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Lines of thought : diagrammatic representation and the scientific texts of the Arts Faculty, 1200-15000

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Citation
Verboon, A. R. (2010, October 12). *Lines of thought : diagrammatic representation and the scientific texts of the Arts Faculty, 1200-15000*. Retrieved from https://hdl.handle.net/1887/16029

Version:	Not Applicable (or Unknown)
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Lines of Thought

Diagrammatic representation and the scientific texts of the arts faculty, 1200-1500



Annemieke Rosalinde Verboon

Lines of thought

Diagrammatic representation and the scientific texts of the arts faculty, 1200-1500

Proefschrift

ter verkrijging van
de graad van Doctor aan de Universiteit Leiden,
op gezag van Rector Magnificus prof.mr. P.F. van der Heijden,
volgens besluit van het College voor Promoties
te verdedigen op 12 oktober 2010
klokke 16.15 uur
door

Annemieke Rosalinde Verboon
geboren te Delft
in 1975

Promotiecommissie

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INTRODUCTION

In the first pages of an early-fourteenth century treatise on logic, a miniature drawing shows a teacher and two students below a luxuriant tree.[1] [*See* figure 1]. The teacher in this image is the personification of dialectic, one of the seven liberal arts.[2] Lady dialectic points, with her left hand, to the trunk of the tree and holds, in the other, a book that she shows to the reader of the manuscript. She also addresses two young men, who stand under the tree on the right. These two students (clerks) do not seem to notice their teacher and instead gesture and deliberate vividly. They should be seen as a representation of the reader himself, who contemplated this first page of a treatise on logic, Boethius' translation of the *Isagoge*. In the following pages he was introduced, in an abbreviated way, to the basics of logical thought - although the 1118 folia of this large manuscript would hardly have struck him as a summary.[3]

In the image, Lady Dialectic initiated her students into logical thought by showing them a diagrammatic tree. She points with her hand to the base of the tree labelled *sermo* (word). The tree consists of two main branches, one for simple expressions, and the other for complex ones. The left branch of the tree leads in the direction of distinctions in simple terms, beginning with a first bud, inscribed with *predicabilia* and featuring five petals: *genus, species, differentia, proprium* and *accidens*. Next, from the *predicabilia* flower, grows another flower, this time of the 'predicaments' with the ten categories shown in its petals. Meanwhile, the right branch leads to 'composed words' (*orationes*), which are expressions that use more than one word, from which fans out seven kinds of propositions written on the petals ('affirmative', 'negative', and so on).

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[1] London, *British Library*, Burney 275, f. 166r. See: J. Forshall, *Catalogue of manuscripts in the British Museum*, New series I. (Vol. 1 part 2: The Burney manuscripts) (London, 1840).

[2] *Dialectica* meant, in a broad sense, just 'logic', and was the prevalent term until the thirteenth century, when *logica* prevailed. See: E.J. Ashworth, "Language and logic," in *The Cambridge companion to medieval philosophy*, ed. A.S. McGrade (Cambridge, 2003), 73–96, here 79.

[3] See, for a more detailed description of this manuscript and its historiated initials: M. Camille, "Illuminating thought: the trivial arts in British Library, Burney ms. 275," in *New offerings, ancient treasures: Studies in medieval art for George Henderson*, ed. P. Binski and W. Noel (Sutton, 2001), 343–366.

From this first right-hand bloom, a second bud sprouts, showing off the four modalities (*modi*) of a proposition.[4]

The form of the tree was considered an ideal visualization of hierarchy and coherence, in which both the whole and the individual parts could be shown. The ramifying branches united in the trunk, the origin, and thereby asserted an organic connection between the variety of single, derived parts. Thus, the organic construction of trunk, branches and leaves served to systematize the content, in a hierarchical ordering from large to small.

This miniature encapsulates the project of this book: the study of diagrams in scholastic treatises.

Some scholars have claimed that «most manuscripts» of Boethius' logical work «were not illustrated, partly because the subject matter did not lend itself to pictorial representation, but mainly because most manuscripts were schoolbooks: working, utilitarian texts produced for the relatively poor masters and students of the thirteenth and fourteenth centuries».[5] This book will show the contrary to have been the case: visual representations in scholarly texts are to be found especially in medieval masters' and students' schoolbooks.

The miniature described above in Boethius' translation of the *Isagoge*, for instance, was painted into a manuscript collection, made for Franciscus Caraccioli of Naples, who was Chancellor of the University of Paris (d. 1316).[6] Almost every text in the Chancellor's volume starts with a painted miniature. Such images are not directly comparable to the drawings found in students' manuals, which are generally poorly executed, and often accompanied by annotations and commentaries.[7] But despite the lower level of execution, the unpretentious university textbooks featured many drawings.

The later medieval period was one of growth for universities and featured the introduction of the Aristotelian corpus. Around the year 1200, the previously central position of monastery and cathedral schools gradually decreased, in favour of new educational institutions: universities, the *studia* of the mendicant

[4] See, for a more detailed description of this initial, Chapter 2, page 72.

[5] D. Bolton, "Illustrations in manuscripts of Boethius' works," in *Boethius. His life, thought and influence*, ed. M. Gibson (Oxford, 1981), 428–437, here 430.

[6] London, *British Library*, Burney 275, f. 2r: «*Liber diversarum liberalium artium quem dedit domino Regi. R. Dominus Franciscus Carachioli, Cancellarius Parisiensis*». ('The book of diverse liberal arts which Franciscus Caraccioli, Chancellor of Paris, gave to the lord King R.'). The intended king was most probably Robert of Anjou (known as Robert the Wise), King of Sicily (1277–1343).

[7] P.O. Lewry, "Thirteenth-century examination compendia from the Faculty of Arts," in *Les genres littéraires dans les sources théologiques et philosophiques médiévales. Définition, critique et exploitation. Actes du colloque international de Louvain-la-Neuve 25-27 mai 1981*, ed. P. Hadot (Louvain-la-Neuve, 1982), 101–116, here 101, 103; C. Lafleur, *Quatre introductions à la philosophie au XIIIe siècle* (Montréal-Paris, 1988), 145–147.

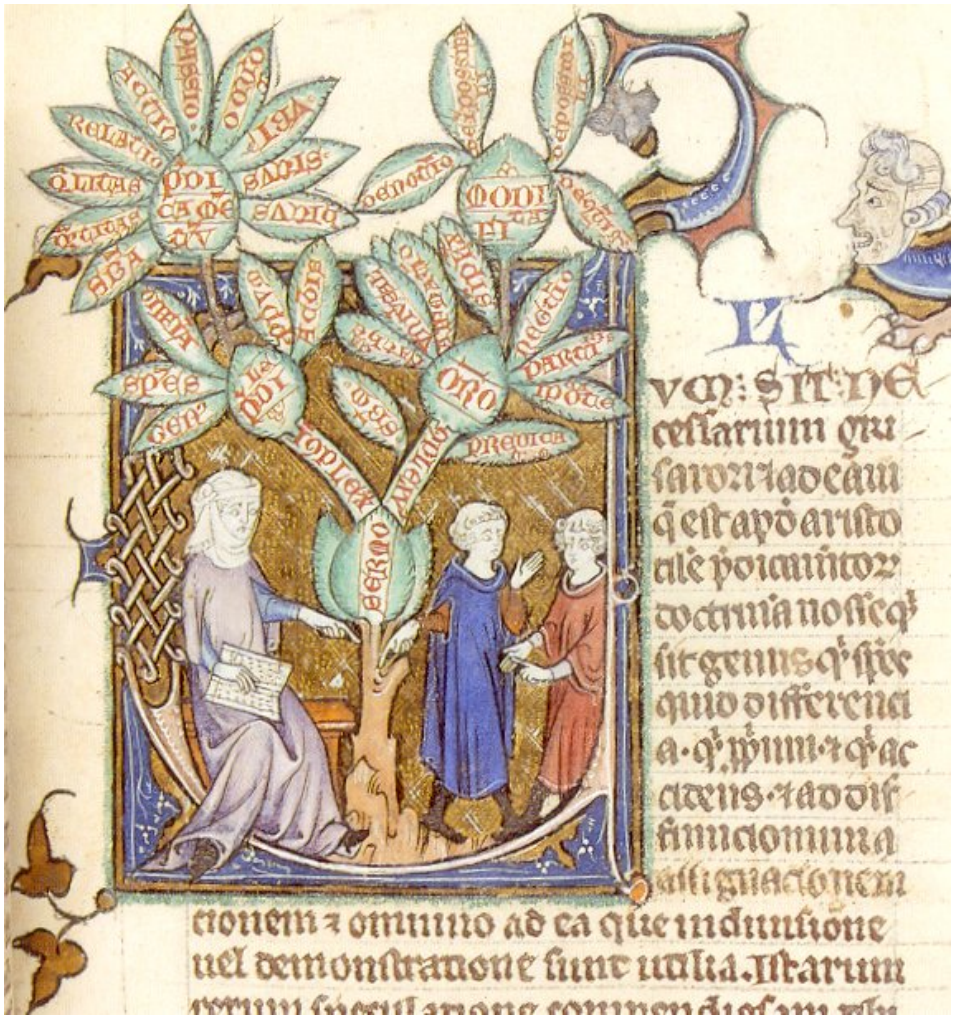


Figure 1 Boethius, *Isagoge, translatio.* London, *British Library*, Burney 275, f. 166r. Dated 14th century.

orders and town schools. At this time members of Arts faculties in particular burst out of the old, conventional frameworks: they were numerous, young, spiritually independent, and zealous in the cause of modernized teaching, especially in Paris.[8] These new educational structures grew along with the towns in which they were generally situated, and to secure their rights and position within a town, facing local authorities, ecclesiastics and the king, the community of teachers and students needed new, stable institutional structures: the *studia* and universities.[9]

The institutional elaboration of the universities occurred somewhat later than the introduction of the Aristotelian corpus of knowledge. Twelfth-century urban teachers and *magistri* had already realized that there existed a completely unexplored area of knowledge supplied by Aristotle (384–322 BC) and had begun to piece the titles of Aristotle's corpus together using vague references in the existing literature before identifying and then translating the relevant works from Greek and Arabic versions. These works had all been translated into Latin by around 1150, and then entered the education system only slowly around 1200, at which time the University of Paris developed out of the conglomeration of existing schools in the city.[10]

The university was, from the beginning of the thirteenth century, an institution of fairly autonomous scholarship, transmitting the understanding of language, God and the natural world. It was quite different from the modern university: it was never a centre of research and there were no research degrees, research institutes or fellowships. Instead it was a place where undergraduates acquired learning from masters and the medieval faculty of Arts was a springboard to higher studies or to a professional life outside university.[11]

The newly extended knowledge of the Aristotelian corpus had a great impact on the thought of the thirteenth century, and the seeming totality of Aristotle's system procured an overwhelming enthusiasm and interest. Scholars could study Aristotelian philosophy as a large and ideal unity ranging from zoology up to metaphysics. The thirteenth century was therefore the period in which Aristotelian philosophy was intellectually processed. All major and minor philosophers wrote commentaries on Aristotle, leaving us a massive body

[8] J. Verger, "Des écoles à l'université: la mutation institutionelle," in *La France de Philippe Auguste. Le temps des mutations*, ed. R.-H. Bautier (Paris, 1982), 817–846, here 834–840.
[9] J. Verger, "La faculté des arts: le cadre institutionnel," in *L'enseignement des disciplines à la Faculté des arts (Paris et Oxford, XIIIe-XVe siècles)*, ed. O. Weijers and L. Holtz (Turnhout, 1997), 17–42, here 18–20.
[10] C.H. Lohr, "The medieval interpretation of Aristotle," in *The Cambridge history of later medieval philosophy from the rediscovery of Aristotle to the disintegration of Scholasticism 1100-1600*, ed. N. Kretzmann, A. Kenny, and J. Pinborg (Cambridge, 1982), 80–98, here 83; J. Marenbon, *Later medieval philosophy (1150-1350)* (1987; London–New York, 1991), 7.
[11] C.H. Lohr, "Curriculum of the faculty of arts at Oxford," *Mediaeval studies* 26 (1964): 143–185, here 144.

of documents on later medieval philosophy. This was therefore an extraordinary period –although the enthusiasm for Aristotelian ideas was by no means universally shared– and witnessed in reality only a slow transition from twelfth-century Platonism to thirteenth-century Aristotelianism.[12]

The massive entry of Aristotelian texts into the West at the beginning of the thirteenth century changed education. Medieval education was based around authoritative texts and teaching meant expounding on these texts, while learning meant familiarizing oneself with their content. The surviving curricula testify to an intensive initiation of students into Aristotelian ideas in the thirteenth century. The Aristotelian works then constituted a major part of the material on which students were examined, following about four years of study. This changed education in two ways. First, it intensified the use of didactic techniques, such as the commonly used lectures on prescribed texts and the equally common disputations. During the read lectures, the lecturer posed *questiones* as counter arguments, and then dismissed them by appealing to the text discussed. In disputations, the *questiones* were advanced and refuted by students and masters present.[13] Secondly, the moment the translations crossed the threshold of the Arts faculty, *magistri* began to write commentaries and adaptations. These 'manuals' provided the student with short, convenient and cheap summaries, which saved time and money for busy students reading many books.

The Burney-volume described above was produced for the man who examined the masters of Arts and the students, and who was responsible for the quality of education in general in the Arts faculty. The Chancellor's volume represents in fact a conservative, even reactionary vision of the curriculum at a time when teaching was much affected by the impact of the New Aristotle (Aristotelian texts introduced after 1150).[14] The volume reflects the debate between the Chancellor and the masters of Arts over what texts were to be read and how. The texts are assembled as a prescribed reading list for the Arts curriculum and they present one ideal of the course of study, consisting in twenty-one treatises covering the *trivium* and *quadrivium* of the traditional liberal arts.[15]

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[12] See for Southern's emphasis on a slow transition: R.W. Southern, *Scholastic humanism and the unification of Europe* (Cambridge, 1995–2001). See also: W. Courtenay, "Intellectual frontiers in the high and late middle ages," in *Frontiers in the middle ages. Proceedings of the third European congress of medieval studies (Jyväskylä, 10–14 June 2003)*, ed. O. Merisalo (Louvain, 2006), 31–48, 36; S.P. Marrone, "Medieval philosophy in context," in *The Cambridge companion to medieval philosophy*, ed. A.S. McGrade (Cambridge, 2003), 10–50, here 32–34.

[13] Marenbon, *Later medieval philosophy (1150-1350)*, 18–19.

[14] Camille, "Illuminating thought: the trivial arts in British Library, Burney ms. 275," 344–345.

[15] Among the twenty-one texts in the Burney volume are the treatises of Priscian, Cicero, and Pseudo-Cicero, *Institutiones*, *De inventione*, *Rhetorica ad Herennium*; Boethius, Aristotle, Euclid, and others, Boethius' translation of Aristotle's *Priora* and *Posteriora Analytica* and other works; *De musica*; *Elementa*, and other texts; Ptolemy, *Almagest*.

STATE OF RESEARCH

The scholarly study of scientific diagrams started in 1979, with Elisabeth Eisenstein's *The printing press as the agent of change*.[16] Eisenstein takes the printing press as a decisive invention in the movement towards the intellectual revolutions of early-modern times. This, she argued, was because the printing press transmitted objects that could otherwise hardly have been transmitted, like animals, plants, instruments and so on. Thanks to the printing press, text and images multiplied, standardized and fixed knowledge. The ideas at work in the thesis of Eisenstein exercised a lot of influence on subsequent research on the subject, even if her explanation is nowadays no longer considered satisfactory.[17]

Einstein's thesis was elaborated on by Bruno Latour in the 1986. He claimed in his essay *Visualization and cognition*, that modern scientific culture relies on specific quantitative and qualitative developments in science, among which he includes the printing press, linear perspective and naturalism.[18]

After the sociologised science history of the 1970s and 1980s, there is the materialised and culturalised science history from the 1990s onwards, although some 'material' aspects of science were already furthered by Eisenstein and Latour as described above. Around 2000, several publications about visual material in the sciences of the early-modern period were published. This literature indicated interesting new angles of which the study of medieval scientific diagrams can take advantage of.

Baigrie (1996) collects papers dealing with the role that scientific illustrations play in the creation of scientific knowledge. Knowledge, in this collection, is understood not only as created by means of thinking, but also through other cognitive and material resources employed by scientists in their work: images and experiments, for instance. Many of the essays are responses to the idea of the 'visual revolution' leading to the 'Scientific Revolution', and give a set case studies of visual material, mostly during the sixteenth to the nineteenth centuries.[19]

Freeland and Corones (2000) collected historical essays about sixteenth- and seventeenth-century science around the themes 'change and continuity' and 'word and image'. In their introduction, they stress that all famous early renaissance developments, which influenced the Scientific Revolution, emerged out of the Middle Ages – if only by the rejection of it. The second theme in this publication raised questions about the function of diagrammatic representation

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[16] E. Eisenstein, *The printing press as the agent of change* (Cambridge, 1979).
[17] See footnote 27.
[18] B. Latour, "Visualization and cognition: thinking with eyes and hands," *Knowledge and society: studies in the sociology of culture past and present, a research annual* 6 (1986): 1–40, here 1–3.
[19] B.S. Baigrie, *Picturing knowledge: historical and philosophical problems concerning the use of art in science* (Toronto, 1996), xvii.

and that of textual interpretation.[20]

The collected papers by Lefèvre, Renn and Schoeplin (2003), meanwhile, present different perspectives on the cognitive functions diagrammatic representations had for *engineers*. Science considered as a social activity permits a broad analytical perspective on the subject, including interactions with practical knowledge, iconographic history, ideas about structuring knowledge and the scientist's own agenda.[21]

Striking in the existing literature is the emphasis on the modern period as the beginning of scientific images. The most explicit example comes from Bruno Latour. He claimed in his essay *Visualization and cognition*, that imaging craftsmanship is specific to our modern scientific culture, since modern scientific culture relies on specific quantitative and qualitative developments in science, among which he includes the printing press, linear perspective and naturalism.[22] The printing press allowed for a «cascade of ever simplified inscriptions that allow harder facts to be produced at greater cost» - the more and more simplified visual representations of data that permitted harder and ever more convincing facts to be produced, at the cost of precision and detail, in an increasingly competitive field.[23] The reverse is also true, for Latour: «The earlier we go back in history of science, the more attention we see being paid to the setting and the less to inscriptions [visual representations p.ex.] themselves».[24]

Martin Kemp put it in his *Seeing and picturing* (1997) like this: «The rise of illustration as a major tool of science in the European Renaissance depended upon the revolution of the means for depiction – most especially the invention of perspective in the fifteenth century – and upon the invention of the printed book with printed illustrations».[25] He clearly saw a separation in the fifteenth century: «In mediaeval science – up to around 1450 – texts of many of the sciences [...] were at best sparsely illustrated, and many of those illustrations were not intended to convey technical information about the science in the text».[26]

Central tropes nowadays in the literature hold that the medieval and renaissance period are opposed, or at least very divergent to one another, in observational techniques, naturalistic rendering and in intellectual ways of under-

[20] G. Freeland and A. Corones, eds., *1543 and all that* (Dordrecht, 2000).
[21] J. Renn W. Lefèvre and U. Schoepflin, eds., *The power of images in early modern science* (Basel, 2003). See for more Renaissance machine literature: W. Lefèvre, *Picturing machines 1400-1700* (Cambridge, 2004).
[22] Latour, "Visualization and cognition: thinking with eyes and hands," here 1–3.
[23] ibid., 16. I thank Victor Gijsbers warmly for the interesting discussion we had about the work of Bruno Latour.
[24] ibid., 17.
[25] M. Kemp, "Seeing and picturing. Visual representation in the twentieth century," in *Science in the twentieth century*, ed. J. Krige and D. Pestre (Amsterdam, 1997), 361–390, 363.
[26] ibid., 362.

standing. Many subsequent publications on the topic depart from the idea of a 'visual revolution' that took place during the Renaissance with the discovery of perspective drawing and the printing press –which led to the scientific revolution–.

Some scholars have questioned commonplace assumptions about the role of the printing press and new illustrative techniques in the Scientific Revolution more firmly.[27]

Medieval scholarly works are however not exempt from images; we have just achieved a particularly scant understanding of scientific diagrammatic material after 1200 and before 1500.

Franklin argued that the mental training brought about by medieval (and renaissance) diagrams prepared the ground for the Scientific Revolution.[28] Departing, again from the same convention, Givens, Reeds and Touwaide tried to highlight elements of continuity between the medieval and renaissance periods by recording a continuous and multifaceted tradition.[29]

The existing literature deals further with representations in the *moral* do-

[27] Eisenstein's thesis - that the scientific revolution of the seventeenth century was made possible by the printing of texts and images - is no longer considered a satisfying explanation. Her generalizations concerning scientific manuscripts, among which texts on the supposed necessity of deterioration, reflect a lack of familiarity with handwritten sources.
Crossgrove, for instance, claimed that we should understand medieval text criticism as an attempt to improve the original text rather than as a bid to restore the author's authentic version, see: W.C. Crossgrove, "Textual criticism in a fourteenth century scientific manuscript," in *Studies on medieval Fachliteratur*, ed. W. Eamon (Brussels, 1982), 45–58, here 57. See also: L.E. Voigts, "Scientific and medical books," in *Book production and publishing in Britain 1375-1475*, ed. J. Griffiths and D. Pearsall (Cambridge, 1989), 345–402, esp. 350–351.
Febvre and Martin demonstrated that medieval authors on natural phenomena continued to be read widely in print. They argued that printing did not initially play much part in developing scientific theory and that printing brought no sudden or radical transformation. See: L. Febvre and H.-J. Martin, *The coming of the book: the impact of printing, 1450-1800*, (Originally published as: L'apparition du livre. 1958) (London, 1997), 258–60, 276–7.
See for other critics about her hypothesis also: A. Grafton, "The importance of being printed," *Journal of interdisciplinary history* 11 (1980): 265–286; and, P. Needham, "Review of E. Eisenstein, The printing press as the agent of change, Cambridge 1979," *Fine print* 6 (1980): 23–35.
See, for a more recent debate, about the consequent dependence on the accreditation of these reports of questionable travelers, informants and collectors: L. Daston, "The language of strange facts in early modern science," in *Inscribing science*, ed. T. Lenoir (Stanford, 1998), 20–38; N. Rennie, *Far-fetched facts* (Oxford, 1995).
[28] J. Franklin, "Diagrammatic reasoning and modeling in the imagination: the secret weapons of the scientific revolution," in *1543 and all that*, ed. G. Freeland and A. Corones (Dordrecht, 2000), 53–115, 53–115.
[29] J.A. Givens, K.M. Reeds, and A. Touwaide, *Visualizing medieval medicine and natural history, 1200-1500* (Aldershot–Burlington, 2006).

main[30], or with *pictorial* images in scientific texts[31], or with diagrams in *early* medieval scientific texts.[32]

Only a few publications deal with *scientific abstract pictures* in the high and late Middle Ages. John Murdoch's *Album of science: Antiquity and the Middle Ages* (1984) provides one of the earliest analyses of historical scientific images. With almost 300 pictures covering all disciplines and all types of image, from instruments to abstract figures, he attempted a first typology of visual material in the sciences. Within the standard 'schemata' he distinguished for example tables, trees, *rote* and squares. More than ordering and describing the drawings, he focused on how these images express and prove the arguments in their accompanying texts.[33] My book aims to extend his approach, and describe the diagrams also in relation to their iconographic tradition.

Murdoch claimed that: «diagrammatic and pictorial material is very rarely found in Aristotle and Galen, whose work formed the backbone of non-mathematical science in antiquity and the Middle Ages. Most is found in manuscripts of encyclopedic works or handbooks».[34] Hereafter he remarked: «nor is it merely the early manuscripts of such works [encyclopedia] that are plentifully covered with figures and diagrams, but also that were written in the later Middle Ages, even though they then appeared side by side with the codices of the Aristotelian translations and other scholastic science».[35] The fourteenth-century initial with which this book started is nonetheless inserted in a base text. How does this relate to Murdoch's observation?

Olga Weijers dealt with scientific pictures dating from 1200 onwards in a chapter about the layout of scientific texts.[36] Layout and illustrations have a direct relationship with the reading and the consultation of texts, but they differ from a text's content in that lay-out and illustration are, according to Weijers,

[30] Of interest also, though not confined to scientific diagrams, is the *Divina Quaternitas* of Esmeijer, in which she studied diagrammatic pictures on the four levels of exegetical interpretations. See: A.C. Esmeijer, *Divina quaternitas. A preliminary study in the method and application of visual exegesis*, (Originally published as: Divina Quaternitas. Een onderzoek naar methode en toepassing der visuele exegese. 1973) (Amsterdam, 1978).

[31] See, for studies on *pictorial* medieval imagery in, respectively, medicine and natural history: Givens, Reeds, and Touwaide, *Visualizing medieval medicine and natural history, 1200-1500*; J.A. Givens, *Observation and image-making in gothic art* (Cambridge, 2005).

[32] Obrist published several historical studies on cosmological diagrams in an attempt to reconstruct antique figures on the basis of early-medieval manuscripts. See: B. Obrist, *La cosmologie médiévale. Textes et images. I. Les fondements antiques* (Florence, 2004); B. Obrist, "Le diagramme isidorien des saisons, son contenu physique et les représentations figuratives," *Mélanges de l'école française de Rome. Moyen Âge* 108 (1996): 95–164.

[33] J.E. Murdoch, *Album of science: Antiquity and the Middle Ages* (New York, 1984).

[34] ibid., 31.

[35] ibid., 277.

[36] O. Weijers, *Le maniement du savoir. Pratiques intellectuelles à l'époque des premières universités (XIIIe-XIVe siècles)* (Turnhout, 1996), 222.

material destined to facilitate the use of the book. Here I will consider images as an entity of greater complexity and regard them as to facilitate the use of the book, or rather the text, but also in its capacity to complicate the text's meaning because of additions, defects and changes, or to give proof of the argument.

In 1980 a study by Evans was published, in which he tried to demonstrate how graphic means express logical thought-processes. By rationalizing diagrammatic forms, he related the components of a diagram to modes of thinking.[37] This interesting approach, however, fails to embed the historicity of scientific diagrams. Some aspects of scientific images risk not to be self-evident or logic, because they were copied from another context, possibly in an altered state, carrying 'strange' connotations with it. Each scientific image is relational. The historical tradition of diagrams will, by contrast, play an important role in this book, for it bears to an extent on the meaning and significance of a given diagram.

North (2004) aimed to illustrate how medieval scholars thought with pictures. Imagination is, as a creative process, part of scientific exploration, and a graphic aid might be the visual outcome of this process, as an embodiment of the underlying idea. Or the pictures might illustrate the results of the scientific exploration, as a representation of the obtained data. In either case, drawn images are born out of mental images that went before them. According to North, scientific representations are sophisticated and different from many other (not scientifically orientated) visual representations, in that they have to do with logical coherence and abstraction. By focusing on the *interaction* of drawn images and reasoned arguments, North described the thoughts his selection of mathematical diagrams represented. Images are here regarded as creating scientific entities. [38] This is an important observation also underlying my study.

My approach

The existing literature has presented several approaches that aided my search for the most interesting angles through which to present medieval scientific counterparts. The above-mentioned studies took a different direction and dimension than the present book aims to do.

Later medieval scientific diagrams, dating from the thirteenth to the fifteenth centuries, have not yet been studied in their specific historical settings and in connection with their iconographical traditions. My book attempts to

[37] M.W. Evans, "The geometry of the mind," *Architectural Association Quarterly* 12 (1980): 32–55.
[38] J. North, "Diagram and thought in medieval science," in *Villard's Legacy: Studies in medieval technology, science and art, in memory of Jean Gimpel*, ed. M.-T. Zenner (Aldershot, 2004), 265–287, esp. 267.

fill in at least a part of that gap in the existing literature by studying the diagrammatic representations in medieval manuscripts of the Arts faculties. I will not only take into consideration the theoretical content into which the diagrams are bound, but also the historical dimension of the intellectual and institutional context.

These aspects lead me to the following problem: how did diagrams function as a manifestation of scientific theory and practice at Arts faculties from about 1200 to around 1500?

The notion of 'working' or of 'functioning' of diagrams is one through which I seek to identify and describe a series of specific intellectual situations, to place them into original context and to establish their *raison d'être* at the time they were used. The difficulty lies in defining a 'specific situation'. Scientific diagrams relate to the verbal information in the accompanying text, but as the text was never an autonomous entity abstracted from the materiality of the book, from ideological factors or perhaps from personal biases, the diagrams were neither.[39] The diagrams are therefore related to the complex of factors that construed the intellectual atmosphere in which a text was written and read: patronage, target readership, research practices, educational and research systems, didactics, scientific developments, scientific theorems, dissemination networks, finances, and the like. Each relationship would provide a perspective illuminating different roles for diagrams in particular sciences.[40] Moreover, diagrams thereby might be understood not merely to respond to a social need and to fulfill their intended roles, but also to transform that need, exceed it or dispose of it.[41] In short, not only a theory of the diagram is envisaged but also the history of a particular (set of) diagram(s) and processes of their transmission.

What are diagrammatic representations? Diagrams are abstract spatial and visual representations that select and highlight aspects of a doctrine explained or acted upon in a text.[42] Diagrams depend on their theoretical content rather

[39] See the discussion about hermeneutics and the history of the book by N. Jardine, "Books, texts and the making of knowledge," in *Books and the Sciences in History*, ed. M. Frasca Spada and N. Jardine (Cambridge, 2000), 393–407.

[40] M. Kemp, "Vision and visualization in the illustration of anatomy and astronomy from Leonardo to Galileo," in *1543 and all that*, ed. G. Freeland and A. Corones (Dordrecht, 2000), 17–51. A reworking of this paper has been published as: M. Kemp, "Temples of the body and temples of the cosmos Vision and visualization in the Vesalian and Copernican revolutions," in *Picturing knowledge: historical and philosophical problems concerning the use of art in science*, ed. B.S. Baigrie (Toronto, 1996), 40–85. See also: Jardine, "Books, texts and the making of knowledge," 395.

[41] See also: G. Didi-Huberman, "Imitation, représentation, fonction. Remarques sur un mythe épistémologique," in *L'image. Fonctions et usages des images dans l'Occident médiéval*, ed. M. Pastoureau (Paris, 1996), 59–86, here 82–85.

[42] North, "Diagram and thought in medieval science," here 267. J. Franklin takes diagrams to be «pictures, in which one is intended to perform inference about the thing pictured, by mentally following around the parts of the diagram». See: Franklin, "Diagrammatic reasoning and model-

than on experience. As a result, illustrations in herbals and bestiaries are therefore commonly not called diagrams, because they are descriptive and based on experience –even if theoretical premises play a role in representing animals and plants–. Diagrams such as tables, concentric circles, tree-structures are, by contrast, often abstract. Even tree figures, which sometimes have a pictorial component, are abstract in the sense that they are bound up with theories and could be developed and corrected on the basis of internal considerations.[43]

The term 'scientific diagram' is invoked because of its accessibility, despite of its anachronistic aspect when applied to the Middle Ages. Our modern understanding of the concept 'science' is not the same as how medieval men understood *scientia*. In the Middle Ages the term *scientia* was used for the intellectual disciplines, such as natural philosophy, ethics, theology and metaphysics. It was not so much used for technological, experimental and mathematical studies of nature, for which we would use the term 'science' nowadays. Our concept of science which derives from the scientific revolution, designates the natural sciences and technology. In the Middle Ages the mechanical Arts were instead taught and developed in guilds. The medieval concept of *scientia* therefore comprises natural philosophy, ethics, theology, metaphysics and logic, and some occult and pseudo-sciences. The medieval university transmitted the understanding produced in these intellectual disciplines.[44]

The selected period, from about 1200 to around 1500, covers the development of young universities all over Europe and the intellectual processing of the Aristotelian works prescribed in their curricula. As described above, the Aristotelian texts were all translated by about 1150 and entered education only slowly thereafter. Education, in turn, transgressed its old institutional framework, and developed out of schools into universities, which was the case in Paris, for instance. The intellectual and institutional structures of learning in the thirteenth century were considerably different from those of the twelfth century. By the year 1500, universities were to be found all over Europe. The processing of Aristotle's work had not been concluded by then, but the proce-

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ing in the imagination: the secret weapons of the scientific revolution," here 54. C. Meier defines a diagram as follows: «*Als diagrammatische Darstellungsformen werden hier solche figuralen Entwürfe verstanden, die mit geometrischen, raumstrukturierenden Mitteln auf der Bildfläche unter Verwendung auch von Texten und eventuell echten Bildelementen Konstrukte produzieren, mit denen sie in visueller Vermittlung Erkenntnisse und Bedeutungen transportieren, kognitive Prozesse initiieren und lenken*». See: C. Meier, "Die Quadratur des Kreises. Die Diagrammatik des 12. Jahrhunderts als Symbolische Denk- und Darstellungsform," in *Die Bildwelt der Diagramme Joachims von Fiore. Zur Medialität religiös-politischer Programme im Mittelalter*, ed. A. Patschovsky (Ostfildern, 2003), 23–53, here 23. I. Maclean added 'quantification' as a prerequisite: «diagrams <are> abstract, quantified, spatial representations». See: I.W.F. Maclean, *Logic, signs and nature in the Renaissance: the case of learned medicine* (Cambridge, 2002), 172.

[43] North, "Diagram and thought in medieval science," 267–268.

[44] Courtenay, "Intellectual frontiers in the high and late middle ages."

dure of incorporation was fully developed by the fifteenth century. The many compendia and anthologies, composed to help students to process the numerous Aristotelian texts, continued to be used in printed form.

The decision to study the Arts faculty resulted from the preceding premises. Aristotle's natural philosophical works were read and commented on primarily in this faculty and among all the European Arts faculties in the later Middle Ages, those of Paris, Oxford and Prague will receive special attention here. Paris and Oxford were influential universities with prominent Arts faculties, while Paris was one of the most important centres of learning throughout the Middle Ages, with a peak in the thirteenth century, when influential masters like Thomas Aquinas and Albert the Great taught there. Oxford was especially strong in the fourteenth century, and led the field in thinking about the nature of quantity and in experimentation with modes of 'quantitative' reasoning. From the middle of the fifteenth century one saw the emergence of new universities in the German Empire, such as that founded at Prague, which attracted a large population of secular students.[45]

The analysis of the main problem is undertaken by means of four questions:

1. Where were diagrammatic representations encountered and how were they understood?
2. What is the impact of the form of diagrams on their content? And how did diagrams relate to the corresponding text?
3. What is the impact of new intellectual approaches on their form and content?
4. What is the impact of the social and institutional context, in which the diagrams were drawn and used, on their form and content?

In order to obtain answers to these questions, three case studies of visual data have been carried out, on the basis of the available material: the Tree of Porphyry, the four elements, and the powers of the soul. These cases cover three important domains studied at the Arts faculty: logic, physics and psychology and at the core of these three domains lay Aristotle's *Categorie* (and the *Isagoge* by Porphyry), *De generatione et corruptione* and *De anima.*

The choice of multiple case studies from divergent disciplines was made to enable comparisons of similarities and dissimilarities in diagrammatic functions between disciplines. Kemp concludes, for instance, that in the seventeenth

[45] See about the intellectual frontiers from a monastic to a scholastic culture about 1200 and a return to monastic culture about 1400, with attention for the place of the universities in this process: ibid.

century there was no common relationship, in terms of visualization and illustration, to all disciplines.[46] Was this also the case for scientific diagrams in the Middle Ages?

The choice of logic, physics and psychology is not accidental. These three domains covered the most fundamental problems in medieval science in the Arts faculty, dealing with 1. language, reasoning and truth, 2. the inanimate world and 3. the animate world. As such, they represent nearly all knowledge transmitted by the Arts faculty. The following overview summarizes the angles covered by the three case studies chosen for this study.

Case studies	**Problems**	**Domains**	**Authoritative base texts**
Tree of Porphyry	Language and the art of reasoning	Logic	*Categorie*, *Isagoge*
Material substance	Nature and the visible world	Physics	*De generatione et corruptione*
Powers of the soul	The human being and his cognition	Psychology	*De anima*

The distribution of the case studies over these three domains also represents different phases in the Western European intellectual digestion of the Aristotelian corpus. The old logic was a topic continuously studied since Antiquity. New logic textbooks were composed by the mid of the twelfth century to convey 'old knowledge' to a new audience of university students. The other two case studies are based on the reception of the New Aristotle. The *De generatione et corruptione* was introduced before 1187, and *De anima* around 1220–1235.[47] The scientific community responded profoundly to these works, generating many new questions and solutions.

Structure

This book consists of four chapters corresponding to the four sub questions, in which three themes will be illustrated by the study of three particular sets of diagrams. The themes, illustrated by the case studies, are presented chronologically and thematically. The sub questions subject the diagrams to different kinds of analysis, placing them in varied relationships and contexts.

[46] Kemp, "Vision and visualization in the illustration of anatomy and astronomy from Leonardo to Galileo."

[47] B.C. Dod, "Aristoteles Latinus," in *The Cambridge history of later medieval philosophy from the rediscovery of Aristotle to the disintegration of Scholasticism 1100-1600*, ed. N. Kretzmann, A. Kenny, and J. Pinborg (Cambridge, 1982), 45–79, here 76.

The space of this first question is defined by an exploration of sources produced and received in the Arts faculty, and secondly by medieval and modern statements about these medieval diagrams in scientific texts. A preliminary problem that arises is the nature of medieval scientific diagrams, and into which texts they are inserted - this will be under discussion in *Chapter 1: About the sources*, p. 1.

Further, for lack of medieval statements about the role of scientific diagrams, I analyze the terminology used to refer to diagrams in relation to the verbal context. Thanks to some medieval statements, some of the meanings and roles medieval learned men attributed to their visual material can be established. This chapter is also dedicated to the character of the literary and institutional context of diagrams, including teaching practices and the place of these books in university curricula. This chapter will show that the sources used in this book were truly considered 'scientific' in the period under study, but it also serves to outline the general context in which these diagrams were usually functioning.

Another question is how diagram, text and theory relate to each other, for the presence of visual elements is commonly and primarily understood in the context of the associated text. I continue therefore with an analysis of writings and diagrams, their structures, themes and aims. This theme centres on the play of complexity, morphology and reduction between figure, text and theory. How was knowledge abstracted and organized into a visual system? This theme will be dealt with in *Chapter 2: Form, content and the Tree of Porphyry*, p. 35, pivoting around thirteenth-century Paris.

The existing secondary literature about the morphology of diagrams leaves us with a contradiction: model vs. uniqueness. At stake is the rationality of the diagrammatic form and the relationship between the literal and visual notations running parallel to one another in the text.

The *Tree of Porphyry*, a diagram of logical reasoning, turned out to be especially interesting in this respect because it was systematized as a representation long after the conceptualisation of both its form and content. The Tree of Porphyry is part of the 'old logic', and had been available throughout the Middle Ages, in Boethius' translation. Logic was an important means of acquiring knowledge about the nature of thoughts and permitted a careful description of concepts. The characteristic tree form of the Tree of Porphyry will be carefully analysed in terms of its morphology and taxonomy, in order to interrogate its rationality and to open up possible new meanings. Its iconographic history will be unraveled, back to the first visual representations in Boethius' work. Despite its long historical tradition, the case of the Tree of Porphyry pivots mainly around manuscript copies of the thirteenth-century *Tractatus*, circulating in Paris from the 1260's onward.

In a further theme, the framework of analysis is expanded, to deal with the

question of how diagrams interacted with new interests in science. I place the diagrams in relation to more general scientific developments, by placing them not only in the context of the theory of the text, but also in the theory of the discipline or even broader. When scientific concepts change, one expects images to change with them. Some images, however, became autonomous as a way of explaining natural phenomena.[48] They remained unaltered and continued to accompany treatises despite significant conceptual changes in the theory illustrated, which shows how strongly some visual conceptualizations dominated in some scientific practices.[49]

Tradition and renewal in images and in scientific conceptualization is therefor the subject of a third theme in this book, in *Chapter 3: Changing matters: measuring qualities*, p. 89, where I focus on fourteenth-century Oxford and Paris. The fourteenth century featured a new interest in the nature of quantity and in experimentation with modes of quantitative reasoning, as well as a preoccupation with issues of logical form. This new movement of thought is commonly described as the Nominalist or Terminist movement, the leaders of which were a group at Paris and in Oxford, the latter called the 'Calculators'.[50]

The case of the elemental diagrams directs our attention to theories of matter, the first principle and building block of the physical world. The physics of Aristotle and Plato (429–347 BC) became the framework for medieval theory of matter. The freshly studied books *De generatione et corruptione* and *Physica* breathed new life into Aristotelian thinking about the changing qualities in the elements in the thirteenth century. The question of how new conceptualizations in science related to visual materials is answered by study of the diagrammatic representations developed in Paris and Oxford. These elemental diagrams are then examined in the light of tradition and renewal in iconography and science.

In a last theme, I situate diagrams within their broader, associated scientific practices. The content and form of scientific figures related not only to the structures, themes and aims in the accompanying writings but also to the whole of scientific culture, including research practices, the criteria of research and its place in education. Imagery was subject to cultural changes, changing practices and changing methods. After all, the text and the images were resources men of learning employed in their activities. These practices take possession of texts

[48] See, for instance: C. Lüthy, "The invention of atomist iconography," in *The power of images in early modern science*, ed. W. Lefèvre, J. Renn, and U. Schoepflin (Basel–Boston–Berlin, 2003), 117–138; K. Müller, *Visuelle Weltaneignung. Astronomische und kosmologische Diagramme in Handschriften des Mittelalters* (Göttingen, 2008); K. Müller, "Irritierende Variabilität. Die mittelalterliche Reproduktion von Wissen im Diagramm," in *Übertragungen: Formen und Konzepte von Reproduktion in Mittelalter und Früher Neuzeit*, ed. B. Bussmann et al. (Berlin, 2005), 415–436.
[49] Lüthy, "The invention of atomist iconography," 117–138.
[50] Marrone, "Medieval philosophy in context," 37.

and diagrams, influenced their use and production and thereby produced differentiated uses and meanings.[51]

The analysis in this chapter looks at the scientific culture under consideration and sheds light on dissemination of knowledge, on teaching practices and on methodology, all as part of the wider scientific culture. The relationship between diagrams and their scientific context will be considered in *Chapter 4 The powers of the soul in teaching*, page 155, based on manuscripts that circulated in fifteenth-century Central-Europe, especially around the intellectual hub of Prague.

For this last theme, about the mediating role of images between culture and science, diagrams showing the powers of the soul are of interest. The capacities of the soul dealt with functions that would nowadays belong to biology, like the nutritive and sensory capacities, and to psychology. The diagrammatic representations of the powers of the soul (and also the functions of the brain) were related to the discourse about the soul presented in the *De anima* by Aristotle. This book was reintroduced in the middle of the twelfth century, with a new translation on the basis of Greek texts in 1268. Many textbooks were subsequently compiled to transmit the discussions raised by the *De anima*. The *Parvulus philosophie naturalis* was such a textbook and study of it shows that textbooks are crucial to understanding the ways knowledge was handed down from generation to generation and from place to place, and how knowledge became standardized.

The chronological and geographical directions determined by the preservation and availability of the sources nevertheless allow a broad approach. As mentioned above, the distribution of the case studies over the domains of the old logic, physics and psychology convey different phases in the incorporation of the Aristotelian corpus. The case of the Tree of Porphyry, for example, represents a form of continuity. The other two case studies are based on the reception of the New Aristotle in the decades around 1200. The geographical distribution of the manuscripts in Paris, Oxford and Prague allows the verification of cases based on the coincidence or not of regional traditions.

The spectrum of domains and key issues in late medieval scientific knowledge is not comprehensively dealt with here, however. Logic, physics, and psychology cover the fields of reasoning, the inanimate nature and animate nature, though, and these subjects give a good idea of medieval scientific knowledge in the Arts faculty from the thirteenth to the fifteenth centuries. By choosing three different cases in three different sciences I obtained a broad spectrum of findings, and was able to make comparisons and identify disciplinary specificities.

[51] Jardine, "Books, texts and the making of knowledge," 393; R. Chartier, *The order of books* (Oxford, 1994), 2–3.

TOOLS OF INVESTIGATION

Since medieval scientific illustration is far too large and dynamic a field to be squeezed into a single book, this one is necessarily far from comprehensive. But insight into the character of visual material in medieval scientific manuscripts, a field in which the size of the overall archive is unknown and even the extant materials barely studied, can only be achieved by means of case studies. This avoids the use of misleading criteria, based on modern conceptions of science, when approaching medieval texts and scientific diagrams in their particular historical environments.

The method of a restricted set of case studies also entails certain problems. A focus on three case studies, sited in the main disciplines, necessarily leaves out many other dimensions which could have yielded numerous and possibly very different results. This difficulty can only be overcome by being very careful in presenting results. Generalizations about all scientific medieval diagrams cannot be made, since such generalization is not the goal of a case study, which mandates the study of a certain object in all its variants and facets. 'All variants and all facets' implies, however, decades of further work. This difficulty is removed by imposing themes, as dealt with above, which guide and narrow down analysis of the diagrams.

One of the most central concerns for this study was how to locate scientific visual representations, which are poorly described and often just omitted in library catalogues. Art historians pay little attention to these figures, for they are often only simple drawings done by an unskilled hand. But even the beautiful miniatures representing diagrams in Burney 275 are omitted from the catalogue.[52] [*See* figure 1]. These absences are partly due to the age of some of these catalogues, which date from the nineteenth century, but working with antiquated catalogues is a necessary reality in the absence of more modern ones. Sometimes, historians of philosophy have to encounter scientific visual representations in their medieval sources of philosophical texts, but only a few of them incorporate or even mention the pictorial material from manuscript sources in the text editions. Some of them include a representative example, while others redesign a diagram typographically in their critical editions.[53]

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[52] Forshall, *Catalogue of manuscripts in the British Museum*, Burney 275.

[53] L.M. de Rijk had the Tree of Porphyry typographically redesigned in his edition of the *Tractatus* of Peter of Spain. He chose a stylized Tree of Porphyry exempt from pictorial additions, providing the minimum features of the figure discussed. Jacques Fontaine chose to draw a figure of a manuscript copy as a representative example of the figures drawn in the *De natura rerum* of Isidore of Seville, and edited the inscriptions in the figures. The so-called *figura solida* in Fontaine's edition of *De natura rerum* is clearly based on the copy found in Munich, Clm 14300, f. 7v. The *mundus-annus-homo* figure, for instance, is derived from Paris, *Bibliothèque nationale*, lat. 6413, f. 5v. The advantage of such a method is that one does not have to synthesize an ideal composite figure. Unfortunately, Fontaine himself did not mention from which manuscript he

In order to assemble a coherent set of diagrams used in the medieval Arts faculty, I combined a systematic and historical perspective. The systematic set of diagrams is based on the literary relationships between base texts and commentaries, *expositiones*, *summe* and the like. The difficulty here is one of identification, for the textual sources in play in this research often remained anonymous, considered philosophically or theologically rather 'unimportant', with rather general, derivative *incipits* that repeat the opening line of the –often Aristotelian– source on which they comment.[54]

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copied the figures.
But neither Fontaine nor De Rijk's solution is adequate: the first ignores the many peculiarities and significant differences between manuscript illustrations and with the second the danger is to generalise on the basis of one example. The fact that I was able to identify the manuscripts forming the basis of Fontaine's drawings, proves my point: the figures are different from manuscript to manuscript and thus not 'editable'. See: J. Fontaine, ed., *Traité de la nature suivi de l'épître en vers du roi Sisebut à Isidore* (Bordeaux, 1960), fig. 4 (212bis), fig. 5 (216bis). See also: L.M. de Rijk, ed., *Peter of Spain (Petrus Hispanus Portugalensis). Tractatus called afterwards Summule logicales* (Assen, 1972). But both methods are a helpful reference in locating figures.

[54] Helpful are repertories specialised in commentaries on Aristotle. See: C.H. Lohr, "Medieval Latin Aristotle commentaries," *Traditio* 23 (1967): 314–413; C.H. Lohr, "Medieval Latin Aristotle commentaries," *Traditio* 24 (1968): 149–245, C.H. Lohr, "Medieval Latin Aristotle commentaries," *Traditio* 26 (1970): 135–216, C.H. Lohr, "Medieval Latin Aristotle commentaries," *Traditio* 27 (1971): 251–351, C.H. Lohr, "Medieval Latin Aristotle commentaries," *Traditio* 28 (1972): 281–396, C.H. Lohr, "Medieval Latin Aristotle commentaries," *Traditio* 29 (1973): 93–197, C.H. Lohr, "Medieval Latin Aristotle commentaries," *Traditio* 30 (1974): 119–144. Also helpful are specialized catalogues surveying the commentaries on Aristotle written in a certain library. See for France: Lohr, "The medieval interpretation of Aristotle"; C.H. Lohr, "Aristotelica Gallica: Biblioteca M-Z," *Theologie und philosophie* 63 (1988): 79–121; W. Senk, *Repertorium commentariorum medii aevi in Aristotelem latinorum quae in bibliothecis publicis asservantur* (Warschau, 1982). See for Great Britain: C.H. Lohr, "Aristotelica Brittanica," *Theologie und philosophie* 53 (1978): 79–101. See for the Czech Republic: G.B. Korolec, *Repertorium commentatorium medii aevi in Aristotelem latinorum quae in bibliotheca olim Universitas Pragensis nunc Knihovna CSR vocata asservantur* (Wrocław, 1977). See for Poland: M. Markowski and Z. Wlodek, *Repertorium commentatorium medii aevi in Aristotelem latinorum quae in Bibliotheca Jagellonica Cracoviae asservantur* (Wrocław, 1974). See for the Netherlands: L.M. de Rijk and O. Weijers, *Repertorium commentatorium medii aevi in Aristotelem latinorum quae in bibliothecis publicis Neerlandicis asservantur* (Amsterdam, 1981). See for Italy: S. Zamponi, *Commenti ad Aristotele nella Biblioteca Forteguerrina di Pistoia. Commentaria Medii Aevi in Aristotelem latina* (Florence, 1977); S. Zamponi, *Commenti ad Aristotele nell'Archivo capitolare di Pistoia. Commentaria Medii Aevi in Aristotelem latina* (Florence, 1978). See for Spain: C.H. Lohr, "Aristotelica Hispalensia," *Theologie und philosophie* 50 (1975): 547–564; L. Robles, "Aristteles latinus. Repertorio de manuscritos españolas," in *Actas del V Congreso internacional de filosofía medieval*, vol. 1 (Madrid, 1979), 333–460. See for Switzerland: C.H. Lohr, *Aristotelica Helvetica: catalogus codicum latinorum in bibliothecis Confederationis Helveticae asservatorum quibus versiones expositionesque operum Aristotelis continentur* (Freiburg, 1994). See for Belgium: A. Pattin, *Repertorium commentatorium medii aevi in Aristotelem latinorum quae in bibliothecis Belgicis asservantur* (Leiden, 1978) See also: C.H. Lohr, "Medieval Latin commentaries on Aristotle in manuscripts in libraries outside of Italy (according to Kristeller, Iter italicum III)," *Freiburger Zeitschrift für Philosophie und Theologie* 34 (1987): 531–542.
Very useful also was Olga Weijers' repertoire of medieval Parisian masters and texts in several

This systematic set of diagrammatic representations, dating from the same period, is extended and historically situated with regard to preceding diagrams on the basis of textual and pictorial traditions. Thanks to Barbara Obrist' studies, we know how essential it is to take the pictorial traditions of diagrams into consideration. This 'vertical' mapping is vital to establishing the historicity of diagrams. After all, it is meaningless to study the relationship between, for instance, a fourteenth-century text and its image without taking into consideration that the image originally belonged to a tenth-century text.

A spot check of about five manuscript versions of a text suffices to decide whether a particular text will generally contain diagrams. This is evidently not a foolproof method, but in most cases it meant that 50% of the surviving manuscript copies were consulted. The number of diagrams studied per case study varies for the simple reason that the numbers of surviving manuscript copies of a certain text are unequal. The minimum of copies consulted, is adjusted in cases where many more copies are available. The number of manuscript copies that must be surveyed in each case is not just a statistical matter. Over time one begins to understand the topic and perspective of a certain text, allowing easier evaluation of whether the figure in question 'fits' it or not. This accumulated experience proved a useful short-cut. All the data on numbers of copies, and success or failure in finding images in the manuscripts consulted is entered in tables, which have been added to the appendices.

volumes. See: O. Weijers, *Le travail intellectuel à la Faculté des arts de Paris: textes et maîtres (ca. 1200-1500)*, 7 vols., Studia artistarum: études sur la Faculté des arts dans les universités médiévales (Turnhout, 1994–2007). See for some specialized repertories: J. de Raedemaeker, "Une ébauche de catalogue des commentaries sur le De anima parus aux XIIIe, XVe et XVe siècles," *Bulletin de philosophie médiévale edité par la S.I.E.P.M* 5 (1963): 149–183; J. de Raedemaeker, "Une ébauche de catalogue des commentaries sur le De anima parus aux XIIIe, XVe et XVe siècles," *Bulletin de philosophie médiévale edité par la S.I.E.P.M* 6 (1964): 119–134; J. de Raedemaeker, "Une ébauche de catalogue des commentaires sur les Parva Naturalia parus aux XIIIe et XVe siècles," *Bulletin de philosophie médiévale* 7 (1965): 95–108. And see: M. Grabmann, *Methoden und Hilfsmittel des Aristotelesstudiums im Mittelalter*, vol. 5, Sitzungsberichte der Bayerischen Akademie der Wissenschaften (Munich, 1939).

CHAPTER 1

ABOUT THE SOURCES

1.1 INTRODUCTION

This research studies scientific diagrams drawn from books featured in the curricula of Arts faculties and encompasses the period from 1200 until 1500, in which era major changes took place in the domain of the arts. These three areas of interest - books, diagrams and the Arts faculty - form the focus of this chapter. These subjects have already been touched upon in the introduction to this book. As an extended introduction to the topics to come, I describe here in greater detail the character of the sources used for this research, discussing diagrammatic material as well as treatises. I also introduce the institutional setting in which these texts were read, and set out the visual representations that were observed, conceived and consulted within the context of the Arts faculty.

The statutes of the era, describing for instance the curricula of the Arts Faculty in Paris, demonstrate that much teaching was dedicated to newly translated, hitherto unknown texts by Aristotle. In a first instance I will describe how such Aristotelian texts entered the medieval curriculum. Special attention is paid to the teaching of the *De anima*, *De generatione et corruptione* and several texts on logic – the basic texts underpinning the three case studies that are the foundation of the present work. The charters of the University of Paris provide a way to reconstruct the reading lists of the period.

The University of Paris acted as a pioneer, and many other universities were designed in the image of Paris. The statutes of the arts faculty of Paris, then, are especially appropriate as a point of departure. Of course it should be noted in this context that the European Arts faculty was far from a homogeneous institution. Every university maintained its proper statutes, regulations and curricula. In some faculties a particular text was read in the baccalaureate phase, in another in the master's degree phase. Sometimes students took three months of lecture on a particular text, in another place a year or six months. The details

of the prescribed texts changed in time and from faculty to faculty, but the basic texts were generally read in every faculty of arts. The curriculum of the Parisian faculty may therefore be used to sketch the reading lists of Arts faculties more generally.

Next I take a closer look at the books and (sub)genres of books used in universities at the time. To facilitate the learning of these new Aristotelian texts, manuals and other 'study-aids' were developed, especially in the context of university education from the thirteenth century onwards. This heterogeneous genre of 'study-aids' seems to have been especially susceptible to the insertion of diagrams.

The ultimate basis of my research lies in scientific diagrams. Medieval scholars did not leave us documents about the role and significance of scientific diagrams for their readings and their construction of knowledge. There are no parchments left, for example, that are inscribed with diagrams that possibly hung in classrooms. But we have texts, discussed, commented on and dictated by masters, written by students, and illustrated with diagrams. Occasional, explicit references to diagrams and other clues as to how medieval diagrammatic material was perceived may nonetheless give some insight into the views and mindset of medieval scholars.

1.2 The New Aristotle

Until the twelfth century, Aristotle was largely unknown, except for his works in logic. Twelfth-century urban teachers, *magistri*, pieced the unknown works together on the basis of vague references in the available works by Aristotle, Boethius, Cicero and others. By the middle of the twelfth century, they had come to realize that there was a whole corpus they only knew of by name. Naturally they then tried to learn more about it and so it was that from the later twelfth century onwards, most of the works of Aristotle were translated from Greek and Arabic versions.[55]

This 'new Aristotle' comprised the *Physica*, dealing with the general principles of change; *De generatione et corruptione*, dealing with the four sublunary elements that explain generation and corruption; *De anima, Parva naturalia, De animalibus*, dealing with animate nature; *Metaphysica*, dealing with the essence of being; *Meteorologica* (Books 1–3) dealing with a great variety of natural phenomena; *De celo et mundo*, dealing primarily with the eternal motion of the celestial bodies; and finally *Analytica posteriora* (part of *logica nova*), dealing with scientific procedures.[56]

[55] Lohr, "The medieval interpretation of Aristotle," here 83.
[56] ibid., 85.

The influence of Aristotelian thinking was significant in part due to the critical, questioning character of the scientific enterprise. Medieval masters were able to claim authority for Aristotle's teachings solely on the basis of reason – and not on the sacred character of a text.[57] His teachings comprised everything subject to scientific treatment, from zoology to ontology. Because of the comprehensiveness of his work's purview, Aristotle was of importance to all thinkers, philosophers, and theologians.

Christian theologians, for example, sought to harmonize Christian doctrine with Aristotelian metaphysics in order to supply a rational basis for dogmatics. The connection between science and philosophy in Aristotle's work, and the overlap between philosophy and theology in the thirteenth century, thus also established a connection between theological and scientific thought. At first glance, Aristotelianism seemed further removed from Christianity than Platonic doctrine, but, as Aristotle's philosophy became progressively more interwoven with theology, it helped to extend the range of intellectual domains available to theological supervision. This advantage constituted also a problem: as theologians adopted Aristotelian science as a foundation, every discovery of a scientific error automatically attacked not only Aristotle but also the Church.[58] And there were certainly many attacks.

Indeed attempts to disengage from Aristotle began at the very moment his work entered the Latin west in the thirteenth century.[59] For instance, medieval men were deeply Christian and found themselves unable to accept certain Aristotelian beliefs. Besides, there were many disagreements as to what Aristotle actually meant in his generally concise and sometimes underdeveloped statements. Moreover, certain Aristotelian solutions were considered unsatisfactory and medieval natural philosophers chose to ignore them in favor of other doctrines. Aristotelian thought nonetheless continued to play a role in determining the situation of physics until empiricism in the sixteenth century and mathematical physics opened a new stage in the seventeenth century.[60]

Even if the Aristotelian system was of importance to all medieval thinkers, the introduction of these new Aristotelian works was not straightforward. In 1210, a synod at Paris promulgated the prohibition of the natural philosophical works and commentaries of Aristotle, under penalty of excommunication.[61]

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[57] ibid., 91.

[58] See, for this synthesis between theology and science: E.J. Dijksterhuis, *The mechanization of the world picture: Pythagoras to Newton*, (Originally published as: De mechanisering van het wereldbeeld. 1950) (Oxford, 1961), 127–130.

[59] A. Maier, *Die Vorläufer Galileis im 14. Jahrhundert. Studien zur Naturphilosophie der Spätscholastik*, Storia e Letteratura 22 (1949; Rome, 1982), 2–6.

[60] See, for the concept of Aristotelianism: E. Grant, "Ways to interpret 'Aristotelian' and 'Aristotelianism' in medieval and renaissance natural philosophy," *History of science* (25) (1987): 335–358.

[61] CUP, I, no. 11 (1210), 70: «*Nec libri Aristotelis de naturali philosophia, nec commenta legan-*

Five years later one could read: «The Aristotelian books about Metaphysics and natural philosophy are not to be read, nor are handbooks of these».[62] One of the handbooks (*summa*) challenged here was probably Avicenna's (980–1037).[63]

The effectiveness of this ban is doubtful. First, the renewal of the warning against Aristotle's natural philosophical texts after five years suggests that their prohibition was not strongly enforced. Secondly, these initial interdictions were restricted to Paris. The University of Toulouse tried to benefit by promising Parisian students classes in Aristotelian natural philosophy.[64] That said, many Parisian commentaries on logic from the first half of the thirteenth century are extant, but very few address natural philosophy, which indicates that scholars did not teach the natural philosophies *publicly*.[65]

Private lectures and readings, however, continued during the period of the ban, as witnessed by various traces.[66] William of Auvergne, for example, a Parisian doctor writing in 1248, made ample use of the suspect books.[67] And during the years of the ban the English scholars Robert Grosseteste and Roger Bacon remained in Paris, indicating, according to some modern scholars, that the ban was not severely enforced - otherwise they would have returned to Oxford, where the *libri naturales* were studied as early as the first half of the thirteenth century.[68]

Prohibitions of the natural philosophical treatises were outdated by 1231. The papal bull *Parens scientiarum* by Gregory IX requested that the prohibitions be revisited:

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tur Parisius publice vel secreto. Et hoc sub poena excommunicationnis inhibemus» (H. Denifle and A. Chatelain, eds., *Chartularium Universitatis Parisiensis: sub auspiciis consilii generalis facultatum Parisiensium ex diversis bibliothecis tabulariisque collegit et cum autheticis chartis contulit Henricus Denifle, O.P. in arvhivo apostolicae sedis romanae vicarious, academiae scientiarum vindobonensis socius auxiliante Aemilio Chatelain, bibliothecae universitatis in Sorbona conservatore adjuncto* (Paris, 1889–1897)). (From here on called CUP).

[62] CUP, I, no. 20 (1215), 78–79: «*Non legantur libri Aristotelis de methafisica et de naturali philosophia, nec summe de eisdem*». See also CUP, I, no. 11 (1210), 71, where Denifle and Chatelain identified the prohibited texts, based on manuscripts mentioning the embargo.

[63] L. Bianchi, "Les interdictions d'Aristote au XIIIe siècle," in *L'enseignement de la philosophie au XIIIe siècle autour du 'Guide de l'étudiant' du ms. Ripoll 109. Actes du colloque international*, ed. C. Lafleur (Turnhout, 1997), 109–137.

[64] Weijers, *Le maniement du savoir. Pratiques intellectuelles à l'époque des premières universités (XIIIe-XIVe siècles)*, 10.

[65] Grabmann, *Methoden und Hilfsmittel des Aristotelesstudiums im Mittelalter*, 26.

[66] E. Grant, *A sourcebook in medieval science* (Cambridge (Mass.), 1974), 42.

[67] H. Rashdall, F. M. Powicke, and A. B. Emden, *The universities of Europe in the Middle Ages*, vol. 1: Salerno-Bologna-Paris (1895; London, 1936), 358.

[68] Roger Bacon himself mentions that the *libri naturales* were read in Paris in 1237, but this date is dubious since Bacon was not even in Paris that year. See: Roger Bacon, *Compendium studii theologie*, chapter II, 14. See also: Weijers, *Le maniement du savoir. Pratiques intellectuelles à l'époque des premières universités (XIIIe-XIVe siècles)*, 17 n. 39; Grabmann, *Methoden und Hilfsmittel des Aristotelesstudiums im Mittelalter*, 31.

> «since we have learned that the natural philosophical books, which were prohibited at Paris, in the council of the province, are said to contain some useful and useless matter, we command, so that what is useful is not spoiled by what is useless, that [...], you entirely exclude what you shall find erroneous [...] so that [...] the rest may be studied without postponement and without offense».[69]

The thereupon established committee to examine the books never reported the results. Hence, though the prohibition on the natural philosophical books was never officially cancelled, they nevertheless found their way into official studies in Paris.[70]

By the end of the thirteenth century, however, anti-Aristotelian sentiment had grown up again, notably in Paris. Some of Aristotle's ideas, as explained by Averroes (1126–1198), notably about the immortality of the soul and the eternity of the world, were considered incompatible with the Christian faith. Some scholars, like Siger of Brabant (c. 1240–1280s) and Boethius of Dacia (13th c.), tried to study Aristotle without questioning its implications for faith and claimed in self-justification that they spoke as natural philosophers and not as theologians. This struggle led to a discussion about the limits of human reasoning, which culminated in a clash in the years after 1270.

In 1270 the bishop of Paris, Stephen Tempier, condemned thirteen propositions. Masters tried to save their studies from condemnation by swearing to stick to philosophical matters and not to deal with theology. A second warning followed in 1277 and in the same year the bishop prepared a condemnation featuring a list of 219 condemned propositions.[71] Scholars who did not comply, faced excommunication. Despite the fact of this ban in Paris throughout the thirteenth century, by 1255, within a half century of their translation, all of Aristotle's philosophical treatises had become a required part of the master of Arts program at Paris, as at Oxford and other universities.[72]

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[69] CUP, I, no. 87 (1231), 143–144: «*Ceterum cum, sicut intelleximus, libri naturalium, qui Parisius in Concilio provinciali fuere prohibiti, quedam utilia et inutiliata continere dicantur, ne utile per inutile vitietur, [...] que ibi erronea seu scandali vel offendiculi legentibus inveneritis, illativa penitus resecetis, ut que sunt suspecta remotis incunctanter ac inoffense in reliquis studeatur.*».

[70] Weijers, *Le maniement du savoir. Pratiques intellectuelles à l'époque des premières universités (XIIIe-XIVe siècles)*, 10.

[71] CUP, I, no. 473 (1277), 543–558. See: J.M.M.H. Thijssen, *Censure and heresy at the University of Paris, 1200-1400* (Philadelphia, 1998), 44.

[72] See, regarding the condemnation of 1277: Thijssen, *Censure and heresy at the University of Paris, 1200-1400*; J.A. Aertsen, K. Emery, and A. Speer Jr., eds., *Nach der Verurteilung von 1277. Philosophie und Theologie an der Universität von Paris im letzten Viertel des 13. Jahrhunderts*, Studien und Texte (Miscellanea Mediaevalia 28) (Berlin-New York, 2000).

1.2.1 READING LISTS

In this section I take a closer look at the texts actually read in the Arts faculty, especially *De generatione et corruptione, Categorie, Isagoge, Tractatus*, and *De anima*, in order to present the direct and daily context in which the diagrams in question were employed. In the present work, the prescription of certain texts in the curricula of the Arts faculty, or very close proximity to these texts, is considered a criterion for describing a diagram as 'scientific'. Establishing the reading list of the Arts faculty is therefore methodologically useful, but also provides a handy introduction to university life in the Middle Ages.

The University of Paris has not left us with many charters about its early organization; but the Arts faculty has preserved the most.[73] These statutes indicate when and how which texts were taught, as well as matters of daily routine, rules, privileges and bans. We are therefore relatively well informed about the texts masters were supposed to lecture on and the numbers of lectures students had to attend for exams. On the basis of these charters, reading lists can be established.

At the end of the nineteenth century, Denifle and Chatelain published virtually all the interesting, preserved documents concerning the history of the University of Paris in their *Chartularium Universitatis Parisiensis*.[74] Their chronological ordering of diverse texts, in four sizeable volumes, complicates thematic research. For an overview of the curricula of the Arts faculty, the documents dated 1215, 1231, 1252, 1255, ante 1350 and 1366 are especially instructive, serving to describe the curriculum *de forma*: in other words, the syllabus as structured by the established rules and describing the required minimum of work.[75]

For a more complete and realistic understanding of the books read in universities, one should compare the Parisian curriculum with the curricula of, for instance, the universities of Oxford and Prague. Both were similar to the

[73] The first record of what resembles a curriculum for students dates from the close of the twelfth century. It concerns a list of texts-books, ascribed to Alexander Neckam, who taught in Paris in the end of the twelfth century. In that text, the students were advised to study, among other books, Aristotle's *Metaphysica*, as well as the and *De generatione et corruptione* and the *De anima*: «*Inspiciat etiam Metaphysicam Aristotelis et librum eiusdem De generatione et corruptione et librum De anima*» (Cambridge, *Gonville and Caius College*, ms. 385 (605)). See, for the list of texts-books ascribed to Alexander Neckam: C.H. Haskins, *Studies in the history of mediaeval science* (1924; New York, 1960), 356–376.

[74] Denifle and Chatelain, *Chartularium Universitatis Parisiensis: sub auspiciis consilii generalis facultatum Parisiensium ex diversis bibliothecis tabulariisque collegit et cum autheticis chartis contulit Henricus Denifle, O.P. in arvhivo apostolicae sedis romanae vicarious, academiae scientiarum vindobonensis socius auxiliante Aemilio Chatelain, bibliothecae universitatis in Sorbona conservatore adjuncto*.

[75] Weijers distinguished clearly between a curriculum *de forma* and the reality of teaching. See: Weijers, *Le maniement du savoir. Pratiques intellectuelles à l'époque des premières universités (XIIIe-XIVe siècles)*, 9, 14.

Parisian curriculum but provided looser statutary descriptions of the subjects, and thereby complementary to the Parisian curriculum. The difficulty, however, is that the editor of the Oxford charters edited the document thematically, while his Parisian equivalent did so chronologically.[76] The charters of the University of Prague are later, following its foundation in 1348.[77] Other sources giving insight into the student's library are an exam guide, *cedule actuum* and a register of loans, dating from 1402 to 1536, left to us by the early library of the Sorbonne.[78] Inventories of college libraries can also be illuminating, like those of the Sorbonne and the College Dormans-Beauvais.[79]

Some terminology and notion of daily structure help us to read the statutes. In the early universities, masters developed specific teaching methods to process the prescribed corpus of texts. A student heard lectures, attended close reading sessions and participated in several genres of exercise, dictation and debate. The classical pedagogical structure was one of *lectio*, *questio* and *disputatio*.

In lectures, the masters compared several commentaries on a base text, using different commentaries depending on the subject, though those of Thomas Aquinas, Albert the Great, Averroes and Avicenna were prevalent. In Paris, a student was to attend morning lectures, from September to June, on the regular reading days *(dies legibiles)* of the master under whom he was enrolled. Common terminology spoke of 'hearing' and 'reading' lectures, depending on the perspective of student or master. Lectures and disputation were the backbone

[76] S. Gibson, ed., *Statuta antique universitatis Oxoniensis* (Oxford, 1931). Hereafter *Stat. ant.*. See also: J.A. Weisheipl, "Curriculum of the arts faculty at Oxford in the early fourteenth century," *Mediaeval studies* 26 (1964): 143–185; G. Leff, *Paris and Oxford universities in the thirteenth and fourteenth centuries* (London–New York–Sydney, 1968); O. Weijers and L. Holtz, *L'enseignement des disciplines à la Faculté des arts (Paris et Oxford, XIIIe-XVe siècles)* (Turnhout, 1997).

[77] K. Beránek, J.V. Cěrný, and M. Pravdová, eds., *Liber decanorum facultatis philosophicae universitatis Pragensis (1367-1585)* (Prague, 1830). See also: P. Spunar, "La Faculté des arts dans les universités de l'Europe centrale," in *L'enseignement des disciplines à la faculté des arts (Paris and Oxford, XIIIe–XVe siècles)*, ed. O. Weijers and L. Holtz (Turnhout, 1997), 467–475; O. Odložolík, *L'université Charles IV. 1348-1948* (Prague, 1948); V. Chaloupecký, *L'université Charles à Prague. Sa fondation, son évolution et son charactère au XIVe siècle* (Prague, 1948).

[78] C. Lafleur, ed., *L'enseignement de la philosophie au XIIIe siècle autour du 'Guide de l'étudiant' du ms. Ripoll 109. Actes du colloque international* (Turnhout, 1997); J. Veilliard and M.-H. Jullien de Pommerol, *Le registre de prêt de la bibliothèque du Collège de Sorbonne (1402-1536) = Diarium Bibliothecae Sorbonae: Paris, Bibliothèque Mazarine, ms. 3323* (Paris, 2000); Jullien de Pommerol, M.-H., *Sources de l'histoire des universités françaises au Moyen Âge* (Paris, 1978).

[79] See, for more about medieval college library collections: L. Delisle, *Le cabinet des manuscrits de la Bibliothèque nationale*, vol. III (Paris, 1881), vol. 3; T. Kouamé, *Le collège de Dormans-Beauvais à la fin du Moyen Âge. Stratégies politiques et parcours individuels à l'Université de Paris (1370-1458)* (Leiden, 2005); R.H. Rouse, "The early library of the Sorbonne," *Scriptorium* 21 (1967): 42–71 and 227–251; R.H. Rouse and M.A. Rouse, "La bibliothèque du collège de Sorbonne," in *Histoire des bibliothèques françaises*, ed. A. Vernet, vol. 1: Les bibliothèques médiévales du VI siècle à 1530 (Paris, 1989), 113–123.

of university instruction, and questions played a role in both. 'Hearing' a lecture meant that a student was to attend and listen to a lecture that would be read out loud. 'Reading' a lecture meant that the student (bachelors of Arts taking the role of the teacher) was 'to read' the lecture, that is 'to teach'. The morning lectures, roughly speaking, entailed a discussion of the problems generated by a given text, and in the afternoon classes, one then paraphrased that text, like in tutorials. The afternoon classes were assigned to bachelor students.

The *questiones* are abundantly preserved in literary form, starting generally with the interrogative particle *Utrum*. After a short proposition, an affirmation of the proposed solution followed first, and then a negation.

