinct from the sublime, causes love, not fear, and pleasure, not pain. Burke, like Batteux, stresses that the result of imitation (in the visual arts) is pleasure, another reason that precludes astronomical demonstration instruments from prompting a sublime experience.[49]

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44. Burke 1887, pt ii, sections i–viii, xiii.
45. Burke 1887, pt ii, sections i–iv, cit. section iv.
46. Burke 1887, pt ii, sections iii–iv.
47. Burke 1887, pt iii, section viii. 'Graham', refers to George Graham, see above in this chapter.
48. Burke 1887, pt iii, sections xii–xviii, xxvi.
49. Burke 1887, pt i, section ixv.

On the other hand, Burke states that a drawing can have the same effect as the object it represents.[50] Also, though "The ideas of the sublime and the beautiful stand on foundations so different, that it is hard, I had almost said impossible, to think of reconciling them in the same subject, without considerably lessening the effect of the one or the other upon the passions", such combinations are to be expected in nature as well as art. Burke concludes that

> […] the sublime suffers less by being united to some of the qualities of beauty, than beauty does by being joined to greatness of quantity, or any other properties of the sublime. There is something so overruling in whatever inspires us with awe, in all things which belong ever so remotely to terror, that nothing else can stand in their presence. There lie the qualities of beauty either dead or unoperative; or at most exerted to mollify the rigor and sternness of terror, which is the natural concomitant of greatness.[51]

This brings us to the question of whether astronomical demonstration instruments can inspire terror in a sufficient degree for them to affect us in the same way as the space they represent. Joseph Wright of Derby's *A Philosopher Giving that Lecture on an Orrery, in which a Lamp is put in the Place of the Sun* (*Fig.* 9.6, p. 152) represents a rare attempt to recreate the visual effect of an orrery, as opposed to an exact account of its features, and to represent the individual responses of the viewers. It is one of several paintings where the artist made the contrast of light and darkness an essential part of the composition, but in this case, this contrast has a particular bearing on the subject of the image.[52] The partial darkness, or blackness as Burke calls it when compared to other colours, introduces obscurity, and, like the figures obscuring parts of the orrery, dissolves the "clearness" of the instrument itself. Wright also opens up the orrery in several ways, drawing the viewers into the thing they are looking at. The rings of the instrument are reflected on their bodies, and the girl in the middle of the painting has moved her hand into the armillary hemisphere. She almost touches one of Saturn's moons, as if to comment on size and relativity: the sphere of the orrery is infinitely smaller than the real moon it represents, yet in comparison to the vastness of space, a real moon is of less significance than a child's fingertip. The shiny surface below reflects parts of the orrery's heavenly bodies, making the solid base of the instrument dissolve into a miniature space, where a further solar system—perhaps one of the possibly infinite numbers of such systems?—

50. Burke 1887, pt ii, sections iii–iv.
51. Burke 1887, pt iv, section xxiv.
52. For discussions of this painting, see Nicolson 1968, pp. 40, 112–115; Busch 2000, pp. 33–37; and especially Fraser 1988, pp. 121–124, who addresses the experiences and emotions of the persons depicted in the painting.

can be glimpsed. Thus as interpreted by Wright, the orrery in function seems an excellent example of an object combining the properties of the beautiful and the sublime. At the same time he demonstrates that the viewer's experiences not only depend on the properties of what is seen, but also on those who see it.

Wright's painting can be read as an allegory of the process of the human intellect towards illumination. The brightly lit boy and girl, fascinated and smiling, experience the desire for and pleasure in novelty, which according to Burke is the first and simplest emotion of the human mind, and characteristic of childhood. The children are absorbed in the orrery itself, with its small, smooth, bright objects that move, lit by the lamp at the centre, representing the sun. Interpreted in Burke's terms, they see beauty, and feel pleasure. The young man to the right, who looks towards the philosopher as if for guidance, seems to represent a more mature version of curiosity, illustrating that "Some degree of novelty must be one of the materials in every instrument which works upon the mind; and curiosity blends itself more or less with all our passions".[53] The half-

9.6 Joseph Wright of Derby, *A Philosopher Giving that Lecture on an Orrery, in which a Lamp is put in the Place of the Sun*, 1764–1766. Oil on canvas, 147.3 × 203.2 cm. Derby Museum and Art Gallery, Derby, acc. no. 1884-168.

