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The Flemish Anatomist Andreas Vesalius (1514–1564) and the Kidney

Key Words

Anatomy
Kidney
De Humani Corporis Fabrica

Abstract



Andreas Vesalius was born in Brussels on December 31, 1514 from a long line of physicians. He died in Zante in 1564. He was a typical son of the Renaissance. In 1543, his two most important books were published: *De Humani Corporis Fabrica, Libri Septimum* and the *Epitome*. The former was a book of over 700 pages with several illustrations, highly systematically composed and fully indexed. Andreas Vesalius was the first modern anatomist who based his anatomical descriptions on personal observation. The kidney was a fascinating organ to Vesalius, whose function, particularly regarding the production of urine, he did not fully grasp. He makes short work of the 'perforated membrane theory' which was the current conception of the origin of urine in the kidney. Andreas Vesalius broke with the established rigid and fabricated way of teaching anatomy, and introduced the modern concept of learning based on personal observations, using illustration combined with a critical spirit and sense of experiment.

Andreas Vesalius (born in Brussels on December 31, 1514, died in Zante in 1564) was the descendant of a notable lineage of physicians. Some knowledge of the period and the places in which he lived and of his family background are important for an appreciation and understanding of his achievements.

Andreas Vesalius and His Time

The period in which he lived was extremely rich in important events such as the 'discovery' of the New World, the rise of Protestantism followed by the Counter-Reformation and the deployment of the Renaissance in all its aspects. The Renaissance implies not only the rediscovery of ancient Greek and Roman literature but also the spirit of scientific inquiry. That rebirth of learning is typified in the persons of Leonardo da Vinci, Copernicus, Galileo, Petrarch, Erasmus and Vesalius.

All this makes the Renaissance one of the most fascinating periods in world history.

Vesalius was born and grew up in the low countries along the sea which were part of the seventeen provinces (fig. 1). These low countries which nowadays comprise mainly The Netherlands, Belgium, Luxembourg and the north of France, had a certain form of cultural and economic as well as political autonomy. These countries belonged together in the 15th and 16th centuries under the subsequent dynasties of the Burgundian dukes and the Austrian and Spanish Habsburgs. Due to the strong development of the cities, these provinces had an extremely successful economy: their level of prosperity was comparable with that of the northern Italian cities. Bruges, Ghent and later also Antwerp became European metropolises with elaborate international contacts, which were obviously fruitful for the spread and development of art.

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Fig. 1. The 17 provinces of the low countries: the political map 1506-1559.

This art production gained a hitherto unequalled level. The favourable economic conditions created an optimal climate for the deployment of talent in several aspects of art. The Burgundian dukes, through their eclectic and refined interest in art, founded the base whereupon later generations could further develop their skills. The renewed Flemish Primitives clearly dominated this fascinating period. In addition, one has to mention the richness and influence of the polyphonic Flemish music [1].

The forefathers of Vesalius originated from Wesel (Wesalius – Vesalius), a town situated at the confluence of the lower Rhine and the Lippe (see fig. 1). They belonged to a Brabantian family where medicine was practised from generation to generation. His great-great-grandfather, Pieter Van Wesel, was a doctor and wrote a commentary on Avicenna. His great-grandfather was professor in medicine and vice-chancellor for periods of 3 months (rector trimesteris) at the University of Leuven, founded in 1425 by Jan IV of Brabant. His grandfather, Ever-



Fig. 2. Andreas Vesalius, at the age of 28. The only known authentic portrait. By Johannes Stephanus van Calcar [woodcut in ref. 7].

ard, was physician at the court of Maximilian of Austria and Maria of Burgundy, and wrote commentaries on the ten books of Rhazes dedicated to King Al Mansor. Everard had a son by an unmarried woman, Margareta Swinters (or Winters). The child was named Andreas and this bastard son became the father of the great anatomist. The illegitimate birth of Andreas Vesalius senior prevented him from becoming a royal physician and so he contented himself with the study of pharmacy and eventually became court dispenser to Margaret of Austria and later to her nephew, Charles V. After some 30 years of service he dared to address a request to the emperor asking him to legalize his birth, probably for the sake of his four children. In October 1531, the emperor granted the request of 'notre bien aimé Valet de chambre et apoticaire Andries de Wesele' and as a sign of special benevolence, at no cost.

