



BRAIN RENAISSANCE

From Vesalius to Modern Neuroscience

Marco Catani
Stefano Sandrone

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OXFORD
UNIVERSITY PRESS

Oxford University Press is a department of the University of Oxford. It furthers the University's objective of excellence in research scholarship, and education by publishing worldwide.

Oxford New York
Auckland Cape Town Dar es Salaam Hong Kong Karachi
Kuala Lumpur Madrid Melbourne Mexico City Nairobi
New Delhi Shanghai Taipei Toronto

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Argentina Austria Brazil Chile Czech Republic France Greece
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Published in the United States of America by
Oxford University Press
198 Madison Avenue, New York, NY 10016

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Library of Congress Cataloging-in-Publication Data
Catani, Marco, author, commentator, translator.

Brain renaissance from Vesalius to Modern Neuroscience / translated, with commentary, by Marco Catani, Stefano Sandrone.
p. ; cm.

Translation and commentary of those chapters of *De humani corporis fabrica* dedicated to the brain.

Includes index.

ISBN 978-0-19-938383-2 (alk. paper)

eISBN 978-0-19-938385-6

I. Sandrone, Stefano, author, commentator, translator. II. Vesalius, Andreas, 1514-1564. *De humani corporis fabrica*. Selections. English. Analysis of (work): III. Title.

[DNLN: 1. Vesalius, Andreas, 1514-1564. 2. Brain—anatomy & histology. 3. Anatomy—history. 4. Physicians—history. WL 300
QP376
612.8'2—dc23
2014032888

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To Raffaella, Giulia, Matteo and Chiara Maria with whom I share a wonderful journey (Marco Catani)

To my beloved grandfather Renato (Stefano Sandron)

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PREFACE

Brain Renaissance, from Vesalius to Modern Neuroscience has been written to mark the birth of the remarkable anatomist Andreas Vesalius five centuries ago, and the 450th anniversary of his lonely death on the coast of Greece.

Born in Brussels in 1514, Vesalius studied in Paris and Leuven. As professor of anatomy in Padua he began writing the *De Humani Corporis Fabrica* at the age of 24. It took him four years to complete what is still considered a true landmark in the history of medicine. He supervised all aspects of the making of the book and his final publication in 1543 represented the final act of the realization of a true masterpiece of science and art.

How can a book published almost 500 years ago still be relevant to contemporary neuroscience? Andreas Vesalius was a Renaissance man who dared question the received wisdom of his day, which came from ancient teachings about the human body and mind. Inspired by the finest cartographers and artists of his time, Vesalius laid down a modern paradigm in science: the power of direct observation. The result was a new anatomy of the human body.

Five hundred years later, technological development permits the scientific and medical community to study the anatomy of the human body with a greater spatial and temporal resolution. Concerning the brain, the so called neuroimaging techniques, such as positron emission tomography (PET), functional magnetic resonance imaging (fMRI), and Diffusion Tensor Imaging (DTI) tractography are essential tools for the analysis of organized neural systems in working and resting states, both in normal and pathological conditions. These methods, when complemented with microscopy techniques could open the possibility of mapping the entire wiring of the human brain.

As neuroscientists we exploit the advantages offered by modern neuroimaging techniques. But we are also deeply aware that our approach to neuroscience, although modern in the tools employed, intellectually owns much to Vesalius's philosophy. Our book grew from a wish to understand the roots of our own discipline, which has involved tracing the origins of neuroscience back to the extraordinary period of artistic, intellectual, and scientific awakening, the Renaissance, and back to Vesalius.

The book is divided into three parts and readers can start at any of these parts, depending upon their personal interests.

Part 1 provides an account of what is known of the life of Andreas Vesalius. The story of the man behind the *Fabrica* is almost as fascinating as the *Fabrica* itself.

Part 2 of the book gives in English the eighteen chapters of Vesalius's *Fabrica* dedicated to the brain, originally in Latin, the international language in his time.

Each of the translated chapters on the brain has brief explanatory notes. For those with direct relevance to modern neuroscience, we also provide a glance at the progress made since Vesalius wrote his book.

Part 3 offers a brief overview of the major discoveries in neuroscience to have emerged since the publication of the *Fabrica*. Here we track the evolution of ideas and approaches to understanding the brain within their historical context, and pay tribute to the work of many pioneers. As our account moves toward modern times, the brain is perceived in terms of the major technical achievements of each era: the brain as an electrical device or in the 21st century, as a *connectome*, which identifies the brain as an intricate wiring system, a sort of 'social network' for random but controlled interactions.

Working on this book has taken us on an unforgettable journey, inspired by the work of Vesalius.

We wrote *Brain Renaissance* to share our understanding of Vesalius and his legacy, and the history of neuroscience. We also wrote it for the next generation of neuroscientists: we especially hope young readers will be inspired by it to spend a life in science. Marco Catani and Stefano Sandron
Zakynthos 7th September 2014

ACKNOWLEDGMENTS

First in our list is Craig Panner, Associate Editorial Director of Medicine Books at OUP, New York who went well beyond his editorial duties to publish the book exactly the way we wanted it. Grazie Craig!

We owe Matt Dawson a huge debt of gratitude for all his work on the different versions of the entire manuscript. Also Ruth Richardson read some of the chapters in bits and pieces and gave precious advice on the final structure of the book. Antonio Damasio provided very helpful suggestions to fill some gaps in modern history of neuroscience. Dr Giuseppe Zappala' (Pippo) proofread the entire book and gave fruitful comments.

In the initial preparatory stages of the book, Professor Rik Vandenberghe organized for us a timely and rather wonderful tour of the places associated with the life of Vesalius in Leuven. Herma Verbruggen was our enthusiastic guide through the streets of the town. During the tour we met Edo Put, Senior Researcher at the Belgian State Archives in Leuven, who allowed us to take a close-up photograph of the name of Vesalius enlisted in the 1530 register of the Collegium Castrense.

In Padua Giuseppe Ongaro and Maurizio Rippa Bonati gave us precious information on the life of Vesalius and his relationship with other academics living in the Italian town at the time.