53. Burke 1887, pt i, section i.

smile of the young man to the left, writing, also seems to repeat the experiences of the children in a more mature manner, in his case pleasure—his smile perhaps indicates the mind's pleasure at its own intellectual process, as identified by Batteux and Lind. The young woman to the left and her pendant, the young man to the right, with his cheek resting in his hand in the classic gesture of melancholia, are as absorbed as the children, but they are not smiling. Their faces rather express awe or fear at the realization of the meaning of what they are seeing, recalling Nollet's comment that the marvels that we perceive speak to the heart as well as the mind.[54] The philosopher who presides over the scene is more difficult to read. While the title refers to a philosopher giving a lecture, he is in fact not lecturing, but contemplating the notes taken by his student. His glance could be understood as that of a teacher checking results, but also as that of a philosopher contemplating the meaning of those results, as the young man and woman are contemplating the meaning of the orrery, again creating a dialogue between naïve and mature versions of the same experience—in this case awe, as his serious expression indicates. The subject occupying all these intellects is space, which is here at the same time a beautiful toy, an object of study, and a manifestation of sublime and incomprehensible infinity. The partly hidden light may be the light of knowledge, but equally the light of faith, for, as we have seen, to study the cosmos is to study its Creator, and to gain some understanding of it is to gain some understanding of Him, so far as it is humanly possible.[55]

While one painting does not constitute proof of a general argument, Wright's account of an orrery in the process of being experienced indicates that astronomical instruments were indeed capable of imitating that which they represented, and of causing an effect similar to that of the subject so represented. Looking at an orrery, some viewers would be willing to suspend disbelief, and see and experience space in a mechanism made of wood and metal, as they might see and experience a hero in a piece of marble. Acts of imagination were in fact explicitly required of participators in astronomical demonstrations. Harris and Nollet mingle abstract astronomical information, explanations of the applications of the instruments, and exhortations to their audience to use their imagination to compensate for circumstances that could not be correctly represented in the instrument.

The clockwork demonstration instrument known as the *Pendule de la création*

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54. Nollet 1743, vol. 1, p. xli.
55. See Jones 1966, p. 15: "In books written for the instruction and amusement of amateurs, especially ladies and young people, the instruction extended to moral and religious applications that included the physico-theological ideas of the poetry of the time"; Walters 1997, 129: "polite science celebrated the notion that nature demonstrated the wisdom and working of God".

9.7 & 9.8 Claude-Siméon Passemant, Joseph-Léonard Roque and François-Thomas Germain, *Astronomical clock*, called the *Pendule de la création du monde*, completed 1754. Wood, patinated, silvered and gilded bronze, enamel, 150 × 92 × 76 cm. Musée national des châteaux de Versailles et de Trianon, inv. no. VNB 1036.1.

du monde (*Figs* 9.7 & 9.8) can arguably also be interpreted as an attempt to visualize the experience of space as sublime.[56] In the lower part of the case, made of patinated, silvered and gilded bronze, water cascades over rocks, and above, clouds rise towards a radiant sun—representing the four elements in a composition visualizing the Creation, especially the verses in Genesis where God calls forth light, separates the waters from the heavens, causes the waters to gather in one place so that dry land appears, and sets the sun, moon, and stars in the sky "to divide the day from night, and let them be for signs, and for seasons, and for days, and years".[57] Set among the elements thus represented are the moveable components of the instrument: a moon and a rotating terrestrial globe, engraved with a map of the world, and a separate tellurium of the solar system. The sunburst, containing a clock, is aligned with the terrestrial globe, so that its downward ray indicates the sun's zenith on the globe.

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56. See for this instrument Durand, Bimbenet-Privat & Dassas 2014, pp. 280–281.
57. King James Version, Gen. 1:14.

The multiple suns and planets in the *Pendule* visually create a sense of several planets and planet systems, literally a *pluralité des mondes*. The instrument can thus be read as a fusion of Genesis with the new world-view: God's creation, visualized through the billowing baroque forms of the elements and the triumphant, radiant sun, is not limited to Earth; rather, it is an action that encompasses the cosmos, in a sort of Big Bang *avant la lettre*. In daylight, the effect of the *Pendule* is impressive, but in the dark—in which the Creation began, according to Genesis—and lit with candles, its precision dissolves into partial obscurity and, as in Wright's painting, darkness becomes part of the spatial, perceptual, and emotional experience of the viewer. The Creator is not visible, but the sunburst is reminiscent of baroque monstrance designs, and this allusion indicates that the *Pendule* is indeed a religious object. Its theme reminds us that time is yet another aspect of the sublime. According to Christian belief, time has a beginning and an end, and thus is not the same thing as infinity, but it nevertheless represents vastness, a scale difficult for humans to grasp. Nollet describes astronomy as an ancient practice, beginning at the moment when the first humans looked up at the stars, but the *Pendule* goes even farther back, to when God was at work at the very beginning of time, before the creation of Adam and Eve.