Besides the lectures and questions, students themselves engaged in lively debates. Depending on the university the disputes took place regularly, say weekly, (the *disputationes ordinarie*), or exceptionally, once a year, the *disputationes de quolibet*. The Arts faculty adopted the weekly disputes following the example of the theology faculty, but they seem not to have enjoyed the same importance as they did in the latter. In the Arts faculty these disputes were exercises rather than scientific meetings.[80] Students attended these weekly disputes for two years and in their third year participated actively. The student initially took the role of the opponent and only after a year might he be admitted to respond to the question. Although Prague was founded on the example of the Sorbonne, many aspects of Sorbonne practice were only introduced in Prague in a simplified form, or else with a delay. While in the Sorbonne the form of questions and disputes was fully developed, in Prague one continued with the traditional pedagogical tools: lectures and explications. The disputes became dominant in Prague only later.[81]

After obtaining the bachelor degree, the student (21 years old at least) should attend two more years of lectures and continue to participate in disputes. After these two years, a jury finally decided, having heard the master candidate pronounce some pledges, whether to attribute to him the right to teach - his master's diploma. Only then was he licensed to incept and give ordinary lectures. Thus, after the student arrived, he attended lecture for six years, before he was allowed to read (i.e. to lecture) himself:

> «Let no one read about the artes in Paris before his twenty-first year, and that he had heard at least six years about the artes, before he has access to reading».[82]

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[80] B.C. Bazàn et al., *Les questions disputées et les questions quodlibétiques dans les facultés de théologie, de droit et de médecine* (Turnhout, 1985), 89.

[81] Spunar, "La Faculté des arts dans les universités de l'Europe centrale," 471.

[82] CUP, vol. I, p. 78, no. 20: «*Nullus legat Parisius de artibus citra vicesimum primum etatis sue annum, et quod sex annis audierit de artibus ad minus, antequam ad legendum accedat, […]*». See, for more a more detailed discussion of the completion of a student's obligations: Leff, *Paris and Oxford universities in the thirteenth and fourteenth centuries*; O. Weijers, *Terminologie des univer-*

The Categorie, the Isagoge and the textbook titled Tractatus

Logic enjoyed a predominant position in the curriculum of medieval Arts faculties, for through it one studied the basic elements of logic and the theory of argumentation. It belonged therefore not only to early training, but served all other branches of learning, since logic was held to establish the correct art of thinking and reasoning. Medieval scholars considered logic the skill by which one learns to discern between true and untrue statements.[83] They taught courses in logic within the faculty structure, but also outside the faculty in the *collegia* (student schools) and *burse* (student houses). Students from the higher Faculties gave these courses in the colleges and houses.[84]

The Paris curriculum of 1215 stated that teachers should teach the old and new Aristotelian logic using the *ordinarie* method, i.e. by close reading, and not *ad cursum* (cursive).[85] The Anglo-Saxon 'nation' at Paris described, in 1252, the examination requirements for the baccalaureate in the following way: one had to attend a read lecture series on Aristotle's 'old logic', meaning, the *Predicamenta* and *Periarmenias*, at least twice – once using close reading and once using cursively.[86]

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sités au XIIIe siècle (Rome, 1987); Weijers and Holtz, *L'enseignement des disciplines à la Faculté des arts (Paris et Oxford, XIIIe-XVe siècles)*; Weijers, *Le maniement du savoir. Pratiques intellectuelles à l'époque des premières universités (XIIIe-XIVe siècles)*; O. Weijers, *La 'disputatio' à la faculté des arts de Paris* (Turnhout, 1995); E.D. Sylla, "The Oxford Calculatores," in *The Cambridge history of later medieval philosophy from the rediscovery of Aristotle to the disintegration of Scholasticism 1100-1600*, ed. A. Kenny, N. Kretzmann, and J. Pinborg (Cambridge, 1982), 540–563, here 542–543; A. de Libera, *César et le Phénix: distinctions et sophismata parisiens du XIIIe siècle* (Pisa, 1991); A. de Libera, "La logique de la discussion sans les universités médiévales," in *Figures et conflits rhétoriques*, ed. M. Meyer and A. l'Empereur (Brussels, 1990), 59–81; A. de Libera and I. Rosier, "Argumentation in the Middle Ages," *Argumentation* 1, no. 4 (1987): 355–364; A. Maierù, "Methods of teaching logic during the period of the universities," in *University training in medieval Europe*, ed. A. Maierù (Leiden, 1994), 117–153; J. Hamesse, "Le vocabulaire de la transmission orale des textes," in *Vocabulaire du livre et de l'écriture au Moyen Âge*, ed. O. Weijers (Turnhout, 1989), 169–194. See also: J. Miethke, "Die mittelalterliche Universitäten und das gesprochene Wort," *Historisches Zeitschrift* 251 (1990): 1–44; Bazàn et al., *Les questions disputées et les questions quodlibétiques dans les facultés de théologie, de droit et de médecine*; A. Kenny and J. Pinborg, "Medieval philosophical literature," in *The Cambridge history of later medieval philosophy from the rediscovery of Aristotle to the disintegration of Scholasticism 1100-1600*, ed. A. Kenny, N. Kretzmann, and J. Pinborg (Cambridge, 1982), 11–42.

[83] L.M. de Rijk, "Specific tools concerning logic education," in *Méthodes et instruments du travail intellectuel au Moyen Âge*, ed. O. Weijers (Turnhout, 1990), 62–81, here 62–63.

[84] H.A.G. Braakhuis, "School philosophy and philosophical schools," in *Die Kölner Universität im Mittelalter. Geistige Wurzeln und soziale Wirklichkeit*, ed. A. Zimmerman (Berlin-New York, 1989), 1–18, here 1; A.L. Gabriel, "Prepatory teaching in the Parisian Colleges during the fourteenth century," in *Garlandia: studies in the history of medieval universities*, ed. A.L. Gabriel (1961), chap. 4.

[85] CUP I, no. 20 (1215), 78–80: «*Et quod legant libros Aristotelis de dialetica tam de veteri quam de nova in scolis ordinarie et non ad cursum*».

[86] CUP I, no. 79 (1231), 136–139: «*Insuper quod audiverit libros Aristotelis de Veteri logica, videlicet*

An almost contemporary document, dating to around 1255, lists the books for the second phase of university education: Porphyry's book, *Predicamenta* and *Periarmenias, Divisiones* and the *Topica* of Boethius, except the fourth. Porphyry's book is obviously the *Isagoge*, known in Boethius' translation. The readings of these books started on the feast of Saint-Rémy (October 1) and were to be continued until the feast of the Annunciation of the blessed Virgin (March 25) or the last day on which one could read before Annunciation.[87] Masters read these logic books for about six months (holidays included).

One record (from before 1350) gives a description of the demands made of bachelors at the College of Sainte-Geneviève. In order to obtain one's bachelor degree one had to hear the old art, i.e. the *Isagoge*, *Predicamentum*, *Periarminias*, once by close reading and twice cursory, or vice-versa. One also had to hear the *parva logicalia*, which comprised the *Sex principia*, the *Topica* by Boethius, the *Divisiones* by Boethius, the *De accentu* by Priscian and the *Barbarismus* of Everardus de Bethunie.[88]

The examiners in the English nation required that the candidates master roughly the same titles. It was also required by that nation that the student was at least fourteen years old, and had to swear that he had attended at least two years of lectures on logic texts in Paris or elsewhere, in the context of a *studium generale* (a school featuring at least six masters), and that they were consequently then in their third year of attending classes about these same books.[89]

The nature of preparatory instruction in logic can be grasped through the structure of early thirteenth-century textbooks, especially the *Tractatus* by Peter of Spain. First, the student was instructed in the *introductiones* (the basic propositions) then the *predicabilia* (*genus, species, differentia, proprium*, and *accidens*), the *predicamenta*, syllogisms, topics (*loci*), and finally the fallacies. These teachings were known as the *logica antiquorum*. Next, there were lectures grouped together under the name *parva logicalia*, representing the *logica modernorum*. Sometimes masters added other explanations, for example about the rules for logical debating games, logical paradoxes, rules of consequence etc.[90]

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librum predicamentorum et librum periarmenias bis ad minus ordinarie, et semel cursorie».

[87] CUP I, no. 246 (1255), 278: «*Veterem logicam, videlicet librum Porfirii, predicamentorum, periarmenias, divisionum et thopicorum Boecii, excepto quarto, in festo Annunciationis beate Virginis vel ultima die legibili precedente».*

[88] CUP II, appendix 1185 (14) (ante an. 1350), 678–679 : «*< vos jurabitis > quod audivistis veterem artem, scilicet librum Porphirii et Predicamentorum et Peryarminias semel ordinarie et bis cursorie, vel e contra. […] Item, quod audivistis parva logicalia, scilicet librum Sex Principiorum, Thopica Boetii, Divisiones Boetii, Priscianus de accentu, et Barbarismus».*

[89] CUP II, appendix 1185 (4) (ante an. 1350), 673–674 : *Primo, vos jurabitis quod uso estis 14 (sic!) annorum. […] vos jurabitis quod […] audivistis ad minus duos annos libros loycales Parisius vel alibi, ubi est studium generale sex magistrorum ad minus, et quod estis in tercio anno audiendi predictos libros».*

[90] Braakhuis, "School philosophy and philosophical schools," 1–2.

The *Isagoge* occupied a firm position in university teachings from 1215 onwards. It was read to bachelor students during their first two or three years in the Arts faculty, or else in a *studium generale*, which was by this time virtually a synonym for university.[91]

The *Isagoge* is a short text of roughly 15 folia, easily carried in one's pocket, or in the sleeve as was customary in the period under study. Evidently, not every student could afford a copy of his own. These unfortunates could borrow a copy from the library or consult one *in situ*. The Sorbonne library possessed at least two copies of the *Tractatus*, one a legacy of master Adenulph of Anagni and another of Gerard of Abbeville.[92] It is not known whether one of these copies was chained up in the large library or whether they were available for loan. The Sorbonne library usually granted permission for lending a book when it owned two copies, which was the case for the *Tractatus*. The books from the Abbeville bequest were, as a rule, chained in the *magna libraria* of the Sorbonne.[93]

In an Oxford college in 1268 all books of old logic should be heard, at least twice.[94] Around 1409, a student should have assisted to lectures on Porphyry's *Predicamenta*, six books of the *Principia* (the *Six principles* is a book about the Categories chapter 5–10), the *Elenchi* and *Barbarismus* of Donatus. These lectures need to be sufficient commentated and read integrally by a master or bachelor in the college or in the hall and recited immediately.[95]

De generatione et corruptione

Aristotle's treatise *De generatione et corruptione* dealt with the search of the physical conditions and causes of the production and destruction of things and of individual beings.

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[91] See, for the concept of the *studium generale*: Weijers, *Terminologie des universités au XIIIe siècle*, 34–51.

[92] An entry in the catalogue of the ancient library of the Sorbonne mentions: *'XLVI, nr. 6: in uno volumine Tractatus et Sincategoreumata magistri Petri Hyspani ex legato magistri Adenulfi, prepositi Sancti Odomari. Incipit in 20. fol.: Modo queritur, in pen.: est excelsa. Precium XII sol'* (Delisle, *Le cabinet des manuscrits de la Bibliothèque nationale*, 57). See also: Rijk, *Peter of Spain (Petrus Hispanus Portugalensis). Tractatus called afterwards Summule logicales*, xcvi; M. Grabmann, "Adenulf von Anagni. Propst von Saint-Omer (âXX 1290). Ein Freund und Schüler des hl. Thomas von Aquin," in *Mittelalterliches Geistesleben. Abhandlungen zur Geschichte der Scholastik und Mystik*, vol. 3 (Munich, 1956), 306–322. The other exemple is donated by Gerard of Abbatisville as states the provenance in the book, Paris, *Bibliothèque nationale*, lat. 16611: «*iste liber est collegii pauperum magistrorum parisiensium in theologie facultate studentium ex legato magistri Geroudi (!) de Abbatisvilla*».

[93] Rouse, "The early library of the Sorbonne," 230.

[94] *Stat. ant.*, 26: «*omnes libros veteris logice ad minus bis audierint*».

[95] *Stat. ant.*, 200, 17–19: «*Iurabunt insuper singuli pro se determinaturi quatuor libros logicales, videlicet, Porphyrii Predicamentorum, sex Principiorum et Elenchorum, et Barbarismum Donati*».

Gerard of Cremona (ca. 1114–1187) traveled from Lombardy to Toledo to translate, and make accessible to the West, many Arabic versions of classical Greek works and also some contemporary Arabic works. Before his death he translated, among others, the *De generatione et corruptione* by Aristotle from the Arabic into Latin. William of Moerbeke translated a further version from the Greek prior to 1274.[96]

The introduction of the *De generatione et corruptione*, like that of all Aristotelian natural philosophical works, encountered difficulties because of the ban in place from 1210–1231. For although natural philosophy was firmly rooted in the curriculum of the University of Paris in the thirteenth century, its adversaries attempted to subvert its study. They considered a number of ideas dangerously conflicting with the Christian faith. Many of the condemned propositions in 1277 affected the *De generatione et corruptione*, and some targeted the elements in particular. For instance: no. 107 condemned the proposition that the elements are eternal, and no. 202 condemned the proposition that the elements were made out of chaos, but subsequently became eternal.[97] In 1325, some of these condemnations would be annulled, thanks to the popularity of the teachings of Thomas Aquinas.[98]

The 1215 charter had banned the teachings of Aristotle's books about natural philosophy[99], while in 1231 the wish to expurgate the *libri naturales* was expressed.[100] The 1252 charter, addressed to the English nation, mentioned the study of *De anima* but excluded the *De generatione et corruptione*.[101] *De generatione et corruptione* is first explicitly mentioned in a charter dating to 1255.[102] This 1255 charter specified the period of its reading: all «must finish the texts they began on the feast of St. Remy [October 1] at the times noted below, and not before».[103] The time 'noted below' meant that *De generatione* was to be read until «the feast of the Chair of St. Peter», celebrated on February 22. This meant masters would read *De generatione* to their audience of students over a period of five months.

The same charter also granted the option to read the text in half that time:

> «Moreover, each of these aforementioned texts, if read by itself, not with another text, can be finished in half of the lecture period assigned before.

[96] Dod, "Aristoteles Latinus," here 76.
[97] CUP I, no. 473 (1277), 543–558.
[98] Grant, *A sourcebook in medieval science*, 47.
[99] CUP I, no. 20 (1215), 78–79. *See* footnote 62.
[100] CUP I, no. 87 (1231), 143–144. *See* footnote 69.
[101] CUP I, no. 201 (1252), 228: «*Item librum De anima semel audiverit vel sit in audiendo, sicut predictum est*».
[102] CUP I, no. 246 (1255), 278: «*librum De generatione in cathedra sancti Petri*».
[103] CUP I, no. 246 (1255), 278: «*[…] quod omnes et singuli magistri nostre facultatis imposterum libros, quos in festo beati Remigii inceperint, temporibus inferius annotatis absolvere, non ante, teneantur*».

> No one may finish the said texts in less time, but anyone may take more time».[104]

It is not quite clear what is meant by «read by itself, not with another text». Could one read *De generatione* in half of the time if one did not read all the other natural philosophical books at the same time? That seems too obvious. *De generatione et corruptione* is only a short treatise – as are most of Aristotle's works. It also seems purposeless to allow students to read it in three months by itself, if they still had to read about 25 books a year (as mandated by the charter of 1255). Could this injunction instead have constituted a warning to read the original text and not to substitute *De generatione et corruptione* with one of the many textbooks then circulating? We will not be able to confirm this for sure.

By 1350 a bachelor's degree exam candidate in Sainte-Geneviève had to swear that he had attended lectures on Aristotle's *Physica, De celo, De generatione, Metheora, De anima* and the short natural philosophical treatises. This requirement was indispensable.[105] In 1366 it was repeated that students admitted to the licentiate had to have heard *De generatione et corruptione,* among many other Aristotelian works on physics and metaphysics, and that he has heard mathematical works. This requirement applied to the Arts faculty as well as to any other *studium generale* in Paris.[106] At Oxford, in 1268, the *De generatione et corruptione* was equally a required lecture course for those preparing for the bachelor's degree exam.[107]

In 1340, the author of the statute stated that bachelors were supposed to have 'read' books cursorily (that is to have lectured on them) in schools in order to receive a license to incept. Students had to swear to have read two logic books and one of natural philosophy, four books of *Celi et mundi*, or three of *De anima*, or four of the *Meteora*, or two books of the *De generatione et corruptione* or *De sensu, De memoria* and *De sompno* or *De motu* with *De minutis naturalibus* (sic).[108]

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[104] CUP I, no. 246 (1255), 278: «*Quilibet autem predictorum si per se legatur, non cum alio, poterit finiri in medietate temporis sue lecture pretaxati. In minori autem non licebit cuiquam predictos libros terminare. Plus tamen temporis licebit cuiquam apponere*».

[105] CUP II, no. 1185 (14) (before 1350), 676/ 678: «*< Vos jurabitis > … quod audivistis librum phisicorum, De celo, De generatione, Metheorum, De anima, et parvos libros naturales –(Non dispensatur).*».

[106] CUP III, no. 1319 (1366), 145: «*Item quod nullus admittatur ad licentiam in dicta facultate, nec in examne Beate Marie, nec in examine Sancte Genovefe, nisi ultra predictos libros audiverit Parisius vel in alio studio generali librum Physicorum, de Generatione et Corruptione, de Celo et Mundo, Parva Naturalia, videlicet libros de Sensu et Sensato, de Sompno et Vigilia, de Memoria et Reminiscentia, de Longitudine et Brevitate vite, librum Metaphysice, vel quod actu audiat eundem, et quod aliquos libros mathematicos audiverit*».

[107] *Stat. ant.*, 26, 9–10, xc.

[108] *Stat. ant.*, 32, 9–10, xcv n. 3.: «*Quos libros debent bachilarii legere antequam incipiant in artibus. […] iuret se legisse cursorie duos libros logicales ad minus, unum de veteri logica, et alterum de nova,*

The *De generatione et corruptione* was a required course for determiners at Oxford in 1268.[109] In the fourteenth century, it was not required for undergraduates, but a bachelor might lecture cursorily on this work, thus offering optional courses for undergraduates.[110] At Oxford, moreover, *De generatione* had to be read in one term,[111] which comprised at least 30 reading days, with three terms making up a year.[112] In 1431 those who wished to 'determine' at Oxford had to have heard, among others, three terms of natural philosophy, among which the *De anima* featured, but also *De celo et mundo, De proprietatibus elementorum, Meteorica, De vegetabilibus et plantis, De animalibus* and some further not named small books.[113]

De anima

Masters taught psychology, as a part of natural philosophy, in the Arts faculty.[114] The basic text in this field was the *De anima* of Aristotle. Before 1265, medieval scholars consulted the *De anima* and the other Aristotelian *libri naturales* through Averroes' *latinus*, a corpus of commentaries on these works composed by Averroes and translated from the Arabic into Latin by Michael Scot (in 1220), Gerard of Cremona and others. This so-called *vetus translatio* was replaced around 1268 by the *nove translationes*, which were made on the basis of Greek versions. For example, the Flemish Dominican William of Moerbeke (ca. 1215 - ca. 1286), a prolific translator of Greek texts, revised a previous translation of the *De anima*, (by James of Venice from 1125–50), and probably completed the text before 1268.[115]

De anima lived through anxious moments, because of the ban on natural philosophical texts in the early years of the thirteenth century mentioned above, but still quickly became an official part of studies at Paris.[116] Evidence for this includes a statute of 1252 for the English nation at Paris, which mentions the

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vel ambos de nova, et unum de libris naturalibus, videlicet libros quatuor Celi et mundi, vel tres libros De anima, vel quatuor libros Metheororum, aut duos libros De generacione et corupcione, vel librum De sensu et sensato, cum libris De memoria et reminiscencia et De sompno et vigilia, vel librum De motu animalium cum duobus libris De minutis naturalibus […]».

109 *Stat. ant.*, 26.

110 *Stat. ant.*, 32, 9–10. See footnote 108.

111 Weisheipl, "Curriculum of the arts faculty at Oxford in the early fourteenth century," 174.

112 *Stat. ant.*, lxxx, n. 12.

113 *Stat. ant.*, xciv.

114 Psychology was a term first used in the fifteenth century. See: O. Pluta, *Die Psychologie des Peter von Ailly. Ein Beitrag zur Geschichte der Philosophie des späten Mittelalters* (Amsterdam, 1987), 8.

115 Dod, "Aristoteles Latinus," 76; Grant, *A sourcebook in medieval science*, 40–41.

116 Weijers, *Le maniement du savoir. Pratiques intellectuelles à l'époque des premières universités (XIIIe-XIVe siècles)*, 10.

required study of logic and grammar, and that the baccalaureate candidates had to have heard lectures on *De anima* or had to be in the course of attending lectures about it before a license to 'determinate' was granted to them.[117] The well known Parisian student guide 'Ripoll' (dated c. 1240) also cites *De anima* along with *De animalibus* and *De plantis* as a cluster of texts that did justice to the tripartite division of the soul (see chapter 4).[118] The very earliest scholastic account of the use of *De anima* is the *Liber de anima* by Peter of Spain (d. 1277, not to be confused with Peter of Spain, the author of the logic treatise *Tractatus*), which dates to around 1250.[119]

So although the 1277 condemnation referred to the *De anima*, and considered obscure some of its themes, including the nature and functions of intelligence in the human being and the active intellect, it is unclear how this affected the readings of *De anima* in Paris at the end of the thirteenth and fourteenth century. Parisian commentaries, *sententie, expositiones, questiones* and *summe* have certainly survived from this period, indicating that lecturing on *De anima* continued nonetheless, and it continued to be an important text.[120]

In 1255 *De anima* was read in combination with some other natural philosophical texts or logical books.[121] And around 1350 we hear again of the *De*

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[117] CUP, I, no. 201 (1252), 228: «*Bachellarius autem licentiandus in artibus Parisius ad determinandum [...]. Item antequam ad examinacionem recipiatur [...] quod audierit in artibus per quinque annos vel quatuor ad minus Parisius continue vel alibi [...]. Insuper quod audiverit libros Aristotilis de* Veteri logica *[...]. Item quos audiverit Prissianum minorem et Barbarismum [...] Prissianum magnum [...]. Item librum De anima semel audiverit vel sit in audiendo, sicut predictum est [...]*».

[118] Lafleur, *L'enseignement de la philosophie au XIIIe siècle autour du 'Guide de l'étudiant' du ms. Ripoll 109. Actes du colloque international*, xiv.

[119] Grabmann, *Methoden und Hilfsmittel des Aristotelesstudiums im Mittelalter*, 27. See also: Weijers, *Le travail intellectuel à la Faculté des arts de Paris: textes et maîtres (ca. 1200-1500)*, here vol. 7, 164.

[120] Thirteenth-century scholars working on *De anima* in Paris included: Adam of Buckfield, Giles of Rome, Guido Vernani Arimensis, William of Alnwick, William of Auvergne, James of Douai, Jacobus Lombardus, John Peckham, John of La Rochelle, Matthew of Aquasparta, Paul of Venice, Peter of Ailly, Peter of Aquila, Peter of Spain. See: ibid.

[121] The list sums up the compulsory texts in the first phase of study: almost all were Aristotelian writings, among which *De anima*. CUP, I, no. 246 (1255), 278: «*Veterem logicam, videlicet librum de Porfirii, predicamentorum, periarmenias, divisionum et topicorum boecii, excepto quarto, in festo Annunciationis beate Virginis vel ultima die legibili precedente; Priscianum minorem et majorem, topica et elenchos, priora et posteriora dicto tempore vel equali terminare teneantur. Ethicas quantum ad quatuor libros in xij septimanis, si cum alio legantur; si per se non cum alio, in medietate temporis. Tres parvos libros, videlicet sex principia, barbarismum, Priscianum de accentu, si simul legantur et solum in sex septimanis. Physicam Aristotelis, metaphisicam et librum de animalibus in festo sancti Johannis Baptiste; librum celi et mundi, librum primum metheorum cum quarto in Ascensione; librum de anima, si cum naturalibus legatur, in festo Ascensionis, si autem cum logicalibus, in festo Annunciationis beate Virginis; librum de generatione in cathedra sancti Petri; librum de causis in septem septimanis; librum de sensu et sensato in sex septimanis; librum de sompno et vigilia in quinque septimanis; librum de plantis in quinque septimanis; librum de memoria et reminiscentia in duabus septimanis; librum de differentia spiritus et anime in duabus septimanis; librum de morte et*

anima in the statutes enumerating the conditions for the bachelor's exam in the Parisian College of Sainte-Geneviève, for which *De anima* is on the list of compulsory texts.[122] In 1366 one had to read the *De anima* in full or in part, together with grammar and logic, again during the early stages of training.[123]

The prescribed time for the reading of the *De anima* in Paris was about six months in the year 1255. The statute explicitly urged masters not to rattle off their lectures, and incited them to take the indicated time permitted, according to the length and difficulty of the text.[124] The statute states that each teacher is permitted to spend more time on a given part of a book if needed.[125]

Later statutes of Paris do not inform us about the duration of lecturing on *De anima*. But fifteenth-century statutes from Central-European universities continue to refer to the study of *De anima*. In Greifswald's statutes of 1456 one heard lectures on *De anima* for 3 months, and had exercises on the text for half a year (simultaneously with other texts).[126] In Leipzig (statutes of 1471–1490) one heard lectures on *De anima* for between 7 weeks and 2 months, and did exercises for 4 months.[127] In 1431 those who wished to 'determine' at Oxford had to have heard, among others, three terms of natural philosophy, among which the *De anima* featured.[128]

De anima and its subject - the powers of the soul - thus formed a central part of the medieval curriculum. Besides official statutes that indicated what one should do, traces of actual lectures about the *De anima* in university edu-

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vita in una septimana».

[122] CUP, II, no. 1185, item 14 (about 1350), 678: «*Item, quod audivistis librum phisicorum, De celo, De generatione, Metheorum, De anima, et parvos libros naturales*».

[123] CUP, III, no. 1319 (1366), 145: «*Item quod audiverint veterem artem totam, librum thopicorum, potissime quoad quatuor libros, et libros Elenchorum, Priorum et Posteriorum complete; etiam librum De anima in toto vel in parte. […] Item statuimus auctoritate predicta quod scolares antequam ad determinandum in artibus admittantur, […] dicti libri legantur*».

[124] CUP, I, no. 246 (1255), 277–278: «*Anno Domini MCCL quarto. Noverint universi, quod nos omnes et singuli magistri artium de communi assensu nostro nullo contradicente propter novum et inestimabile periculum quod in facultate nostra imminebat, magistris aliquibus lectiones suas terminare festinantibus, antequam librorum quantitas et difficultas requireret, propter quod et magistri legendo, et scolares in audiendo, minus proficiebant, super ruina nostre facultatis anxiantes, et statui nostro precavere volentes, pro communi utilitate et studii nostri reparatione ad honorem Dei et universalis ecclesie statuimus et ordinavimus, quod omnes et singuli magistri nostre facultatis imposterum libros, quos in festo beati Remigii inceperint, temporibus inferius annotates absolvere, non ante, teneantur […]*».

[125] CUP, I, no. 246 (1255), 278: «*Si autem aliquis aliquam partem alicujus libri legerit, ita quod totum terminare noluerit aut non possit, legat in portione temporis portionem libri contingente*».

[126] J.G.L. Kosegarten, *Geschichte der Universität Greifswald* (Greifswald, 1857), 309.

[127] «*[…] Pro de generatione duo menses ad maximum; minimum septem septimane, similiter pro de anima […]*». See: F. Zarncke, *Die Statutenbücher der Universität Leipzig aus den ersten 150 Jahren ihres Bestehens* (Leipzig, 1861), 398.

[128] *Stat. ant.*, xciv. See footnote 113.

cation can be found in manuscripts containing commentaries on it.[129] Further, medieval library catalogues mention the possession of copies of the *De anima*. The library of the Parisian Collège de Dorman-Beauvais, for instance, owned a copy of the *De anima* and an *Expositiones super De anima*.[130]

1.3 STUDY-AIDS

The massive entry of Aristotelian texts into the West at the beginning of the thirteenth century changed education. The moment the translations crossed the threshold the Arts Faculty, all students entering the university were initiated into Aristotelian thought. All this new knowledge was for the most part processed using so-called study-aids, a new genre of texts summarizing and abbreviating the new Aristotelian knowledge.

The basic texts, often Aristotle's, were called *littera* or *textus*, and these were the subject of readings through which the commentator explained the basic text. The *littera* generated many problems (*questiones*) whose attempted solution constituted a significant part of the scientific literature of the thirteenth and fourteenth centuries. A variety of literary sub-genres of the textbook were produced to provide study and teaching material: *abbrevationes, compendia, conclusiones, flores, auctoritates, tabule* etc. The many copies still extant in libraries testify to their heavy use by students and masters understanding texts, preparing exams and revising material. These university sources are grouped under the name study-aids, but are far from a homogeneous set.

Modern scholars often consider the study of textbooks, short commentaries, anthologies, editions and translations to be derivative. Since the 1960's, however, more attention has been paid to the minor literary products of masters of arts, and especially to their role in the introduction of Aristotelian thought during the thirteenth century.[131] The many variant names of study-aids indicate various intentions, functions and meanings for educational commentaries.

[129] See, for inventories of inedited commentaries on the *De anima*: Raedemaeker, "Une ébauche de catalogue des commentaries sur le De anima parus aux XIIIe, XVe et XVe siècles"; Raedemaeker, "Une ébauche de catalogue des commentaries sur le De anima parus aux XIIIe, XVe et XVe siècles"; J. de Raedemaeker, "Informations concernant quelques commentaires du De anima," *Bulletin de philosophie médiévale* 8–9 (1966–1967): 87–110; A. Thirry, "A propos de certains commentaires médiévaux du De anima. Résultats de quelques recherches," *Bulletin de philosophie médiévale* 8–9 (1966): 63–87. See also: A.F. Smet, *Initia commentariorum quaestionum et tractatuum latinorum in Aristotelis libros De anima seaculis XIII, XIV, XV editorum* (Louvain, 1963).

[130] Kouamé, *Le collège de Dormans-Beauvais à la fin du Moyen Âge. Stratégies politiques et parcours individuels à l'Université de Paris (1370-1458)*, 284–285.

[131] Jacqueline Hamesse has drawn our attention to the *florilegia* since the 1960's, in many publications. See: J. Hamesse, "Les florilèges philosophiques du XIIIe au XVe siècle," in *Les genres littéraires dans les sources théologiques et philosophiques médiévales. Définition, critique et exploitation. Actes du Colloque international de Louvain-la-Neuve 25-27 mai 1981*, ed. J. Hamesse (Louvain-la-

In addition, because some names were only used locally or in a certain period, they can provide a sense of the time and place of production, and thus give insight into the context of creation.

Furthermore, the presence of certain textbook sub-genres in a university shows which teaching tools were then in use in a given locality. *Notule*, for example, were only used at Oxford.[132] Some scholars have pointed out that the study of these (sub)genres is crucial to understanding how knowledge was handed down from generation to generation and from place to place. Through handbooks practices became standardized, calibrated and replicated, doctrines became normalized, authors canonized, and paradigms created.[133]

It seems appropriate, therefore, to describe the character of some of these texts, their justifications, objectives, and audience, for these coincide importantly with the scientific visual representations such texts included. This section therefore presents several literary sub-genres, each indicating different practices, intentions and functions, among the sources underlying this study.

John Murdoch observed that «the illustrations are notoriously few in the manuscript copies of Aristotle and Galen and of their medieval translations and seemingly endless commentaries».[134] Instead Murdoch claimed that «the bearers of most of the visual representations of theory were not copies of central works [...], but instead encyclopedic and handbook works of Roman and early medieval heritage», «but also that were written in the later Middle Ages, even though they then appeared side by side with the codices of the Aristotelian translations and other scholastic science».[135] He remarked that the presence of diagrams, understood as pedagogical tools, in these books is only natural due to their didactic purpose.[136] As explanation is put forward that pictures are not necessary for comprehension of the text. Understanding consists in grasping the

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Neuve, 1982), 181–191; J. Hamesse, "Les florilèges médiévaux d'Aristote," *Bulletin de philosophie médiévale* (1965): 52–84; J. Hamesse, *Les auctoritates Aristotelis. Un florilège médiéval. Etude historique et édition critique* (Louvain-Paris, 1974). See also: C. Flüeler, "Die verschiedenen literarischen Gattungen der Aristoteleskommentare: Zur Terminologie der überschriften und Kolophone," in *Manuels, programmes de cours et techniques d'enseignement dans les universités médiévales*, ed. J. Hamesse (Louvain-la-Neuve, 1994), 75–116; Lafleur, *Quatre introductions à la philosophie au XIIIe siècle*; P. Hadot, ed., *Les genres littéraires dans les sources théologiques et philosophiques médiévales. Définition, critique et exploitation. Actes du colloque international de Louvain-la-Neuve 25-27 mai 1981* (Louvain-la-Neuve, 1982). Grabmann also wrote a useful account on study-aids in his *Methoden und Hilfsmittel* of 1939.

[132] Flüeler, "Die verschiedenen literarischen Gattungen der Aristoteleskommentare: Zur Terminologie der überschriften und Kolophone," here 95–96.

[133] See especially the contribution of Nick Jardine and pages 4–5, in: M. Frasca Spada and N. Jardine, *Books and the sciences in history* (Cambridge, 2000).

[134] Murdoch, *Album of science: Antiquity and the Middle Ages*, x.

[135] ibid., 277.

[136] ibid., 31.

essence by means of the mind's higher faculties, as Aristotle puts it roughly.[137]

I will verify Murdoch's observation about the localisation of diagrams for the period from the thirteenth to the fifteenth centuries. A first preparatory inventory I made showed that texts in the Arts faculty made significantly more use of visual representations than did juridical and theological texts, though these latter were not totally devoid of illustration.[138]

My research on sources from the thirteenth to the fifteenth centuries refines this observation. I show that base texts indeed rarely featured diagrams, but that some translations and commentaries do contain figures. Boethius' translation of Porphyry's *Isagoge* did so, for instance, as did his commentary on the same text (see chapter 2). Encyclopedias were then not much in demand anymore. Moreover, the observation that very few diagrams are found in the authoritative base texts implies that most such figures were medieval inventions.[139]

1.3.1 Revision material

The base text was supposed to be at the disposal of students and many university statutes required students to bring their own copy of the text to lectures.[140] But books were expensive, costing about 16 to 20 weeks of a master's salary, and sometimes more in the case of a large book.[141] Material was expensive, but the costs for copying still higher, so efforts were made to reduce the price as far as possible: small formats, tight lines, cursive handwriting, and abbreviations. Only the richest students could hire professional scribes to copy the required texts. Poorer students had to copy the necessary text themselves or hire a destitute student or chaplain to do the work.[142]

It is understandable that young students needed revision material to prepare themselves for oral examinations. The amount of books set was enormous, and manuals provided the student with short, convenient and cheap summaries, which saved masses of time and money, since not all *littera* were easily accessible, were often rare and were always expensive. Students therefore sought cheaper

[137] ibid., 277; C. Lüthy and A. Smets, "Words, Lines, Diagrams, Images: Towards a History of Scientific Imagery," *Early Science and Medicine* 14, no. 1–3 (2009): 398–439, 425.

[138] Medical texts, especially about anatomy and surgery, also made abundant use of pictures. Medicine was practiced in its own faculty but also outside, 'in the field', which makes its setting hard to specify. Medical representations fall, therefore, beyond the scope of this study, as does visual material from the law and theology faculties.

[139] Some figures nonetheless have antique predecessors. Barbara Obrist traced the antique forerunners of some early-medieval manuscripts. See: Obrist, "Le diagramme isidorien des saisons, son contenu physique et les représentations figuratives."

[140] Rashdall, Powicke, and Emden, *The universities of Europe in the Middle Ages*, 423.

[141] C. Bozzolo and E. Ornato, *Pour une histoire du livre manuscrit au Moyen Âge* (Paris, 1980), 26.

[142] J. Verger, *Les gens de savoir dans l'Europe de la fin du Moyen Âge* (Paris, 1997), 87.

and more practical ways to process the huge number of texts. Manuals, abbreviating the essential doctrines of an author, fulfilled these criteria, serving the student as a vade-mecum of all the examined subjects.

The textbook was an aid to memory in which the student found summaries of the topics the examiners could question him about.[143] The manuals' authors drew the most important lessons from the base texts and clearly presented them, giving a skeleton summary of each chapter and dealing with any difficulties that a chapter featured. Frequently asked exam questions and their answers were collected and presented in different, but always condensed forms.

The same text may initially have served as an aid for understanding and then later as an aid for revision.[144] Besides, as Hamesse argued in the case of the Parisian *florilegia*, such study-aids had the advantage that controversial elements of the base text could be omitted in order to any possible danger.[145] In these conditions, the success of *florileges*, repertoires, encyclopedias and the rest, is readily understandable.

Students and masters copied the texts they wanted, for instance by borrowing a copy through *pecie*, a system in which every quire of a text was rented separately from a stationer's shop. This system made simultaneous copying possible, and thus augmented productivity without lowering the quality of the text. It is doubtful whether the *pecia* system was used for the diffusion of texts taught outside the Arts faculty.[146] Also, outside Paris, the *pecia* system was not even customary for Arts texts.

Instead, masters dictated texts to gatherings.[147] Writing inevitably generated mistakes and discordant variants among students' copies were most unfortunate when a teacher commented orally on a text before his audience. Teachers might rapidly dictate textbooks in order that students might correct their copies. Dictation was a useful way to retain control over the quality and diffusion of texts and to prevent stationery shops from commercializing textbooks. Dictating texts in class, during the so-called *pronunciatio*, obviously affected teaching methods, notably the time scheduled for lecturing.[148] The practice

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[143] Hamesse, "Les florilèges philosophiques du XIIIe au XVe siècle," 183.

[144] Lewry, "Thirteenth-century examination compendia from the Faculty of Arts," here 101, 103. See also: Lafleur, *Quatre introductions à la philosophie au XIIIe siècle*, 145–147.

[145] Hamesse, "Les florilèges philosophiques du XIIIe au XVe siècle," 183.

[146] Flüeler, "Die verschiedenen literarischen Gattungen der Aristoteleskommentare: Zur Terminologie der überschriften und Kolophone," 89 n. 28, 97.

[147] See, regarding the *pecia* system: G. Fink-Errera, "Une institution du monde médiéval: la 'pecia'," *Revue philosophique de Louvain* 60 (1962): 184–243; G. Pollard, "The pecia system in the medieval universities," in *Medieval scribes, manuscripts and libraries. Essays presented to N.R. Ker*, ed. M.B. Parkes and A.G. Watson (London, 1978), 145–161; L.-J. Bataillon, B.-G. Guyot, and R.H. Rouse, eds., *La production du livre universitaire au moyen âge. 'Exemplar' et 'pecia'*, Actes du symposium tenu au Collegio San Bonaventura de Grottaferrata en mai 1983 (Paris, 1988).

[148] Fink-Errera, "Une institution du monde médiéval: la 'pecia'," 231. See also: Flüeler, "Die

of dictating was repeatedly prohibited in Paris, but the prohibition was poorly observed and ultimately abandoned.[149]

Masters abbreviated texts in order to offer their students, who had just begun their studies, fundamental philosophical notions in concise form.[150] The majority of the anthologies were compiled in the Arts faculty, and these textbooks were essentially intended for students of this faculty.

Secondary customers included brothers in provincial convents, who were less good at understanding the base texts, or else did not have the means to afford original books. This was the case for Albert the Great, who wrote for his friars: «for the use of the brothers and by extension for everyone reading this, and wanting to understand natural science».[151] Some intended their work for young friars as a teaching aid for oral pedagogy and so provided bibliographical references and further questions with which lectors could broaden a lesson.[152] In the case of William of Ockham's exposition of, and study-questions on, Aristotle's Physics (*Expositio librorum Physicorum* and *Questiones in libros Physicorum*) the text has been considered to have been the fruit of classroom lectures delivered in a *studium artium* of the Franciscan Order Ockham had entered.[153]

1.3.2 Genres

It would be an enormous challenge, as the directors of the *Typologie des sources du moyen âge occidental* stated, to categorize all university sources, such as *abbrevationes, compendia, conclusiones, flores, auctoritates, lexica* etc., using well-defined criteria.[154] One consideration is that genres in the Middle Ages were fluid: genres were born one out of the other and remained affiliated; genres evolved,

verschiedenen literarischen Gattungen der Aristoteleskommentare: Zur Terminologie der überschriften und Kolophone," 88. See, for more detailed study about orality and writing in medieval universities: Miethke, "Die mittelalterliche Universitäten und das gesprochene Wort," 1–44.

[149] The prohibition against dictation was abolished in Paris in 1452. CUP IV, no. 2690 (1452), 727: «or they read to be penned down, or not, notwithstanding the old statute, which we have in hands, of not reading to be penned down» – *«sive legant ad pennam sive non, non obstante antique statuto de non legendo ad pennam, super quo dispensamus»*. And, CUP IV, no. 2690 (1452), 733:«In the foresaid statutes of us, which we have in hands, we declare that of no one is demanded to swear not to read (i.e. lecture) for dictation» – «*In predictis statutis nostris dispensamus et declaramus ne ab aliquot exigatur iuramentum de non legendo ad pennam*».

[150] Grabmann, *Methoden und Hilfsmittel des Aristotelesstudiums im Mittelalter*, 56.

[151] Albert the Great, *Physicorum* lib. VIII.I.I.1: *«ad utilitatem fratrum et per consequens omnium in eo legentium et desiderantium adipisci scientiam naturalem»* (A. Borgnet, ed., *Albertus Magnus. Opera omnia* (Paris, 1890–1899)).

[152] See also: Maierù, "Methods of teaching logic during the period of the universities," 14–15.

[153] J.A. Weisheipl, "Ockham and some Mertonians," *Mediaeval studies* 30 (1968): 163–213, here 167.

[154] Hadot, *Les genres littéraires dans les sources théologiques et philosophiques médiévales. Définition, critique et exploitation. Actes du colloque international de Louvain-la-Neuve 25-27 mai 1981*.

ramified, generated offspring; genres were mixed and interdisciplinary.[155] They have progressed only little in their intention to publish volumes on the subject. Here I offer a short overview of these genres, based on the seminal and still useful studies of Martin Grabmann (1939) and Charles Lohr (1967).[156] They divided the study-aids into several sub-genres:

1. Commentaries, whose purpose it was to explain the Aristotelian text. This subgenre originated in the lectures of masters. Some sub-genres of the commentary are:
   (a) *Glossa*
   (b) *Commentum* or *expositio*
   (c) Paraphrase
2. Abbreviated adaptations of a work, for instance the *abbrevationes, summule, compendia*, and *epitomata*, which indicated briefly the contents of individual works.
3. *Questiones*, dealing with disputed points of Aristotelian interpretation, in which a master took a position on the disputed issue.
4. *Conclusiones*, giving the principle Aristotelian theses and argumentation.
5. Treatises or monographs, dealing with special problems.
6. The *lexica*, often named *tabule*, in which Aristotelian entries are given alphabetically.
7. Excerpt and quotation literature, like *flores* or the *auctoritates*, made up of excerpts from Aristotelian works.[157]

The 'compendium' is a collective term. Compilers wrote compendia to summarize material in a comprehensive way and with a certain freedom of arrangement, and he copied the material without adding own work. The objective of a compendium was limited: they met the student's need to acquire his

[155] L. Genicot, "Du genre et de quelques genres," in *Les genres littéraires dans les sources théologiques et philosophiques médiévales. Définition, critique et exploitation. Actes du Colloque international de Louvain-la-Neuve 25-27 mai 1981*, ed. P. Hadot (Louvain-la-Neuve, 1982), 279–286, here 281–282.
[156] Grabmann, *Methoden und Hilfsmittel des Aristotelesstudiums im Mittelalter*; Lohr, "Medieval Latin Aristotle commentaries," here 314.
[157] See also: Hamesse, "Les florilèges philosophiques du XIIIe au XVe siècle," 181; Hamesse, "Les florilèges médiévaux d'Aristote"; Hamesse, *Les auctoritates Aristotelis. Un florilège médiéval. Etude historique et édition critique*.

grades. They gathered definitions, schemes, disputed questions, extracts of *auctores*, comments and theses of the master. Compendia, in short, were manuals and class notes.[158]

The title of the *Parvulus philosophie naturalis*, my main source in chapter 4, shows at once that we are dealing with an abbreviated version of the natural philosophical works of Aristotle, *parvulus* meaning 'very small' or 'very short'. The *Parvulus philosophie naturalis* by Peter of Dresden is an excerpt from de *Philosophia pauperum*, which is in turn an excerpt from several natural philosophical texts by Albert the Great (*Summule Alberti*).

The *Termini naturales* meanwhile, the main source for chapter 4 in my study, is a collection of Aristotelian concepts in physics. The text explains briefly Aristotle's terminology, giving definitions and examples. It is a kind of lexicon, though not alphabetically arranged, and was useful in the study of Physics, helping to distinguish various concepts.

The title of a text is not always a clear indication of its character, especially when descriptions in later manuscripts and early printed books were used to label earlier works. Texts operated under various names that changed over time and sometimes from university to university. The same text could be called a *commentaria, opus, explanatio, glossa, tractatus, summa, interpretatio, lectura* or *lectiones*. The meaning of terms also change in the course of time.[159] Sometimes, moreover, titles are not true to the original and should be mistrusted as anachronistic. [160] For example, the thirteenth-century *Tractatus* of Peter of Spain, the main source for chapter 3, was known as the *Summule logicales* from the sixteenth century onwards. *Summule* is therefore also the name library catalogues used to describe this work, as they relied on the attribution given in printed editions. In manuscripts, the work was exclusively known as *Tractatus*. *Summule* and *Tractatus* do not fall in exactly the same (sub)genre, *Summule* being an abbreviated adaptation of a work while the term *Tractatus*, as mentioned above, indicates independence from the Aristotelian text, and a work of an original character.

Student's notes from lectures are a specific sub-genre of textbook texts, called *reportationes*.[161] Hastily written and freely phrased, one example of the so-called *Copulata super libros De anima Aristotelis cum textu iuxta doctrinam doctoris sancti Thome de Aquino* is now kept in Berlin.[162] This text is one of the sources used for chapter 4. In it, the student Johannes Parsow noted the text

[158] Genicot, "Du genre et de quelques genres," here 284.
[159] Flüeler, "Die verschiedenen literarischen Gattungen der Aristoteleskommentare: Zur Terminologie der überschriften und Kolophone," 88.
[160] ibid., 80, 84.
[161] See on note-taking: C. Burnett, "Give him the white cow: Notes and note-taking in the universities in the twelfth and thirteenth centuries," *History of universities* 14 (1995): 1–30.
[162] Berlin, *Staatsbibliothek*, theol. fol. 247.

down while attending a formal lecture given by Lambertus de Monte (Domini), who taught in Cologne in the second half of the fifteenth century.[163] The *littera* (here *De anima*) was dictated in small portions, written in widely spaced lines and often in thick script. Each small portion is followed by an explanation. The copyist gave the lecturer's glosses on words and phrases in lines above the *littera*, written in a finer script. He added, again in a finer script, the commentary in the margin, adjacent to the relevant parts of the base text. Often reference is made to the relevant part by repeating the first words of the lemma commented on.

To keep up with the words of the lecturer, students practiced a kind of shorthand, standard in university studies. Students might then have made a fair copy of their abbreviated notes after the lecture.[164] Sometimes they compared their versions for completion and had the result corrected by their teacher. *Reportationes* existed at the time in official reports as well as private notes.[165]

Many more (sub)genres must remain undiscussed here: *sententia, scriptum, ratio, expositio, questio, pronunciatio, exercitium, disputata, circulus, conclusio, propositio, puncta, recollectio, copulata, explanatio, translatio, dictata*, to name only the most commonly used descriptions. The quantity of study-aids was enormous.

Jacqueline Hamesse observed that the many anthologies composed to help students to process Aristotelian texts were in the end more a threat than a blessing. The success of these anthologies caused a form of decay, since compilers cut extracts from their original context, and these became isolated and corrupted by all the copying. Eventually, students simply read the extracts.[166]

1.4 FIGURA AND PICTURA

This section will briefly explore the meaning of *figura* and *pictura* for scientific imagery, considering abstract as well as pictorial representations of the medieval period. The bearing of the terms *figura* and *pictura* on medieval scientific dia-

[163] V. Rose, *Die Handschriften der Kurfürstlichen Bibliothek und der Kurfürstlichen Lande*, vol. 2: Die Handschriften-Verzeichnisse der Königlichen Bibliothek zu Berlin, 3 vols., 3 (Berlin, 1901–1905), no. 983, 1249. Rose added, as proof for this hypothesis, the end of the text written by Parsow in order to compare it with the end of the version printed at Cologne in 1494 (Hain 1713).

[164] A. Piltz, *Studium Upsalense. Specimens of the oldest lecture notes taken in the mediaeval university of Uppsala* (Uppsala–Lund, 1977), 29.

[165] J. Hamesse, "Reportatio et transmission de textes," in *The editing of theological and philosophical texts from the Middle Ages. Acts of the conference arranged by the department of classical languages, University of Stockholm, 29-31 August*, ed. M. Asztalos (1984), 11–34, here 15–16.

[166] Hamesse, "Les florilèges philosophiques du XIIIe au XVe siècle," 191.

grams has not yet been explored.[167]

There was no systematic terminology employed for scientific visual representations. Medieval scholars called the same diagram a *figura* or a *pictura* or, more sporadically, an *exemplum*. One would expect a preference for *figura* when it concerned an abstract, non-figurative representation, and *pictura* for a figurative representation. But this was not the case. The so-called *figura solida*, for instance, was a geometric representation of the four elements. Authors denoted the *figura solida* as «*subiecta pictura declarat*», «*subiecta expressi pictura*», and «*subiecta expressi figura*».[168] The description could even change within a single phrase: «*sub scribatur figura [...] ad videndum satis faciat pictura*».[169] The words *diagramma* and *schema* were known in the Middle Ages, but they are not mentioned in the sources used for this study.[170]

The meaning of *figura* fell roughly into two categories: when in combination with *forma* to denote a physical character, or alternatively to denote a didactic character.

Early medieval thinkers took *figura* as an outer manifestation, a contour, a geometrical outline or a plastic representation.[171] In all these descriptions of *figura* is the idea of an exterior (and accidental) figure encasing an inner (essential) form. Some examples. Boethius (480 – 524/525), for instance, saw a figure as a geometrical outline when he wrote that a triangle is a species in the genus *figure*, as white is a species of color.[172] In Papias' *Elementarium doctrine erudimentum* (ca. 1045) one finds: «A figure encloses the way a circle encloses».[173] Hugh

[167] There are studies about the meaning of *figura* in other domains: theology, music, logic and theatre. In medieval music theories a *figura* is a certain system of tones, see: F.A. Gallo, "Figura and Regula. Notation and Theory in the Tradition of Musica mensurabilis," in *Studien zur Tradition in der Musik. Kurt von Fischer zum 60. Geburtstag*, ed. H.H. Eggebrecht and M. Lütolf (Munich, 1973), 43–48. In theatre, *figure* are stage figures, see: G. Ehrstine, "Das figurierte Gedächtnis: Figura, Memoria und die Simultanbühne des deutschen Mittelalters," in *Text und Kultur: Mittelalterliche Literatur 1150-1450*, ed. U. Peters (Stuttgart, 2001), 414–437. In logic a *figura* is a type of syllogism, see: J. Celeyrette, "Figura/figuratum par Jean Buridan et Nicole Oresme," in *Quia inter doctores est magna dissensio. Les débats de philosophie naturelle à Paris au XIVe siècle*, ed. S. Caroti and J. Celeyrette (Florence, 2004), 97–118.

[168] For example: Oxford, *St.-John's College*, 17, fol. 39r; Cambrai, *Bibliothèque municipale*, 937, fol. 45v; Einsiedeln, *Biblioteca Abbatiale*, 167, p. 92.

[169] Paris, *Bibliothèque nationale*, lat. 7361, fol. 51v.

[170] Paris, *Bibliothèque nationale*, lat. 6512, fol. 138v: «*figure istud est scema*». Obrist distinguished a *schema* used to designate a geometric figure from a *diagramma* used for geometric figures to prove a mathematic truth. See: Obrist, *La cosmologie médiévale. Textes et images. I. Les fondements antiques*, 22.

[171] E. Auerbach, "Figura," *Archivum Romanicum* 22 (1938): 436–489, here 437, 440–441.

[172] Boethius, *Porphyrii introductio in Aristotelis Categorias*, II. *De specie* 2: «*Dicitur autem species et ea que est sub assignato genere, secundum quam solemus dicere hominem quidem speciem animalis, cum sit genus animal, album autem coloris speciem, triangulum vero figure speciem*» (A. de Libera and A.-Ph. Segonds, eds., *Porphyre. Isagoge. Texte grec et latin* (Paris, 1998)).

[173] Papias, *Elementarium*: «*Figura est que sub aliquo fine ut circulus vel aliquibus continetur*» (quo-

of Saint-Victor (1096–1141), philosopher, theologian and appointed canon at the Victorine monastery, wrote that visible forms have both *figure* and *colores*. *Figura* then, designated the exterior aspect of realities, their contour and their form, as these appeared to the eye.[174] Hugh described hereby both actual drawings and mental representations. The French scholar Pierre Bersuire (ca. 1290–1362) defined figures in his *Repertorium vulgo dictionnarium morale*: «figura is taken as the outer picture or [outer] form. . . .».[175]

In theology, the relationship between biblical events, for example between the Old and the New Testaments, is also called a *figura* (a pre-figuration of the latter by the former). In the above-mentioned *Repertorium* of Bersuire, one finds such a symbolic meaning given to *figura*:

> «Note, that 'figura' is taken for the external image or form. Therefore, that which is called *figura* in the science [theology], are the inner mysteries beneath its external, historical and verbal manifestation».[176]

Figura is, as such, the visual manifestation of an object or a mystery. Figures are taken to be impressions, like ideas, prints, shadows and images. In the *Repertorium*, which is a large repertoire of religious and moral matters, one might expect such a theological definition. It facilitated research into the different biblical meanings of a certain word.

Another aspect of '*figura*' is exposed when '*per figuram*' means '*per exemplum*. Lambertus de Monte (1430/5–1499) explained that '*figuraliter* means 'generally'.[177] And Gerard of Harderwijk (d. 1503) explained regarding a (mental)

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tation in: Díaz de Bustamante, J.M., "Imago, figura, idea: evolucíon del concepto de mundo y universo hasta el Renacimiento," in *A Imagem do Mundo na Idade Média: Actas do Colóquio Internacional*, ed. H. Godinho, A.P. Morais, and J.A. Frazão (Lisbon, 1992), 113–122, here 121). See also the reprint (Turin 1976), the first edition (Milan 1476) or the manuscript Paris, *Bibliothèque nationale*, lat. 7609.

174 Hugh of Saint-Victor, *Eruditionis Didascalice*, Liber 7, chap. 26 *De tribus invisibilibus Dei*: «*Species est forma visibilis, que oculo discernitur, sicut colores, et figuras corporum*» (J.-P. Migne, *Patrologia Latina* (Paris, 1844–1855), 176, 812D); Hugh of Saint-Victor, *De specie figurisque rerum*, chap. IX: «*Species est forma visibilis, que continet duo, figuras et colores. Figure autem rerum multis modis apparent mirabiles*» (ibid., 176, 819B). See: P. Sicard, *Diagrammes médiévaux et exègese visuelle. Le 'Libellus de Formatione Archae' de Hugues de Saint-Victor*, Paris-Turnhout (1993), 162. Patrice Sicard erroneously referred to *De tribus diebus* of the same author.

175 Pierre Bersuire, *Repertorium vulgo dictionnarium morale. Pars II*: «*Nota, quod figura accipitur pro exteriori imagine seu forma*» (Hieronymus Scotus, Venice 1583). Pierre Bersuire studied, in the 1340's, at the University of Paris. He composed his *Repertorium* by 1355. The work enjoyed long-lasting success. See: É. Hitier, "Bersuire, Pierre," in *Dictionnaire de biographie française*, ed. M. Prévost and R. d'Amat (Paris, 1954), 169–70.

176 Pierre Bersuire, *Repertorium vulgo dictionnarium morale. Pars II*: «*Nota, quod figura accipitur pro exteriori imagine seu forma. Et inde est, quod in scientialibus illud figura dicitur, ubi sub exteriori apparentia historie vel litere interiora mysteria continentur*» (Hieronymus Scotus, Venice 1583).

177 Lambertus de Monte, *Copulata super libros De anima Aristotelis Anima*, 2, fol. 21 RA 12: «*figuraliter, id est communiter*».

representation that it is a figurative representation, since it is exemplary and outwardly.[178] Here, *'figuraliter'* refers to a written description that was 'in general', 'in brief' or 'illustrative' in character.

Pictura is, if it's possible, an even more complicated concept. Bersuire does not give a definition of *pictura*, as 'there are hardly authorities' - «*quasi nulle sunt auctoritates*».[179] There are, nonetheless, many opinions about the meaning of *pictura*. Roughly speaking a *pictura* is a representation (of God or the world) or a painting. Some aspects of *pictura*-as-representation are of interest to us here.

In one sense, *pictura* was related to 'picturing': something used to give a description. For instance, «zoography was the description of animal natures, or a picture of animals».[180] Phrases like «so that we discern by pictures» - «*ut ex picture discceremus*» indicate their perceived pedagogical value.[181] Indeed, quite often *pictura* was complementary to writing: «Comprehend then, by means of this picture, the part of logic that the subject of the *diffinitiones* learns to describe and to paint».[182]

Related to its pedagogical meaning was the mnemonic value of *pictura*. The above-mentioned Papias declared that a picture is an image expressing the species of something that, when observed, leads the mind to remembrance.[183]

Hugh of Saint-Victor clarified the interchangeability of *figura* and *pictura*. He made elaborate use of diagrams, explaining that every *pictura* is a *figura*, but not every *figura* is a *pictura*. *Figure* can be written (meaning: the letters of the alphabet) or drawn *figure*: pictures. Both can be seen and in both can a meaning be discerned.[184] The *verbum intrinsecum* is expressed by a *figura*, which could be either a spoken or written word (*verbum extrinsecum*). A picture is, according to Hugh of Saint-Victor, superior even to a word, because words refer to *res* by

[178] Gerard of Harderwijk, *Categ.* 2, 4 p. 131 A 13: «*istud autem patet figuraliter, id est exemplariter sive superficialiter hoc modo*».
[179] Pierre Bersuire, *Repertorium, vulgo dictionnarium morale. Pars III* (Hieronymus Scotus, Venice 1583).
[180] Remigius (Autissiodorensis monachus), *Musica sive Commentum in Martianum Capellam*, II 5, 15, p. 174, 31: «*hinc zoographia dicitur descriptio de naturis animalium, sive ipsorum animalium pictura*».
[181] Gregorius, M., *Epistole*, 11, 10.
[182] Commentarius in Martianum Capellam, *De nuptiis Philologie et Mercurii*, e codice Berolinensi, I, p. 226, 12: «*Intelligas ergo per picturam illam partem logice que diffinitionibus rem docet exponere et depingere*».
[183] Papias, *Elementarium*. Paris, *Bibliothèque nationale*, lat. 7609, f. 173a : «*pictura est imago exprimens species alicuius rei, que dum visa fuerit, ad recordationem mentem reducit*». The reprint of Papias (Turin 1976) of the edition made in Venice in 1496 has a lacuna between the entries *pecuosus* and *placitum*, therefore the Paris manuscript is used. The first printed edition was set in Milan in 1476.
[184] Sicard, *Diagrammes médiévaux et exègese visuelle. Le 'Libellus de Formatione Archae' de Hugues de Saint-Victor*, 162–163.

means of a convention, while pictures represent the *res* itself in a figurative way, and are thus more immediate and enjoy greater similitude.[185]

The verbal association of both *figura* and *pictura* with *'representare'*, *'depingere'*, *'ostendere'* and *'sub oculos ponere'* all indicate that figures are to express, to show, to visualize: in short, to externalize something. That 'something' is very often described in writing (in the accompanying text), and only sometimes formulated in thoughts. In some rare cases, mostly in anatomy, the 'something' might be seen live. Guido of Vigevano (d. 1349), for example, asserted that he demonstrated the anatomy of the human body openly and clearly by rightly painted figures.[186]

A second association, with words like *patere* and *declarare* indicate that the figure was intended to clarify, exemplify or illustrate a discourse. The diagram is, in that sense, dependant on the accompanying text. It reads for example in master Albert's *Termini naturales* «as shows in the following figure» – «*ut patet in sequenti figura*».[187] Isidore of Seville denoted the so-called *figura solida* as «subiecta pictura declarat» – «the figure below makes clear».[188]

The border between a visual and a mental image was not a clear one.

> «I say that the imagination is good», Nicole Oresme (c. 1323 - 1382) wrote. «This is evident in Aristotle, who imagined time by means of a line. Similarly [...] it is [...] imagined that active force is to be thought of by means of triangular surfaces. Again, that is why imagination makes me more easily understand what is said».[189]

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With these words, Oresme, considered one of the most important physicists of the fourteenth century, defended the use of mental imaging in science. Or did he defend the use visual *imagery* in science, as Marshall Clagett suggested?[190] In fact, both interpretations are possible. One can have mental and material images

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[185] Sicard, *Diagrammes médiévaux et exègese visuelle. Le 'Libellus de Formatione Archae' de Hugues de Saint-Victor*, 161.

[186] Guido of Vigevano, *Anatomia*, prologue: «*demonstrabo anothomiam corporis humani patenter et aperte per figuras depinctas recte*» (E. Wickersheimer, ed., *Anatomies de Mondino dei Luzzi et de Guido de Vigevano* (Geneva, 1977)).

[187] Paris, *Bibliothèque nationale*, nal. 566, f. 55v (15c).

[188] Oxford, *St.-John's College*, 17, fol. 39r.

[189] Nicole Oresme, *Questiones super geometriam Euclidis*, q.10, 85–91: «*Dico quod ymaginatio est bona, et hoc patet per Aristotelem qui ymaginatur tempus per modum linee. Similiter [...] ymaginatur quod virtus activa ymaginanda est ad modum superficierum triangularum. Iterum, secundum istam ymaginationem possum facilius intelligere ista que dicuntur [...]*» (M. Clagett, ed., *Nicole Oresme and the medieval geometry of qualities and motions: A treatise on the uniformity and difformity of intensities known as Tractatus de configurationibus qualitatum at motuum* (Madison (Wisc.)-London, 1968), appendix.)

[190] ibid., 50.

of the same object, as testified by the many visual representations illustrating manuscript copies of Oresme's text.

Mental and the material figures were nonetheless not always equally appreciated. For the usual Platonist reasons, Thierry of Chartres (d. 1150) considered a thought circle to be a true circle, but not a drawn circle. A drawn circle was understood as an image and an image of a thing could not be close to the true thing, for matter was held to corrupt everything in which it featured.[191]

Some examples: Papias confirmed that «a picture is said to be like a structure; it is after all a constructed image, not the truth».[192] And Guibert of Nogent (d. 1124) wrote: «a picture is a sign, not the truth».[193]

The immediate function of a visual representation was to visualize a discourse and to render it accessible. Figures made accounts more easily understandable. Oresme explains: «following this imagination I can more easily understand what is said about uniformly difform qualities».[194]

Marsilius of Inghen noted that the principles of pure mathematics are based on figuration of term (*figuratio*), and not on observation.[195] So pure mathematics is rendered comprehensible by creating mentally reproduceable, visual solutions. The concept *terminorum* means 'mathematically', though in a calculative form without the use of numbers and hence closer to geometry.[196]

Hugh of Saint-Victor wrote, in his book about the Noah's Ark, that, «it is painted in visible form, so that, when you have seen the whole picture, you can understand more easily what is said about the parts».[197]

Adalbold of Utrecht (d. 1026) is also quite clear about his intentions, when referring to the Tree of Porphyry: « a figure be added for those for whom our

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[191] M. Lemoine, "Théologie et philosophie de l'image," in *L'image dans la pensée et l'art au Moyen Âge. Colloque organisé à l'Institut de France le vendredi 2 décembre 2005*, ed. M. Lemoine (Turnhout, 2006), 27–40, here 30.

[192] Papias, *Elementarium*: «*pictura autem dicta quasi factura, est enim imago facta, non veritas*» Paris, *Bibliothèque nationale*, lat. 7609, fol. 173va.

[193] Guibert of Nogent, *Moralia in genesin*, II 3, 24 col. 78a: «*pictura vero signum est, non veritas*».

[194] Nicole Oresme, *Questiones super geometriam Euclidis*, q.10, 85–91: «*[…] secundum istam ymaginationem possum facilius intelligere ista que dicuntur de qualitatibus uniformiter difformibus etc*» (Clagett, *Nicole Oresme and the medieval geometry of qualities and motions: A treatise on the uniformity and difformity of intensities known as Tractatus de configurationibus qualitatum at motuum*, appendix).

[195] Marsilius of Inghen, *Abbrevationes Physicorum*, fol. 7ra 36: «*principia pura mathematica sunt nota ex figuratione terminorum, et non per experientiam*».

[196] See, for a more detailed treatment of the concept *termini*, chapter 3.

[197] Hugh of Saint-Victor, *De archa Noe*, I, iii, 40–44: «*in forma visibili depinxi, ut, cum totum videris, que deinde de parte dicuntur, facilius intelligere possis*» (P. Sicard, ed., *Hugonis de sancto Victore opera*, vol. 161, Corpus christianorum. Continuatio mediaevalis (Turnhout, 1994)). See also: Sicard, *Diagrammes médiévaux et exègese visuelle. Le 'Libellus de Formatione Archae' de Hugues de Saint-Victor*, 155.

words are not sufficient for understanding, seeing a picture will be satisfying».[198]

In short, the meanings of *figura* and *pictura* cannot clearly be distinguished. In short, *figura* and *pictura* were both thought of as geometrical outlines: general, short and illustrative; they clarified and exemplified. They expressed and visualized that which was no longer there or had never been present before the eyes.

Modern scholars are no better than medieval ones when it comes to terminology. They use the concepts diagram, picture, figure, representation, image and graph for the same thing, whether a modern visual representation or a medieval one.[199] Instead of focusing on the terminology used, it is again more fertile to look at the varied functions modern scholars have ascribed to medieval scientific visual representations, since this illustrates more clearly the main scholarly controversies about these sources.

There are two broad schools. One group of scholars considers diagrams to be models, like trees, circles, squares, dichotomies, in which a selective number of properties of a reality or theory were displayed. The other faction presents the structure of a diagram as logically coherent, with meaningful graphic components, stating that the edges (joint lines) of the figure refer to the physical world, other diagrams or thought-processes. My hypothesis is that the same figure cannot be both - for how can a diagram be a general model and *at the same time* possess a unique morphological structure coherent with a specific reality?

When it comes to the morphology of diagrams, scholarship may be divided into two loose camps. The first of these includes scholars such as Murdoch, Franklin, North and Carruthers, who all base their opinions on a vast repertoire of medieval diagrams, and understand these diagrams as models.

According to North, abstraction into models is done for the purpose of reasoning. Diagrams therefore display a selected number of properties belonging to a given reality or theory and so help to prove a point and explain its conditions of validity. Some forms are more simplistic. Tabulation eases the task of setting out correspondences and aids learning by rote. The tree-structure of the particular diagram in play in this chapter bespeaks greater scientific sophistication than a table because of its representation of logical subordination and succession. Sometimes, models were made by means of visual conventions, like perspective, cross section or scale models, and for North this creativity is another sign of sophistication.[200]

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[198] Adalbold of Utrecht, *Commentary on Boethius*: «*subscribatur figura, ut quibus ad intellectum nostra non sufficit lingua, […] ad videndum satisfaciat pictura*» (Paris, *Bibliothèque nationale*, lat. 7361, fol. 51v.)

[199] See about the problems of typological names: Lüthy and Smets, "Words, Lines, Diagrams, Images: Towards a History of Scientific Imagery," esp. 420-424

[200] North, "Diagram and thought in medieval science."

Morphologically identical structures are the basis for Murdoch's classification of mostly early medieval scientific diagrams. He discriminated between standard types of figures, such as tables, dichotomies and trees, *rote* and circular diagrams, and squares of opposition. Murdoch implies that some figures belong to the same group because they display the same morphology.[201]

Carruthers considers diagrams as models for memory. In her view a medieval student would have been trained in an extensive repertoire of (mental) figures in order to store and recollect all the learned fragments of text. She took her examples of (mental) imagery from meditative readings upon which foundation readers of the era - mostly preachers - could build, add and modify. Morphologically identical structures permitted the combination of structurally identical data and thus the creation of new ideas and new arrangements. Although working on (mental) imagery essentially in the spiritual realm, Carruthers suggests that 'images', whether mentally or physically pictured, shared many features with the teaching diagrams so abundantly produced during the Middle Ages.[202]

Some diagrams demand bodily movements, so as to provoke a physical and spiritual track. This aspect had a regulating effect on memory training. By participating in and marking the visual space the reader was wandering in, he would inculcate the subject matter in his memory.[203]

In a second camp we find scholars like Givens and Evans, who understand the structure of a diagram as meaningful and rational. Givens asserts that the structure of a diagram visually communicates information about the external - and sometimes internal - physical structure of a particular object or phenomenon in the real world. She based this view on diagrams concerning nature and the natural order. The figures in her study therefore function as inferences concerning the physical world.[204]

Evans rationalizes the form of diagrams by relating the components of a diagram to specific modes of thinking. For Evans, graphical illustrations demonstrate logical thought-processes. For example, the value of a circle as a vehicle for expressing concepts is defined by Evans as a concentric stratification that expresses hierarchy and continuum. It demonstrates the philosophical procedure of *interrogatio*, because the information supplied by the diagram varied according to which way the wheel was turned. The tree, on the other hand, embodies the analytic ramification of a division, corresponding to the scholastic procedure of *distinctio*. The tower and the ladder in turn embody improvement and

201 Murdoch, *Album of science: Antiquity and the Middle Ages*, 29–61.
202 M. Carruthers, *The book of memory. A study of memory in medieval culture* (Cambridge, 1990), here chapter 1 *Models for the Memory*, 30, 148, 250.
203 J.-C. Schmitt, "Les images classificatrices," *Bibliothèque de l'Ecole des Chartes. Revue d'Erudition* 147 (1989): 311–341, here 339.
204 Givens, *Observation and image-making in gothic art*, 102.

progress.[205]

Consequently, the impression given by the existing secondary literature is contradictory: how can a diagram be both a model and at, the same time, be in the possession of a unique morphological and rational structure? The problem is important, since the rationality and logical coherence of the diagram are at stake here.[206]

1.5 Conclusion: Handbooks of explanatory character

This chapter described in greater detail the sources used for this book. The sources are selected for their scientific character, which is for this book established on their participation in the universities curricula. In a first part, therefore, the base texts of the selected case studies are highlighted within the context of the entry of the new Aristotelian corpus and its systematic study in the Arts Faculty.

In a second part is studied in what kind of texts diagrams are to be found. John Murdoch observed that 'the illustrations are notoriously few in the manuscript copies of Aristotle and Galen and of their medieval translations and seemingly endless commentaries'.[207] Instead, Murdoch claimed, that 'the bearers of most of the visual representations of theory were [...] encyclopedic and handbook works'.[208] Indeed, most diagrams are found in handbooks for Arts teachings (I did not look at encyclopaedia because these were not studied in the Arts faculty).

The observations made on the basis of my research further sharpens the observation that diagrams appeared in handbooks. Many diagrams from the thirteenth to the fifteenth century are drawn in adaptations, abbreviations, compendia and *expositiones*. Other medieval university genres, however, were considered less apt for illustration. Medieval students barely encountered figures in *florilegia*, *questiones, conclusiones* and *auctoritates*.

The reason for this distinction was probably intrinsic to the character of both categories. *Florilegia*, *conclusiones* and *auctoritates* remained very close to the base text, excerpting and quoting it. The *questio* probably developed as a literary form for the advanced in which all the arguments were written by one author.[209] They would stick closely to the original wording of the arguments

[205] Evans, "The geometry of the mind," 32–55.
[206] I will deal with this problem throughout my study, but in particular in chapter 2, page 30.
[207] Murdoch, *Album of science: Antiquity and the Middle Ages*, x.
[208] ibid., 277.
[209] Marenbon, *Later medieval philosophy (1150-1350)*, 12–13, 19.

made by several authorities. On the other hand, commentaries, compendia, abbreviations and adaptations expounded concisely on the main points. Theses handbooks form therefore the lion's share of the sources underlying my research.

The last section dealt with nomenclature. The medieval authors mentioned above stressed strikingly different aspects when dealing with scientific imagery, as compared to contemporary scholars. The medieval authors accentuated on the one hand the form of the *figura*, by characterizing it as an externalization, whether geometric or metaphysical and, on the other hand, they stressed its function by characterizing it as a medium for clarifying, exemplifying and illustrating the subject matter.

Although medieval scholars did not describe figures as models or as rational designs in the way contemporary scholars do, they do seem to be preoccupied with the problem of the reliability of a representation. Medieval thinkers considered externalized forms of thought less reliable than thought, since its relationship with reality was held to be looser than that of a thought. Nevertheless, externalizing an idea with an image was thought closer to reality than externalizing the idea in words.

Strikingly, I found no medieval statements about the function of scientific imagery that were expressed in terms of storage and recollection. Some figures, however, give proof of having been mnemonic aids, as I will show notably in *Chapter 2, Form, content and the Tree of Porphyry*, page 35. Nor did I find statements about figures being manipulable and dynamic, through which the reader could be given the responsibility for creating the specific meaning of the figure.

The main conclusion of this part is that the terminology remains too ill defined to allow a proper accounting. Possibly, the statue of scientific images is left vague because they are regarded with little interest and considered subsidiary to the theory. It is important to realize that scientific images are nonetheless an integral part of scientific practice, even if the awareness of its impact has disappeared.[210]

[210] Cf. Lüthy and Smets, "Words, Lines, Diagrams, Images: Towards a History of Scientific Imagery," 438: 'visual structures can be seen to have constituted the unquestioned starting point of scientific theory formation and practice'.

Chapter 2

Form, content and the Tree of Porphyry

2.1 Introduction

This book began with a miniature of Lady Dialectic instructing two students by means of a tree-diagram. [*See* figure 1.] The teacher casually extended her foot beyond the framework of the initial letter 'C' as though she, being a personification, belonged not to the physical world of the students but to an imaginary realm. Indeed, the youngsters do not seem to notice her and pursue a lively discussion among themselves. The tree is real and tactile - they can point their finger at it – but, it also burst out of the space of the initial, existing outside the text in a space beyond the two students, like a mental structure. It is thus at once a vegetative and physical tree and also an abstract framework to organize information.