By talking to Franco Guida, neurosurgeon of the Venetian USLL number 12, we realized that a chapter on Vesalius and Venice was necessary and this resulted in the addition of [chapter 8](#). Doctor Luigi Scorolli double-checked the translation of [chapter 26](#) on the eye and the legends for [figures A1](#) and [A20](#) in the appendix.

We are very thankful to a number of people that provided some of the figures reproduced in our book: Antonio Di Ieva for [figure 17.3](#), Alberto Bizzi for [figure 17.5](#) (left), Gabriele Polonara for [figure 17.5](#) (right), and Andres Lozano for [figure 19.9](#).

Pascale Pollier, Theo Dirix, and Mark Gardiner organized a very stimulating conference in Zakynthos where the search for the grave-place of Andreas Vesalius continues to these days.

We are also very honored for the words of praise written by Alistair Compston, Stanislas Dehaene, Sergio Della Sala, Pim Levelt, and Marsel Mesulam. Their appreciation means a lot to us.

Finally we would like to thank the other members of the Catani family for alleviating our sufferance with music, food, football playing, turning bubbling into first words, and infinite patience.

Vesalius's Life: The Anatomy of an Anatomist

VESALIUS, A MAN OF HIS TIME

Andreas Vesalius was born in Brussels on the last day of 1514. In the same year, Leonardo da Vinci abandoned all hope of completing what would have become, if published, the most beautiful treatise on human anatomy of all time. Much of it was based on human dissection, a practice that artists often performed to better appreciate the proportions of the body. But by the time Vesalius was born, Leonardo had moved to Rome, to the court of Pope Leone X, who promptly forbade him from conducting such dissections. It was a moment that changed the course of history. Leonardo did as he was told, ended his anatomical observations, and returned to drawing and civil engineer occupations. Within thirty years Leonardo was long dead—his illustrations of the human body still remaining unpublished—and Vesalius had shown that dissection was as much a method of scientific enquiry as an aid to the pursuit of art. Vesalius succeeded where Leonardo had failed: he published in 1543 the first map of the new human anatomy, *De Humani Corporis Fabrica* (On the Fabric of the Human Body).

In many respects Vesalius was perfectly placed to see the power of an atlas and to raise awareness of its benefits to the medical field. The fifty years of life granted to him span a period of great intellectual awakening. Europe widened its horizons toward the New World, which inspired a remapping of the geographical borders of human knowledge. Scholars and thinkers ventured to explore new areas of mathematics, philosophy, art, astronomy, science, and religion. This sudden and rapid accumulation of information required a systematic approach. Cartography grew out of necessity. Maps and globes became popular forms of visual representation of new lands, continents, and skies. Atlases gave the coordinates for further exploration. In a climate fueled by an exploratory spirit, maps became not only artistic displays but also visual accounts of the known and unknown. At a glance they provided a portrait of the achieved and the achievable.

Vesalius was a contemporary of many outstanding cartographers. Among them was Gemma Frisius, so well known for his astral maps that, as in the case of Vesalius, a lunar crater was dedicated to him. Then there was Gerardus Mercator, Gemma's student, maker of the finest terrestrial globes of the time. In addition to their deep knowledge of geography and astronomy they offered unique technical skills. Mercator was an exceptional engraver of brass plates, a mastery that he put to good use in map making. This ability to translate conceptual knowledge into visually appealing yet informative maps made his works stand out as representative of a new intellectual figure: one person comprising the scholar, the artist, and the craftsman. In Vesalius's early academic formation, observing these masters at work was a thrill to him. He was in awe of their skills, so it is no surprise that the young physician became to anatomy what Mercator and Frisius were for geography and astronomy.

The fact that Vesalius was so open to new thinking and new visual representations may explain why he was so quick to break boundaries—in particular those between the three roles traditionally involved in the teaching of anatomy during dissections: the professor who read from Galen's texts of reference while seated on an elevated chair (*lector*, the reader), the barber-surgeon who actually performed the dissection at the anatomical table (*sector*, the dissector), and the assistant (*ostensor*, the demonstrator), who indicated the anatomical structures as they were named by the reader and dissected by the barber-surgeon (Figure 1.1). Vesalius liked to do things differently. To him dissection

was a one-man show where he could perform hands on, indicating the anatomical parts as he exposed them and even providing his own commentary.