The *Pendule* is unique, but the belief it expresses was not, as we have seen. To 18th-century audiences, nature was God's creation, including infinite space and all that might be in it. That the Christian pictorial convention of an anthropomorphic God may have been difficult to reconcile with the changing world-view can be inferred from Isaac Newton's words on God in the 'General Scholium' of *The Mathematical Principles of Natural Philosophy* (1729 [1713]): "He is utterly void of all body and bodily figure, and can therefore neither be seen, nor heard, nor touched; nor ought to be worshipped under the representation of any corporeal thing [...] We know him only by his most wise and excellent contrivances of things [...]".[58] The *Pendule* can be experienced as an attempt to "show" this Newtonian God in the act of contrivance, while astronomical demonstration instruments in general demonstrate the "wise and excellent" result.

The aesthetic experience

It thus seems reasonable to claim that astronomical demonstration instruments could be thought of not only as demonstrations of space, but as imitations, and that an experience of space—be it pleasure or awe—could be stirred by the instrument, as an experience of the heroic might be stirred by the imitation of a hero's physical form in marble. Experiencing a demonstration of an orrery

58. Newton 1729, p. 391.

could thus be regarded as parallel to experiencing a sculpture. Plainly, the sharp division between the nature and effects of art and science as defined by Batteux was not valid for everyone: scientific facts affected not only the mind but the heart. Taking this reasoning a step further, astronomical demonstration instruments could not only be analogous to art: for those who saw God in nature, they could be analogous to a religious, physico-theological art.

It remains to consider how far the materials, design, and three-dimensionality of these instruments were concerned in such experiences. Participation in an astronomical demonstration could lead to what Batteux describes as the mind taking pleasure in its own intellectual activity, and Lind defines as the aesthetic experience: we appreciate the ability of an aesthetic object to challenge and ultimately satisfy our perceptional curiosity, and the aesthetic experience consists of the pleasure taken in the process of making the object intelligible. It must not be too easy to interpret, nor too difficult; if it is too trivial we become bored, if it is too chaotic or complicated we become frustrated and the experience is unenjoyable.[59] Astronomical demonstration objects were sufficiently complicated to hold attention on repeated occasions—as indicated by the long, detailed explanations necessary for the setting up and interpretation of the demonstrations, especially as orreries of the more advanced kind also had moveable parts so they could imitate a variety of astronomical phenomena. Yet Lind identifies a category of objects that are not art, and for which aesthetic statements are their secondary function, while their primary function is, for example, to provide information.[60] Such objects tend to lead our attention away from the arrangement of the medium—which is what provides the aesthetic experience—to what the arrangement is *about*. An orrery or armillary sphere might be supposed to fall into this category; however, as Wright's painting and the writers quoted above indicate, in experiencing, for example, an orrery, Lind's "arrangement of the medium fuses with the meaning conveyed by that medium", so that the object becomes art. While understanding that the information conveyed is about the universe, the mind would remain fixed on the instrument and continue to experience it as an aesthetic object, and at the same time experience space *through* the instrument, existing, perceiving, comprehending, and feeling in several dimensions simultaneously. The significance of three-dimensionality becomes apparent in Wright's image or the *Pendule de la création du monde*, for three-dimensional objects, be they orreries or sculptures, envelop the viewer in the same space that they themselves occupy. When this object space literally *is*

59. Lind 1993, pp. 9–10.
60. Lind 1993, pp. 16–17.

space, the viewer is in some sense transported. The cosmos is no longer outside the room, or up in the sky, but is an all-encompassing infinity that begins at a child's fingertips. Instruments of spectacular materials and design might be considered more conducive to this state of mind than more modest examples (*Fig.* 9.9), yet we should remember Wright's realization that perception to a large extent depends on the perceiver.

9.9 Anonymous maker for John Jones, *Orrery*, late 18th century. Wood, copper alloy, paper, 16.4 × 33.6 cm. History of Science Museum, Oxford, inv. no. 29710.

To conclude, astronomical demonstration instruments were made to gain and hold attention, but this effect does not solely depend on materials, design, and craftsmanship, nor on the fact that they demand intense observation, attention, and imagination, nor on the complex information they convey. They occupy an ambiguous and paradoxical position in relation to Batteux's divisions between truth and verisimilitude, science and art. As noted above, it could be argued that these instruments are the exact opposite to art, since they are truths about nature, but do not look like it; i.e., they have no real visual similarity to the night sky as seen by the human eye. On the other hand, they might be said to be art because they seem like truth as we know it to be but are in fact idealized imitations.[61] Burke stipulated another division—that between the beautiful and the sublime—although he admitted that these opposing qualities could be found in the same object. Orreries and armillary spheres are not only embodiments of this opposition, their design and function specifically combine them. Finally,

61. See also Lind 1993, p. 10: "Ambiguity, paradox, metaphor, simile [...] are tricks of the trade in every artistic discipline."

these instruments elicit experience, and, as Wright so beautifully demonstrated in his painting, experience depends on individual reception. Not only different people, but the same person at different stages of emotional and intellectual development will perceive them differently. The fluidity of this reception tends to further destabilize attempts at definite statements about the objects themselves, and about the nature of science and art.