Trees, wheels, columnar tables and the human figure are all structures that can be visually compartmentalized, utilizing such natural divisions as branches and leaves, spokes and rings, torso and limbs. These compartments become enclosed areas for the accommodation of verbal material to be learned and remembered. Such diagrams serve to illustrate the conceptual relationships between the various components, and the relations between each part and the whole.[211]

For centuries now, differentiated information has been organized and depicted in tree diagrams.[212] The simplicity and ubiquity of this dichotomous

[211] M. Carruthers and J.M. Ziolkowski, *The medieval craft of memory. An anthology of texts and pictures* (Cambridge, 2002), 215.

[212] The tree-structure was highly favoured in the early-modern times to describe the epistemology of different disciplines. See for the use of tree figures in the early modern period: S. Siegel, "Wissen, das auf Bäumen wächst. Das Baumdiagramm als epistemologisches Dingsymbol im 16.

form seems self-evident. Its shaping as a tree, guides the reader from a general concept through a series of successively more specific concepts. Its structure indicates the relationships between the concepts and their position in the overall hierarchy. Because of its self-explanatory appearance the symbiosis of theory and image is therefore often taken for granted, or the tree diagram is understood as the product of a necessary mental operation.

COHERENCE

In this chapter, however, the assumed symbiosis between the structure of the diagram and the text is questioned, using the case of the historical Tree of Porphyry, mainly in the context of Paris from about the middle of the thirteenth century to the fourteenth century.

The presence of visual elements in scientific texts is primarily understood in terms of their relationship to the associated text. A text and its visual illustrations generally run parallel to one another, constituting alternative renditions of the same content, and an unproblematic identity between text and figure is often assumed as a result. Not so; text and image have always had an ambiguous relation - sometimes complementary and sometimes competitive.

A historical deconstruction of an important diagram will help to clarify why certain choices concerning its structure were made and show that a diagram, like a text, is a historically specific composite of several sources. By breaking the figure down through the several stages by which it emerged, its varied components can be related to different texts. This will hopefully help to answer the question of how knowledge is abstracted and organized in a visual system.

This chapter then discusses the structure of a tree-diagram in relation to its text. Tree-diagrams provided a summary of elementary logic, showing students how to proceed from one concept to another through a series of intermediary stages. The organic progress from trunk to branches and then to buds served to systematize logical concepts, illustrating logical subordination and succession, hierarchy and coherence, and showing the whole as well as its individual parts. The ramifying branches unite in the trunk, their origin, and thereby realize an organic connection between each derived part.

The choice of the Tree of Porphyry diagram is based on its fame, and on the field in which it operated. The Tree of Porphyry was the plain, traditional diagram that accompanied medieval logic, and since logic was such a central

Jahrhundert," *Frühneuzeit-Info* 15 (2004): 42–55. See also: J.J. Berns, "Baumsprache und Sprachbaum. Baumikonographie als topologischer Komplex zwischen 13. und 17. Jahrhundert," in *Genealogie als Denkform im Mittelalter und Früher Neuzeit*, ed. K. Heck and B. Jahn (Tübingen, 2000), 155–176.

discipline during the Middle Ages, it and one of its diagrams require a central place in this book. Every scholar in the whole of medieval Europe knew this figure and the corresponding theory by heart and as such the case of the Tree of Porphyry permits a broad discussion of manuscripts dating from the ninth to the fifteenth centuries. As a part of the old logic, it was studied long before the New Aristotle arrived in the Latin west and its study continued after the introduction of the *logica modernorum* in the thirteenth century.

The Tree of Porphyry is a particularly interesting case regarding the logical coherence of diagrams, since its tree-structure was not conceived at the same moment as the overall diagram. The period examined corresponds to the introduction of Peter of Spain's *Tractatus*, the manual of logic used in the university milieu around the middle of the thirteenth century. The choice of the *Tractatus* limits this close study to the Parisian tradition of logic, although the diagram known as the Tree of Porphyry was widely used across the continent of Europe.

As a semiotician, Umberto Eco provides valuable observations on the Tree of Porphyry.[213] He studied the ancient and medieval theory of genera, species and differences and effected numerous visual reconstructions. Most of these reconstructions, however, are not historical. By contrast, Ian Hacking and Michael Evans present the historical Tree of Porphyry.[214] Hacking dealt with the figure from the perspective of a logician, analyzing its structural coherence using logic theory.[215] Although Hacking is not a medievalist working on manuscripts, the majority of his examples, conceived a priori as a logician, coincide accurately with historical examples. Evans, an art historian already mentioned above, studied the motif of the dichotomy in the Tree of Porphyry.[216] He based his opinion on a single manuscript example, which prevented him from considering the diagram in dynamic, historical terms.[217]

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[213] U. Eco, *Semiotics and the philosophy of language* (Bloomington, 1984).

[214] I. Hacking, "Trees of logic, Trees of Porphyry," in *Advancements of learning. Essays in honour of Paolo Rossi*, ed. J.L. Heilbron (Florence, 2007), 221–263. I thank Ian Hacking and Marc Kirsch for their kindness in providing me with a copy of this article before its publication. I also thank Ian Hacking for his encouragement and his invitation to lecture about the Tree of Porphyry at the *Collège de France* when this chapter was at a preliminary stage.

[215] Jaap Mansfeld likewise reconstructed many ancient logical doctrines, which permit easy logical comparison to the Tree of Porphyry. See: J. Mansfeld, *Heresiography in context. Hippolytus' elenchus as a source for Greek philosophy* (Leiden–New York–Cologne, 1992).

[216] Evans, "The geometry of the mind." See also above, page xx, and page 31.

[217] Besides Evans, some other art historians have dealt with tree figures in general or with one in particular, mainly studying those in the domain of law or morality, and have made some useful observations. See, by way of selected bibliography: C. Klapisch-Zuber, *L'ombre des ancêtres. Essai sur l'imaginaire médiéval de la parenté* (Paris, 2000); K.-A. Wirth, "Von Mittelalterlichen Bildern und Lehrfiguren im Dienste der Schule und des Unterrichts," in *Studien zum städischen Bildungswesen des späten Mittelalters und der frühen Neuzeit*, ed. H. Patze, K. Stackmann, and B. Moeller (Göttingen, 1983), 256–370; G.B. Ladner, "Medieval and modern understanding of

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My approach to the problem is innovative in that it consists of a careful examination of the same historical diagram consulted in a large set of medieval manuscripts. The above mentioned authors all base their opinions on a single (manuscript) copy. As a result they overlook the diversity, multiplicity and development of a given diagram.

The next section of this chapter, *2.2: Logic and the art of reasoning*, page 40, deals with the objective of medieval logic and the subject-matter of the Tree of Porphyry, in order to provide the background against which we should understand the *Tractatus*, its sources, and its tree-diagram.

Next, I pose the question of where the tree-figure that eventually became the Tree of Porphyry came from, and how its design has developed. The most systematic way to establish the sources of the figure is by tracing its associated verbal (textual) tradition of commentary through time. Logic commentaries have been well studied and are accessible in modern editions, and repertories of *incipits* (i.e. the beginning words of a text - often the only way of identifying a medieval text). In the case of the Tree of Porphyry it worked well to collect a corpus of figures by following that figure's associated tradition of commentary. During this long tradition of commentary the diagram was added to and adapted. The pictorial sources and references of Ammonius, Boethius, Jepa, John of Damascene, Avicenna and Peter of Spain will be examined and dealt with in *2.3: Form and inference*, page 44.

In a fourth section the morphology of the Tree of Porphyry will be compared with the textual description. How, this section asks, is textual knowledge abstracted and organized into a comprehensive visual system? The relationship between theory and the tree-diagram will also come into play in this section labelled *2.4: Collation of the Tree of Porphyry*, page 57, and special attention will be paid to the play of complexity, morphology and coherence.

A last theme of this chapter addresses the question of the utility of the tree-metaphor for a logic diagram. The literal context of the accompanying text is abandoned here and the Tree of Porphyry is situated among the multitude of tree-diagrams drawn in the thirteenth century. This topic will be dealt with in *2.5: Meaning and relevance of the tree*, page 78.

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symbolism: a comparison," *Speculum* 54 (1979): 223–256; M. Lurker, *Der Baum in Glauben und Kunst* (Baden–Baden, 1976); U. Kamber, *Arbor amoris. Der Minnebaum. Ein Pseudo-Bonaventura-Traktat* (Berlin, 1964); A. Katzenellenbogen, *Allegories of the virtues and vices in mediaeval art* (London, 1939); A. Watson, *The early iconography of the tree of Jesse* (Oxford, 1934); F. Saxl, "Aller Tugenden und Laster Abbildung. Eine spätmittelalterliche Allegoriensammlung, ihre Quellen und ihre Beziehungen zu Werken des frühen Bilddrucks," in *Festschrift für Julius Schlosser zum 60. Geburtstag*, ed. A. Weixlgärtner and L. Planiscig (Zürich–Leipzig–Vienna, 1927), 104–121.

SOURCES

The Parisian tradition of logic is represented by Peter of Spain's *Tractatus*.[218] This *Tractatus* was widely used among Paris students from the thirteenth century onward and later in medieval universities throughout the continent.[219] It functioned as an introduction to logic. Virtually every copy featured a tree-diagram, arranging and representing logical concepts. In England however this treatise did not establish a solid footing. The Oxford tradition of logic is to be found instead in the compendium *Cum sit nostra*.[220] The treatise mentioned above, featuring the miniature of Lady Dialectic and her tree-diagram, stands in the Oxford tradition. It is a sophisticated, inversed and elaborate adaptation of the logic tree.

The popularity of the *Tractatus* is testified to by the many copies handed down to us. More than 400 manuscript copies have survived (and 166 printed editions).[221] These copies are spread all over Europe and are kept in university libraries and monasteries. The largest part of these copies date from the fourteenth century (ca. 40%). A small part date from the thirteenth century, after 1230 (ca. 15%), most of which were written after the introduction of the treatise to Paris after 1260. In almost every copy a Tree of Porphyry is shown (ca. 78%) as well as a second figure called the 'Logic square of opposition' (ca. 42%). Here I concentrate on the manuscripts made during Peter of Spain's life up to the fourteenth century, in order to limit the enormous amount of manuscript sources available. By adding extant copies of Boethius' translation of the *Isa-*

[218] See for the Parisian tradition of logic: L.M. de Rijk, "On the genuine text," *Vivarium* 8 (1970): 10–55, here 24–34; De Rijk, *Peter of Spain (Petrus Hispanus Portugalensis). Tractatus called afterwards Summule logicales*, lxx.

[219] The *Tractatus* was very popular in the Italian cities, especially in Dominican *studia*. The provincial chapter of the Dominicans decided in 1340 at Pisa that the *Tractatus* was to be taught in every monastery of the order. See: T. Kaeppeli, "Acta capitulorum provincialium Provinciae Romanae (1234-1344)," in *Monumenta ordinis fratrum praedicatorum historica*, vol. 20 (1941), 319. See also: De Rijk, *Peter of Spain (Petrus Hispanus Portugalensis). Tractatus called afterwards Summule logicales*, xvi.

[220] See for the Oxford tradition of the «Cum sit nostra»: L.M. de Rijk, *Logica modernorum: A contribution to the history of early terminist logic. 2/1. The origin and development of the theory of supposition* (Assen, 1967), 416–448. The Oxford tradition probably developed on basis of the Parisian school of the *Parvipontani*, the portrait of whose founder is shown in one of the following diagrams. See page 67. The divergences between the two traditions are however not so great as to make them entirely independent. See: A. de Libera, "The Oxford and Paris traditions in logic," in *The Cambridge history of later medieval philosophy from the rediscovery of Aristotle to the disintegration of Scholasticism 1100-1600*, ed. N. Kretzmann, A. Kenny, and J. Pinborg (Cambridge, 1982), 174–187, here 175.

[221] De Rijk, *Peter of Spain (Petrus Hispanus Portugalensis). Tractatus called afterwards Summule logicales*, c; J.P. Mullally, *The Summulae Logicales de Peter of Spain* (Notre Dame, 1945), 133–158. Weijers speaks about ca 400 manuscripts of the *Tractatus*, of which about 300 are commentaries, fragments and translations. Weijers, *Le travail intellectuel à la Faculté des arts de Paris: textes et maîtres (ca. 1200-1500)*, here vol. 7, 181.

goge to extant copies of the *Tractatus* one already counts about 600 manuscript copies. Including all the Trees of Porphyry in all the commentaries on the *Isagoge* and on the *Tractatus* would boost this figure to an extraordinarily large number.

For this part of my research about 90 copies were consulted, dating from the ninth to the fifteenth centuries, the majority of them figuring among the Latin translations of the *Isagoge* by Boethius or among the manuscript copies of the *Tractatus* by Peter of Spain. It was necessary to study an enormous amount of manuscripts over a range of many centuries in order to be able to obtain an overview of the whole pictorial tradition, which changed gradually but decisively.

The sources of this chapter have their origin in different places. As a specific Parisian style of the Tree of Porphyry proved non-existent, manuscript copies all over the continent were used. In Central Europe the treatise was commonly used from the 1350's onwards.[222] See Appendix C.1, page 265 for a survey of the consulted manuscripts.

2.2 Logic and the art of reasoning

The common way to divide up medieval logic into an old logic, a new logic and a modern logic, has roots in the medieval period itself. The 'old logic' (*logica vetus* in Latin) consisted of a corpus of books known to the early Middle Ages, between c. 780 and c. 1000: the *Categorie* and *De interpretatione* of Aristotle translated by Boethius, the *Isagoge* of Porphyry, also translated by Boethius, and Boethius' monographs *(Introductio ad syllogismus categoricos; De syllogismo categorico; De syllogismo hypothetico; De divisione; De differentiis topicis)*. By 1159 the entire new logic was in place, consisting of the rest of the recovered and translated *Organon* of Aristotle.[223] This collection of his six works on logic was commonly designated as the *logica nova*: *Topica*, *Analytica priora*, *Analytica posteriora* and *De sophisticis elenchis*.[224]

The set of books of the old and the new logic formed the point of departure for logical inquiry, in original work beginning in the thirteenth century. The *logica modernorum* is the title for this logic invented by medieval thinkers. Among these works are: *Tractatus (Summule logicales), Sophismata,*

[222] De Rijk, *Peter of Spain (Petrus Hispanus Portugalensis). Tractatus called afterwards Summule logicales*, xcviii-xcix. See also: Rashdall, Powicke, and Emden, *The universities of Europe in the Middle Ages*, 440–448; H. de Ridder-Symoens, "Universities in the Middle Ages," in *A history of the university in Europe*, ed. W. Rüegg, vol. 1 (Cambridge, 1992), 424.
[223] Ashworth, "Language and logic," here 75.
[224] Dod, "Aristoteles Latinus," here 74–79.

Distinctiones, Syncategoremata, Tractatus de proprietatibus terminorum, Insolubilia etc.[225] Hence, what had previously been considered the 'new' logic at the time of its translation, was from the thirteenth century considered, along with the rest of Aristotelian logic, to be 'old' compared to its 'modern' successor.[226]

Peter of Spain started his *Tractatus* with the words «Dialectic is the art possessing the way to the principles of all the curriculum's subjects».[227] Logic is the art of reasoning. And as reasoning is conducted through language, the study of logic must begin with an examination of terms and their functions. Logic leads us from one truth to another and language is shaped to state these truths. This process leads inevitably to tensions and scepticism regarding the human ability to convey truth through speech. But as far as logic is concerned, all agreed that it has to do with truth and that as such logic is the preparation for all the other sciences.[228]

There are different variants of logic, notably logic as a linguistic science or as a rational science. In the late thirteenth and fourteenth centuries the notion of logic as a rational science became dominant, associated with the rediscovery of the *Analytica posteriora*. Logicians argued that logic counted as a science because it dealt with universal, necessary principles governing logical phenomena. This included the apparently deviant phenomena of fallacies, but also individual arguments and the study of being. The latter is included because the study of being embraces not only real beings but also beings of reason ('second intentions'). Nominalists and realists disagreed about 'second intentions': were these common objects, at once universals and logical structures, or were they mental constructions, reflections of individual things?[229]

A 'standard' Tree of Porphyry does not exist. There are many manuscript copies of this Tree-diagram, some early-printed editions, and a few modern editions. None of these resemble the Trees of Porphyry found in thirteenth-century manuscripts, but, a modern version is a useful device to explain the structure of the Tree of Porphyry, to those unfamiliar with the topic.[230] [*See* figure 2.1].

In its most basic form, the figure consists of a column of terms connected to each other by lines. The highest term in the column, 'substance', is one

[225] A. de Libera, *La philosophie médiévale* (Paris, 1989), 9–10.
[226] F.C. Coplestone, *A history of medieval philosophy* (New York, 1972), 234.
[227] Peter of Spain, Tractatus: «*Dialectica est ars ad omnium methodorum principia viam habens*» (ed. De Rijk, *Peter of Spain (Petrus Hispanus Portugalensis). Tractatus called afterwards Summule logicales*).
[228] Ashworth, "Language and logic," 77–78.
[229] ibid., 80.
[230] A.R. Verboon, "The medieval Tree of Porphyry: the logic, organic and diagrammatic structures," in *The tree symbol, allegory, and structural device in medieval art and thought*, ed. A. Worms and P. Salonius (Turnhout, 2010), (forthcoming).

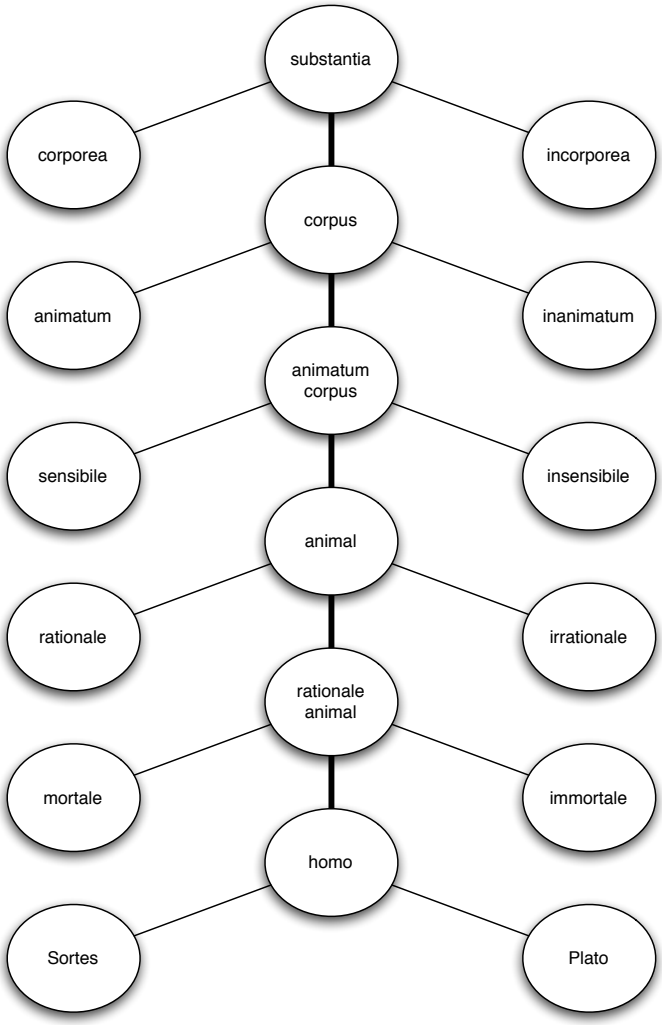


Figure 2.1 A modern edition of the Tree of Porphyry.

of the ten Aristotelian categories or predicaments. The other nine categories, besides substance, are: 'quantity', 'quality', 'relation', 'place', 'time', 'posture', 'state', 'action' and 'passion'. Substance is the first and most fundamental mode of being and is on this account essentially distinct from the nine others, which express accidental modes of being.

None of these categories is subordinate or reducible to another. Every such categorical name stands at the top of its own series. The figure is introduced as an example of the procedure of division, taking 'substance' as the specific case. But, at least in theory, ten Trees of Porphyry are possible, with the name of a different category on top. If these ten trees were drawn up, they would comprise all sorts of possible worldly entities. 'Substance' is, however, not just a random example. One of the most important tasks of logic was to study the notion of the 'essence' of a given thing, as substantiated by its 'substance', or 'being'.[231]

The Tree of Porphyry deals with defining species and genera. A genus is a collective term uniting and characterising several species on specific common grounds. Each species can turn into a genus if the species can be divided in smaller units for which this subaltern genus is the collective name. The highest term in the column is 'substance' (*substantia* in Latin). Its division into the species bodily and non bodily substances is stated through a pair of derivative branches. The bodily (*corpus* in Latin) species of substance becomes the genus for the underlying species, here of inanimated and animated bodies (*inanimatum / animatum corpus* in Latin).[232] An animated body is in turn the genus for percipient animated substances (*animal sensibile* in Latin). Percipient animated bodies, a species of animated bodily substances, are the genus for rational animated bodies (*rationale animal* in Latin). Rational animated substances, a species of percipient animated bodies, are the genus for mortal and immortal animated bodies.[233] Finally, mortal animated bodies, as a species of rational animated bodies coincide with 'man' (*homo* in Latin). Man is thus the most specified species, further specifiable only into individuals, like Plato, Socrates, and Cicero. The central column therefore features those species which can in turn become a genus for the subsequent, subaltern row.

The side columns show the *differentie specifice* in contradictory pairs. The diæresis of the genus is therefore dichotomous and works with single *differentie*: the second member of the pair is the negation or privation of the first. Note that only the left column is further developed.

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[231] Mansfeld, *Heresiography in context. Hippolytus' elenchus as a source for Greek philosophy*, 78–79, 89, 91.

[232] Animated bodies cannot be translated as animals. This is because a plant is not an animal, but nonetheless animated for it moves and grows.

[233] The division between mortal and immortal was neither made by Porphyry, nor Peter of Spain. The diagrammatic representation shows this division, which goes back to Boethius' translation of the *Isagoge*, in the section *De differentia* 10.4- 10.8 9 (and not in *De specie*).

Genus and *species* are essential *predicabilia*. They describe an essential relation of a predicate to a subject. To describe a *singulare* in a predicate, one can use the Porphyrian *predicabilia*: *genus, species* but also *proprium, accidens* and *differentia*. With help of the five *predicabilia* one could define the relationship between the predicate and its subject, a predicate being that part of a sentence that serves to describe or characterize a subject. The predicates are vital for a correct interpretation of the ten categories. In Latin manuals a predicate is further explained by using questions, like 'What is it, one can say about a dog?' – *Quid est quod de cane predicatur*. By answering such a question one will uncover a predicate which gives a closer description of the dog, like 'brown', which is a quality, or 'sick' which is a condition.

The genus animated body (*corpus animatum*) for example, comprises human beings, animals and vegetation. The *differentia specifica* makes a distinction in which species differ from their common genus, for example the application to human beings of the predicate 'being reasonable', which serves to distinguish man from animals and plants. A *proprium* is a predicable of property, common to all members of a kind but not constituting an element of the definition of that kind, like the 'capability to laugh'. And an *accidens* is an attribute that is not essential to the nature of something, for example 'to sit' or 'white'.[234]

2.3 Form and inference

The following sections will take a closer look at the relationship between diagrammatic form and scientific inference. I underline here the importance of taking into account the historicity of diagrams when analysing collation and the logical coherence between diagrams and theory. The canonical Tree of Porphyry, as presented above is the result of a tradition of commentary ten centuries long. A historical deconstruction of the figure will serve to clarify why certain choices regarding its structure were made.

The roots of the doctrine of the Tree of Porphyry are quite ancient. The Tree of Porphyry is named after Porphyry, a third-century Greek philosopher who wrote an *Introduction* (*Isagoge* in Greek) to the *Categories* of Aristotle.[235] Porphyry was born in Syria (233/234–310) and wrote an introduction (*Isagoge* in Greek) to the *Categories* of Aristotle at the demand of the Roman senator Chrysaoris, who complained about not understanding a word of the Aristotelian work. Porphyry did not initiate this discussion; before him Seneca,

[234] The examples are taken from Porphyry, *Isagoge, translatio Boethii*, I.6: «*Est autem genus quidem ut animal, species vero ut homo, differentia autem ut rationale, proprium ut risibile, accidens ut album, nigrum, sedere*» (ed. De Libera and Segonds, *Porphyre. Isagoge. Texte grec et latin*).

[235] Some assert that it was Porphyry who invented the figure. See for example: Kamber, *Arbor amoris. Der Minnebaum. Ein Pseudo-Bonaventura-Traktat*, 130.

Cicero, and of course Aristotle and Plato had all discussed the division of substance.[236]

A visual illustration of the definition and analysis of 'substance' from Antiquity is not extant, either in Porphyry's *Isagoge*, or in other treatises. Porphyry gave the following example for the definition and analysis of 'substance':

> «What I mean should become clear in the case of a single type of predication. Substance is itself a genus. Under it is body, and under body animate body, under which is animal; under animal is rational animal, under which is man; and under man are Socrates and Plato and particular men».[237]

The phrasing in Porphyry's text is remarkably spatial, using words like 'above' and 'under' when discussing the relation between concepts. The adjectives 'above' and 'under' indicate a localization of the concepts in a specific order. The phrasing does not, however, remind one of a tree-like analysis. Porphyry's direct commentator Ammonius characterized the above description as a 'chain'.[238] Ibn al-Tayyib (d. 1043) termed it a 'line'.[239] These descriptions indicate that the concepts were grasped as a series in a certain order. The surviving copies of Porphyry's commentator Ammonius (fifth century) are illustrated with the so-called 'square of opposition', but not with the figure which would later become known as the Tree of Porphyry.[240]

The first figures are to be found in Boethius' works.

2.3.1 The condensation of texts and diagrams by Boethius

Boethius (ca. 480–ca. 525) translated the *Isagoge* from Greek into Latin and then wrote a commentary and a dialogue.[241]It offers an introduction to the

[236] See, for modern illustrations of the textual stemma described by Alcinous, Seneca, Porphyry, Cicero and Stoics: Mansfeld, *Heresiography in context. Hippolytus' elenchus as a source for Greek philosophy*, 79, 96, 98–101, 107.

[237] Porphyry, *Isagoge*, II.4 (translated by J. Barnes, ed., *Porphyre. Introduction* (Oxford, 2003), 6; De Libera and Segonds, *Porphyre. Isagoge. Texte grec et latin*, II.6. De Libera preferred to translate 'οὐσία' as 'essence' and not, as Boethius does, with 'substantia' ('substance'), (ibid., 47 n. 45).

[238] Ammonius, *In Isagoge*, 70.13

[239] Ibn al-Tayyib, *In Isagoge*, 171. See: Barnes, *Porphyre. Introduction*, 108.

[240] See for an account of the origin of the so-called Square of Opposition: I.M. Bocheński, *A history of formal logic* (Notre Dame, 1961), 37 n. 14; M.W. Sullivan, *Apuleian logic - the nature, sources, and influence of Apuleius's Peri Hermeneias* (Amsterdam, 1951), 64–66; D. Londey and C. Johanson, *The logic of Apuleius. including a complete Latin text and English translation of the Peri hermeneias of Apuleius of Madaura* (Leiden, 1987); D. Londey and C. Johanson, "Apuleius and the square of oppositions," *Phronesis* 29 (1984): 165–173.

[241] See for a full enumeration of the extant manuscripts: L. Minio-Paluello, ed., *Categoriarum supplementa. Porphyrii Isagoge, Translatio Boethii, et Anonymi Fragmentum vulgo vocatum 'Liber sex principiorum'*, Aristoteles Latinus (Bruges–Paris, 1966), xvi-xxii.

basic conceptual vocabulary of medieval logic and is as such one of the first text students had to read. The *Isagoge* then was frequently commented on in the Middle Ages and the Tree figure became a standard component of these commentaries.

As one of the last philosophers of the Western Roman Empire and with his excellent knowledge of Greek, Boethius is seen as one of the most important transmitters of antique knowledge to the Latin west. Boethius considered his main goal to be explaining the compatibility of Aristotelian dialectics with Platonic metaphysics as presented by Porphyry.

There are four types of diagrams in the earliest manuscripts of the *Isagoge, translatio* and the Commentary on the *Isagoge*. Three of these are in the Translation, and a fourth in the Commentary. The Dialogue contains no figures and is not dealt with here. I found the majority of these figures in manuscripts dating from the thirteenth and fourteenth century. About 350 copies of such texts remain to us, (see Appendix C.1, page 265, for a survey of the consulted manuscripts for this chapter). Based on the numbers of extant manuscripts it seems the Commentary and the Dialogue elicited reduced interest from the twelfth century onwards, but that the *Isagoge, translatio* attracted undiminished interest.

The earliest surviving diagram in the *Isagoge, translatio* is in an eleventh-century manuscript. The figure is drawn in the margin of the section concerning the *De genere* and specifically occupied with clarification of the *predicabilia*:

> «a genus is, for example, 'animal'; a species is, for example, 'man'; a difference is, for example, the 'capacity to reason'; a *proprium* is, for example, the 'capacity to laugh'; an accidens is, for example, 'white', 'black' or 'to sit'».[242]

The diagram consists of two columns with seven rows. The five *predicabilia* of *genus*, *species*, *differentia*, *proprium* and *accidens* are inscribed in the left column. In the adjoining column are five examples corresponding to these predicabilia: *animal, homo, rationale, risibile,* and finally *album, nigrum, sedere* for the *accidens*.[243]. The figure ends in the second to bottom row with the words *Ecce totum*: 'that is all' or 'see all that'. The bottom row is empty. This figure thus enumerates the five predicates alongside five examples in the form of a table, which, due to its pointed upper row resembles a house. [*See* figure 2.2]. This tabulation has nothing in common with the dichotomously designed Tree

[242] Boethius, *Isagoge, translatio*, De genere, 2.21–2.23: *«Est autem genus quidem ut 'animal', species vero ut 'homo', differentia autem ut 'rationale', proprium ut 'risibile', accidens ut 'album', 'nigrum', 'sedere'»* (Minio-Paluello, *Categoriarum supplementa. Porphyrii Isagoge, Translatio Boethii, et Anonymi Fragmentum vulgo vocatum 'Liber sex principiorum'*).

[243] *See* footnote 234.



Figure 2.2 Boethius, *Isagoge, translatio*. Cologne, *Dombibliothek*, ms. 191, f. 2v. Dated 11th century.

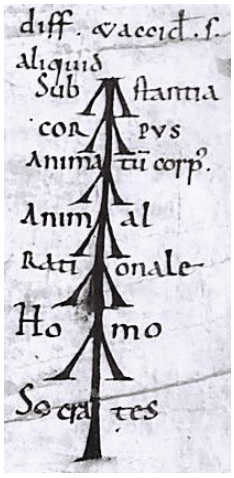


Figure 2.3 Boethius, *Isagoge, translatio*. Cologne, *Dombibliothek*, ms. 191, f. 4r. Dated 11th century.

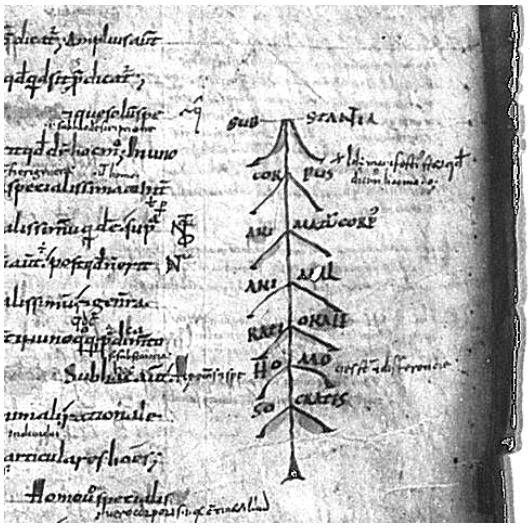


Figure 2.4 Jepa, *Commentary on the Isagoge*. Paris, *Bibliothèque nationale*, ms. lat. 2949, f. 47r. Dated 9th/10th century.

of Porphyry.[244]

In the very same copy a second diagram appears, this time in the margin of a section about the *De specie*. This figure places the terms substance, animated body, animal, rational, *homo* and Socrates underneath each other. It illustrates the text appearing some twenty-five lines further on, where it reads:

> «Substance is indeed itself a genus; under which comes body; under body, animated body under which animal; under animal, animal capable of reason under which man; under man, Socrates, Plato and particular men».[245]

The plain enumeration of concepts one below the other, makes of this figure a table in which different concepts are organized hierarchically. The lines dividing the different concepts should be seen as struts or brackets. Regardless, these lines do not effect a division. [*See* figure 2.3].

This figure may be compared to another found in an *Isagoge, translatio* featuring glosses by someone called 'Jepa' and dating from the ninth century.[246] In the margin of the section concerning the *De specie* of the *Isagoge* translation is a figure like the one described above. [*See* figure 2.4]. Here the letters of the concept terms are divided to the left and the right of the vertical line. Horizontally the concepts are kept apart by lateral branch lines.

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244 Cologne, *Dombibliothek*, 191.

245 Boethius, *Isagoge, translatio*, De specie 4.23–4.26: «*Substantia est quidem et ipsa genus, sub hac autem est corpus, sub corpore vero animatum corpus sub quo animal, sub animali vero rationale animal sub quo homo, sub homine vero Socrates et Plato et qui sunt particulares homines*» (Minio-Paluello, *Categoriarum supplementa. Porphyrii Isagoge, Translatio Boethii, et Anonymi Fragmentum vulgo vocatum 'Liber sex principiorum'*).

246 Paris, *Bibliothèque nationale*, lat. 12949.

A third diagram in the *Isagoge, translatio* by Boethius appears in the margin alongside the text chapter *De differentia*. At that point the text reads:

> «all the per se differences concerning animal are: animated and endowed with sensory perception, reasonable and deprived of reason, mortal and immortal. The difference 'animated' and 'endowed with sensory perception' make up the substance of the animal (the animal is indeed an animated substance endowed with sensory perceptions), whereas 'mortal' and 'immortal', 'reasonable' and 'not having reason' are the differences that divide the animal: it is by these differences that we divide genera and species».[247]

At the top of the figure is written *substantia*, while below, in a table of four rows and two columns, are inscribed the four antithetic pairs of *animatum–inanimatum, sensibile–insensibile, rationale–irrationale, mortale–immortale*. [*See* figure 2.5]. These pairs are the 'differences' of the *genera*. The *genera* themselves are not inscribed in this figure. A triangle hanging below the figure mentions the names of Socrates and Plato, individuals among the species 'man'.

This sort of diagram was copied relatively often. In a copy kept in Munich, the antithetical difference *corporeum–incorporeum* replaces the pair *animatum–inanimatum*.[248] Suspended below in the triangle we find this time the individual named Cato. Yet a third example appears in the margin of an early copy now kept in Paris.[249]

Lastly, Boethius' commentary on the *Isagoge* features a figure that resembles the later Tree of Porphyry. Instead of a tabulation of species, genera or differences, we see here a synthesis of the three. The earliest copies of this diagram date from the ninth and the tenth centuries, and are now both kept in Paris.[250] In the central column the list of species is enumerated. The inscriptions read: substance, body, animated, animal, rational. The lowest tier *–homo–* is lacking. From the middle column lateral lines extend, ending in medallions containing the five antithetical pairs of differences: *corporeum–incorporeum, animatum–inanimatum, sensibile–insensibile, rationale–irrationale,*

[247] Boethius, *Isagoge translatio*, De differentia 8: «*ut, cum per se differentie omnes huiusmodi sint animalis, animati et inanimati, sensibilis et insensibilis, rationalis et irrationalis, mortalis et immortalis, ea quidem que est animati et sensibilis differentia, constitutiva est substantie animalis -est enim animal substantia animata sensibilis- ea vero que est mortalis et immortalis differentia et rationalis et irrationalis, divisive sunt animalis differentie ; per eas enim genera in species dividimus.*» (Libera and Segonds, *Porphyre. Isagoge. Texte grec et latin*). My translation into English.

[248] Munich, *Bayerische Staatsbibliothek*, Clm 14516, f. 7r.

[249] Paris, *Bibliothèque nationale*, nal. 1611, f. 58v; Munich, *Bayerische Staatsbibliothek*, clm 14516, f. 7r.

[250] Paris, *Bibliothèque nationale*, lat. 12958; Paris, *Bibliothèque nationale*, lat. 13955. Only one manuscript is possibly older, and dated in the eight or ninth century (Roma, *Patr. Marist.*, sine num. (2r-11r), but I was not able to verify whether this copy contained a drawing of the Tree of Porphyry.

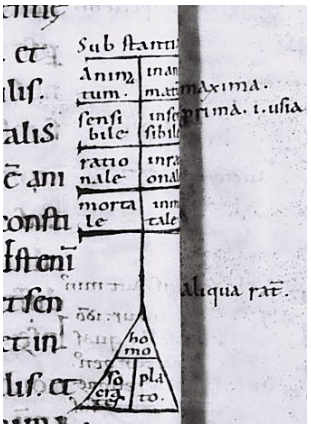


Figure 2.5 Boethius, *Isagoge, translatio*. Cologne, *Dombibliothek*, ms. 191, f. 10v. Dated 11th century.

mortale–immortale.[251] [*See* figure 2.6]. This example not only synthesises the previous diagrams in the *Isagoge, translatio*, it also conceives of the diagram as a dichotomous form.[252]

The synthetic dichotomous diagram was composed, then, on the basis of two earlier margin figures from the *Isagoge, translatio*, embedded and announced in the Commentary by Boethius. This indicates, in my view, that Boethius was responsible for the figure that would come to be named the Tree of Porphyry.

It is important to underline at this point that we are dealing with a different treatise here. The synthetic figure in Commentary-copies combined the two previously mentioned types of diagrams found in the *Isagoge translatio*. In the Commentary the draughtsmen reassembled these older diagrams, combining the pairs of 'differences' with the enumeration of 'species'.

It is significant, consequently, that the figure is inserted within the text. In both copies the figure is announced with the words «the description dedicated to this matter presents to the eyes an example below» - (*cuius rei subjecta descriptio sub oculos ponat exemplum*). In the Commentary the diagram was embedded and announced, which indicates that the figure was conceived as an integral part of the Commentary. The figures in the translation of the *Isagoge*, on the other hand, are not embedded in the text, nor announced. The diagrams in the *Isagoge, translatio* were not integrated in the text but instead added as a gloss in the margin.

Such synthetic, dichotomous diagrams would eventually replace individual tables of differences and species during the twelfth century.

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[251] Paris, *Bibliothèque nationale*, lat. 13955, f. 22r.

[252] Another known example of such a diagram in an early manuscript is incomplete since the medallions on both sides are not filled in: Paris, *Bibliothèque nationale*, lat. 12958, f. 38r.

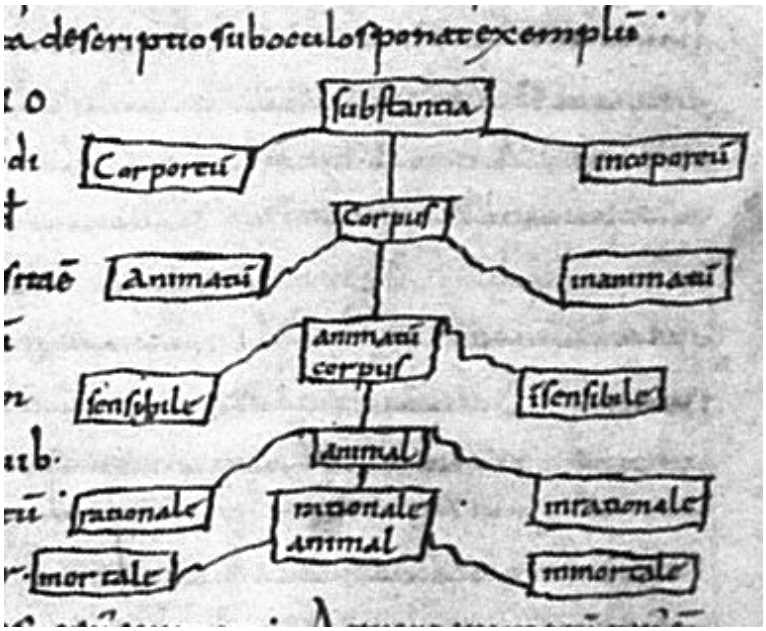


Figure 2.6 Boethius, *Commentary on the Isagoge.* Paris, *Bibliothèque nationale*, ms. lat. 13955, f. 22r. Dated 10th century.

2.3.2 DICHOTOMOUS STRUCTURES

John Damascene (ca. 676–ca. 749) was born into an Arab Christian family. In the west he was known as 'Doctor of the Church'. He wrote his *Dialectica*, also known as *Capita philosophica*, but circulating often without a title at all, between 742 and his death in 749. The *Dialectica* is an introduction to the *Isagoge*. Damascene, a Neo-Platonist, dealt only with logical terminology insofar as it applied to theology.[253] For that reason scholastics were interested in his work. That his treatise was influential is testified to by William Ockham, who referred often in his *Summa logice* to the *Dialectica* of John Damascene.[254] Robert Grosseteste (ca. 1170–1253) translated the *Dialectica* from the Greek into Latin and by doing so made it available to Western Europe.

There are thirteen Latin manuscript copies extant[255] and 229 Greek copies.[256] The two Latin manuscripts consulted, both dating from the

[253] D. Stiefenhofer, *Des heiligen Johannes von Damaskus genaue Darlegung des orthodoxen Glaubens* (Munich, 1923), xv.
[254] O.A. Colligan, ed., *St. John Damascene. Dialectica. Version of Robert Grosseteste* (New York–Louvain–Paderborn, 1953), v.
[255] S.H. Thomson, *The writings of Robert Grosseteste, Bishop of Lincoln, 1235–1253* (Cambridge, 1940), 45, 47.
[256] P.B. Kotter, *Die Schriften des Johannes von Damaskos. Institutio elementaris. Capita Philosophica*

thirteenth century, featured embedded figures in the text. Both copies date from the thirteenth century in Paris. One of these manuscripts was the property Gerard of Abbeville, and his legacy is kept in the Sorbonne library.[257] Another copy comes from the abbey Saint-Victor in Paris.[258] The former contains two figures, the latter one. Both figures in the *Dialectica* are the same. Their peculiarity consists in their verbal form. They are organised more as a tabulated phrase than as a figure. The table's appearance is provoked by the word *generalissimum genus* in the running text, and it highlights some keywords of chapter 30, mainly concerning *Divisio entis et substantie*:

> «Substance is the most general genus; which is being divided in <*here starts the tabulated phrase*>: a body is a species of substance and a genus of animal. Animated is a species of body and a genus of sensory. Sensory animal is a species of animates and a genus of rational. Rational is a species of animal and the genus of mortal. Mortal is a species of rational and the genus of man. Man is the most specified species: it is a species of mortal, like the species Peter and Paul, which is a nature, form and substance, according to the Church Fathers».[259]

The diagrams here have a dichotomous structure. [*See* figure 2.7]. Damascene gave the examples of the *zoophyton et plantam* (plant-like animals and plants) for non-animate bodies. As examples of mortal rational animals Damascene gave on the left wing *homo* and on the right *bovem, canem et talia* (cow, dog etc). In doing so Damascene touched on a controversial point. Porphyry argued in *On Abstinence* that animals are rational, rejecting the division of animals into rational and irrational.[260] In the *Isagoge* however Porphyry would say that all animals are irrational, except for man, a rational species alone. John Damascene seemed to follow Porphyry's reluctance to divide the animated species into rational and irrational, and adapted the diagram accordingly.

Many commentaries were subsequently written on the *Isagoge* and the *Categories*, but not all of them record a diagram.[261] I have, for instance, not found figures in the commentaries on the *Isagoge* by Gilbert of Poitiers, Peter Abelard,

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(Dialectica) (Berlin, 1969), 38.

[257] Paris, *Bibliothèque nationale*, lat. 16598, f. 37r and f. 46r.

[258] Paris, *Bibliothèque nationale*, lat. 14700, f. 18v.

[259] John Damascene, *Dialectica*, XXX.1.1–2.31: «*Substantia generalissum genus est; hoc dividitur in:* <*figure*>. *Corpus species substantie et genus animati. Animatum species corporis et genus sensibilis. Sensibile animal species animati et genus rationalis. Rationale species animalis et genus mortalis. Mortale species rationalis et genus hominis. Homo specialissima species: species enim est mortalis, et species Petri et Pauli, que est natura et forma et substantia secundum sanctos Patres*» (Colligan, *St. John Damascene. Dialectica. Version of Robert Grosseteste*.

[260] Porphyry, *On abstinence*, III 21–23. See also: Barnes, *Porphyre. Introduction*, 111.

[261] The tree of Porphyry is, for example, recorded in an anonymous commentary in a thirteenth-century manuscript kept in Munich, *Bayerische Staatsbibliothek*, Clm. 14564, f. 4r.

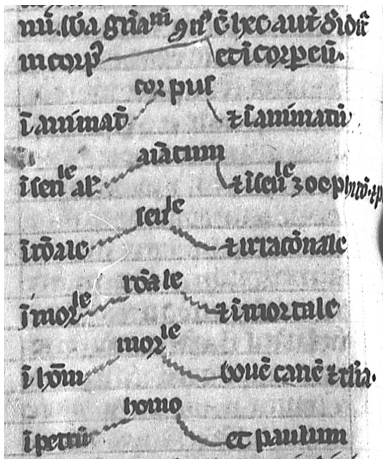


Figure 2.7 John Damascene, *Dialectica.* Paris, *Bibliothèque nationale*, ms. lat. 14700, f. 318v. Dated 13th century.

Gerard of Nogent, Peter of Alvernia, and Abelard of Bath.[262]

The logic treatise of Avicenna (980–1037) consists of nine parts, of which the first part comprises an introduction similar to the *Isagoge*. In Avicenna's *Logica* we read «its known example being the category substance».[263] On the basis of this citation Von Prantl asserted that it referred to the visual representation of the Tree of Porphyry.[264] But in none of the six manuscripts examined for the present study a diagram was drawn.[265] To my mind the line referring to an example denotes the commonly used *verbal* example of the category 'substance'.[266]

Concerning the pictorial tradition some conclusions can now be drawn. Several types of diagrams occur as *marginalia* in Boethius' translation of Porphyry's *Isagoge*. There is a diagram of differences, and a diagram of genera and species: each illustrates the appropriate section of text in the translation. The fact that all these figures are *marginalia* indicates that they were not considered

[262] I have consulted: Gilbert of Poitiers (Paris, *Bibliothèque nationale*, lat. 16080; ibid., lat. 16092; ibid., lat. 16595; ibid., lat. 16598; ibid., lat. 16611; ibid., lat. 15088; ibid., lat. 14697), Peter Abelard (Milano, *Biblioteca Ambrosiana*, M 63 Sup; Paris, *Bibliothèque nationale*, lat. 13368), Guibert of Nogent (Paris, *Bibliothèque nationale*, lat. 16618), Peter of Auvergne (Paris, *Bibliothèque nationale*, lat. 16170), Abelard of Bath (Paris, *Bibliothèque nationale*, lat. 13368) and some anonymous commentaries (Paris, *Bibliothèque nationale*, nal. 1374 (2x); ibid., lat. 13368).

[263] Avicenna, *Logica*, fol. 8rA: «*Vulgatum autem exemplum huius est categoria substantie*». I used the printed edition of Venice 1508, as there is not yet an edition of Avicenna's *Logica*.

[264] See K. von Prantl, *Geschichte der Logik im Abendlande*, vol. 3 (Leipzig, 1855), 338.

[265] I know of seven Latin copies of Avicenna's *Logica*, based on the database of the *Research project Medieval Logical Manuscripts* of L.M. de Rijk and E.P. Bos. http://www.etcl.nl/derijk/rbquery.htm

[266] This example is elaborated in a way comparable to the *Isagoge*. Compare footnote 245 with Avicenna, *Logica*, fol. 8rA: «*Substantia etenim non habet genus supra se, sub qua est corpus, sub corpore vero corpus animatum, sub corpore animato animal, sub animali, animal rationale mortale, sub animali autem rationale est homo, sub homine vero est Socrates et Plato et similia*».

as an integral part of the translation, and presumably were thus not a part of the original Greek *Isagoge*, and consequently not designed by Porphyry himself. These figures in Boethius' translation disappeared in the course of the twelfth century. Instead Boethius' commentary on Porphyry's *Isagoge* now increasingly featured a different type of diagram, embedded and announced in the text: indeed such diagrams appear in copies dating from the ninth century on. This new figure was an attempt to combine information about genera, differences and species together into one figure. The result has the basic structure of the canonical Tree of Porphyry. Its form stabilized and replaced other diagrams definitively during the twelfth century.

2.3.3 The case of Jepa. The alternative.

That the canonical Tree of Porphyry is an assemblage of two figures glossing the *Isagoge, translatio*, and designed for Boethius' *Commentary* would also explain why Jepa inserted an isolated leaf, showing the canonical Tree of Porphyry presenting differences and species, into the translation of Boethius, when there was already a (species) figure in the margin [*See* figure 2.4].[267]

Jepa (or Icpa) was the otherwise anonymous tenth-century logician who glossed the *Isagoge*.[268] He came across the new design in Boethius' commentary, since he used it to research his glosses, and must have considered it an appropriate supplement to the translation, acting as a gloss itself. [*See* figure 2.8]. The hand is not trained in formalised writing, which fits the action of an individual commentator or glossator. The glosses were written at least a century after the text itself, which dates to the ninth century.[269] The manuscript probably comes from Auxerre, since besides Porphyry's glosses, it includes commentaries by a certain Henri (of Auxerre?).[270]

Jepa (?) also drew, in the *Categorie* of Aristotle (24r-39v), five abstract figures dealing with categories, species and genera.[271] None are Trees of Porphyry, but

[267] Paris, *Bibliothèque nationale*, lat. 12949.

[268] C. Baeumker and B.S. Freih. von Waltershausen, "Frühmittelalterliche Glossen des angeblichen Jepa zur Isagoge des Porphyrius," *Beiträge zur Geschichte der Philosophie des Mittelalters* 24, no. 1 (1924): 6–60, here 11.

[269] Baeumker and Von Waltershausen suggested that the glosses were written around the turn of the ninth to the tenth century. They do not date the inserted loose pieces of folia. M.-P. Lafitte, conservator at the manuscripts department of the *Bibliothèque nationale de France*, suggested a dating in the tenth or even eleventh century for the loose folia to me, for which I owe her my thanks. Obviously it remains my responsibility to endorse her suggestion. ibid., 13.

[270] ibid., 6–60; Grabmann, *Methoden und Hilfsmittel des Aristotelesstudiums im Mittelalter*, 20.

[271] It would not be appropriate to elaborate on the other figures in this particular manuscript. They would nonetheless be of interest for further study, especially because some of the figures seem quite different to those of the Latin tradition. One figure (26v) shows a table in which the

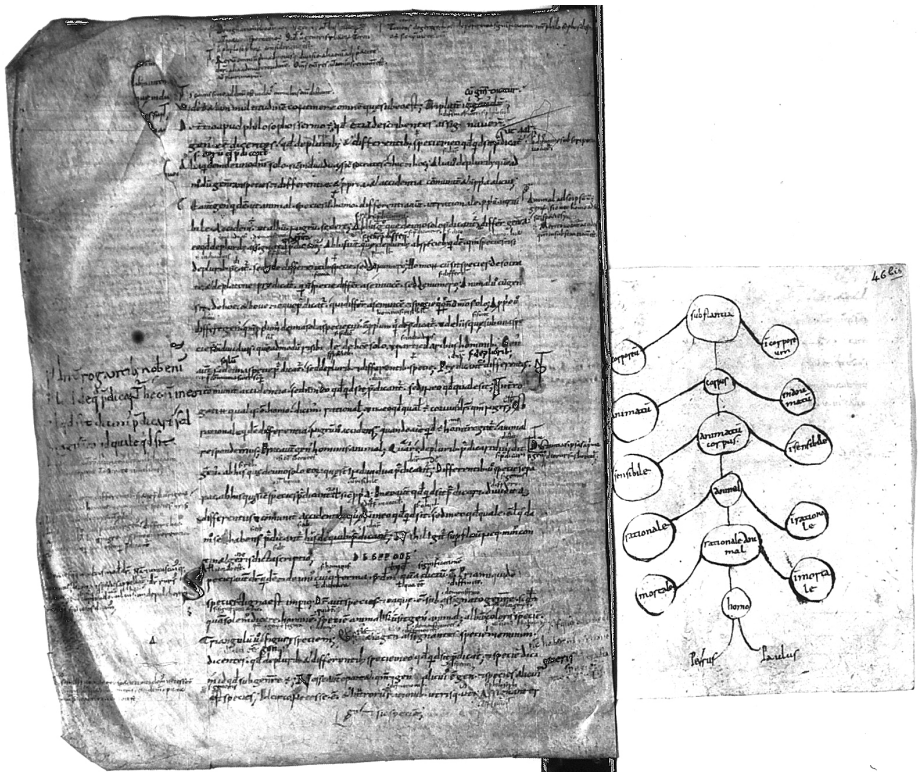


Figure 2.8 Jepa, *Commentary on the Isagoge.* Paris, *Bibliothèque nationale*, ms. lat. 12949, f. 46v-46bis. Dated 9th/10th century.

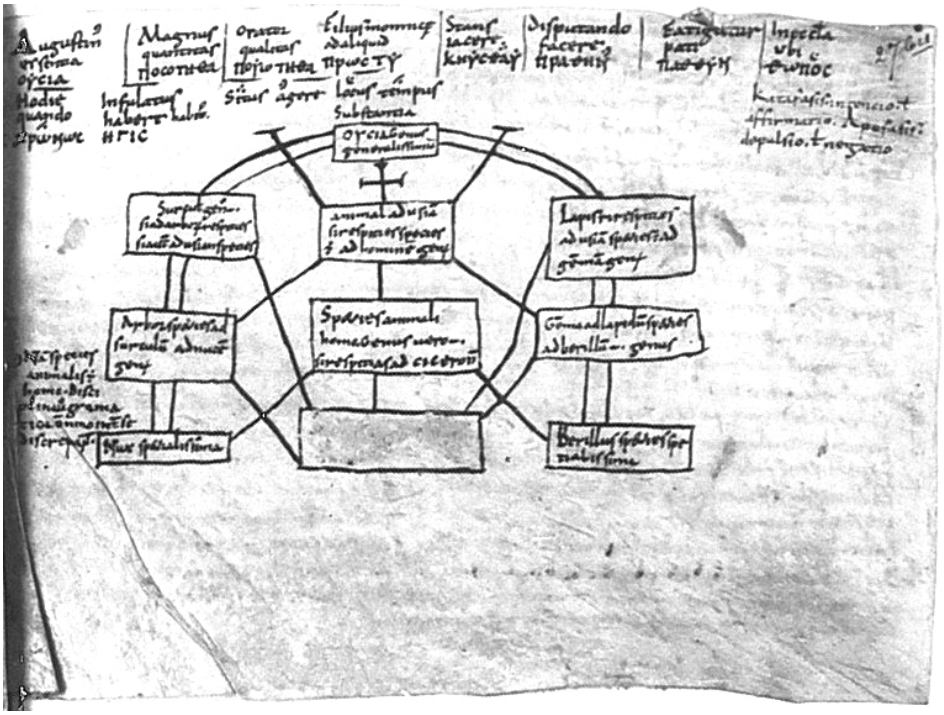


Figure 2.9 Jepa, *Commentary on the Isagoge.* Paris, *Bibliothèque nationale*, ms. lat. 12949, f. 27bis. Dated 9th/10th century.

they do give examples of how genera and species relate to each other. Some of these figures were inserted on a loose leaf. [*See* figure 2.9].

At the top of the figure shown is written «*Augustinus magnus orator filius Monice stans disputando fatigietur in ecclesia*». This phrase is a study aid to help the reader remember the categories (here eight instead of ten); 'Augustinus' is substance, *magnus* is a quantity, *orator* is a quality, *filius Monice* is a relation, *stans* is a posture, *disputando* is an action, *fatigietur* is a state, and *in ecclesia* is a place. Lacking are the categories 'passion' and 'time'. Until this point it had acted as an adequate memory aid. The reference to Augustine is not accidental. Augustine was thought at the time to have written a Latin summary of Aristotle's *Categorie*, though today this supposition is considered spurious.

The figure below this line shows, in the middle column, the traditional example of 'human being' as a species of substance, in order to illustrate the theory of the predicabilia. The two parallel columns show matching examples: on the left, a 'tree' which is the species of a 'cutting' (*surculus* in Latin) and the genus 'nut tree', below which is the 'nut' (*nux specialissima*). On the right, one finds discussed a 'gem', which is a species of a 'stone' and in turn the genus of a 'diamant' (*berillus* in Latin).

In the centre column of the figure is placed the descent from substance or essence, written in Greek as OYCIA (οὐσία), to animated substance, man and then Cicero. Lines between the three examples lead the way to the equivalents: animal–tree–gem are related to man–nut–diamant. Other lines are visible, leading to an erased text frame, but are incomprehensible.[272]

2.4 Collation of the Tree of Porphyry

The Trees of Porphyry dealt with so far were not designed in the form of real trees, for they have no trunk, branches, leaves, flowers or even the slightest vegetation that could remind one of a tree. This would change in the thirteenth century, when the metaphor of the tree was attached to the tradition of diagrams of logic in versions of the *Isagoge*. And not only that; simultaneously the metaphor of a man's figure came to be connected to the diagram. Here I show at what stage of the evolution of the Tree of Porphyry these metaphors became attached to it.

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series *scientia*, 'discipline' and 'grammar' are equated to 'colour', 'white' and 'coloured'. Moreover, another figure (f. 16v) is in the form of bound leaves, and another (f. 31r) is designed like a plant or a tree.

[272] With many thanks to Ian Maclean, whose Greek transcription of this figure I was kindly allowed to use.

2.4.1 THE TREE METAPHOR: DRAWING BRANCHES AND LEAVES

The Tree of Porphyry reached a high point when Peter of Spain used the figure in his manual. As a systematic manual, Peter's *Tractatus* was composed to meet the needs of the public and the objectives of the new university. It belonged to a literature familiar to continental Arts students, who found the *Tractatus* a helpful systematic supplement in their study of the old logic.[273]

Peter of Spain himself came around 1220 to Paris as a young boy (*ab annis teneris*), probably at the age of 15, to study the *artes* and theology.[274] In 1229 Peter left Paris during the Academic strike of that period. After a riot between residents of the university and the municipal authorities, the masters suspended their lectures. As a result arbitrators decided that nobody was allowed to reside in Paris for studies. Many students and masters obeyed this regulation and left Paris for Oxford, Cambridge or small *studia generalia*. Peter left for Leon, where he taught logic and presumably wrote his *Tractatus*.[275] The treatise arrived in Paris in the '60-'70's of the thirteenth century.[276]

Peter compiled the *Tractatus* on the basis of similar compendia with which he was familiar from his Paris period. It is not clear for whom Peter wrote his treatise. It has been suggested that he wrote it to instruct the children of a nobleman at the court of Castile and Leon. Another hypothesis is that it was meant for students at Salamanca.[277] Regardless, in the *Tractatus* Peter avoided difficult philosophical questions and employed common parlance. As such, the *Tractatus* is a manual that provides an introduction for beginners. After 1400,

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[273] Libera, "The Oxford and Paris traditions in logic," 177–178. See also: J.P. Beckmann, "Logik," in *Lexikon des Mittelalters*, vol. 5 (Munich, 1991), 2074.

[274] De Rijk, *Peter of Spain (Petrus Hispanus Portugalensis). Tractatus called afterwards Summule logicales*, xxx-xxxi.

[275] ibid., xxxiv-xxxv, lix. See, for the rejection of the identification of Peter of Spain as Pope John XXI, and other ideas regarding his identity: A. d'Ors, "Petrus Hispanus O.P., Auctor Summularum," *Vivarium* 35 (1997): 21–71; S. Tugwell, "Petrus Hispanus: Comments on some proposed identifications," *Vivarium* 37 (1999): 103–113; A. d'Ors, "Petrus Hispanus O.P., Auctor Summularum (II). Further documents and problems," *Vivarium* 39 (2001): 209–254; A. d'Ors, "Petrus Hispanus O.P., Auctor Summularum (III). 'Petrus Alfonsi' or 'Petrus Ferrandi'," *Vivarium* 41, no. 2 (2003): 249–303; S. Tugwell, "Auctor Summularum. Petrus Hispanus OP Stellenis," *Archivum fratrum praedicatorum* 76 (2006): 103–115.

[276] According to De Rijk the *Tractatus* was composed in the Iberian Peninsula and could not have reached Paris before the 1260s. The oldest copies (the so-called *Omnes homines*-glosses to the *Tractatus*) date from 1260–70 and derive from Parisian libraries, which makes it plausible that the treatise was successfully introduced in this time to Paris. In Italy the *Tractatus* enjoyed as much fame, while in the Empire the book spread only later, from the mid-fourteenth-century on. The text was hardly noticed in England. De Rijk, *Peter of Spain (Petrus Hispanus Portugalensis). Tractatus called afterwards Summule logicales*, xxi, xliii-xliv, xcviii-xcix. See for the history of the oldest glosses: De Rijk, "On the genuine text," 10–55.

[277] De Rijk, *Peter of Spain (Petrus Hispanus Portugalensis). Tractatus called afterwards Summule logicales*, lix-lxi.

the *Tractatus* was also known as the *Summule logicales* (it is often described as such in catalogues), a title that implies its limited ambitions.[278]

The diagram in Peter's *Tractatus* is generally embedded in the paragraph about *De specie*, in the second book of the *De predicabilibus*. There the text reads:

> «For this to be clearer, we employ the example of one category. Substance is a first genus; under which is body; under body the animated body, under which is animal; under animal the rational animal; under which is man; under man are individuals, like Socrates and Plato and Cicero. And all this shows in a figure, called the Tree of Porphyry».[279]

Note that in this paragraph only the species are described, whereas the figure combined those species with their differences. Note also that Peter of Spain, nor Porphyry, mentioned the division in mortal and immortal, which would become common in diagrammatic representations.[280]

Next, the author announced his figure with the words: «And all this shows in the figure, that is being called the tree of Porphyry» – «*Et hec omnia patent in figura, que dicitur arbor porphirii*» or, in more abbreviated style, «as shows in the figure» – «*ut patent in figura*». This is the first time that the figure was explicitly called the Tree of Porphyry. In the *Syncategoreumata* Peter of Spain had referred to the Tree of Porphyry as a «categorical arrangement in the straight line».[281]

Alongside the explicit naming of the figure as the Tree of Porphyry, the diagram figuratively became a tree. This introduction of vegetative ornaments to the Tree of Porphyry occurred during the thirteenth century. Schadt has asserted that twelfth-century figures show evidence of some abstract, vegetative ornaments, but that only in the fifteenth century the Tree of Porphyry was really drawn as a tree.[282] My study, by contrast, gives evidence to place this

[278] ibid., xxi. See also page 23.

[279] Peter of Spain, *Tractatus*, II, De specie 9.26–10.1: «*Ut autem istud sit magis planum, sumatur exemplum in uno predicamento. Ut substantia est genus primum; sub hac autem corpus; sub corpore corpus animatum; sub quo animal; sub animali animal rationale; sub quo homo; sub homine sunt individua, ut Sortes et Plato et Cicero*» (ibid.).

[280] *See* footnote 233.

[281] Peter of Spain, *Syncategoreumata* VIII. 77: «*Quod autem terminus dicens quid ut 'homo', 'animal' et consimiles predicentur ratione essentie et subiciantur ratione substantie, patet per ordinationem predicamentalem* secundum rectam lineam. *Quia secundum quod homo ordinatur* in linea predicamentali *supra Sortem et Platonem et supra alia individua, sic nominat essentiam er ratione illius predicator*» (translation by J. Spruijt in L.M. de Rijk and J. Spruijt, eds., *Syncategoreumata. Peter of Spain, Studien und Texte zur Geistesgeschichte des Mittelalters* (Leiden–New York, 1992), 376–377), (my emphasize). See also: De Libera and Segonds, *Porphyre. Isagoge. Texte grec et latin*, 48, n. 45.

[282] H. Schadt, *Die Darstellungen der Arbores consanguinitatis und der Arbores affinitatis: Bild-*

process within a shorter period, since fully realised tree figures were already extant in the thirteenth century, as the following examples will demonstrate.

Besides the manuscript master Adenulphus of Anagni left to the Sorbonne library (which has probably not survived), Gerard of Abbeville (1225–1272) also left his copy to the Sorbonne, about twenty years earlier.[283] This copy (Paris, *Bibliothèque nationale*, lat. 16611) thus dates from the thirteenth century and remains in the holdings of the Sorbonne. [*See* figure 2.10]. The figure is a lavishly drawn tree, with a trunk, branches, many leaves and a top. The leaves are drawn to accommodate the text. The figure is somewhat untidy: the draughtsman erroneously placed branches carrying the inscriptions corporeal–incorporeal above *substantia*. Two pairs of branches below he tried to correct his mistake by skipping a pair of leaves. Because of this correction he came out short a pair of branches at the bottom of the figure, and had to leave out the names of Socrates and Plato.

Many more examples of full tree figures of the Tree of Porphyry exist dating from the thirteenth century onwards.[284] Another beautiful example, now kept in London, *British Library*, for instance, show clear roots, a trunk, leaves and a top.[285] [*See* figure 2.11]. In this example the concepts are written on enlarged leaves. Or are they fruits – fruits of thoughts, or fruits which, as an image of pleasure, overwhelm and obscure thought?.[286] This figure precedes an *auctoritates librorum logices* (so colophon).[287]

This tendency to full tree drawing occurred not only in the *Tractatus* of Peter of Spain but also in the figures for Boethius' *Translatio*.[288] The earliest

schemata in juristischen Handschriften (Tübingen, 1982), 82–83. One of his examples is not a Tree of Porphyry: Vatican, *Biblioteca apostolica Vaticana*, Ottob.lat. 1406, fol. 29.

[283] Paris, *Bibliothèque nationale*, lat. 16611: «*Iste liber est collegii pauperum magistrorum parisiensium in theologie facultate studentium ex legato magistri Geroudi de Abbatisvilla*».

[284] Paris, *Bibliothèque nationale*, Arsenal, lat. 728, ff. 1v-2r; Rome, *Biblioteca Casanatense*, 806, f. 3r; Vienna, *Österreichische Nationalbibliothek*, 2389, f. 0v; idem, 5199, f. 18r; Pavia, *Biblioteca Universitaria*, cod. Aldini 450, f. 89v; Graz, *Universitätsbibliothek*, 1039. f. 166v; Munich, *Bayerische Staatsbibliothek*, Clm. 7658, f. 203v.

[285] London, *British Library*, Royal 8 A. XVIII. Previously reproduced in Murdoch, *Album of science: Antiquity and the Middle Ages*, 50, fig. 43.

[286] See for example the fruits in the *arbor philosophie* as described by Theoldulph of Orleans, in: C. Cuissard, *Théodulfe. Évêque d'Orléans. Sa vie et ses oeuvres. Avec une carte du Pagus Avreilianensis au IXe siècle* (Orléans, 1892), 250.

[287] Incipit: «*Neque genus neque species videtur simpliciter dici*». See G.F. Warner and J.P. Gilson, eds., *Catalogue of western manuscripts in the old Royal and King's collections*, vol. 1: Royal mss. 1 A. I to 2 E. XI (Oxford, 1921), 215–216.

[288] Resp. Darmstadt, *Hessische Landesbibliothek*, ms. 2282, f. 1; London, *British Library*, Burney 275, f. 166r. Other examples of vegetative trees in Boethius' translation are: Paris, *Bibliothèque nationale*, lat. 6289, f. 3r; Paris, *Bibliothèque nationale*, nal. 209, f. 5v; Paris, Paris, *Bibliothèque nationale*, Arsenal, 728, f. 2r; Vienna, *Österreichische Nationalbibliothek*, 235, f. 2v; Vienna, *Österreichische Nationalbibliothek*, 5199, f. 17v; Vienna, *Österreichische Nationalbibliothek*, cvp 5196, f. 15r.

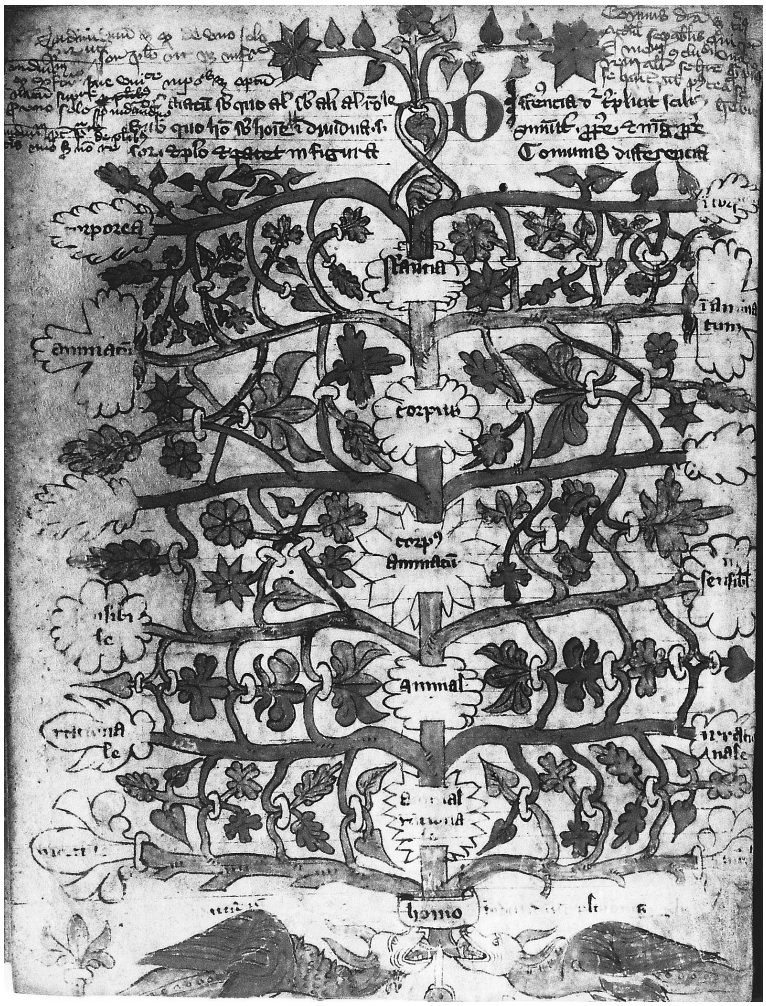


Figure 2.10 Peter of Spain, *Tractatus.* Paris, *Bibliothèque nationale*, ms. lat. 16611, f. 8v. Dated 13th century.

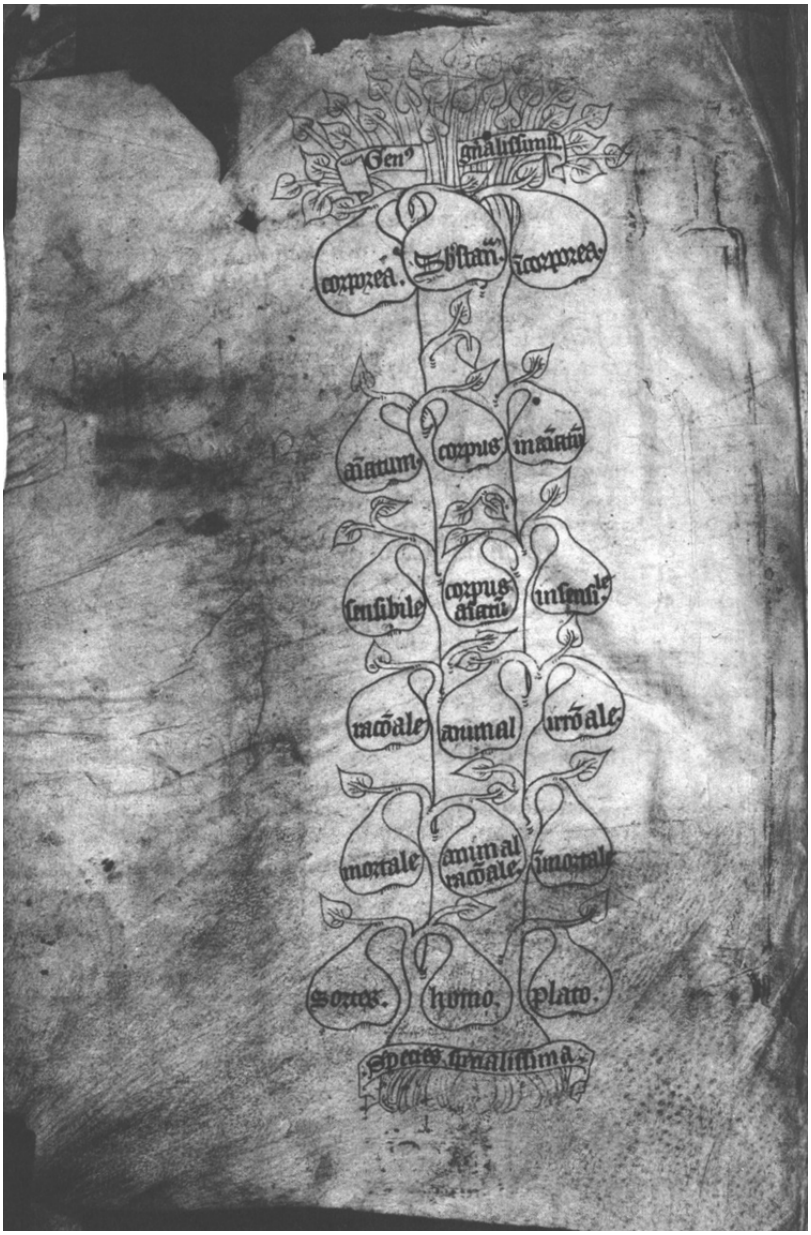


Figure 2.11 Boethius, *Isagoge, translatio.* London, *British Library*, ms. Royal 8.A.XVIII, f. 3v. Dated 14th century.

example of a vegetative (but not yet arboreal) Tree of Porphyry is in a copy of the translation by Boethius dating to 1140. On top of the figure lush leaves were added and the inscriptions also end in curly leaves - but it is not yet a tree. The text itself, Boethius' *Isagoge, translatio*, does not announce the figure as a Tree. [*See* figure 2.14]. See below for a more elaborate description of this figure.

