SQUARES AND DIOPTERS

THE DRAWING SYSTEM OF A FAMOUS ANATOMICAL ATLAS*

Tim Huisman

The anatomical atlas *Tabulae sceleti et musculorum corporis humani* (1747) by the Leiden anatomist Bernard Siegfried Albinus (1697-1770) and the Amsterdam draughtsman Jan Wandelaar (1692-1759) has attracted much admiration over the years.[1] Its large plates, pairing a sharp depiction of anatomical details to a mysterious, dreamlike atmosphere, are a highlight in the history of anatomical illustration as well as one of the most impressive achievements in the graphic arts of eighteenth-century Holland (Figure 1). The most elaborate account of how the *Tabulae sceleti et musculorum* was made can be found in Hendrik Punt's dissertation *Bernard Siegfried Albinus (1697-1770) On 'Human Nature', Anatomical and Physiological Ideas in Eighteenth Century Leiden* (1983). This book also contains a reconstruction of the remarkable drawing method that lies at the core of the atlas and which gives it much of its particular character. Punt's reconstruction of this drawing method, however, leaves open some questions. This article — originating from research for an exhibition at the Museum Boerhaave — is intended to answer those questions.

Albinus' motives

It was Albinus' aim to make an anatomical atlas that would be a radical im-

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[1] On Albinus and Wandelaar's atlas, see J.L. Choulant, *History and Bibliography of Anatomic Illustration* (Ed. Chicago, 1920); H. Punt, *Bernard Siegfried Albinus (1697-1770) On 'Human Nature', Anatomical and Physiological Ideas in Eighteenth Century Leiden* (Amsterdam, 1983); Museum Boerhaave, *De volmaakte mens, de anatomische atlas van Albinus en Wandelaar* (Leiden, 1991).

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provement on all previous illustrated works on anatomy. Earlier anatomical atlases, such as Andreas Vesalius' *De humani corporis fabrica* (first published 1543) or Govard Bidloo's *Anatomia humani corporis* (1685) left a great deal to be desired in Albinus' opinion. The plates in these books were often unclear and misleading. Albinus blamed many of these inaccuracies on a lack of guidance and control over the artist by the scientist. More or less left on his own before the anatomical preparations, the artist often misinterpreted details through a lack of scientific knowledge and represented them incorrectly in his drawings. Besides that, the skeletons and muscle-manikins were usually represented in dramatic and tortured poses. In Albinus' opinion this served no purpose. It only obscured the anatomical information of the illustrations or distracted the viewer's attention.

Another problem Albinus noted in anatomical illustrations, was caused by the fact that in order to be reproduced, the drawings had to be transferred onto woodblocks or copperplates. To do this, an engraver was brought in as a third man in the production team of the anatomical atlas. A third link in the chain from anatomical preparation to two-dimensional representation resulted in more inaccuracies and mistakes.

In his own atlas Albinus would avoid these shortcomings, mainly by establishing a close collaboration with his illustrator Jan Wandelaar, a draughtsman-engraver who specialised in book illustrations and from 1720 onwards in the illustration of scientific works. Albinus met Wandelaar in 1723 when they were both working on a re-edition of Vesalius' *De humani corporis fabrica*, Albinus as editor and Wandelaar as engraver.[2] Besides having artistic skill and craftsmanship as an engraver, Wandelaar — according to Albinus — also distinguished himself by his inquisitive and enthusiastic character. He was always ready to accompany the anatomist in the dissecting room to make sketches and eager to learn more about human anatomy.[3]

With Wandelaar as collaborator on his ambitious project to make the perfect anatomical atlas, Albinus could overcome the shortcomings that in his opinion had marred previous anatomy books. Because of their close collaboration, the anatomist was always at hand to correct mistakes made by the artist in the early stages of the drawing process, or to make small explicative sketches in the margins of Wandelaar's drawings to clarify certain anatomical

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[2] Published as *Andreae Vesalii opera omnia et chirurgica* (Leiden, 1725). The initiative for this edition was taken by Boerhaave.