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Change in the individual was the desired result of the study of nature and the contemplation of art alike. In Falconet's definition, the highest function of sculpture is to inspire the viewer to virtue, and Burke states that "[t]he elevation of the mind ought to be the principal end of all our studies", and these studies are ultimately a "contemplation of the works of infinite wisdom", that is, of God.[62] This effort at self-improvement, the *cultura animi*, seems to be the principle that ultimately bridges art and science, sculpture and scientific instruments.[63]

62. Burke 1887, pt i, section xix.
63. For the *cultura animi* in early modern experimental science, see Corneanu 2011.

10.1 The Observation Room in the old Observatory, Stockholm, architect Carl Hårleman, 1753. The instruments on display are (from the left) a refracting telescope by John Dollond, a quadrant by John Bird, and a reflecting telescope by John Cary.

10 A material turn in the study of early modern scientific heritage

THINGS MATERIAL CAN provide essential information about our past. This chapter discusses the nature and relevance of early modern material scientific heritage.[1] The focus is on the possibilities and particular difficulties of dealing with tangible objects as opposed to immaterial heritage. Material scientific heritage could potentially provide relevant contexts not just for historians of science, but for any cultural historian. Methods of a number of disciplines as well as interdisciplinary approaches are advocated. The main institutional settings of research and research output discussed here are the museum and the university. The case of astronomical heritage is used as an example.

There has been a renewed interest in material culture in the humanities in the past few years. We may talk of a material turn as opposed to (or superseding) a linguistic turn. There is a rich source of early modern material heritage which can provide the cultural historian with various forms of information and context. Why are these sites, monuments, and artefacts so interesting?

What is material scientific heritage?

Material heritage is the tangible and physical heritage of the past—objects, artefacts, sites, and monuments. This can be contrasted with immaterial heritage, or intangible heritage, which is not manifested in a physical form, and encompasses traditions, knowledge, skills, and languages which are passed on from generation to generation. Both material and immaterial heritage are recognized at the international level by UNESCO as valuable and worth preserving.[2] The

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1. This chapter was first published in Wåghäll Nivre *et al.* 2013, pp. 269–284.
2. UNESCO 1972; UNESCO 2003.

perceived relevance of material heritage has varied, but at present is attracting increased interest among academics.[3]

Material scientific heritage is material heritage which is related to science. Here we have two problematic issues: How closely related to science must material heritage be to be classified as "scientific"? And what do we mean by "science"? The concepts of science, scientific, and scientist are in contemporary usage strongly linked to the natural sciences, meaning those used to study the physical world, for example, physics, chemistry, geology, biology, and botany. Science is considered to be "a branch of knowledge conducted on objective principles involving the systematized observation of and experiment with phenomena".[4] When we think of science, we often refer to the method of observation, and in particular to research in the form of observation and experimentation at a university or similar institution. The concept of science exists in opposition to pseudoscience, and its practitioners are trained professionals as opposed to amateurs. However, if we wish to use the words science, scientific, and scientist when referring to early modern Europe it becomes complicated, because to do so is anachronistic, in that these terms were first used in their current sense in the 1830s.[5] In early modern Europe, "science" referred to a generalized knowledge base, more so than our contemporary understanding of the term. A further complication is that what was considered science and a scientific object changed with time.[6]

In order to make sense of the term "material scientific heritage", I am inclined to start with a contemporary definition of science in order to outline the field, even if anachronistic. For example, I call both a 17th-century telescope and an 18th-century air pump scientific instruments, because it makes sense to me in my contemporaneity, whereas an early modern user would most likely have categorized the first as optical and the second as philosophical.[7] In early modern Europe, collections of material scientific heritage were not divided from collections of material artistic heritage, regardless of the institution.[8] Sweden has an outstanding example of an early modern collection of material heritage with such an adisciplinary approach to learning: the Augsburg Art Cabinet in the Gustavianum (Uppsala University Museum). It was presented to the Swedish King Gustav II Adolf in 1632 by the councillors of Augsburg. The cabinet

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3. See, for example, Hicks & Beaudry 2010.
4. Allen 2008, pp. 790, 1081.
5. Collini 2008, p. xi–xii.
6. Daston 1998.
7. Warner 1990.
8. Impey & MacGregor 1985.

contained ancient artefacts, natural history specimens, coins, household equipment, paintings, musical instruments, scientific instruments, and so on. It promoted a kind of cross-disciplinary learning and referencing which later became unfashionable. Remarkably, the cabinet survives with most of its original contents intact. This is unusual, as such collections were often dispersed in the 19th century, when art and science were separated in the construction of disciplinary boundaries. In recent decades there has been a renewed interest in recreating these early modern multidisciplinary collections, but they are hard to reconstruct, as objects need to be traced in a great number of different types of institutions.