This arboreal development of the figure's design and name is broadly characteristic of the second half of the thirteenth century when the tree-designation was applied to figures in many other disciplines.[289] Schadt posited the *Arbor juris*, a juridical illustration dealing with blood-ties between family members, as the basis of this tendency to add vegetation.[290] The juridical figure was only called an *arbor juris* from the tenth century, regardless of the degree of naturalism.[291] The *Arbor juris* thus leads the way chronologically. The fact that the *Arbor juris* was called a tree and designed as a tree in the tenth century, long before the Tree of Porphyry, does not explain, however, why the Tree of Porphyry only became a real tree in the thirteenth century. A hypothesis in this matter is formulated below.

2.4.2 The anthropomorphic tree

The Tree of Porphyry also appears in another metaphor, in the form of man's body: the so-called *syndesmos* figure. In one version the man's figure is drawn behind the logic diagram of *predicabilia*, for example in one of the earliest copies of the *Tractatus* by Peter of Spain, now kept in Córdoba and dating from the second half of the thirteenth century.[292] A personification with a crown is drawn and on his body appear the seven medallions containing the concepts of the Tree of Porphyry. This drawing of the Tree of Porphyry is announced *ut patent in figura*. [*See* figure 2.12]. The *Tractatus* in this edition was bound together with the *Syncategoreumata* by the same author and the *De syllogismis categoricis* of Boethius.[293] Within this type of diagram, sometimes only the man's head, hands and feet were shown popping out behind the logical figure. In other instances the body of the man blended in with the figure. See for example the following, beautiful figure in a fifteenth-century manuscript.[294] [*See* figure 2.13]. Here, the crowned man leans on a tree-like structure, featuring leaves that look more like hearts than foliage, and thus nicely match the 'hearts' of which his

[289] Schadt, *Die Darstellungen der Arbores consanguinitatis und der Arbores affinitatis: Bildschemata in juristischen Handschriften*, 291, n. 285, n. 286.
[290] ibid., 84.
[291] Klapisch-Zuber, *L'ombre des ancêtres. Essai sur l'imaginaire médiéval de la parenté*, 37.
[292] Córdoba, *Biblioteca del Cabildo*, ms. 158.
[293] De Rijk, *Peter of Spain (Petrus Hispanus Portugalensis). Tractatus called afterwards Summule logicales*, cvii-cviii.
[294] Bryn Mawr, *Bryn Mawr Library*, Gordan 92.

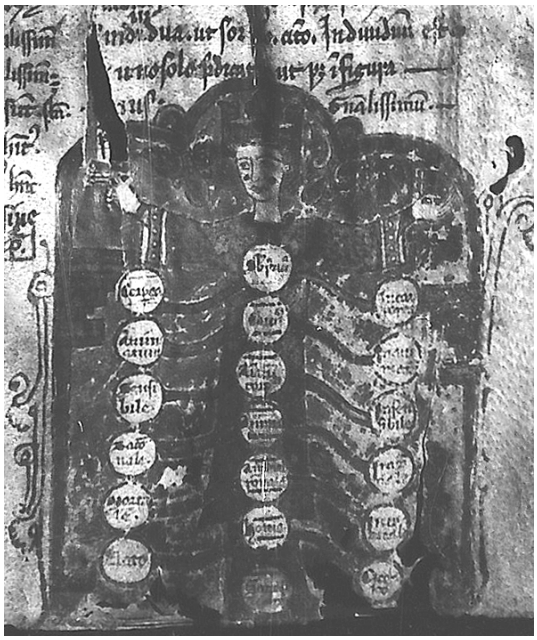


Figure 2.12 Peter of Spain, *Tractatus.* Córdoba, *Biblioteca del Cabildo*, ms. 158, f. 33r. Dated second half of the 13th century.

body consists, and which serve to define the human being in relation to substance.[295]

The all-embracing posture of the man in this figure is called *syndesmos* (in Greek), i.e. 'connection'.[296] His gesture is a sign of the cosmocrator who effectuated harmony in the cosmos. An important *Syndemos* figure was Christ, or else an Old Testament substitute like Adam or David.

Such a stance also occurs in the pictorial tradition of genealogical theories, in particular the *arbor juris*. In these juridical, dichotomic diagrams the *syndesmos* figure is presented with a beard and a nimbus, or a crown.[297] The beard indicates an old man, probably Adam, the ancestor of humanity: as the origin of the human species he carries the *arbor consanguinitatis* through time and completes this cycle as Christ – the Adam *novus*. The crowned and beardless man is presumably the Emperor Justinian, to whom we owe the uniform rewriting of Roman law, the *Corpus Juris Civilis*. Justinian as an *syndesmos* figure would be especially apt for the *arbor juris,* which demonstrated laws of consanguinity in

[295] Other examples I found of the Tree of Porphyry combined with the *Syndesmos* motif: Munich, *Bayerische Staatsbibliothek*, Clm 7205, f. 10v; Paris, *Bibliothèque nationale*, lat. 6657, f. 4r; Monte Cassino, *Archivio della Badia*, cod. 362, f. 102v.

[296] A.C. Esmeijer, "La macchina dell'universo," in *Album discipulorum aangeboden aan Professor Dr. J.G. van Gelder ter gelegenheid van zijn zestigste verjaardag, 27 februari 1963*, ed. J. Bruyn et al. (Utrecht, 1963), 5–15, here 6–7; Esmeijer, *Divina quaternitas. A preliminary study in the method and application of visual exegesis*, 97.

[297] Schadt, *Die Darstellungen der Arbores consanguinitatis und der Arbores affinitatis: Bildschemata in juristischen Handschriften*, 90–91, 94.

the juridical domain. The oldest extant manuscript containing the *Institutiones* of Justinianus dates from the tenth century and contains a family tree blended with a man's figure.[298] Beardlessness was often used as a sign designating a person from antiquity.[299] However, the bare feet of the *syndesmos* figure are more difficult to associate with an imperial identity.

The *syndesmos* motif is well-known from genealogical theories, but was by no means restricted to that domain. *Syndesmos* figures appeared in diagrams dealing with the four elements, the winds, *mappe mundi*, and diagrams of macro-micro relationships. The *syndesmos* posture, as the mark of the cosmocrator of harmony, was appropriated by other symbolic personages, like Christ, David and Adam, but also by *Sapientia*, *Philosophia*, Wisdom and various worldly rulers.[300]

The motif became especially widespread after the twelfth century. Besides its transportation to the Tree of Porphyry it is also seen in, for example, a *Breviari d'Amor* of Matfre Ermengaud[301], in the Brussels manuscript containing Jacob van Maerlant's *De nature bloeme*, in the *Aurea Summa* of Henricus de Segusio[302], Petrus Lombardus' Commentary on the psalms[303] and Joachim da Fiore's Commentary on Isaiah.[304]

What then is the identity of the *syndesmos* man in the Tree of Porphyry? This man wears a crown and often stands barefoot. In keeping with the *syndesmos* figure in the genealogical domain one could readily think of a king or emperor. But identification with a ruler is not plausible. Presumably one has to think instead in the direction of an intellectual authority, say Porphyry himself, or Aristotle. Both names exist as identifications for the *syndesmos* of the Tree

[298] Turin, *Biblioteca nazionale*, cod. Taurin. D111, 13, f. 67v. Esmeijer, *Divina quaternitas. A preliminary study in the method and application of visual exegesis*, 109, 175 n. 54.
[299] Schadt, *Die Darstellungen der Arbores consanguinitatis und der Arbores affinitatis: Bildschemata in juristischen Handschriften*, 97.
[300] Esmeijer, *Divina quaternitas. A preliminary study in the method and application of visual exegesis*, 98–109, n. 13, n. 14; Schadt, *Die Darstellungen der Arbores consanguinitatis und der Arbores affinitatis: Bildschemata in juristischen Handschriften*, 95, n. 215, 219, 220.
[301] Madrid, *Biblioteca Nacional*, cod. res. 253, f. 3v.
[302] Admont, *Stiftsbibliothek*, cod. 109 (12), f. 41v. Esmeijer, *Divina quaternitas. A preliminary study in the method and application of visual exegesis*, fig. 105.
[303] Dublin, *Chester Beatty collection*, ms. 32, f. 1r. ibid., fig. 106. See for a reproduction also: E.G. Millar, *The library of A. Chester Beatty: a descriptive catalogue of the Western manuscripts*, vol. 1 (Oxford, 1927–1930), plate 83.
[304] Vienne, *Österreichische Nationalbibliothek*, cod. 1400 (theol. 71), f. 24v. Esmeijer, *Divina quaternitas. A preliminary study in the method and application of visual exegesis*, fig. 108.



Figure 2.13 Peter of Spain, *Tractatus*. Bryn Mawr, *Bryn Mawr Library*, ms. Gordan 92, f. 6v. Dated 15th century.

of Porphyry.[305] In some cases a crown[306] or a cross[307], drawn at the top of the figure, are present as the mere residue of a more substantial man figure.

In the Córdoba manuscript above [*See* figure 2.12]. I am inclined to think that the personification is meant to be Lady Rhetoric, for she holds a town spire in her right hand, judging, pronouncing justice and curbing disputes.[308]

2.4.3 Conflicts within the metaphor

We now have two metaphors: the image of the tree and the image of the *syndesmos*. As the tree design was more widespread, the Tree of Porphyry was named after it, and especially because the tree-image is intimately intertwined with the logic structure, the remaining of this chapter will concentrate on the tree metaphor. What does it mean for a diagram to be portrayed as a tree? Is the image of a tree, with its trunk, branches and leaves an apt image for the theory of logic? I shall indicate two conflicts between the logic of the diagram and the

[305] The inscription 'Porphyry' is added to identify the *syndesmos*-figure behind the Tree of Porphyry in Monte Cassino, *Archivio della Badia*, cod. 362, f. 102v.
[306] Graz, *Universitätsbibliothek*, cod. 1039, f. 166v, Assisi, *Biblioteca Comunale*, cod. 293, f. 25; Vienne, *Österreichische Nationalbibliothek*, cvp 5248, f. 5v; ibid., 2389, f. ov.
[307] Paris, *Bibliothèque nationale*, Arsenal 728, f. 2r; Darmstadt, *Hessische Landesbibliothek*, 2282, f. 1v.
[308] See for comparison the personification of *Rhetorica* in Theodulph of Orleans' description of the *arbor philosophie*. See below, page 67.

logic of the tree. The first is a problem of direction and the second is a problem of symmetry.

A rather unique diagram, now kept in Darmstadt, might serve as a point of departure.[309] This manuscript was possibly made in Paris around 1140. The content of the treatise, texts of Porphyry, Aristotle and Boethius, indicates its origin in a learned environment. The quires are moreover sewn with a chain stitch *more studentium*.[310] The owner of the manuscript is unknown, but an origin in a learned environment is made yet more plausible by a portrait of the Parisian master Adam de Parvo Ponte (d. 1159) on the first leaf. Adam was a representative of the Parisian school of the Petit-Pont.[311] In the bottom right corner of the page sits master Adam, in the company of Socrates, Plato and Aristotle. The four are depicted sitting around a crowned Lady Dialectic (*dialectica domina* in Latin), who stands in the middle. [*See* figure 2.14]. Lady Dialectic holds in her left hand a snake and in her right hand the Tree of Porphyry. She took over the attributes of the crown and the flower-sceptre characteristic of Lady *Sapientia* or *Philosophia*.[312] Dialectic in this era was increasingly identified with logic and human mental powers: an image of worldly philosophy as opposed to theology. The snake is therefore in this context a symbol for sophistry, while in the hand of Lady Dialectic the Tree of Porphyry becomes a symbol for the power of reason.

There is much to say about this diagram, which shows some foliage on top, but is not yet a tree. For a start: Schadt has pointed out the possibility of a general motif of the *dominus arboris*. He also characterizes Lady Dialectic as a *syndemos* figure. This seems unreasonable to me: we are dealing here with a personification of Dialectic who carries the Tree of Porphyry as an attribute in her hand, a motif firmly in the tradition of late classical personifications like Lady *Philosophia, Sapientia, Dialectica, Terra* etc. The *syndesmos* figure belongs to quite another pictorial tradition.[313] I am inclined to think that the draughtsman designed this image in the spirit of the *arbor sapientie*, as conceptualized by Theoldulph of Orleans (d. 817). Theodulph described a circle (representing the world) in which a tree was planted. Lady Grammar sits at the tree's roots, coax-

[309] Darmstadt, *Hessische Landesbibliothek*, 2282, f. 1v. See for a reproduction also: L.H. Heydenreich, "Dialektik," in *Reallexikon zur deutschen Kunstgeschichte*, ed. O. Schmitt et al (Stuttgart, 1933), 1387–1399, here 1398, fig. 8. [*See* figure 2.14].
[310] K.H. Staub and H. Knaus, *Die Handschriften der Hessischen Landes- und Hochschulbibliothek Darmstadt*, vol. 4: Bibelhandschriften. Ältere theologische Texte (Wiesbaden, 1979), 245 nr. 156.
[311] It has been argued that the Oxford tradition of logic is based on the school of the *Parvipontani*. See: L.M. de Rijk, "Some thirteenth-century tracts on the game of obligation," *Vivarium* 14 (1976): 26–49, here 35, n. 47. See also: De Libera, "The Oxford and Paris traditions in logic," 175.
[312] Heydenreich, "Dialektik," 1393.
[313] Schadt, *Die Darstellungen*, 99–100.

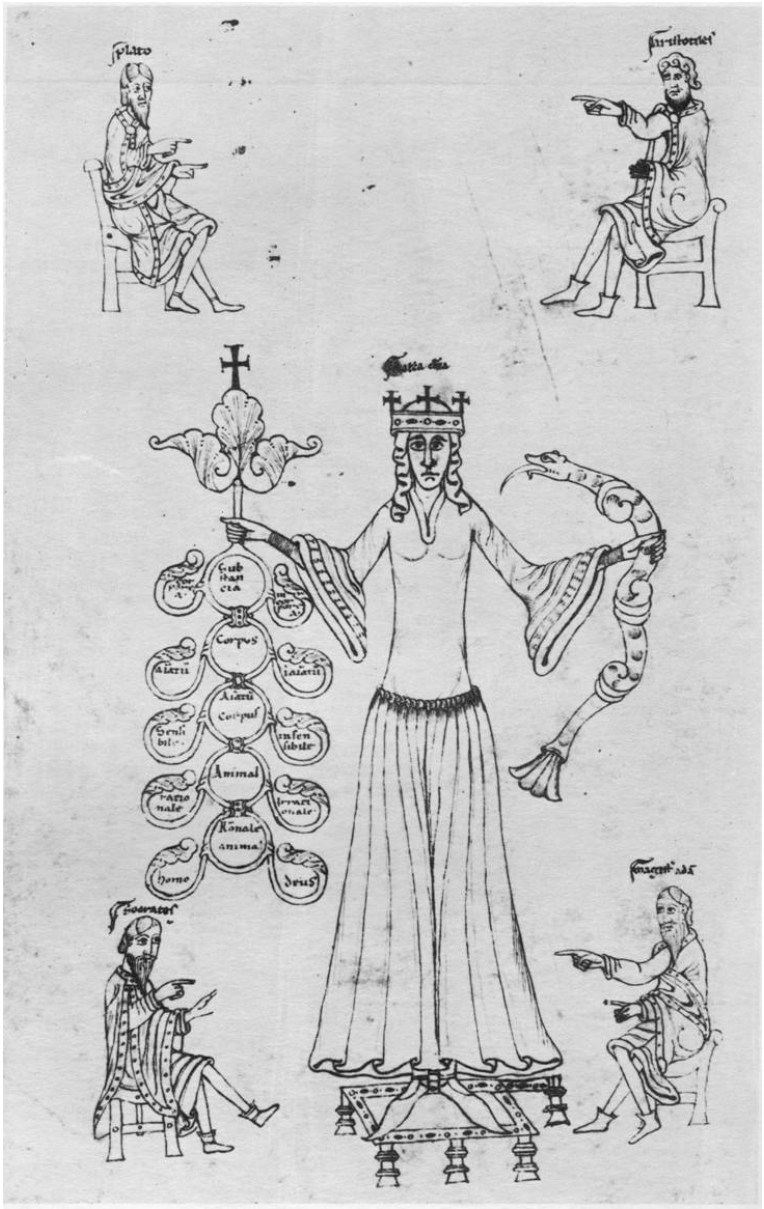


Figure 2.14 Boethius, *Isagoge, translatio*. Darmstadt, *Hessische Landesbibliothek*, ms. 2282, f. 1v. Dated ca. 1140.

ing forth the tree and holding it.[314] Grammar's attributes are here the whip and a sword. Sprouting from Grammar are the other disciplines: the trivium and the quadrivium. Lady Philosophy is placed in the top of the tree, with a diadem in her hair. On branches sprouting from the trunk sit the Ladies Rhetoric and Dialectic, the latter's body enlaced by a serpent. One could thus consider Lady Dialectic holding the Tree of Porphyry as a 'sub-tree'.[315]

But more importantly Evans has asserted that Lady Dialectic, in the Darmstadt manuscript, holds the Tree of Porphyry upside down.[316] But though this is indeed a very particular example, it is not true that she holds the Tree upside down. As we have seen above all Trees of Porphyry looked that way. Instead she simply holds it by the top of the figure. Evans even acknowledged this contradiction: «to get the full benefit of the tree image, it was necessary for the *divisio* to expand upwards». In this moment Evans points out something of interest.

Upward growth

Examples of this Darmstadt copy create feelings of conflict between the upward growth of a real tree and the downward direction of logical meaning in the Tree of Porphyry.[317] The Tree of Porphyry is organized from top to bottom. The most general concept 'substance' is hence placed on top, while the smallest concepts, individual men, are placed at the bottom of the figure. An organic tree, however, grows from bottom to top, such that its ramification becomes more and more complex the further up it grows. The orientation of the branches mitigates the conflict between the upward growth of a real tree and the downward orientation of the Tree of Porphyry. Thus it has been asked: 'could a pine-tree, with its drooping branches fit the image of the Tree of Porphyry?'. But the answer is no, for the conflict remains the same. Pine-trees also grow from bottom to top and therefore, to fit in the image of a real tree, should have 'substance', the general genus, as its roots.

Alain de Libera decided, regarding this conflict, that the Greek word οὐσία in Porphyry's *Isagoge* should better be translated as 'essence', and not with 'sub-

[314] Theodulph of Orleans, *De septem liberalibus artibus in quadam picture depictis*, 3–4: «*huius (scil. arboris) Grammatica ingens in radice sedebat, gignere eam semet seu retinere monens*» (ed. *Monumentum Germaniae Historica*. Poetae latini medii aevi. vol. 1, (Berlin, 1981), 544–547, here 544). See also: A.C. Esmeijer, "De VII liberalibus artibus in quadam pictura depictis. Een reconstructie van de arbor philosophiae van Theodulf van Orléans," in *Album amicorum. J. G. van Gelder*, ed. J. Bruyn et al. (The Hague, 1973), 102–113; Cuissard, *Théodulfe. Évêque d'Orléans. Sa vie et ses oeuvres. Avec une carte du Pagus Avreilianensis au IXe siècle*, 249–250.

[315] Theodulph of Orleans, *De septem liberalibus artibus in quadam picture depictis*, 7–35, (*Monumentum Germaniae Historia*, 1981). See also: Wirth, "Von Mittelalterlichen Bildern und Lehrfiguren im Dienste der Schule und des Unterrichts," 278–279.

[316] M.W. Evans, *Medieval drawings* (London–New York–Sydney–Toronto, 1969), 32, plate 70.

[317] Evans, "The geometry of the mind," 36.

stance' as Boethius did in his *Isagoge translatio*, since for the latter: «*sa connotation 'substrative' ou 'sub-jective' contredit l'image spatiale de l'Arbre*».[318] It is indeed not obvious to place 'sub-stance' at the top of a tree. 'Essence' by contrast does not have this connotation, but it encounters other objections. 'Essence' has the connotation of a 'core', which one should expect to be in the middle of something (for example a circle figure). Furthermore, the tree metaphor originated with Peter of Spain, who used Boethius' translation and thus the word 'substance'. The more correct Greek 'essence' has no textual-historical relation with the tree metaphor of the Tree of Porphyry.

Internal conflicts and contradictions in tree metaphors occur frequently. Plato described an inverted tree when he compared the human intellect with a plant that has its roots in the higher regions of heaven.[319] Giovanni Boccaccio (1313–1375) featured a descending tree in the *Genealogia Deorum*, but was troubled by the contradiction between an upwards growing natural tree and the descending genealogical tree, explaining it by stating «versa in celum radice».[320] The *arbor sapientie* was also sometimes considered disturbingly inverted: 'the inverted tree, that has roots in the top' – «*arbor versa, que habet radices in capite*».[321] Later in time, Benvenuto da Imola and Botticelli's illustrations of the Tree of knowledge in the *Divina Commedia* are also inverted trees, with the roots pointed to the heavens and the crown to the earth.[322] The inverted tree metaphor was indeed known to all three monotheistic religions, in which it symbolizes the growing knowledge of God as an ascension from crown below to the roots above.[323]

The conflict between an upwards growing physical tree and the downwards orientated Tree of Porphyry was also observed by medieval draughtsmen. Some draughtsmen tried to cope with their conflicted feelings by drawing the branches 'growing' naturally upwards, while the concepts remain organised from top to bottom.

One example is a manuscript copy kept in Wolfenbüttel.[324] This fifteenth-

[318] De Libera and Segonds, *Porphyre. Isagoge. Texte grec et latin*, 47 n. 45.
[319] Plato, *Timeus*, 90a, (J. Zeyl, ed., *Plato. Timeaus* (Indianapolis–Cambridge, 2000).
[320] E.H. Wilkins, "The genealogy of the genealogical trees of the Genealogia Deorum," 23 (1925): 61–65, here 65. See also: Watson, *The early iconography of the tree of Jesse*, 45.
[321] Rome, *Biblioteca Casanatense*, cod. 1404, f. 19v. Wirth, "Von Mittelalterlichen Bildern und Lehrfiguren im Dienste der Schule und des Unterrichts," 285. See for a description of this manuscript: Saxl, "Aller Tugenden und Laster Abbildung. Eine spätmittelalterliche Allegoriensammlung, ihre Quellen und ihre Beziehungen zu Werken des frühen Bilddrucks," 104–121.
[322] G.B. Ladner, "Vegetation symbolism and the concept of Renaissance," in *De artibus opuscula XL. Essays in honor of Erwin Panofsky*, ed. M. Meiss (New York, 1961), 301–322, here 109–310, n. 30.
[323] See also, for the concept of the inverted tree: M. Eliade, *Traité d'histoire des religions* (Paris, 1949); A. Jacoby, "Der Baum mit den Wurzeln nach oben und den Zweigen nach unten," *Zeitschrift für Missionskunde und Religionswissenschaft* 43 (1928): 78–85.
[324] Wolfenbüttel, *Herzog August Bibliothek*, 800 Helmst.



Figure 2.15 Peter of Spain, *Tractatus*. Wolfenbüttel, *Herzog August Bibliothek*, ms. 800 Helmst., f. 16v. Dated 15th century.

century copy of the *Tractatus* shows an elaborate figure of a tree with a root, branches, an axed crown and medallions instead of leaves. [*See* figure 2.15]. It is very difficult to infer correctly here: two lines originate in 'substance' and form the differences 'bodily' and 'not-bodily' but these are represented higher up the series or tree than their own genus (substance).[325]

There are also examples in which a compromise is reached between a natural tree and a comprehensible logical diagram by drawing the branches horizontally. One of those examples is already seen in the copy Gerard of Abbeville left to the Sorbonne [*See* figure 2.10]. In a second example, dating to around the turn of the fourteenth century, the draughtsman also drew the 'branches' horizontally, even though in this example one cannot even characterize the figure as a tree.[326] [*See* figure 2.16]. This figure, drawn prior to the *Tractatus*, encapsulates the paragraphs to come.

A successful solution to the contradiction described above was attained in the figure with which this chapter started: the historiated initial at the beginning of the translation of the *Isagoge* by Boethius.[327] [*See* figure 1]. The tree in the Burney-copy is however not a Tree of Porphyry. It represents so much more than the genera and their differences. On the other hand the figure is still heavily inspired by the Tree of Porphyry. The tree-figure is embedded in the capital *C(um sit necessarium)* inside which the teacher, Lady Dialectic, instructs two students in the basics of logic.

From the trunk sprouts a first leaf, on which is written *sermo* (word). Words can be composed into phrases (*complexus*) or exist on their own (*incomplexus*). The left branch is the road to the theories of simple words, leading to the first flower inscribed '*PDI*' as an abbreviation for *predicabilia*. There are five petals of *predicabilia* shown: *genus* (genus), *species* (species), *differentia* (difference), *proprium* (the proper) and *accidens* (the accidental), which are all applicable to real things and individuals. Then a second flower, growing from the first, shows the ten categories in its petals: *substantia* (substance), *qualitas* (quality), *quantitas* (quantity), *relatio* (relation), *actio* (doing), *passio* (undergoing), *quando* (time when), *ubi* (place where), *situs* (position) and *habitus* (having).

The branch on the right shows complex words, expressions that use more than one word, the *orationes*. These propositions consist in a subject and a predicate. A sentence is made up of seven kinds of propositions, and fan out in seven petals paired on the right and on the left: categorical or hypothetical, universal or particular, affirmative or negative, and simplex. Finally the branch ends with the *modi* (modalities) in which these propositions are: necessary, impossible,

[325] Other examples: Vienna, *Österreichische Nationalbibliothek*, cod. 235, f. 2v; Vendôme, *Bibliothèque municipale*, cod. 0205, f. 6v.
[326] Vienna, *Österreichische Nationalbibliothek*, cod. 2389.
[327] Previously reproduced in Murdoch, *Album of science: Antiquity and the Middle Ages*, 51, fig. 44.

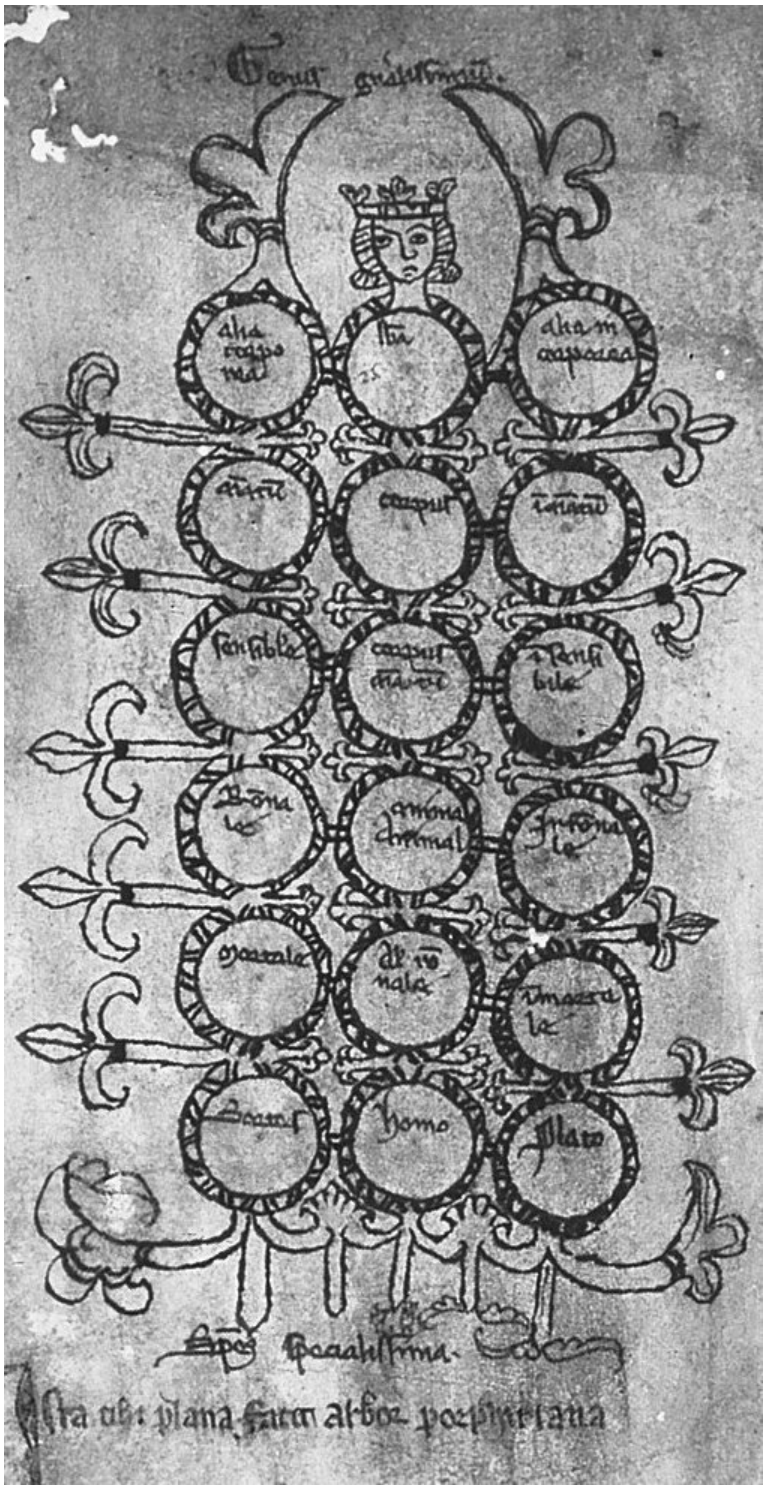


Figure 2.16 Peter of Spain, *Tractatus.* Vienna, *Österreichische Nationalbibliothek*, cod. 2389, f. ov. Dated late 13th/14th century.

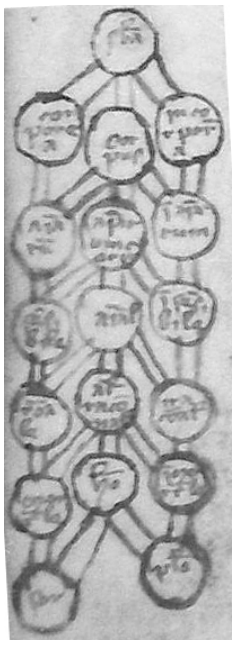


Figure 2.17 Boethius, *Isagoge, translatio.* Barcelona, *Archivo de la corona de Aragon*, ms. Ripoll 134, f. 2v. Dated 14th century.

possible or contingent, as shown in the final four petals.

The compilation hosting this illustration was Oxford's favourite compendium of logic, called the *Summule ad modum Oxonie* (summaries in the Oxford way).[328]

Assymetric reading

A second conflict, regarding the composition of the figure in relationship to the theory it illustrates, is the lateral and asymmetric reading direction of the two sides of the tree. The branches on either side of the trunk are antithetical: bodily and not bodily, rational and irrational etc. Antithetical branches should be read laterally.

The theory of the Tree of Porphyry is, however, asymmetric, which necessitates an inorganic reading of the lateral branches.[329] Each of the pair of branches has a positive and a negative side. The negative side is on each occasion a blind alley: non-animated bodies, like stones and minerals, are the end of their series. So, although the Tree of Porphyry is drawn symmetrically, only the left side

[328] Further research is needed on this compilation and the logic compendia 'Cum sit nostra' *ad usum Oxonie*. See, for the Oxford tradition of the 'Cum sit nostra': De Rijk, *Logica modernorum: A contribution to the history of early terminist logic. 2/1. The origin and development of the theory of supposition*, 416–448. See further: E.J. Ashworth, "Les manuels de logique à l'université d'Oxford aux XIVe et XVe siècles," in *Manuels, programmes de cours et techniques d'enseignement dans les universités médiévales*, ed. J. Hamesse (Louvain-la-Neuve, 1994), 351–370.

[329] Evans, "The geometry of the mind," 39.

allows one to descend down the logical figure: which makes sense when we recall that the whole canonical debate illustrated revolved around the definition of mankind and so leads directly towards mankind. The figure after all does not deal with the definition of horse, or plant, or even the difference between horse and man.[330]

In some copies the symmetry is yet further elaborated. Lines connected the blind alley back to the main column.[331] In the left column these lines allow a correct inference, but reconnecting the right wing with the species below is incorrect because the contradictory *differentie specifice* have no direct relation with the species below.[332] [*See* figure 2.17]. A comparable attempt was made by the draughtsman who drew dogs biting into the concepts in the right column, leading one back to the main column.[333] [*See* figure 2.18]. Presumably, these connections between the negative differences are drawn in an attempt to make the figure more self-supporting by indicating the direction of reading. Logically, however, they are incorrect.

A rare but logically coherent figure appears in an eleventh-century copy of the Commentary on the *Isagoge* by Boethius.[334] This figure describes the differences of substance and takes these as a description for the species.[335] [*See* figure 2.19]. Substances are shown as either bodily or non-bodily; bodily substances in turn are either animated or inanimated, (such as stone and metal); the animated ones are either sensible or else not sensible (such as plants). Below, the draughtsman wrote something which was later erased and should read that sensible animated bodies are either rational or irrational (the latter of which are animals). Next, the sensible animated bodies are either mortal or immortal, of which the latter are such as the (pagan) gods. Corresponding to the mortal, sensible animated body is the 'human being', the definition of which was the objective of stating this series diagram form. It is unclear what the draughtsman had in mind when he drew several lines departing from the (erased) rational and irrational beings. In this design it is clear that the right site of the figure is of no importance and that the series leads directly to mankind.

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330 See herefore the useful logical discussion of the Tree of Porphyry in: Eco, *Semiotics and the philosophy of language*, 57–68.

331 Also in: Barcelona, *Archivo de la corona de Aragon*, Ripoll cod. 134, f. 2v; Paris, *Bibiothèque nationale*, lat. 6657, f. 4r; Paris, *Bibiothèque nationale*, Arsenal, cod. 728, f. 2r; Monte Cassino, *Archivio della Badia*, cod. 362, f. 102v; Rome, *Biblioteca Angelica*, cod. 953, f. 60r.

332 Barcelona, *Archivo de la corona de Aragon*, Ripoll ms. 134.

333 Vienna, *Österreichische Nationalbibliothek*, cvp 5248.

334 St. Gall, *Biblioteca Abbaziale*, cod. 831. In the prologue of the manuscript copy in which this unique figure was drawn, it is stated that with the topic is Boethius' commentary on the *Isagoge* as translated by Victorinus, a Christian neo-Platonist.

335 See, for comparison, a similar, modern figure of the Tree of Porphyry drawn in: Eco, *Semiotics and the philosophy of language*, 60.

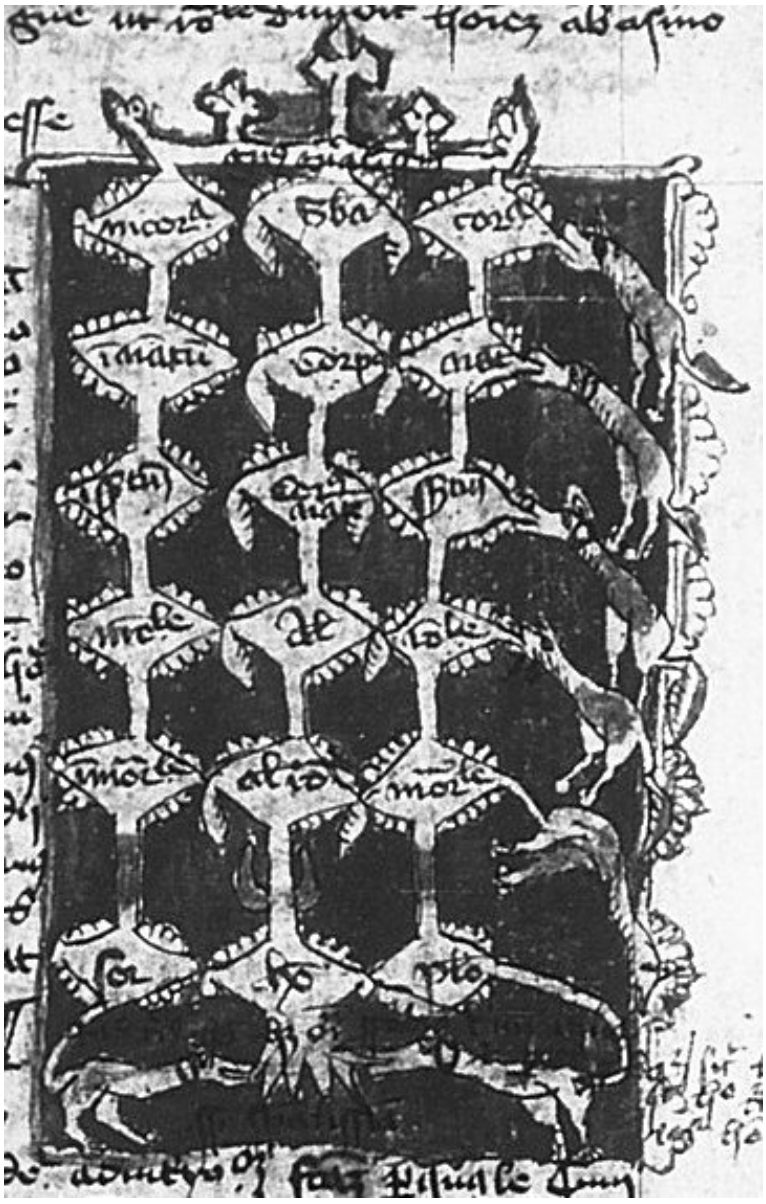


Figure 2.18 Peter of Spain, *Tractatus.* Vienna, *Österreichische Nationalbibliothek*, ms. CVP 5248, f. 5v. Dated 14th century.

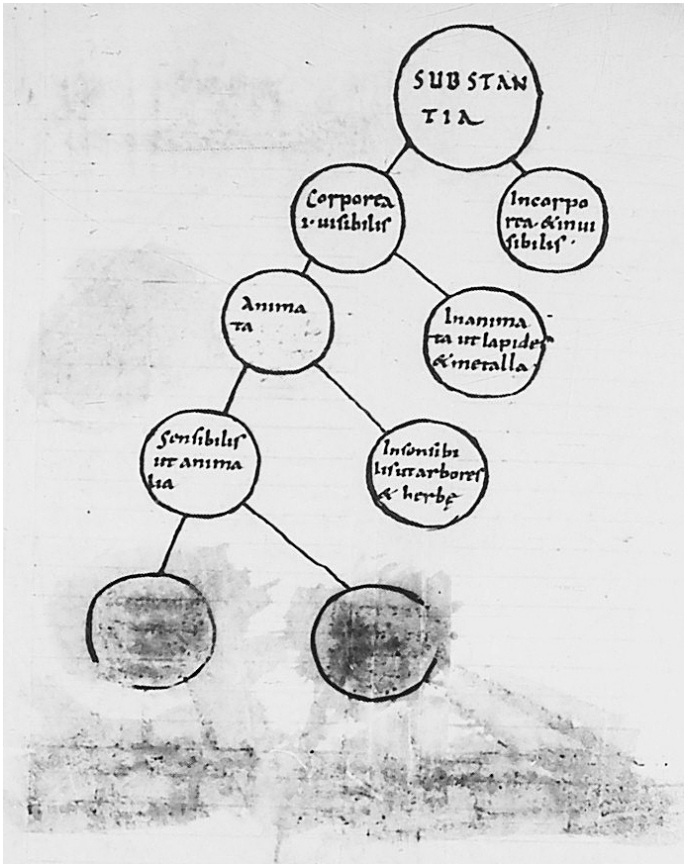


Figure 2.19 Boethius, *Commentary on the Isagoge.* Saint-Gall, *Biblioteca Abbaziale*, cod. 831, f. 184v. Dated 10th/11th century.

The tree is an indirect image with a symbolic character that includes hierarchy, ramification, organic growth, flowering, cyclical life, fresh and rotten fruits and the like. It works only deficiently for the Tree of Porphyry. The representation of hierarchy works, organic growth also - though invertedly and only in the case of the branches on the left side. The other inferences, by contrast, do not work at all. The tree metaphor is, overall, not a very consistent image for the Tree of Porphyry. Feelings of conflict, because of the inverted quality of the tree, become yet more explicable when one realizes that the Tree of Porphyry had not always been shown as a tree figure. Evans, though aware of the risk of comparing scholastic methods with visual art, is convinced that the graphics in the Tree of Porphyry were used for logic argumentation.[336] My study of the pictorial tradition, and my logic analysis of the Tree of Porphyry sheds a different light on the tree metaphor, which was added later to an already existing figure.[337] The Tree of Porphyry started out as a simple dichotomy. In its earliest forms the drawings readily support good inferences and the logical coherence of the diagram is not problematic at all.

2.5 Meaning and relevance of the tree

In the previous section, I argued for the need to analyze the structure of diagrams in terms of logic coherence. Illogical inferences often had an explicable cause in the iconographic history of the diagram. Here I will try to explain why, if the tree metaphor was not very useful in conveying the meaning of Tree of Porphyry, the tree metaphor was nonetheless employed so widely. And also why the tree metaphor was widely used only from the thirteenth century onwards. Indeed one could even go further and wonder why the Tree of Porphyry should be designed as a dichotomy at all: the oldest examples of figures in the translation were after all tables (and were not named 'trees'). Besides, the tree metaphor was not the only metaphor employed. We also saw above the image of the *syndesmos* as a common metaphor for the Tree of Porphyry. What, then, was the benefit of organizing the *predicabilia* into a tree?

If the answer cannot be found in the (already rather broad) textual tradition of the *Isagoge*, we should look instead for the design's meaning in a broader intellectual, theological and social context. The hypothesis I will put forward in this chapter presented itself when I realized how many tree-figures were made in the twelfth and thirteenth century. The Tree of Porphyry became standardized

[336] Evans, "The geometry of the mind," 35.

[337] See also: A.R. Verboon, "Einen alten Baum verpflanzt man nicht. Die Metapher des Porphyrianischen Baums im Mittelalter," in *Visuelle Modelle*, ed. I. Reichle, S. Siegel, and A. Spelten (Munich, 2008), 251–268.

as a tree in the course of the thirteenth century, as we saw above in section 2.3: *Form and inference*. This process fits into a general tendency.

Pictorial traditions for diagrams had been so enlarged and interwoven during the thirteenth century that certain diagrams emerged as veritable independent entities, with multiple perceived applications.[338] The tree figure in particular was applied to various subjects: the Tree of Love, the Tree of Virtues, the Tree of Vices, the Tree of Science, the Tree of Life, Tree of Knowledge, Tree of Wisdom, the genealogical Tree, Tree of Jesse, Tree of the Ten Commandments and the ages of man, Tree of affinity and consanguinity, Tree of heresies. And there is the Tree of Porphyry. We can truly speak in terms of a representative uniformity for the tree model in this period.

2.5.1 Device of structure

Due to spreading literacy in Western Europe, most of this diagrammatic material was created for the purposes of people seeking to write down material they had to present orally: sermons and prayers, school lectures and homilies.

Wirth has claimed in this context that the majority of diagrams worked, therefore, in the service of catecheses.[339] The image of the tree in particular belonged to the *artes predicandi*, used to instruct ordinary people. The necessity of reading the, often Latin, inscriptions in the figures presupposes a lettered milieu, a priori clergymen.

The fifteenth-century preacher Mauritius of Leiden thus stated «*predicare est arborisare*».[340] *Arborisare* was considered a rhetorical instrument of great value for (spiritual) orators. The sermon was supposed to be constructed like a tree, in which the introduction is like a trunk connecting the branches with the roots.[341] Mauritius of Leiden explained that the parts of the sermon are the branches, on which the fruits of Salvation hang.[342] The branches connect to the core of the sermon organically, each subdivision departing from the trunk.

In this period, in which writing materials were costly, learned men entrusted wisdom to their memory, in the knowledge that they were supposed to be able to reproduce a long discourse on demand. The majority of the tree figures

[338] F. Saxl, "A spiritual encyclopedia of the later middle ages," 5 (1942): 82–142, here 112.
[339] Wirth, "Von Mittelalterlichen Bildern und Lehrfiguren im Dienste der Schule und des Unterrichts," 282.
[340] D. Roth, *Die mittelalterliche Predigttheorie und das Manuale Curatorum des Johann Ulrich Surgant* (Basle, 1956), 128–130; Kamber, *Arbor amoris. Der Minnebaum. Ein Pseudo-Bonaventura-Traktat*, 70.
[341] Johann Ulrich Surgant, *Manuale Curatorum*, f. 204v: «*Hanc faciem committo memorie commendandam, quia meo judicio bene dirigit et sapere facit naturam introductionis*». See: Roth, *Die mittelalterliche Predigttheorie und das Manuale Curatorum des Johann Ulrich Surgant*, 129, n. 288.
[342] ibid., 130 n. 294.

in the moral domain were thus plausibly used for a better oral diffusion by preachers and confessors, who have seen, read and taught its contents.[343] If used by lettered laymen they possibly served for prayer or for meditation by a pious individual.[344] Can we understand the development of the visual tree repertoire in the thirteenth century in the same spirit?

Since the 1960's, some scholars have rediscovered the role played by the art of memory in medieval and renaissance culture.[345] The working of mnemonics is mostly studied in terms of mental images. Sometimes the same argument extends to physical pictures.[346] In the *Craft of thought* on early monastic visualizations and rhetoric, Carruthers has shown that «words and images *together* are 'two' ways of the same activity».[347] At a minimum, she is clear that mental pictures shared similar features with drawn diagrams.[348]

Bolzoni, in *The web of images*, which studies the rhetorical, logical and mental equipment of late-medieval preaching, described schemes as primarily mental: a structure that orders, while helping to create, content. These schemes take various forms: as words, mental pictures, physical pictures, and combinations of the preceding. They are «schemes straddling the border between the visible and the invisible, between reading and writing, memory and invention, exegesis and recycling».[349]

Wirth stated that the many visual representations surviving from the thir-

[343] A similar process of standardization took place in the context of *exempla*, which preachers of the mendicant orders of the Dominicans and Franciscans used to preach to the great mass of the people from the early thirteenth century onwards. In time uniformity and repetition took over from the invention of new *exempla*. The repetition of exactly the same *exempla* in a defined corpus of the most essential notions, which became increasingly better ordered, facilitated the improvisation of the preacher. It also facilitated his memorization and that of his flock. The tool of the *exempla* thus became increasingly efficient. See: J.-C. Schmitt, "Recueils franciscains d'exempla et perfectionnement des techniques intellectuelles du XIIIe au XVe siècle," in *Bibliothèque de l'Ecole des Chartes. Revue d'Erudition*, vol. 135, 1 (1977), 5–21, here 20.

[344] Schmitt, "Les images classificatrices," here 340.

[345] P. Rossi, *Clavis universalis: arti della memoria e logice combinatoria da Lullo a Leibniz* (Milan–Naples, 1960); F.A. Yates, *The art of memory* (London, 1966); Carruthers, *The book of memory. A study of memory in medieval culture*.

[346] Carruthers and Ziolkowski, *The medieval craft of memory. An anthology of texts and pictures*. See for more literature on mnemotechnics and diagrams (mainly) outside the medieval scientific realm for example: G. Hasenohr, "Méditation méthodique et mnémonique: un témoignage figuré ancient (XIIIe-XIVe s.)," in *Mélanges d'histoire, d'histoire de l'art et d'archéologie offerts à J. Stiennon*, ed. J. Deckers and R. Lejeune (Liège, 1982), 365–382; J.B. Friedmann, "Les images mnémotechniques dans les manuscrits de l'époque gothique," in *Jeux de mémoire. Aspects de la mnémotechnie médiévale*, ed. B. Roy and P. Zumthor (Montréal–Paris, 1985), 169–184.

[347] M. Carruthers, *The craft of thought: meditation, rhetoric and the making of image, 400-1200* (Cambridge, 1998), 142.

[348] Carruthers, *The book of memory. A study of memory in medieval culture*, 250.

[349] L. Bolzoni, *The web of images. Vernacular preaching from its origins to St Bernardino da Siena*, (Originally published as: La rete delle immagini: predicazione in volgare dalle origini a Bernardino da Siena. 2001) (Aldershot–Burlington, 2004), 6.

teenth century were created for the purposes of people needing to make compositions that were initially oral in form: sermons and prayers, school lectures and homilies, as stated above. The figures used in the service of catechesis were composed to help the preacher to recall his sermon in all its facets.[350]

Esmeijer was one of the first to explore figures with a character between words and images, the so-called 'typological' figures. She considered these figures visual-exegetic representations made in the service of preaching. She evoked the role of the *ars memorativa* in the interpretation of the commentary in which the figures appeared, and the complementary role therefore played by the interpreting reader.[351]

Carruthers insists on a visual memory. Students, she argued, would have mentally marked the important passages, memorizing them, noting the shapes of the letters, the position of the text on the page, and would then allocate each segment, with the teacher's comments 'attached' to a given textual image.[352] Preferably, a student studied his text from the same manuscript each time, getting used to its handwriting and layout.[353] Studying from the same copy brought mnemonic benefits, as one remembered given passages their by dog-ears, the colour of the ink, marginal spaces up to the edge of the book, titling: in short, everything that made your copy recognizable as your own.

Images in mnemonics often combine two functions: they can serve as a 'fixative' for memory storage, or as cues to start the remembering process. The one is, according to Carruthers pedagogical, the latter is meditational.[354] Bolzoni made the same distinction: schemes form the link between individual mystical exaltation and the didactical moment (of preaching).[355]

Basic didactics consisted in the use of structures to perform tasks of mnemonic inculcation, such as collating texts. This corresponds with the way in which the memory was thought to be structured in the Middle Ages. No memory came into existence passively, instead one had to construct memories during one's upbringing and education. Memory was seen as a consciously constructed system able to store and recollect different bits of information, like a library, and its maintenance and creation thus required the attention and care of the student.[356] Hence, Carruthers insists on the 'craft' of thought in several

[350] Wirth, "Von Mittelalterlichen Bildern und Lehrfiguren im Dienste der Schule und des Unterrichts," 282.
[351] Esmeijer, *Divina quaternitas. A preliminary study in the method and application of visual exegesis*.
[352] Carruthers, *The book of memory. A study of memory in medieval culture*, 159–160.
[353] This was what Hugo of St. Victor advised his students, but the idea was presumably a common one. ibid., 215.
[354] ibid., 253.
[355] Bolzoni, *The web of images. Vernacular preaching from its origins to St Bernardino da Siena*, 7.
[356] Carruthers, *The book of memory. A study of memory in medieval culture*, 33.

of her book titles. Tool making, the creation of images in the first place, was an essential part of this craft of memory and also of didactical use, because of its active role in digesting chunks of knowledge. The beholder could use the image as a cognitive tool, hence images were useful in teaching that had as its objective effective thinking.

The didactical and meditational aspects were nonetheless intertwined. The meditative act was generated by reminiscing, cogitation, shuffling and the collating of 'things' stored in memory.[357] These 'things' we should comprehend not as concepts or objects but as memory cues, used for constructing new work. Pictures do not stick in the mind as concepts or objects but as «an inventory of synaesthetic, syncretic memory cues». This inventory can be «drawn upon, drawn out from and used for constructing new work».[358] The beholder therefore used images for further thinking. They act as reminders, pointing to something else.

The concepts in a diagram are, as such, like key words, each of which brings other texts, sayings and explanations along with it. The very structure allows 'fishing', to use another metaphor commonly used in the Middle Ages.[359] It invites the reader to wander, in quest of different doctrines, in parallel diagrams, that might enrich the figure. Medieval thinkers did not reserve this meditational feature for writings and images in the spiritual realm, although in recent times there has been quite some attention paid to preachers' tools and schemes for related spiritual purposes.[360] If we understand meditation broadly, in the sense of rumination and reflection, these ideas of fixation and recollection are of utility for the interpretation of scientific visual representations.

2.5.2 Pulling trees: a few examples

It is worth pausing over the phenomenon of 'pulling' or 'fishing', to see how this phenomenon could actually work for the Tree of Porphyry. I will therefore employ an example from a copy of the *Clavis Physice*, written by Honorius Augustodunensis (1080–1157), and nowadays kept in Paris.[361] There will be no attempt at a detailed exposition of the philosophy in it or at a comprehensive

[357] Carruthers, *The craft of thought: meditation, rhetoric and the making of image, 400-1200*, 4.
[358] Carruthers and Ziolkowski, *The medieval craft of memory. An anthology of texts and pictures*, 148.
[359] Carruthers, *The book of memory. A study of memory in medieval culture*, 247.
[360] Studies consecrated to catechetical diagrams are: Bolzoni, *The web of images. Vernacular preaching from its origins to St Bernardino da Siena*; Sicard, *Diagrammes médiévaux et exègese visuelle. Le 'Libellus de Formatione Archae' de Hugues de Saint-Victor*; Esmeijer, *Divina quaternitas. A preliminary study in the method and application of visual exegesis*; Saxl, "A spiritual encyclopedia of the later middle ages"; Katzenellenbogen, *Allegories of the virtues and vices in mediaeval art*.
[361] Paris, *Bibliothèque nationale*, lat. 6734, f. 2v.

survey of the issues the text raised. My main purpose in dealing with the diagram in the *Clavis physice* is to show how Carruthers' notions of 'pulling' and 'fishing' might work for the Tree of Porphyry.

The figure in question shows the steps of being. [*See* figure 2.20]. At the top God is shown in a medallion. From him two lines depart ending respectively in a medallion inscribed *anarchos* and in one marked 'without beginning' (*sine principio*): both terms meant the same thing.[362] In the second tier is inscribed *archetypus mundus*, the archetype of all that is in the world – the ideas and the spirit of God. The archetypical world is a kind of Platonic Idea of the world, an insubstantial model of all creation, and also a link between God and His actual creation. Related to the archetypical world, placed on the right, are the Dionysian names *Bonitas, Essentia, Sapientia* and *Vita*. These were manifestations *(theophaneia)* of God through which we know of His existence. These manifestations, which are universal forces of causation, survive in the Son (who is also the Word): «*in filio cause omnium*» - (in the son are the causes of all things).

From the third tier onwards, the visible world comes into existence. Honorius divided beings into five categories: the intellectual, rational, sensitive, vital and corporal. The angels contemplate God in His manifestations, and they are, as such, an *intellectualis creatura*. Below the angels is man, a rational being, *rationalis creatura*. Beneath man is placed *sensibilis vita animantium*, a being endowed with senses, like an animal. He is, equally, a *vitalis creatura*, that is endowed with life and sense perception. Beneath the percipient being is the mere vital one, the <*creatura*> *vegetabilis*, like a tree, which is a *motabilis creatura*, a being endowed with motion (because a tree grows). The last tier is reserved for the inanimate being, *corpus*, lacking any movement *motu carens*, like stones and qualities such as colours.[363]

This figure is found in the *Clavis Physice*, by Honorius Augustodunensis, and obviously shaped after the dichotomous model of the Tree of Porphyry. Neither of them, in this period, are actual trees. The resemblance between the two figures was previously noticed by Marie-Thérèse d'Alverny and Frances Yates.[364] Neither of them, however, observed that the Vienna copy of the *Clavis*

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[362] Honorius Augustodunensis, Clavis Physice, (16) Prima divisio nature: «*Prima itaque divisionis nature differentia nobis visa est in eam que creat et non creatur, que species de solo Deo recte predicatur, qui solus omnia creat et ipse a nullo creatur. Ipse anarchos, id est sine principio, ipse principalis causa omnium que sunt, ipse principium, quia ex se sunt omnia, ipse medium, quia per ipsum subsistunt omnia, ipse finis, quia ad ipsum tendunt omnia […]*» (P. Lucentini, ed., *Clavis physicae* (Rome, 1974)). This excerpt is similar to John Scotus Eriugena, *De divisione nature*, liber I, 11.

[363] M.-T. d'Alverny, "Le cosmos symbolique du XIIe siècle," *Archives d'histoire doctrinale et littéraire du Moyen Âge* 28 (1953): 31–81, here 48–55.

[364] ibid., 50; F.A. Yates, "Ramon Lull and John Scotus Erigena," *Journal of the Warburg and Courtauld Institutes* 23 (1960): 1–41, here 14.

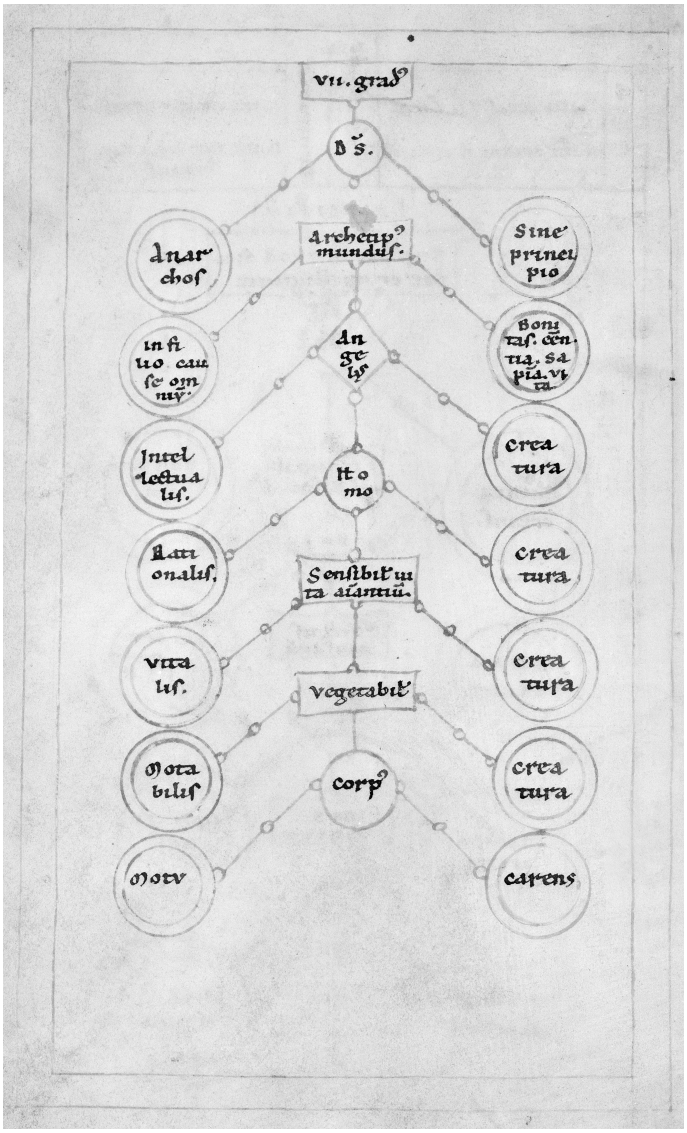


Figure 2.20 Honorius Augustodunensis, *Clavis physice.* Paris, *Bibliothèque nationale*, ms. lat. 6734, f. 2v. Dated second half of the 12th century.

Physice actually depicts the Tree of Porphyry in its appendices.[365]

Augustodunensis used Eriugena's *De Divisione Nature*, in which there is a good deal of logic from the *Isagoge* and the *Categories*, as a main source.[366] The textual tradition of the Tree of Porphyry was therefore closely present for Honorius Augustodunensis.

There are however several differences between the Tree of Porphyry figure and the Seven grades figure from the *Clavis physice.* The *differentie* of the created world in the *Clavis* are placed in opposing pair of branches, but the content is a single phrase: *motu–carens, motabilis–creatura, vitalis–creatura, rationalis–creatura, intellectualis–creatura*. Dividing them on the two sides of the central descending line looks nice, but it is without substantive explicatory utility.

Another difference of importance is that *corpus* is in the Tree of Porphyry on top, and in the *Clavis physice* at the bottom. In the *Clavis physice* one descends from the uncreated world to the created one, and from the angels to the body – the result of emanation. However, in the textual description in the *Clavis physice* the order starts with *corpus* and ends with 'God'. For this figure then, the draughtsman thought that it would be more proper to visualize God at the top, and *corpus* as the lowest unit, far below. With the idea of a division to left and right he alluded to the mechanism of *divisio* and *analysis*, a central idea in Eriugena's *De divisione nature*, which amounts to the idea of division and multiplication of the one primary Cause into various primordial causes, then into manifestations and on into *genera*, *species* and particular things. Subsequently, in the *analysis*, the multitude gathers itself back up, through the same stages, to the one Cause, which is God. Honorius, however, does not show any division in his diagram; in other words only emanation (or definition), and no *analysis*.

Borrowing an existing compositional structure facilitated memorization thanks to its rigid structure, and boosted improvisation through recollection and collation. By enlarging the group of similar figures, one increased opportunities for systematic instruction. For instance, by equating logical concepts with physical ones, Honorius Augustodunensis juxtaposed Plato's and Aristotle's analyses by placing Plato's doctrine into an Aristotelian illustration. The Tree of Porphyry is a logical figure that gives an example of definition by using the specific case of man in relation to the broad category of substance. Their genus and species are only conceptual or semantic entities (meta-things). The seven steps diagram in the *Clavis physice*, however, shows a taxonomic picture of the whole of reality: if God as highest being and highest genus is the principle of all things, then the things found below are real beings. In

[365] Vienna, *Österreichische Nationalbibliothek*, ms. 3605, (1r-103v), 13c. Diagram of the Tree of Porphyry on fol. 104r.

[366] D'Alverny, "Le cosmos symbolique du XIIe siècle," 39.

this introduction of vertical causation, the Aristotelian diæresis is transformed into a *scala entis*, a platonic ontological scale. In the *Clavis physice* we are talking about the natural world using a schema borrowed from the exposition of the relationship between abstract logical concepts. Aristotle himself had sharply distinguished between the physical and the logical sense of genus.[367] But Eriugena, and hence Augustodunensis, made the steps of abstraction coincide with the degrees of real existence: he thereby emancipated a structure illustrative of logic for use in other domains.

The mechanism of 'pulling' and 'fishing' between the two diagrams works between the Seven degrees diagram in the *Clavis physice* and the Tree of Porphyry, which were both in the twelfth century unadorned with vegetative elements, and whose collation depended on the bare diagrammatic structure. The 'pulling' and 'fishing' of theories between the multitude of fully drawn diagrammatic tree structures would appeal even more to scholars in the thirteenth century. The collation and substitution of parallel doctrines would, at that time, become self-evident to the reader and the orator.

The model of the Tree of Porphyry is appropriated with less severity in the lavishly decorated logic tree in the Burney-copy with which we started this chapter. Lady Dialectica teaches the students the basics of logic by showing them a tree diagram that stands between them. The diagram is Aristotelian logic in a nutshell, which every student had to know by heart in order to pass their baccalaureate exam. [*See* figure 1.]

The tree-diagram is a vegetative tree and at the same time an abstract mould in which to organize information. The student must accept the figure, fix it in his mind and accommodate it with his previous experiences. One of these previous experiences is, without doubt, the canonical Tree of Porphyry which had by then already had an existence of its own. The Tree of Porphyry puts the category 'substance' to the use, whereas the Burney-tree defines the various categories without showing their actual functional relations.[368] The Burney-initial 'C' displays a variation of the diagram which 'communicates' with the tradition of the Tree of Porphyry. Following intensive study, the Tree of Porphyry changes into a model in the reader's mind, which he can adjust, employ and even apply in other situations. He can compose verbal phrasing using the key-concepts in the tree and build upon that start. He must therefore set free the visual figure, abstract it and formalise it in his mind. As a result, the acquired bits of information and the visual model abide in one's mind, even when they are no longer visually present.

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[367] See for a discussion about substance, being and division between Plato, Aristotle, Seneca, Cicero and the Stoic: Mansfeld, *Heresiography in context. Hippolytus' elenchus as a source for Greek philosophy*, 78–109.

[368] Camille, "Illuminating thought: the trivial arts in British Library, Burney ms. 275," 365.

2.6 Conclusion: Learning as a performance

This chapter dealt with the morphological structure of the Tree of Porphyry on the basis of a systematic examination of manuscript copies of the *Isagoge*, Boethius' commentary and the *Tractatus*. Several conclusions concerning the pictorial tradition can be drawn.

This chapter demonstrated that the Tree diagram was synthesized from several diagrams that conveyed different pieces of knowledge, based on examination of the iconographic history of the Tree of Porphyry. There is thus a clear tension between the origins of the diagram, its form and its name, the 'Tree of Porphyry'.

To recap, some diagrams occurred as marginalia in Boethius's *Isagoge, translatio*. These diagrams, not exactly trees, sought to present every type of information: differences, species, and genera. Meanwhile, in the text of Boethius' commentary on the *Isagoge*, there were attempts to put these different fragments of knowledge into a more global representation. The result took the form of the Tree of Porphyry. This diagram had the basic structure of the canonical tree of Porphyry, but not yet the arboreal features. It stabilized formally and replaced the marginal diagrams in the *Isagoge* during the twelfth century. The diagrams in the *Isagoge* had remained marginalia, whereas the synthesis of the Tree was embedded in the text of Boethius' commentary and was announced by it. This observation led to the suggestion that it might have been Boethius who synthesized the preceding figures into the Tree of Porphyry.

Throughout this process we cannot really speak of trees. As far as we can tell, on the basis of what has been preserved, Peter of Spain was indeed the first to write down the name Tree of Porphyry in a manuscript. The tree-nomenclature derives most probably from the *arbor iuris*, the trees of consanguinity seen in eighth-century manuscripts. Vegetative elements were present before Peter of Spain used the word *arbor*, but these diagrams are not drawn as trees or called trees. Once Peter designated the diagram as a tree, it began to be drawn with all the characteristics of a tree and the logical branches became pictorial branches. Only then, in other words, was the tree drawn like a tree, with roots, a trunk, branches, leaves, a crown etc. A real tension emerged in the wake of this change, operating vertically and created by opposing directions of organic growth and reading logic. Scribes attempted to make the trees more tree-like, and offered trees with the branches growing upwards. This, however, was logically incoherent – a fascinating illustration of the tension that can be created between image and logic. Some draughtsmen point up the struggle with this tension and sought to resolve the conflict over direction by drawing a tree with horizontal branches.

The drawing of Porphyry's Tree like a real tree is understandable given the thirteenth-century's growing repertoire of tree figures in the moral domain.

Students were not only supposed to learn the rudiments of logic but also the form in which they could store the bits of information learned. The storage of information served the student eventually as a way of recovering specific bits of knowledge on demand.

Holding a repertoire of images in one's mind allows one a significant suppleness in the collation of doctrines and texts solely through visual similarity. Morphologically identical structures permit one to combine data stored using the same structure and hence to create new ideas, new arrangements. The composition of the tree is therefore a mental structure that is infinitely expandable. Being trained in a repertoire of figures permitted one to collate flexibly different doctrines during lectures, disputes, and sermons.

Tree-diagrams, then, cannot be considered self explanatory. Trees all look the same, but they might support different inferences. And the same subject can be visualized using different morphologies. Choices were made when translating ideas visually. Text and diagram, in the case of the Tree of Porphyry, are not fully congruent. Which choices were made became clear here after careful examination of the pictorial history of the Tree of Porphyry in many manuscript copies. The choice of the tree metaphor proved explicable only within its broader social culture, in which oral practise and mnemonics played a vital role.

The tree-diagram in the Burney-volume with which we started this chapter seems to be more coherent. The draughtsman ordered different logical concepts which could be placed bottom-up, and therefore avoided the tension in direction. It is a complex pedagogical image. There is interplay between the reader of the text, and the students in the picture with whom the reader of this copy was to identify himself. The book held by Lady Dialectic is shown to the reader, but not to the students. The students in the picture deliberate about logic by rote. They practise the notion of learning as a performance, rather than as reading texts. The reader is summoned to enter the learning process similarly and to memorize the tree figure, which stimulates and provides a template for memorization. The university, then, was the place where students learned to engage in verbal disputations. Diagrams are a basic part of the learning process in that they allow the reader to analyze data and to organize concepts and theories. The tree-diagram, here flourishing lavishly and growing beyond the frame of the 'C' and into the margin, underlines the notion of learning and orating rather than reading or writing.

Chapter 3

Changing matters: measuring qualities

3.1 Introduction

«I caused», Roger Bacon says, «young men to be trained in languages, in figures, in numbers, in tables, in the use of instruments, and in many other necessary things [...]».[369] Bacon (c. 1214–1294), an English scholar teaching at the University of Oxford and later at Paris, was known as the Wonderful Teacher (*Doctor Mirabilis*). With the help of mathematics, he made advances possible in the physical sciences. Bacon pressed his students to develop numerous skills: they had to master languages, train themselves in the crafts of image making, and get the hang of various instruments. Bacon's own master was Robert Grosseteste (c. 1170-c.1253), also an English scholar teaching in the University of Oxford and Paris. Grosseteste equally considered figures and tables to be crucial to study: «No one could understand natural philosophy without taking into account lines, angles and figures».[370] Bacon and Grosseteste were both celebrated natural philosophers who leaned heavily on mathematics and geometry in their studies of natural phenomena.

These great scholars searched for new ways to describe natural phenomena

[369] Roger Bacon, *Opus tertium*, cap. 17: «*et feci juvenes instrui in linguis, et figuris, et numeris, et tabulis, et instrumentis, et in multis necessariis*» (J.S. Brewer, ed., *Fr. Rogeri Bacon: Opera quaedam hactenus inedita* (London, 1859)). See also: Roger Bacon, *Perspectiva*, V, (J.H. Bridges, ed., *The 'Opus majus' of Roger Bacon* (London, 1897)).

[370] Robert Grosseteste, *Tractatus de fractionibus*, begin: «*Utilitas considerationis linearum, angulorum et figurarum est maxima, quoniam inpossibile est sciri naturalem philosophiam sine illis*» (ed. M. Curtze, "Zwei Beiträge zur Geschichte der Physik im Mittelalter. 1. Das Buch Euclids de gravi et levi. 2. Der Tractatus de fractionibus et flexionibus radiorum des Robertus Linconiensis," *Bibliotheca mathematica. Zeitschrift für Geschichte der mathematischen Wissenschaften* 3, no. 1 (1900): 51–59, here 55).

and their work reflects a new attention to geometry and mathematics. They used logic and geometry, and urged their students to make equal use of it in their own study, because it had come to seem necessary to them in their quest to understand natural philosophy. Like Grosseteste, Bacon studied the propagation of light, and felt that a mathematical approach in optics was the solution to understanding the operation of all physical forces.

Optics, but also the sciences of weight, harmonics, astronomy and the 'latitude of forms', were *scientie medie*, situated between mathematics or geometry on one hand and natural philosophy on the other. Geometrical forms like lines could be used to demonstrate the reflection and refraction of light by being shown changing direction. Bacon, Grosseteste (and also John Peckham) therefore illustrated their treatises on optics with geometric diagrams. These were used to deal with theories of light and vision, visual perception, binocular vision, errors of vision, and many other problems concerning reflection and refraction.[371]

SHIFTING EMPHASES

This new methodological emphasis on geometry and graphing is the topic of this chapter. Below, I will discuss the impact of the new intellectual approaches on the form and content of diagrams, using the example of the diagrammatic representation of the four elements (substantial matter) and their primarily qualities, in the Carolingian period and in the fourteenth century. The use of two periods of investigation permits comparison and illustrates conceptual change by testing the interaction between verbal and visual notation. Changed occurred in the thirteenth century: the freshly studied books *De generatione et corruptione* and *Physica* breathed new life into thinking about substantial matter and change. As a result, both visual and verbal systems of notation were reconsidered, permitting new representations of the problem, of the method and of the answers, in the search for new solutions.

A case study of the elements and their qualities is of special interest. The four elements were a central notion in natural philosophy and natural science for they determine the constitution of the physical world. With this subject, we broach the study, by physics, of the reality of things - the visible world of the sublunary realm.[372]

The case study deals with some new, fourteenth-century ideas about and approaches to the variability of phenomena in the physical world. The new movement of thought in the fourteenth century is commonly described as the Nom-

[371] Murdoch, *Album of science: Antiquity and the Middle Ages*, 146–147.

[372] A. Maier, *An der Grenze von Scholastik und Naturwissenschaft. Die Struktur der materiellen Substanz. Das Problem der Gravitation. Die Mathematik der Formlatituden* (Rome, 1952), 3–5.

inalist or Terminist movement. Representatives of this new kind of physics included the so-called Oxford Calculators and the Parisian Nominalists. These scholars did not satisfy themselves with a demonstration of the immutable behind the changes observed in nature. Instead they sought answers, to the question of the constitution of material substance, in the qualities of the material itself. These scholars eventually moved away from traditional Aristotelian conceptions, and, in contrast to Aristotle, began to consider the qualities of material substance as measurable. The most significant result in this area was the *'latitudo formarum'* ('latitude of form'). The result emerged from the question of how qualities (such as heat, or motion) could vary in intensity (we would say temperature or velocity in these respective examples), and how one should measure such variations when distributed over a given subject or time.

Consequently, the guiding questions posed here are: to what extent did diagrammatic representations reflect the new approaches?; to what extent were the diagrams themselves new or else use inherited diagrammatic structures?; to what extent did these images help in resolving and understanding the transformations in scholars' views concerning substantial matter?

The existing literature has tended to show that the exact relationship between new approaches in science and the attendant visual conceptions varies widely from case to case.Lüthy, for instance, observed that until well into the seventeenth century the spherical form of globular particle diagrams survived, unperturbed, the most profound conceptual changes in matter theory.[373] This implies that visual representation does not always keep pace with scientific developments. In the case of medieval cosmology and astronomy, however, Müller observed that the main theories and observations of the day produced very different, although equally accurate, corresponding diagrams of the spheres.[374]

This chapter, in contrast, will focus on changing substantial matter and will add thereby another perspective on just how new scientific approaches impacted the form and content of diagrams.

Only a few scholars have worked on the abstract diagrams of the four elements.[375] *La cosmologie médiévale* by Barbara Obrist, published in 2004, is by

[373] The survival of the globular conception of atoms in different scientific theories remains a mystery; it is not very apt, let alone sophisticated to have such a long pictorial history. Lüthy concludes that the outcome of images is independent of scientific theories. Lüthy, "The invention of atomist iconography."