Andreas Vesalius' interest in medicine, more particularly in anatomy, was more than inherent. During his childhood, he was already dissecting small animals such as mice and rats.



Fig. 3. The striking and turbulent scene represented on the title page of the *Fabrica* and the *Epitome*. It shows a public anatomy conducted by the young Vesalius and is crowded with symbols reflecting his ideas.

A Short Biography [2–4]

Andreas Vesalius was born in Brussels (Brabant-Flanders) on December 31, 1514.

Between 1530 and 1533 he followed courses in 'arts and philosophy' at Leuven. He studied medicine in Paris (1533–1536), without having the opportunity to obtain his degree because of the hostilities between Charles V and the French king François I. Back in Leuven he assembled his first skeleton with the help of his friend a Frisian student, Renier Gemma, with bones from one of the city gallows.

He wrote and published a paraphrase of Rhazes' ninth book for King Al-Mansor [5]. He obtained the authorization of the city magistrate to perform public anatomical demonstrations on cadavers, an event which had not taken place for more than 18 years at this university.

He rashly left Leuven and never returned after a dispute with the anatomist J. Thriverius on the place of bloodletting in 'dolor lateralis' (pleurisy), at that time a highly controversial subject. The vicious insinuation by Thriverius of Vesalius having Lutheran sympathies was probably more decisive for the move of the ambitious anatomist.

He went to Italy, where on December 5, 1537, he graduated in medicine at Padua, a famous university at that time governed by the Venetian senate. Indeed, this university held a great attraction for the whole European intellectual community, not only in the arts, literature and philosophy, but as a centre of the scientific renaissance, characterized by the development of a progressive and critical way of thinking. During one of his visits to Venice he met his fellow countryman, the artist Johannes Stephanus Van Calcar, who was a recent arrival in Venice, where he had entered the school of Titian.

The day after his graduation, Vesalius was appointed as professor at the University of Padua. This university needed skilled anatomists to perform the public anatomies in the months of December and January. The teaching of anatomy was highly valued by the numerous Italian and foreign medical students and could not be omitted in any way. It belonged to the duties of the second professor of surgery. The quality of his teaching and the demonstrations was so high and its reputation spread so quickly among other Italian universities that he was invited for a public course on anatomy at the renowned University of Bologna (1540). There his demonstrations supported the course of Matheus Curtius (1475–1542). In 1538 he published his *Tabulae Anatomicae (Tabulae Sex)*, loose anatomical sheets for the use of students who could attach them to the walls of their rooms [6]. These drawings (made in collaboration with Van Calcar) were far better than anything that had been published up to that time in this particular field.

In 1543 his two most important books were published: *De Humani Corporis Fabrica Libri Septem* and the *Epitome* [7, 8]. His fame grew so fast that he was soon nominated physician of Emperor Charles V.

He was married in 1546 in Brussels to Anna Van Hamme. Vesalius was ennobled on April 20 1556 and nominated earl.

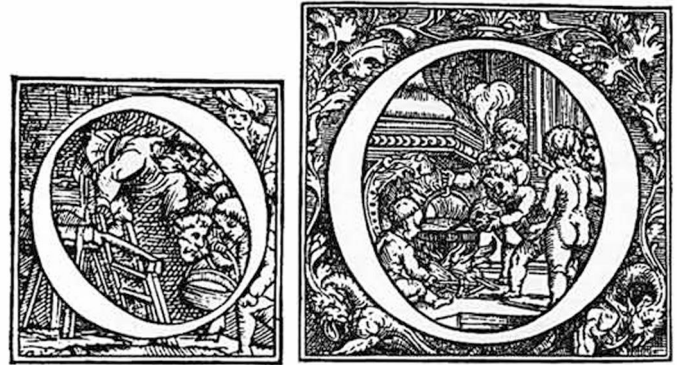


Fig. 4. Each of the seven books of the *Fabrica* (1543) begins with a very large, histrionic capital, the chapters with a somewhat smaller ornamental letter, representing in a delightful way scenes from the work of an anatomist or from surgical and obstetric practice. The chapter on the kidneys starts with a small O ('organa') and represents the putti receiving the head of a criminal from the executioner standing on the scaffold. The large O (p. 257 of the *Fabrica*) demonstrates that in order to get a clean skull the head was boiled in a kettle.