In the 18th century, it became increasingly popular to create particular sites for observational and experimental science. However, if we think of these places only in terms of modern disciplinary boundaries, it will lead us astray, as disciplinary boundaries and relevant contexts are constantly changing. The cross-disciplinarity of early modern science can confuse. It presents a juxtaposition of science and pseudoscience, amateur and professional, research and play, scientific instrument and toy. It strikes us as odd that in the 18th century the Royal Swedish Academy of Sciences had not only astronomical instruments in its observatory, but also an Egyptian mummy, an embalmed child, ancient coins, exotic animals, plants, utensils, weapons, and archaeological finds from Swedish graves. Many of the artefacts collected and activities performed at the site were probably not "scientific" in our contemporary use of the word. Still it makes sense to label the site and the artefacts as scientific heritage because they are related to—even if not synonymous with—our understanding of science. Yet if we were to study this site by focusing solely on astronomy as defined in a modern research department of astronomy, much of the history of this site would be neglected or considered pointless.

An interesting account of early modern astronomy was given in the English poet Edward Sherburne's book *The Sphere of Marcus Manilius Made an English Poem: With Annotations and an Astronomical Appendix* from 1675.[9] The book contains up-to-date astronomy and an annotated English translation of the astronomical and astrological poem *Astronomicon* by the Roman poet Marcus Manilius from the 1st century AD. It is an example of the strong relationship between classical scholarship and astronomy so relevant to astronomers in the 17th century, and motivated by the very long series of observations to hand—astronomy was an ancient practice, and not one of the sciences developed in the early modern times. The book contains 'A catalogue of the most eminent astronomers, ancient

9. Sherburne 1675.

and modern'.[10] The list starts with the first man, Adam. His particular achievement, according to Sherburne, was to teach his son Seth astronomy. Seth is thus the second name in the catalogue, and the third is another near descendant of Adam, Enoch, with many biblical men to follow: Abraham, Moses, and Solomon (the Bible has several quotations related to the stars, enough to justify astronomy as an activity for those in 17th-century religious orders). Besides biblical figures, Sherburne included names such as Ptolemy and Hipparchus, who were well-known for their astronomical work. More surprising, though, was his inclusion of Julius Caesar, the poet Ovid, and Charlemagne. This inclusive definition of astronomer makes our modern understanding of a university-educated person involved in research at an institution seem rather narrow-minded. The early modern people who labelled themselves astronomers were as varied as those listed by Sherburne, but they all shared an avid interest in the theoretical and practical observation of the heavenly bodies.

The material heritage of astronomy has recently attracted international attention. Concerned that the achievements of science were underrepresented on the World Heritage list, in 2008 UNESCO and the International Astronomical Union (IAU) signed a memorandum of understanding to draw attention to and raise sites connected to astronomy to World Heritage status. A global thematic study of monuments from the earliest remains of human activity up to space heritage has been undertaken and published by the International Council on Monuments and Sites (ICOMOS).[11] Embracing a vast material and produced in a short time by a limited number of people, the study is necessarily highly selective. The editors are Clive Ruggles, an astronomer and archaeologist, and Michel Cotte, a historian of technology, and most of the contributors focus on archaeology and technology in relation to astronomy. The first of the case studies is the "Thaïs bone", an inscribed bone fragment thought to be a 12,000-year-old record, possibly of observations of solstices. Other studies include the astronomical rock panels in Lascaux, the pyramids of Giza, Stonehenge, the Pantheon in Rome, Strasbourg cathedral, and many examples outside Europe. Modern applied astronomy and space heritage are also highlighted. The working definition of astronomical material heritage is rather varied.

Interestingly, though, Ruggles and Cotte downplay the role of material scientific heritage, asserting that the "core of scientific knowledge is mainly intangible".[12] The relevance of archives and documents is strongly emphasized. They oppose an evaluation of scientific sites where the history of architecture

10. Sherburne 1675.
11. Ruggles & Cotte 2010.
12. Ruggles & Cotte 2010, p. 7.

and urbanism is given priority, and promote one which first takes immaterial scientific results into account. This statement was likely more the result of the editors' hope that historians of architecture should not be the only researchers to decide which astronomical sites be included in the World Heritage list than any dismissal of the importance of material scientific heritage.