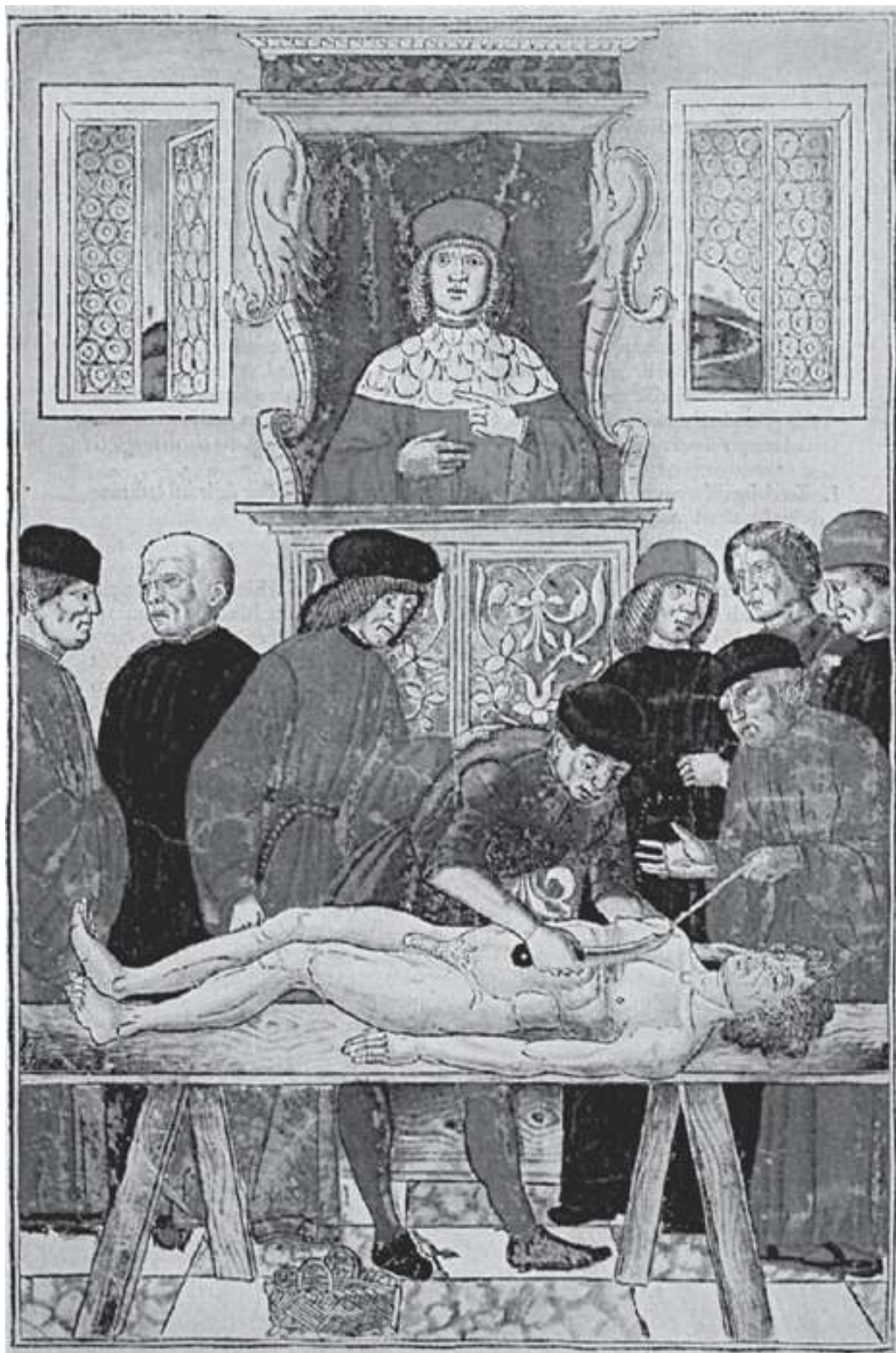


FIG 1.1 Johannes de Ketham's *Fasciculus Medicinae* (1493). A group of students attend the anatomy lecture around the dissection table. The lecturer sits on the high chair and reads from the classic texts. The dissector has a knife in his hand and isolates the internal organs, muscles and nerves. The demonstrator indicates with a stick in his hand the anatomical parts under examination.

When Vesalius began his education, the anatomical observations of the Greek-Roman physician Galen were regarded as unquestionable truths. This is a remarkable fact given that they had been made over a thousand years earlier. But the direct experiential knowledge that Vesalius acquired through his dissections is the main reason behind his departure from traditional anatomical teachings and his

refusal to accept classical anatomical knowledge as the only source of truth. Vesalius had stressed on many occasions that Galen's accounts derived from animal observations did not match the real anatomy of the human body.

Vesalius laid down a new paradigm in medical knowledge: a revolutionary inductive approach that seeks direct evidence to explain the wonders of the human form. Vesalius was not prepared to take for granted what had not been clearly demonstrated for the human body at the dissection table. His anatomy was based only on knowledge derived from direct observation, which led him to identify significant differences between animals and humans. If he had not dissected it, or had not seen it, he chose not to mention it rather than report the words of others. His work constitutes the expression of a firm belief, one that now underpins modern science in the power of observation as a direct source of knowledge.

Such approach to anatomy left him open to harsh criticism. The most severe came from eminent Galenists, medieval anatomists, and humanists, many of whom were close acquaintances. They felt that Vesalius was not able to understand anything beyond the visible, an ability with which only those of great intellect were endowed. After all, they argued, one can surely see that human dissections are not even strictly necessary: anatomical problems could and should be solved by disputation alone.

Indeed, it is not Vesalius's words that do most of the talking but his illustrations. He could see so much more than he could say. In his book there is a clear discrepancy between the highly informative and esthetically mesmerizing quality of the illustrations, and the repetitive but didactic style of the written text. His images were the real breakthrough, revealing a new human anatomy—one that was immediately accessible to everyone, even those who had no medical education or could not read. A cogent parallel is with some of the masterpieces on European cathedral walls created by Renaissance painters to illustrate scenes of the Bible. Vesalius's illustrations are still, five hundred years later, a treasure trove of anatomical knowledge. Considering that most of the illustrations were made by his artist fellows and that some of the new anatomical observations are in the figures rather than in the text, one may wonder if the artists more than Vesalius should be credited with the discoveries.

Yet given the revolutionary way in which Vesalius approached anatomy, it is surprising to find no reference to his achievements in the thousands of eponyms used to describe all the many parts of our bodies (Singer, 1952). Falloppia has his tubes, Willis his arterial polygon, Rolando his scissure, Broca and Wernicke their own regions of the brain, Golgi his cells. But the truth is that Vesalius made few original contributions to existing anatomical knowledge. His writings on the brain, for example, are often limited to short summaries of what Galen had previously said.

Vesalius so rigorously identified, labeled, and systematized the individual parts of the body that when his great book *De Humani Corporis Fabrica* was published, it quickly became one of the most celebrated works of its time. That same year, 1543, Copernicus published his *De Revolutionibus Orbium Coelestium* (On the Revolution of the Heavenly Spheres), a direct attack to the ancient Ptolemaic doctrine of the solar system. This is a significant and beautiful coincidence because both books are revolutionary in a shared sense. They mark a break with conventional theories: one explored the macrocosm of space, the other the microcosm of the human body. Together, they brought an end to dogmatic tradition and signaled the beginning of a new inquisitive search for the mysterious workings of Nature and Science—a search that continues to this day.