[374] Müller dealt with variability of figures in the same text, giving the example of the *Dragmaticon philosophie*. See: Müller, "Irritierende Variabilität. Die mittelalterliche Reproduktion von Wissen im Diagramm." See also by her: K. Müller, "Formen des Anfangs. Sphärendiagramme aus dem 13. Jahrhundert," in *Diagramme und bildtextile Ordnungen*, ed. B. Schneider (Berlin, 2005), 85–96; Müller, *Visuelle Weltaneignung. Astronomische und kosmologische Diagramme in Handschriften des Mittelalters*.

[375] See for the period up until the twelfth century: Esmeijer, *Divina quaternitas. A preliminary*

far the most comprehensive study on early medieval notions of cosmology as expressed in text and image. Her objective was to demonstrate that the study of nature was not rediscovered only during the Renaissance, but rather that the rational explanation of natural phenomena also occurred in the period from the seventh to the twelfth centuries. This scientific curiosity expressed itself over the course of these centuries not only in text but also in many pictures, including astronomical ones, and in pictures of physical structures such as the elements and their primary qualities.[376]

Art historians have paid only limited attention to visualizations of the four elements and their studies have generally been directed to the pictorial representations of the elements as mythological gods, personifications, animals or symbols such as earth, a spring, clouds and a flame.[377]

The objective of my chapter is to analyze, through the prism of scientific renewal, late-medieval pictures that dealt with the question of the compound of material substance, by contrasting them to the previous repertoire of elemental diagrams. The period after the twelfth century has not hitherto been explored when it comes to the diagrammatic representation of the qualities and elements.

SCHEME AND SOURCES

The first section of this chapter, *3.2: Nature and the fundaments of being*, page 94, deals with the main theories of the four elements and qualities that the fourteenth century inherited. This philosophical background of elemental theories provide the setting against which we should understand the fourteenth-century scientific developments in the understanding of substantial matter, and includes theories developed by Aristotle in his *De generatione et corruptione* and *De celo*, in Plato's *Timeus* and in the medical tradition transmitted by Avicenna. Then, after a short survey of medieval commentators, I briefly describe the essentials of the new fourteenth-century interest in the mixture and quantification of qualities.

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study in the method and application of visual exegesis. Studies on isolated elemental figures are equally useful: D'Alverny, "Le cosmos symbolique du XIIe siècle"; M.M. Gorman, "The diagrams in the oldest manuscripts of Isidore's. With a note on the manuscript traditions of Isidore's works," *Studi medievali* 42, no. 2 (2001): 529–545; B. Eastwood, "The diagram of the four elements in the oldest manuscripts of Isidore's De natura rerum," *Studi medievali* 42, no. 2 (2001): 547–570; B. Eastwood, *The revival of planetary astronomy in Carolingian and Post-Carolingian Europe* (Aldershot, 2002); H. Bober, "In Principio. Creation before time," in *Essays in honor of Erwin Panofsky*, ed. M. Meiss (New York, 1961), 13–28; L. Pressouyre, "Le cosmos platonicien de la cathédrale d'Anagni," *Mélanges d'archéologie et d'histoire* 78 (1966): 551–593.

[376] Obrist, *La cosmologie médiévale. Textes et images. I. Les fondements antiques*.

[377] See for example: A. Uthor, "Elemente," in *Reallexikon zur deutschen Kunstgeschichte*, ed. G. Frey, E.J. Beer, and K.-A. Wirth (Stuttgart, 1958), 1256–1288. See, for some pictorial examples, also: Murdoch, *Album of science: Antiquity and the Middle Ages*, 347, fig. 281.

To capture the differences that characterized the transition from one approach to substantial matter to another, the manuscript sources of this chapter are derived from two different periods. These two periods correspond to two sections in this chapter, in each of which representative diagrams are shown.

In section *3.3: Harmonizing qualities and elements*, page 105, the early-medieval tradition is illustrated using sources from the Carolingian period, featuring manuscript copies of the work of Isidore of Seville (ca. 560–636). Several main theories by Aristotle and Plato came down over time to Isidore and merged in his *De natura rerum*. The diagrammatic structures in his book consequently show aspects of both traditions. By the time of Isidore the pictorial tradition regarding these questions was well established; he did not have to invent the diagrams himself.

In section *3.4: Measuring qualities and motions*, page 121, some diagrams of the fourteenth century are dealt with. The new, quantitative approach to physics in the fourteenth century was especially prominent in Oxford and Paris. Amongst the Oxford 'Mertonian Calculators' were John Dumbleton, Richard Swineshead and William Heytesbury and their name Calculators links these authors with mathematics and science.[378] The Parisian Nominalists featured, among others, Nicolas Oresme, Albert of Saxony, John Buridan and Marsilius of Inghen. After careful exploration of the few available sources I selected diagrams in works of interest to the question of scientific conceptual change. These are: the alchemical-pharmacological *Icocedron* of Walter Odington; the treatise *De configuratione* of Nicolas Oresme; and the unknown *Termini naturales* of William Heytesbury (adapted by a Master Albert, John Garisdale and Thomas Netter) in the tradition of the Oxford Calculators.

Oresme's approach to the quantification of qualities has received quite some attention from historians. His geometrical method of presenting the configurations of qualities was made famous by Duhem in particular.[379] Since then, scholars have discovered that Oresme was preceded, not followed, by similar work written at Merton College, Oxford.[380] A search through about 50 copies of

[378] J.E. Murdoch, "Philosophy and the enterprise of science in the later middle ages," in *The interaction between science and philosophy*, ed. Y. Elkana (New Jersey, 1974), 51–74, here 67, n. 39; Sylla, "The Oxford Calculatores," here 561–562.

[379] P. Duhem, *Études sur Léonard de Vinci, ceux qu'il a lus et ceux qui l'ont lu*, 2 vols. (Paris, 1906–1909).

[380] See for example: Maier, *An der Grenze von Scholastik und Naturwissenschaft. Die Struktur der materiellen Substanz. Das Problem der Gravitation. Die Mathematik der Formlatituden*, 257–288; M. Clagett, *The science of mechanics in the Middle Ages, 1200-1400* (Madison (Wisc.), 1959), xxv-xxvi. See also: P. Marshall, "Nicole Oresme on the nature, reflection, and speed of light," *Isis. An international review devoted to the history of science and its cultural influences* 72 (1981): 357–374; U. Taschow, *Nicole Oresme und der Frühling der Moderne: Die Ursprünge unserer modernen quantitativ-metrischen Weltaneignungsstrategien und neuzeitlichen Bewusstseins- und Wissenschaftskultur* (Halle, 2003).

natural philosophical textbooks, compiled by masters working in Paris, showed that the topic of the four elements and the quantification of qualities were salient in Paris, but also that these texts, besides the *De configuratione*, were not further illustrated. See Table C.2, page 267, for a survey of the manuscripts consulted for this chapter.

Later fourteenth-century and fifteenth-century Oxford textbooks, copied in the wake of Oresme's introduction of the 'configuration' diagram, used this new diagram to illustrate their texts. The hitherto rather unnoticed treatise called the *Termini naturales* is such a textbook. It is an introductory text of definitions and divisions for beginner students in natural philosophy and concerns in particular the configuration of qualities.[381]

3.2 Nature and the fundaments of being

The four elements (fire, air, water and earth) were an essential and traditional notion in the physics of the era under study, for they were held to determine the constitution of the physical world. Physics as a discipline belonged to cosmology, which was in turn divided into an astronomical domain and a sublunary physical one. In astronomical cosmology one examined the unchangeable order of the cosmos. The orbit of the sun and stars in turn determined the process of generation and corruption in the sublunary domain. In other words, the movements of heavenly bodies and stars were thought to cause physical phenomena on earth. Physical cosmology, by contrast, had as its object the changing sublunary domain and the elements were a part of this sublunary physics. Knowledge of the changeable was thought, however, to help to understand the unchangeable order, an understanding of which was considered to be more valuable.[382]

In this section the main theories regarding elements and qualities that came down to the fourteenth century will be set out concisely. In particular, Plato and Aristotle played major roles in the history of theories of matter. Plato put forward the idea that things are composed of matter and of form. Aristotle, meanwhile, held form to be only one of the four causes of generation. Both considered the four elements as building blocks, connecting the *prima materia* and things.

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[381] Weisheipl refers to this treatise in 1966 by its incipit, mentions it again in 1968 by title, and lists it finally in his *Repertorium Mertonenense* of 1969. See: J.A. Weisheipl, "Developments in the arts curriculum at Oxford in the early fourteenth century," *Mediaeval studies* 28 (1966): 151–175, here 174–175. See also: Weisheipl, "Ockham and some Mertonians," here 198; J.A. Weisheipl, "Repertorium Mertonense," *Mediaeval studies* 31 (1969): 174–224, here 216–217. Grabmann did not mention the *Termini naturales* in his seminal study. See: Grabmann, *Methoden und Hilfsmittel des Aristotelesstudiums im Mittelalter*.

[382] Obrist, "Le diagramme isidorien des saisons, son contenu physique et les représentations figuratives," here 106.

3.2.1 Elements and qualities in Antique theories

Aristotle's treatise *De generatione et corruptione* searched for the physical conditions and the causes of production and destruction of things and of individual beings.[383] In this text, Aristotle combined logical-combinatorial thinking with physical-chemical thinking. The idea behind the first approach is that there are only four primary qualities: heat and cold, dryness and humidity. Aristotle saw the four qualities, hot, cold, dryness and humidity, as an immediate cause of the interaction between the elements. In other words, these tangible qualities, made up of two pairs of contraries presenting principle differences, were held to combine to form the four elements. Each and every composite in the sublunary realm was thus a mixture of the four elements and each element possessed two of the qualities. Fire, for example, is dry and hot while air is hot and humid; water is humid and cold and earth is cold and dry.[384] All other combinations were thought impossible because the constituents form opposites. The theory of opposites occupied a central place in Aristotelian thought.

A second idea at work in Aristotle's *De generatione et corruptione* is physical-chemical in character, namely the notion that the transmutation of elements can only take place when one of its two qualities is replaced by another. Hence such a transformation takes place most readily between two elements having a quality in common. Water can become air if heat is added, replacing wetness. Water cannot become fire, however, for it possesses wetness - the opposite quality to the hotness of fire. Every element was also held to feature an active and a passive quality. Hotness and coldness were the active qualities, while humidity and dryness were passive.[385] The possible transformations were therefore systematized and determined by the relations between the elements: the *syzygia* (meaning 'union' in Greek), but also known by the Latinized term *conjugatio*. Many figures were created to illustrate this *syzygia*, as will be demonstrated below. Stoic thinkers would also simplify the Aristotelian theory by attributing only one quality to each element: air is cold, water is humid, fire is warm and earth is dry.[386]

In the *De celo*, Aristotle employed a cosmographic approach to the ele-

[383] See for example: M. Rashed, ed., *Aristote. De la géneration et la corruption*, Nouvelle édition (Paris, 2005); H.M. Robinson, "Prime matter in Aristotle," *Phronesis* 19 (1974): 168–188; G.A. Seeck, *Über die Elemente in der Kosmologie des Aristoteles. Untersuchungen zu 'De generatione et corruptione' und 'De caelo'*, Zetemata. Monographien zur klassischen Alterumswissenschaft, Heft 34 (Munich, 1964).

[384] Aristotle, *De generatione et corruptione*, II.3 (330b31sq.), (Rashed, *Aristote. De la géneration et la corruption*).

[385] Aristotle, *De generatione et corruptione*, II.3 (331a7 sq.).

[386] G. Freudenthal, "The theory of the opposites and an ordered universe: Physics and metaphysics in Anaximander," *Phronesis* 31 (1986): 197–228; G.E.R. Lloyd, "Hot and cold, dry and wet in early Greek thought," *Journal of the History of Science* 84 (1964): 92–106.

ments.[387] He placed the elemental substances of water, air and fire in concentric layers around the earth.[388] The natural place of each of the four elements was therefore between heaven and earth (the centre), depending on their weight. Earth therefore, as a heavy element, goes below, and fire, as a light element, found a high place, close to the periphery of heaven. Water and air, as intermediary elements, were thought to be situated in between these extremities.[389] Around the earth existed first a sphere of water, then air and finally fire. Aristotle had a series of arguments to proof the spherical nature of the whole constitution, and one of these arguments was a geometrical proof of the spherical character of water: when a drop is poured into something it always runs to the hollowest place, which is the closest to the centre.[390] This demonstration reappears in Calcidius' Commentary on the *Timeus*, and was repeated by other neo-Platonists.[391]

The elements, in their concentric spheres, were held to stay in place because the position they find was natural to them and once they find it they have achieved their destiny and must remain immobile.[392] This is the case in Plato's cosmology, but Aristotle, who wanted to save the idea of the eternal, circular, intelligent and quick movement of the celestial substances, introduced a fifth element above fire: the ether, of which the heavenly bodies were, according to him, composed. The ether, being without contradictions, was immobile and incorruptible. It moved naturally in a circular motion around the centre of the cosmos.[393]

These natural places were related to the corporeal elements, since the movements of the latter were thought to depend on the movement of the former. The cyclical transformations of the elements, by means of the qualitative changes in four possible combinations, as discussed above, were in turn thought to be at the origin of the generation and corruption of elementary substances. Overall, then, these eternal movements were held to assure cohesion and continuity between the constituents of the world.[394]

Aristotle's teacher Plato provided another model. In his *Timeus*, he dealt with qualities and elements on different occasions. In a first myth, he described the

[387] See for example the recent publication of A.C. Bowen and C. Wildberg, eds., *New Perspectives on Aristotle's De caelo*, Philosophia Antiqua, 117 (Leiden, 2009).
[388] Aristotle, *De celo*, II.4 (287a2–10; 287a30–287b4), (C. Dalimer and P. Pellegrin, eds., *Aristote. Du ciel* (Paris, 2004).
[389] Aristotle, *De celo*, II.4 (311a22 sq.).
[390] Aristotle, *De celo*, II.4 (287b-14).
[391] Obrist, *La cosmologie médiévale. Textes et images. I. Les fondements antiques*, 241.
[392] Freudenthal, "The theory of the opposites and an ordered universe: Physics and metaphysics in Anaximander."
[393] Aristotle, *De celo*, I.3–4.
[394] Obrist, *La cosmologie médiévale. Textes et images. I. Les fondements antiques*, 230.

constituents of the world. He attributed to heaven and earth two extremities, respectively the element of fire and the element of earth. Air and water were intermediary. The extremities were linked to the intermediaries by means of a proportional analogy.[395] The analogy was considered to be of geometrical character by commentators like Proclus.[396]

In a second myth, Plato considered the structure of the elemental substances. The most basic part of the elements were, on this account, triangles (isosceles or scalene), which made up the surface of the different elemental bodies. The body of fire was therefore covered with 24 triangles, resulting in a tetragon. Air, meanwhile, was composed out of 48 triangles forming an octahedral. Water was an icosahedra composed out of 120 elementary triangles and the surface of earth was covered with 24 isosceles triangles. Finally a fifth, most noble composition of triangles, was used by the Demiurge to fabricate the universe, and was traditionally related to the dodecahedron (sphere).[397] This second myth was not commented on by Calcidius (or else not preserved as part of his writings).[398]

Plato assigned several different qualities to the elements and used these to characterize the elements geometrically. Fire, for example, was thought by Plato to be the most mobile element precisely because it had only a small number of sides. Likewise, it was light because it consisted of only a few triangles. Moreover, its pyramidal form, pointed on one side and blunt on the other, also had meaning – on one side it protruded sharply into heaven and on the other it dissolved into the form of the earth.[399]

The Neo-Platonists established geometrical proportions for each element separately. Thus Proclus (d. 485) laid out six primordial qualities and assigned three to each element: fire was sharp, thin and mobile; earth was blunt, thick, and immobile; air was sharp, thick and mobile; and finally water was thick, blunt and mobile.[400]

Theories of the elements and qualities are also represented in the medical treatises concerning humoural theory and featuring commentaries on Galen (129 – 199/217) and Avicenna. Physicians were interested less in a theoretical explanation of the inorganic substantial world, and more in the qualities and distribution of powers in the elements, and also, in organic substances, by their division according to intensity and equilibrium in organic substances.[401]

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[395] Plato, *Timeus*, 31b-32c.
[396] Obrist, *La cosmologie médiévale. Textes et images. I. Les fondements antiques*, 231.
[397] Plato, *Timeus*, 54d-55c.
[398] Obrist, *La cosmologie médiévale. Textes et images. I. Les fondements antiques*, 235.
[399] Plato, *Timeus*, 55e-56b.
[400] Proclus, *Commentary on Timeus*, 151c (E. Diehl, ed., *Procli Diadochi in Platonis Timaeum commentaria*, 3 vols. (Leipzig, 1903–1906), vol 2, 40, 2ff).
[401] Maier, *An der Grenze von Scholastik und Naturwissenschaft. Die Struktur der materiellen Sub-*

The humours (also called temperaments) have their roots in Hippocratic medicine, where the human being is described in connection with humours and their qualities, seasons and life stages.[402] Galen linked the four humours to Aristotle's natural philosophical theory of the four elements, and also to the notion of the four elementary qualities in the mixture of the body.[403] Avicenna then transmitted the Galenic tradition to the Latin west and to Islamic culture.

3.2.2 MEDIEVAL COMMENTARIES

The theory of the four elements, as the key for understanding the macrocosm and microcosm, was broadly accepted in the medieval context. Aristotle's physics became the main framework for medieval theories of matter.

Although Plato's system had less impact than Aristotle's, several commentaries did try to make sense of it by commenting on the *Timeus*. The most important among these latter are Calcidius' Commentary on the *Timeaus*, Macrobius' Commentary on *De somno Scipionis*, and thirdly the *De nuptiis Mercurii et Philologie* of Martianus Capella (fl. 470). The works of Macrobius and Martianus Capella especially had a lasting effect, for they were used for lecturing in schools from the ninth century onwards.

Macrobius' commentary was written to facilitate the soul's contemplation of the heavenly order and the movement of the world. Arithmetic features importantly in it, since numbers were thought to have a regulating role in the structure of the cosmos. He devoted a chapter to the relationships of the elements.

The work of Calcidius was more slowly integrated, and mostly influenced the high Middle Ages. Calcidius dealt with the numerical proportions that were thought to establish cohesion between the elemental substances. He also discussed the geometry of the bodies and the analogical relationship between the elements, favouring Aristotle's two pairs above Plato's preference for three qualities per element. As mentioned above, he did not discuss the Platonist solids.[404]

Boethius' (d. 524–25) treatise *De consolatione philosophie* played an equally important role in the transmission of Platonic knowledge. This work was a standard book throughout the Middle Ages and is a great dialogue between

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stanz. Das Problem der Gravitation. Die Mathematik der Formlatituden, 6.

[402] K.-O. Fischer, "Vom Säfteschema der Hippokratischer Medizin," in *Die Geheimnisse der Gesundheit. Medizin zwischen Heilkunde und Heiltechnik*, ed. P. Kemper (Frankfurt am Main, 1994), 76–94, here 82–88.

[403] M. Kutzer, "Temperament," in *Historisches Wörterbuch der Philosophie*, ed. J. Ritter and K. Gründer, vol. 10 (Basle, 1998), 981–986, here 981; G. Harig, *Die Bestimmung der Intensität im Medizin. System Galens* (Berlin, 1974), 38–51.

[404] Obrist, *La cosmologie médiévale. Textes et images. I. Les fondements antiques*, 234–235.

Lady *Philosophia* and Boethius about the causes of the human soul's alienation from its genuine self and possible ways to recover from this estrangement. The cosmic order, understood as the result of the power of divine providence, is contrasted with the whimsical and unpredictable life of the character Boethius in the book. In poem III, metrum 9, the harmony of the elements in particular is considered as a proof of the goodness that defines God.[405] Medieval scholars have seen this poem as the core of the *De consolatione*.[406]

Boethius was followed by Cassiodorus (ca. 487–580) and Isidore of Seville (ca. 560–636). These scholars are considered educators and encyclopaedists rather than original thinkers.[407] Through their works the philosophical learning of late antiquity was transferred from antique, secular schools and transmitted as a section of their encyclopaedic surveys.

The title of *De natura rerum* indicates that natural philosophy in the days of Isidore of Seville had as its objective the investigation of the causes and principles of the phenomena and substances of nature. In the *De natura rerum* Isidore assembled all the knowledge from ancient books that he thought relevant. However, philosophy as such does not form a part of Isidore's encyclopaedic work. His main source was Lactantius, who in turn drew on Cicero's *De natura deorum*, and on Lucretius' poem, for his section on materialistic philosophy.[408] Isidore followed the tripartite scheme of qualities: for him earth is obtuse, dense and immobile, and so on. It is therefore quite similar to the formulation of Calcidius in his commentary on the Platonic doctrine of elements in the *Timeus*.[409]

3.2.3 Motion and mixture (1100–1400)

Motion, or change, is understood to occur in various phenomena, such as movement from one place to the other, growing up, creation, chemical changes and so on.[410] The *De celo*, for instance, deals with the circular movement of the heavens, and the rectilinear movements of the elements and of mixed bodies (held to be moved by the dominant element they contain). Aristotle thought nature a cause of motion.[411]

[405] emphSee 473.
[406] H. Liebeschütz, "Boethius and the legacy of antiquity," in *The Cambridge history of later medieval philosophy from the rediscovery of Aristotle to the disintegration of Scholasticism 1100-1600*, ed. A.H. Armstrong (Cambridge, 1967), 538–564, here 547.
[407] J. Marenbon, "Boethius: from Antiquity to the Middle Ages," in *Routledge history of philosophy*, ed. J. Marenbon, vol. 3: Medieval philosophy (London–New York, 1998), 11–28, here 24–25.
[408] Liebeschütz, "Boethius and the legacy of antiquity," here 555–557, 562–563.
[409] Fontaine, *Traité de la nature suivi de l'épître en vers du roi Sisebut à Isidore*, 43.
[410] R.P. Multhauf, "The science of matter," in *Science in the Middle Ages*, ed. D.C. Lindberg (Chicago-London, 1978), 369–390, here 371.
[411] Aristotle, *Physica*, 2.1 (192b13-23).

However, in the thirteenth century the newly rediscovered and studied books *De generatione et corruptione* and *Physica* motivated a different approach to the question of changing qualities in elements. The object of the eight books of the *Physica* is the determination of the principles of natural things. Aristotle studied the subjects and causes of natural change, seeking to answer the question of what the essence of things might be, if the principal elements of all things are subject to change? In the *Physica*, he set out his doctrine of matter and form, drawing a model according to which motion and change always involve an underlying something, a *substratum*, that remains constant throughout all changes. Indeed Aristotle held change itself to be the successive presence, in the unchanging *substratum*, of contrary and opposite forms.[412]

In part III of *De generatione et corruptione*, Aristotle dealt with the combination of elements, their unity and plurality, , meanwhile, the nature of the oppositions, the relationship between the elements and the primordial qualities, the transformation and cyclical path of the elements, and the presence of four elements in every composed body.[413]

The persistence of the elements in a compound became a major subject in the fourteenth century. For, if all substances are composed out of the four elements, how can these elements *exist* in a compound? This question implied others, no less thorny. For example, when substances of a certain mixture are transformed, say, by heating, do the original elements persist in the new compound? Do the components undergo an internal change and then persist in a modified form in the new substance? And how does this process take place?

The intensio and remissio of forms

In the later Middle Ages the possible answers to these questions regarding the nature of a compound and the dynamics of modification can be classified into three approximate groups, corresponding to the views of Avicenna (980–1037), Averroes (1121–1198) and Thomas Aquinas (1225–1274).

According to Avicenna, the human *complexio* (mixed qualities) does not correspond to a single, fixed proportion of elements or qualities. Instead, the parts can vary somewhat and this variation he called 'latitude'. Hence, an element could possess varied qualities, within a certain latitude, without ceasing to be that element.[414] The idea of latitude in the case of human health was then combined with the doctrine of the four humours. Thus, a temperate complexion

[412] J.E. Murdoch and E.D. Sylla, "The science of motion," in *Science in the Middle Ages*, ed. D.C. Lindberg (Chicago-London, 1978), 206–264, here 209. See also: H. Carteron, ed., *Aristote, Physique* (Paris, 1926), 23, 53.
[413] C. Mugler, *De la génération et de la corruption* (Paris, 1966), xi-xii.
[414] E.D. Sylla, "Latitudes of form," *Archives d'histoire doctrinale et littéraire du moyen âge* 40 (1973): 223–283, here 227–228.

featuring a perfect mixture of qualities (humours) represents health. The latitude of health was then quantified using the four Aristotelian qualities (hot, cold, wet and dry). The extremes of the latitude were the limits of health: if one moved away from the temperate complexion, one could become hot, (or cold, or any other quality), to any degree up to the fourth degree. The fourth degree caused apparent damage, and beyond that degree death followed.[415]

Avicenna also thought that the substantial forms of the elements persist in any given mixture. He considered all four elements to be present in every particle of the mixture. The qualities of these elements, however, could undergo change, and could fuse into a new substantial form. Though in medicine this view was much adhered to, natural philosophers rejected it, for in the Aristotelian theory contradictory elements cannot be simultaneously present in something. The medical and pharmacological tradition, with its concept of a range of numerically designated degrees of qualities (latitude) would play a role in subsequent theories.[416]

Averroes too pondered the question of matter and change. According to him the qualities and the substantial forms (for example the elements) both undergo *remissio* during their transformation, contrary to the Aristotelian doctrine in which a substantial element (like earth) does not vary in degree. Averroes did not think that elements consisted of substantial material. Averroes' position found adherents who then furthered the discussion about the *remissio* and *intensio* of elements.[417]

Thomas Aquinas, for example, adopted a compromise between Avicenna and Averroes, when he explained changes in matter through the *remissio* of the four qualities and their endowment with a new form. According to Thomas, the elements do not persist in a compound or *mixtum*, but the qualities of these elements make their influence felt, and therefore the elements persist *virtualiter*. The qualities are thereby preserved, in the sense that during a fusion they transform into a middle quality. The Thomistic conception was widely discussed and nuanced by followers.[418]

LATITUDES OF QUALITY

The physical basis of alteration –in other words the *intensio* and *remissio* of forms– influenced the concept of 'latitudes of qualities', the theories of which

[415] Murdoch and Sylla, "The science of motion," 323. See, for more about the medical pharmacological tradition: M. McVaugh, *Arnaldi de Villanova opera medica omnia II: Aphorismi de gradibus* (Granada-Barcelona, 1975).
[416] Dijksterhuis, *The mechanization of the world picture: Pythagoras to Newton*, 201; Maier, *An der Grenze von Scholastik und Naturwissenschaft. Die Struktur der materiellen Substanz. Das Problem der Gravitation. Die Mathematik der Formlatituden*, 23.
[417] Multhauf, "The science of matter," 384.
[418] ibid., 385.

latter were hotly debated in fourteenth-century Oxford and Paris. The Oxford Calculators were, together with the Parisian Nominalists, the representatives of a new kind of physics. The Calculators developed consistent theories all of their own and these differed from those developed in Paris, but they had also some essential basic notions in common.[419]

In both schools of thought the subject in which qualities were held to inhere could feature a certain variety of intensity of the quality as a result of a series of different forms existing within it. It was not, however, the quality itself that was thought to increase or decrease in intensity, because qualities could not be disembodied. Instead, quantity and quality could vary only within a given form (*complexio*). In this respect, 'latitude' meant the opposite of 'indivisible'. Qualities were thought to have latitudes and the range of the latitude would be determined by the minimum and maximum possible degrees of the quality. For example, in this theory there is not one indivisible quality of 'whiteness', but instead varying degrees of whiteness. The latitude of a quality is however conceptual or abstract and does not necessarily physically exist in a material body.[420]

Two main theories circulated about how one should conceive of these latitudes. The first theory was known as 'the succession of forms', and the second as 'addition theory'. Briefly, in the succession of forms theory, *intensio* and *remissio* occur when a subject takes on a series of forms, each one destroying its predecessor. According to the addition theory, meanwhile, quality is increased by serial additions of a new bit of the same form –much as a body of water is increased by adding a further drop of water. The addition theory was put forward by Duns Scotus in the early fourteenth century.[421] Obviously the main difference between the two is that in the succession theory the preceding form is destroyed and replaced, while in the addition theory the preceding form is preserved.[422] This preservation is not, however, an exact survival of the previous form, which was thought to be preserved *within* the new, higher degree, as a part of that new, higher degree that is equal to the old, lower degree. The latitudes or degrees are treated in these cases as continua, much like lines in their mathematical properties.[423]

A following problem then was how qualities, such as hotness, coldness and so on, but also hardness, velocity and even grace or virtue, can be measured, if they do not combine arithmetically? For something of 2 degrees plus something of 3 degrees does not make something of 5 degrees.

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[419] Sylla, "Latitudes of form," 225.
[420] ibid., 229–230.
[421] Maier, *An der Grenze von Scholastik und Naturwissenschaft. Die Struktur der materiellen Substanz. Das Problem der Gravitation. Die Mathematik der Formlatituden*, 54–55.
[422] Sylla, "Latitudes of form," 230.
[423] Murdoch and Sylla, "The science of motion," 233.

The additive theory, it was suggested, could be worked out mathematically, using line segments. Degrees and latitudes came to be imagined as lines: higher degrees contained lower degrees, just as longer lines contain shorter lines.[424]

Qualities were variously distributed over a given subject. Qualities could be *uniformly* distributed, or *difformly* (i.e. not uniformly) distributed. *Difformly* distributed qualities themselves were divided into two kinds. First, *uniformly difform* qualities increased or decreased at a constant rate from one end of the subject to the other. It was, for instance, believed that light decreased in intensity at a constant rate. *Difformly difform* qualities, by contrast, were held to be distributed difformly over a subject.[425] The same concepts could also be applied to the measurement of other qualities. For example, through adding or subtracting degrees of temperature a quantitative treatment of increases or decreases in heat could be undertaken. The same concepts could also be applied to local motion, in which the distribution of velocity was considered over time.

Mean speed theorem

At Merton College, Oxford, a method was developed to express the amount by which motion (a quality) increases or decreases in velocity (a form of *intensio* and *remissio)* as a function of time (extent). The Calculators were credited for the so-called 'mean speed theorem' that described uniformly accelerating motion: a uniformly accelerated or decelerated motion, they held, would correspond to its mean degree.[426] With the help of this theorem, one could correlate accelerations with the given spaces traversed. For example: in a uniform acceleration from zero velocity, three times as much distance is traversed in the second half of the total elapsed time as in the first half.[427]

Heytesbury's *Regule solvendi sophismata* ('Rules for solving sophisms'), which extensively applied concepts of latitudes and degrees to motion, is a book of logical-mathematical techniques, with a strong basis in logic.[428] Swineshead's *Book of Calculations* too developed variant cases, involving latitudes, degrees and distribution of intensities over a certain extent, which demonstrated the same rules.[429] One of the latter's interests was measurement in cases in which the quality in play was infinite in both intensity and extent. Swineshead himself did not use geometry to measure the intensity of qualities, but the

[424] ibid., 233; Sylla, "Latitudes of form," 251–264.
[425] Murdoch and Sylla, "The science of motion," 233–234.
[426] See about the 'mean speed theorem': Clagett, *The science of mechanics in the Middle Ages, 1200-1400*, 255–329.
[427] Heytesbury, *Regule solvendi sophismata*, fol. 4ov (Venice 1494). Cited in: Murdoch and Sylla, "The science of motion," 235.
[428] On this work, see: C. Wilson, *William Heytesbury: medieval logic and the rise of mathematical physics* (Madison (Wisc.), 1956).
[429] Murdoch and Sylla, "The science of motion," 236.

commentators on his texts often added geometric figures to his text.[430] The same is true of Heytesbury's texts, as we will see below.

The name 'Calculators' links these authors with mathematics and science. The mathematics involved is, however, not numerical. No calculations or computations were made, in the modern sense of those terms. Instead the Calculators used a form of verbal reasoning in which many variables, as well as their relations and derived equivalences are kept in mind with minimal use of numbers.[431] In other words, these calculative techniques were a form of verbal phrasing through which variables and their relationships can be considered. The arguments are phrased *in terminis*, which is to say that the letters *a, b, c* and so on were used to represent velocities, degrees of a quality, or distances, for instance, and we should see these combinations as calculations.[432]

CONFIGURATION THEORY

It was against this background that Nicolas Oresme (c. 1320-25 - 1382) developed his own system for measuring qualities and motions. Oresme was intensely related to the Oxford physics through his configuration theory. He is considered the heir of the Merton College kinematics of the 1330's and 1340's, despite his institutional affiliation to the College de Navarre in Paris on the European mainland. Oresme treated the topic of the *intensio* and *remissio* of forms, among other questions, in his *De configuratione qualitatum et motuum*.[433]

Oresme presented his results using geometrical graphs. He proposed a system of measuring qualities in two dimensions: one being longitude and one latitude. Latitude here referred to the intensity of a quality (or motion) while longitude meant the extent of the qualified body. Oresme thereby 'plotted' intensity (*intensio* and *remissio* of forms) versus extent as a graphical representation. On the horizontal axis, he represented the extent of a subject, marking it off into sections using vertical lines to represent the intensity of the quality at each point of the subject.[434] See section 3.4.2 of this chapter for discussion of examples of the resulting diagrammatic representations.

Oresme differed from his Oxonian colleagues in that he considered the 'quantity of quality' equal to its 'intensity' multiplied by its 'extent'. The product of 'intensity multiplied by extent', corresponded, in the case of motion over time, to the total distance traversed. This distance was, for Oresme,

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[430] Murdoch, *Album of science: Antiquity and the Middle Ages*, 159.

[431] Murdoch, "Philosophy and the enterprise of science in the later middle ages," 67, n. 39; Sylla, "The Oxford Calculatores," 561–562.

[432] ibid., 562; Maier, *An der Grenze von Scholastik und Naturwissenschaft. Die Struktur der materiellen Substanz. Das Problem der Gravitation. Die Mathematik der Formlatituden*, 258–260.

[433] The work is also known as *De difformitate qualitatum*, or *De uniformitate et difformitate intentionum*.

[434] Murdoch and Sylla, "The science of motion," 237.

real, whereas for the Oxford authors, it had no ontological status. Oresme considered the latitude of a quality to be an intensive measure of a specific quality, and not, like the Calculators, as a range or an abstraction.[435]

Oresme meant two things by 'configuration': first, he understood it to be an external geometric and spatial configuration and, secondly, as the internal arrangement of intensities of qualities in a body. He thought that differences in internal configuration explained many physical and psychological phenomena, which could not be explained solely on the basis of the four elements in a body. For example, two bodies might consist of equal amounts of qualities or elements present with the same intensity, but the configuration of the intensities might yet differ because differences in the configuration - the inner qualitative structure - might cause the bodies to experience different effects.[436]

3.3 Harmonizing qualities and elements

The Platonic and Aristotelian modes of thinking, and their differences and similarities, pervaded the early Middle Ages. Aristotle's *De generatione et corruptione* in particular was the starting point for a number of diagrams found in the commentaries. Below, four standard figures will be dealt with: two quadrupled circle diagrams, a figure known as the *figura solida*, and finally the *syzygia elementorum*. These diagrams are found mostly in Isidore of Seville's *De natura rerum*.

3.3.1 Quadruples

Two figures demonstrate the Aristotelian conception of elements (in which each contains two qualities). Obrist calls one the *mundus-annus-homo*-diagram, abbreviated to the *mundus*-figure by Fontaine.[437] The other is called the *annus*-figure in the existing literature. Many examples of both of these figures have survived and have been reproduced by Obrist, Sears and Murdoch.[438]

[435] Sylla, "Latitudes of form," 229; Murdoch and Sylla, "The science of motion," 239.

[436] Clagett, *Nicole Oresme and the medieval geometry of qualities and motions: A treatise on the uniformity and difformity of intensities known as Tractatus de configurationibus qualitatum at motuum*, 15.

[437] See for a survey of the eight figures in the *De natura rerum*: Obrist, "Le diagramme isidorien des saisons, son contenu physique et les représentations figuratives," 99; Fontaine, *Traité de la nature suivi de l'épître en vers du roi Sisebut à Isidore*, 16–17.

[438] Obrist, "Le diagramme isidorien des saisons, son contenu physique et les représentations figuratives"; Murdoch, *Album of science: Antiquity and the Middle Ages*; E. Sears, *The ages of man: medieval interpretations of the life cycle* (Princeton, 1986).

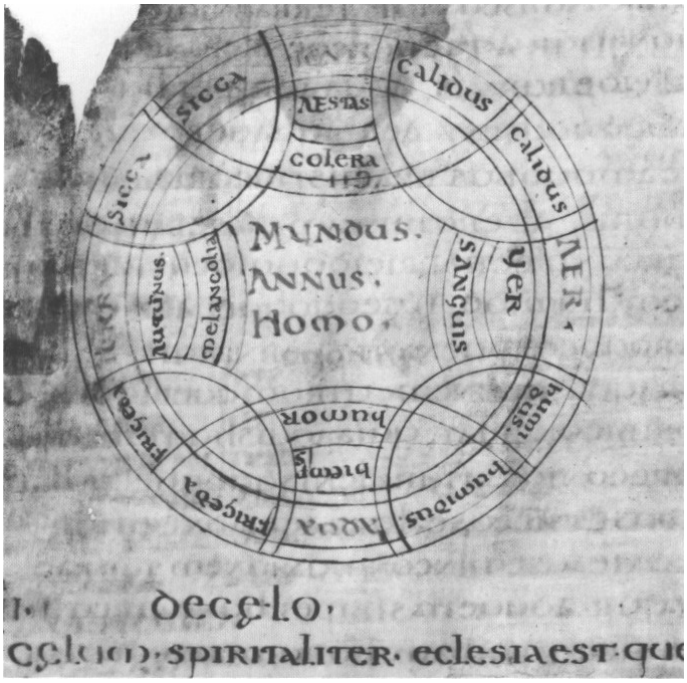


Figure 3.1 Isidore of Seville, *De natura rerum*. Paris, *Bibliothèque nationale*, lat. 6413, f. 5v. Dated 8th century.

An early *mundus*-diagram, now preserved at the *Bibliothèque nationale de France*, dates to the middle of the eighth century.[439] [*See* figure 3.1]. The figure is inserted into chapter XI.2 of the *De natura rerum*, in a section describing how the qualities relate to the elements and how the different elements are united:

> «Earth, he <Ambrose> says, is dry and cold, water is cold and humid, air is warm and humid, fire is warm and dry. It is because of these qualities, susceptible of uniting one to another, that all things blend one with another. Indeed, earth, being dry and cold, is united to water because of the quality cold, which they both own. Water is united in its turn to air because of humidity, for air too is humid. And water, having, in a certain sense, two arms - one of coldness and one of humidity - seems to embrace, using the respective arm, earth and air, earth with de one of coldness, air with the one of humidity. [...] Consequently, in Greek we call 'communal principles' what one calls 'elements' in Latin, because they unite and correspond to one another. The circular figure here below shows these elements *simultaneously* joint and yet distinct:
>
> | World (Mundus) | Year (Annus) | Human being (Homo) |
> |---|---|---|
> | dry and hot, fire | Summer | yellow bile |
> | hot and humid, air | Spring | blood |
> | humid and cold, water | Winter | phlegm |
> | Cold and dry, earth | Autumn | melancholy». |
>
> [440]

Through a system of circles and segments the Paris copy of the diagram portrays the idea of a harmonious, concordant cycle of the four elements, with their corresponding qualities, seasons and humours. The four elements are written in coloured ink into the outer rim of the circle, each occupying their own section: fire above, water below, earth left and air right. This order of the elements does not correspond with the physical order, for earth is not placed at the bottom, unlike the lightest element, fire, which is indeed placed above. The circle should therefore not be understood as an effort to geographically represent reality, but

[439] Paris, *Bibliothèque nationale*, lat. 6413.

[440] Isidore of Seville, *De natura rerum*, XI.2–3: «terra, inquit, arida et frigida est, aqua frigida atque humida, aer calidus atque siccus. Per has enim iugabiles qualitates sic sibi singula conmiscuntur. Terra enim, cum sit arida et frigida, coniungitur aque per cognationem qualitatis frigide. Rursus aqua aeri per humorem, quia humidus est aer. Aqua vero quasi quibusdam duobus brachiis frigoris atque humoris, altero terram, altero aerem videtur conplecti, frigido quidem terram, aerem humido. [...] Unde et graece cena dicuntur que latine elementa vocantur, eo quod sibi conveniant et concinant. Quorum distinctam communionem subiecti circuli figura declarat:

Mundus	Annus	Homo
siccus calidus ignis	estas	cholera rubea
calidus humidus aer	ver	sanguis
humida frigida aqua	hiemps	phlegma
frigida sicca terra	autumnus	melancholia»

(Fontaine, *Traité de la nature suivi de l'épître en vers du roi Sisebut à Isidore*, 214-217). My translation into English.

as a conceptual construction. This cycle explains the presence of the qualities, which are inscribed in semicircles crossing the four elements in such a way that fire intersects with the qualities 'dry' and 'hot'. 'Hot' is a quality fire shares with air, but air is also 'humid', a quality in turn shared with water. Water intersects with the qualities 'humid' and 'cold' and shares the quality 'cold' with earth. Earth is 'cold' and 'dry', and with this latter quality the cycle is complete, because 'dry' is also shared with fire.

Within the semicircle of each element, the four seasons are inscribed. Fire corresponds with summer, earth with autumn, water with winter, and air with spring. In a fourth scale the humours are incorporated: *cholera* for fire and summer, *sanguis* for air and spring, *humor* (also called *flegma*) for water and winter, and finally *melancholia* with earth and autumn. The three units in the centre of the circle - *mundus, annus, homo* - are the end results of the respective characteristics of the qualities, seasons and humours. Remarkably, the text explains the elements and the combination of qualities but not the seasons or humours. According to Obrist, who takes him as the designer of the figure, the discrepancy perhaps means Isidore combined text and figure from different sources.[441]

The medical tradition is clearly present in this diagram. Medical aspects are mentioned analogue to the cosmological ones. Galen related the four humours to Aristotle's natural philosophical theory of the four elements and the four elementary qualities.[442] In Hippocratic medicine the human being is described in terms of humours (blood, yellow bile, black bile and phlegm), and their qualities, seasons and life stages.[443]

The circle-figure is an appropriate form for expressing the concepts of harmony, equilibrium and contraposition. The *mundus*-figure was modelled on the basis of Aristotle's theory of elements, in which a series of paired qualities are attributed to explain a cyclical journey and the harmony and equilibrium of contrapositions play an important role at microcosmic and macrocosmic levels. Concentric circles can be used to emphasize the equivalence of various terms, but they can also express a decreasing or increasing value, or emphasize a centric view.[444] These possibilities are not used in the *mundus*-figure discussed above.

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[441] Obrist, "Le diagramme isidorien des saisons, son contenu physique et les représentations figuratives," 118.

[442] Kutzer, "Temperament," 981; Harig, *Die Bestimmung der Intensität im Medizin. System Galens*, 38–51.

[443] Fischer, "Vom Säfteschema der Hippokratischer Medizin," 82–88.

[444] A centric view is expressed in the 'onion' model of the circle-diagram wherein for example the geographical position of the elements are ordered hierarchically. See for example: Oxford, *Bodleian Library*, Digby 107, fol. 52r (repr. in Murdoch, *Album of science: Antiquity and the Middle Ages*, 287); London, *British Library*, Add. 18210, fol. 69r (repr. in ibid., 285); Naples, *Biblioteca Nazionale*, XIII.G.38, pars II, fol. 62r (repr. in ibid., 281); Paris, *Bibliothèque nationale*, lat. 6734, fol. (repr. in ibid., 275); London, *British Library*, Ar. 83, fol. 123r.

Related to this *mundus*-figure is the so-called *annus*-figure, also featured in the *De natura rerum*. The *annus*-figure shows the qualities present in the elements, and also the winds and the seasons. Its text reads:

> «With the help of definitions, we have touched upon the succession of the seasons following the definitions of the ancients, let us now expound how these seasons are united with one another by natural bonds. Indeed, spring is composed of humidity and fire, summer of fire and dryness, autumn of dryness and coldness, winter of coldness and humidity. Consequently, seasons take their names from the blend *(temperamentum)* of their communion, of which are here presented the figure:
>
> Year
>
> Spring, humid and warm: Occident
>
> Summer, warm and dry: South
>
> Autumn, dry and cold: Orient
>
> Winter, cold and humid: North».[445]

In the corresponding figure the names of the seasons are inscribed in the same compartments, placed at the primary compass points of the figure, as the four wind directions (though rotated clockwise a quarter of a turn): *ver*, *estas*, *autumnus* and *hiemps* corresponding with, respectively, *oriens, meridies, occidens*, and *septentrio*.[446] [*See* figure 3.2]. The qualities are then placed in semicircles intermediate between and overlapping with those containing the seasons and wind directions. The resulting cycle is one of the seasons of the year. The seasons are changing and alternating periods between which the sun regularly departs from her course only to rise again, the following year, in all its variety yet without confusion. The seasons originate in the courses of the stars - that is why God said <in Genesis 1:14> while instituting them «let them be for signs, and for seasons, and for days, and years».[447]

The absence of the elements in this figure is indeed remarkable, as Obrist noted. The elements were held to be the primary sensible bodies in existence and their changing properties were considered the basis of every possible transmutation in the sublunary domain. The changing seasons themselves were

[445] Isidore of Seville, *De natura rerum*, VII.4: «Quoniam certis distinctionibus vicissitudines temporum iuxta priorum definitiones prestrinximus, nunc qualiter eadem tempora naturalibus vinculis sibi invicem conligantur expediamus, autumnus ex siccitate et frigore, hiemps ex frigore et humore. Unde etiam sunt tempora a communionis temperamento dicta, cuius communionis heac est figura: Annus Humidum calidum ver: oriens Calida sicca estas: meridies Siccus frigidus autumnus: occidens Frigida humida hiemps: septentrio», (Fontaine, *Traité de la nature suivi de l'épître en vers du roi Sisebut à Isidore*, 201–203). My translation.

[446] Paris, *Bibliothèque nationale*, lat. 5543, f. 136r.

[447] Isidore of Seville, *De natura rerum*, VII.1: «Unde et Deus, cum hec instituere, dixit: et sint in signa et in tempora et in dies et in annos [...]», (Fontaine, *Traité de la nature suivi de l'épître en vers du roi Sisebut à Isidore*, 198–199). Translation borrowed from the King James version of the Bible.

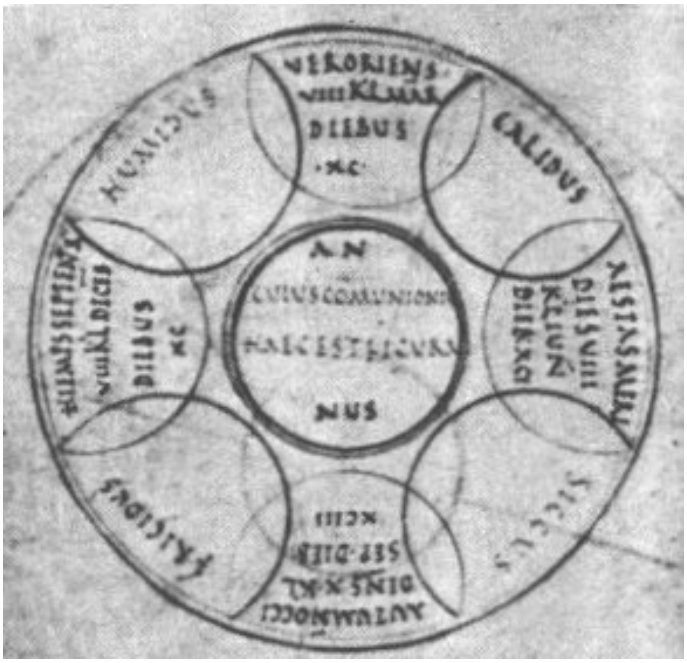


Figure 3.2 Isidore of Seville, *De natura rerum*. Paris, *Bibliothèque* nationale, lat. 5543, f. 136r. Dated 11th century.

thought to be only a direct, visible manifestation of the cyclical combination of the elements. In the figure, however, the role of the elements is omitted, and the seasonal cycle is instead presented as the result of changing qualities. Obrist suggested that this omission was possibly caused by a contraction, over time, of the relevant theories.[448]

The figures of Isidore were widely diffused. Boethius' figures resemble the Isidorean ones to such an extent that they must have been copied from them. The Isidorean figures also migrated to Bede's *De natura rerum*.[449] Commentaries on the *Timeaus*, by contrast, do not seem to have played a role in the design or transmission of didactic figures. Manuscript copies of Calcidius' Commentary on the *Timeus*, for example, included many geometrical-mathematical figures but none about the elements.[450]

[448] Obrist, "Le diagramme isidorien des saisons, son contenu physique et les représentations figuratives," 117.
[449] Bober, "In Principio. Creation before time," 19.
[450] See: J.H. Waszink, *Timaeus a Calcidius translatus commentarioque instructus* (London–Leiden, 1962).

3.3.2 FIGURA SOLIDA

In chapter 11 of *De natura rerum*, Isidore dealt with the Platonic viewpoint in which each element possesses *three* qualities. The circular figures dealt with above, by contrast, are based on the idea that a quality is attributed to two different elements, and the circular figure is an apt form to demonstrate such relations. But how to demonstrate the relationship of four elements when each possesses three qualities that are shared between those four elements? Such considerations resulted in a figure called the *figura solida*, also found in Bede's *De natura rerum* and in Boethius' *De consolatione philosophie*. The text by Isidore accompanying the *figura solida* reads:

> «Parts of the world. There are four parts in the world: fire, air, water and earth. Their nature is as follows: fire is thin, sharp, and mobile; air is mobile, sharp and thick; water is thick, blunt and mobile; earth is thick, blunt and immobile. They mix with one another as follows: earth, being thick, blunt and immobile is connected with the thickness and bluntness of water, while water joins with air in their shared thickness and mobility. Further, air is tied to fire by having sharpness and mobility in common. Earth and fire, however, are separated one from another, but are connected by water and air. In order that these things are understood without undue confusion, I have expressed them in the following figure (*subiecta pictura*). This figure is a solid based on geometric ratio. Fire: thin, sharp mobile; air: mobile, sharp, thick; earth: thick, blunt, immobile; water: thick, blunt, mobile».[451]

The corresponding figure is a cube. The faces of the cube are made to represent the six qualities and the four points of intersection on the cube embody the intersection of three qualities of which an element is composed. [*See* figure 3.3].

In modern times, we are used to fully developed, six-faced cubes. In the Middle Ages, though, three faces were considered to be the minimum required to project a three-dimensional figure: two squares facing one another and a third one constituting the bottom of the cube. One then had to imagine the other squares that made up the cube oneself. We should understand this particular figure, therefore, as a projection of two squares, which make up, with the help

[451] Isidore of Seville, *De natura rerum*, XI.1: «De partibus mundi. Partes mundi quattuor sunt: ignis, aer, aqua, terra. Quarum hec est natura: ignis tenuis, acutus et mobilis; aer mobilis acutus et crassus; aqua crassa, obtunsa, et mobilis; terra crassa, obtunsa, inmobilis. Que etiam sibi ita conmiscuntur. Terra quidem crassa, obtunsa, inmobilis, cum acque crassitudine et obtunsitate conligatur. Deinde aqua aeri crassitudine et mobilitate coniungitur. Rursus aer igni communione acuti et mobilis conligatur. Terra autem et ignis a se separantur, sed a duobus mediis aqua et aere iunguntur. Hec itaque ne confusa minus colligantur, subiecta expressi figura: Hec figura solida est secundum geometricam rationem. Ignis tenuis acutus mobilis. Aer mobilis acutus crassus. Terra crassa, obtunsa inmobilis. Aqua crassa obtunsa mobilis», (Fontaine, *Traité de la nature suivi de l'épître en vers du roi Sisebut à Isidore*).

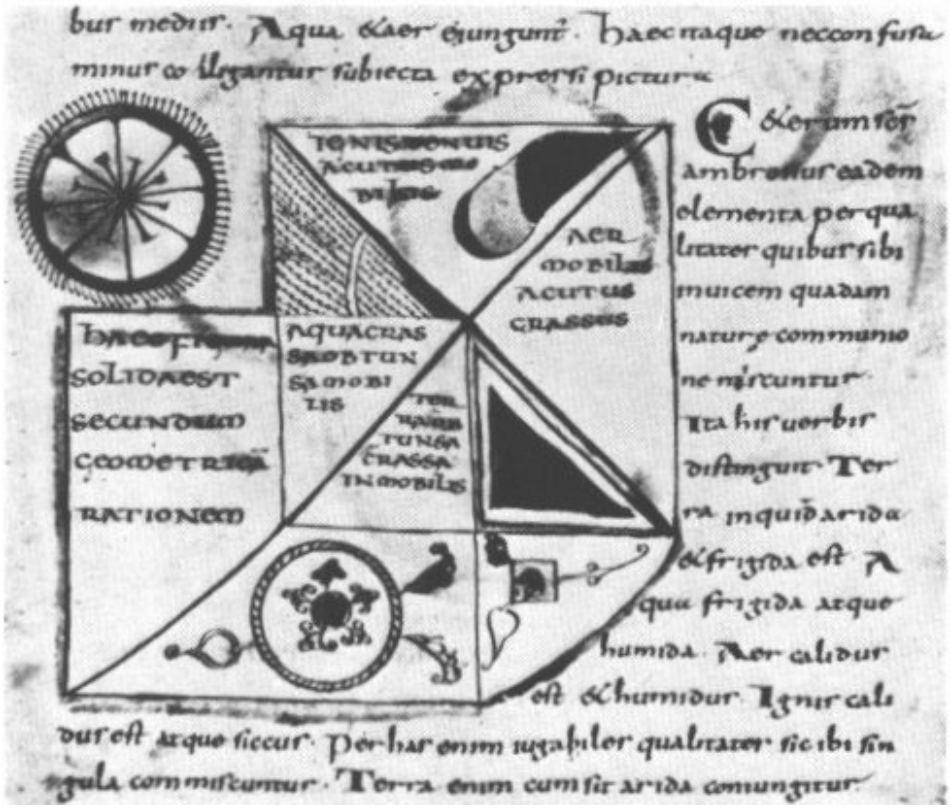


Figure 3.3 Isidore of Seville, *De natura rerum*, Laon, *Bibliothèque municipale*, ms. 443, f. 8v. Dated 9th century.

of intermediary lines, a cube with three faces.[452] Three-faced cubes and six-faced ones are both also found in Calcidius' Commentary on the *Timeus*.[453]

Much has been written about the interpretation of the *figura solida* as a cubic form. Murdoch, for example, wrote that later medieval copyists of the *figura solida* did not understand three-dimensionality at all and therefore corrupted the figure heavily.[454] Gorman asserted that Isidore never used the word *cybus* or *cubus*, that the earliest manuscripts do not support the idea of a cube figure, and that the cube could not, therefore, be the archetype of the *figura solida*.[455] Gorman is incorrect, for Isidore of Seville wrote plainly, in his *Etymologie*, that

[452] D'Alverny, "Le cosmos symbolique du XIIe siècle," 77 n. 1.
[453] Three-sided cubes in Calcidius are for example seen in Valenciennes, *Bibliothèque municipale*, 293, f. 20v and 22r.
[454] Murdoch, *Album of science: Antiquity and the Middle Ages*, 280–281.
[455] Gorman, "The diagrams in the oldest manuscripts of Isidore's. With a note on the manuscript traditions of Isidore's works," 531.

a cube is a proper, solid figure (*figura propria solida*) containing length, width and height.[456]

Eastwood, for his part, asserts that the *figura solida* was originally a circular figure, in which the elements and qualities were organized as a wheel made up of three irregular triangles.[457] He classified twenty-six copies of the *figura solida*, dating from the seventh to the ninth century, and he grouped the figures into different stages of corruption, relying on the idea that over the course of time the copyists lost the understanding of the *figura solida* as a three-dimensional figure. A chronology of deterioration is, in my opinion, not as obvious as Eastwood attempts to argue. First, the manuscripts chosen by Eastwood show deterioration within an overall period of two centuries, but almost all the manuscripts he relies on date from the ninth century. Secondly, many of the examples he cites in his third group were produced later than the examples he classified in his final phase of deterioration. Thirdly, the manuscripts Fontaine, the editor of the *De natura rerum*, considered to best approach the original are placed into Eastwood's second stage of deterioration.[458]

While Eastwood's classification is vulnerable to numerous objections, it is nonetheless unambiguously clear from the documents that not all the draughtsmen in question were bothered by a perfect spatial rendering of the cube, and that many did not have a clear notion of how to construct the image of a solid.

Fontaine suggested that Isidore designed the *figura solida* himself, since it is the only figure in his book that he presented in the first person singular: '*subiecta expressi pictura*'.[459] Obrist, by contrast, argues that Isidore possibly borrowed an existing figure from some other context in which geometry played an important role.[460] Calcidius was an important supplier of knowledge about the *Timeaus*, but he could not have been the source because he did not comment on the geometrical treatment of the elements. Next in importance to him was Macrobius' Commentary on *De somno Scipionis* (book I.9), which deals with the construction of the cube and the number eight.[461] The *Institutiones* of Cassiodore might equally have played a role in the design of the figure, for in that

[456] Isidore of Seville, *Etymologie*, III.12.3: «*Cubus est figura propria solida que longitudine, latitudine et altitudine continetur*» (J.-Y. Guillaumin and P. Monat, eds., *Isidore de Séville. Étymologies* (Besançon, 2004)).
[457] Eastwood, "The diagram of the four elements in the oldest manuscripts of Isidore's De natura rerum," 549–550.
[458] ibid., 555–557.
[459] Fontaine, *Traité de la nature suivi de l'épître en vers du roi Sisebut à Isidore*, 16–17.
[460] Obrist, *La cosmologie médiévale. Textes et images. I. Les fondements antiques* 276, 278.
[461] Esmeijer, *Divina quaternitas. A preliminary study in the method and application of visual exegesis*, 38. A *figura solida* in Macrobius' Commentary on the *De somno Scipionis*, Book X: *De partibus mundi*, is seen in, for example, Paris, *Bibliothèque nationale*, lat. 15171. See also: Bober, "In Principio. Creation before time," 17.

text he wrote:

> «... solid numbers are those that are contained by longitude, latitude and altitude, like the pyramids that rise like flames, and such as (what follows from the figure) cubes, which are like dice, and such as (what follows from the figure) spheres, whose roundness is everywhere equal».[462]

Isidore copied this text exactly for his *Etymologie* III, 7. The accompanying text in *De natura rerum* includes the phrase «this solid figure corresponds to the geometrical ratio» - «*Hec figura solida est secundum geometricam rationem*». This geometrical *ratio*, in other words, determined the numerical proportions between the elements and also the necessity and rationality of the two intermediary elements placed between the extremes of water and fire.[463]

Unlike Calcidius, Isidore did not seem to bother with mathematics and largely ignored the Platonic numbers. Isidore did, however, employ the expression *figura solida*, which belongs to the geometrical domain.[464]

Several examples of the *figura solida* strive towards a geographical orientation.[465] In many copies a diagonal rib is drawn, from the upper right point of

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[462] Cassiodorus, *Institutiones* II, 4, 6: «*solidus numerus: 'solidus numerus est qui longitudine et latitudine vel altitudine continentur, ut sunt pyramides, qui in modum flamme consurgunt, ita (sequitur figura) cybi, ut sunt tessere, ita (sequitur figura) sphere, quibus est equalis undique rotunditas*» (R.A.B. Mynors, ed., *Cassiodori senatoris Institutiones* (Oxford, 1937)). See also: Augustine, *De quantitate anime* 6, 10–12, 21, (Champagne de Labriolle, P., ed., *Dialogues philosophiques II. Dieu et l'âme: Soliloquia. De immortalitate animae. De quantitate animae* (Turnhout, 1948), 246–249) dealing with the three dimensions of space. See also: H.-I. Marrou, *St. Augustin et la fin de la culture antique* (Paris, 1938), 262.

[463] See, for the elemental theory of Calcidius, for example: Waszink, *Timaeus a Calcidius translatus commentarioque instructus*.

[464] Obrist argues that Isidore borrowed the expression from Calcidius. See: Obrist, *La cosmologie médiévale. Textes et images. I. Les fondements antiques*, 274.

[465] Besides his discussion of small pictures, Eastwood also discussed a small group of manuscripts in which a man's figure and a peacock were drawn. See Eastwood's 'The diagram of the four elements' for a reproduction of such a figure. A man's figure is drawn full length, with a fold in his lower body; his hands and head seem to support the whole picture. Next to him, a peacock is drawn picking grapes from the floor. Eastwood suggested the hypothesis that the human figure is shown pulling or pushing the figure into two or three dimensions in order to create a daring puzzle for students who, prompted by the distortion, are supposed to complete, mentally, the dimensions. The peacock, a symbol for (intellectual) beauty and persistence, is supposed to motivate the student in his efforts. Despite this wonderful interpretation, I think we should prefer Werckmeister's comparison with capital representations and take the human figure and the peacock as decorative. See: Eastwood, "The diagram of the four elements in the oldest manuscripts of Isidore's De natura rerum," 563–564; O.K. Werckmeister, "Three problems of tradition in pre-Carolingian figure-style. From Visigothic to insular illumination," *Proceeding of the Royal Irish Academy* 63 (1962): 167–189. See also: Esmeijer, *Divina quaternitas. A preliminary study in the method and application of visual exegesis*, 39; B. Teyssèdre, "Un exemple de survie de la figure humaine dans les manuscrits précarolingiens: les illustrations du De natura rerum d'Isidore," *Gazette des beaux-arts* 102 (1960): 19–34. See for a Visigothic context of reliefs and

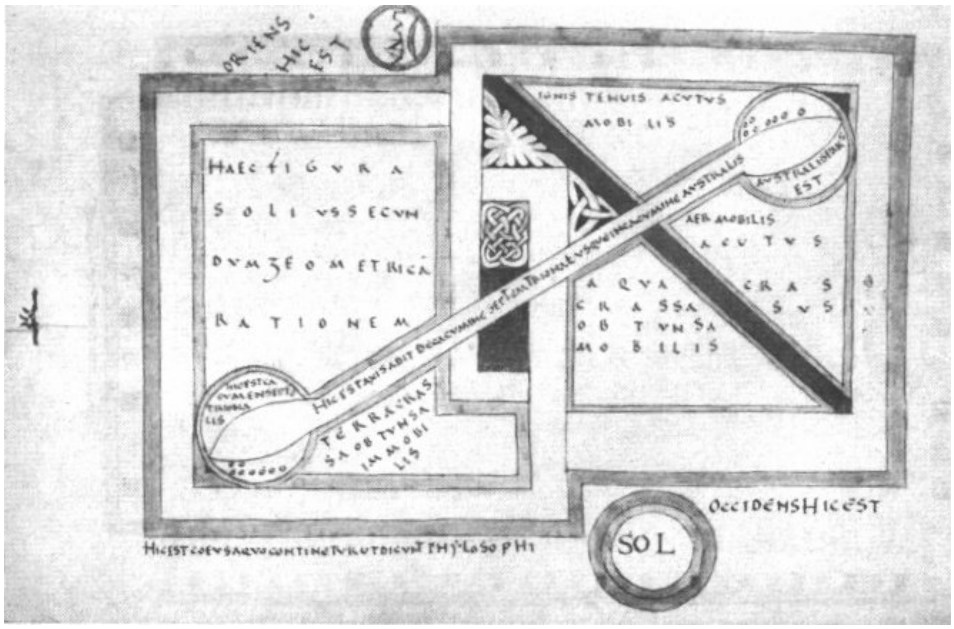


Figure 3.4 Isidore of Seville, *De natura rerum*. Rome, *Biblioteca apostolica Vaticana*, Ross. 247, f. 6or. Dated 11th century.

the back panel down to the bottom left-hand point of the front panel.[466] This diagonal is often visually confusing because the ribs overlap each other spatially incorrect.

The diagonal line was, in my view, originally conceived as the axis (of the earth) running from north to south, as the copy in the Vatican Library explains: «This is the axis. It runs from the extreme in the north to the extreme in the south».[467] [*See* figure 3.4]. The opposing diagonal is not drawn in the Vatican copy, but its final points feature the inscriptions *occidens hic est* and *oriens hic est*, indicating that we are dealing with the western and eastern ends of the earth. The western end is accompanied by a picture of the sun, while the picture accompanying the east is a moon. It is not clear to me why the west and east are identified with, respectively, a sun and moon, though almost all *figure solide* show two circles that are to be identified as the sun and the moon, and which

manuscripts also: E.A. Lowe, *Codices Latini Antiquiores*, vol. 5: France : Paris (Oxford, 1950), nr. 567; Fontaine, *Traité de la nature suivi de l'épître en vers du roi Sisebut à Isidore*, 24, 49, 72.

466 See for example: Paris, *Bibliothèque nationale*, lat. 6400 G, f. 122r; Paris, *Bibliothèque nationale*, lat. 6413, f. 4v; Munich, *Bayerische Staatsbibliothek*, Clm 16128, f. 15r ; Vatican, *Biblioteca Vaticana Apostolica*, Vat. Regin., lat 310, f. 24r ; Vat. Ross. 247, f. 6or; Einsiedeln, *Stiftsbibliothek*, 167, p. 92; Laon, *Bibliothèque nationale*, 443, f. 8v.

467 Vatican, *Biblioteca Vaticana Apostolica*, Vat. Ross. 247, f. 6or: «*Hic est axis. Abit de cacumine septemtrio usque in cacumine australis*».

are labelled as such.[468] The same diagonal is seen before: [*See* figure 3.3]. These inscriptions have nothing to do with the text in question.[469] But the assertion made by some - that these images are the result of a *horror vacui* - is untrue.[470]

In fact this three dimensional character to the diagram supports Obrist's view that the elements enjoyed a topographical aspect.[471] However, the position of the elements does not relate to a wind direction: indeed the solid figure is not geographically correct, because the elements are not placed on the axes of the figure.

The form of the *figura solida* as a cube is an interesting solution to the problem of how to connect *three* qualities to an element and place all four in a corner. The spatial character of the *figura solida* - as a cube with a north and a south pole - also corresponds to the Platonic idea of how particles are constructed, since, as mentioned above, Plato assigned a cube to the element earth as its physical model.

3.3.3 SYZYGIA ELEMENTORUM

The possible combinations of qualities were systematized in what is now called the *syzygia* (meaning 'union' in Greek) or *conjugatio* (in Latin). The *syzygia elementorum* is a figure of which the earliest extant examples date to the eleventh century, although its description in text goes back to Aristotle. The *syzygia* is first and foremost seen in copies of the *De consolatione philosophie* and in its related commentaries. The Commentary on the *Timeus* (53b) by Calcidius is also an important source for this figure.

The Demiurge, in the *Timeus*, created a perfect and harmonious cosmos based on pure rational principles. The soul of the world (*anima mundi*) was, on this account, composed out of numbers. It starts, obviously, with the number 1, from which everything else came into existence. The series that fol-

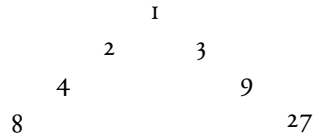
[468] The names of the sun and the moon are inscribed in Baltimore, *Walters art museum*, ms. 73, f. 7v (12c). See for an earlier reproduction: H. Bober, "An illustrated medieval school-book of Bede's De natura rerum," *Journal of the Walters Art Gallery (1956-1957)* 19-20 (1956): 64–97, fig. 5; Bober, "In Principio. Creation before time," fig. 3; Esmeijer, *Divina quaternitas. A preliminary study in the method and application of visual exegesis*, fig. 12.

[469] As observed by Murdoch, *Album of science: Antiquity and the Middle Ages*, 281.

[470] As has been maintained by Teyssèdre and Eastwood. See: Teyssèdre, "Un exemple de survie de la figure humaine dans les manuscrits précarolingiens: les illustrations du De natura rerum d'Isidore," 24; Eastwood, "The diagram of the four elements in the oldest manuscripts of Isidore's De natura rerum," 562. Esmeijer thought that the pictures were a residue of the relationship between the elements and geometrical forms: the cube and traces of the triangle and the circle. See: Esmeijer, *Divina quaternitas. A preliminary study in the method and application of visual exegesis*, 38.

[471] Obrist, "Le diagramme isidorien des saisons, son contenu physique et les représentations figuratives," 107, n. 50.

lows is composed of the first even and uneven numbers until they reach the cube: 2x2x2 = VIII and 3x3x3 = XXVII. This idea was illustrated by the so-called lambda figure[472]:



In Plato's opinion the lambda figure explained the existence of the elements air and water in between fire and earth, because between the cubes of two numbers there must necessarily be two other mean numbers, which are in the same proportion to each other. This series of numbers symbolizes, because of its perfection, the coherence of the broader creation and is, as such, incorporated into the poem «*Tu numeris elementa ligas*», in which Boethius (ca. 480–525) addressed the Creator:

> «O you who governs the universe following an eternal order [...] You unite through the numbers of the elements so that the cold could meet the flame, the dry the liquid, so that a purer fire does not evaporate nor heavy earth sink».[473]

This poem was repeatedly illustrated with a figure called the *syzygia elementorum*.[474] [*See* figure 3.5]. Observation of this figure explains immediately the advantages of a visual representation. The names of the four elements are written one below the other. Placed on top is fire, below which appear air, then water and finally earth. This order corresponds with the physical ordering of the elements: the floating fire ascends upward and the earth, heavy by its weighth, is stable.[475] The order of the elements, in their concentric layers around the earthly globe, clearly follows Aristotle's cosmological theory of the four elements.

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[472] R.S. Brumbaugh, *Plato's mathematical imagination* (Bloomington, 1954), 227. See for a medieval example for instance: Murdoch, *Album of science: Antiquity and the Middle Ages*, 35, fig. 283.

[473] Boethius, *De consolatione philosophie*, III.ix 1 + 10–12 : «*O qui perpetua mundum ratione gubernas, [...]. Tu numeris elementa ligas, ut frigora flammis; arida conveniant liquidis, ne purior ignis; evolet aut mersas deducant pondera terras*» (Boethius, *De consolatione philosophiae*, ed. L. Bieler (Turnhout, 1957)), see also: C. Moreschini, ed., *Boethius. De consolatione philosophiae opuscula theologica* (Munich–Leipzig, 2000); Pressouyre, "Le cosmos platonicien de la cathédrale d'Anagni," 565.

[474] For example: Paris, *Bibliothèque nationale*, lat. 736, fol. 51v; Paris, *Bibliothèque nationale*, lat. 15104, fol. 194v; Madrid, *Biblioteca nazional*, Vit. 20.I, fol. 54v.

[475] Boethius, *De consolatione philosophie*, IV.6: «*pendulus ignis surgat in altum, terreque graves pondere sidant*» (translation borrowed from Boethius, *De consolatione philosophiae*. See also Moreschini, *Boethius. De consolatione philosophiae opuscula theologica*).

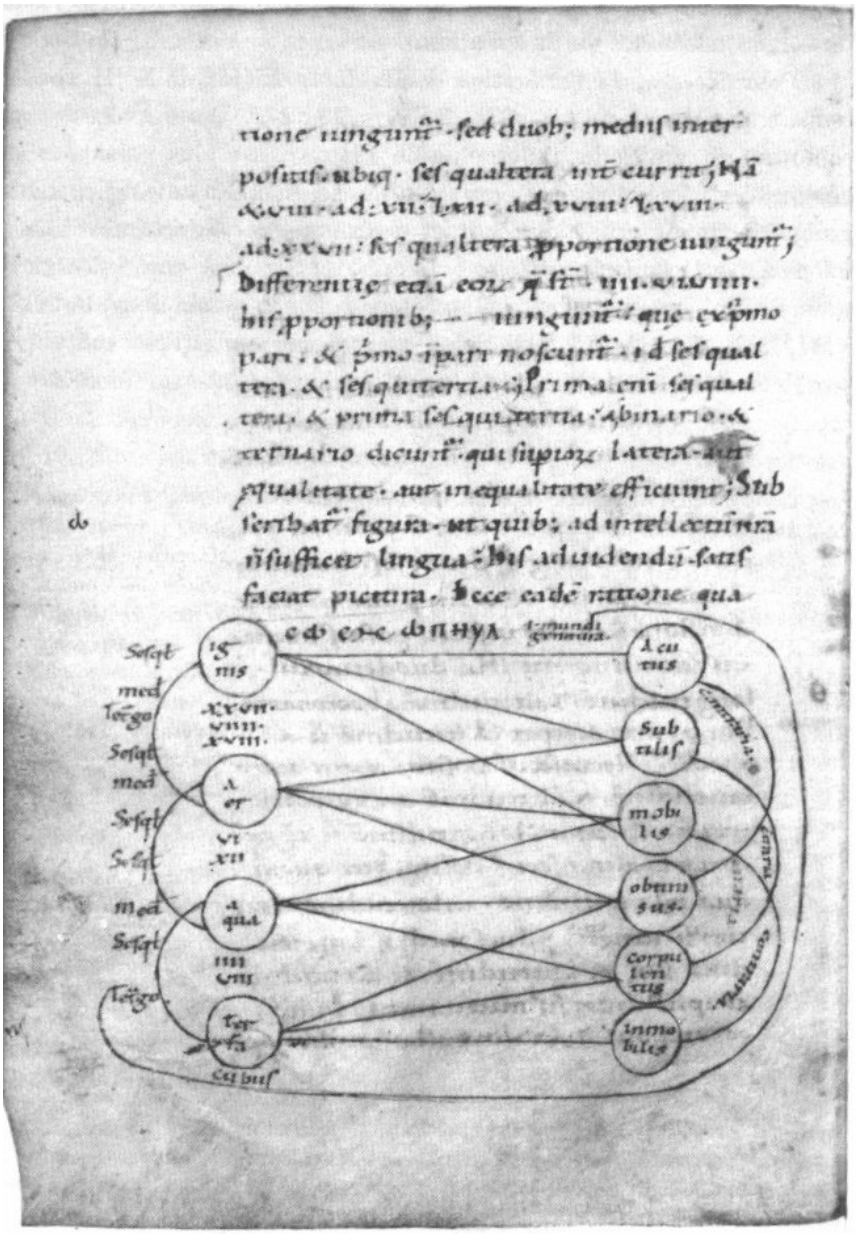


Figure 3.5 Adalbold of Utrecht, Commentary on *De consolatione philosophie*. Paris, *Bibliothèque nationale*, lat. 7361, f. 51v. Dated 12th century.