The thematic study only has a few case studies of early modern sites and artefacts. Ruggles and Cotte justify this choice by stating that studies of that kind have already been published, and that the material heritage from the early modern period is vast. The quantity of heritage cannot be doubted, but I cannot agree that the astronomical heritage of a country such as Sweden has been fully covered in print. That said, a comprehensive thematic study would have been an impossible task, and the omission allows a greater number of sites and objects to be brought into focus, showing the rich variety of cultural heritage connected to astronomy. There is room for researchers in other disciplines to contribute to the global history of astronomy and its many cultural contexts. The thematic study of astronomical material heritage is a very promising example, and hopefully will encourage the further study of the material heritage of other sciences.

Availability, problems, and possibilities

We are surrounded by material heritage from the past. Libraries and archives are essential institutions for material scientific heritage, sometimes also being the sites where early modern science was practised. But it is easily forgotten that many early modern libraries collected and displayed *naturalia*, coins, exotic artefacts, and scientific instruments, to be used together with library books.[13] Many libraries and archives provide excellent research facilities and tools for the study of text and the materiality of text; few offer a similar degree of access to the non-text-based objects in their collections.

Next to libraries, museums are the obvious institutions for early modern monuments, objects, and artefacts. Museums and their collections have the potential to be key resources for material research, but there is one main drawback: many of them are not capable of meeting the needs of academic research, as they lack the facilities and infrastructure. However, some, such as university museums, are making exceptional efforts to facilitate academic research and teaching;[14] and some are publishing extensive information about their holdings, making conservation reports accessible, and digitizing artefacts and site records. This is in stark contrast to institutions whose collections are not even

13. Garberson 1998, pp. 45–64.
14. Lourenco 2005.

properly catalogued, making it difficult for the researcher to know of their existence. The example of the Royal Swedish Academy of Sciences is not unusual, with its scientific instrument inventory of some 6,000 items, of which only some 300 are described in its published catalogue.[15] Producing qualitative catalogues is not just a question of compiling lists, of course, and the research required is specialized and time-consuming, leaving it beyond the reach of many institutions. Another problem is that many objects are on display in inaccessible cases or not at all, and remote storage is often awkward to access. There is also a perceived tension between university and museum research which needs to be overcome. University researchers tend to believe that museum research is lacking in theory, and it may be true that some museum research is innocent of theory, or that it is largely invisible in an exhibition context. Museum researchers, meanwhile, tend to think that university research is bogged down in theory and productive disagreement, and blind to the evidence of the heritage it supposedly addresses.[16] This rift between artefact-minded scholars, antiquarians, and "men of letters" already existed in early modern Europe.[17] The ideal, of course, would be co-operation, which would allow for both theoretical perspectives and a full consideration of material cultural heritage.[18]

Artefacts and objects can find their way into very different kinds of collections and museums. In Stockholm and its vicinity, the material scientific heritage of the early modern period is found in a number of collections. The largest is in the Royal Swedish Academy of Sciences, but notable collections are also found in the National Museum of Science and Technology, the National Maritime Museums, Nordiska museet, the Royal Collections, the Swedish History Museum, the Royal Armoury, the Army Museum, and Nationalmuseum, the Gustavianum (Uppsala University Museum) in Uppsala, and Skokloster Castle. Ambitions to present the scientific heritage in the original settings are found at Skokloster Castle, the Royal Collections, and at the Gustavianum. The Academy of Sciences until recently exhibited its collection at Stockholm Observatory, the only one of these institutions to display scientific instruments in an original setting (*Fig.* 10.1, p. 160).[19] The museums all have different concerns. At the National Museum of Science and Technology, one is most likely to find scientific instruments displayed in the context of industry and technology; at the Maritime Museum, navigation; at the Nationalmuseum, art and design; at the Army

15. Pipping 1977.
16. Hatt 2008.
17. Haskell 1993, pp. 159–200.
18. Trischler 2008.
19. The Royal Swedish Academy of Sciences closed the museum in 2013; see chapter 4.

Museum, conflicts and warfare; at Nordiska museet, ethnography; at the Swedish History Museum and the Royal Armoury, history; and at the Gustavianum, academic research and teaching. All of these contexts are equally relevant to the past uses of scientific instruments. There are many useful and appropriate approaches to the interpretation of scientific instruments.