He lived in Madrid in 1559 where he belonged to the court of Philip II. In 1564, he made the long trip to Jerusalem. On his return voyage he became ill and put ashore after a heavy storm on the island Zante, where he died in October 1564. The only authentic portrait of this fascinating man was made by Stephanus Van Calcar (fig. 2).

In 1543, the printing house of Johannes Oporinus in Basel took care of the masterpiece of Andreas Vesalius Bruxellensis: *De Humani Corporis Fabrica Libri Septem* [seven books dealing with the construction, function (fabrica) of the human body] (fig. 3, 4)¹. It turned out to be an impressive book containing 760 pages with more than 270 wonderful woodcuts, and weighing approximately 7 kg. A masterpiece of human anatomy was born, never seen or published before, wherein in addition to the anatomical descriptions, the author tries to correlate the structure and function of the different organs. More than 200 times, Vesalius disagrees with the current ideas of the time which were dominated by the texts of the brilliant Claudius Galenus of Pergamum (130–200 AD).

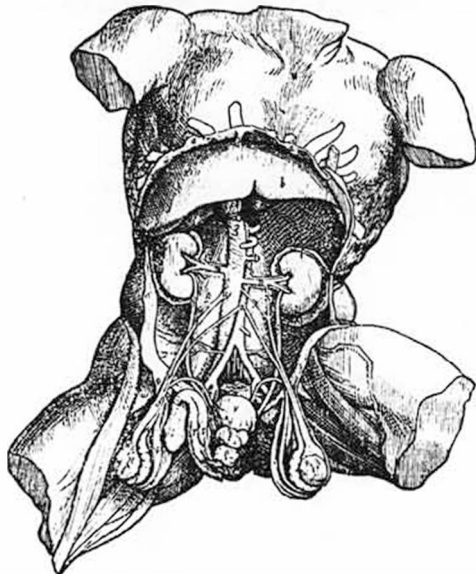
The scientific spirit in Europe of the 16th century had obviously not yet acquired the critical mentality which would develop in the coming centuries. Concerning medicine, particularly anatomy, further investigation was considered unnecessary since everything had already been described. Doubting the ideas of Hippocrates and Galen was, according to the at that time established doctors and professors, unthinkable: 'Galenus obus nomium bonorum, post Hippocratum et nihil a Galeno, outi nec ab Hippocratem per perram esse scriptum um

¹ In the same year, the Pole Nikolaus Copernicus (1473–1543) published his book *De revolutionibus orbium caelestium libre vi*, which laid the foundation of modern astronomy.

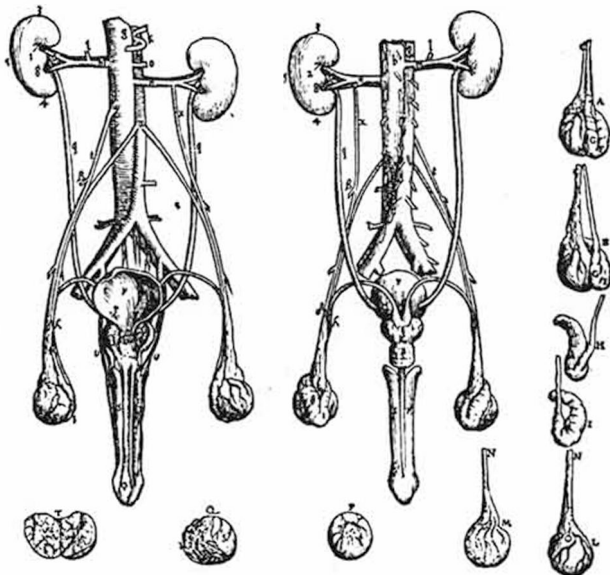
VIGESIMAPRIMA QVINTI LIBRI FIGVRA.
 QVAE TRES PROPRIAS CONTINET TABEL.
 Las sectionis serie inuicem subsequentes, ac appositissime renū sinus meatumq;
 urinariorum principia ostendentes.