In this figure the six primordial platonic qualities - *immobilis*, *corpulentus*, *obtusus*, *mobilis*, *subtilis* and *acutus* - are inscribed in a column of medallions placed parallel to the four elements. The two columns of elements and qualities connect to each other by lines, each element being thereby related to three qualities. The semicircular lines indicate the contrary qualities.

Every element in this figure is accompanied by a number: *terra* VIII, *aqua* XII, *aer* XVIII, *ignis* XXVII. And Boethius dedicated a complete chapter to numbers and their proportional relationships in his *De institutione arithmetica*. In it the reader learned that 2x2x2=VIII and 3x3x3=XXVII are cubic numbers, because they are both the result of three numbers. The numbers VIII and XXVII are also related one to the other by the numbers XII (=2x2x3) and XVIII (=3x3x2). This series of numbers is regular because every following number is one and a half times larger than the previous one. This is known as a sesquialteral progression, in which 8:12=12:18=18:27.[476] This formula, as found in in *De arithmetica*, was the result of Pythagorean and Platonic number symbolism, a domain which was of fundamental importance to philosophy.

In the so-called *syzygia elementorum*, virtues, numbers and proportions were understood in their relation to the creation and to the essence of the universe. The *syzygia elementorum* is distinguished by its arithmetical addition: it shows the relationships between elements, qualities, the numbers 8, 12, 18 and 27 (each the result of adding half of the previous number), and the harmony of the creation.

The earliest preserved example of a *syzygia elementorum* is found in a manuscript dated to shortly after 1065, now preserved in the Vatican Library.[477] This manuscript is a compilation of treatises: it contains parts of the *Etymologie*, a part of Bede's *De natura rerum*, a paragraph from an anonymous author, and then a part of Isidore's *De natura rerum* concerning the *figura solida*. A *figura solida* appears on the recto side of the folia on which the *syzygia elementorum* is drawn.[478] [*See* figure 3.6]. The diagram accompanies a discussion entitled *Excerptum de quattuor elementis*, written by an anonymous author.[479]

The figure was rotated horizontally and remained unfinished. It includes a pyramid (*pyramis*) indicating fire, a circle (*spera*) for air, an icosahedron (*cose-*

[476] Bober, "In Principio. Creation before time," 15.

[477] Vatican, *Biblioteca Vaticana*, Regina lat. 123. Earlier reproduced by Esmeijer, *Divina quaternitas. A preliminary study in the method and application of visual exegesis*, fig. 15. See: A. Wilmart, *Codices Reginensis Latini* (Rome, 1937–1945), 290–291.

[478] See, for other early examples of the *syzygia*: Madrid, *Biblioteca Nacional*, Vit.20.I, f. 54v (11c) and Oxford, *St. John's College*, 17, f. 13 (ca. 1100), reproduced by Bober, "In Principio. Creation before time," fig. 5 and 6; Esmeijer, *Divina quaternitas. A preliminary study in the method and application of visual exegesis*, fig. 13b.

[479] See, for the *Excerptum de quattuor elementis*: Mynors, *Cassiodori senatoris Institutiones*, 168, appendix B. See x-xlix of the same edition for a survey of the preserved manuscripts.

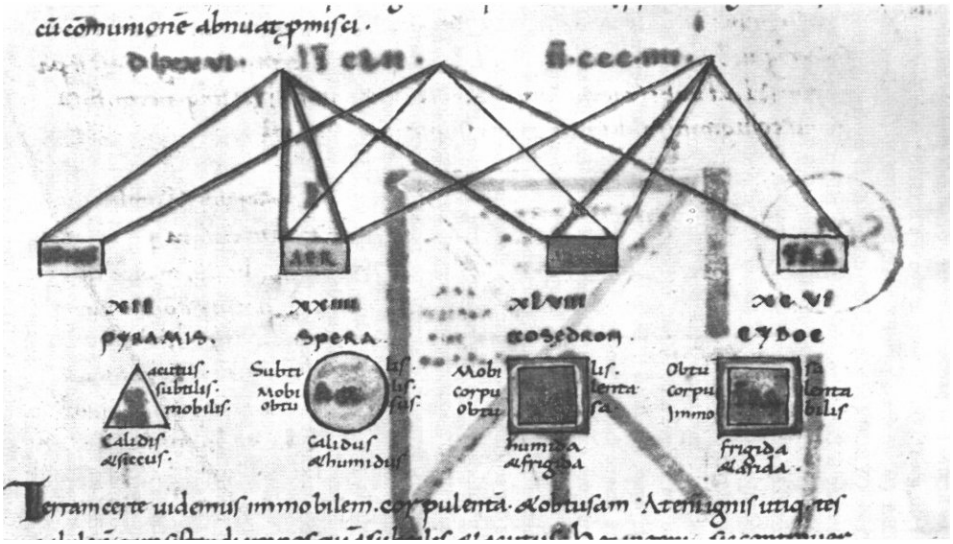


Figure 3.6 Compilation of treatises of Beda, Isidore of Seville, Pliny, Hygine, Macrobius and Calcidius. Vatican, *Biblioteca apostolica Vaticana*, Regin. lat.123, f. 129r. Dated 1056

dron) for water, and a cube (*cyboc*) for earth. The draughtsman did not differentiate between a cube and an icosahedron and the series again draws on the platonic geometrical figures (consisting of triangles): a tetrahedron for fire, an octahedron for air, an icosahedron for water and a cube for earth.[480] The numbers XII, XXIIII, XLVIII and XCVI appearing at the bottom of this Vatican-copy of the *syzygia* seem to correspond to the elements, although it is not quite clear how.[481]

The origin of the pictorial tradition of the *syzygia* is unknown. The earliest copies of the *syzygia elementorum* are found in schoolbooks (like the above-mentioned Vatican example), suggesting that the figure was already an established teaching tool in the eleventh century. The peak of production of this figure was during the twelfth century. By this time the figure must have been so well known that it could easily have migrated beyond a school context, and,

480 Obrist, *La cosmologie médiévale. Textes et images. I. Les fondements antiques*.

481 There is indeed a number theory concerning polyhedra, but it is not exactly in the sequence of the one mentioned above. Polyhedra are considered composite structures, by means of which they have been cut out of spatial matter. Twenty-four right-angles isosceles triangles are needed to form the cubic square. Twenty-four right-angled triangles (of 30 and 60 degrees) are required for a tetrahedral fire-particle, 48 for an octahedral air-particle and 120 for an icosahedral water-particle. This sequence does not explain the 'doubling' sequence of 12, 24, 48 and 96 in the Vatican-copy of the *Excerptum de quattuor elementis*. See: Pressouyre, "Le cosmos platonicien de la cathédrale d'Anagni," 572, n. 4; Dijksterhuis, *The mechanization of the world picture: Pythagoras to Newton*, 16–17.

without a textual accompaniment, could have become monumental art. A known example is the presence of the *syzygie elementorum* as a mural painting in the crypt of the cathedral of Anagni, where it appears as part of an encyclopaedic-theological program dating to the end of the twelfth or early thirteenth century.[482]

3.4 Measuring qualities and motions

Let us turn now to a few specific fourteenth-century treatises dealing with the quantification of the qualities. A first work of interest is the alchemical-pharmacological *Icocedron* by Walter Odington. The question of mixtures was not only dealt with by natural philosophers but also by chemists, who derived their knowledge not only from theoretical foundations and through logical coherence, but also from empirical experience. Alchemical compounds and pharmaceutical compounds are affected by the quantities or dosages applied and were seen as syntheses of disparate volumes of qualities.[483] Odington worked, during the first decades of the fourteenth century, at Oxford, in Merton College. He must have met Thomas Brardwardine and was highly influenced by the Calculators, but he also stands in an alchemical and pharmaceutical tradition. Only one diagram of his system for calculating the degrees of intensities has survived and this unparalleled diagram is of interest due to its early date and its domain of application.

Another work of interest is *De configurationibus qualitatum et motuum* by Nicolas Oresme, who wrote this treatise about latitudes in the late 1350s while he was at the College de Navarre in Paris. Oresme is considered as the inventor of the so-called 'configuration' diagrams. Clagett, who was an historian of science, noted that the Italian Franciscan Giovanni di Casali had used this graphing method, in his *De velocitate motus alterationis*, as early as 1346.[484] Although Oresme did not invent the technique, his account is clearer and further developed, and so we concentrate here on his achievements.

The most original contributions to kinematics and dynamics made at Merton College were made before 1350. Some authors continued after that date

[482] Pressouyre, "Le cosmos platonicien de la cathédrale d'Anagni," 551–93; Esmeijer, *Divina quaternitas. A preliminary study in the method and application of visual exegesis*, 39–40.
[483] See, for the medieval theory of compound medicines: M. McVaugh, *The medieval theory of compound medicines* (Princeton, 1965); M. McVaugh, "Quantified medical theory and practice at fourteenth-century Montpellier," *Bulletin of the history of medicine* 43 (1969): 397–413; D. Stillman, "Medieval ratio theory vs compound medicines in the origins of Brardwardine's rule," *Isis. An international review devoted to the history of science and its cultural influences* 64 (1973): 67–77. See also: E.D. Sylla, "Medieval quantifications of qualities: the 'Merton School'," *Archive for the history of exact sciences* 8 (1971): 9–39, here 16–18.
[484] Clagett, *The science of mechanics in the Middle Ages, 1200-1400*, 332.

though, mostly by adapting the earlier work. In the late fourteenth century the physics and logic of the earlier Merton scholars were studied in elementary outlines and teaching manuals.[485] These texts are simplified and codified, taking the form of definitions and distinctions of the various terms in physics. Here we shall also look at some of these fourteenth- and fifteenth-century handbooks, in which Oresme's geometric configurations were added in the margin.

3.4.1 Qualities in an alchemical compound

Walter of Odington (also called of Evesham) was a Benedictine monk active in Oxford from at least 1316 to 1330.[486] In his text *Icocedron*, so called because of its twenty chapters, the author dealt with elements, qualities and degrees.[487] The *Icocedron* exists in only four copies and only the Digby-copy contains a diagrammatic representation.[488] The text in this copy is inserted into a wider compilation of many short chemistry texts about metals, stones, minerals and their transmutations.[489]

The last chapters of the *Icocedron* deal with the *intensio* and the *remissio* of qualities. Skabelund and Thomas discussed these chapters in 1969, and their comprehensive discussion remains extremely useful, despite the fact that they did not discuss the figure.[490] Murdoch included the figure in his collection of scientific diagrams but the scope of his book did not permit him to present Odington's theory in detail.

A central notion in the *Icocedron* is that Odington distinguishes the *intensive*

[485] Clagett, *The science of mechanics in the Middle Ages, 1200-1400*, 629–633.

[486] Thorndike suggested that Walter might have sojourned in Paris, writing an alchemist treatise there in 1331. See: L. Thorndike, *A history of magic and experimental science* (New York, 1960), vol. 3, 132–133. See, for more biographical details: D. Skabelund and P. Thomas, "Walter Odington's mathematical treatment of the primary qualities," *Isis. An international review devoted to the history of science and its cultural influences* 60, no. 3 (1969): 331–350, here 332; H. Davey, "Walter of Evesham or Walter of Odington," in *Dictionary of national biography*, ed. L. Stephen and S. Lee (London-Oxford, 1909), 702. See, for a transcription of chapter 16 of the *Icocedron*: Thorndike, *A history of magic and experimental science*, 683–684.

[487] Oxford, *Bodleian library*, ms. Digby 119. Inc: «*Alkymiste moderni temporis sunt plerique delusores*». Fol. 147r : «*Nemo pervertat vel occultet quod ego, frater Walterus de Otyntone monachus de Evesham, duxi caritatis intuitu manifestare. Qui autem fecerit maledicciones, Dei incurrat; sed amantibus sapienciam gratis communicetur, et quia tractatus xx. capitulis concluditur, Ycocedron nominetur*».

[488] London, *British Museum*, Add. 15549, ff. 4r-20v; Cambridge, *Trinity College*, 1122, ff. 177v-183v; Oxford, *Bodleian Library*, Digby 119, ff. 142r-147v; Oxford, *All Souls College*, 81, f. 18r.

[489] W.D. Macray, *Catalogi codicum manuscriptorum bibliothecae bodleianae. Pars IX. Codices a viro clarissimo Kenelm Digby* (Oxford, 1883).

[490] Skabelund and Thomas, "Walter Odington's mathematical treatment of the primary qualities."

quantity of a quality, like temperature, from the *extensive* quantity of quality, for instance the volume of heat. And, significantly, Odington tried to employ relationships between qualitative intensities and qualitative amounts assigning numerical degrees to the intensities. Thus, when two bodies at the same temperature were brought together, their (volume of) heat was added. *Extensive* qualities, in other words, were held to behave arithmetically. The behaviour of *intensive* qualities was described according a more difficult concept in the language of functional relations – verbally, for one did not use symbolic algebra at this time. Heat was thereby combined by simple addition, but temperatures not so: water at 3° added with water at 4° does not result in water at 7°.

Odington mentioned several rules for the composition of qualities, which he reformulated in a table and in a diagram. These rules concerned the composition of equal quantities of different intensity, of similar qualities, of contrary qualities, of weakening and of augmenting qualities, and finally the composition of different quantities at the same intensity. One of the rules proposed was the 'law of motion', which became known in Thomas Brardwardine's formulation. Odington might have met the latter in Oxford.[491]

The diagrammatic representation shows the relations between the elements. [*See* figure 3.7]. The four corners of the square are inscribed with *ignis* (top left), *aqua* (top right), *aer* (bottom right) and *terra* (bottom left). *Aer* and *aqua* are written upside down, so that the reader must rotate the square, either physically or mentally, to read these labels. These elements are shown as a mixture (*prout in mixto*) of two qualities, placed in brackets.

Fire, in this image, is hot and dry. Air is hot and wet. Water is wet and cold. Earth is cold and dry. Obviously, nothing is hotter than elemental fire, whose main constituent, hotness, is set to its maximum of four degrees. This maximum setting of four degrees was common in the medical-pharmacological tradition.[492] The diagram indicates the degree settings of the dominant and non-dominant qualities in each of the primary elements. Fire is therefore composed of heat in the 4° degree and of dryness in 3°. Water is cold in the 4° and wet in the 3°. Air is shown as wet in the 4° and hot at the degree 2° 30' (the middle of the 3°, i.e. 2.50°). Earth, finally, is composed of dryness in the 4° and heat at 2° 30'.

The two diagonals of the square in the figure deal with weakening (*obtun-*

[491] Brardwardine's Law: «The proportion of velocities in motions follows the proportion of the power of the motor to the power of the thing moved». This Law appears in Brardwardine's *Tractatus de proportionibus* of 1328. M. McVaugh, "Arnald of Villanova and Brardwardine's Law," *Isis. An international review devoted to the history of science and its cultural influences* 58 (1967): 56–64, here 56; Skabelund and Thomas, "Walter Odington's mathematical treatment of the primary qualities," 331, 335.

[492] Murdoch and Sylla, "The science of motion." See, for more about the medical pharmacological tradition: McVaugh, *Arnaldi de Villanova opera medica omnia II: Aphorismi de gradibus*.

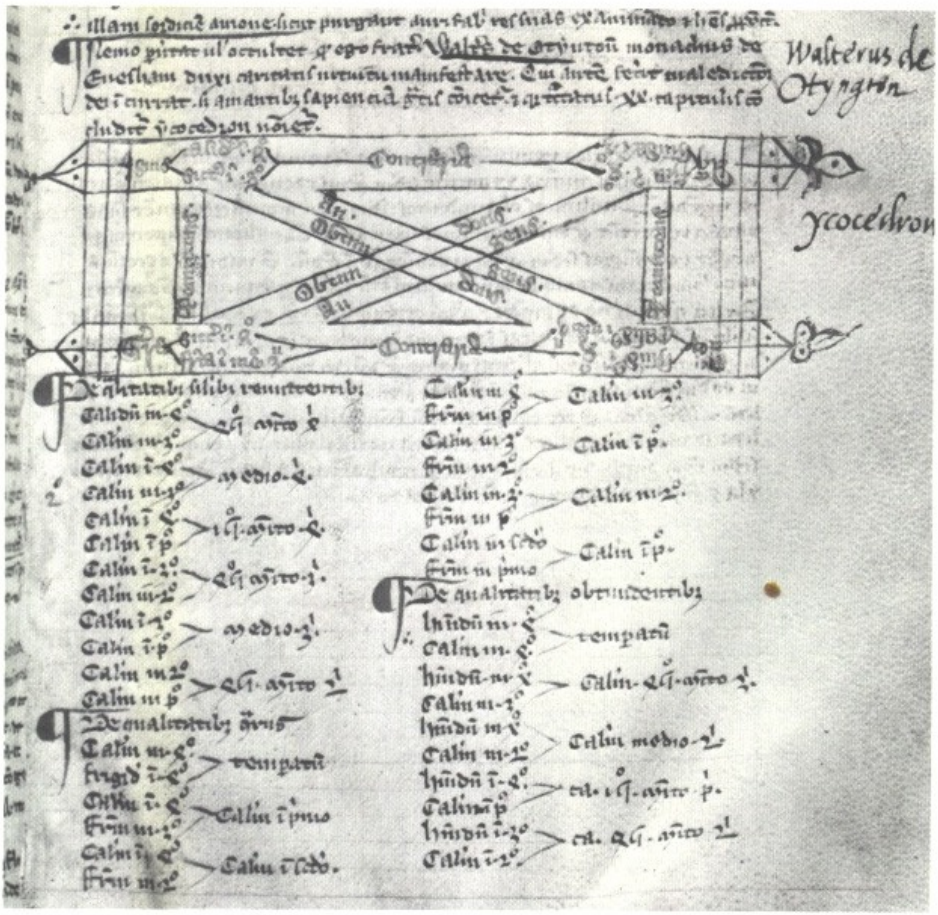


Figure 3.7 Walter of Odington, *Icocedron*. Oxford, *Bodleian Library*, Digby 119, f. 147r. Dated in the first half of the 14th century.

dens) and strengthening (*augmens*) intensities in different qualities. The text reads:

> «Weakening qualities hold their more intense powers according to the degree and return to degrees the more remiss according to minutes. Augmenting qualities advance the more remiss according to minutes and retain the proper degree».[493]

For Odington, every degree exists in 60 'minutes', so that 4° is equal to 240'. A modern notation, with decimals, is placed here between brackets. If we were to take humidity at 4° and heat at 3°, this would mean a weakening of humidity to 3°45' (that is 3.75°). Dryness in fire, meanwhile, strengthens the heat of air. The table teaches the reader that if one mixes dryness at 4° with hotness at 1° the result would be an augmentation of hotness to 1°15' (that is 1.25°). The same holds true for the diagonal band between earth and water. The example given in the figure mentions that the heat in fire at 4° is weakened by the wetness at 4° present in air. The result of this mixture is temperate (Skabelund and Thomas take it to be 4°).

Two vertical lines in the figure, one drawn between fire and air, the other between water and earth, are labelled *remittens*. This relates to the rule held to govern the composition of different intensities of similar qualities (*de qualitatibus similibus remittentibus*): «*similar qualities are remitted minute by minute, but remain in the degree of whichever is the more intense*».[494] The example shown in the figure indicates that if dryness in the 4° in earth is mixed with the dryness in fire at 3°, the resulting degree of dryness is decreasing, but would yet remain on the higher side. The table below indicates that the result of the compound would be a degree of 3° 45' (or 3.75°). The humidity of 4° in air will equally weaken when mixed with the 3° humidity true of water (resulting in 3° 45').

On the horizontal bands in this illustration we read *De qualitatibus contrariis*, and this concerns the rule held to govern the composition of equal quantities at equal intensity in contrary qualities. The heat at 4° in fire and the coldness of 4° in water are, for example, contrary. Its mixture results in a temperate degree, as it reads, and Skabelund and Thomas take this to be 0°.[495] In Aristotelian tradition, however, there was no mixture possible between opposites, because there was no natural body corresponding to the result. Odington

[493] Walter Odington, *Icohedron*, *Bodleian Library*, Digby 119, 147v:«Qualitates obtundentes secundum gradum intensiores tenent suas vires et remittunt gradus remissiores secundum minuta. Qualitates augmentes promovent remissiores secundum minuta et retinent proprium gradum», (translation borrowed from Skabelund and Thomas, "Walter Odington's mathematical treatment of the primary qualities," 334, n. 14).

[494] *Bodleian Library*, Digby 119, 147v: «*Qualitates similes remittuntur secundum minuta sed remaneant in gradu intensioris*». The translations into English are all borrowed from Skabelund: ibid., here 334.

[495] ibid., 338.

surprisingly claims that one can combine hot and cold, but it is not clear just *what* is at 0°. The same applies to dryness and humidity at 3° and present in the contrary sites of earth and air (both mentioned, in this image, on the lower horizontal band).

The theory of mixing qualities in the *Icocedron* is a crossing of several traditions: first, quantitative procedures in alchemy, secondly, Aristotle's *Categorie* of quantity and quality, further developed as the *intensio* and *remissio* of forms by the Mertonians, third, the theories of local motion prevalent at Merton College and in Paris, and fourth, the quantitative treatment of pharmaceuticals by Galen, al-Kindī, and Arnald of Villanova.[496]

Odington made a genuine attempt to calculate Galen's vague notion of four degrees of intensity in the qualities of medicines, by measuring the qualitative intensities of compound medicines. There also seems to have been a connection with the efforts of Arnald of Villanova.[497] However, the pharmaceutical tradition had its own compositional procedure that did not refer to the mixing of qualities from different sources; it also specified the degree in a single body.[498]

Below the diagram and following on the verso of fol. 129, the calculated proportions of the quantities of qualities in a compound are repeated, but in tabulated form. In this table Odington specifies qualities' numerical degrees for similar, contrary, weakening and augmenting qualities.[499]

The figure and the table are complementary. The table is a work of reference, giving the results of a set of compounded degrees. Not all the intensities of forms in the qualities are worked out in the table. It starts with 'hot-hot', then moves on to 'hot-cold', then to 'hot-humid' and finally to 'hot-dry', each case supported by seven examples. A complete list would amount to sixteen examples of whole numbers, for ten series of combined elements, rather than just four. It is unclear whether Odington thought it unnecessary to complete the series, or whether he did not want to waste parchment. The results of the unmentioned combinations can, however, be deduced in theory by the reader, giving the latter a lot of responsibility.

The diagram was a practical instrument, an active teaching tool through which the reader was supposed to participate and thereby train himself in Odington's rules. The degrees mentioned in the figure are the maxima for the four elements. These maxima constituted less of a challenge if the composition

[496] Skabelund and Thomas, "Walter Odington's mathematical treatment of the primary qualities," 333.
[497] See: McVaugh, "Arnald of Villanova and Brardwardine's Law," 54–64; M. Clagett, *Giovanni Marliana and late medieval physics* (New York, 1941), 35, n. 4.
[498] Skabelund and Thomas, "Walter Odington's mathematical treatment of the primary qualities," 343.
[499] See, for a full description of the table and its modern algebraic notations: ibid., 336, n. 18, 337–341.

of the maxima remained maximal, at 4°. If, on the other hand, the reader substituted these maximal degrees with lesser intensities, then he also had to apply the arithmetical rules, and practice them until he mastered its principles.

A reader had to move from corner to corner and up and down the diagram so as to compose intensities in all the possible combinations. When the reader turned the page upside down, the same exercise would be repeated, beginning with wetness and coldness, instead of with heat, but still calculating its changing degree. The text gives no indication that the reader should rotate the figure physically or mentally. By turning the page, however, the figure becomes spatially descriptive, because the four elements in its extreme corners then constitute the borders of the sublunary domain.

The diagram is therefore an instrument with which one can read off the behaviour of 'temperature' when mixing qualities of equal intensities, and of different intensities. The rules are expressed in the table below the diagram, and in the accompanying text. We are told, for example, that mixing 4° of the quality dryness with 3° of the quality dryness would result in 3.75° (or 3° 45' in minute notation), which implies a weakening by a quarter degree. Many compositions are not written out explicitly in the table, but can be deduced on the basis of the rules given. The rules hold only for the mixing of equal quantities of the qualities. The other quality in a given element is thereby ignored. For instance: what happens to the quality of heat (in fire) if the fire also contains two doses of the dry quality in the mix described immediately above, (the double quantity at the 3° 45' degree of dryness)?

Skabelund and Thomas completely omit to consider the diagrammatic representation of the functional relations:

> «The absence of algebraic notation left but three ways of expressing relationships: geometrical, verbal and tabular. Nicolas Oresme's geometric-graphical method was not yet invented, and verbal algebra was beset by an inadequate terminology, which helps explain why Odington relies heavily on the tabular forms and why these still contain gaps».[500]

The diagram helps by indicating the type of relation in play, whether an augmenting or weakening relation, a remitting one, or a contradictory one. But neither the text, nor the diagram, nor the table give an explanation of how to calculate functional relations. The diagram does not solve the problem of calculating degrees. We do not learn why dryness of the fourth degree plus dryness of the third degree should make dryness of 3° 45'. Instead, the reader is the one who can make the diagram work and thereby find the solution by applying the rules. The diagram in fact gives an understanding of the situation of changing intensities in qualities in a compound only insofar as it states the mechanism.

[500] ibid., 337 n. 20.

Odington's diagram is, on balance, fairly innovative. It presents the reader clearly with the four elements and the qualities out of which an element exists. The structure is very different from the Carolingian diagram of elements, in which the elements are ordered in such a way that the qualities they have in common embrace or intersect. The diagonals in the centre of the Carolingian diagram indicated contradictory qualities and this was not the case in Odington's diagram. Their contradictory relations are set out horizontally, and the diagonals instead indicate augmenting and weakening degrees. The order of the elements is therefore not cyclical. Also new in Odington's treatment is the fact that he suggests that a mixture of contrary qualities results in a temperate degree.

3.4.2 Geometric representations of latitudes

In the early fourteenth century, Nicolas Oresme, the Mertonians and others passed from measuring the variation of intensity in qualities, like heat, to measuring variations in velocities (conceived of as an intensity of the quality motion). Oresme based his ideas on Merton College kinematics and his configuration theory was therefore closely related to the Oxford physics.

Nicolas Oresme's visual configurations

Oresme had studied arts in Paris, probably with Jean Buridan, from whom he might have taken his interest in natural philosophy. After this, Oresme enrolled in the theology faculty, where he appears first in the records of the College de Navarre in 1348. He became a master of theology several years later, in 1355 or 1356, and subsequently Grand-Master of the College de Navarre until 1362. Later, he occupied several ecclesiastical positions and parallel to his university-career he developed a friendship with the Dauphin, the future Charles V, for whom he worked as a counsellor from 1364 until Charles' death in 1380.[501]

Oresme dealt with the geometry of qualities and velocities in two treatises, *De configurationibus* and his *Questiones super geometriam Euclidis*. The former is a treatise on the figuration of powers and the measure of difformities, and consists of three parts: a first section on figuration and the power of the uniformity and difformity of permanent things, a second part on the power and the figuration of successive things, and a third section on the acquisition and measurement of quality and velocity.

[501] Clagett, *Nicole Oresme and the medieval geometry of qualities and motions: A treatise on the uniformity and difformity of intensities known as Tractatus de configurationibus qualitatum at motuum*, 4.

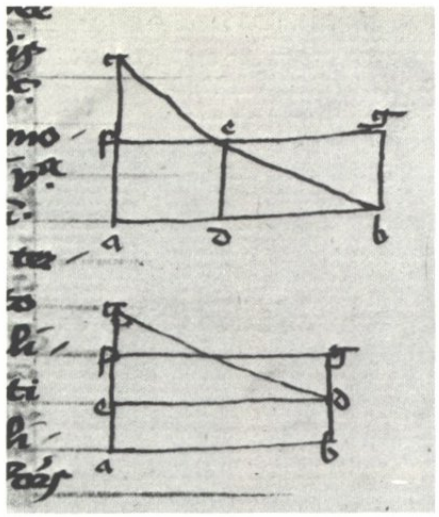


Figure 3.8 Nicolas Oresme, *Tractatus de configurationibus qualitatum et motuum*. London, *British Library*, Sloane 2156, f. 191r. Dated 15th century.

The visual configuration Oresme is famous for, consists basically in a graph of two variables, with a horizontal line depicting longitude or extent, and a vertical line representing altitude, latitude or intensity. By connecting the tops of the uprights representing the intensity one gets a figure held to represent the configuration of a quality.

A uniformly difform intensity over an extent, time for example, is imagined as a combination of regularly intensifying or decreasing motion, represented on a vertical line, with a horizontal line depicting a certain distance over time. A quality on the horizontal line is therefore measured against variations of the intensity of this quality shown on the vertical line. In the case of a uniform intensity of the given quality (*qualitas uniformis*) the configuration is represented as a rectangle. In the case of difformly increasing intensity(*qualitas difformiter difformis*), meanwhile, the configuration would be a stair figure, a set of semicircles, or some other irregular figures. The terminology of 'uniform', 'uniformly difform', 'difformly difform' was thereby applied to velocities in local motion 'over time', instead of 'over space', as would be the case for a quality like heat in an extended subject.

As mentioned above, the Oxford Calculators were credited with having developed the so-called 'mean speed theorem' for understanding uniformly accelerated motion. In this, the amount by which motion (a quality) increases or decreases in its velocity (an intensity) was described as a function of time (understood as an extent): a uniformly accelerated or decelerated motion therefore corresponded to its mean degree.[502]

[502] See about the 'mean speed theorem': Clagett, *The science of mechanics in the Middle Ages, 1200-1400*, 255–329.

Using the mean speed theorem one could correlate uniform accelerations with the spaces thereby traversed. [*See* figure 3.8]. The geometrical proof shows that the area of the triangle *abc*, in the upper figure, representing the uniformly difform motion, is equal to the area of the rectangle *abgf* that could be built by replacing the triangle *cef* with *beg*. Thus, the distance traversed by a thing in uniformly difform motion equalled the distance traversed by a thing moving uniformly with a speed equal to the mean speed of the uniformly difform motion. The configuration of quality or motion was thus represented by a solid figure, with a base representing the subject and a vertical line representing the intensity.

Contrary to the Oxford scholars, Oresme attributed meaning to the 'quantity of quality', which was the product of the intensity of velocity multiplied by the extent in time. The product of quality and quantity corresponded to the area of the imagined configuration, in other words the surface of the geometric, two-dimensional solid. The product also represents the total distance traversed.[503] Nicolas Oresme represented thus the results of the so-called 'Merton mean speed theorem' using geometrical representation.

The system of correlating two concepts visually on two drawn lines was known of in geometry (cartography) and astronomy.[504] Latitude in the Oxford tradition was imagined as a single geometrical dimension, or line. Nicolas Oresme, however, elaborated the notion of latitude using the notion of longitude, as was customary in geometry, and he thereby added a second geometrical dimension transferring the terms from one domain into the other by making use of the twin concepts of latitude and longitude.[505]

In question 11 of the *Questiones super geometriam Euclidis*, Oresme asked whether a linear quality can be represented by a surface. He argued subsequently that it could, and justified his presentation of geometrical figures in the *Questiones super geometriam Euclidis* by invoking some authorities:

> «I say that the question should be answered affirmatively, which could be conformed by *Perspectivi* such as Witelo and Grosseteste, who represent the intensity of light in this way, by Aristotle, who in Physica IV represents time by a line, and by <Johannes> Campanus, who in his commentary on Euclid V says that anything that is of the nature of a *continuum* can be represented by a line, a surface or a body, which he proves

503 Murdoch and Sylla, "The science of motion," 238–239.

504 Clagett, *The science of mechanics in the Middle Ages, 1200-1400*, 333.

505 Nicolas Oresme, *De configurationibus*. I.ii *De latitudine qualitatum*: «*Ergo sicut in motu locali illa dimensio dicitur longitudo spatii seu vie secundum quan exigitur successio, ita conformiter huiusmodi intensio secundum quam requiritur successio deberet dici longitudo ipsius qualitatis*» (Clagett, *Nicole Oresme and the medieval geometry of qualities and motions: A treatise on the uniformity and difformity of intensities known as Tractatus de configurationibus qualitatum at motuum*.)

for ratios.»[506]

Then Oresme applied the idea of linear quality as a surface to velocities, discussed the difform quality through the example of a semi-circle, and stated that the scale for the representation cannot be chosen randomly.

In *De configurationibus*, Oresme expounded somewhat on the use and role of geometric representations:

> «When I had began to set in order my conception of the uniformity and difformity of intensities, certain other things occurred to me to add to the topic so that the treatise might be useful not only as an exercise but also as a discipline. In this tract I have attempted to treat clearly and distinctly those matters which some other people seem to perceive in a confused way, to express obscurely, and to apply in an unsuitable fashion, and I have attempted to apply them usefully to certain other matters».[507]

Thus Oresme explicitly announced his book as a tool for training and organized study. As a tool for training it was meant for students who were thereby to familiarize themselves with the rules and principles of measuring qualities. Elsewhere, he wrote that the consideration of these lines naturally helps and leads to knowledge of any intensity.[508]

De configuratione might also be useful 'as a discipline' or 'for organized study', the two variant translations provided by Clagett. Oresme writes, in his *Livre d'éthiques*, that he understands '*ars*' as the practical sciences, and 'doctrine' as the speculative sciences. Elsewhere, in the *Ethics*, he understands 'discipline'

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[506] Nicolas Oresme, *Questiones super geometriam Euclidis*, Q. 11, 29.2: «*Respondeo, quod questio est vera, et posset confirmari per perspectivos, qui ita ymaginantur intencionem luminis, sicut Utilo et Lincolniensis, et per Aristotelem 4° Physicorum qui imaginatur tempus ad modum linee, et per Commentatorem quinto huius, ubi vult quod omne habens naturam continui potest ymaginari sicut linea aut superficies aut corpus, sicut declarat de proporcionibus*» translation for the greater part borrowed from H.L.L. Busard, ed., *Quaestiones super Geometriam Euclidis' de Nicole Oresme* (Leiden, 1961), 28–29, 111). See also: Clagett, *The science of mechanics in the Middle Ages, 1200-1400*, 333, 361 n. 14.

[507] Nicolas Oresme, *De configurationibus*. I.o *Incipit prohemium*: «*Cum ymaginationem meam de uniformitate et difformitate intensionum ordinare cepissem, occurrerunt michi quedam alia que huic proposito interieci ut iste tractatus non solum exercitationi prodesset sed etiam discipline. In quo ea que aliqui alii videntur circa hoc confuse sentire et obscure, eloqui ac inconvenienter aptare studui dearticulatim et clare tradere et quibusdam aliis materiis utiliter applicare*» (translation borrowed from Clagett, *Nicole Oresme and the medieval geometry of qualities and motions: A treatise on the uniformity and difformity of intensities known as Tractatus de configurationibus qualitatum at motuum*, 158–159). See also: Clagett, *The science of mechanics in the Middle Ages, 1200-1400*, 347.

[508] Nicolas Oresme, *De configurationibus*, I.i *De continuitate intensionis*: «*consideratio ad cuiuslibet intensionis notitiam naturaliter iuvat et ducit*» (Clagett, *Nicole Oresme and the medieval geometry of qualities and motions: A treatise on the uniformity and difformity of intensities known as Tractatus de configurationibus qualitatum at motuum*).

as speculative science. Thus 'doctrine' and 'discipline' seem equivalent and are both identified as a speculative science.[509]

We should indeed not confuse Oresme's 'configurations' with empirical study. The external figures he used were imaginative in character. He writes that

> «although indivisible points, or lines, are nonexistent, still it is necessary to feign them mathematically for the measures of things and for the understanding of their ratios».[510]

He adds that the line of intensity «is not actually (*secundum rem*) extended outside of the point, but is only so extended in the imagination (*secundum ymaginationem*)».[511] Latitude is thus not a really existing external entity waiting to be abstracted from physical processes. The configurations are tied to existing physical things only in the sense that they *stand 'for things'*.[512]

OXFORD ELEMENTARY HANDBOOKS

The discussion of the different *latitudines formarum* and their visual representations appeared in several Oxford textbooks. A group of four related texts were compiled, in which the basic concepts used in the discussions of the intension, remission, latitudes and degrees of forms were described. This group exists today in about twenty-three manuscripts of William Heytesbury's *Termini naturales*, John Garisdale's *Libellus de terminis naturalibus sive termini naturales*, Magister Albert's *Termini naturales seu physicales* and Thomas Netter's *Termini physicales* (also *De terminis naturalibus* or *Introductio ad naturalia*).[513]

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[509] Clagett, *The science of mechanics in the Middle Ages, 1200-1400*, 347.

[510] Nicolas Oresme, *De configurationibus*. I.i *De continuitate intensionis*: «*Etsi nichil sunt puncta indivisibilia aut linee, tamen oportet ea mathematice fingere pro rerum mensuris et earum proportionibus cognoscendis*» (Clagett, *Nicole Oresme and the medieval geometry of qualities and motions: A treatise on the uniformity and difformity of intensities known as Tractatus de configurationibus qualitatum at motuum*).

[511] Nicolas Oresme, *De configurationibus*. I.i *De continuitate intensionis*: «*Huiusmodi vero linea intensionis de qua nunc dictum est, non extenditur extra punctum vel extra subiectum secundum rem sed solum secundum ymaginationem*» (ibid.).

[512] E.D. Sylla, "Mathematical physics and imagination in the work of the Oxford Calculators: Roger Swineshead's 'On natural motions'," in *Mathematics and its application to science and natural philosophy in the Middle Ages. Essays in honor of Marshall Clagett*, ed. E. Grant and J. E. Murdoch (Cambridge, 1987), 69–101, here 74, 75, 84. See also Maier, who claimed that we should understand the figures as real, concrete figures of qualities, for Oresme regularly spoke of *imaginare per figuram* and seldom of *designare*. The geometrical figure is on this understanding identified with the represented concept. Maier, *An der Grenze von Scholastik und Naturwissenschaft. Die Struktur der materiellen Substanz. Das Problem der Gravitation. Die Mathematik der Formlatituden*, 306–307.

[513] Paris, *Bibliotèque nationale*, lat. 6673; Paris, *Bibliotèque nationale*, nal. 566.

Six of these manuscripts date from the fourteenth century and the rest from the fifteenth century.

The *Termini naturales* might have played a role in preparing advanced undergraduate students to respond during the well known Oxford disputations.[514] A treatise such as the *Termini naturales* provided an elementary outline of the definitions and divisions supplied for the use of undergraduate students in physics as they prepared to solve natural philosophical problems.[515]

The Oxford calculators William Heytesbury and Richard Swineshead were both concerned with an exhaustive presentation and rigorous demonstration of how one could measure a given distribution of a quality in as many cases as possible. They both followed a growing tradition of 'sophisms' – puzzling propositions or examples to be resolved by the appropriate application of logical-mathematical rules. These sophisms were compiled to train students to use such rules.[516]

Some of the manuscripts of the *Termini naturales* describe the text as «*secundum usum Oxonii*», which means that this treatise was then in current use in Oxford schools.[517] This Oxford method points to a mathematical treatment of concepts in natural philosophy.[518] The presence of several fifteenth-century adaptations also suggests that the *Termini naturales* was related to the Oxford curriculum in the fifteenth century, according to De Rijk.[519]

Weisheipl dismissed of the *Termini* as a 'naïve summary'[520] and 'of little speculative importance'.[521] Elsewhere, however, he stated that it is 'sophisticated and compiled with preoccupation'.[522] Besides these few lines written by Weisheipl and De Rijk about the *Termini naturales*, this text has remained un-

514 See about the core texts of the Oxford calculators (not the *Termini naturales*) and their use in the disputations *de sophismatibus*: Sylla, "The Oxford Calculatores," 540–563.

515 The text is considered to have a predecessor in the *Summa (in VIII libros) Physicorum*. Usually attributed to the Oxford master Robert Grosseteste (c. 1168–1253), but nowadays considered to be written by an anonymous master in arts, probably at Oxford around 1270–80. See: J.E. Bolzán and C. Lértora Mendoza, eds., *Suma de los ocho libros de la 'Fisica' de Aristóteles (Summa physicorum)* (Buenos Aires, 1972). See also: J.A. Weisheipl, "Book review of: J. E. Bolzán and C. Lértora Mendoza, Suma de los ocho libros de la 'Fisica' de Aristóteles," *Isis. An international review devoted to the history of science and its cultural influences* 68, no. 4 (1977): 641.

516 Murdoch and Sylla, "The science of motion," 234, 236.

517 Munich, *Staatsbibliothek*, Clm 5961; Madrid, *Biblioteca nacional*, 6004: «*Termini naturales secundum usum oxonie*».

518 See: Libera, "The Oxford and Paris traditions in logic," here 175.

519 De L.M. de Rijk, "Logica Oxoniensis. An attempt to reconstruct a fifteenth century Oxford manual of logic," *Medioevo. Rivista di storia della filosofia medievale* 3 (1977): 121–164, here 155, 163.

520 Weisheipl, "Developments in the arts curriculum at Oxford in the early fourteenth century," 175.

521 Weisheipl, "Ockham and some Mertonians," 198.

522 Weisheipl, "Book review of: J. E. Bolzán and C. Lértora Mendoza, Suma de los ocho libros de la 'Fisica' de Aristóteles."

noticed.[523]

Twenty-three copies of the *Termini naturales* exist, in several different adaptations.[524] The copy at Munich, *Bayerische Staatsbibliothek*, Clm. 8777 is said to be «*compilata a magistro Wilhelmo Hesbri*», that is compiled by master William Heytesbury.[525] The colophon of the copy at Munich Clm. 8950 mentions: «*explicit expositio terminorum naturalium magistri Wilhelmi Hesberi*».[526] William Heytesbury (a.1313–1372/1373), as a Fellow of Merton College, Oxford, was one of the personalities that made the faculty of Arts in Oxford famous in the fourteenth century. He was a Doctor of Theology by 1348 and might have been Chancellor of the University from 1353–1354.[527]

Other copies were named «*Termini physicales editi per magistrum Albertum*».[528] We do not know who this 'Master Albert' was, but the text is ascribed to him in more than one copy.[529] Again another copy is said to be an

[523] See, for the De Rijk: Rijk, "Logica Oxoniensis. An attempt to reconstruct a fifteenth century Oxford manual of logic," here 155, 163. See also further, on page 133.

[524] Assisi, *Biblioteca Comunale*, ms. 690, ff. 314r-319r (15c) (Magister Albert); Barcelona, *Archivo de la corona de Aragón*, Ripoll. 141 (commt. of John of Garisdale); Escorial, *Real Biblioteca de S. Lorenzo*, g IV 31, f. 86r-102r (14c) (commt. of John of Garisdale); Florence, *Biblioteca Laurentiana*, Plut. 83, cod. 28 (15c), ff. 1–7v (14c acc. to Thorndike and Kibre); London, *British Library*, Royal 8. Z. XVIII (membr. 14c), ff. 69v-75 (with commt.); Madrid, *Biblioteca nacional*, 6004 (16c) (commt. of John of Garisdale); Munich, *Bayerische Staatsbibliothek*, Clm. 5961 (1441), ff. 22r-26r; Munich, *Bayerische Staatsbibliothek*, Clm. 8997 (14c), ff. 163r-167r (Magister Wilhelmus Hesbri); Munich, *Bayerische Staatsbibliothek*, Clm. 8950 (a.1418) (Magister Wilhelmus Zesbini); Naples, *Biblioteca Nazionale*, VIII.F.10 (1425), ff. 107r-114r; Oxford, *Canonici Misc.*, 393 (1402, Padua), ff. 78r-83r; Oxford, *New College* 289 (15c.), ff. 38r-50v (with commt. of John of Garisdale until f. 52v); Padua, *Biblioteca universitaria*, 1123 (14c), ff. 36v-39r; Paris, *Bibliothèque nationale*, lat. 6673 (15c), ff. 41–48; Paris, *Bibliothèque nationale*, nal. 566, f. 49r-58r (15c) (Magister Albert); Vatican, *Biblioteca apostolica* vaticana, Vat. lat. 5132 (15c), ff. 41r-48v; Vatican, *Biblioteca apostolica vaticana*, Vat. lat. 1062 (commt. of John of Garisdale); Vienna, *Dominikanerkloster*, 93/57 (14c), ff. 99r-109v; Vienna, *Nationalbibliothek*, lat. 4698 (c.1375), ff. 114v-120v; Worcester, *Cathedral library*, F. 118 (14c/15c), ff. 32r-35r. From: Weisheipl, "Repertorium Mertonense," 216–217.
See also: L. Thorndike and P. Kibre, *A catalogue of incipits of mediaeval scientific writings in Latin. Revised and augmented edition* (London, 1963), 901; Weijers, *Le travail intellectuel à la Faculté des arts de Paris: textes et maîtres (ca. 1200-1500)*, vol. 6, 117- 118; De Rijk, "Logica Oxoniensis. An attempt to reconstruct a fifteenth century Oxford manual of logic," 133; R. Sharpe, *A handlist of Latin writers in Great Britain and Ireland before 1540* (Turnhout, 1997), 776–777.

[525] Munich, *Bayerische Staatsbibliothek*, Clm 8997, f. 167r. See: Weisheipl, "Ockham and some Mertonians," 198.

[526] De Rijk, "Logica Oxoniensis. An attempt to reconstruct a fifteenth century Oxford manual of logic," 133.

[527] Weisheipl, "Repertorium Mertonense," 212.

[528] Paris, *Bibliothèque nationale*, nal. 566, f. 49r.

[529] My edition of these two manuscripts ascribed to Master Albert is added to the appendices. Assisi, *Biblioteca Comunale*, ms. 690, ff. 314r-319r, here f. 314r: «*Termini naturales seu physicales editi per magistrum Albertum*». See also: E.M. Buytaert, "The Tractatus logicae minor of Ockham," *Franciscan studies* 24, no. 2 (1964): 34–100, here 35–42.

«*expositio terminorum naturalium magistri Wilhelmi Zesbini*».[530] There is also an adaptation by John of Garisdale.[531] Of this last adaptation five copies are known.[532] Only two copies of Netter's *De terminis naturalibus* are known to have survived, meanwhile, and both are preserved in the *Bodleian Library*.[533] Thomas Netter of Walden (1377/80–1430), was active in Oxford several decades after Heytesbury's death. He took his degrees in Oxford and spent several years teaching there. He is known for being the chief opponent of Wycliffe. Many other adaptations of this text are anonymous; the relation between these texts has never been studied.[534]

Termini naturales seu physicales

The fifteenth-century Paris copy of the *Termini naturales seu physicales* shows several geometric configurations in its margins and the text mentions an attribution to a 'Master Albert'.[535] It says, to be precise, that he had *'editi'* the text, which could mean 'composed' or 'edited', as opposed to *'scribere'* which means 'to copy'.[536] Presumably, then, Albert re-edited Heytesbury's *Termini*. The two

[530] Munich, *Bayerische Staatsbibliothek*, Clm 8950, a.1418. See: Thorndike and Kibre, *A catalogue of incipits of mediaeval scientific writings in Latin. Revised and augmented edition*, 901.

[531] Oxford, *New College*, 289, (15c), ff. 38–52, here f. 52: «*Expliciunt Termini naturales secundum Johannem Garisdale*». See: De Rijk, "Logica Oxoniensis. An attempt to reconstruct a fifteenth century Oxford manual of logic," 142; Weisheipl, "Repertorium Mertonense," 217; Weisheipl, Developments', 175.

[532] John Garisdale, *Termini physicales/naturales*: Oxford, *New College* 289, ff. 38–52 (15c); Vatican, *Biblioteca apostolica Vaticana*, lat. 1062; Madrid, *Biblioteca nacional*, 6004 (16c); Barcelona, *Archivo de la corona de Aragón*, Ripoll. 141; Escorial, *Real Biblioteca de S. Lorenzo*, g IV 31, f. 86r-102r (14c). See: ibid., 216–217; Thorndike and Kibre, *A catalogue of incipits of mediaeval scientific writings in Latin. Revised and augmented edition*, 902; G. Antolín, *Catálogo de los códices latinos de la Real biblioteca del Escorial*, vol. 2, 5 vols. (Madrid, 1910–1923), 297.

[533] Oxford, *Bodleian Library*, Bodley 676 (SC 2593), ff. 149–161; Oxford, *Bodleian Library*, Digby 75, item nr. 18. Incipit: «*Natura est duplex, scilicet natura naturans et natura naturata [...]*». Lohr mentions only Oxford, *Bodleian Library*, Sc 2593, ff. 149-(161), (15c.). Lohr, "Medieval Latin Aristotle commentaries," here 182–183. See also: F. Madan and H.H.E. Craster, *A summary catalogue of western manuscripts of the Bodleian Library at Oxford* (Oxford, 1922), 442; T. Tanner, *Biblioteca Brittanico-Hibernica* (London, 1748), 746–748.
An excerpt of *Linea naturalium* in Oxford, *Bodleian Library*, Bodley 676 (ff. 4r-6r) is printed in: Clagett, *The science of mechanics in the Middle Ages, 1200-1400*, 632, n. 4. Much the same things are included also in Netter's *De terminis naturalibus* on ff. 149–160 of the same manuscript.

[534] Florence, *Biblioteca Laurentiana*, Plut. 83, cod. 28 (14c); Vienna, *Nationalbibliothek*, 4698, 14c, ff. 114v-120v (TR 318); Prague, *Archivio Capituli metropolitani*, 1419, ff. 63–68. See: Thorndike and Kibre, *A catalogue of incipits of mediaeval scientific writings in Latin. Revised and augmented edition*, 902.

[535] Next to the Paris copy mentioned above, another copy of the *Termini physicales* ascribed to Master Albert is: Assisi, *Biblioteca Comunale*, ms. 690, ff. 314–319 (15c).

[536] P. Bourgain, "La naissance officielle de l'œuvre," in *Vocabulaire du livre et de l'écriture au moyen âge. Actes de la table ronde. Paris 24-26 septembre 1987*, ed. O. Weijers (Turnhout, 1989), 195–205, here 200, 205. See also: F.P.W. Soetermeer, "Terminologie de la librairie à Bologne," in

surviving fifteenth-century copies ascribed to Master Albert may have served as an *exemplum* to be copied by students.[537]

An summary of the text (on the basis of the Paris and Assisi copies) gives an idea of its contents.

It begins by stating that nature is the principle of motion and of rest. There are two sorts of motion: instantaneous (*subitus*) and continuous or successive motion (*successivus*). Instantaneous motion is motion caused without any resistance (and is not divisible). Continuous motion, on the other hand, is caused by a subject's interior potential. Motion is said to occur in *terminus a quo* or *terminus ad quem*, meaning, respectively, motion from the given moment onwards and motion towards a certain point.

There are then ten predicaments specified: 'quantity', 'quality', 'relation', 'place', 'time', 'posture', 'state', 'action' and 'passion', and motion is held to be present in four of these predicaments ('substance', 'quantity', 'quality' and 'place'). Motion is present as follows in these predicaments: in 'substance' as generation and corruption, in 'quantity' as augmentation and diminution, in 'quality' as changing place and local motion. Finally, motion in 'place' is said to occur when a body moves from place to place.

A body can exist, states the text, either in a single body or in a composite body. Bodies are said to be able to move in six directions: upwards, downwards, left, right, forwards and backwards. In mixtures (composite bodies), the body moves towards the natural place of those elements dominant in the given body. Fire, for instance, moves upwards. Bodies are also said to move according to their power and resistance.

The *Termini naturales* specifies that there are two kinds of resistance in bodies: an intrinsic one and an extrinsic one. Intrinsic resistance is caused by opposed elements in a mixed body. For instance, a mixture in which earth dominates, goes downwards, but this movement would be slowed down by the presence of a fire-component in the mixture. Extrinsic resistance comes from outside the body. Dense air, for example, would reduce the movement of a certain body through this air. If, therefore, we imagine a mixed body in a vacuum, it would move only according to its intrinsic resistance. A simple, non-composite body, however, would not move at all in a vacuum. Motion, meanwhile, is said to exist in a natural mode and a violent mode. Natural motion is intrinsic to the body, like earth's downward movement. If one throws earth up in the air, therefore, this upward movement is called 'violent'.

The *gradus summus* is a term used in the *Termini naturales* meaning the maximum degree of a body when not mixed with its contrary quality. Thus the max-

Actes du colloque Terminologie de la vie intellectuelle au Moyen Âge. Leyde-La Haye 20-21 septembre 1985, ed. O. Weijers (Turnhout, 1988), 88–95, here 90.

[537] See, for a list of the consulted manuscripts for this chapter, Table C.2, page 267.

imum degree of a quality in which 'white' is completely absent, (for instance in the colour 'black'), has no 'latitude of white' at all. Further, if a quality has a high degree of intensity it is called a *gradus intensi*, and a *gradus remissi* if the degree of intensity is low, meaning, in the latter case, that the distance to a state of no degree at all is a short one. Intensifying in this context also means gaining perfection, and *remissio* means losing it.

Intensification of degrees is said in the text to occur *uniformiter* or *difformiter*. Uniformly intensifying motion means that a certain amount of latitude is acquired in a certain period of time, and the same amount is then acquired again in the succeeding, equal time span. Difform intensification means a gain of more latitude in one time period than in the other.

The elementary parts are held to be active or passive and the active part is said to dominate the passive part. Among the elements, which all have an active and a passive part, these parts are labeled *reactio* and *passio*. Of course, there are said to be four elements: fire, water, air and earth. These have four primary qualities: hot, wet, dry and cold, which result six combinations, of which two are impossible. Hot and dry is, for instance, fire, in which heat dominates. Hot and wet combine in air, in which wet dominates. Wet and cold is water, in which cold dominates. Cold and dry is earth, in which dry dominates. In the other two combinations, the qualities were thought contradictory and therefore could not result in a natural body.

Fire was considered the lightest element and was therefore situated in the highest region of the sublunary. Below it came air, then water and, in the lowest position, earth, the heaviest element. The text states that fire is a greater quantity than air, which is in turn a greater quantity than earth <here the copyist made a mistake: this should be 'water'>, etc. The smallest quantity is said to be all the more dense. Meanwhile, elements that share a primary quality, like fire and air, or air and water, or water and earth, or earth and fire, are described as *symbola*. The other combinations, by contrast, are called *dissymbola*. Elements are thus homogeneous bodies if all their parts are of the same nature and are heterogeneous if not all their parts are the same.

In a uniform quality, the quality is equally intense throughout, intensity here being the measurement of the distance to its o degree. A difform quality is one in which one part is more intense than in the other. Further, there are two types of difform qualities, a 'uniformly difform' one and a 'difformly difform' quality. The latter are those in which the intensity differs throughout the subject. In the latitude of a 'uniformly difform' quality, the intensity of the quality intensifies or weakens at a regular rate through the subject.

Motion, for its part, is held to exist in two ways: uniformly and difformly (non-uniformly). Uniform motion is that which over an equal period of time traverses an equal space. Difform motion means crossing unequal distances over



Figure 3.9 Master Albert, *Termini physicales*. Paris, *Bibliothèque nationale*, lat. nal. 566, f. 55v, left margin. Dated 15th century.

a series of equal periods of time. Difform motion is sub-divisible into two kinds: 'uniformly difform' and 'difformly difform'. The first means motion that acquires or loses its latitude uniformly; the latter means gaining or losing latitude at irregular rates.

The acceleration and deceleration of motion is held to exist in two ways: uniformly and difformly. Uniform acceleration of motion means that in an equal period of time, the same latitude of motion is acquired. In the case of deceleration, an equal latitude is lost. Conversely, if the acceleration of motion is difform, then in equal cycles of time the latitude of motion is acquired at unequal rates. Uniformly difform acceleration means the intensity of motion augments in one time span just as much as in another. When weakening, likewise, the latitude decreases equally. When motion accelerates in a difformly difform way, the intensity acquired in one cycle of time is greater than in another.

The *Termini naturales* continued: There are four types of cause cited: material causes, formal causes, efficient causes and final causes. The first two causes are intrinsic and the other two are extrinsic.

The *Termini naturales* then provides a description of several solids and geometrical concepts, such as a column, a pyramid, a sphere, a (semi)-diameter, a cube, a pentagon, a hexagon, a plane-angled triangle, an acute-angled triangle and a surface.

So far for a summary of the *Termini naturales*. See for a transcription of this text: Appendix A.

Oresme's configurations became a common good in the fifteenth century so that geometric diagrams, demonstrating the working of the measurements of qualities, also adorned the Oxford handbooks. Oresme's configuration techniques were therefore, not surprisingly, used to interpret the text of Master Albert's *Termini naturales seu physicales*.

There are several geometric figures drawn into the Paris-copy, some on fol. 55v and two on 56v. The first diagram is a rectangle, labelled *uniformis*, representing uniform quality or motion over a given extent. [*See* figure 3.9]. The figure is drawn next to the discussion of difform qualities but clearly belongs to

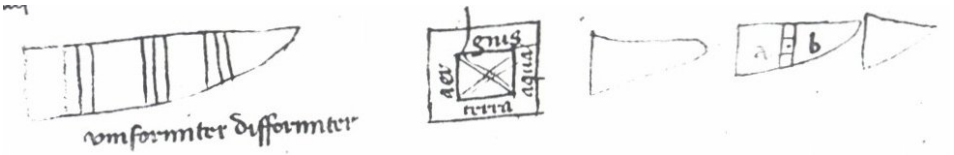


Figure 3.10 Master Albert, *Termini physicales*. Paris, *Bibliothèque nationale*, lat. nal. 566, f. 55v, bottom margin. Dated 15th century.

the question of uniform intensity, since the latitude of intensity in this drawing remains at the same distance to the base line throughout the space.

A second figure is labeled *uniformiter difformiter* and represents a regularly increasing intensity over a given extent. [*See* figure 3.10]. It is drawn, correctly, into the bottom left-hand margin, facing the discussion about 'uniformly difform' qualities. The diagram has its base line at the top and the perpendiculars that form the latitude therefore point downwards. Oresme considered this positioning less fitting but equally valid, stating that:

> «it could be extended in any direction whatsoever, except that it is more fitting to imagine it standing up, perpendicularly, on the subject as informed with the quality».[538]

The meaning of the repeated, perpendicular lines drawn in the 'uniformly difform' configuration is unclear. Sometimes perpendicular lines indicated the division of the surface so as to facilitate, or prove, the mean speed rule, by measuring out the surfaces in question. This is the case in the uniformly difform diagram placed further to the right in the bottom margin. [*See* figure 3.10]. The figure here is divided in an 'a' and a 'b' part, with segments dividing up the surfaces. The 'a' and 'b' labels are not referred to in the accompanying text. The fact that the draughtsman started this figure three times indicates that he was not very sure of his rendering.

In the bottom margin, verso-side of fol. 56, a third and fourth illustration of the uniformly difform quality are drawn. [*See* figure 3.11]. This time there are compartments numbered from one to five, to facilitate correlation between the geometric parts. This renders geometrically visible the way in which the quality (velocity) acquires equal intensities over equal periods of time. A last figure represents a uniformly difform quality, where every perpendicular representing intensity increases constantly over equal time periods.

Nicolas Oresme and the Mertonians formulated and analyzed the application

[538] Nicolas Oresme, *De configurationibus qualitatum et motuum*. I.i *De continuitate intensionis*: «*convenientius ymaginatur in sursum perpendiculariter stare super subiectum qualitate informatum*» (Clagett, *Nicole Oresme and the medieval geometry of qualities and motions: A treatise on the uniformity and difformity of intensities known as Tractatus de configurationibus qualitatum at motuum*).

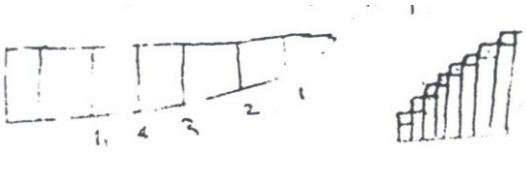


Figure 3.11 Master Albert, *Termini physicales*. Paris, *Bibliothèque nationale*, lat. nal. 566, f. 56v, bottom margin. Dated 15th century.

of latitudes and degrees to motion *secundum imaginationem* (according to the imagination). This means that the analysis was based on creative imagination and not *secundum cursum nature* (that is 'according to the order of nature').[539] In 'the addition theory' of qualitative intensification, the degrees, in a given latitude of quality, were imagined as lines. When a quality was made more intense (through addition of a new part of the form), the (imagined) line was lengthened. The additive nature of intensities could be worked out through the analogy of line segments alone.[540]

Although they searched for solutions in physical matter itself, this whole investigation was still considered a part of logic.[541] The Oxford treatises were adaptations of works, in the venerable medieval, logical tradition of inventing complex examples, called sophisms. Heytesbury used calculatory techniques and introduced these into disputations on natural philosophy. The application of calculatory techniques was questionable, however, for in many cases the Calculators did not discuss what really happened physically: many of their cases, in the usual fourteenth-century manner, were possible only in the imagination. These examples were not experimental, and were not meant to be tested by an appeal to nature. The whole investigation was still considered, in other words, a part of logic.

The geometrical representations help us to understand the problem of configuration of intensity. The diagrams reflect the procedure of 'overlapping' two figures that was used for measuring. In this technique one figure was of the internal configuration of acceleration and the other showed the mean speed. It presents thereby the 'actual' configuration and its geometrical measurement at the same time. The reader then needs to 'calculate' the mean speed and the space traversed, by means of the geometrical surface shown. This technique granted understanding and also proved the mean speed theorem, thereby solving the problem. Many other configurations, however, were not developed to prove a theorem but were merely developed to visualize the composition of qualities in a geometrical way. In those cases the configurations do not prove anything but instead illustrate or imagine a parallel notation to aid understanding.

Although the two-dimensional graph was a known technique in cartogra-

539 Murdoch and Sylla, "The science of motion," 246–247.
540 ibid., 233.
541 Sylla, "The Oxford Calculatores," 558, 563.

phy and astronomy, and latitude was already commonly imagined as a single geometrical dimension or line, the external configuration associated with Oresme can still be called innovative. The two-dimensional structure was newly adapted at this time to the domain of dynamics.

Oresme's graphical representation approaches the principle of coordinates, but is not exactly comparable to a modern method of coordinates.[542] The letters *abcdefg* stand for distances and intensities in Oresme's work, but are not measurable. The configuration does not have a quantifiable grid. The idea of function is there, and Oresme tried to visualize that, but this function was, however, not imagined like modern ones in which the numerical relationship of one size with another is central.[543] Instead, Oresme's representation remains speculative. He realized a unified theoretical science, but on the basis of imagined quantitative concepts.[544]

3.4.3 The square of oppositions

Further copies of the group of texts around *Termini naturales* feature a figure that deals with the possibility of mixing the qualities of elements. One example is the Munich-copy of William Heytesbury's *Termini naturales*. [*See* figure 3.12]. The figure is basically a square and the primary qualities are inscribed in circles placed in its corners: *calidum, siccum, frigidum* and *humidum*. The names of the elements are inscribed on the bands connecting the corners: *ignis, terra, aqua* and *aer*. Two qualities relate to each element. Around the figure four banderols announce the four possible combinations: dry-hot, hot-wet, wet-cold, cold-dry. The diagonals, meanwhile, indicate the two impossible combinations (*contradictorius*): hot-cold and wet-dry. The relationship hot-dry is marked *contrarius*; the relation wet-cold is marked *subcontrarius*; and the hot-wet and dry-cold combinations are marked *subalternus*.

This particular diagram was inserted in a copy now kept in Munich, *Bayerische Staatsbibliothek*. The manuscript was compiled in 1441, about a century later than the text itself. It contains *expositiones* about various logical treatises

[542] H. Wieleitner, "Über den Funktionsbegriff und die graphische Darstellung bei Oresme," *Bibliotheca mathematica. Zeitschrift für Geschichte der mathematischen Wissenschaften* 14, no. 1 (1914): 193–243, here 193. See also: H. Wieleitner, "Der 'Tractatus de latitudinibus formarum' des Oresme," *Bibliotheca mathematica. Zeitschrift für Geschichte der mathematischen Wissenschaften* 13 (1913): 115–145.

[543] ibid., 145.

[544] Buridan thought, according to Thijssen, that the relation of mathematical objects to reality is of a semantic nature and not a matter of abstraction. Buridan placed mathematical objects on the level of the intellect: an extra-mental reality. See: J.M.M.H. Thijssen, "Buridan on mathematics," *Vivarium* 23 (1985): 55–78, here 76. See also: Sylla, "Mathematical physics and imagination in the work of the Oxford Calculators: Roger Swineshead's 'On natural motions'."

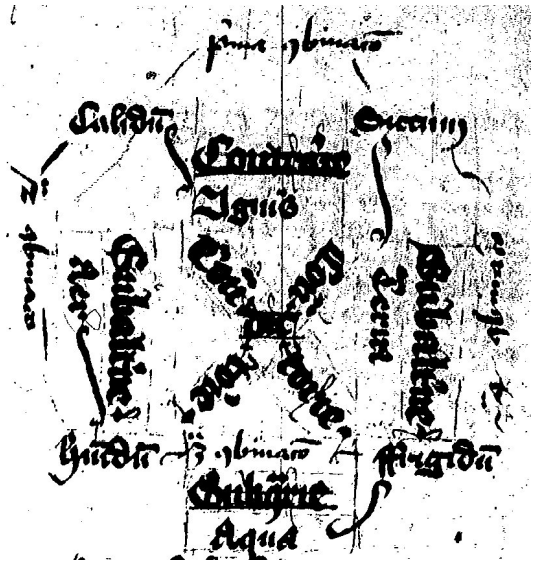


Figure 3.12 William Heytesbury, *Termini naturales*. Munich, *Bayerische Staatsbibliothek*, Clm 5961, f. 24r. Dated 1441

(*In universalia Porphyrii*, *De predicamenta*, *De sex principiorum*), and also a *Termini theologicales*, a *Termini naturales* and a *Termini metaphysicales.* Helmold Arendorp of Saxony claimed to have written this study volume.[545]

The figure is inserted at a moment in the text about the six possible combinations:

> «There are six combinations of primary qualities, of which two are impossible and four are possible. [...] The first combination is this: hotness and dryness, which corresponds to fire, for in fire are hotness and dryness in which hotness dominates. The second combination is hotness and humidity, which corresponds to air, which consists of hotness and humidity with humidity dominant. The third combination is humidity and coldness, corresponding to water, which is humid and cold and in which coldness dominates. The fourth combination is coldness and dryness, which corresponds to earth, being cold and dry, and in which dryness dominates. The fifth combination is hotness and coldness and this combination does not correspond to any element, for this combination is impossible, since hotness and coldness are contradictory qualities. [...] The sixth combination is humidity and dryness and this combination does not correspond to any element either for this combination is also impossible, since dryness and humidity are contradictory, as is shown in the following figure of elemental qualities and their combinations».[546]

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545 «*Codicem scripsit Helmoldus Arendorp de provincia Saxonie de castro Bremensi in Luneborch*» (K. Halm, G. Thomas, and W. Meyer, eds., *Catalogus codicum latinorum bibliothecae regiae Monacensis* (Wiesbaden, 1968), 59).

546 Munich, *Bayerische Staatsbibliothek*, ms. 5961, f. 24r. This section is excerpted from *De generatione et corruptione* II.3.

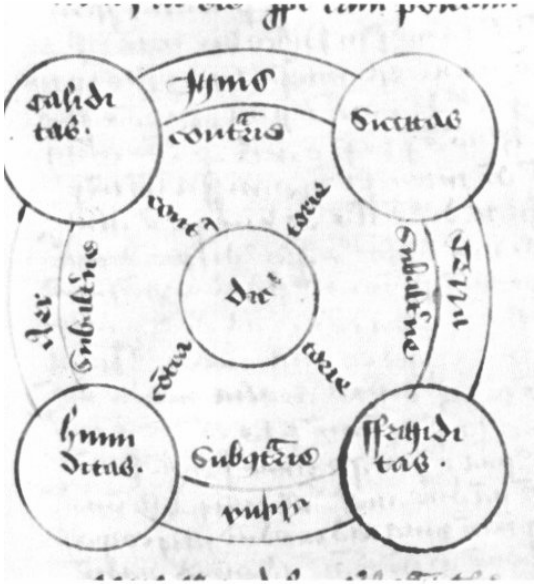


Figure 3.13 Thomas Netter, *De terminis naturalibus*. Oxford, *Bodleian Library*, Digby 75, f. 129r. Dated 15th century.

The figure was integrated with the text: placed within the text and verbally announced as «*ut patebit in sequenti figura*» (as is shown in the following figure). It was therefore possibly envisaged by Heytesbury himself, despite the fact that this particular manuscript was copied about a century later.

The diagram fits into the Aristotelian view of changing material matters, which considered that the principles of motion are contraries. In other words, motion (or generation, or change in general), occurs when one contrary (or its intermediate) changes into another contrary (or its intermediate). Aristotle writes that everything that comes to be or passes away comes from, or passes into, its contrary or else an intermediate state.[547] Contraries cannot act upon each other to produce motion, since each contrary cannot become its opposite or an intermediate. There must also be a substratum in which the contraries can inhere. The substratum, while sustaining motion, remains the same thing before, during and after a given motion.

Contrariety and contradictions were common concepts in Aristotelian physics, but there was no discourse about 'subaltern' or 'subcontrary' in that physics and the accompanying text in the *Termini naturales* does not clarify these concepts either. The troubling terminology derives clearly from the domain of logic, where the modalities of propositions are visualized with the so-called 'square of opposition' in logic.

Murdoch considered this diagram, drawn in the *Termini naturales*, 'silly'. He maintained that the 'square of opposition' was a visual device, used to imply the

[547] Aristotle, *Physica*, 1.5; 188b, 23–95.

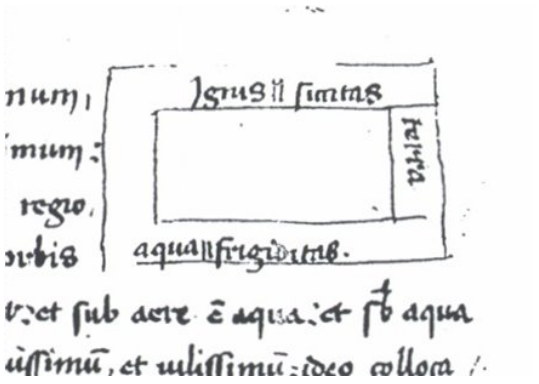


Figure 3.14 Master Albert, *Termini physicales*. Paris, *Bibliothèque nationale*, lat. nal. 566, f. 54r. Dated 15th century.

existence of relations in the doctrine about the elements that are not there: a case of what he calls 'force-fitting'. He asserted, about a similar figure, that it is «not only inappropriate, but without any foundation in the theory of elements, to apply the other logical relations presented by a square of opposition (contrary, sub-contrary, subaltern) to the four primary qualities».

The figure, with its strange terminology, might indeed be troubling, but it did not prevent draughtsmen from copying it more often. Instead of a square, the diagram in the manuscript copy signed 'Digby 75' has the look of a circle, but the terminology is the same as in the figure in the *Termini naturales* of Heytesbury. [*See* figure 3.13]. The four 'corners' are reserved for the four qualities. On the band between the qualities, the elements are inscribed. The diagonal lines indicate the contradiction between hot and cold and between wet and dry. The relationship between hot and dry is contrary, while the relations dry-cold and hot-wet are both subaltern, and the relation between wet and cold is labeled 'sub-contrary'. The diagonal contradiction indicates the impossibility of the combination. The other copy in the *Bodleian Library* (Bodley 676) is, however, more sober.

A fifth figure is drawn in Master Albert's *Termini naturales*.[548] On fol. 55v of the Paris-copy, in the middle of the bottom margin, the draughtsman started drawing. The result is a double-rimmed square with two diagonal lines. The space in between the double-rimmed square is inscribed with the names of the four elements: *ignis, aqua, terra* and *aer*. [*See* figure 3.10]. The diagram illustrates the discussion about the four elements, their prime qualities, and their possible combinations, as described on fols. 54r and 54v. In a window in folio 54r, a similar figure remained unfinished: a double square inscribed with *ignis* | *siccitas, terra, aqua* | *frigiditas*. The outlines of the figure are drawn within the margin, and it appears just after the description of the sixth combination. The diagram is announced in the text as «*ut patet in sequenti figura*». [*See* figure 3.14].

[548] Paris, *Bibliothèque nationale*, nal. 566, f. 55v (15c).



Figure 3.15 Peter of Spain, Tractatus. Paris, *Bibliothèque nationale*, lat. 16611, f. 5r. Dated 13th century.

A similar figure remained unfinished in the Assisi-copy of this text.[549] There the picture is announced, right after the description of the six combinations, with the words «*ut patet in figura primum*», indicating that this figure was originally conceived in association with this specific text.

The Paris-copy of Master Albert's *Termini naturales*, interestingly, shows several attempts to draw correct diagrams and a few unfinished ones. It shows that the draughtsman was not clear about what he was trying to do. He was likely only a young student. Natural philosophy was studied in the Arts faculty, which one entered at the age of about fifteen. So, the study of natural philosophy was in many cases a juvenile activity.

Should we, then, consider the attempt to align the elemental theory of oppositions with the square of logical oppositions as a silly, juvenile activity? But this verdict begs the question of why the draughtsmen tried such a substitution, especially since the effort to perform that substitution recurs in multiple cases. If only because the figure appears in several copies of the *Termini naturales*, it seems only fair to follow the line of thought suggested in the diagram.