A FLEMISH FORMATION IN BRUSSELS AND LEUVEN

Andreas Vesalius was born and spent most of his childhood in a house on Rue de Minimes, a street located in the neighbourhood of Sablon, just south of the ramparts of Brussels. The house, situated within the second city walls, no longer exists. It was dismantled to make way for a convent, which later became a modern church. Instead, a single marble tablet with a brief Latin inscription marks Vesalius's birthplace: "In this area, in the XVI century, was the home of the outstanding author Andreas Vesalius of Brussels . . . who in 1542 sent to print his illustrious book *De Humani Corporis Fabrica* for the happiness of posterity." The birthplace of the father of modern human anatomy is then, a little underwhelming. You have to go two kilometers south for a more appropriate tribute.

Place de Barricades in Brussels is the square where the French writer Victor Hugo lived throughout 1851 while in exile. He was frequently visited by his friend Charles Baudelaire, a man whose poems reveal a fascination with death. The view from Hugo's window would have thrilled Baudelaire because, dominating the square, standing erect and tall, was a newly built bronze statue of the great anatomist. Beautifully poised, it depicts Vesalius with a flowing robe, a pen in hand, and an anatomical book tucked under his left arm. A plaque at his feet indicates his date of birth as December 31, 1514, a year that contrasts with the incorrect 1515 inscribed on the tablet found at Vesalius's birthplace.

Andreas was one of four children—three brothers and one sister—born to Andries Vesalius and Isabella Crabble. Little is known about Vesalius's mother other than that she was the daughter of Jacob Crabble. Vesalius's father came from a very influential family of physicians and pharmacists, many of whom personally attended royalty. Vesalius's great-great grandfather Peter had been physician to the Emperor Frederick III; his great grandfather Johannes physician to Maria Borgogna, wife of the Emperor Maximilian I, and professor at the University of Leuven (Belloni, 1964). Vesalius's grandfather Everard diagnosed the ailments of Charles V of Spain. Finally there was his father, whose duties, as royal apothecary to Charles V of Spain and later to Philip II, King of Spain, meant that he was often away from the family. It was left to Isabella to tend to the early education of the children (O'Malley, 1964).

It is an illustrious lineage that gave Vesalius a lot to live up to. And he was proudly aware of it. In a letter dated 1546 he tells of the derivation of his surname. His family was formerly called Wijting and came originally from the town of Wesl, in the Rhenian region of western Germany (Belloni, 1964; O'Malley 1964). Emperor Frederick III granted his great-grand-father Johannes the privilege of using the surname Wesalia, which evolved quickly into Vesalius (Belloni, 1964).

Both his medical heritage and his birthplace meant that young Vesalius became exposed to the decaying flesh of the dead from a very early age. His family home, on the outskirts of Brussels overlooked Gallows Hill. Here criminals were executed and their bodies left to be picked at by foraging birds (Nuland, 1995). As a child, running across the fields near the hill, Vesalius frequently stumbled upon and tentatively approached the corpses (Vesalius, 1546). Their visceral constituents would have been as memorable to him as the repulsive smell. As he grew, so did his curiosity. By vivisectioning animals found in the neighbourhood, he learned more about the joys of anatomical discovery (Zilboorg, 1943). And perhaps sneaking into his father's library to read the abundance of formal anatomical books, he was given a taste of what these discoveries could mean. By the age of 1

he had clear idea of what he wanted to do with his life: to study medicine.

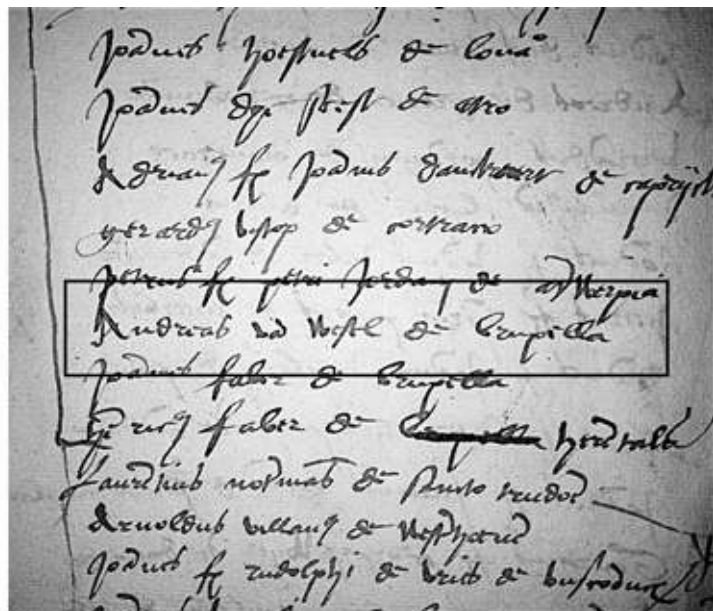
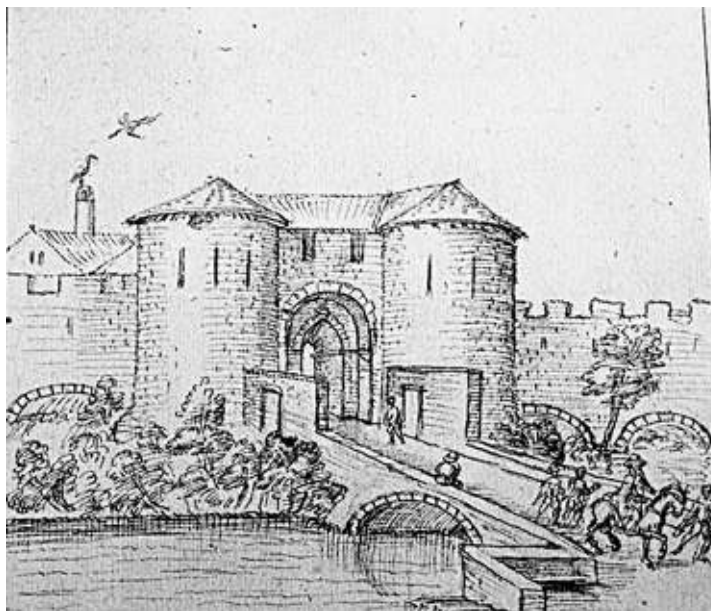


FIG 2.1 At age 15, Vesalius enrolled in the Faculty of Arts at the Pedagógium Castrense (Castle College). The name of Andreas Vesalius (Andreas da Wezl de Bruxella) appears on the faculty's register (1530).