VIGESIMASECVNDA QVINTI LIBRI FIGVRA.



VIGESIMATERTIA QVINTI LIBRI
 FIGVRA.



quam'. In this context appears an impassioned young man, who has barely reached the age of 28, who writes a book in which on several occasions Galen's descriptions and concepts are questioned or disputed based on personal observations, and in which different interpretations are given to particular organ functions.

Vesalius and the Kidney

A first valuable and interesting document dealing with Vesalius and the kidney consists of the eyewitness report of Baldasar Heseler, a diligent and scrupulous German student of medicine (from Leignitz), which comprises reports of lectures on the 'Anatomy of Mundinus' given by Matheus Curtius at Bologna in January–February 1540 and of the anatomic demonstrations performed by Andreas Vesalius in conjunction with those lectures. After a long and complicated journey, this Latin text arrived in the Royal Library of Stockholm, and was found and translated by Ruben Eriksson [9] in 1959.

On the morning of Monday January 20, 1540, at the church of San Francisco in Bologna, Matheus Curtius taught the anatomy and physiology of the kidneys. In the late morning, Vesalius performed his tenth demonstration and used a dog and a human body for the dissection of the renal region. Baldasar Heseler noted:

In this morning's dissection D. Andreas first showed the dissection about the kidneys of which Curtius had already lectured. And first he dissected the kidneys of a dog showing us very carefully, how the interior membrane lining the renal cavity consists of the vena and arteria emulgens, which enters the renal substance through its concave side, how it divides into several branches, and finally through their union from both sides in this way constitutes a membrane. He showed how, through this thin membrane, the blood is filtered, and how in healthy persons the urine passes into the renal cavity and is then conveyed to the bladder through the ureter; and how preternaturally stones, sand, hairs, and also blood are emitted, but how the orifices of the

Fig. 5. Kidney illustrations from book five of *De Humani Corporis Fabrica* [Translated from the original Latin text [10].] **Top** Figure 21, 1–3, p. 371: 'The twenty-first figure of the fifth book consists of three small special plates which follow one another in the sequence of dissection and show very clearly the sinus of the kidneys and the origin of the urinary passages'. The dog kidney was used by Vesalius on purpose, as he regarded the human organ as too fatty to demonstrate what he had in mind, namely that the existing theory of filtration through a membrane behaving as a sieve ('membrana cribri malo') was wrong. **Middle** Figure 22, p. 372: 'The present figure follows the twentieth in the sequence of dissection. In it the ends of several ribs have been fractured and turned upwards and outwards so that the hump of the liver is here seen in the same way that its hollows are brought into view in the twentieth figure. The kidneys stripped of their fatty covering present themselves, and the origin and course of the seminal veins and arteries are shown'. **Bottom** Figure 23, p. 374: 'In this, the twenty-third figure are two special plates of which I shall appropriately call one the right and the other the left. In each plate, we have depicted the kidneys, bladder and seminal organs resected from the body with portions of the vena cava and the artery. On the right these structures are delineated from the anterior aspect, and on the left, from the posterior. On the left we have opened in particular the bladder and its neck or common passage for the semen and urine which are still intact on the right'.

Fig. 6. ‘... anyway we sometimes see that the left kidney is higher than the right one, particularly in those subjects with a large liver and small spleen, as if this liver would push the right kidney down ...’.

Fig. 7. ‘The kidney consists of a fleshy substance of high density, firm and hard, and absolutely not crossed by fibres. Indeed, the renal mass is like the liver and the lungs, free of fibres, the only present fibres along the blood vessels serve to attract, maintain, and reject.’

veins close at once. [And he showed us how] blood in the urine issues when the retaining faculty of the orifices of the veins and arteries are slackened. In the same manner, the hepatic flow occurs through the anus, namely when the orifices of the mesaraic veins are weakened so that they cannot retain the chyle extracted from the intestines. Some however, falsely maintain, that this thin membrane has its origin in the outer membrane that surrounds the renal substance, as he clearly demonstrated to us. Then he also showed us the portion of both the kidneys in man, their connections, their parts, how the venae [and arteriae] emulgentes from the vena cava and the great aorta run to the renal cavity, and how the ureters run to the bladder. He dissected both, and we saw much fat in them. He showed, how at each side above the inner membrane the orifices and vena and arteria emulgens were visible, how they were mutually combined and constituted the inner lining, which was as a filter to the rather large renal cavity, where the urine is contained etc. [10].