Museums are the physical repositories of material heritage, and therefore any cultural historian who wishes to engage with material heritage is likely to have to deal with museums. An understanding of how museums relate to their collections—inventories, conservation policy, display—is therefore important. Museums are seldom transparent about bias in their interpretation and presentation, for several reasons: institutional considerations and management goals, fear of criticism, wishing to write a success story, audience considerations, and the display of artefacts considered as a medium. Museum management is well aware that the value of any museum is linked to the status of its collections and its site, that large visitor numbers are crucial, and for that they need to boost their main assets. For material heritage, UNESCO has chosen the key concepts of "integrity and authenticity" as guidelines for nomination as a World Heritage site.[20] Even if a cultural history museum does not aspire to the World Heritage list, it will certainly try to profile the integrity and authenticity of its heritage. A thorough account of the theoretical perspectives does not always sit well with the press or the public, particularly if the originality, authenticity, or uniqueness of the artefacts or site is questioned. Few exhibition designers are keen to include long texts or explanations; few general visitors spend a lot of time reading labels. Yet, however frustrating the lack of information about the theoretical premises for museum displays may be for cultural historians, a museum display is not solely there to satisfy the needs of academic visitors.

Researchers may find research libraries and archives easier to use, being better equipped for research support, so why should they bother to consult museums in view of the difficulty of procuring the information needed? The answer is that dealing with museums about material heritage may be difficult for the researcher, but the rewards are gratifying. Interpretations of material culture can provide new information where none was previously available, stronger evidence for certain arguments or, in some cases, evidence for alternative or opposing theories, and provide essential context.

20. Ruggles & Cotte 2010, p. 10.

Engaging with material heritage

It may seem contradictory that the current interest in material heritage is growing as more material becomes available online in databases. Perhaps this interest is nourished by the very fact that no digitization can replace the "real thing". It could be argued, like Jules David Prown, that "Artefacts constitute the only class of historical events that occurred in the past but survive into the present. They can be re-experienced; they are authentic, primary historical material available for first-hand study. Artefacts are historical evidence."[21] If we accept that artefacts are historical evidence, their interpretation is relevant to any cultural historian.

There are a number of concerns that need to be taken into account when working with material heritage. One is authenticity. If past users or the decay of materials have not changed the artefact, it is possible that conservators have. Even some of the best-known icons of material heritage have doubts as to their provenance and originality. But what is authenticity? It is easy to claim and very difficult to verify. After all, scientific instruments were often recycled or adapted to new technologies. In telescopes, for example, lenses were very expensive investments, and once the tube of the telescope was old, the lenses were normally unmounted and reused in a new instrument. Fortunately, the high financial value of such artefacts has often led to the documentation of such changes in the archival record—but in the case of less expensive items this information is often lost. Statements about authenticity are often based on a number of more or less well-founded assumptions. It can be established by examining the artefact, its material, function, and design, and any related documentation. In order to match the material heritage with documentary sources, a number of observations can be used, such as comparisons of descriptions and object, markings, its match to the space where it once stood, and so on. Considering the importance of authenticity, the study of original artefacts is advisable, as is familiarity with a broad range of similar objects from the same period in order to compare materials and designs.

New scientific techniques can provide additional information about materials (when conservators allow such investigations). Laboratory research tools such as x-ray interferometry can be used to verify, say, the shape of optical surfaces in early modern telescopes. Such work has been carried out by the Museo Galileo on Galilei's lenses and their replicas (made by the Italian National Institute of Optics in Arcetri, the Italian National Institute for Nuclear Physics in Florence, and the Experimental Station for Glass in Murano) and by the Dioptrice pre-

21. Prown 1993, pp. 2–3.

1775 refracting telescopes project. Materials analysis of the metal of astrolabes is another example of studies that can shed light on how scientific instruments were made.[22] All such studies provide information about the production and technical quality of the instruments available to early modern natural philosophers, and these methods, originally developed for the natural sciences, are now frequently used by archaeologists and conservators, and are beginning to be used more widely by cultural historians.

There has been a strong focus on textual source material in the history of science and ideas.[23] There is, however, a growing insight that artefacts, monuments, and sites can provide equally relevant information and contexts.[24] That is not to say that a text cannot be studied from a material viewpoint; on the contrary, the text is also an artefact. Whether it is handwritten or printed, whether it is in black letter, a small notebook, or gilded letters meticulously carved on a stone tablet, it all may be relevant for our understanding of its context. The context is thus dependent on both immaterial and material qualities. Consideration of the materiality of a text requires an investigation of its physical aspects.