At age 15, Vesalius chose to move to Leuven and, on February 25, 1530, enrolled in the Faculty of Arts at the Pedagógium Castrense (Castle College) (Figure 2.1), the very same college where his father studied before him and his younger brother Franciscus after him. Most of the teaching was done in a building (now known as Universiteitshal) that had formerly housed the local wool market. The college taught wealthy young men of the distinct subjects, including grammar, rhetoric, algebra, astrology, and music. By the time Vesalius arrived, the university was at the forefront of the humanist movement, which preferred individual thought and evidence over an established doctrine or faith. This new spirit was celebrated with the founding of a new language college.

The Trilingual College was originally established in 1517 using the funds of the wealthy patron and scholar Jeroen van Busleyden and under the cultural guidance of Erasmus of Rotterdam, leading humanists of the time. It taught not only Latin, the standard language for any educated individual, but also Greek and Hebrew. It was here that Vesalius benefited from a new approach to languages, which would later allow him to access and compare original anatomical texts.

Vesalius completed his studies in three years and in the summer of 1533, at the age of 18, made his way across the border to Paris, where he would spend the next four years studying what he loved the most: anatomy and medicine.

VESALIUS MEETS GALEN IN PARIS

The University of Paris was an outpost of humanist spirit and of Galenic tradition. Here, scholars sidestepped the cultural domain of medieval thinking and Arabic medicine by re-examining the original Greek texts and re-translating them into Latin.

At the medical school, most of these texts were the works of Galen of Pergamon (129–216 AD) who had been the undisputed authority in anatomical teaching for over a thousand years (Nutton 2002; Rocca, 2003). This Greek-speaking Roman physician was a prolific author, having written some six hundred treatises covering anatomy, physiology, hygiene, therapeutics, semiotics, and pathology. Only about a third of his works survive today (Boudon-Millot, 2007).

The Roman law (*lex de sepulcris*) had prohibited dissection of the human body, forcing Galen to make most of his anatomical observations from oxen, pigs, and monkeys (Manzoni, 2001). He expected his followers to make further speculations as when they could. The problem was that few of them ever speculated further. In the Middle Ages, Galen's work was translated into Arabic and Latin and became the only and irrefutable source of anatomical knowledge to both Muslims and Catholics.

By the time Vesalius arrived in Paris, Galen's anatomical works had been completely retranslated from Greek into Latin as many earlier translations contained mistakes (Castiglioni, 1943; Lowry 1979).



FIG 3.1 Portraits of Jacobus Sylvius (1478–1555) and Johann Guenther von Andernach (1505–1574).

Two of these academics involved in the retranslation of Galen's work would become Vesalius' anatomy teachers: the Latin scholar Jacobus Sylvius and Johann Guenther von Andernach, who had

taught Vesalius Greek in Leuven (Cushing, 1943) (Figure 3.1). They took a shine to the enthusiastic young Vesalius and asked him to replace the barber-surgeon during anatomical demonstrations (Simeone, 1984). This was a great privilege for the 18-year-old medical student. The barber-surgeon was responsible for the actual cutting process, the dissection of the body (Foster, 1901), leaving Sylvius or Guenther to read anatomical texts aloud to the students from the reader's chair (Singer, 1943; Benini and Bonar, 1996).

Vesalius gained practice in the art of dissection and learned more from direct experience than from his teachers. As Vesalius writes in the *Fabrica*:

“When I first studied the bones with Matthaeus Terminus, distinguished physician in all branches of medicine and lifelong friend and companion of my studies, our supply was very abundant. After we had studied them long and tirelessly we dared at times to wager with our companions that even blindfolded we could, for the space of a half-hour, identify by touch any bone offered to us. Those of us who wished to learn had to study all the more zealously since there was virtually no help to be had from our teachers in this part of medicine”.

Nevertheless, his teachers were respected anatomists of the time. Sylvius improved the nomenclature, which before his time was in disarray, including the introduction of the term *corpus callosum*. His teaching was eloquent and his anatomical dissections very popular among the students (Singer, 1957).

Guenther, on the other hand, contributed to anatomy more through his translation of Greek texts into Latin than with practical dissections. He translated Galen's book *De Anatomica Administrationibus* (On Anatomical Procedures) in 1531 and, five years later, assisted by Vesalius produced his own textbook for medical students—*Institutionum Anatomicarum, Secundum Galeni Sententiam* (Anatomical Institutions According to the Opinion of Galen).

While respectful for the teaching he received from these men, Vesalius's frustration grew. Owing to the anatomical differences between humans and animals, mismatches between the Galen descriptions and what actually Vesalius saw as he dissected became increasingly clear to him. Sylvius would try to minimize these issues by saying that anatomy could have changed since Galen described it, and “not always for the better” (O'Malley, 1964). Galen's word, Sylvius said, was the absolute truth, and anatomical evidence should adapt around it. But to Vesalius, the need for clarity became more and more urgent.

In July 1536, war broke out between Henry II, king of France, and Charles V, the Holy Roman emperor. Vesalius, as son of the apothecary to Charles V, was forced to flee Paris before graduating and before making his feelings about dissection truly known. He returned to Brussels and then Leuven, where in 1537 he completed his dissertation entitled *Paraphrasis In Nonum Librum Rhazae Medici Arabis*, namely a commentary to the ninth book of Rhazes.

In Leuven, Vesalius found himself well-connected to men of power and wealth. After lamenting to the burgomaster about the lack of opportunity to explore human anatomy in Paris, Vesalius was granted permission to perform public dissections in Leuven. He began roaming execution sites to collect body parts until he had assembled an entire skeleton. Through the dead flesh of executed men Vesalius learned more and more about the realities of the true human body. The more learned, the more he began to dream about Italy, the cradle of medical knowledge.