This very interesting text shows that Vesalius was giving anatomical demonstrations, using animals (in this case a dog) and human material. He drew the students’ attention to the differences between these two species concerning the kidneys. Later, in the *Fabrica*, he returns extensively to this issue (p. 516, line 9 ff.). This neutralizes the severe criticisms by his contemporaries and by modern authors for passing the kidney of this animal for that of man.

The main section dealing with the kidneys in Vesalius’ major book *De Humani Corporis Fabrica* is found in book five, entitled ‘Organis Nutritioni...’, more particularly in chapter 10 *De Renibus*’.

This book five begins with a number of illustrations with an extensive index and explanation of symbols, five of them (figures 20–25, pp. 370–380) relating to the kidneys (fig. 5). Chapter ten is entirely devoted to the kidneys and consists of three-and-a-half pages (pp. 514–517) containing one figure schematically representing, according to Vesalius, the false teaching of his contemporaries on the formation of urine (see below).

The kidney chapter of book five starts by describing the localization of both kidneys in the abdominal cavity. Vesalius localized the right kidney higher than the left, however, in some cases, he mentioned that an opposite situation is found (p. 514, chapter 19, lines 18–20) (fig. 6).

quàm iecur descendat, uterque autem ren uenæ caux, quâ sub iecoris corpore ducitur, uicinus esse contendat, merito dextrum sinistro elatiorem esse plerunque cernimus. quippe non rarò etiam sinister dextro elatior obseruatur, in his præcipue quibus lien minor & iecur maius obtigit: perinde ac si id dextrum renem deorsum deprimeret, ille autem sinister alius ascendere, fibris subijci sineret. Porro contrarium hunc situm renibus non tam loci, quo aptè locari possent, occasione, quàm ne è directo utriusque serofum sanguinem attrahant, ac alter in contrarium reuellens alterius munus prohibear, accidisse constat. Neque etiam in renum situ Galeni ratio

illum emundant. Superficiem iecoris gibbo similiter impenfe leuam & lubricam sortiuntur, ut & colorem in tenerubrum & resplendentem. Substantia nanque constant carnea, densa, admodumq; solida & dura, parumq; à cordis substantia variante, præterquam quod nullis omnino fibris intertextitur. Renum enim substantia fibrarum, ut & iecoris pulmonumq; substantia, ex pers est: uasorum per ipsam diffusorum fibris ad attractionem, retentionem & expulsionem famulantibus. Quum enim sanguinis serum renes excolare oporteret, neq; commodè uenæ caux magnæq; arteriæ corporebus, uti iecur, ad uenam cauam adnasci poterint insignis

The second part of the text contains Vesalius’ own ideas concerning kidney architecture and function (fig. 6–10). Furthermore the author dwells extensively and with passion on the misconceptions and misinterpretations of his contemporaries concerning the kidneys (fig. 8):

There are so many concoctions invented by other professors of anatomy concerning the functions, structures, membranes and vessels splitting up in the kidneys. Galen claims that the vessels (vein and arteries) split up in the kidney mass where the blood is retained within the renal mass during which the urine together with part of the bile present in the blood is passed through and discharged in the urine. Our doctors, who follow Galen’s ideas, describe however the structure of the kidney in an uncritical and false way. Where they do not take into account the distribution and localization of the vessels they invent many things, among them sieving membranes. Others, having an aversion to the practice of dissection sit on their high chairs, self-sufficient as Prometheus and consider their assignment as fulfilled after having created a human body by means of their imagination.