We can speculate as to why there has been comparatively little interest in scientific artefacts such as instruments. There are several difficulties in studying material heritage that may seem offputting. Materiality is one. Transmediality is a difficulty the researcher needs to handle, but it is normally not part of university training in the same way as textual analysis. The differences in media mean that when the researcher describes a three-dimensional object in words, exact reproduction is not possible, even though the object has to be verbalized—that is, translated from one medium into another. This necessitates interpretation. In this, meaning can be distorted or lost; it is elusive, and can be inconclusive as evidence. Initial barriers also include specialized terminology and forgotten uses, representing tacit knowledge and science that is partly alien to our modern understanding, and with it a loss of context. Jim Bennett suggests that artefacts which fail to correspond to our present understanding and definition of science are difficult to approach. This seems to be changing, though, because the history of science is not only a history of ideas.[25] One influential study is Steven Shapin and Simon Schaffer's *Leviathan and the Air-Pump*, which links the history of science with the history of political thought, focusing on the social setting for experiments with the air pump, and the validity of the empirical

22. Newbury & Notis 2005.
23. Grafton 2006.
24. Pickering 2010.
25. Bennett 2008.

method in 17th-century Britain.[26] Another approach is the replication of scientific experiments. Otto Sibum has shown that by studying science practice with material objects, it is possible to recover some of the tacit knowledge that was necessary for past scientific experiments, which is not evident from the study of texts alone.[27]

In my own experience in producing exhibitions, it seems some stories are very difficult to present using material scientific heritage. The medium of display is quite different from the written text. Therefore it is possible that the exhibition and the accompanying catalogue end up telling different stories. The most significant difference is in the medium. Display and space work very differently from a text. The rhetorical means of convincing visitors to an exhibition are largely dependent on its form: in a publication, illustrations can be used to support arguments; in a display, however, if the original artefact is used, physical size, texture, and three-dimensionality are distinguishing characteristics. Artefacts are also generally conspicuous. An illustration is easily manipulated to adjust the size, viewpoint, and highlighting of particular details, but this is more difficult in an exhibition, where design and layout can instead be used in some cases to lift the importance of specific objects: a small object with little visual impact may be singled out as very important by being placed in a separate case, in an elevated position, with special lighting; intentional correspondences are achieved by juxtaposing objects to demonstrate similarities or differences. In the end, it must be accepted that artefacts in a collection are well-suited to tell some types of stories, whereas other stories elude the medium of material heritage. It is striking that certain phenomena have left many material traces for posterity whereas others are lacking. One such example in Sweden is that there is ample written evidence of the early modern Copernican debate, but apparently very few illustrations, paintings, or three-dimensional artefacts.[28]

Should there not be greater urgency to study material heritage, as its objects seem to offer an alternative story? In order to understand the instruments, an interdisciplinary or multidisciplinary approach is likely to be most successful, since the instruments are relevant not only to the disciplines they investigate and demonstrate, but also to history and the social sciences, to arts and handicrafts. Hopefully, these difficulties will be challenged. There is certainly a great potential for cultural historians of various disciplines to contribute with studies of different methods and approaches. Some disciplines—archaeology, ethnography, art history—tend to interpret material heritage more than others. New

26. Shapin & Schaffer 1985.
27. Sibum 2000.
28. Sandblad 1973.

contexts for material scientific heritage may become relevant with the use of methods and perspectives from neighbouring fields. It cannot be denied that many of the properties of our early modern scientific heritage embody qualities that are not purely scientific in a modern sense. I believe that bridging the current gap between the sciences and humanities will provide the most interesting studies in this field. Interest in material scientific heritage as a resource for interdisciplinary research is growing. Astronomy can serve as an interesting example, as the meetings of the Inspiration of Astronomical Phenomena (INSAP) and the European Society for Astronomy and Culture (SEAC) show, with their discussions of astronomy's multifarious connections to cultural expressions as varied as history, religion, poetry, dance, music, painting, and architecture. Particular forms of interdisciplinary work are labelled accordingly. Archaeoastronomy, ethnoastronomy: words indicating a combination of archaeology, ethnography, and the phenomena of the sky.

*

The interpretation of early modern scientific heritage is relevant to many disciplines, and further studies may bring new contexts to light. This heritage is little researched and offers a great potential for the prospective researcher of different disciplines. In order to understand this heritage better, and to make it relevant and comprehensible, research of an interdisciplinary nature is needed, with museums and universities working in co-operation. If an interest in materiality persists it will likely make museums more relevant to university research, and have consequences for both sorts of institution. It is reasonable to claim that the invention of new techniques of the early modern period contributed to the formation of our new industrial world. New scientific techniques also influenced culture in various ways, as when mathematical and optical inventions influenced painting and literature. The techniques, concepts, and modes of interpretation of the natural sciences can help us better understand the cultural expressions of early modern times. But the opposite is also true. New scientific techniques did not develop out of a vacuum, but out of a broad culture. It is not only relevant to ask what the science of art is, but what the art of science is. If we were to use all the tools available to cultural historians to analyse our material scientific heritage, I am optimistic that we would find a broader, better understanding of early modern culture and science.

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