The terminology of 'subalternity' and 'subcontrariety' remind one of the terminologies used in the medieval diagram called 'the square of opposition'. Let us take a look, therefore, at the square of opposition. [*See* figure 3.15]. The left upper corner is labelled 'affirmative universal', which is applicable to, for example, the proposition 'all men are mortal'. The contrary to this proposition

[549] Assisi, *Biblioteca Sacro Convento fondo antico comunale*, ms. 690, f. 317r.

is 'all men are not mortal', which is an example of a universal negative proposition, and is labelled in the upper right-hand corner. The corner positions at the bottom are reserved for the particular propositions, on the left affirmative and on the right negative. These propositions are both 'subaltern to' the phrases in the upper part. A particular affirmative is a phrase like 'Some men are mortal', which is in a subcontrary relationship to the phrase 'Some men are not mortal'. The subcontrary propositions, in other words, differ in quality, where subaltern propositions differ in quantity. The diagonals in the square, meanwhile, describe the contradictions.[550]

The logical square of opposition was a visual device used to explain the relations between affirmative, negative, universal and particular propositions, so that one might systematize phrases for syllogisms. Syllogistic logic is about useful premises for a correct form of argumentation, in which the conclusion is deduced from the premises. For example, a syllogism is: if 'all men beings are mortal', and 'Greek are human beings', then 'Greek are mortal'. This is a deductive argument, made on the basis of two premises.

The use of the terms from the 'Square of opposition in logic' in a figure of the four elements implies that the terms were held to act upon a same inference. The Square of elemental opposition seeks to represent the behaviour of changes in structures of matter. This behaviour was described in terms of contradiction, contrariety, subcontrariety and subalternity. These terms were borrowed from logic and used to explain the intensification and diminishment of qualities and quantities in the changing structure of a given material substance. The application of the same inference to the figure of elements would imply the following, *hypothetical* reading:

A subaltern relationship indicates a difference in quantity (some of a set/all of a set), while contrary relationships indicate a difference in quality (such as mortal/not mortal), and contradictory relationships indicate a difference in both quality and quantity. Thus the four possible combinations of qualities in an element are specified by the quantity and quality of the qualities. In the context of the *intensio* and *remissio* of forms, we should understand the concepts of quantity and quality in terms of the extent and intensity of a given quality. A certain degree in quality is thus measured by its intensity, while an augmentation or decrease in quantity means a change in the extent of the given quality.

If we continue with the argument of inference this would mean the following. The diagonal lines between hot, cold, dry and wet would indicate a *contradictory relation* between hotness and coldness, and between dryness and wetness. Inferentially, this means that the qualities (intensities, like

[550] See for further reading: C. Williamson, "Squares of opposition," *Notre Dame journal of formal logic* 13 (1972): 1–19.

degree) as well as the quantities (extents, like volume) of these qualities are counterbalanced. For example, a certain degree of hotness mixed with the same degree of coldness would see one neutralize the other. There would be something at 0° and without the slightest volume. Therefore, Aristotle argues that this combination is impossible. Contradictory qualities are opposed in volume and in degree and the same holds true for the relation between dryness and wetness.[551]

The *contrary relation* between hotness and dryness (as in fire) infers that there is only a difference in quality, which means that in a mixture the temperature will change but not the volume. Dryness in earth is, for example, weakened by hotness in fire. When mixing the contrary qualities of coldness and wetness, the quantity does not alter but the intensity does: the coldness in earth is strengthened by the humidity of water. The *subcontrary relationship* between humidity and coldness is like a contrary relation, in which there is only a difference of quality, and not quantity.

The relationship between wetness and hotness in air, meanwhile, is considered here as a 'subaltern' one. The prefix 'sub' in *'subaltern'* might indicate that this relation is subordinate to an 'alternate' relation, although it is not clear to which of the *'alternate' relations* this would be. If we continue the parallelism of concepts between the figure of elements and the logical square of opposition this would mean that the relation between wetness and hotness is one of a difference in quantity. In a mix of wetness and hotness the quantity of both are therefore altered but their intensity (temperature) is not. In the transformation-process of subaltern qualities, the volume, (the extent) of, say, hotness, diminishes in contact with wetness, with the result that the volume of wetness augments. This would also imply that the temperature remains unaltered. The volume of dryness in earth likewise diminishes if mixed with coldness, with the result that

[551] The text of the Munich-copy of the *Termini naturales* does not seem to be very precise in this matter, since the fifth combination of hot and cold is said to be contrary instead of contradictory, whereas the sixth, which is equally impossible, (between dry and wet), is said to be contradictory. William Heytesbury, *Termini naturales*: «The fifth combination is hotness and coldness, and this combination does not correspond to any element, which combination is impossible, because hotness and coldness are contrary, and contrary qualities cannot be in one and the same name. The sixth combination is wetness and dryness, and this combination does not correspond to any element, because this combination is impossible, because it is made out of contradictories, as shows the following figure which is about the qualities and combinations of elements»
«*Quinta combinatio est caliditas et frigiditas: et isti combinationi non correspondet aliquod elementum, quia illa combinatio est impossibilis, quia caliditas et frigiditas sunt contrarie, et qualitates contrarie non possunt inesse eidem, et hoc denominative.*
Sexta combinatio est humiditas et siccitas: et isti combinationi non correspondet aliquod elementum quia illa combinatio est impossibilis quia est faxta ex contradictoriis, ut patebit in sequenti figura que est de qualitatibus et combinationibus elementorum» (Munich, *Bayerische Staatsbibliothek*, Clm 5961, f. 24r).

the volume of coldness in the mixture augments. The intensity of both should remain the same, however.

If one applies the terminology of logic to the elements, the above-mentioned interpretation would be the necessary inference. It remains a 'silly' reading, but it might explain what the draughtsman was thinking and why the drawing reappears more than once. There is, however, no direct proof for this reading, and neither does it clarify the term *'subcontrary'*.

This diagram is not the only example of 'fitting' using the square of logical oppositions. Nicolas Oresme himself designed as many as three figures in his *Livre du ciel et du monde*, in which he took the logical square of oppositions figure as a model. The logical relations he thereby represented explain a variety of thoughts.

A first one appears in chapter 31 of his *Livre du ciel et du monde*, where he explains that

> «he seeks to demonstrate as a universal law that whatever is not without a beginning is not without an end and, if it is not without an end, then it is not without a beginning; also that what has no beginning is everlasting and, if it is everlasting, it is without a beginning. The contradictory of that which is always capable of being is that which cannot possibly always be, and its contrary is that which is always capable of not being; the contradictory of this latter is that which is not always capable of not being». And «In order to illustrate this» Oresme clarifies «it by means of a figure very similar to that used to initiate children to logic».[552]

It is, then, clear that Oresme developed his figure in line with the square of logical oppositions on purpose, using a figure known to pupils from treatises by Boethius or Peter of Spain.

In the following, chapter 32, Oresme again used the model of the square of logical oppositions to illustrate the relationships between 'always being' (*tousjours estre*), 'always not being' (*tousjours non estre*),' having beginning' (*avoir commencement*) and 'having an end' (*avoir fin*). In chapter 33, he repeats this scheme again: first, that which is 'without beginning' (*sanz commencement*), secondly, that which is 'without end' (*sanz fin*), thirdly that which 'has an end' (*avoir fin*) and fourth, that which 'has a beginning' (*avoir commencement*). All

[552] Nicolas Oresme, *Le livre du ciel et du monde*. I.31, 51b-51c: «Ou. .xxxi. chappitre il veult monstrer universelment que chose qui n'est pas sanz commencement n'est pas sanz fin, et se elle n'est sanz fin, elle n'est pas sanz commencement; et que chose qui est sanz commencement est sanz fin, et se elle est sanz fin, elle est sanz commencement. <Figure>. De ce qui est touzjours possible estre, la negacion contradictoire est non touzjours possible estre et son contraire est touzjours possible non-estre, et de cecy la contradictoire est non touzjours possible non-estre. Et pour ce miex entendre, je le desclaire en une figure presque semblable a une que l'en fait pour la premiere introduction des enfans en logique», translation borrowed from A.D. Menut and A.J. Denomy, eds., *Nicole Oresme. Le livre du ciel et du monde* (Madison–London, 1968).

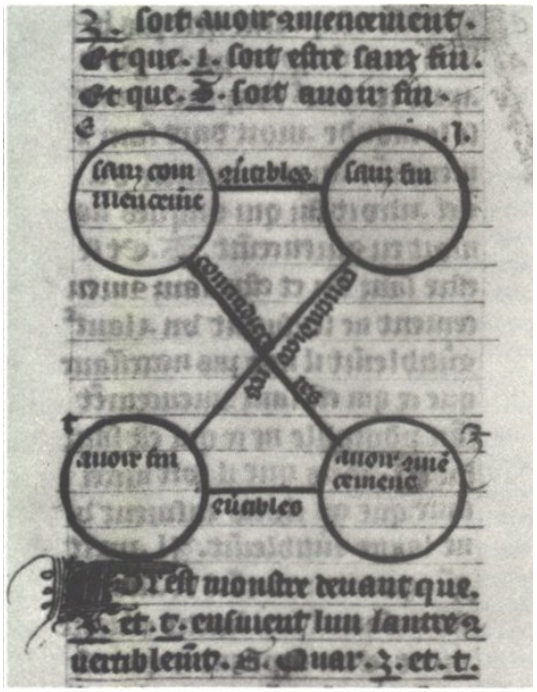


Figure 3.16 Nicolas Oresme, *Livre du ciel et du monde*. Paris, *Bibliothèque nationale*, fr. 1082, f. 53r. Dated late 14th century.

three examples of convertible terms are visualized with a diagram resembling the logic square.[553] For an example of the figure in chapter 33: [*See* figure 3.16].

In contrast to the configuration diagrams, the square representation was based on an existing diagrammatic structure. Its redeployment in new contexts was not new either, and its application to the combinations of elements not entirely successful. The square of elemental opposition could only partly help to understand and solve the problem of combining qualities in a compound. It works very well, however, as a way to see at a single glance which combinations are possible and which are not.

The difference in intensity and extent of qualities is possibly implied by means of the parallel of 'alternity', 'contradiction' and 'contrariety' and the idea of parallelling two separate problems by means of similar argumentative mechanisms might work well, especially if one of the two mechanisms is already well known (which was the case for the square of logic opposition). In this case, though, the parallel between the two structures does not give much insight into the problem of the composition and transformation of elements.

[553] Walter Burley (ca. 1275–1344), a prominent philosopher, also developed a figure dealing with the doctrine of 'the first and last instances' on the basis of the traditional square of opposition. See, for a reproduction of this figure: Murdoch, *Album of science: Antiquity and the Middle Ages*, 70–71.

The diagram therefore reflects essentially the traditional, Aristotelian principles of the contrary qualities that cause motion and change, and not so much the newly acquired theories regarding the quantity of quality.

3.5 Conclusions: From perfection to measurement

Here I would like to return to the central theme of this chapter: the impact of the new quantifying approaches on the form and content of elemental diagrams.

To recap: the common Isidorean elemental diagrams took the form of circle diagrams, in which the relationship among elements and qualities was expressed in terms of contraries and intermediaries. This Carolingian visual material showing the four elements coincided with a synthetic envisioning of the universe in quadruples of elements, qualities, winds, seasons and so on. The four elements are in this system the roots of all being, and are bound in geometrical proportions by their qualities heat, cold, dryness and moisture, to the greater whole. The parallel between the elements and qualities and the seasons, ages, winds, humors and so on, suggests a web of relations among many micro- and macro-cosmological structures. The reader would sense the symmetry. As such, the diagram acts as a physical backdrop and claims the perfection of creation.

In fourteenth-century treatises on the measurement of change in qualities and motion, the focus was usually on the measuring of change and motion itself. This tendency marks out the fourteenth century as a time when there was an (incomplete) move away from the analysis of primary qualities in terms of opposites and transmutation, and away from analyzing motion in the Aristotelian terms of agent, patient, mover and moved, all of which had been prevalent in previous works. Change was increasingly understood as a change in qualities, the measurement of which consisted in establishing the degree of intensity of the quality (a quantification of qualities). Aristotle, by contrast, had not considered qualities measurable. In the light of this new, fourteenth -century interest in measuring the latitudes of intensities, the intensification and remission of qualities in material substances (and in motion) became a point of scholarly exploration.

These new interests and new solutions demanded the replacement of the old visual schemes with new diagrams representing the structure of substantial matter. The idea of the interlinked comprehensiveness of micro- and macro structures although, did not completely disappear. The cosmological diagrammatic structures were therefore dropped in this period in favor of the specific structure of the subject.

In this chapter three types of diagrams from the fourteenth century have

been discussed: first, the alchemical–pharmacological square designed by Walter Odington; secondly, the external configurations represented in geometrical diagrams by Nicolas Oresme and Master Albert; and finally the square of elemental opposition that appears in several copies of the *Termini naturales*.

Odington developed his image on the basis of Avicenna's latitudes of health - a measurement of how the components in a compound related to each other. The diagram he designed to accompany his writing illustrated the effect of intensifying and weakening qualities in the changing structure of a compound.

The geometrical configurations, on the other hand, became popular in the second half of the fourteenth century and are of a different character. Nicolas Oresme wanted to visualize internal configurations externally, so that one could follow and distinguish the different possible configurations that could characterize them. Differences in internal configuration were held to explain many physical and psychological phenomena, which were otherwise not explainable on the sole basis of the four elements in a body. The same kind of geometrical configurations were also used in several Oxford treatises to illustrate the various possible configurations of changing intensity in the quality of a given subject.

The square of elemental opposition, meanwhile, the last diagram dealt with in this chapter, is of a more traditional character. This diagram fits into the Aristotelian tradition, with its central doctrine that change occurs because of opposites. It copies the diagrammatic model of logical opposition of the *Isagoge*-commentary tradition. But it also strongly resembles Odington's alchemical–pharmacological diagram, which also finds its basic structure in the notion of opposition.

The analyses of the diagrams undertaken in this chapter permit us to answer the questions posed in the introduction to this chapter.

To what extent were the diagrams dealt with here new diagrammatic structures and to what extent were they borrowed? The square of elemental opposition and also Odington's diagram are both based on a known diagrammatic structure, called the square of opposition, which hailed from the field of logic.

Confusing was, in the case of the square of elemental opposition, the application of the elements and qualities to the four modalities of logical propositions, and the equivalence implied between the two sets of ideas by this application. Borrowing the structure of the square of logical opposition was, however, not uncommon: several other such transfers have been noted in this chapter. *Not* common however was the rigorous application of the imported logical terminology - which does not seem to make sense. Still, it was copied several times and my hypothesis is that the draughtsman saw a parallel between quantity and the singular-universal on the one hand, and quality and affirmation-negation pairs on the other. The parallel does not hold, but that does not invalidate the attempt.

The study of natural philosophy was, as we have seen, a juvenile activity. Natural philosophy was studied in the Arts faculty, which one entered at the age of about fifteen. As such, this attempt or mistake or exaggeration in rigorous application can be understood: the young draughtsman was possibly too eager or just very confused about what he was doing. The multiple try-outs of figures, in the Paris-copy and Assisi-copy of the *Termini naturales*, also point in this direction. The educational aspect is also apparent overall in the Oxford texts, which were designed as handbooks for the aid of students. They might even be aids for understanding treatises presenting sophisms: complex logic problems, solved in public by students.

In Odington's diagrammatic square, the transfer of the diagrammatic structure was more casual and worked well because of the familiarity of the transferred structure. The relationships between the qualities of the elements were expressed through the possible contradictions and contraries of qualities in a compound, and through the growing and falling quantities of those qualities. The diagram indicates the type of relationship in play, but does not give the formula of the function in question. The configuration diagram made use of the idea of latitude and longitude already known in other domains, but was otherwise completely new.

Now, did these new diagrams reflect the new approach of the fourteenth century and how? Odington's diagram and Oresme's graphs in fact reflect the new approach differently. Odington invented a tool by means of which the reader could read off the behavior of the qualities when elements transform. The diagram is an instrument, by means of which readers and students could train themselves in the application of the rules he established. The description of the behavior of the qualities was reduced by Odington to the idea of the weakening or augmenting intensity (say, temperature, for instance) of the qualities. The degree by which the intensity alters could be deduced from the table placed below the diagram. Oresme indicated intensity and also extent (for example volume, quantity or time). Oresme's approach to acceleration or other intensifying qualities implied, moreover, an augmentation of the quantity of quality. The quantity of the quality in a given form was visualized through a latitude, which represented the degree of intensity. The extent was visualized through a longitude and his graph was therefore a geometric volume. The square of elemental opposition, by contrast, fails to reflect the new approach, but instead gives a clear, traditional overview of the possible combinations of qualities.

And how did these new diagrammatic structures help to understand or solve the problem of transformation in substantial matter? The configuration graphs helped by giving an overview of the mechanism and the effect involved in changing qualities in the elements, and they applied the new insights about the quantity of quality in the composition of compounds. The configuration graphs also

help to understand the internal configuration of physical phenomena, which are otherwise not explainable on the basis of the four elements, since an augmenting quality in a thing or a diminishing quality in a thing might well have the same amount, but its configuration can still be different. The configuration diagrams made these differences visible and explicit.

The configuration diagram, furthermore, was not only an illustration, but also a tool and a geometric proof (of the mean-speed theorem). Oresme moved from variation in the intensity of permanent qualities to variations in velocities. In the case of the mean-speed theorem, the graph helped to solve the problem of acceleration. According to the Oxford Calculators, uniform acceleration over a period of time was shown thereby to be equal to its mean speed. Oresme added the longitude of time to the latitude of intensity. This graph also delivered the solution for the measurement of the total distance traversed during a given acceleration: the surface of the resulting figure represented the distance traversed. The total distance could be read off by the reader, by looking at the geometrical figure and measuring the total surface. The reader therefore 'experienced' the proof of the theorem by measuring it. In the other cases the configurations gave insight into the internal composition of things.

The square of elemental opposition first and foremost made the oppositions clear. If all it had done was to demonstrate these opposite relations, the diagram would have been sound and useful, if simple. This square stood essentially in the traditional Aristotelian doctrine of opposites, matching the textual explanation it was supposed to capture. However, it failed to reflect the new approach. The draughtsman possibly tried to make it compatible with the new approach, by differentiating between the quality and quantity of a quality in contrary, contradictory and (sub)altern relations.

Odington's diagram helped in calculating the degree of qualities in a compound. It does not give an immediate understanding of the formulae used, but one could deduce these, with some effort, from the accompanying table. The diagram also grants understanding of what happens to the configuration of qualities when elements change, but it does this somewhat more abstractly than did Oresme's geometrical graphs, because Odington's diagram does not represent a real thing by analogy.

Instead of claiming the perfection of creation by insisting on its symmetry, some fourteenth-century diagrams were reconsidered and came to function as tools and instruments of measurement and calculation. These diagrams became a form of scientific practice, in that they provided evidence for the theorems asserted, or acted as a training instrument, to help readers master the rules of functional relations.

Nicolas Oresme's diagrams reflect the expectations of Roger Bacon and Robert Grosseteste - that mathematics and geometry could solve natural philo-

sophical problems. All these scholars trained students through figures, and considered lines, angles and figures not only useful, but also necessary for understanding. The diagrams Grosseteste used, inspired Oresme to think about the quantities of qualities in the form of solids. The educational aspect was also stressed by Oresme, who wrote his treatise and developed his configurations to train students in the use of the configuration rules and to aid the autonomous study of the speculative doctrine of the quantification of qualities. The next chapter will focus on the impact of the disciplinary and educational context on the form and content of diagrams.

Chapter 4

The powers of the soul in teaching

4.1 Introduction

Andreas Vesalius, the illustrious Flemish anatomist, recalled in his *De humani corporis fabrica* (1543) how, as students at the *Pedagogium Castrense* of Louvain University in the early sixteenth century, he and his fellow-students had been shown a figure from a book during class. The image presented the ventricles of the brain:

> «To help us grasp each point in which we were being instructed we were shown a diagram taken from some pearl of philosophy. This diagram depicted the aforesaid ventricles, and we students copied it down in our notebooks with accuracy in proportion to our interest in scholastic writing. We were persuaded that it showed, not merely the three ventricles, but all the parts, not merely of the brain but of whole the head. But the whole thing was a figment of the imagination of people who had never seen the brilliance of our Creator in the fabric of the human body; the following account will show how wrong their account of the structure of the brain was.»[554]

[554] Andreas Vesalius, *De humani corporis fabrica*. VII.I: «*Ceterum ut singula que ita nos edocebamur, aptius assequeremur, tabula quedam ostendebatur nescio a qua Philosophie Margarita deprompta, dictosque iam ventriculos oculis subiiciens, quam nos discipuli prout scholastice picture quisque erat studiosior, suis commentariis expressius appingebamus. Necque hac figura tres duntaxat ventriculos complecti nobis persuedebatur, verum ipsam quoque omnes simul capitis partes, nedum cerebri, ostendere arbitrabamur. Atque hec Opificis nostri solertiam in corporis humani fabrica nunque inspicientium sunt figmenta, qui quam in cerebri constructione enarranda aberrent sequens sermo ostendet*» (J. Pigeaud, ed., *Andreas Vesalius. De humani corporis fabrica, (editio princeps: Basle 1545)* (Paris, 2001), 623. Translation borrowed from J.B. Carman Richardson W.F., ed., *Andreas Vesalius. On the fabric of the human body. A translation of De humani corporis fabrica libri septem* (Novato, 2009), 164–165).

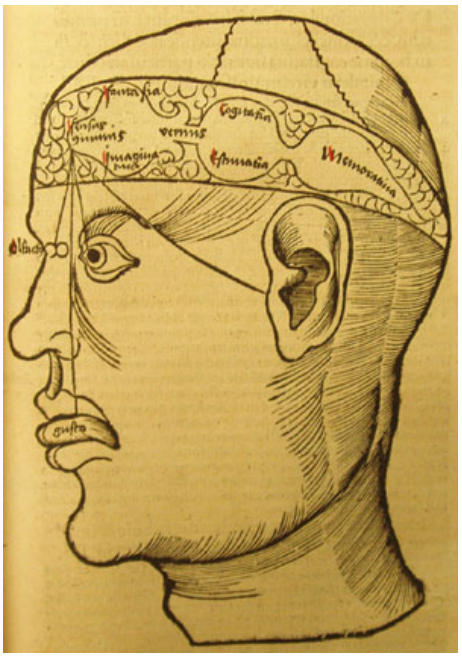


Figure 4.1 Gregor Reisch, *Margarita philosophica* (Johann Schott: Freiburg 1503). London, *King's College London*, B765. R3 M2. Dated 1503.

The book Vesalius referred to, some 'pearl of philosophy', has been identified as the *Margarita Philosophica* by Gregor Reisch, first published in 1503 in Freiburg.[555] An illustrated encyclopaedia, the *Margarita philosophica* was widely used as a university textbook during the early sixteenth century. The particular picture he copied shows a human head in a profile position turned to the right. [*See* figure 4.1]. Several lines are shown leading from the external senses, the mouth, ears, eyes and nose – touch was not represented in this picture –, to the first capacity housed in the front ventricle of the head: the common sense. The other powers located in the front ventricle are the imagination and the power of fantasy. The middle ventricle contains the *estimativa* and the cogitative power, while the posterior ventricle is reserved for memory. The passage between the front and the middle ventricle is labelled 'worm' (*vermis* in Latin) indicating an organ similar to a worm, which could be opened and closed and which allowed the passage of thoughts to the anterior parts of the head. Consequently, one could facilitate the passage of good thoughts by nodding one's head, and by shaking it prevent the settling of bad thoughts. Vesalius was not impressed: as if one could understand the brain by inventing such an image!

A key point, readily obscured by Vesalius' complaints, is that his teacher was not teaching anatomy, but psychology, using the *Margarita Philosophica*, a widely used manual in the early sixteenth century. The *Margarita philosophica* touched

[555] C. Singer, *Vesalius on the human brain* (Oxford, 1952), 6 n. 18.

on all the subjects a student would encounter in the Arts faculty, including the topic of memory and the senses.[556]

This chapter therefore is about the question how diagrams relate to scientific practice. One of the practices that influenced the use and production of scientific books and thereby facilitated the creation of differentiated uses and meanings, is teaching.

The *Margarita Philosophica* is typically such manual among many produced in the early sixteenth century providing an overview of the subject matter to be learned, and therefore central in teaching. A favorite of the fifteenth century teaching was the manual *Parvulus philosophie naturalis*, compiled by Peter of Dresden in the Prague region around the year 1400, and featuring quite a general and common title that was used to indicate that one was dealing with a compendium on Aristotle's *Physica* and *Libri naturales*. Peter devoted part three of his book to the powers of the soul and the text is often accompanied by large scale drawings, showing the functions of the brain, or more precisely: the powers of the rational soul. Does this picture enjoy the same function as the brain-diagram in Vesalius' classes?

This chapter therefore is more precisely about the question of how diagrams representing the functions of the brain relate to a 'daily' scientific practice in a tangle of audience, copyists, teachings, notes, dictations and books, with special emphasis on the diagram-rich manuscripts of the *Parvulus philosophie naturalis*. Some angles are especially crucial here: first, the question of transmission from teacher to students; secondly, the question of dissemination, and lastly, the question of simplification, didactics and normalization.

These three angles are also inter-related in the following ways. First, we possess quite a few images and other data about the visual representations of the powers of the soul, which allows us to see how such images mediated between members of the learned community and their individual practices. We know, for example, who the student draughtsman was in some cases, and in whose classes he made his drawing. Secondly, the *Parvulus* served virtually all of Central Europe, travelling with teachers and students to other university towns. And thirdly, teaching is a process associated with the toning down. Textbooks with images used in teaching are associated with the simplification of complex doctrines. They played a negotiating role by translating research into something general readers and students could comprehend and appreciate. At the same time, text books have a very important role in the maintenance of a given discipline. Exactly because of the toning-down of doctrines and its systematization, textbooks advanced the process of normalization. This normalization of

[556] See for more details: B. Halporn, "The Margarita Philosophica: a case study in early modern book design," *Journal of the early book society for the study of manuscripts and printing history* 3 (2000): 152–166; J. Ferguson, "The Margarita philosophica of Gregorius Reisch: a bibliograpy," *The Library. Fourth series* 10 (1929): 194–216.

doctrines is necessary for the achievement of consensus and subsequent consolidation of questions and doctrines.[557]

With a focus on the *Parvulus philosophia naturalis*, this chapter has its geographical and chronological focus in fifteenth-century Central Europe, with a centre in Prague, for that is where this textbook circulated. There is no relevant tradition of diagrammatic representation to be found in Paris, Oxford, Cambridge, Montpellier or Bologna.

In the fifteenth century, the centers of scientific learning were no longer limited to Oxford or Paris, but were scattered all over Europe, thus altering the intellectual scene significantly.[558] During the last decades of the fourteenth century, many new universities were founded in Central Europe. The first university on the eastern side of the Alps was founded in 1348, at Prague, by the king of Bohemia and the Holy Roman Emperor Charles IV, on the model of the Sorbonne at Paris. Prague offered a sizeable *studium*, which attracted many students, including some from the furthest corners of Poland, Sweden and Hungary. These were settled in Prague according to their nationality, in four different university 'nations': Bohemian, Bavarian, Saxon and Polish.

The chronology of this chapter is, however, considerably enlarged to do justice to the historicity of the diagram under study. The topic of the powers of the soul is related to the study of the *De anima*. The ideas of Aristotelian psychology had survived in the antique medical texts (especially Avicenna's adaptation of Galen's work) and subsequently transmitted to the Latin West. Direct access to *De anima* was possible after its translation into Latin around 1220–1235, and in an improved version since 1268. The study of *De anima* was undertaken within the university right from the moment of its arrival, with a short interruption in the early thirteenth century during the ban on Aristotle's natural philosophical works.

However, the earliest surviving diagrammatic representation resembling that much later produced by Reisch, dates from the middle of the fourteenth century. Other types of illustrations, dating from around 1100, before the reintroduction of the *De anima*, have also survived. Given this chronology, this chapter covers the range of diagrams from 1100 until 1503.

The psycho-philosophical aspects of the soul, notably the mind-soul problem, but also the localization of the soul in the human body and the processing of data obtained from the senses into memory, are widely discussed in the existing

[557] Jardine, "Books, texts and the making of knowledge," 403.

[558] On the multiplication of universities and the rise of schools of thought, see M.J.F.M. Hoenen, "Late medieval schools of thought in the mirror of university textbooks. The Promptuarium argumentorum (Cologne 1492)," in *Philosophy and learning: universities in the Middle Ages*, ed. M.J.F.M. Hoenen, F.H.J. Schneider, and G. Wieland (Leiden–New York–Cologne, 1995), 329–369.

literature.[559] But the diagrams that illustrated manuscript copies of texts about the soul are much less studied.

Walther Sudhoff, who was an historian of medicine, wrote the first comprehensive study about the medieval brain and its pictorial tradition in 1913.[560] His objective was to establish the predecessors of the anatomical images he had seen in various incunabula. He concluded that figures locating the brain faculties all looked the same and that printers and woodcutters stuck to this 'servile' pictorial tradition until the early phases of printing.[561] Sudhoff placed the diagrams in a teleological order, oriented towards the printed end-point, and not realizing that some of the diagrams he described had been conceived by physicians and others by philosophers. This chapter, by contrast, aims to contextualize the diagrams discussed in their proper domain.

Since Sudhoff, further surveys have added some more unknown diagrams to his set. Clarke, a neurologist, published, in cooperation with Dewhurst, an illustrated history of brain function from antiquity to the present day.[562] To answer the question of how medieval thinkers understood the brain, Clarke dealt with the iconography of the brain, and in particular with the localization of functions in the brain, in an attempt, so he said, to bring history and science together.

Where Sudhoff stressed the rigidity of the pictorial tradition, Clarke observed medieval developments in the pictorial history of the brain related to medical evolution. Clarke therefore studied visual renderings of the powers of the soul in relation to the ideas at work in books. But the anthology of pictures presented by Clarke does not do justice to the social-scientific culture in which

[559] See the publications of: C. di Martino, *Ratio particularis. Doctrines des sens internes d'Avicenna à Thomas d'Aquin* (Paris, 2008); D.N. Hasse, *Avicenna's De anima in the Latin West* (London–Turin, 2000); P.J.J.M. Bakker and J.M.M.H. Thijssen, *Mind, cognition and representation. The tradition of commentaries on Aristotle's De anima* (Aldershot, 2007); H. Lagerlund, ed., *Forming the mind. Essays on the internal senses and the mind/body problem from Avicenna to the medical Enlightment* (Dordrecht, 2007).

[560] During the early twentieth century, Walther Sudhoff, and also Karl Sudhoff, published many studies about medieval medicine and anatomy, some of them including parts about brain anatomy. See: W. Sudhoff, "Die Lehre von den Hirnventrikeln in textlicher und graphischer Tradition des Altertums und Mittelalters," *Archiv für Geschichte der Medizin* 7 (1913): 149–205; K. Sudhoff, "Neue Beiträge zur Vorgeschichte des 'Ketham'," *Archiv für Geschichte der Medizin* 5 (1911–1912): 280–301; K. Sudhoff, "Eine Pariser 'Ketham' – Handschrift aus der Zeit König Karls VI. (1380–1422)," *Archiv für Geschichte der Medizin* 2 (1909): 84–100; K. Sudhoff, "Anatomische Zeichnungen (Schemata) aus dem 12. und 13. Jahrhundert und eine Skelettzeichnung des 14. Jahrhunderts," *Studien zur Geschichte der Medizin* 1 (1907): 51–65.

[561] Sudhoff, "Die Lehre von den Hirnventrikeln in textlicher und graphischer Tradition des Altertums und Mittelalters," 204–205.

[562] E. Clarke and K. Dewhurst, *An illustrated history of brain function. Imaging the brain from antiquity to the present* (1972; Oxford, 1996), 21; Y. Violé O'Neill, "Diagrams of the medieval brain. A study in cerebral localization," in *Iconography at the crossroads: Papers from the colloquium sponsored by the Index of christian art, 23-24 March 1990*, ed. B. Cassidy (Princeton, 1993), 91–105.

images of the soul's powers were originally conceived and received.

Contrary to their efforts, this chapter does not aim to give an overview of illustrated doctrines about the soul. Neither Sudhoff nor Clarke studied the drawings thoroughly, but instead isolated many single examples of a manuscript copy.[563] This chapter fills in that void by studying, systematically, several manuscript copies of the same text, and doing so in a historical perspective over several centuries, taking into account the specific scientific context for which each diagram was meant.

A first concern will be the problem of the brain's functions as part of the rational soul. The main problems discussed by the antique protagonists, Aristotle and Galen, are about the constituents of the soul, the localization of the soul in the body and the localization of the senses in the head. These problems recurred in later disputes between natural philosophers and physicians. The next section of this chapter, section *4.2 The human being and his cognition*, page 162, provides an outline of the philosophical developments, against the background of which we should understand scientific imagery regarding the contents of the head.

Subsequently the question is posed of just how brain-diagrams conceptualized and visualized invisible functions and processes of cognition, in both the medical-anatomical realm and the philosophical realm, in order to establish a sense of the pictorial interactions between the two disciplines. The presence of these two disciplinary strands in the iconographic history under study permits a comparison of the respective conceptualizations and visualization of brain function within each discipline. In section *4.3 The visualization of the brain* , page 169, I show how both disciplines could lay claim to the pictorial cross-section of the head that showed the powers of the soul.

The intellectual context and conventions, in which the cross section of the head was conceived and received, thereby established, we will be able to turn to its subsequent reception, using the late medieval example of the *Parvulus philosophie naturalis* and some of its adaptations. A case study of the role played by several versions of the cross-sectioned head in late-medieval education, will also demonstrate these images' interaction with scientific analysis and the effect of their dissemination. Showing and copying pictures in class for didactic purposes appeared a facet of teaching at the *Pedagogium Castrense* of Louvain University, where Vesalius studied in the early sixteenth century.[564]

We will see whether this was also common in the preceding period through the case of the *Parvulus philosophie naturalis*, in section *4.4, The cross section:*

[563] The same is true for the otherwise interesting work of Ynez Violé O'Neill, who concentrated in her study on the anatomical localization of functions, taking sources from the Salernian medical realm of the high Middle Ages. See: Violé O'Neill, "Diagrams of the medieval brain. A study in cerebral localization."

[564] See page 155.

transmission and dissemination, page 199.

The *Parvulus philosophie naturalis* by Peter of Dresden has come down to us in at least 59 manuscripts and 24 printed editions.[565] In view of these 59 preserved copies, it was probably one of the most widely used textbooks on natural philosophy in the fifteenth century featuring a drawing of the soul's powers. Case study of the *Parvulus philosophie naturalis* and its intellectual context is therefore instructive.

The *Parvulus* circulated mainly in Central European university towns: Prague, Leipzig, Cracow, Vienna and, somewhat further afield, Cologne and Uppsala. The oldest manuscript handed down to us dates from about 1414 and is now kept in the University Library of Wrocław (Breslau in German). A second copy in the same library is dated 1425. In Cracow four copies are preserved, one of which is dated 1416, another 1424–46, and in Berlin a copy exists dating to 1419/20. Peter had thus compiled his *Parvulus* before 1414, though where he wrote his book is unknown.

The constraints of producing a dissertation did not permit me to study all these manuscripts in a satisfactory way, so the focus is on a few among them. I worked with 12 copies (20%) of the *Parvulus philosophia naturalis* manuscript copies.[566] Three of these copies contained a drawing dealing with the powers of the soul, designed in the figurative form of a man's head and body, often in profile. I am convinced that more figures will turn up when the remaining copies of the *Parvulus* are studied in the course of future research.[567] Many of the copies of the *Parvulus philosophie naturalis* have been commented on.[568]

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[565] Lohr, "Medieval Latin Aristotle commentaries," here 352–354. Lohr identifies 59 manuscripts containing the *Parvulus philosophie naturalis*. Incipit: «*Natura est principium et causa movendi et quiescendi eius in quo est principium per se et non secundum accidens. Et alia est forma, alia materia. Explicit: sed Deum non agnoscit per abstractionem, quia similitudo abstracta simplicior est illo a quo fit abstractio; Deo autem nihil est simplicius*».
L. Thorndike added the manuscript copy: Vatican, *Bibliotheca Apostolica Vaticana*, Palatine 1050, 15c, ff. 168v-173v. See: Thorndike and Kibre, *A catalogue of incipits of mediaeval scientific writings in Latin. Revised and augmented edition*, 902.

[566] Berlin, *Staatsbibliothek zu Berlin - Preussischer Kulturbesitz*, lat. qu. 17; lat. qu. 71; theol. qu. 289; theol. fol. 247; lat. qu. 94; London, *Wellcome Historical Medical Library*, 55; Norrköping, *Stadsbibliotek*, 426 fol. (not mentioned by Lohr in his 'Medieval Latin Aristotle commentaries'); Uppsala, *Universitebibliotek*, C.133; C.231; C.622; C.629 (not mentioned by Lohr); Wolfenbüttel, *Herzog August Bibliothek*, 1009 (906 Helmst), with many thanks to Margaret Dobby, who kindly checked this manuscript for figures for me.

[567] The *Summa naturalium* of Albert of Orlamünde, with which the *Parvulus philosophie naturalis* was often bound in, is generally not illustrated (I have checked Paris, *Bibliothèque nationale*, lat. 6523A; lat. 6524; lat. 6749C; lat. 16222; lat. 16635; nal. 157).

[568] Grabmann distinguished eight different commentaries, and none of them yet been identified: Berlin, *Staatsbibliothek zu Berlin - Preussischer Kulturbesitz*, lat.qu.17, f. 201r. Incipit: «*circa initium presentis tractatuli videndum est, quid sit philosophia naturalis; unde ille terminus philosophia capitur*»; Berlin, *Staatsbibliothek zu Berlin - Preussischer Kulturbesitz*, lat.qu.17 commt PPN, f. 218r. Incipit: «*Iste tractatus cuius est ens mobile subiectum, in tres dividitur partes, quarum partium*

In addition to the drawings found in the *Parvulus philosophie naturalis*, I looked at some comparable natural philosophical manuals that circulated in Cologne, home to one of the most important universities in Europe by the end of the fifteenth century. The regent masters of the so-called *Bursa Montana* and *Bursa Laurentiana*, two competing schools of thought in Cologne, both compiled textbooks in which they dealt with souls. These summaries circulated in student notes, were corrected and improved, and eventually got printed. [See Appendix C.3, page 268, for a survey of the consulted manuscripts.]

4.2 THE HUMAN BEING AND HIS COGNITION

One of the most fundamental problems in medieval psychology, or philosophy of mind or soul, was generated by Aristotle.[569] Aristotle and Avicenna, who incorporated much material from Galen, were therefore the most eminent philosophers offering teachings on the soul in the Latin West. Commentators of the *Translatio vetus* of the *De anima* of Aristotle, read this book through the *De anima* of Avicenna.[570]

Avicenna's compendium of the theory of the soul is arranged according to Aristotelian tradition. The works is divided in five sections: a general notion

prima correspondet libris phisicorum»; Berlin, *Staatsbibliothek zu Berlin - Preussischer Kulturbesitz*, Theol.qu.289, f. 99r. Incipit: «*Natura est principium. Iste tractatus qui communiter intitulatur tractatulus philosophie naturalis, dividitur principalissima divisione in duas partes*»; Berlin, *Staatsbibliothek zu Berlin - Preussischer Kulturbesitz*, lat.qu. 71, f. 130r. Incipit: «*Circa initium huius primo queritur, quid sit philosophia, secundo quare philosophia sit studenda*»; Leipzig, *Universitätsbibliothek*, cod. 1084, f. 133r. Incipit: «*Ex quo tractatus presens, cuius naturam investigare intendimus, introductorius est in physicam naturalem in libris Aristotelis traditum*»; Wolffenbüttel, *Herzog August Bibliothek*, cod. 1008, f. 1v. Incipit: «*Iste liber Parvulus philosophia intitulatus; Vienne,* Hofbibliothek*, 5178, f. 3r. Inc.: Introductorium philosophie naturalis*»; Vienne, *Hofbibliothek*, 5242, f. 5r. Incipit: «*Natura est principium. Iste liber de cuius subecto superius dictum est, principaliter dividitur in tres partes: tractatus primus correspondet libro physicorum, secundus correspondet libro de generatione et corruptione, tertius autem correspondet libro de anima*». See: M. Grabmann, *Die Philosophia pauperum und ihr Verfasser Albertus von Orlamünde* (Münster, 1918), 29–33, here 30–33.

In De Raedemaeker's inventory two commentaries on the *Parva philosophie naturalis* were listed, both anonymous : Munich, *Bayerische Staatsbibliothek*, CLM 8301, ff. 169–228; Vatican, *Biblioteca apostolica Vaticana*, Pal.lat. 1050, ff. 96r-173r. See: Raedemaeker, "Une ébauche de catalogue des commentaires sur les Parva Naturalia parus aux XIIIe et XVe siècles."

[569] Psychology is a term first used in the fifteenth century, but it is more appropriate to to say that Aristotle wasconcerned with the philosophy of mind or soul. See: Pluta, *Die Psychologie des Peter von Ailly. Ein Beitrag zur Geschichte der Philosophie des späten Mittelalters*, 8; J. Bobik, "Faculties of the soul," in *New catholic encyclopedia*, ed. B.L. Marthaler, vol. 5, 17 vols. (New York–St. Louis–San Francisco [etc.], 1967), 585–587; R. Pasnau, "The mind-soul problem," in *Mind, cognition and representation. The tradition of commentaries on Aristotle's De anima*, ed. P.J.J.M. Bakker and J.M.M.H. Thijssen (Aldershot, 2007), chap. 2.

[570] Martino, *Ratio particularis. Doctrines des sens internes d'Avicenna à Thomas d'Aquin*, 87.

of the soul, the vegetative soul and the external senses, vision, internal senses and the motive faculties, and the last book covers the rational soul. From the soul, which is one, the faculties flow into the organs. There are three vegetative faculties (nutrition, growth and reproduction). There are five extrenal and five internal senses. There is a practical and theoretical intellect. There are different degrees of abstraction, from sense perception to intellection.[571]

The different questions and teachings emerging from *De anima* are not easily summarized. Nevertheless, its content has to be sketched out, if the visual manifestations of the theories is to be intelligible. Some of these teachings will therefore be presented strongly abridged and simplified, by means of introduction to the visual representations to come. The problems here discussed concern issues about the general constitution of the soul, the localization of the rational power and also the quantity of the senses and their correlation. The process of intellection, in which the senses assist somewhat, will be presented while discussing some drawings in 4.3.2, *Three separate powers*, page 188.

4.2.1 THE TRIPARTITE SOUL

According to Aristotle the soul is the vital principle and source of all activities. The soul was considered to be the origin of powers providing sensibility and motion to the body. Hence the capacities of the soul deal with functions, like the nutritive and sensory capacities.

Aristotle distinguished three powers of the soul. These three powers were sometimes also identified with three different souls, and hence named 'power' and 'soul' in turn. The vegetative power is concerned with the maintenance and development of organic life, and allowed for nutrition, growth, and reproduction. Then there was a sensitive power, active in motion and sense perception. And finally there was a rational power, only possessed by man and responsible for consciousness and intellect. The vegetative power was shared by plants, animals and human beings. The sensitive power was shared by animals and human beings. Only human beings possessed, in addition, a rational power.[572]

Galen maintained the tripartite structure of the soul but clustered the powers differently. He divided the vegetative power in two, distinguishing between the 'vital virtues' allowing the passions, and the 'natural virtues' allowing for nutrition, growth and reproduction. Next, he combined Aristotle's rational and sensitive powers into one soul, because he saw these as inorganic. Galen housed these powers in the three main organs: the natural powers resided in the

[571] Hasse, *Avicenna's De anima in the Latin West*, 2.

[572] Aristotle, *De anima*, II, 1–6 (D.W. Hamlyn, ed., *Aristotle. De anima. Books II and III (with passages from book I)* (Oxford, 1993). See for further reading for example: M.C. Nussbaum and A.O. Rorty, eds., *Essays on Aristotle's De anima* (Oxford, 1994).

liver, the vital powers in the heart, and the animate powers in the brain. Galen thus made a division between the powers which on the basis of their physical ground.[573]

The most important components of the brain were the three ventricles, also called cells, which were filled with the fluid of animate spirits. The brain, as the seat of the animate soul, was also responsible for imagination, reason and memory. The liver converted food into natural spirits and transported these to the heart, which returned a part to the lungs. Another part of these natural spirits were mixed with the pneuma and then transported to the brain as 'vital spirits'. Galen considered the pneuma to enter the body via the lungs and from there through arteries to the heart. In the brain, vital spirits were transformed into animate spirits and transported to the rest of the body through the nerves, thus animating it. Transforming and transporting animate spirits was thus the brain's prime function.[574]

Late-medieval natural philosophers struggled with the concept of the compound nature of the soul, consisting in a vegetative, sensitive and rational part. Aristotle himself had considered the soul dependent on the body, and thus thought of the powers of the soul as mortal. The only exception he made concerns the highest power of the soul, the agent intellect, which was not located in a specific part of the body and is thus distinct, independent, unaffected and eternal: «And this intellect is distinct, unaffected, and unmixed, being in essence activity.»[575]

The question then arose of whether the general intellect or the individual soul survives death. Siger of Brabant, who followed Averroes on the matter, separated the intellectual part of the soul from the individual body, a super-individual intellect, thus allowing the soul to survive death. His solution sharpened the debate about the essence of the soul. Like Albert the Great, Thomas Aquinas rejected the idea of a super-individual intellect for all human beings and tried instead to save the individuality of each soul. He thought it absurd to postulate a single intellect for all men, for then every man should think the same. He argued instead that the entire intellectual soul survives death, because it has an independent existence (as form) from the body (material). The intellect was therefore held by Thomas to experience its existence absolutely and independent of time, whereas the senses could only experience their existence in the

[573] Galen, *On the natural faculties*, VIII, sect. 3; Galen, *On the usefulness of the parts of the body*, VIII, sect. 10–14. See: T.L. Tieleman, ed., *Galen and Chrysippus on the Soul. Argument and refutation in the De Placitis Books II-III* (Leiden–New York–Cologne, 1996), 55–60. See for further reading for example: R.E. Siegel, *Galen on psychology, psychopathology, and function and disease of the nervous system* (Basle, 1973).

[574] C. Singer, *A short history of anatomy and physiology from the Greeks to Harvey* (New York, 1957), 58–60.

[575] Aristotle, *De anima*, III, 5. Translation borrowed from Hamlyn, *Aristotle. De anima. Books II and III (with passages from book I)*.

present. As such, the intellectual substance was imperishable.[576]

4.2.2 THE CEPHALOCENTRIC VERSUS THE CARDIOCENTRIC SOUL

The most explicit controversy between Galen and Aristotle turned on the location or origin of what Aristotle called the rational soul and Galen the animate soul. Galen argued against the assertion that the brain was secondary to the heart, influenced in this matter by Plato, who dealt with human perception in the *Timeus*. In the Platonic model the soul consisted of three parts: the rational part in the head, presumably in the brain, and the other two parts in the heart and in the abdomen. The internal senses do not have an organ, contrary to the external senses that make use of physical organs - the eyes for sight for instance, but they have nonetheless a physical seat in he brain. The brain was thus the most important organ and the seat of all mental processes:

> «Now we ought to think of the most souvereign part of our souls as god's gift to us, given to be our guiding spirit. This, of course is the type of soul that, as we maintain, resides in the top part of our bodies. It raises us up away from the earth and toward what is akin to us in heaven, as though we are plants grown not from the earth but from heaven».[577]

Aristotle argued that the heart was the body's most important organ, being the origin and appreciation of sensation and thus the centre for thought. Touch and taste were held to be directly related to the heart, since it was the 'hottest' organ. The other senses were located near the brain –cold and wet– so that their work would not be disturbed by the heat of the heart. The brain was an important structure to Aristotle, but second to the heart. The brain functioned, in fact, as a means of cooling the heart's heat.

> «since everything requires an opposing counterweight in order that it achieves the moderate state [...] - because of this nature has devised the brain in relation to the heart's location and heat. [...]. The brain, then, makes the heat and boiling in the heart well-tempered».[578]

At this point Galen asked himself: why should the brain be cooling the heart and not rather the heart be heating the brain, for the latter is placed above

[576] Albert the Great, *Summa de homine*, 35 (Borgnet, *Albertus Magnus. Opera omnia*); Thomas Aquinas, *De unitate intellectus contra Averroistas*, 243–314 (R. McInerny, ed., *Aquinas against the Averroists: 'On there being only one intellect'* (West Lafayette (Ind.), 1993). See: B. Mojsisch, U.R. Jeck, and O. Pluta, "Seele," in *Historisches Wörterbuch der Philosophie*, ed. J. Ritter and K. Gründer, vol. 9 (Basel, 1995), 2–22, here 15–16.

[577] Plato, *Timeaus*, 90a, (translation borrowed from Zeyl, *Plato. Timeaus*, 85–86.)

[578] Aristotle, *De partibus animalium*, II chap. 7 (652b) (translation borrowed from J.G. Lennox, ed., *Aristotle. On the parts of animals I-IV* (Oxford, 2001), 29).

it and heat tends to rise? On these grounds he argued that if the brain were destined only for refrigeration, it would have to be a useless, shapeless sponge, but, if the brain was not merely a sponge, one had to locate mental functions in the cerebral hemispheres more precisely. Consequently, Galen gave a detailed description of three ventricles, and hinted vaguely at their association with the internal senses located in the brain. He distinguished five external senses: sight, smell, taste, hearing and touch. The remaining function of the animal soul, which proceeded from its principal faculty, Galen divided into imagination, reason and memory.[579]

The great Persian philosopher Avicenna (980–1037) systematized the work of Galen and Aristotle in a huge compilation called the *Canon*. Regarding the seat of cognition, he sided with Aristotle, as is clear from his *Canon*:

> «if physicians thought the whole matter over as thoroughly as they should, they would take Aristotle's view instead. They would find that they have only been regarding at appearances instead of realities, and taking non-essentials for essentials. The establishment of this truth is for the philosopher and natural scientist, and not for the doctor as doctor. But the latter, looking on members as being initiators of the faculties instead of as their manifestation –this despising or ignoring philosophy– fails to see which things are prior».[580]

Throughout the Middle Ages the controversy between the cardiocentric and cephalocentric views continued. In general, medieval followers favored Galen's

[579] E. Clarke and C.D. O'Malley, *The human brain and spinal chord. A historical study illustrated by writings from Antiquity to the twentieth century* (Berkeley-Los Angeles, 1968), 18. Ynez Violé O'Neil, however, challenged the idea that the ventricular system was the only favored localization, and argued for a competing physiological vision placing the functions in the vertex, on the basis of the positions maintained by William of Conches and masters of Salerno in the twelfth century. He argued that William of Conches had placed the cells in the head but not particularly in the brain. See: Y. Violé O'Neill, "William of Conches' descriptions of the brain," *Clio medica* 3 (1968): 203–223; Violé O'Neill, "Diagrams of the medieval brain. A study in cerebral localization," 91–105.

[580] Avicenna, *Canon*, Lib. I, sect. I, doc. VI, cap. I.: «*Quod si hoc negotium accurate atque ad veritatis amussim expendatur, comperietur certe sese habere, prout sentit Aristoteles et non prout Medici. Quippe quorum ratiocinationes deprehendentur ex propositionibus probabilibus deprompte, non necessariis in quibus non nisi rerum conspicuarum evidentias consectantur. Sed enim ad Medicum, quatenus est Medicus, haudquaquam spectat, istarum sententiarum veritatem cognoscere, verum id proprium Philosophi munus est, aut naturalium rerum studiosi. Etenim modo detur Medico, dictas istas partes esse facultatum illarum principia, haud profecto, quatenusartem medicandi exercet, magi facere debet, an eedem facultates ex aliis aliquibus principiis prioribus deducantur, nec ne, huius tamen ignoratio hominem Philosophum quempiam minime deceret*», (Hieronymus Nempei (Louvain 1658), 73. Translation borrowed from O.C. Gruner, *A treatise on the Canon of medicine of Avicenna incorporating a translation of the first book* (London, 1930), 111). See also: Clarke and O'Malley, *The human brain and spinal chord. A historical study illustrated by writings from Antiquity to the twentieth century*, 21.

suggestion that the ventricles were the center of psychological activity. Although many thus considered the brain the central organ of the body, others supported the heart in this role. Galen, Aristotle and Avicenna were often invoked to support the polemics on the subject, as we will see below.

4.2.3 Localization of the internal senses in the ventricles

The position identifying five senses was based on the fourth book of Avicenna's *De anima*. Avicenna was the first to organize the internal senses in a systematic way. He also introduced a new operation of a new faculty called the estimative power. His 'five sense' narrative then comprised the common sense, imagination (also fantasy), cogitative power, estimative power and memory.[581]

Their functions were held to be the following: the common sense received all sense impressions, and thus the form of an object, from the five external senses vision, hearing, smell, taste and touch. The common sense then combined and divided these forms and images into one 'common' picture for comparative use. The common sense is, following Avicenna, the sense making distinction between, for example, white and soft, and establish that both, for example, belong to honey. Next, the 'merged' forms and images passed to the imagination and were stored there for further reference, after the sense-impressions had subsided. Hence, the imagination preserved what the common sense received. Both were located in the anterior part of the brain alongside one another.[582]

The cogitative faculty, was then held to compose and divide forms, so as to derive information that may not have been sensed or that may not even have existed. Especially in sleep or in madness, the cogitative power acts freely and may perceive unreal forms. The cogitative faculty is often combined or equated with imagination. The cogitative power prepares intellectual knowledge in close connection to the estimative power.[583]

The middle cell of the brain was held to contain cogitation and estimation. Estimation received 'intentions', that are in itself not sensible aspects, which are nonetheless 'felt' by the intermediary of the external senses. These intentions consisted of information that motivated certain actions taken by individuals. The traditional example is of a sheep fleeing from a wolf because he 'estimated' the hostile 'intentions' of the wolf. Estimation then forms a judgement.[584]

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[581] Di Martino, *Ratio particularis. Doctrines des sens internes d'Avicenna à Thomas d'Aquin*, here 23.
[582] Di ibid., here 26
[583] Di ibid., here 26; Hasse, *Avicenna's De anima in the Latin West*, 2.
[584] Di Martino, *Ratio particularis. Doctrines des sens internes d'Avicenna à Thomas d'Aquin*, 24–25; Hasse, *Avicenna's De anima in the Latin West*, 2.

Memory, or the retentive faculty, was located, finally, in the posterior cell, positioned in the back of the head. It was held to store all the intentions perceived by the estimation as further references to past time. 'Retention' can be considered, then, as mere storage, whereas 'memory' indicates a mental process.[585]

Albert the Great is aware that the different Greek, Arab and Latin philosophical and medical traditions proposed different classifications of the internal senses. He realized that the differences are sometimes not due to doctrinal oppositions but to a different lexical use of the same nomenclature.In the *Summa de Creaturis*, he attempted to produce an order out of the chaos. He used then the lexical differences as an exegetical instrument.[586]

Albert maintained five-sense classification for the internal senses common sense: the imagination (or *virtus formalis*), an estimative faculty, cogitation or fantasy, an estimative faculty and memory. He analyzed each elaborately. The common sense has three meanings, imagination has six definitions, and the other faculties he analyzed as carefully.[587] Although Aristotle and Avicenna were the most eminent philosophers for Albert. He discussed points of disagreement and aimed to establish a comprehensive account, even if he gave a great weight to the authority of Aristotle.[588]

The difference between the classification of functions into three or four internal senses hung on whether the imagination and fantasy were to be considered one, and whether the common sense was an external sense or an internal one. Thomas Aquinas, for example, held the four-senses position. Concerning the common sense Aquinas took an intermediate position, considering the common sense not as a genus, but as a general (common) root and principle of the external senses, and also the first of the four internal senses. He cites Albert in considering the common sense not a genre of the external senses, where he is at the root at, the beginning, and therefore the cause.[589]

Thomas' doctrine of the internal senses is rather concise. He defined four

[585] N.H. Steneck, "Albert the Great on the classification and localization of the internal senses," *Isis. An international review devoted to the history of science and its cultural influences* 65:2 (1974): 193–211, here 197.
[586] Martino, *Ratio particularis. Doctrines des sens internes d'Avicenna à Thomas d'Aquin*, 69, 71.
[587] ibid., 73, 76, 81.
[588] Hasse, *Avicenna's De anima in the Latin West*, 62; Steneck, "Albert the Great on the classification and localization of the internal senses."
[589] Thomas Aquinas, *Summa Theologie, Prima pars*, q. 18 a.2: «*The internal sense we do not denominate general following the predicate, as we use to do with a genus, but as we denominate a root and beginning of the external sense general*» – «*sensus interior non dicitur communis per predicationem, sicut genus; sed sicut communis radix et principium exteriorum sensuum*» Thomas Aquinas, *Summa theologie*, Rome, ed. Marietti (1962, 1988). Martino, *Ratio particularis. Doctrines des sens internes d'Avicenna à Thomas d'Aquin*, 88–89.

internal senses, two for the forms: the common sense and the fantasy or imagination, and two for the intentions: an estimative faculty and memory.

The three-senses-classification was held by Nemesius of Emesa, Augustine and John Damascene, among others. It was made up of imagination in the anterior cell, cogitation in the middle cell and memory in the posterior cell. The three senses position was based on a broad interpretation and did not necessarily contradict the four or five sense positions, because imagination, fantasy and estimation could be seen on this position as one comprehensive power, under the heading 'imagination'.[590]

4.3 THE VISUALIZATION OF THE BRAIN

Most existing literature on iconographic traditions in science aims to establish the developments in a particular discipline by organizing illustrations and diagrams in a sequence suggestive of progressive understanding.[591] These accounts do not make clear the specific effects of a diagram's particular historical and intellectual context. They, however, do a wonderful job assembling an enormous repertoire of images in order to establish the iconographical tradition. This chapter builds on the repertoire of images assembled in the existing literature by concentrating on the role of these pictures in their anatomical or philosophical setting.

The second argument in this section deals with the visual imagining of the powers of the soul. Just how did surgeons, physicians and philosophers conceptualize and visualize invisible functions and processes of cognition that occur inside the body? Not only was the rational soul inside the body and therefore invisible to the eye, but the soul was also only there when the subject was alive and undissected. Moreover, the powers of the soul operated invisibly among the visible brain tissue, layers and ventricles.

This section about the iconographic history of brain diagrams is presented chronologically, focusing on those diagrams considered crucial. Salient here are diagrams that showed the conventional conception and visualization of brain functions, rather than those diagrams that represent an 'advanced' understanding of the same.

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[590] Steneck, "Albert the Great on the classification and localization of the internal senses," 202–203.

[591] For example: Sudhoff, "Die Lehre von den Hirnventrikeln in textlicher und graphischer Tradition des Altertums und Mittelalters," 149–205; Clarke and Dewhurst, *An illustrated history of brain function. Imaging the brain from antiquity to the present*.

4.3.1 ANATHOMIA CAPITIS PRO MEDICIS - THE PHYSICIANS' HEAD

Early diagrammatic representations of the brain functions are found in the medical domain, more precisely in anatomy, surgery and pathology. The authors based themselves among others on Avicenna, who transmitted Aristotelian and Galenic notions about the soul to the Latin West in his *Canon*, before the reintroduction of the *De anima*.

SURGICAL SLICES

The earliest representation of the brain's faculties is part of a drawing representing the seats of the soul. The figure is inserted into an anonymous text, called *De quaternario*, preserved in a manuscript dating to the late eleventh or early twelfth century, written in the north of Italy or the south of France. The text introduces the divine construction of the world in quadruples, paying special attention to the elements, qualities and humors. One imagines it belonged to a physician, because of the content of the book, but also because the author of *De quaternario* explicitly mentioned the opinion of the *physici*, and followed Galen's tripartite division of the soul over Aristotle's.[592]

The figure representing the location of the faculties of the soul is inserted in the end of the fourth and last book in the text, preceding a short excerpt about the human body. [*See* figure 4.2]. The legend surrounding the circle reads *Principipalia (sic) menbra (sic) virilia quatuor adsunt*, indicating that the figure's subject is the four principal members of a man. The four principal members share paired primary qualities (cold, moist, hot and dry) comparable to the four primary elements and their paired qualities (which are also visualized in the same manuscript on fol. 3).

The circle is divided in four parts. In a clockwise direction, starting top-right, it shows the liver (*epar* in Latin), which is said to be hot and moist. Then there is the heart (*cor* in Latin), with its hot and dry qualities. Thirdly, there are the testicles (*testiculus* in Latin), which are cold and dry according to the text – though the figure has the words cold and moist. And finally, the brain (*cerebrum* in Latin), is characterized by the primary qualities cold and moist. The representation of the brain shows that organ divided into three cells: *fantasia*, *intellectus* and *memoria*. The double lines in the figure of the brain may represent the coronal, sagittal and lamdoid sutures.[593]

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[592] Cambridge, *Gonville and Caius College*, ms. 428/428, f. 50r. The figure is reproduced by Clarke and Clarke and Dewhurst, *An illustrated history of brain function. Imaging the brain from antiquity to the present*, 10, fig. 3 and Murdoch, *Album of science: Antiquity and the Middle Ages*, 357, fig. 287.

[593] Clarke and Dewhurst, *An illustrated history of brain function. Imaging the brain from antiquity to the present*, 9 n. 5.

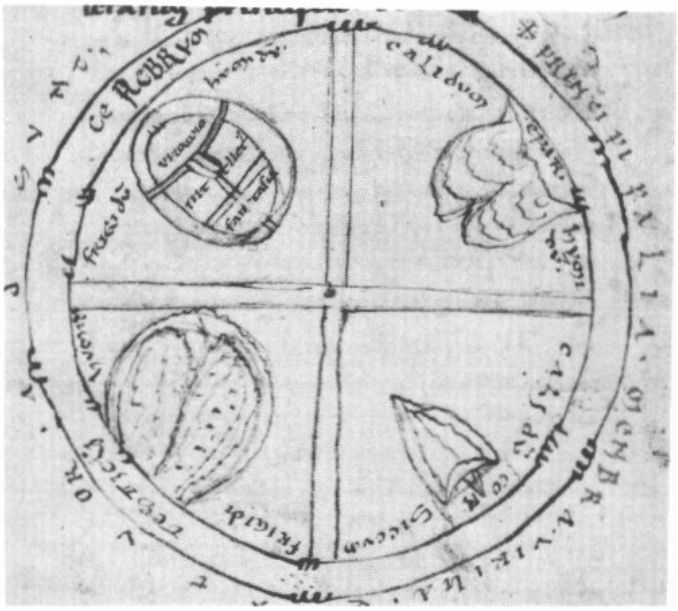


Figure 4.2 Anonymous, *De quaternario.* Cambridge, *Gonville and Caius College*, ms. 428/428, f. 50r. Dated late 11th or early 12th century.

This early figure, then, shows the three known residences of the soul: the heart, brain and liver, and adds a fourth, the testicles. The accompanying text is not explicit about the processes in these body parts, though the text enumerates the four members, and assigns two qualities to each: testicles (cold and moist), liver (moist and hot), heart (hot and dry) and brain (dry and cold). To the brain the author also added the powers, not visualized in the figure, of hearing, smelling, taste and touch, thus combining the intellectual and sensitive powers, as Galen did by locating the animal soul in the brain.

The author explicitly mentions that imagination, intellect and memory are considered primary virtues by physicists (*physici*) which reside in the brain. The heart is designated the second residence of the soul, and is located in the chest. The liver is the third residence, returning spirited air (*divinus spiramen*) to the whole body. It produces blood, black bile and red fluid (which is usually blood) and these are held by the text to be transported through the body in veins, responsible for thickening food. Phlegm has its home in the stomach. And finally the testicles make the body reproduce.

As the text accompanying this image is rather concise, another source may serve to elucidate the figure with more clarity. The following passage, from Avicenna's *Canon*, Book I, which is too late to be a direct source, explains how the author assigned four seats to the three faculties of the soul, dividing the func-

tions of the natural virtues into two: the preservation of the individual and the preservation of the race. Both functions have a seat of their own, respectively the liver and the testicles:

> «It is asserted by many philosophers and all physicians, foremost Galen, that each faculty has its own principle member, which is its seat, and from which its functions emerge. They further assert that the seat of the animal faculty is the brain, and that its function originates there. They add that the natural faculty is two-fold. One of its aspects is concerned with the welfare and preservation of the individual and with securing nourishment to it to the end of its life. The seat of this aspect and the source of its functions is the liver. The other aspect is concerned with the preservation of the race, governing generation and separating out from the bodily humors the spermatic substance. The seat of this aspect and the source of its functions is the testicles. The vital faculty is that which conserves the spirit, which is the vehicle of sensation and movement. It allows it to receive these impressions when it reaches the brain, and makes it capable of imparting life wherever it spreads. The seat of this function is the heart».[594]

This passage makes clear how our anonymous author of the Cambridge manuscript introduced the testicles as a fourth seat of the soul, but leaves ambiguous just how he divided the functions of the liver and the stomach. The diagram showed the four physical seats (liver, heart, testicles and brain) of the soul and systemized these in a circle. Their presentation within a quadruple is not coincidental. As the title announces, the text is devoted to uncovering all quadruples in the world: elements, humors, seasons, temperaments, winds and ages. The text is, appropriately, divided into four books and the manuscript contains several other circular diagrams divided into four compartments, with a personification, symbol or name in each compartment, thus representing the various quadruples dealt with by the text. Often this circular figure is designated as a globe, embracing the basic components of the cosmos. In addition

[594] Avicenna, *Canon*, Lib. I, sect. I, doc. VI, cap. 1: «*Pluribusque Philosophis, ac plerisque omnibus Medicis, sed precipue Galeno, placitum est, cuilibet facultati suam esse tributam partem principem, que eius sit sedes ac scaturigo et a qua cuiusque operatio exerceatur. Sic censent facultatis animalis domicilium esse cerebrum et ab hoc illius edi functiones. Facultatem naturalem esse duplicem alteram, cuius proprium munus est servare individuum, eidemque prospicere, atque hec est, que circa alimentum negotiatur, corporique tum nutricationem prestat ad vite usque finem, tum incrementum dat ad constitutum usque auctionis terminum, huius sedem esse jecur et ab eo gestiones illius perfici. Alteram cuius officium est speciem perpetuare, hec in procreando occupatur et ex corporis humoribus semen elaboratum sequestras [cui deinde figuram compagemque ex Creatoris nutu confert]. Istam residere volunt in testibus et ab his actiones eius prodire. Facultatem denique vitalem in corde habitare et ab hoc eius procedere operationem hec autem facultas spiritui regundo ac moderando preest, qui sensus motusque est vehes nam et eumdem conficit ac preparat ut dum in cerebrum appulsus est, movendi sentiendique vim recipiat et vivificandi potestatem eidem impertit, quocumque diffundatur*» (Hieronymus Nempei (Louvain 1658), 73. Translation by O.C. Gruner, in Grant, *A sourcebook in medieval science*, 720).

to the circle-cosmos diagrams, the diagram with the four members of man's soul might be seen to represent the components of a microcosm. The idea that perfection comes in quadruples was clearly dominant in this compilation and reflected a common idea that perfection in the physical world was established through order and harmony rooted in laws of number.

Indeed the systematization could have been perfected even further and the shared character of the qualities made more visually evident in the following order, clockwise: testicles (cold and moist), liver (moist and hot), heart (hot and dry) and brain (dry and cold). The draughtsman, however, neglected to arrange the names of the qualities, corresponding to the members, in a visually coherent way. Was he ignorant of the system or was he simply sloppy in his copying?

Of further interest here is the fact that the organ of the brain was depicted as a cross cut, showing the three ventricles divided by sutures. The horizontal cross cut shows a slice of the head obtained when one removes the cranium, a complicated procedure in dissection. The spaces within the ventricles are empty, its function given by the names *fantasia, intellectus*, and *memoria*. The cross cut is, let us note, very different from a profile, even when both show the interior of the head.

A similar drawing of a cross cut of the cranium, and yet completely different, is shown in a Dutch book on surgery by the Flemish Jan Yperman (ca. 1260–ca. 1331). It adds to the previous example a 'naturalistic' rendering of the contents of the head, the result of a surgical operation, but without the 'quadrupled' ideology. It has been suggested that Yperman studied with Lanfranc, a famous physician from Milan, who taught medicine in Paris at the end of the thirteenth century.[595]

The Ghent copy of Yperman's 'Surgery', dated 1328, shows a circular, concentric figure.[596] The surgical diagrammatic representations of the brain were not created to show the functions of the soul per se, but to represent them in passing while essentially discussing the anatomical layers of the skull.

The perspective is from above, showing a horizontal slice of the head and its different anatomical layers or shells, protecting the brain. The three outer shells read, from outside to inside: *cranium*, *dura mater*, *pia mater*. The inner circle is divided into three compartments indicating, from top to bottom, that the top part is in the front, the middle part is in the middle and shared, and the third, lower part, is in the back.[597] [*See* figure 4.3]. The accompanying text is

[595] Van Leersum, *De "Cyrurgie" van meester Jan Yperman*, viii.

[596] Ghent, *Universiteitsbibliotheek*, ms. 126, f. 3v. See for a reproduction: E.C. van Leersum, ed., *De cyrurgie van meester Jan Yperman* (Leiden, 1913), fig. 1; Clarke and Dewhurst, *An illustrated history of brain function. Imaging the brain from antiquity to the present*, fig. 4. I thank Maria Patijn who kindly shared the photos she took of this manuscript.

[597] Jan Yperman, *Cyrurgie*: «*prima partie es vore; dander partie es die monde in den middel; tertia*

somewhat more explicit:

> «The head is divided into three parts as mentioned above. In the first part lies the knowledge of man, such as seeing, tasting and smelling. Seeing serves to make distinctions, or to know the difference between black and white, dark and light and the like. Taste serves to distinguish salted and fresh, and the like. Smell serves to distinguish between stench and fragrance, and the like. In the middle part is the reason (*redene*) and hearing. Reason allows one to ask and answer. Hearing allows one to understand and answer what one hears. And that is why in this part meditation (*tgepeins*) belongs, and also the memory (*memorien*) of man. In the posterior part lies the remembering (*onthoudenisse*) of what one hears or has heard of people, and this lies down in the posterior part of the head. Roger in the Song of Roelant says briefly in Latin: *in prima cellulla sit ymago, in media ratio, in posteriori memoria*».[598]

Jan Yperman placed (1260?–1310?) in the front part seeing, tasting and smelling; in the middle part hearing and reasoning; and in the third part, in the back of the head, memory. In another passage he confirms that the brain has three chambers. The anterior part is held by Yperman to be hot and dry, with many spirits and little marrow (*marchs*). The middle part, being hot and fresh, is constituted by a lot of marrow matter and many spirits. In the middle part are the ears, placed on two bones called the 'rocky bones'. The posterior part is cold and dry and has few spirits and little marrow matter.[599] Similar passages were found in other early vernacular texts:

> «About the brain. The brain has three chambers. The first has the name

es achter». Sudhoff adds that *monde* is the same as *mande*, meaning common, shared or united. See: Sudhoff, "Die Lehre von den Hirnventrikeln in textlicher und graphischer Tradition des Altertums und Mittelalters," 182–183.

[598] Jan Yperman, *Cyrurgie*, Book I, Cap. 1: «*Thoeft es in drien gedeilt alsoet vorseit es. int vorste deel leget die kennesse van den mensche. Alse zien. smaken ende rieken. Dat zien es om ondersceet te hebbene ofkennesse te dragene tusscen wit ende swert. of donker ende licht ende des gelike. Die smaec es te hebbene ondersceet tusscen gesouten ende versch. ende des gelike. Roke es te hebbene ondersceet tusscen stinkende ende wel riekende ende des gelike. Int middelste deel legt die redene ende dat horen. die redene dat es heesch ende andwerde. horen dats verstaen ende andwerde geven [van datmen seyt ende van G] dattie mensce hort. Ende daer omme es in dit deel tgepeins [ende der memorien C] vanden mensche. Int achterste deel so legt die onthoudenisse wat dattie mensce hort of gehort heeft dat gaet liggen int achterste deel van den hoefde. Dus segt cort rogerus in roelandinus in latijn "in prima cellula sit ymago, in media ratio, in posteriori memoria"*» (Van Leersum, *De cyrurgie van meester Jan Yperman*). See also: A. de Mets, *La chirurgie de Maître Jehan Yperman (1260?-1310?). Livres I et II* (Paris, 1936), 26–27.

[599] Jan Yperman, *Cyrurgie*, Book I, Cap. 1: «*Thoeft es van 3 pertiën. Deen voren, dander midden ende terde achter. Voren vander mouden vorwert es thoeft heet ende droghe hebbende vele geesten ende luttel marchs. Die middewert: van den hoefde heef vele marchs ende vele gheesten. Ende es heet ende versch. Ende int middelstre deel staen die oren ende staen op 2 been die men heet stenech been. Dat achterste deel es cout ende droghe hebbende luttel geests ende luttel marchs*» (Van Leersum, *De cyrurgie van meester Jan Yperman*).



Figure 4.3 Jan Yperman, *Cyrurgie.* Ghent, *Universiteitsbibliotheek*, ms. 126, f. 3v. Dated 1328.

> imagination, because it understands and it has little soft <tissue> and a lot of spirits: it is warm and dry. The second has the name *logistica*, and it is receptive, warm and humid. It has both much soft tissue and much spirits. The third has the name memory, it has much soft <tissue> and little spirits, and is cold and dry».[600]

In Jan Yperman's opinion, hearing is an upgraded external sense operating in close cooperation with reason. He followed Aristotle who stated in *De sensu* that hearing makes a rational discourse possible, and thus develops intelligence. When born blind, consequently, one was thought to be more intelligent than when born deaf and dumb.[601] Hearing was therefore held to be very important because one starts to comprehend and answer thanks to this sense, which is why it belongs to reason rather than to the external senses of sight, smell, taste and touch.[602] The Brabant surgeon Thomas Scellinck (14c.) appreciated hearing in a similar way.[603]

Four male figures support the circular drawing of the brain in Yperman's Surgery, each holding a banderol that unveils their identity: master Lanfranc, master Bruun, master Avicenna and master Galienus. Master Bruun might be identified as Bruno of Longobardo, a contemporary of Yperman and Lan-

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600 For instance: Basle, *Universitätsbibliothek*, D.II.11 (dated ca. 1250): «*De ceruel. (L)o ceruel aiij. cambras. la primeira a nom ymaginatiua. car entent et a pauc de mol e molt desperit et es calent e secca. la segonda a nom logistica. so es receptiua, calent e humida. et a mot de cada un. La tresa a nom memoria et a mot de mol e pauc desperit et es frega e seca*» (cited in: Sudhoff, "Die Lehre von den Hirnventrikeln in textlicher und graphischer Tradition des Altertums und Mittelalters," 182). My translation. See also the text from Thomas Scellinck, an excerpt of which printed below in footnote 603.