As an example [see inserted figure and text] today’s important doctors have taught and written that there is a threefold process in the separation of the urine from the blood. They do not argue based on what they observe by themselves dissecting a human body, but they invent according to their own pleasure, cavities and tracks. Consequently, the current opinion maintains two cavities in the kidneys superposed one over the other along the length of this organ. Both cavities are separated by a kind of membrane. The renal artery and vein supply the kidney with serous blood, the porous membrane having small narrow holes separating both cavities will allow passage of aqueous and fine dreg such as bile, while the thicker blood cannot pass. Those stupid architects of their own human construction even add, obviously to propose an even more elegant creation of Nature, the notion that the urinary conduct originates from the bottom of the lower cavity in order to collect the sieved urine.

It is obvious that the eminent Creator of the thing has not assigned such an important function to that single thin membrane perforated like a sieve and that, furthermore, he never even constructed such a membrane in the kidney. On the contrary, it is the renal mass itself, which according to an inborn capacity and within appropriate and correct proportions (‘ac propria ad iustitia temperic’) will filter the serous dreg out of the arterial and venous blood distributed over the renal mass and bringing this filtrate into the cavity, it will leave the kidney through the urinary conduct. I suggest that, in order to understand this unbelievable masterpiece of nature, you take the kidney of a dog since it is lean and in contrast to the human kidney not covered with fat. You will also find two cavities which have been constructed by nature however in a totally different way from what the doctors think. Indeed the renal vein and artery entering the renal mass are transformed into a single structure which according to its hardness and thickness corresponds to the cover of the arteries.

...us in hunc modum deducendum non est, propter communem et vana rationem periclitare aggre-
diar. atq; urinam ita hæc tibi ob oculos ponere, quemadmodum si præfens essem, leuiq; admo-
dum opera in renis sectione demonstrare possem: maxime quum tot fabulæ de renum offi-
cijs, sinibus, membranis, & quæ in renibus distribuuntur uasis, antehac cæteris diu sectionis
professoribus effictæ sint. Galenus inquit simpliciter, uenas ac arterias per renis corpus distri-
bui, & per spissam duramq; renum substantiam, retento sanguine, urinam cum bilis quæ san-
guini adest portione transmitti, inq; urinarium meatum effluere. Nostorum medicorum, &
qui Galenum sequuti sunt omnium, hæc exprimere studentium, alij perperam oscitanterq; re-
nis fabricam aggredientes, & quæ hæc ualorum sit distributio & situs non obseruantes, nescio
quas colatorias membranas ementiuntur. Alij sectionem auerſari, & in altis cathedris seden-
tes, sibiq; ipsis mirificè placentes Promethei, abundè suo munere se perfunctos esse arbitran-
tur, si discipulis imaginatione hominem cõfingant. Atq; hinc illud est, quod præcipuos nostræ
ætatis medicos & docuisse & scripsisse scio, nobis triplicem, quo urina à sanguine in renibus di-

DVA BVS præsentibus figuris medicorum de urina
excolatione commentum exprimere conatus sum, ac superiori
figura renem ab ipsius gibbo uersus sinum cauum ut dissectum
finxi, inferiori autem renis duram & media spelturam porrio.
Cæterum quod singulis indicetur, ipse etiam lectorem ad hunc
hunc modum docebit.



- A Vena & arteria serosum sanguinem reni offerentes.
- B Sinus, in quem medici urinam & arteriam nuper dictam sero-
sum sanguinem profunderè docent.
- C Sinus, in quem urina ex iam dicto sinu colatur.
- D Renis substantia orbicularem sinum hoc amplectens.
- E Bracium & angustissimum renis colatorium, seu membrana cri-
bri modo prius. & urinam ex sinu B indicato in sinum C ita
signatum unà cum bile promouere solent.
- F Urinam è rene ad uesicam deferrens meatus.

Fig. 8. Vesalius' observations on the ideas held by his contemporaries. See text for a translation of the main body. The insert reads: In those two figures, I have attempted to represent the false teaching ('commentum exprimere') of doctors on the straining ('excolatione') of the urine. In the upper figure, I have sketched the kidney dissected from its hump towards the sinus or hollow, but in the lower, only the central portion is seen. The other concepts will be indicated one by one, whereby the index of symbols will be explicative.