[3] "I have often wondered at his spirit, his patience and his resolution; he is moreover ardent and never without a certain impetuous eagerness of effort," Albinus remarked in his memoirs. Albinus, *Annotationes Academicae*, L I praef. p. 8, quoted by Choulant (n. 1), *History and Bibliography*, p. 278.

details.[4] Wandelaar and Albinus also did away with the wide variation of tormented poses that characterised the illustrations of previous anatomical works. In the *Tabulae sceleti et musculorum* the twelve full-page plates of skeletons and muscle-manikins show just three poses, frontal, dorsal and lateral. These poses demonstrate the muscles and bones of the body very clearly, and also express something of the vitality and harmony of a living human being.

The paradox of perspective

One fundamental problem of the anatomical atlas, however, could not so easily be overcome. This was the problem of distortion due to foreshortening. When an artist wants to represent the human anatomy down to its minutest details — as is the case in an anatomical atlas — he has to observe those details close by. However, when the artist is working from a close-up viewing point, he can only draw a very small part of his subject as seen at a right angle, namely that part of the subject that is in the centre of his field of vision. The parts of his subject that are further removed from the centre of the field of vision are seen at increasingly sharper angles. When the artist is for instance drawing a standing skeleton, and the centre of his field of vision is located at the chest of the skeleton, the skull and the feet are seen at such sharp angles that it is hard to determine the relative size and locations of the separate bones of the skull and the feet.

There was a way of avoiding this misleading effect of perspectival distortion. If the skeleton is observed from a considerable distance, all its parts are seen at a right angle (i.e. frontally). But the problem with a viewing point far removed from the skeleton is of course that from such a distance, the artist is unable to discern any details.

So Albinus was faced with a paradox. How could he make it possible for the artist to move close to the subject in order to draw the details, without losing the perspective of a viewing point far removed from the subject. Albinus' solution to this problem, presented in the *Tabulae sceleti et musculorum*, was novel in the field of anatomical illustration.

Albinus divided the drawing process into two stages. The first stage was to draw the skeleton from a considerable distance. To do this the skeleton was set up in the required pose, with the help of strings and pulleys and with a living man as a model. A frame was placed in front of this skeleton, divided by cords into a grid of squares of 7,3 x 7,3 centimetres. Albinus called this 'a diopter'. A

[4] See for instance a preparatory drawing of the spinal column by Wandelaar with handwritten remarks by Albinus, preserved at Leiden University Library as BPL 1843 fol.12.

grid with the same measurements divided Wandelaar's drawing paper, which was removed 40 Rhineland feet (12,5 metres) from the skeleton.[5] According to Albinus, this distance was more or less the equivalent of an indefinite distance and consequently ruled out perspectival distortions. The grids in front of the skeleton and on the drawing paper were an optical aid to simplify the transition from the three-dimensional object to the two-dimensional representation. In this manner the artist made a life-size outline of the skeleton without perspectival distortions, but also without any details (Figure 2).