THE PADUAN SCHOOL OF ANATOMY

Vesalius never confirmed his reasons for leaving Leuven, although an overt dispute with Thriverius Brachelius, the professor of medicine, on the method of bloodletting may have been the push he needed (Saunders and O'Malley, 1950). The allure of Italy to him, and especially the University of Padua, had been too strong. Padua is 50 kilometers west of Venice. There are no as many canals or islands as those of its more illustrious counterpart. Instead, Padua stands on the banks of the Bacchiglione river, looking out toward the tranquil Euganean Hills. Officially founded in 1222, the University of Padua is one of the oldest universities in Italy. From the outset its medical school had played an important role in teaching anatomy and medicine (Del Negro, 2001; Porzionato et al., 2012). Its history already included many eminent scholars, and its tradition encouraged intellectual freedom and independence from papal control—an attractive combination for a man of Vesalius's characters.

So, soon after obtaining his degree, Vesalius packed up his possessions, and climbed aboard a horse-drawn coach to begin the long, tiring journey to Italy. On the way, he passed through Basel, a city in the process of building a great printing tradition. During his short stay there he became acquainted with Robert Winter and Johannes Oporinus, printers who would later offer him precious advice and experience. Like Vesalius, these men did not shy from controversy. Five years after their meeting, Oporinus published the first-ever Latin translation of the Koran in the world. The outcry that the caused had only just subsided when he agreed to publish, in 1543, Vesalius's *Fabrica*.

Vesalius reached Padua in the summer of 1537, where, on December 5, he graduated with the highest distinction as a doctor of medicine (Simeone, 1984). Within a day he was appointed professor of surgery. It was a role that carried a heavy teaching load, but one that delighted the enthusiastic graduate. Public dissections were suddenly his responsibility, and he would soon be performing them for other institutions as well, as far afield as Bologna and Pisa (Benini and Bonar, 1996).

Andreas Vesalius found himself at the beating heart of an anatomical renaissance. And with it came a feeling of belonging. A long list of celebrated anatomists had already graced Padua, many of whom helped place the university at the forefront of medical knowledge (Andrioli and Trincia, 2004). The methodical exploration of the dead had been popular at Padua's medical school as early as the thirteenth century (Ongaro, 2001). Indeed, arguably the first dissection in Padua had been performed by Pietro d'Abano (1250–1315), who used an autopsy to confirm lead intoxication as the cause of a local pharmacist's death. Among other Italian anatomists was Mondino de Liuzzi whose major work *Anathomia Corporis Humani*, was written in 1316 and went through several editions for two hundred and fifty years. His work together with writings of other authors had been collected into a single publication first released in 1491 and titled the *Fasciculus Medicinae*. It was one of many anatomic publications available by the time Vesalius arrived: such books, annotations, collections, and observations circulated widely among the medical students. Padua responded to the growing demand for medical training by erecting a new building dedicated to the teaching of medical theory, practice, and surgery. Padua was to become Vesalius's home.