- A The vein and artery which brings the serous blood to the kidneys.
- B The sinus in which the just-mentioned vein and artery let the serous blood flow, as taught by the doctors.
- C Sinus, in which the urine from the aforementioned sinus is filtered.
- D Circular renal mass which embraces both sinuses.
- E A naive and ridiculous presentation of the kidney function as if the urine together with the bile is allowed to flow from the sinus indicated by B into the sinus indicated by C through a membrane behaving as a sieve.
- F The excretory way towards the bladder of the urine leaving the kidneys.

Fig. 9. Those who are not satisfied with imagination and ghosts, but instead have concentrated on dissection combined with intellectual reflection, have at least observed the start of the urinary conduct, not at the bottom of the renal cavity but in the middle part of the inner side.

In the *Epitome*, written by Vesalius as a guide to the larger work (the *Fabrica*) and considered as a 'triumph of condensation' [9] (12 pages of text, 11 pages with figures and legends) he describes rather briefly the kidneys and their main function.

This office of purgation is most fitly performed by the kidneys, one each on either side of the vena cava and very close to the liver. They quickly draw the greater part of the serous humor of the liver toward themselves and strain

ab inferiori. In superiorum renis uenam arteriamq; finire, easq; serosum sanguinem in illum in-
fundere, deinde membranam sinum interceptientem, tam arctis angustisq; foraminulis peruiam
esse, ut & aqueum illud ac tenuè recrementum & bilem quoq; transmittat, sanguine interim pro-
pter sui crassitudinem non penetrante. Addunt præterea illi humanæ fabricæ stupentes architecti,
ut tanto salicet elegantius Naturæ opus confingant, ex inferiori sinu meatum urinarium ex-
plantari, illumq; urinam iam colatam excipere. Profecto lagacissimus ille rerum Opifex tantum
munus uni membranulæ cribri modo perforatæ non tribuerit, neq; in renibus eandem extru-
xerit. Quin renum substantia facultate sibi innata, ac propria ad iustitiam temperie, ex uenis ac ar-
terijs per ipsius corpus deductis, serosum illud recrementum excolat, ac in sinum qui urinarium
meatum excipitur, diffundit. Quod incredibile artificium ut uideas, caninum renem utpote mad-
lentum, & nulla, quemadmodum humanus est, pinguedine oppletum, ad manum tibi esse ue-
lim, illumq; uti renis administrationem ad præfens libri calcem subiungam, te primum aggre-
di. Post aliquot enim obitas sectionem (dummodo prima non suffecerit) duos in renibus sinus
adinuens, secus multo ac nostri arbitrantur medici, à Natura formatos. Vena enim & arte-
ria in renis corpus subeuntes, in unum degenerant corpus, arteriarum tunicis duritia crassitiedq;
respondens. Hoc cauum & uenæ arteriæ ue modo per renis corpus distributum cernitur. Pri-
mum enim paulatim lætēs, in duas quodammodo partes diducitur: quarum unam quidem
anteriorē alteram uerò posteriorē, renum figuram nempe hanc memora de Arima studio ue-

quibusdam accurate lectionem aggrediendibus ita impoluit, ut hunc adipem in urinarium meatus
operculum quoddam esse, & urinam in renibus excretioni seu colationi præfici, & quoddam ue-
lut colatorium esse, scriptum reliquerint. Qui enim suis imaginationibus & somnijs non con-
tenti, plenam operam unà cum ratione sectioni quoq; impendunt, si nihil aliud, saltem mea-
tus urinarium in initium uiderunt, quod sanè ex altero renis sinu pendet, non quidem ex humi-
liori ipsius sede, sed ex interni lateris secundi istius sinus medio. Incipit enim meatus ille ab
externo latere membrani corporis, ubi primum in ramos scinditur. deinde per eius corporis
medium procedens, ex renum medio in internum renis lateris uenæ cuiusdam instar nrocidit.

it from the blood. In order that they may accomplish this more handily, a notable vein and likewise an artery are extended to the kidney; the kidney receives the serous blood into a membranous sinus which is broad and hollow and divided into many offshoots concealed by the substance of the kidney and covered over with a double tunic. By its function the urine is expelled and led off into another sinus which is prolonged as the urinary passage constructed like a vein; this urine is going to be carried to the bladder [11].