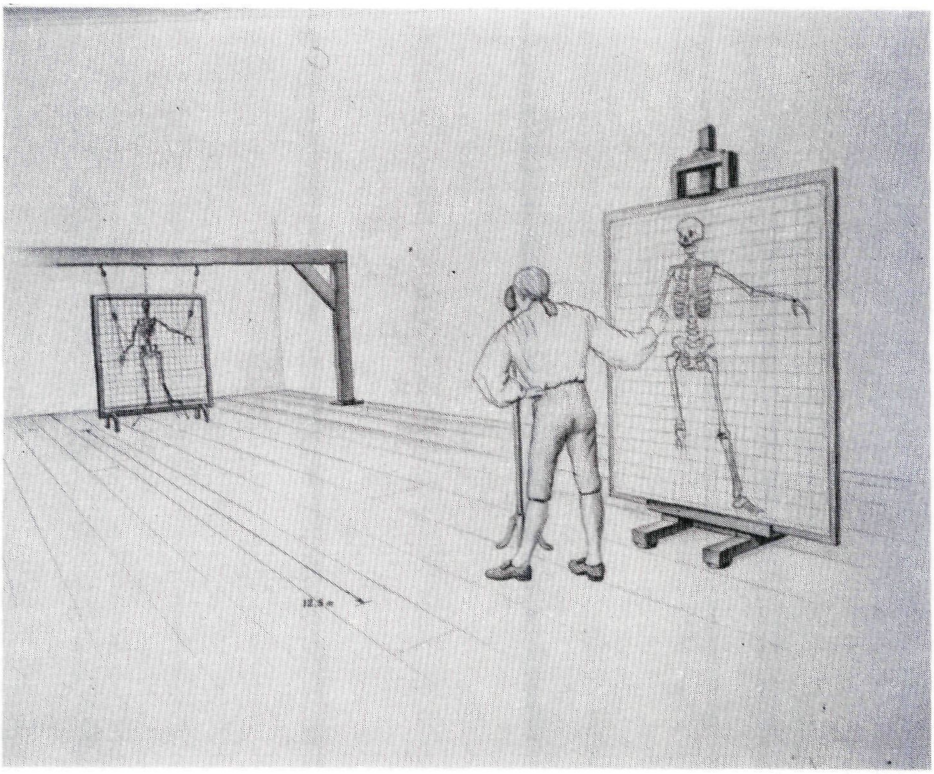

Figure 2 — Modern reconstruction of the drawing system used by Wandelaar. The first stage of the drawing process: the skeleton is drawn from a distance of 40 feet. Reconstruction-drawing made by Bill Easter

[5] This grid of 7,3 x 7,3 cm squares can still be seen on the life-size drawings of the skeletons made by Wandelaar, preserved in the Leiden University Library as BPL 1914 I, BPL 1914 II and BPL 1914 III.

The second diopter

To make it possible for the artist to fill in the details, Albinus came up with the remarkable second phase of his drawing system. And it is this second phase that has never been convincingly explained in the literature so far. In 1983 Hendrik Punt published his dissertation on Albinus, in which we find the most elaborate account of the making of the *Tabulae sceleti et musculorum* to date. According to Punt, the details were drawn with the help of a second diopter, with squares that were ten per cent of the size of the squares of the first diopter; each square of 7,3 x 7,3 centimetres was divided into hundred squares of 7,3 x 7,3 millimetres in the second diopter. "Each of these squares," Punt says, "60.000 in all, could be used as a sight at four feet."[6] Both diopters were set up in a vertical position, the first one directly in front of the skeleton and the second one at a four feet remove from it. The diopters were placed in such a way that the dividing lines of the first one coincided entirely with the corresponding lines of the second. To the artist's eye, on each square of 7,3 x 7,3 centimetres was superimposed a grid with a hundred squares ten times as small. With this partition of his field of vision into minute squares, Wandelaar could determine the location in space of all the details of the skeleton. Consequently, he should now be able to move close to the skeleton to draw the details, without losing the perspective of his original viewing point removed 40 feet from the skeleton.[7]

But, if we try to imagine the artist at work using this system we encounter many difficulties. For instance, by what method did Wandelaar decide which of the 60,000 little squares he would use as a sight? Punt refers to mathematical calculations, but does not elaborate on how these calculations were done. Furthermore, if Wandelaar had chosen one of these 7,3 x 7,3 millimetre squares as a sight, how could he maintain this exact sight when every now and then he had to avert his eyes from the grid-system to the drawing paper in order to make his sketch? And besides that, what did this second frame look like? Was it just as big as the first one, as the total of 60,000 squares seems to suggest. If this was the case, it must have been very difficult indeed for Wandelaar to pick the right square as a sight. But if the second frame was smaller — as the illustration from Punt's book suggests — how then was it moved about in front of the skeleton in such a way that the dividing lines of both grids corresponded with each other (Figure 3)? All in all, Punt's suggested second phase of the drawing method of Albinus and Wandelaar seems to be highly impractical.

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[6] Punt (n.1), *Albinus*, p. 22.

[7] *Ibid.*, pp. 21-32. This explanation of Albinus' drawing system can also be found in the most recent work on the history of anatomical illustration: K.B. Roberts and J.D.W. Tomlinson, *The Fabric of the Body, European Traditions of Anatomical Illustration* (New York, 1992), p. 324.