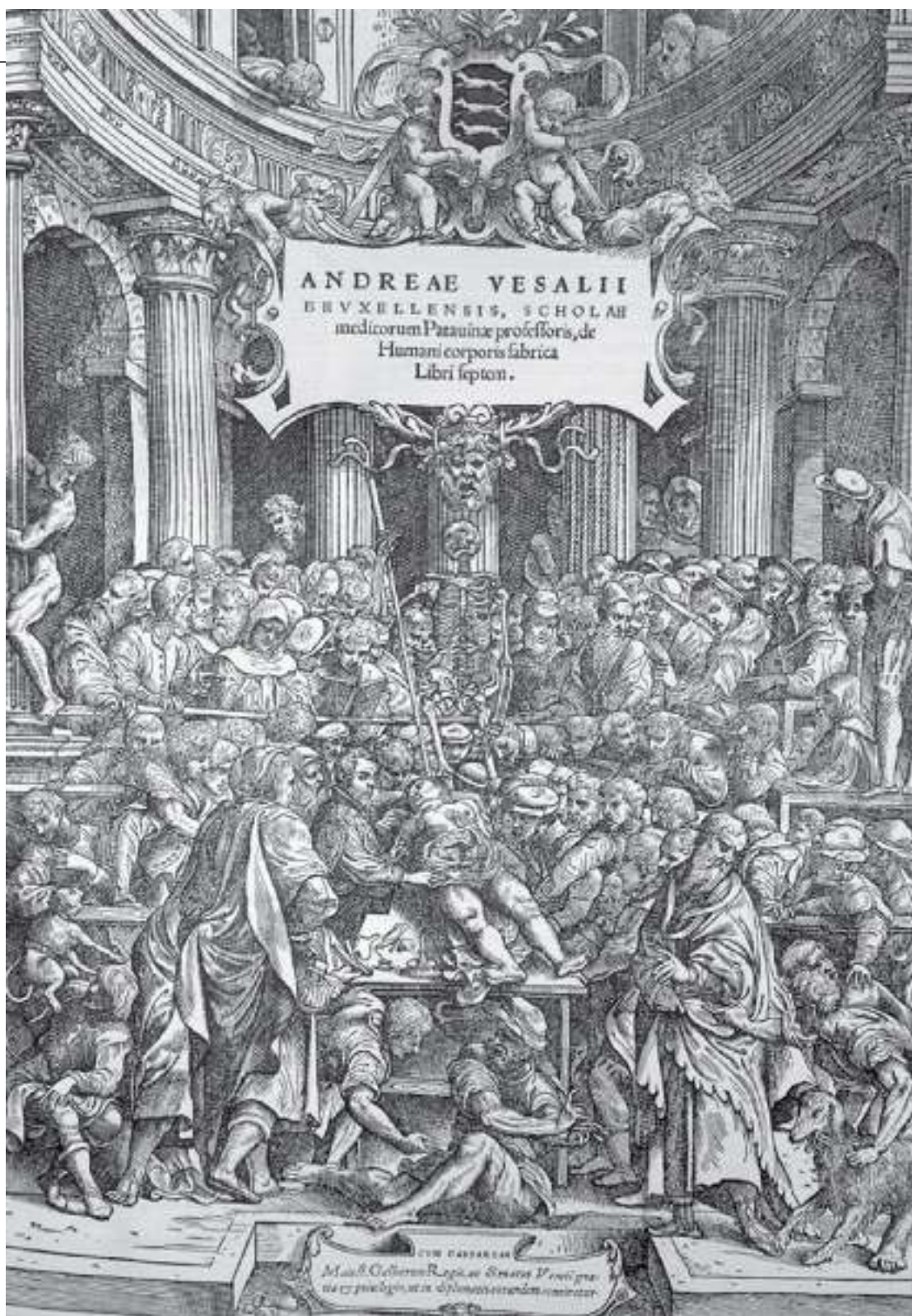


FIG 4.1 The frontispiece image of the *Fabrica* hints at the extreme popularity of Vesalius’s public dissections. Vesalius is the only figure looking directly at the reader. His hands are well in evidence, one touching the cadaver and the other pointing up, perhaps to indicate the link between the mortal body and the eternal soul, the earth and the heavenly spheres.

Vesalius’s public dissections rapidly became popular (Figure 4.1)—in part because of his clear talent for teaching and also because of his engaging style. Gone was the traditional three-man approach to dissections—they were now replaced by a one-man show. Vesalius would display an entire human skeleton or hold up single parts to reveal the anatomy of the bones. He drew figures of the peripheral distribution of arteries, veins, and nerves to assist students’ understanding of the vascular and nervous systems. Students flocked to his lectures, copying his drawings with gusto.

A SLOW DEPARTURE FROM GALEN

For Vesalius, this success in teaching engendered a wish to publish, both to make his work available and to consolidate his academic career. But it was ultimately the fear of plagiarism that prompted the printing of the *Tabulae anatomicae sex* (Six anatomical tables) in April 1538: “since many in various places have sought to copy what I have done, I have sent these drawings to the press” (Vesalius, 1538).

These consist of a collection of large prints, which show the internal organs, including the male and female reproductive systems, the arteries, and the veins, as well as the skeleton in lateral (side), anterior (front), and posterior (back) views (Figure 5.1). These figures, together with a few lines of text and captions, were published to provide students with silhouettes of the human body that they could use, annotate, cutout and hang on their walls (Lindeboom, 1975). Yet they offer few hints of what was to come five years later in the *Fabrica*. There is no clear departure from traditional teaching and in many respects Vesalius replicated Galen’s anatomical errors, including the existence of the *rete mirabile* (a complex set of veins and arteries found in some mammals) at the base of the brain (see chapter 24), as well as the incorrect division of the liver into five lobes and of the sternum (breast bone) into seven bones. The one possible sign that he was preparing to diverge from established tradition was subtle, to say the least. His dedication to the royal physician of Charles V, Doctor Narcissus Parthenopeus Vertunus, contained Vesalius’s statement of intent: “If I shall find this work acceptable to you and to students, someday I hope to add something greater.”

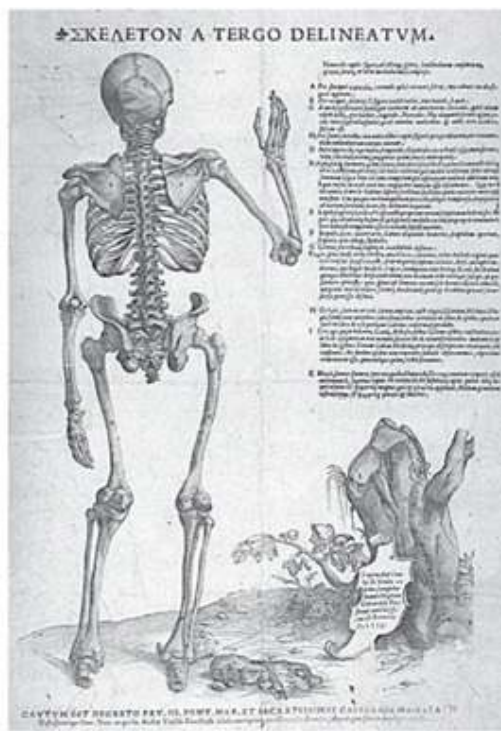
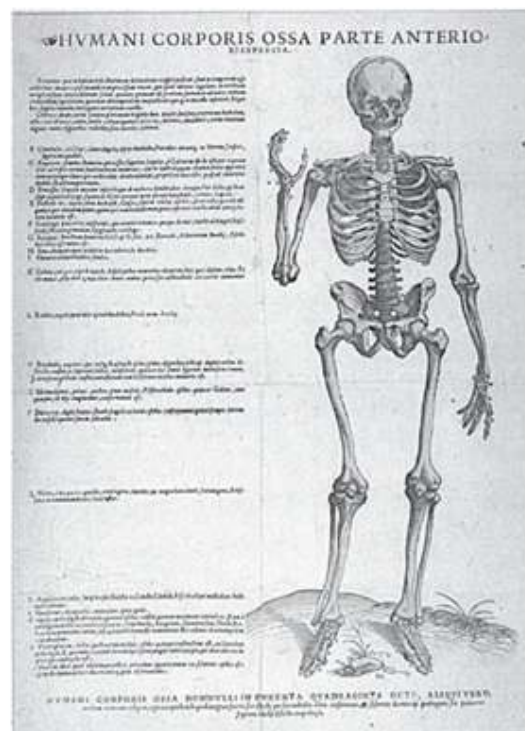
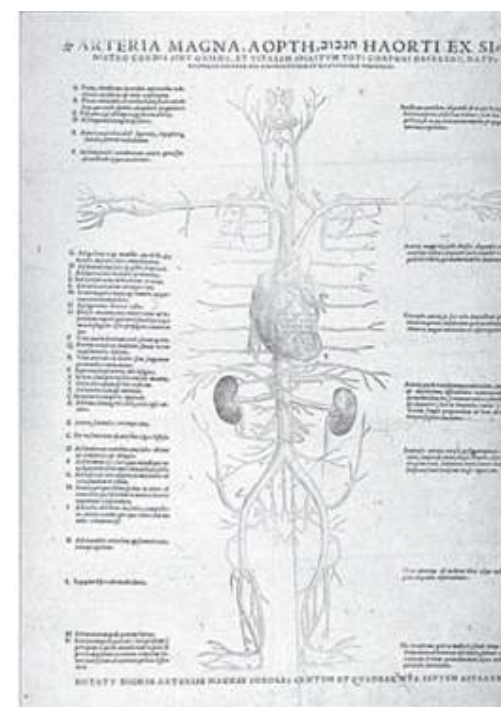
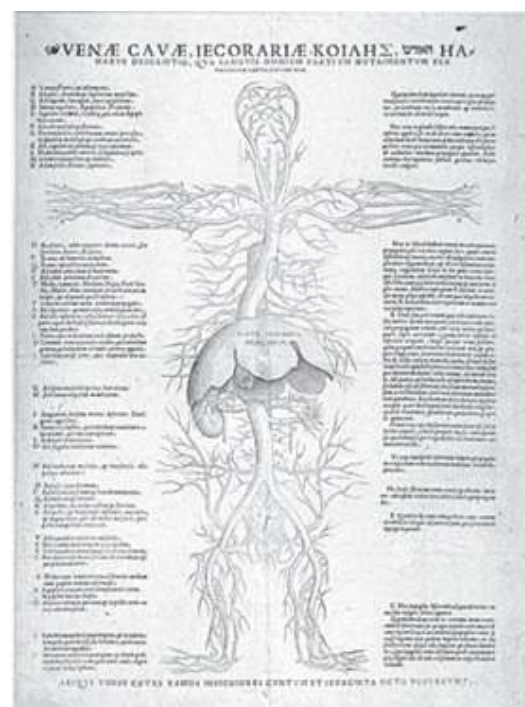