reobscure, notoria	§10.11	
RENAL DVI COLYMBVS Sophistica apud Patuinos professor	§6.23	
*renalis quibusdam dicta uena. 293		
32		
renis canini ad humanum differentia	§16.9	difference between the dog and human kidney
renis fabrica quid	§17.10	
renum cum uenae cauae portionibus delineatio	§14.49	
renum cur alter altero elatior.	§14.49	
renum forma §15.2. magnitudo. ead.		
§. substantia	10	
renum in internis sedibus conformatio	§15.30	concerning the to date neglected interpretation of renal structure function by the professors of anatomy
renum fabrica negligendus habitus ab Anatomis professoribus expensa	§15.38	
renum minus	§15.27. & §16	
renum numerus, situs & usus.	§14.29	concerning the ridiculous dogmatic approach the anatomists have concerning the renal function
de Renum officio ridicula Anatomorum dogmata	§15.2	
renum sinus cuiusmodi inde.	§16.231	
renum sinus delineati	§11.49	
de Renum sinibus falsa quorundam persuasio	§15.51	about the false conviction concerning the renal sinuses
renum sinus delineatio.	§10. & §11.22. & §12.32	
renum tunicae ac nerui	§17.8.21	
renum tunicarum, totiusq; eorundem natura examen	§14.36	
renum uerbrae	167.35	
renibus obliatae uenae & arteriae.	§15.15.	
renuendi mos diuersus	63.30	

Fig. 10. Section of the index of the *Fabrica* referring to the kidneys. Four out of 18 items deal with Vesalius' irritation concerning his contemporaries' teaching on kidney structure and function.

Discussion

Andreas Vesalius was the first modern anatomist who based his anatomical descriptions on personal observation. He took note of the prevailing beliefs of his day, which were mostly based on the writings of Galen, yet he corrected them in more than 200 instances in his work.

Vesalius' work is generally regarded as outstanding, not only for its content, but for the way in which it came into being. Between the ages of 24 and 27 he managed to produce a book over 700 pages long which was richly illustrated, highly systematically composed, and fully indexed, while having it published by one of the finest printers of his time, who worked closely with him. This was a highly original way of working and totally without precedent.

Vesalius was tremendously impatient with the way that anatomy was generally taught at the time and criticised it open-

ly, which must have come across as a hostile indictment to some members of the establishment. This explains why, during his life as well as after his death, he has not always been treated favourably.

The kidney was a fascinating organ to Vesalius ('Profectò sagacissimus ille rerum Opifex tatum munus.... Quod incredibile artificium ut videas'), the function of which, particularly as regards the production of urine, he did not fully grasp. However, such limitations in his ability or his understanding remain inarticulate in his texts. In describing the organ, he makes short work of the 'perforated membrane theory', which was the current conception of the origin of urine in the kidney. He introduces the alternative concept, quite original at the time, that the kidney tissue itself, based on an inherent quality and 'within appropriate and correct proportions' ('ac propria ad iustitia temperè') filters the serous dreg out of the arterial and venous blood distributed over the renal mass and brings the filtrate



into a cavity in order to leave the kidney through the urinary conduct'.

For the young intellectuals of his time, especially students of medicine, Vesalius must have been an impressively appealing personality. This is shown clearly in the notes taken by the German student Baldasar Heseler [9]. He broke with the established rigid and fabricated way of teaching anatomy, and introduced the modern concept of learning based on personal observations, using illustration combined with a critical spirit and sense of experiment. At the same time, he left behind a brilliantly written, richly illustrated and well-structured reference work, painstakingly printed, which has been used and plagiarized for centuries.

The passion with which he engaged in all his activities related to researching, writing and teaching the knowledge of anatomy is expressed in the caption he wrote for one of his best known anatomical figures (fig. 11).

Fig. 11. Vesalius' 'skeletal Hamlet', soliloquizing beside a tomb with the caption 'Vivitur ingenio, caetera mortis erunt': ingenuity will live, all the rest will die.

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