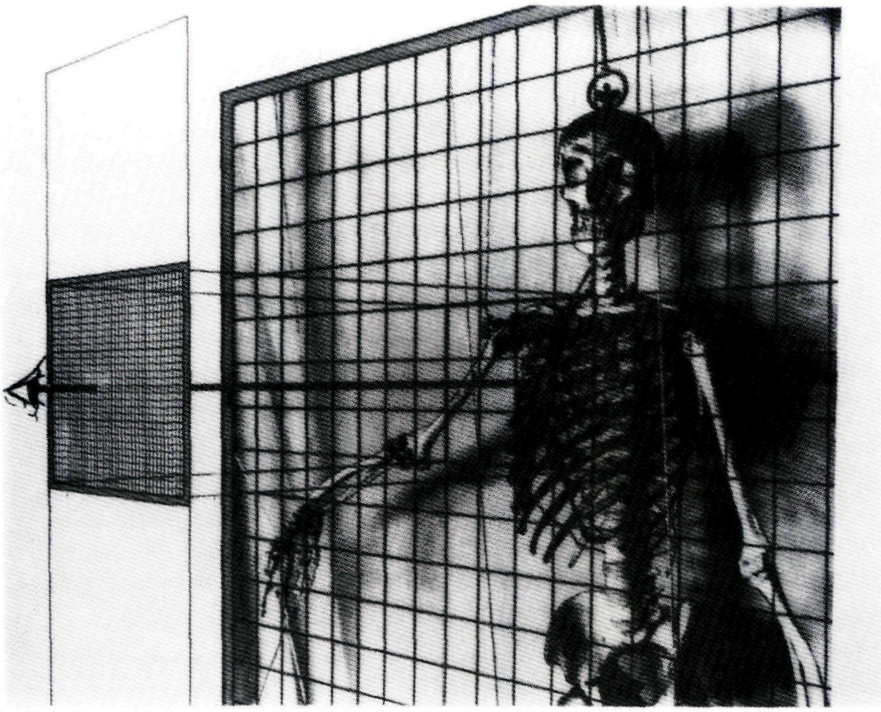

Figure 3 — Reconstruction of the secon phase of the drawing process according to Hendrik Punt. The small size of the second frame was motivated by practical reasons (reproduced with kind permission of the author)

Historia huius operis

In the foreword to his anatomical atlas, the 'historia huius operis' Albinus himself describes how he made Wandelaar work with two grids of squares, or diopters; a bigger one and a smaller one. As outlined by Hendrik Punt, the smaller diopter was used to allow the artist to move close to the skeleton without losing the original perspective. However, when we closely read Albinus' foreword we find that the squares of this second diopter were not one tenth of the size of those of the first diopter. Instead, they were one tenth *smaller*, just as the distance between the second diopter and the original viewing point was ten per cent shorter than the distance of 40 feet between the first diopter and the original viewing point.[8]

The two diopters were placed in an upright position, parallel to each other and at a right angle to the viewing line. The biggest diopter was set up directly in front of the skeleton, the smaller one was placed four feet in front of the bigger one. The grids of squares of the two diopters overlapped each other, with a center point situated at the middle of the left side of the chest of the skeleton. The artist could now choose a position close enough to the skeleton to be able to discern the details. All he had to do was to take care that an intersection of the lines of the smaller diopter corresponded exactly with the intersection of the same lines of the bigger diopter. The point of the skeleton he saw in the produced part of those two points of intersection, he had to jot down on the corresponding intersection of the lines of the grid on his drawing paper (Fig. 4).

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[8] The full translation from the neo-latin of the relevant passage of Albinus' foreword reads:
"It was easy to guide the eye [of the artist] by a so called 'diopter', consisting of four wooden laths in a square form, big enough to frame the whole skeleton and divided into squares by strings. This diopter was placed precisely in front of the skeleton, while exactly the same division as on the diopter was made on the paper on which the artist would draw. From a place the artist had chosen he would look through a 'foramen' (a sight), and he would copy the skeleton. The artist could see which parts of the diopter corresponded with the grid on his drawing-paper.

However, there was something that complicated all this: if the artist wanted to observe one particular part of the skeleton very clearly, it would be necessary for him to look at that part from not too great a distance. But I [Albinus] wanted the various parts to be looked at from a distance of approximately 40 Rhineland feet, so that he [the artist] would not see too many parts too much distorted. However, from that distance the eyes do not have enough visual faculty to see the small details.

To make it possible for the artist to be as close to the skeleton as necessary to observe the details and to see all the parts of the skeleton at once and to take away the lack of visual faculty from the distance of forty feet, the artist was tied down in this manner: I placed the diopter — which I will call the big one — exactly in front of the skeleton, in such a way that the net of strings just touched its most protruding part. In front of that I placed a second [diopter], while a distance of four feet divided both networks of strings. This second one was equal [to the first one] except that the squares were smaller. That is why I will call this the small diopter. I made the squares *one tenth smaller* [my italics, TH], just like the distance of four feet was also one tenth of the distance from which I wanted the skeleton to be seen. So I placed the diopters in such a way that the nets of strings were parallel to each other, and that both were in a vertical position, and that the strings of the first grid corresponded with the strings of the other, while the center was placed in the middle of the left side of the chest.