FIG 5.1 In 1538, Vesalius published six anatomical tables (*Tabulae Anatomicae Sex*), which he used to teach his students.

It is likely Vesalius was well aware of how his *Tabulae* would be received. Many physicians were opposed to illustrations, because they thought that images would degrade scholarship and trivialize that great learning found in classical works containing only text. So while they were popular with students, the *Tabulae* were not considered of great value by academics. Vesalius, though, was undeterred. He saw a great opportunity and decided to embark on a new editorial project, one that would complement his illustrations with an authoritative text.

Later that year, Vesalius edited a new edition of Guenther von Andernach's medical text, under the title *Institutiones Anatomicae, Secundum Galeni Sententiam*. Popular among medical students, the book provided a synopsis of the anatomical writings of Galen. A few years earlier, when he had been a young student of Guenther's, Vesalius had helped him with the dissections, a fact noted in the first edition of the *Institutiones*:

“with the assistance of Andreas Vesalius, son of the apothecary of the Emperor, a young man for which I have high expectations for Hercules, talented and dexterous in both language and dissection of the body, after a long disquisition on the parts [of the body], we came to this conclusion.”

Vesalius corrected many errors that had appeared in the first edition of Guenther’s book. Out of respect to his old teacher, Vesalius attributed the errors to misprints (Castiglioni, 1943). His work on the book provided Vesalius with ample opportunities to revisit Galen’s opinions, and to identify factual errors in Galen’s work by comparison to the actual human anatomy he observed during his dissections. The more he questioned Galen’s findings, the more Vesalius became fully conscious of a new approach to knowledge—one based on direct anatomical observation “to corroborate speculation” (Vesalius, 1539).

The *Venesection Letter* that he published in 1539 can be considered the first manifesto of his new philosophy: in it, Vesalius set out his views on whether the correct method for bloodletting should be based on the teaching of classic authorities or on newly gathered empirical evidence. Unsurprisingly, he introduced new anatomical evidence in support of a modern approach. The true value of his contribution, though, is less in the content of his letter and more in his argument that evidence should be gathered from direct observation, not from mere theoretical disquisition. In publishing his letter, Vesalius had laid out the foundation of the scientific vision that would become the leitmotif of his masterpiece.

THE MAKING OF THE *FABRICA*

With the enthusiasm of youth, his deep knowledge of the shortcomings of classical anatomy, and armed with a unique talent for performing accurate dissections, Vesalius came to a bold decision. He dared to challenge conventional medical beliefs and shake the academic establishment by producing an unprecedented informative atlas of the human body. He knew it would require the dissection of numerous bodies and a team of talented artists and engravers; an endeavor that eventually took him almost five years to complete. In 1543, *De Humani Corporis Fabrica* (On the Fabric of the Human Body) was published: it was immediately recognised as a triumph of the Renaissance spirit in medical science.

The *Fabrica* is composed of seven books, almost seven hundred pages, and more than two hundred illustrations. It is a monumental work.

Vesalius coordinated the entire project from start to finish. He worked tirelessly, almost obsessively, writing and creating, dissecting and drawing, and overseeing the illustrations and the woodcutting, often taking body parts home with him so that he could fit more work into his day.

Vesalius contributed a significant number of figures himself, but it is clear that the *Fabrica* is the work of more than one man. There was a heavy reliance on artistic collaboration, especially with Stephen Calcar, a young Flemish artist, who had been working in the Venice workshop of the great Renaissance artist Titian (Figure 6.1). The volume of work was so great, however, that there is good reason to believe that the team illustrating the *Fabrica* extended beyond Vesalius and Calcar. Considering every illustration at the same difficulty of realization, each would take at least 10 days to complete (Ivins, 1943; McLeod, 1996). It would have been difficult or impossible for only two men to keep up such a fast pace, especially over less than five years—even more so if one considers evidence suggesting that the *Fabrica* was completed more quickly than this. In fact, Vesalius himself indicated that there may have been additional help. Three years after publication, he wrote that all was not happy during the illustrative process, alluding to a poor attitude among the wider team, mentioning “bad temper of artists and sculptors [wood-block cutters] who made me more miserable than did the bodies I was dissecting” (Vesalius, 1546).

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