After the two diopters were set up in this way, the artist chose a position close to the skeleton and convenient when he observed his subject. From this position he had to take care that an intersection of the strings of the smaller diopter exactly coincided with a corresponding intersection of the strings of the bigger diopter, and that the part of the skeleton he saw exactly behind those points was jotted down at the corresponding intersection of the lines of his paper. For I had divided the drawing-paper with exactly the same squares as the bigger diopter.

By copying in this manner all the points behind which there was a part of the skeleton at the corresponding points on his paper, the drawing of the skeleton was made. Because of the small size of the squares the artist could not deviate from the right measurements, at least not in such a degree that he had to resort to estimations ..."

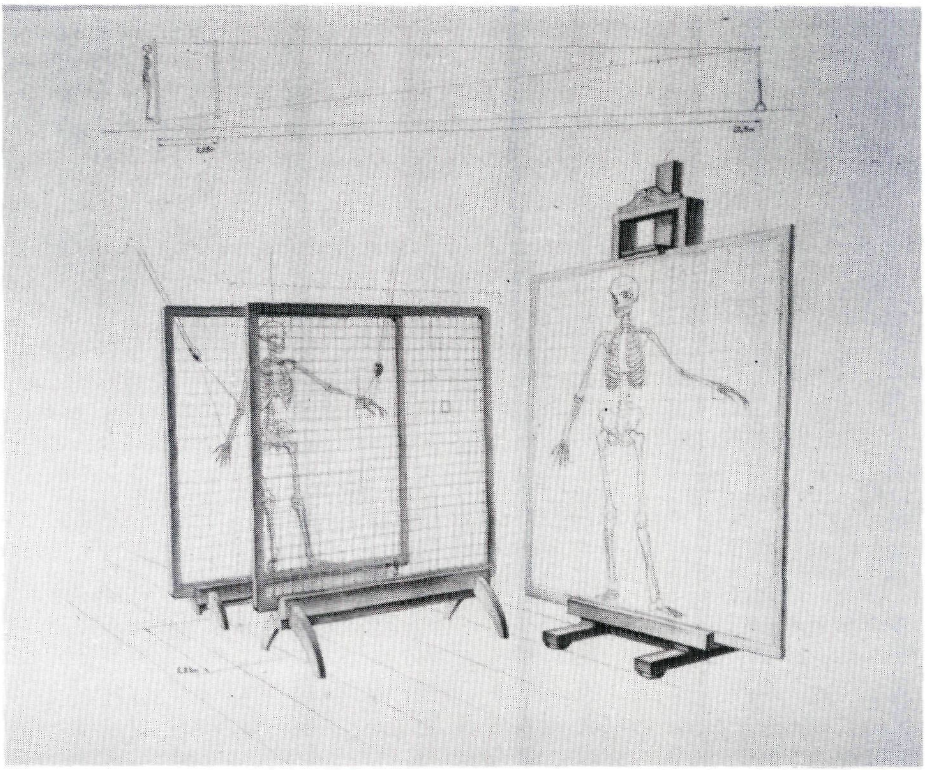

Figure 4 — Second phase of the drawing process: the details are drawn with the help of the second diopter. Modern reconstruction drawn by Bill Easter

Albinus' drawing system was based on the idea of making visible the 'sightlines', the imaginary lines from the original viewing point (removed 40 feet from the skeleton) to the skeleton. This explains why Wandelaar had to take such care to ensure that the intersection point of the smaller diopter precisely overlapped the intersection point of the same lines of the bigger diopter. If the two intersection points overlapped each other, the artist knew that his eye, the two intersection points, as well as the part of the skeleton that lay in the produced part of these points, all lay on the same line, namely the sightline from the skeleton to the original viewing point. In other words, the details in the square between four of those points where the sightlines 'touched' the skeleton were seen by the artist at the same viewing angle as if he were standing 40 feet removed from his subject, although he was now standing much closer. In this way, Wandelaar copied each single square behind which there was a part of the skeleton, on to the corresponding square on his drawing paper. Each time he made sure that he was standing at a viewing point where, to his eye, the lines of the particular square of both of the diopters that he was copying, precisely overlapped each other.

Laborious but successful

Through this original method which, Albinus remarked, was as satisfying to himself as it was laborious to the artist, the three life-size drawings of the frontal, dorsal and lateral aspect of the skeleton were made.[9] These life-size drawings were then further reduced to folio-size by transfering the grid of 7,3 x 7,3 centimetre squares to a grid of 2,5 x 2,5 centimetre squares.[10] In these smaller squares the life-size drawing was copied. The principal lines of these folio-sized drawings were then transferred to the etching ground with a bone stylus and a sheet of paper rubbed on the reverse with red chalk.[11] In this way, Jan Wandelaar obtained an outline of the skeleton which he used as a starting point for his intricate copper etchings. On the pages facing the finished plates of his atlas Albinus printed schematic outlines of the skeletons in which he put the markings of the legenda, thus avoiding interference with the plates themselves.

It must have been a relief to Wandelaar that the complex drawing system with the two diopters only had to be used to produce three views of the skeleton. Once these first three plates of the atlas were completed to Albinus' satisfaction, they could be used as the foundation for the nine plates showing the subsequent layers of the musculature. For this a counterproof of the schematic outline of the skeletons was used as a framework on which the muscles were drawn. This is clearly shown by the preparatory designs that are kept in the Leiden University Library.[12]

With their systematic and mathematical approach to drawing the human anatomy Wandelaar and Albinus achieved impressive results. This was also recognised by their contemporaries. Already in 1749 an English version of the *Tabulae sceleti et musculorum* was published in London and in 1777 it was reissued

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[9] These life-size drawings, in crayon, ink and wash, are preserved in the Leiden University Library as BPL 1914 I, BPL 1914 II, BPL 1914 III.

[10] See BPL 1802 fol. 2,4,6. This method of reducing (or magnifying) designs by using grids was quite common practise among artists since the Renaissance.

[11] Traces of this red chalk can be found on the backside of the preparatory drawings preserved in the Leiden University Library. E.g. BPL 1802 fol. 4.

[12] BPL 1802.

Figure 5 — Joseph Wright of Derby, *The Old Man and Death* (oil on canvas), 1774. Wadsworth Atheneum, Hartford, Connecticut, the Ella Gallup Sumner and Mary Catlin Sumner Collection

reissued in Edinburgh by Andrew Bell.[13] Through the English medical schools Albinus and Wandelaar's atlas soon found its way to America.

But the atlas was not only well received by the medical world. The characteristic features of the skeleton designed by Albinus and Wandelaar were soon to appear in the fine arts. In his manual for budding artists the Amsterdam draughtsman-engraver and collector Cornelis Ploos van Amstel reproduced Albinus' skeletons as models for the study of the human anatomy.[14] A skeleton clearly inspired by the *Tabulae sceleti* is also featured prominently as the symbol of death in a painting by Joseph Wright of Derby (Figure 5).[15]

Without doubt a good deal of the admiration accorded to the *Tabulae sceleti et musculorum* over the years is generated by the mysterious charm of Wandelaar's large copper-etchings. However, its success as an instruction book for medical students as well as artists is largely due to the didactic clearness of its plates, a didactic clearness in which the projection method described in this article played a crucial role.

Summary

The anatomical atlas *Tabulae sceleti et musculorum corporis humani* (1747) by the Leyden anatomist Bernard Siegfried Albinus (1697-1770) and the Amsterdam draughtsman Jan Wandelaar (1692-1759) has attracted much admiration over the years. The plates of the atlas are the result of an unusual drawing method, intended to give a truthful depiction of the location of the different parts of the human anatomy on the flat surface of a book page. Descriptions of this drawing process up till now never convincingly explained all its intricacies. This article is intended to clarify questions about the drawing system that until now have been left open.

Museum Boerhaave
Postbus 11280
2301 EG Leiden
The Netherlands

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[13] *Tables of the skeleton and muscles of the human body* (London, 1749; reissued Edinburgh 1777-1778). For both British editions the plates were re-engraved. Interestingly the plates of the Edinburgh edition have no backgrounds.

[14] Cornelis Ploos van Amstel, *Aanleiding tot de kennis der anatomie in de teekenkunst betreklijk tot het menschbeeld* (Amsterdam, 1783).

[15] *The Old Man and Death* (1774). Compare Judy Egerton ed., *Wright of Derby* (London: Cat Tate Gallery, 1990), p. 83, 84.