601 Aristotle, *De sensu*, 437a.

602 The physician Richard de Fournival (1201 - ca. 1260), however, called sight the noblest sense because we learn so many things through it. Hearing was nonetheless important since both hearing and sight were thought of as the 'gates to memory'. See: E. Sears, "Sensory perception and its metaphors in the time of Richard of Fournival," in *Medicine and the five senses*, ed. W.F. Bynum and R. Porter (Cambridge, 1993), 17–39, here 23.

603 Thomas Scellinck, *Boeck van Surgien*, I.7: «*In desen iii cameren [daer die ziele in haer habiteert ende woent] siin iii edele ende heilighe natueren. In anteriori dat es in die voerste camer die es werm ende droeghe die natuere doet imagineren dat es [visieren ende] ordineren alle dinc. In die middelste camer leghet die natuere die heeft die redene te vernemene ende te verstane watmen hoert ende es heet ende versch dat die ander siin ende heeft veel gheesten ende veel van hersenen. In die achterste leet die natuere vander memorien dat es voer dencken ende onthouden ende si es cout ende droeghe bi dat die ander siin ende hevet veel gheesten ende luttel hersenen*» (E.C. van Leersum, ed., *Het 'Boeck van Surgien' van meester Thomaes Scellinck van Thienen* (Amsterdam, 1928), 24).
In English: «In these three rooms [for the soul dwells and lives in her] dwell three noble and holy natures. In the anterior part, that is the front room, which is warm and dry, is the nature that imagines and arranges all things. In the middle room is the nature 'reason' that receives and understands what one hears and is hotter and fresher than the others, and features many spirits and brains. In the posterior part is laid the nature of memory, apt for thinking and remembering, which is cold and dry and has many spirits but little brains». My translation.

franc.[604] Galen and Avicenna were of course his indirect teachers, and the authorities in his field. By letting his masters support the figure of the brain, Jan Yperman acknowledged and honored his superiors, and placed himself within their tradition.

The drawing of the brain considered here is schematic but also naturalistic since the outer layers and inner divisions correspond to how Yperman conceived the physical reality of the skull and its contents. He was a practicing surgeon and many drawings in his text, such as those showing instruments, were of practical use. This figure, although highly schematic, was also practical in use. It shows which layers a surgeon encountered when opening the human head. The design of the diagram, in its concentric circles, corresponds to the physical reality of shells or protective layers surrounding the soft brain tissue.

The division of the concentric circles into wedges, however, has no practical surgical meaning. The names of the three layers are repeated four times, leaving two wedge-shaped pieces open. This division of the circle into wedges was accentuated by the four personages supporting the figure, who represented all fundamental knowledge then available about the head. The idea of wedges and the four personages are comparable to the quadruple circle-globes that enclosed the basic components of the cosmos.

Skull models: the three-dimensional alternative

In his lecture demonstrations Henry of Mondeville (1260–1320) probably used large parchments, showing drawings, attached to the classroom wall. Mondeville had studied medicine close to Theodoric and Wilhelm of Saliceto in the Italian university town of Bologna, and then in Montpellier, close to Lanfranc in Paris.[605] As a master, Henry of Mondeville gave public lectures in Montpellier (1304) and Paris (1306) and wrote, besides his *Anatomy*, a voluminous *Surgery* that was largely excerpted from Avicenna's *Canon*. The drawings found in manuscript copies of his lectures are reportedly based on demonstrations during his anatomy classes and lectures.[606]

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[604] Clarke and Dewhurst, *An illustrated history of brain function. Imaging the brain from antiquity to the present*, 10.

[605] L.C. Mackinney, "The beginnings of western scientific anatomy: New evidence and a revision in interpretation of Mondeville's role," *Medical History. A quarterly journal devoted to the history and bibliography of medicine and the related sciences* 6, no. 1 (1962): 233–239.

[606] In a fifteenth-century copy of an *Anatomia*, now kept in Berlin, two small pictures of the skull are inserted in the chapter about the *anathomia cranei* (Berlin, *Staatsbibliothek zu Berlin - Preussischer Kulturbesitz*, lat. fol. 219). One figure depicts the skull, seen from above, divided by four serrated commissures. Another shows a similar skull divided in four parts by serrated commissures. In this latter figure the draughtsman added two semi-circular forms in the *mundose*, which present the two openings for the auditory channels. The author described the interior of the skull and placed the virtues (the internal senses) in the ventricles, labelling these with the humours.

Not all visual renderings of anatomical and surgical conceptions about the brain took the form of two-dimensional diagrams. Models of the skull were also common. In chapter two of his first treatise on *Anatomy*, Mondeville describes the use of an extraordinary educational tool, a real skull (or an artificial substitute) :

> «He who wants to demonstrate the interior and exterior anatomy of the head in an observable and perfect way needs an artificial skull, if he has not a real human head at his disposal. Such an artificial skull should be open, milled on its commissures and divided into four parts, so that, after the exterior anatomy has been demonstrated, it can be opened, and the interior anatomy of the membranes and brains can be shown in an observable way. And the exterior of this skull must be completed with hairs, skin, muscles, membranes, bones and ligaments. The interior must be made in a similar way, so that the forms of membranes and brains show visibly».[607]

The artificial skull as suggested to us here was a model of a head. After a master had demonstrated the exterior of the head with its commissures, one could open the head by peeling off an outer layer made in four parts. Once the exterior was peeled off, the anatomy of the interior became visible. In the same way, imitations of the membranes and the brains within were to be made (*ficta*). It is possible that Henry of Mondeville had an academic setting in mind, in which he and his fellow masters were to teach future physicians.

This skull model could have resembled the drawing in a Cambridge copy of Jan Yperman's *Surgery*.[608] [*See* figure 4.4]. The drawing shows a master, sitting on his cathedra and holding a model of a skull in his hand, demonstrating its workings to students seated in front of him.[609]

Some scribes left the windows in other copies empty, leaving it to the purchasers to fill in the sketches. A manuscript copy of the same text, kept in Paris, is such a copy in which spaces are left blank (Paris, *Bibliothèque nationale*, lat. 16642; lat. 16193).
See also: Mackinney, "The beginnings of western scientific anatomy: New evidence and a revision in interpretation of Mondeville's role," 233.

[607] Henry of Mondeville, *Anatomia*, Tractatus I, Caput II: «*Quicunque vult anatomiam ostendere capitis intus et extra, sensibiliter et perfecte, si non posset habere verum caput humanum, ipse debet habere craneum artificiale, aperibile, serratum per commissuras, divisum in 4 partes, ut cum anatomiam extrinsecam ostenderit, illud aperire possit, ut sensibiliter anatomia panniculorum et cerebri videatur. Et debet dictum craneum exterius esse munitum aliquibus, que capillorum et cutis et carnis lacertose et panniculi ossa ligantis vices gerant. Similiter debent interius aliqua esse ficta, que sensibiliter formam panniculorum et cerebri representant*» (J.L. Pagel, ed., *Die Chirurgie des Heinrich von Mondeville* (Berlin, 1892)). See also: D. Jacquart, *La médecine médiévale dans le cadre Parisien. XIVe-XVe siècle* (Paris, 1998), 196–197.

[608] Cambridge, *S. John's College Library*, A 19, f. 2v. See: Van Leersum, *De cyrurgie van meester Jan Yperman*, xxviii-xxx.

[609] I thank Maria Patijn who kindly shared the photos she took of this manuscript. See about this manuscript: G. Bouwmeester and S.M.C. Patijn, "Horror als huiswerk. Het geïllustreerde



Figure 4.4 Jan Yperman, *Cyrurgie*. Cambridge, *S. John's College Library*, A.19, f. 2v. Dated 15th century.

PATHOLOGICAL LABELLING

Very different in conception is a series of figures illustrating pathological treatises. The internal senses here are enumerated strangely among the diseases. In the existing literature this figure is known as the 'disease-man' (known as the *Krankheitsmann* in German). Most examples date from the fourteenth to the sixteenth centuries.

One example will suffice here to demonstrate the idea of the *Krankheitsmann*: a manuscript now kept in the *Bibliothèque nationale de France*, containing several medical texts written in Latin as well as in French, and dated around 1400.[610] On folio 37r of this copy, the copyist arranged numerous diseases in an orderly dichotomy. Since some diseases prevailed at a certain time of the year, the diseases are indexed by season. Such a list facilitated an overview and the recollection of the many possible illnesses. On the verso of the folio a second figure appears, cataloging the same illnesses, adding diagnoses and treatments in an even more appealing visual way: a full page pictorial figure of a man in underpants.[611] [*See* figure 4.5].

Around and on his body, inscriptions of diseases are enumerated. Inscription of the diseases on his body seems more effective as one instantly sees the location of the specific disease involved. Hence diseases like *obtalmia*, *litargia*, *serpigo*, *epilentia* are listed around his head, as are more common ones like stupidity (*stupor mentis*) and hair loss (*casus cappilorum*).[612]

The draftsman portrayed four parts to the head, in which he then inscribed the internal senses. These read, from the forehead to the back: *sensus communis*, *cellula ymaginativa*, *cella estimativa rationis*, *cella memorativa.* The diminutive *cellulla* was used because this ventricle was thought to be the smallest. The functions located in the four cells are not explained or elaborated upon here. The man standing in front of us is alive and in one piece and it is unclear whether his head is cut open to demonstrate the cells or if the names of the functions are painted onto the exterior of his head or bonnet.

Many more of these disease-men, and even disease-women, circulated in the fourteenth and fifteenth centuries.[613] Further research is required to establish

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Cambridge-handschrift van Ypermans Cyrurgie," *Vooys* 26, no. 2 (2008): 109–117.

610 Paris, *Bibliothèque nationale*, lat. 11229, f. 37v.

611 See for reproductions: Sudhoff, "Eine Pariser 'Ketham' – Handschrift aus der Zeit König Karls VI. (1380–1422)," Taf. IV.4; Sudhoff, "Die Lehre von den Hirnventrikeln in textlicher und graphischer Tradition des Altertums und Mittelalters," 192, fig. 6; Murdoch, *Album of science: Antiquity and the Middle Ages*, 304, fig. 259; Clarke and Dewhurst, *An illustrated history of brain function. Imaging the brain from antiquity to the present*, fig. 7; H.W. Magoun, "Early developments of ideas relating the mind with the brain," in *The neurological basis of behaviour*, ed. G.E.W. Wolstenholme and C.M. O'Connor (London, 1958), 4–27, 12, fig. 4.

612 See for a transcription of the inscribed diseases: Sudhoff, "Eine Pariser 'Ketham' – Handschrift aus der Zeit König Karls VI. (1380–1422)," 98.

613 See for some disease women: Munich, *Bayerische Staatsbibliothek*, cod. lat. 4394, f. 115v. See



Figure 4.5 Various medical texts. Paris, *Bibliothèque nationale*, lat. 11229, f. 37v. Dated c. 1400.

the corpus of texts and figures out of which Ketham, considered responsible for the compilation of six figures including the 'Krankheitsmann', compiled his visual material. There may possibly be a German origin to this pictorial tradition.[614]

Of interest is the fact that the internal senses move here from a surgical setting into a pathological setting. The presence of senses in a disease-man is somewhat surprising, since internal senses are not diseases. Possibly their presence was intended to remind the reader that diseases could upset the balance of the three powers. The powers could not become ill, however, otherwise the authors would have mentioned the illnesses of the mental powers. Avicenna, however, defines illness as a disturbance of the operations of the soul. Counting these among the diseases was perhaps considered a way to keep attention on the disturbances in the powers of the rational soul.[615]

Early cutaways: Physicians and the sensitive soul (1310, 1347)

One of the earliest diagrams dealing with the physical seat of the cognitive process is inserted in a compilation written about 1310, now kept in the *University Library* of Cambridge.[616] The manuscript contains 633 folia with texts in French and Latin about natural philosophy, learning, the Liberal Arts, prognostications, a *roman de l'amour* and moral texts.[617] The anonymous author begins a short natural philosophical text (fols. 490r-491r) with the words «how is the human head situated» – «*Qualiter caput hominis situatur?*».

The draughtsman placed a diagram within the margins, integrated with the text. [*See* figure 4.6]. It shows a bearded man in a three-quarter position looking to the right. His head is a cross section, unveiling his powers in five neatly drawn

for a reproduction: Sudhoff, "Neue Beiträge zur Vorgeschichte des 'Ketham'," Taf. VI; Clarke and Dewhurst, *An illustrated history of brain function. Imaging the brain from antiquity to the present*, fig. 16. Also mentioned in: Sudhoff, "Die Lehre von den Hirnventrikeln in textlicher und graphischer Tradition des Altertums und Mittelalters," 193. Another disease woman is drawn in: London, *British Museum*, Arundel & Burney ms. 251, f. 37r, dated ca. 1380. See for a reproduction: Clarke and Dewhurst, *An illustrated history of brain function. Imaging the brain from antiquity to the present*, fig. 5. And: Heidelberg, *Universitätsbibliothek*, cod. Pal. Germ., ms. 644, dated early XVth century. See for a reproduction: K. Sudhoff, "Über medizinische Fachillustrationen aus der Antike in mittelalterlicher Überlieferung," *Mitteilungen der deutschen Geschichte in Leipzig* 10 (1912): 96–99, Taf. IV.1; Clarke and Dewhurst, *An illustrated history of brain function. Imaging the brain from antiquity to the present*, fig. 12.

614 Sudhoff, "Neue Beiträge zur Vorgeschichte des 'Ketham'," 287, n. 1.

615 I thank Karine van't Land warmly for this suggestion.

616 Cambridge, *University Library*, G.G.I.1, f. 490v. See for a reproduction: Sudhoff, "Die Lehre von den Hirnventrikeln in textlicher und graphischer Tradition des Altertums und Mittelalters," 188, fig. 4; Clarke and Dewhurst, *An illustrated history of brain function. Imaging the brain from antiquity to the present*, fig. 39.

617 C. Hardwick, ed., *A catalogue of the manuscripts preserved in the library of the university of Cambridge* (Cambridge, 1858), 1–8.

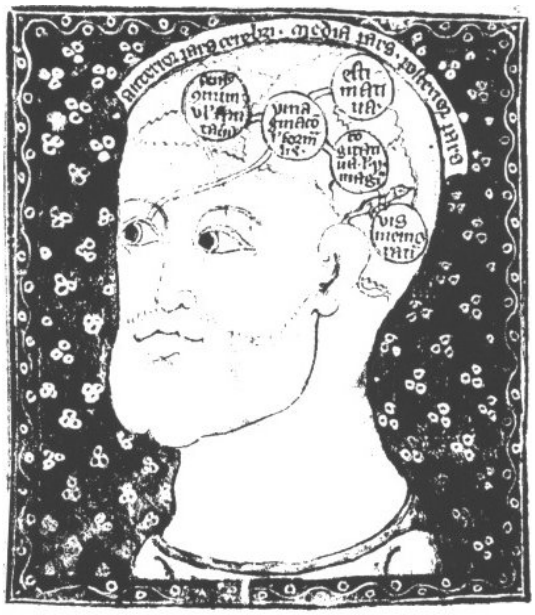


Figure 4.6 Various texts. Cambridge, *University Library*, G.G.I.1, f. 490v. Dated 1310.

circles. A background filled with small flowers frames his head. The banderol above divides the skull into three parts: an anterior, middle and posterior. The first two ventricles drawn in the front contain the *sensus communis vel sensatio*, and the *ymaginatio vel formalis*.[618] In the middle ventricle is the *estimativa* and the *cogitativa vel ymaginativa*, one above the other. The *vis memorativa* is placed in the back of the head.

Between the cogitative power and the memory, just above the ear, a worm is drawn. The text mentions «an organ similar to a worm, which can be opened and closed and whose job it is to memorize» – «*corpus ad similitudinem vermis, quod clauditur et aperitur, cum opus fuerit memorari*». In short: this *vermis* lets thoughts through. The *vermis* had long been an approved organ, and would feature in Reisch's woodcut in the *Margarita Philosophica* to which Vesalius referred. [*See* figure 4.1]. The representation of the *vermis* in the Cambridge copy is especially imaginative, featuring eyes, paws and a tail.[619]

The anonymous author of this text used several sources: Thomas Aquinas' not further specified *Summa*, Avicenna's *De animalibus*, *De naturalibus*, and *Canon*, and the *De differentia spiritus et anime* of Constabilius, which was the

[618] Sudhoff, "Die Lehre von den Hirnventrikeln in textlicher und graphischer Tradition des Altertums und Mittelalters," 184–188.

[619] In a fifteenth-century manuscript now kept in Munich the *vermis* is mentioned in a text bloc explaining the drawing (but is not actually drawn into the figure), *Bayerische Staatsbibliothek*, lat. 5961, cover. The *vermis* is also drawn in Durham, *University Library*, Cosin V.iv.7, f. 47r, reproduced in (Clarke and Dewhurst, *An illustrated history of brain function. Imaging the brain from antiquity to the present*, fig. 23.

Latin name of the Arab physician Costa-ben-Luca (820–912), whose text was translated during the twelfth century and was integrated into the Parisian university curriculum. Although the author promises his reader to expound on *Questio* 79 of Thomas' *Summa*, he goes straight on to Costa-ben-Luca's recital about the anatomical division of cells in the skull. For his descriptions of the internal powers, the author followed Avicenna's *De naturalibus* and the *Canon*.[620]

Another early depiction of the same sort was drawn as part of a cycle of lectures taught by master Berthold Blumentrost.[621] Berthold Blumentrost was a typical exponent of fourteenth-century medieval, international scholarship. He obtained his master's license in the Arts faculty at Paris, probably finished his medical *studium* in Bologna in the early fourteenth century and then held a chair in the Würzburg College of higher education in 1361, where he had already been involved in since 1345. Master Blumentrost taught topics in the *trivium* and *quadrivium*.[622]

This compilation of texts is typical for a master in medicine. The first part, which is thirteenth-century in date, contains Aristotle's *De sensu*. The second part (fols. 50r–64v) dates to the year 1347 and contains several *questiones*: original work from Blumentrost dealing with embryo-logical matters, meteorological matters, *questiones* on nutrition and the four elements. The last part of the manuscript is a medical manual copied by Blumentrost.[623] His *questiones* end with a visualization of the internal senses in a man's head. [*See* figure 4.7].

The picture is drawn on the last page following his *questiones*, as if the draughtsman decided to insert the picture only if there was some space left, before starting a new text on a new folio. This drawing is dated 1347 and is therefore several decades younger than the Cambridge-copy described above.[624]

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620 This text is published by Sudhoff, see: Sudhoff, "Die Lehre von den Hirnventrikeln in textlicher und graphischer Tradition des Altertums und Mittelalters," 184–188.

621 Munich, *Bayerische Staatsbibliothek*, cod. lat. 527, f. 64v, dated 1350. Previously reproduced in ibid., 190, fig. 5; Magoun, "Early developments of ideas relating the mind with the brain," 14, fig. 6; M. Klarer, "Ekphrasis, or the archeology of historical theories of representation: medieval brain anatomy in Wernher der Gartenaere's Helmbrecht," *Word and Image* 15, no. 1 (1999): 34–40.

622 Berthold Blumentrost, *Questiones disputate circa tractatum Avicenne de generatione embryonis et librum meteorum Aristotelis*, Munich, CLM 527, f. 64v: «*Expliciunt questiones disputate a venerabili magistro Berchtoldo licentiato Parysius in artibus, Bononie in medicine […]*» (R. Krist, ed., *Berthold Blumentrosts Quaestiones disputatae circa tractatum Avicennae de generatione embryonis et librum meteorum Aristotelis: ein Beitrag zur Wissenschaftsgeschichte des mittelalterlichen Würzburgs* (Pattensen, 1987), Teil 1, 103, also 10–11).

623 Previously reproduced by Clarke and Dewhurst, *An illustrated history of brain function. Imaging the brain from antiquity to the present*, 30, fig. 40; Krist, *Berthold Blumentrosts Quaestiones disputatae circa tractatum Avicennae de generatione embryonis et librum meteorum Aristotelis: ein Beitrag zur Wissenschaftsgeschichte des mittelalterlichen Würzburgs*, 02; Sears, "Sensory perception and its metaphors in the time of Richard of Fournival," 37, fig. 13.

624 See page 182.

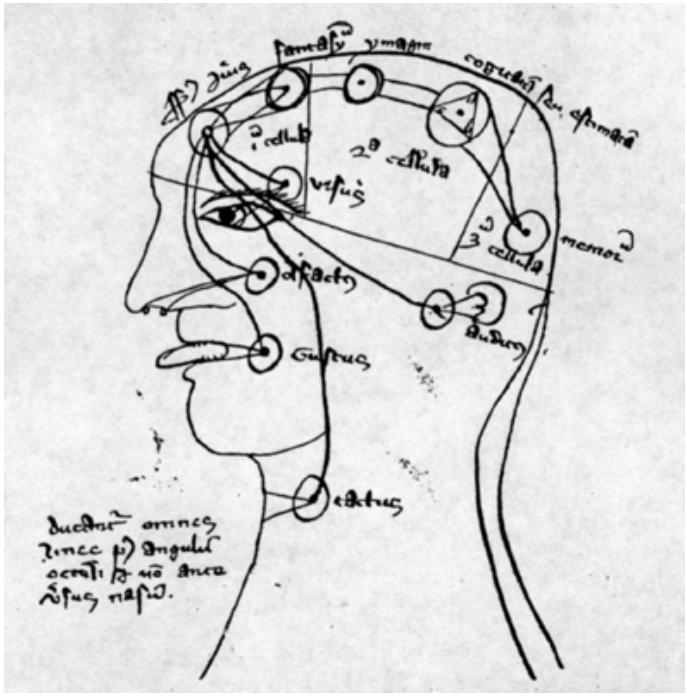


Figure 4.7 Berthold Blumentrost, *Questiones disputate*. Munich, *Bayerische Staatsbibliothek*, cod. lat. 527, f. 64v. Dated 1347.

The treatise that concerns us here survived, to the best of our knowledge, only in one manuscript.

The picture shows a man's head in profile, with a horizontal line dividing the area of the brain from the face. The brain area is then divided into three ventricles, called *cellulle*, in which labelled circles are drawn. The first circle on the left is labelled *sensus communis* then, to the right, follows *fantasia*. In the second ventricle resides *ymaginativa*, followed by a slightly larger circle containing a triangle labelled *cogitative* or *estimativa*. The triangle is numbered, in its angles, with the letters *a*, *b* and *c*. It is unclear what these numbers refer to – there is no matching reference in the text. In the third and rearmost ventricle resides *memorativa*. A double line connects these five internal senses to one another.

From the *sensus communis* five lines depart to the five external senses: *visus*, right above the eye; *auditus*, near the auricle; *tactus*, touch, on the throat, (with smaller lines drawn to the skin); *olfactus*, with additional lines to the nostrils; and finally *gustus*, near the mouth, with additional lines pointing to the tongue. Next to the throat is written «*Ducantur omnes linee post angulum occuli (sic), et non ante versus, nasum*». Does this scribble indicate that the lines are behind the angle of the eyes and not in front of the nose, thus making explicit that the transport of information occurs within the skull and not outside? Or is this scribble meant rather as guidance for the draughtsman (who must then be someone other than the scribe)?

The section in the *questiones* that can be related to this drawing touched on the question of whether the sensitive power is infused first into the brain or first into the heart (Quest. 5), and searches to decide upon the physiological picture of the location of the external senses.[625]

In the development of the argument, the position of the physician (*medicus*) is directly articulated: the physician treats the senses in their location, which is in the brain, but the opposing argument - that the sensitive powers are located in the heart where the soul is created – is also given. The conclusion of Blumentrost then compromises, deciding that the sensitive power is originally infused in the heart, but *instrumentally* infused first into the brain, a position held by Thomas Aquinas. Thomas sought here to compromise between Avicenna (who located the external senses in the front ventricle) and Aristotle (who held that they were located in the heart).[626]

The text also deals with questions about the vital, natural and sensitive spirits (Quest. 15), about the digestive and nutritive virtues (Quest. 48), both of which topics are also related to the topic of the image.

The drawing is announced with the phrase «this is the anatomy of the head for physicians» – «*Ista est anathomia capitis pro medicis*». This inscription implies further that it shows the cephalocentric point of view defended by Galen.

Both copies were related to the medical discourse of their era. The Cambridge-copy was (professionally) painted as part of an anthology in the Liberal Arts, dated 1310. The text mentions the philosopher Thomas Aquinas, but also the physician Costa-ben-Luca and the philosopher-physician Avicenna. The diagram in the Munich-copy of Blumentrost is dated some forty years later, and was possibly drawn by the copyist, probably a student. The text refers to the opinion of Thomas Aquinas, but also mentions the opinion of the physician

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625 Berthold Blumentrost, *Questiones disputate circa tractatum Avicenne de generatione embryonis, et librum meteorum Aristotelis*. Quest. 5: «*Queritur utrum cerebrum sit principaliter subiectum virtutis sensitive.*
Quod sic: illud est subiectum primum, quo impedito inpediuntur ipsi sensus, sed impedito cerebro per sompnum impediuntur sensus; patet: habitus et privatio circa idem.
Puta: ubi medicus procurat subvenire sensibus periclitantibus, ibi est subiectum; <sed> hoc est in cerebro, ergo <etc.>.
In oppositum: primum subiectum virtutis sensitive, ubi primo creatur ipsa anima, <sed> hoc est cor, ergo etcetera, quia: ubi anima, ibi eius potentie.
Dicendum quod vis sensitiva primitive originis est in corde, sed instrumentaliter est in cerebro ut in suo subiecto.
Per hoc soluuntur rationes. Similis questio potest solui de <h>epate, quod ibi sit pincipaliter virtus nutritiva» (Krist, *Berthold Blumentrosts Quaestiones disputatae circa tractatum Avicennae de generatione embryonis et librum meteorum Aristotelis: ein Beitrag zur Wissenschaftsgeschichte des mittelalterlichen Würzburgs*, 36).
626 Thomas Aquinas, *Sentencia libri De sensu et sensato*, 4.277-85 [5.76]; *Sentencia libri De anima*, III.3.195-204. See also R. Pasnau, *Thomas Aquinas on human nature* (Cambridge, 2002).

(*medicus*).

In the early fifteenth century, many more of these figures were depicted in anthologies containing disparate texts from the medical and philosophical realms.[627] For example, a figure dated 1410, now kept at *Trinity College* Cambridge, is inserted in an anthology of prognoses, meteorology, *Secreta philosophorum*, and even a note in English on the taking of Granada.[628] The figure is referred to as «This figure is based on the fifth (and last) book of a medical work» – «*Istud caput pertinet ad quintam conclusionem libri medicine*», but which one? The fifth (and last) book of Avicenna's *Canon* is about medicines and their application and is therefore not relevant to this subject matter.[629] Perhaps the author made a mistake.

These cross-cut examples clearly stand in a different tradition than the surgical slices of Jan Yperman, Henry of Mondeville and the early anonymous Cambridge-copy from *Gonville and Caius Library*. These surgeons were interested in the anatomical constitutions of the head. The functions of the soul were, for them, of secondary importance.

4.3.2 Caput physicorum - The physicists' head

Sometime around 1400, the diagram showing the powers of the soul moved from the medical to the philosophical realm. The first known picture inserted in a philosophical text dates from the first half of the fifteenth century – on the last page of a copy of the *De potentiis anime* by Walter Burley.[630] In the second half of the fifteenth century the presence of the cross-sectioned head in philosophical texts was widespread and, as a result, the following sections will deal with philosophical drawings of the soul.

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[627] Durham, *University Library*, Cosin V.IV.7, f. 47r. Previously reproduced in: Clarke and Dewhurst, *An illustrated history of brain function. Imaging the brain from antiquity to the present*, 20, fig. 23.

[628] Cambridge, *Trinity College*, O.2.40. Previously reproduced in: Sudhoff, "Die Lehre von den Hirnventrikeln in textlicher und graphischer Tradition des Altertums und Mittelalters," 197, fig. 9; Violé O'Neill, "Diagrams of the medieval brain. A study in cerebral localization," 103, fig. 7.

[629] With thanks to Karine van't Land.

[630] Leipzig, *Universitätsbibliothek*, cod. 426, ff. 182v-189r, fig. on f. 189r. Inc.: *Ut dicit philosophus secundo de anima potencie anime quibusdam*». Expl.: *et sensitivum et sic est finis etc.* See: Macray, *Catalogi codicum manuscriptorum bibliothecae bodleianae. Pars IX. Codices a viro clarissimo Kenelm Digby*, 104. Previously reproduced by Steneck, "Albert the Great on the classification and localization of the internal senses," 196, fig. 1.
It has been described as an *'ungeschickte Zeichnung'* (an awkward drawing). See: R. Helssig, ed., *Katalog der Handschriften der Universitäts-Bibliothek zu Leipzig*, IV: Die lateinischen und deutschen Handschriften. Band I: Die theologischen Handschriften (Leipzig, 1926), 659–664. Another drawing showing a head in perspective is inserted in Würzburg, *Universitätsbibliotek*, M.ch.f.123, f. 81v. This drawing is not reproduced, to my knowledge.

Three separate powers

In the fourteenth and fifteenth centuries, the interest of philosophers and theologians shifted towards the abstraction and cognition of sensory data. External senses and internal senses were held to be necessary but not sufficient for cognition. Cognition was thought to start with the reception of sense data. The perceived data, however, were conceived of as 'particulars' and not universals. A process of abstraction from these particular images therefore preceded the subsequent reception of abstract concepts.[631]

How did the process of abstraction took place? Aristotle conceived of an active power, the so-called agent intellect (*intellectus agens* in Latin), which performed the action of abstraction. A second intellective power, called a 'possible' or 'potential' intellect (*intellectus possibilis* in Latin) was then able to receive abstract concepts that resulted in intellective cognition. Aristotle was, however, unclear about the exact function of these powers and their relationship to one another. The inconsistencies later gave rise to numerous conflict among late-medieval philosophers, with the protagonists Albert the Great, his pupil Thomas Aquinas and Siger of Brabant.[632]

This interest in intellective cognition encouraged draughtsmen to incorporate this topic into existing drawings of the souls. For instance, a drawing in the Norrköping-copy of the textbook *Parvulus philosophie naturalis* by Peter of Dresden shows an overview of the cognitive process. This figure, drawn by the Leipzig student Fabian Wachter, has hitherto been ignored in the existing literature. [*See* figure 4.8]. [See also Appendix B.2, 251].

The rational soul is dealt with in the three circles shown above the drawing of the man: the agent intellect (also active intellect), the possible intellect (also passive intellect) and the will. They are called three separate powers (*tres potentie seperate*). In *De anima*, Chapter III. 5, Aristotle described the 'passive' intellect as being securely tied, by way of phantasms, to perception and the body. The other, the 'active' intellect, is pure and free from physical trappings. It is capable of independent and eternal existence.

> «And there is an intellect which is of this kind by becoming all things, and there is another which is so by producing all things, as a kind of

631 Z. Kuksewics, "Criticism of Aristotelian psychology and the Augustinian–Aristotelian synthesis," in *The Cambridge history of later medieval philosophy from the rediscovery of Aristotle to the disintegration of Scholasticism 1100–1600*, ed. N. Kretzmann, A. Kenny, and J. Pinborg (Cambridge, 1982), 623–628, here 628.

632 Z. Kuksewics, "The potential and the agent intellect," in *The Cambridge history of later medieval philosophy from the rediscovery of Aristotle to the disintegration of Scholasticism 1100-1600*, ed. N. Kretzmann, A. Kenny, and J. Pinborg (Cambridge, 1982), 595–601, here 595. See also E.P. Mahoney, "Sense, intellect, and imagination in Albert, Thomas and Siger," in *The Cambridge history of later medieval philosophy from the rediscovery of Aristotle to the disintegration of Scholasticism 1100-1600*, ed. N. Kretzmann, A. Kenny, and J. Pinborg (Cambridge, 1982), 602–622.

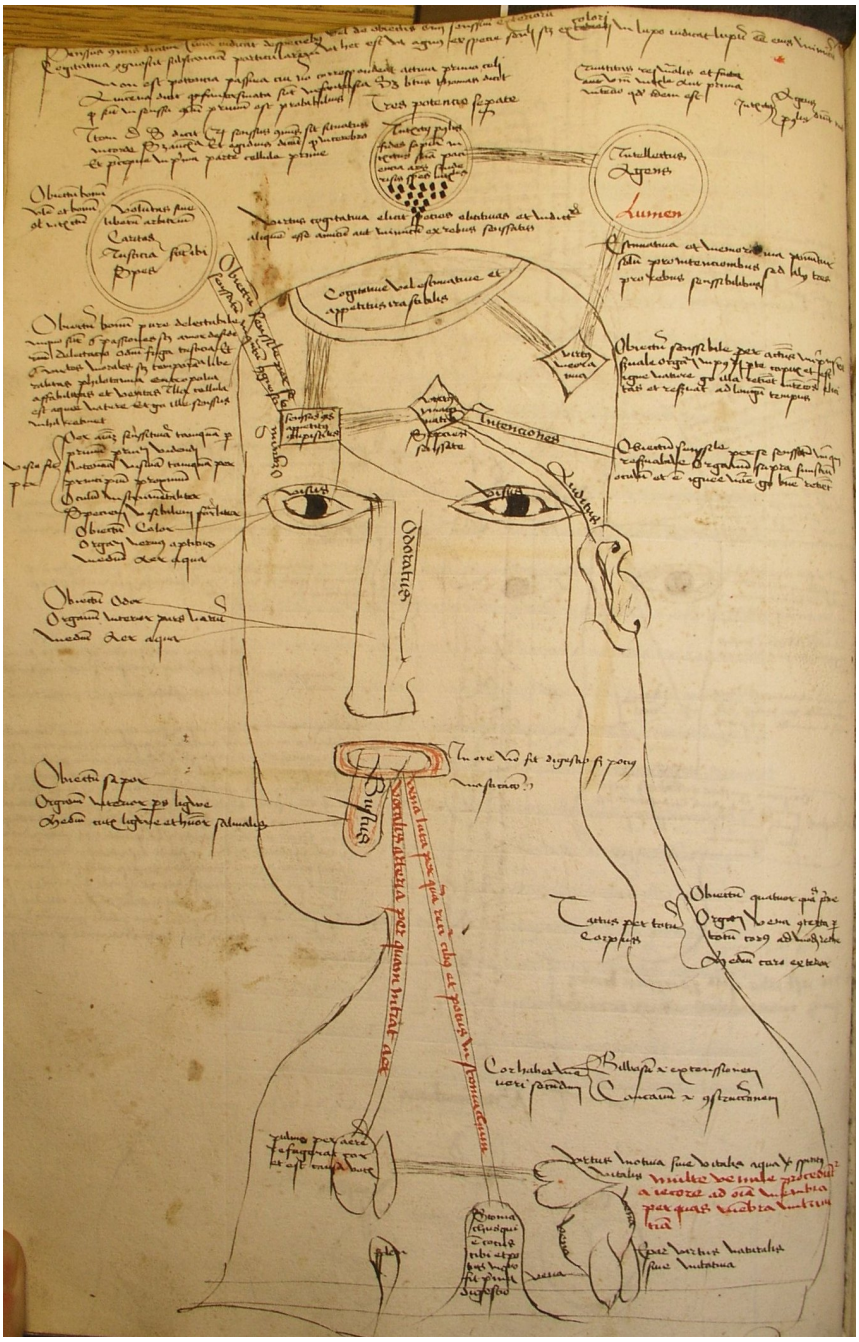


Figure 4.8 Peter of Dresden, *Parvulus philosophie naturalis.* Norrköping, *Stadsbibliothek*, ms. 426, f. 62v. Dated 1481, 1484, 1488.

> disposition, like light, does; for in a way light too makes colours which are potential into actual colours. And this intellect is distinct, unaffected, and unmixed, being in essence activity».[633]

This chapter is one of the most difficult ones in the Aristotelian corpus. Obscure points are how these intellects are to be conceived, and what precisely is the nature of the distinction and relation between them. The active intellect 'illuminates' the object of sense, rendering it intelligible somewhat as light renders colours visible. The passive intellect receives the forms abstracted by the active intellect. The active intellect actuates the passive (a relation similar to that of form to matter). The Arab philosophers of the Middle Ages conceived the active intellect as one universal reason illuminating all men. Albert the Great and Thomas Aquinas interpret the agent intellect and possible one as merely distinct faculties or powers of the individual soul.[634]

The man's head is crowded with lines interconnecting the different powers. The will *voluntas*, circle top left, with its rational appetite, is related to the concupiscent appetite of common sense by a drawn beam. The common sense is because of its concupiscent appetite inclined to concrete, pleasurable objects, whereas the will is not primarily oriented to concrete objects, except insofar as they figure in the abstract conception of goodness conceived by the intellect.[635]

In this figure, then, impressions received by the common sense are transported to the estimation (or cogitation) and also directly to the imagination. The transportation of impressions are drawn as scratchy lines. The same scratchy lines are seen between estimation and memory, between memory and agent intellect, and between the agent intellect and possible intellect. The scratchy beams lack legends but indicate possible a process of enlightenment. The *De anima* III.5 describes the agent intellect as a light. The *Parvulus* describes likewise that the agent intellect radiates abstractions into the possible intellect for further processing into universals.[636] The lines between the agent intellect, the memory and the cogitative power indicate that the agent intellect draws the essence from the sensory data stored in memory and in the cogitative power. The possible intellect then receives the abstract concepts from the agent intellect and causes intellectual cognition to occur. It is unclear why all these relations are drawn as beams of enlightenment.

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[633] Aristotle, *De anima*, III, 5. Translation borrowed from Hamlyn, *Aristotle. De anima. Books II and III (with passages from book I)*.

[634] Mojsisch, Jeck, and Pluta, "Seele," 15–16; L. Oeing-Hanhoff, "Intellectus agens / intellectus possibilis," in *Historisches Wörterbuch der Philosophie*, ed. J. Ritter and K. Gründer, vol. 4 (1995), 432–435, 433.

[635] See for example: Thomas Aquinas, *Questiones disputate de veritate*, Q. xxv, a. 1.

[636] Norrköping, *Municipal Library*, ms 426 fol., fol. 62r (my foliation): «*Intellectus agens est qui abstrahit species ab ymaginatione sive fantasia et sua irradiatione facit illas universales et ponit eas in intellectum possibilem*».

In the drawing, the imagination produces intentions, drawn as a double line inscribed with *intentiones*, which is remarkable because it is usually the estimative power that is able to discern the intentions within sense perceptions. The fragment of text preceding the drawing mentions that abstractions are drawn from phantasms in the imagination, which is a more typical interpretation (along with the role accorded to memory in abstraction).[637]

A similar drawing can be found in a manuscript held in Berlin, which contains an explanation of the *De anima* written by a Cologne master, Lambert of 's-Heerenberg (Lambertus de Monte Domini).[638] [*See* figure 4.9]. [The labels are reproduced in B.3, page 253].

A full picture of the soul is presented, with its intellectual, sensitive and vegetative kinds. The picture is entitled *Caput physicorum* and this title indicates that the drawing was considered to represent the head as perceived by 'physicists', i.e. natural philosophers. Could the draughtsman have intended to overrule the common labelling of the drawing as a 'physician's head', by explicitly calling it a physicists head? By adding the debate about the intellect in the image, such a re-naming might even be fair.[639]

The three circles hovering above the head are labelled in this drawing also the three separated powers (*tres potentie separate* in Latin): the will (*voluntas sive liberum arbitrium*), the possible intellect (*intellectus possibilis*) and the agent intellect (*intellectus agens*).

The process of cognition starts in this illustration, with the data of sense cognition, which are particular. From these sensible images a universal content must be abstracted, a task carried out by the agent intellect. Phantasms, in other

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[637] *See* footnote 636.

[638] Berlin, *Staatsbibliothek zu Berlin - Preussischer Kulturbesitz*, theol. fol. 247, f. 248r ff.: *Expositio saluberrima magistri Lamberti de Monte circa tres libros de anima*. Incipit: *(prooem.) : Circa initium libri de anima queritur primo : Utrum* De anima *sit scientia. Dicendum quod sic, quia de illo est scientia quod habet passiones per principia de ipso demonstrabiles. Sed sic est de anima [...].* (Text): *Bonorum honorabilium – Queritur: Quomodo dividitur iste liber prima sui divisione. Dicendum quod dividitur in prooemium et tractatum [...].* Explicit: *in quo excedit homo alia animalia et naturalia propter perfectionem nature fui a Deo collatam; Qui super omnia est benedictus in seacula seculorum. Amen.* See: Lohr, "Medieval Latin Aristotle commentaries," here 309.

[639] Another, similar, figure is drawn in a compilation of *questiones* about *De anima* by John (Hulshot) of Mechlin, a professor of psychology in Uppsala about 1484. Olov Johansson, a student in Uppsala in the period 1477–1486, wrote this copy. Uppsala, *University Library*, C601, ff. 1r-27r: Johannes Mechliniensis: *Commentarius in libros De anima* [Aristotelis]. Incipit: *Bonorum honorabilium. Circa initium textus de anima est notandum quod iste liber cuius sciencie anima est subiectum dividitur in duas partes [...].* Explicit: [27r]: *[...] ut ait Aristoteles peripateticorum princips primo celi et mundi, quam vero perfectam cognicionem nobis dignetur concedere pater et filius et spiritus sanctus Amen / Expliciunt notata circa libros de anima per venerabilem virum magistrali gloria sublimatum Johannem de Mechelinia anno domini 1484.* Diagram on f. 2v. See: Piltz, *Studium Upsalense. Specimens of the oldest lecture notes taken in the mediaeval university of Uppsala*, 107–119.

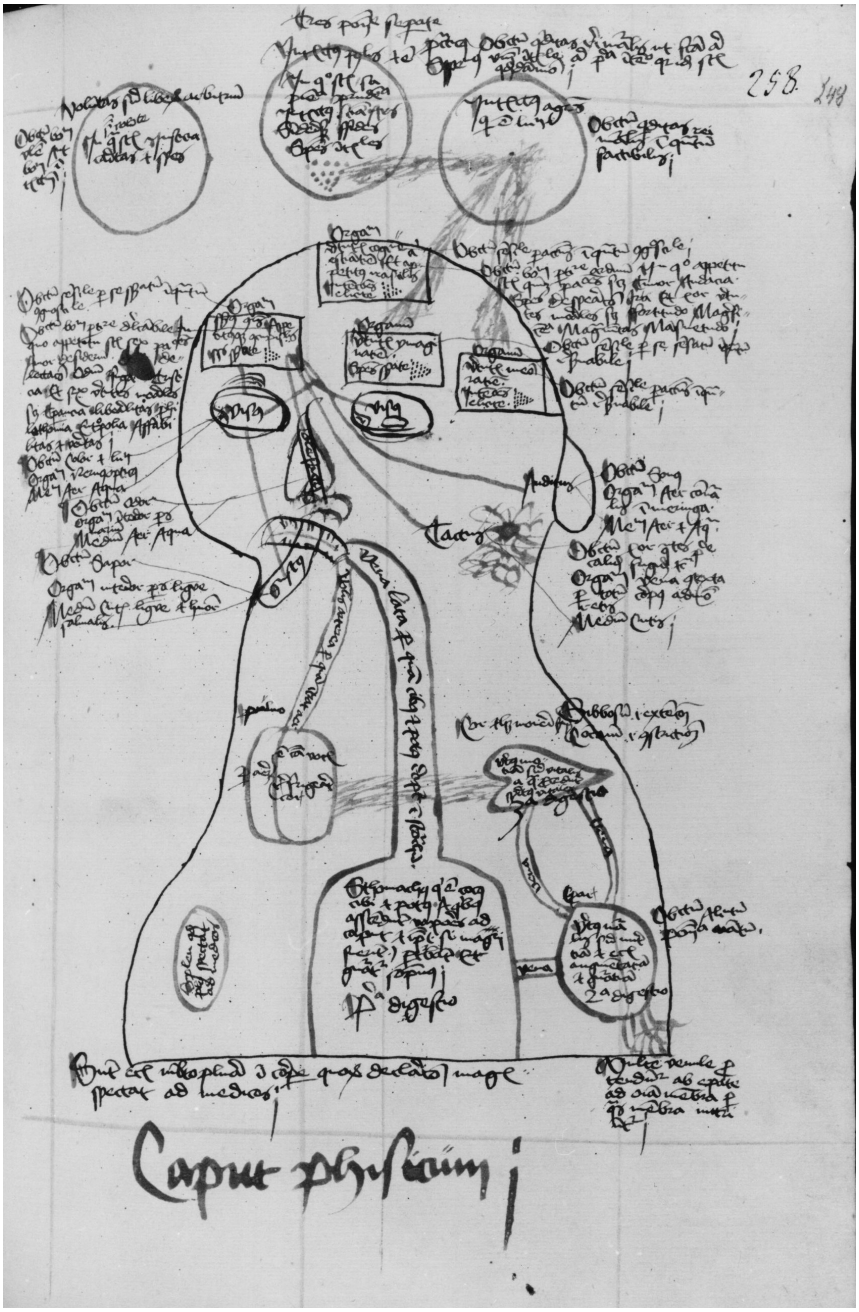


Figure 4.9 Lambertus de Monte, *Expositio saluberrima magistri Lamberti de Monte circa tres libros de anima*. Berlin, *Staatsbibliothek zu Berlin – Preussischer Kulturbesitz*, theol. fol. 247, f. 248r. Dated in the second half of the 15th century.

words, are shown as material and individual in the senses and in the imagination (fantasy) and it is the job of the agent intellect to abstract the essence or 'quiddity' (*quidditas* in Latin) of the sensible thing represented in the phantasm. The agent intellect was held to render sensible things intelligible by abstracting their form from their matter and from their individuating conditions. This process resulted in intelligible *species*, or universal likenesses, which dynamized the possible intellect, allowing it to form concepts out of the abstractions.[640] In the text, one reads that these abstractions (universals) are superior to concrete *species* (particulars) because they are more essential.[641]

In the image in question here, the three cognitive powers are drawn in three circles hovering above the head. Three beams of enlightenment scratched in red ink depart from the agent intellect – to the possible intellect, to imagination and to memory. The agent intellect abstracts on the basis of the images present in the imagination and memory, both of which prepare each phantasm for abstraction by the intellect. The results of the agent intellect then actualize the possible intellect.

A third power is called the *voluntas* or the *liberum arbitrium*. The *voluntas* is presented as a third power, visually distinct from the intellect. The will was defined as the rational appetite – the desire for good as apprehended by reason. The rational appetite was held to be a faculty of the spiritual soul here. It follows intellectual knowledge, and features an inclination to the good as such, and not to concrete objects. Its action consisted in selecting, in the light of reason, the good, though it was free to choose among different forms of good. The will was generally considered an integral part of reason.

A pyramid of small dots marks both the possible intellect and the four interior senses.[642] Those of the interior senses point to the right, directed towards the back of the head, while the one in the possible intellect points downward. Did the draughtsman want to indicate the direction in which the images were held to be processed: from external objects, to particular images, to universal images and finally to the production of abstract concepts?

The only reference to pyramidal forms I know of is in a text passage from Mundino de' Luzzi, a professor of anatomy at Bologna around the year 1300. Mundino mentioned that:

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[640] Mahoney, "Sense, intellect, and imagination in Albert, Thomas and Siger," 607–608.

[641] Lambertus de Monte, *Expositio*, III f. lix v.: «*dicendum quod ista species intelligibilis speciei specialissime etiam est imago representans omnia superiora essentialiter se habentia ad speciem specialissimam quia quecumque sunt realiter eadem per eandem imaginem representantur sicut patet de imagine regis que representat hominem, animal, corpus animatum et sic de aliis*» (Heinrich Quentell 1498 (Hain 11585)).

[642] The same form of dots is seen in the possible intellect of Norrköping, *Stadsbibliotek*, cod. 426 fol., (my foliation f. 62v). I also found pyramidal dots in the non-figurative figures called *specula inmaterialia* and *specula materialia* in Uppsala, *University Library*, C602, f. 92v; Norrköping, *Stadsbibliotek*, cod. 426 fol., (my foliation ff. 57v, 63r).

> «This brain is of a pyramidal form, because the form of the ventricle in the back of the head is pyramidal. This part of the brain he held to be pyramidal because the base of this ventricle needed to receive, and thus needed 'latitude'. In the upper part, it needed to retain, which is why the form of the pyramid is pointed and drawn together in the top, for species are preserved better in a narrow place than in a wide one, and that is why it has that form».[643]

The relationship of the intellect to the body was of utmost importance to medieval thinkers because the answer bore on the survival of the soul after death. The topic was, however, problematic, because Aristotle had sometimes considered the intellect part of the soul, and sometimes as different in nature and separate from the body.

Lambertus followed Thomas Aquinas' interpretation on the topic. For Thomas the potential intellect and the agent intellect were powers of the human soul, and therefore multiplied according to the number of human beings, meaning every man was thought to have intellective powers of his own. Figuratively, every man should have three circles of his own hovering above his head. For Thomas, variation in understanding among human beings was caused by the different development of the three internal senses.

In stating this, Thomas contradicted his master Albert the Great, who required the light of a transcendent being to illuminate the human intellect prior to any possible cognition. For Albert, the agent intellect abstracted intelligible forms from phantasms, and illuminated the potential intellect. Then, the illumination of a divine being (an uncreated intellect), with which the human intellect is united, intervened as the final cause of human cognition. All individual intellects were therefore united, in Albert's view, with a separate intellect.[644]

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643 Mundino dei Luzzi, *Anatomia*. Cerebri anatomia: «*Istud cerebrum est figure piramidalis, quia ventriculus locatus in eo est figure piramidalis, et causa quare illius figure est ventriculus posterior, est quia per partem inferiorem eius, que est eius basis, debet recipere, et ideo debet habere latitudinem, per partem superiorem debet continere, et ideo acumen et stricturam debet habere in cacumine ut retineat recepta, quia species melius conservantur in stricto loco quam in amplo, et ideo fuit talis figure*» (Wickersheimer, *Anatomies de Mondino dei Luzzi et de Guido de Vigevano*).
Other pyramidal forms in the head exist that remind one of Mondino's account. For example, in Munich, *Bayerische Staatsbibliothek*, cod. lat. 527, f. 64v (*See* figure 4.7 in this present book), though representing in that case the cogitative power. The same form of dots is seen in the possible intellect of Norrköping, *Stadsbibliotek*, cod. 426 fol., (*See* figure 4.8). I also found pyramidal dots in the non-figurative figures called *specula inmaterialia* and *specula materialia* in Uppsala, *University Library*, C602, f. 92v; Norrköping, *Stadsbibliotek*, cod. 426 fol., (my foliation ff. 57v, 63r). Double pyramids, rhomboids, were drawn at Cambridge, *Trinity College*, O.2.40, f. 57v, and Norrköping, *Stadsbibiotek*, 426 fol. (*See* figure 4.8 in this book).
Ynez Violé O'Neill suggested that the geometric forms in brain diagrams have to do with the technique of dissections. See: Violé O'Neill, "Diagrams of the medieval brain. A study in cerebral localization," 91–105. See also: Violé O'Neill, "William of Conches' descriptions of the brain," 203–223.

644 Mahoney, "Sense, intellect, and imagination in Albert, Thomas and Siger," 604, 607.

THE TRIPARTITE SOUL

The above-mentioned drawing in the Norrköping-copy of the textbook *Parvulus philosophie naturalis* by Peter of Dresden shows, besides the cognitive process, also an overview of all souls in one picture. [*See* figure 4.8]. [See also Appendix B.2, page 251].

The drawing shows the three powers of man's soul: the vegetative, sensative and rational souls. Regarding the vegetative soul the draughtsman has concentrated on the natural virtues of growth, nutrition and reproduction when dealing with the liver, spleen, stomach and bladder. The heart is considered in this image to be cooled down by the air in the lungs – the same air is also responsible for the voice. The sensitive soul is elaborately described through its external and internal senses, including the so-called concupiscent and irascible appetites. The rational soul, finally, is dealt with in the three circles shown above the drawing of the man: the agent intellect, the possible intellect and the *voluntas*.

Lambertus' drawing, described above, shows a comparable overview of the sensitive, vegetative and rational soul. [*See* figure 4.9]. The common sense makes judgements and discernments about the objects perceived by all five external senses. To illustrate this connection several lines in red ink are drawn from the common sense to the five external senses. The imagination, also called the fantasy, serves here as the storehouse of the forms (phantasms) of perceived objects, even when these objects are no longer present to the external senses. Human beings can thereby form new combinations of stored phantasms, which allow one to create images of the non-existent. The role of the estimative or cogitative virtue is to enable animals to perceive intentions that are not directly known by the external senses and to judge those intentions. Thomas called this sense in man the 'cogitative power'. The final organ shown in the head concerns a memorative virtue. Lambertus thought of memory as storing the intentions it receives from the *estimativa*.[645] Memory, imagination and cogitation are therefore held here to prepare phantasms for the intellect.

The vegetative soul is shown divided into the vital virtues, held to allow for the passions (and located in the heart) and the natural virtues, for growth and nutrition (and residing in the liver). The functions of the vegetative soul are located in this image in several organs. The lungs, for example, have two functions. They cause the voice and they cool off the heart. The stomach, meanwhile, cooks food and drinks, from which process vapours ascend to the head. The stomach is also the place where a first digestion takes place. Regarding the spleen, a remark is added asserting that physicians often examine it. A second digestion, according to the diagram, takes place in the liver, held to be

[645] Lambertus de Monte, *Expositio saluberrima magistri Lamberti de Monte circa tres libros de anima*, III. f. lii: *«[…] sed actus memorative est conservare intentiones quos elicit estimativa»* (Heinrich Quentell 1498 (Hain 11585)).

the residence of the natural virtue responsible for nutrition and growth (and also for decay). Many veins are seen departing from the liver and heading to the many members in order to feed them. The heart has a vital virtue, permitting movement because of its production of vital spirits. The heart is also shown here as responsible for a third digestion. The text mentions four phases of digestion altogether.[646] The rational soul in this diagram is described above.

A COMPETING DRAWING

Though the Galenic solution to the question of the residence of the rational soul in the brain was shown in illustrations much more by medieval scholars, the Aristotelian position was still in use by the end of the fifteenth century. An unmistakably Aristotle-inspired figure, illustrating a text called *Philosophia naturalis* by a certain Henry Plattenberger, was copied into a mid-fifteenth century manuscript, now kept in Prague's *Universitní Knihovna*.[647]

The figure is shown on a full page from his head down to the knees, the head turned to the right and his right hand held up. [*See* figure 4.10]. See also Appendix B.4, page 255, for a transcription of the labels. In the centre of the body a large heart is depicted, inscribed with the operations of the soul. At its base is written: *Cor seu sensus communis*, indicating that the common sense resides in the heart. Further enumerated in the heart in two rows are the operations of the soul and logical operations. Among the first category are listed *cogitatio, intellectio, sensatio, ymaginatio, estimatio, memoratio, fantasia* and, again, the *sensus communis*. On the right side within the heart are the logical operations, among which are: *intuitio, abstractio, compositio, divisio, acceptatio*, and *refutatio*. All these processes are thereby held to occur in the heart.

The brain, consequently, is rather empty, as nothing of any significance happens there. In the centre of the brain we read simply *cerebrum*. The top of the head is labelled the *congregatio specierum* and is therefore probably held to be the place where sense impressions (of species) are perceived by the external senses and then transported to the common sense. The back of the head bears the inscription *organum reservativum*, to indicate that this part is involved in the retention of images. This does not mean, however, that remembering takes place there, since that mental process is located, in this diagram, in the heart.

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[646] Lambertus de Monte, *Expositio saluberrima magistri Lamberti de Monte circa tres libros de anima.* III f. xxx r: «*primo quod retineat cibum in loco digestionis; secundo quod digerat cibum; tertio quod cibum digestus trahatur ad partes aliti; quarto requiratur expulsion superfluorum*». Heinrich Quentell 1498 (Hain 11585). I used the copy in Paris, *Bibliothèque nationale*, Res. 516.

[647] Prague, *Universitní Knihovna*, IV.F.18, f. 143v. On ff. 133–169 the *Questiones de philosophia naturali*, Incipit: *Pro fundamento philosophie naturalis*. This figure is first reproduced in Murdoch, *Album of science: Antiquity and the Middle Ages*, 326, fig. 271. Other copies of this text are passed down, see: Lohr, "Medieval Latin Aristotle commentaries," here 227. Unfortunately, I did not have the chance to examine these copies for figures.

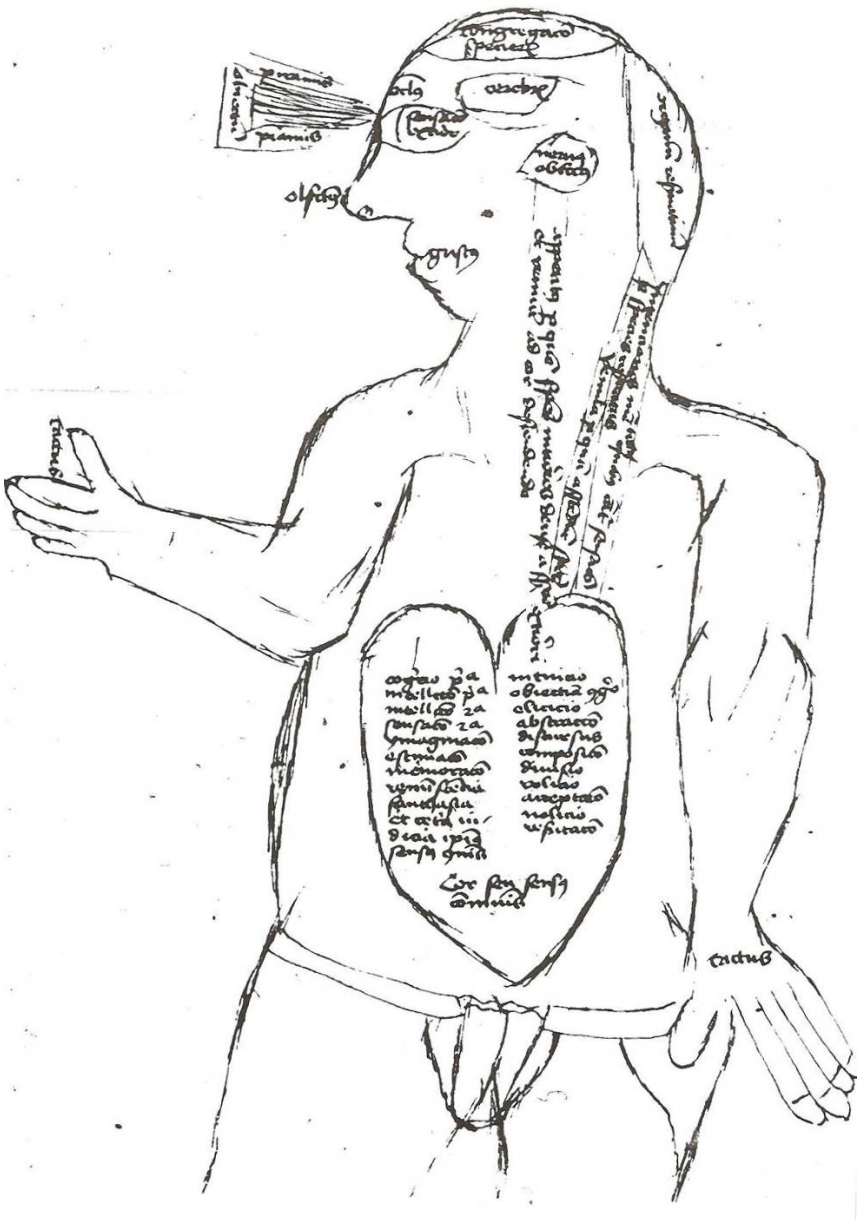


Figure 4.10 Henry Plattenberger, *Philosophia naturalis*. Prague, *Universitní Knihovna*, IV.F.18, f. 143v. End of the 15th century.

The optic nerve (*nervus obticus*) is located here in the centre of the head. A channel runs down from this optical nerve to the heart, transporting information derived from the exterior senses. A second channel, at the back of the body, is shown providing the means by which the vital spirit ascends to the head. Further, four of the five external senses are inscribed in this illustration. The pyramid in front of the eye is drawn to demonstrate how the sight of an object enters the external sense of the eye, from where the impression is then transported, via a vein, to the heart. Avicenna wrote of these rays that they are structured as a pyramidal radiation out from the pupil, with the pointed top pointing into the eye and the broad bottom directed outward to the thing observed.[648]

To recap, the earliest cross section of the head in profile appeared circa 1310 in learned compilations of natural philosophical and medical texts, in which masters dealt with the internal and external senses. The foundational version –a man in profile turned slightly to the right, with a cutaway skull unveiling his internal senses in the interior cells– was supplemented with the external senses almost from the beginning. The earliest cutaway skulls are to be found in medical-philosophical compilations that circulated in *studia* at Würzburg, and in vulgarized compilations dealing with medicine, philosophy, history and anatomy. This allows us tentatively to suggest town schools and *studia* as the environment of origin for such skulls.

The cross section was a wonderful invention, as it permitted the beholder to peek inside the head while still recognizing the human being by its external features. It was especially helpful for visualizing the relationship between the external senses on the surface of the face and the senses inside the skull. The harmonious relation with the cosmos seen in the quadrupled circles was thus totally discarded in favour of a better picture of the physiology of man.

Sometime around 1400 the cutaway head migrated from anatomical and medical anthologies to philosophical treatises. The shift from the medical to the philosophical domain entailed a shift from an anatomical question about localization to the question of human cognition and its uncertain physical seat. The philosophers presented a variety of solutions to this uncertainty. During the fervent discussion of the physical basis of human cognition, the diagram was elaborated with a torso to incorporate the vegetative soul and demonstrate its physicality. Abstract, separated circles hovering above the head represented processes of abstraction performed by human cognition. These shifts of interest also entailed the enlargement of the picture.

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[648] Avicenna, *De anima*, III.5: *«[…] radii lineares exeunt de pupilla ad modum pyramidis, cuius caput est versus oculum et eius basis ad partem rei vise»* (S. van Riet, ed., *Avicenna latinus. Liber de anima seu sextus de naturalibus. Édition critique de la traduction latine médiévale* (Louvain–Leiden, 1968), 213 (35)).

Yperman and Mondeville were mostly interested in the composition of the skull and not so much in the functions of the rational soul dwelling in it. They depicted the skull with its bones, membranes and cells. Later learned physicians dealt with the powers of the rational soul as a part of pathology or in their own right, and depicted a cross-section of the head. The philosophical cross-cuts incorporated not only the head but the entire torso with its organs, to indicate that the soul was related to the entire body and its organic functions. This fits into the debate about the physical seat of the soul in the heart or in the skull. Even if they advocated for the seat of the rational soul in the head, they incorporated the body so as to indicate the existence of the discussion. The diagrams in the surgical tradition, by contrast, depict only the head. In the following section, we will consider the place of the 'natural philosophical' cutaway head more concretely in teaching.

4.4 The cross section: transmission and dissemination

The intellectual context and conventions, in which the cross section of the head was conceived and received, thereby established, we will be able to turn to its subsequent reception, using the late medieval example of the *Parvulus philosophie naturalis* and some of its adaptations. Textbooks as this one, from relatively minor masters, were produced and used on a large scale in the fifteenth century. Their work is still little explored in the scholarly literature, yet attending classes given by modest teachers was the educational reality for most students.

A case study of the role played by several versions of the cross-sectioned head in late-medieval education, will also demonstrate these images' interaction with scientific analysis and the effect of their dissemination. The content and form of a particular piece of scientific writing and illustration of course related directly to the criteria that governed the research and its eventual place in education. These specifics together provided the conditions in which knowledge was acquired and informed how students were to process information. The specific lay-out guided readers through the text and shaped their responses. Naturally, readers were also active recipients; they constituted meaning while processing the book.[649]

Showing and copying pictures in class was a facet of didactic practice at the *Pedagogium Castrense* of Louvain University, where Vesalius studied in the early sixteenth century. Mary Carruthers however, supposes that medieval students studied indeed from books, but did not take notes. Instead, they mentally marked and memorized the important passages, with the teacher's comments

[649] Jardine, "Books, texts and the making of knowledge," 393–407.

'attached' to this textual image.[650] Charles Burnett, by contrast, is of the opinion that students did take notes during lectures, because there was simply too much to memorize.[651]

4.4.1 THE PARVULUS PHILOSOPHIE NATURALIS

The *Parvulus philosophie naturalis*, written by Peter of Dresden in Prague, was one such natural philosophical textbook. Peter of Dresden studied at Prague, where he achieved his baccalaureate and his master's degree, and was then a master at Prague University, which flourished from the 1360s. At another point in his career he was also the rector of the town school in Dresden.[652] Peter left Prague after the decree of Kutná Hora in 1409. He decided to go to Dresden, where he taught theology and canon law. Later, around 1411 or 1412 he got expelled from Dresden for alleged heresy and returned to Prague, where he founded an (elementary) school, got associated with the Hussite movement and was again accused of heresy. Peter of Dresden was burnt to death in 1421 or 1425, several years after the outbreak of the Hussite revolution in 1419.[653]

His main work, the *Parvulus philosophie naturalis* dealt with a medley of Aristotelian texts: the *Physica*, *De generatione et corruptione* and *De anima*, and included topics on the four Aristotelian causes, material, movement, rest, infinity, place, time, the elements, generation, alteration, mixture, the powers of the soul and the intellect.[654]

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650 Carruthers, *The book of memory. A study of memory in medieval culture*, 159–160.

651 Burnett, "Give him the white cow: Notes and note-taking in the universities in the twelfth and thirteenth centuries."

652 Formerly, the *Parvulus philosophie naturalis* had been ascribed to Albert of Saxony. The *Parvulus philosophia naturalis* was often accompanied with commentaries, and frequently combined with a text called the *Philosophia pauperum*. The *Parvulus* of Peter of Dresden was in fact an excerpt from this *Philosophia pauperum*, which in its turn excerpted from several natural philosophical texts by Albert the Great (*Summule Alberti*). Both texts, the *Parvulus* and the *Philosophia pauperum* were therefore logically often combined in the same manuscript. The *Philosophia pauperum* was indeed also written by an Albert, though not the Great, but one from Orlamünde (Thüringen, as it is nowadays called). This Albert was also a Dominican, around 1230, and rector of an order studium. The *Philosophia pauperum* (also called *Summa naturalium*), was a short manual on natural philosophy and psychology that was often used in town schools. See: P. Hossmann, "Albert von Orlamünde," in *Lexikon für Theologie und Kirche*, ed. M. Buchberger, J. Höfer, and K. Rahner, vol. 1, 14 vols. (Freiburg im Breisgau, 1957–1968), 280; F.W. Bautz, "Albert von Orlamünde," in *Biographisch-Bibliographisches Kirchenlexikon*, vol. 1 (1990), 83. See, for the question of authorship: Grabmann, *Die Philosophia pauperum und ihr Verfasser Albertus von Orlamünde*, 29–33; B. Geyer, *Die Albert dem Grossen zugeschriebene Summa naturalium (Philosophia pauperum)* (Münster, 1938), 1-1*. See, for the relation between both texts: Grabmann, *Die Philosophia pauperum und ihr Verfasser Albertus von Orlamünde*, 33–34.

653 Lohr, "Medieval Latin Aristotle commentaries," here 352.

654 Grabmann, *Die Philosophia pauperum und ihr Verfasser Albertus von Orlamünde*, 29–30.

Regarding the tripartite soul, Peter of Dresden provided the following overview: the powers of the soul were divided between vegetative, sensitive and rational parts. The vegetative (or vegetable) power allowed for growth, reproduction and nutrition and was described as concerned with the maintenance and development of organic life. The sensitive power was described as allowing for motion and sense perception. The sensible soul was summarized as differing from its vegetative counterpart through its capacity for apprehension. Indeed apprehension *de foris* - knowing external, material things in the present - was held to occur via five external senses: taste, touch, sight, audition and smell. Apprehension *deintus*, by contrast, was described as occurring via five internal powers: common sense, imagination, fantasy, estimation and memory. And finally Peter summarized a rational power possessed exclusively by man, which allowed for consciousness and intellect. This rational power was subdivided into an 'appetitive power' and a 'motive power' (which caused a given process). The motive power was held to actualize, or put into effect, the appetitive power.[655]

4.4.2 Normalization and diffusion

Peter, like many Germans, left Prague after the decree of Kutná Hora in 1409 (the Kuttenberg decree in German), which gave a majority of votes to the Czechs, thus dominating the majority of foreigners among the university's nations.[656] We know that about 800 masters and students, for example, left for Leipzig, while others went to Heidelberg, Cologne and Erfurt.[657]

Students and masters leaving Prague carried their books, including the *Parvulus philosophie naturalis*, with them and thereby introduced these works into other universities.[658] The strong written tradition of the *Parvulus* shows

[655] Peter of Dresden, *Parvulus philosophie naturalis*: «*Potentie anime dividuntur in vegetativam, sensitivam, appetitivam et in motivam secundum locum, scilicet motu progressionis, et intellectivam. Vel sic dividitur in vegetabilem, sensibilem et rationalem, comprehendo sub sensibili appetitivam et secundum locum motivam. Differunt tamen appetitiva et secundum locum motiva a sensibili quia sensitiva inquantum est de ratione nominis dicit potentiam apprehensivam, sed potentia activa et secundum locum motiva sunt potentie active motive que potentie cum sint in eodem, ut in homine non dicuntur tres anime, sed bene prout sunt in diversis, ut in planta, bruto et homine*» (ed. Vienna 1510 by Hieronymus Vietor).

[656] See for more details: Šmahel, F., "The Kuttenberger decree and the withdrawel of the German students from Prague in 1409," in *History of universities*, vol. 4 (1984), 153–166.

[657] See, on the process and size of the emigration from Prague to other towns: F. Seibt, "Von Prag bis Rostock - zur Gründung der Universitäten im Mitteleuropa," in *Festschrift für Walter Schlesinger*, ed. H. Beuman (Cologne–Vienna, 1973), 406–426, here 412–415.

[658] Spunar, "La Faculté des arts dans les universités de l'Europe centrale," here 468–469. See also: P. Moraw, "Die Universität Prag im Mittelalter. Grundzüge ihrer Geschichte im europäischen Zusammenhang," in *Die Universität Prag (Schriften der Sudetendeutschen Akademie der Wis-*

that there was a great preference for this book in Central European universities. It was used not only in Prague, but was disseminated over an area from Cologne to Uppsala, its spread aided by the decree of Kutná Hora that caused masters and students to leave Prague, though it probably remained unknown in Paris.[659]

The Prague model was because of the exodus quickly imitated in other central European towns: Cracow, Vienna, Pécs, Heidelberg, Chełm, Cologne, Erfurt, Buda, Würzburg, Leipzig and Rostock, where the universities could only really compete with Prague after the latter lost its cosmopolitan prestige.

Of the 800 masters and students who left Prague, a few of them took a copy of the *Parvulus philosophie naturalis* with them, which was subsequently taught on, copied, commentated and reworked in later and other works. A cluster of copies relate the medieval universities of Uppsala, Leipzig and Cologne. The relation between Cologne and Uppsala in particular has been suggested earlier.[660]

The University of Uppsala

The number of preserved *Parvulus* copies (Mss C133, C321, C622, C629) extant at the University of Uppsala indicates that the *Parvulus* was used there by the end of the fifteenth century. Two of these copies contain a commentary (C622 and C629), and the latter also includes a figure (C629).[661]

The *Parvulus* copy of MS C629, found in Uppsala's *Universitetbibliotek*, shows a drawing on the last page of the text (fol. 89v) of the *Parvulus philosophie naturalis*, which is the last site of a quire.[662] The drawing represents a man drawn from his waistline up, looking to the right, holding his right arm up in the air, and holding a stick in his left hand. Above and below the figure, and on his body, short text passages and labels are written, though the inscriptions are difficult to read because of the light ink and rough paper.

The drawn head is a cross section, showing the internal senses in rather shapeless forms. Above his right eye is the label *sensus communis*, written inside

senschaften und Künste, vol. 7 (Munich, 1986), 9–134; Odložolík, *L'université Charles IV. 1348-1948*; Chaloupecký, *L'université Charles à Prague. Sa fondation, son évolution et son charactère au XIVe siècle*; Seibt, "Von Prag bis Rostock - zur Gründung der Universitäten im Mitteleuropa."

[659] Weijers, *Le travail intellectuel à la Faculté des arts de Paris: textes et maîtres (ca. 1200-1500)*, here vol. 7, 21.

[660] Hoenen suggested a relation between the *Promptuarium* anonymously written in Cologne by the end of the fifteenth century and a possible dispute at the University of Uppsala. See Hoenen, "Late medieval schools of thought in the mirror of university textbooks. The Promptuarium argumentorum (Cologne 1492)," 354–355.

[661] Incipit commentary of Uppsala, *Universitetsbibliotek*, C629, f. 24r: «*Natura est principium et causa. Circa initium parvuli philosophie naturalis primo est notandum quid sit philosophia*». Piltz, *Studium Upsalense. Specimens of the oldest lecture notes taken in the mediaeval university of Uppsala*, 128. See also: Lohr, "Medieval Latin Aristotle commentaries," 352–354.

[662] Uppsala, *Universitetbibliotek*, C629, ff. 24r-89r.



Figure 4.11 Peter of Dresden, *Parvulus philsophie naturalis*. Uppsala, *Universitetbibliotek*, C629, f. 89v. Dated *post* 1482.

a tight circle. Above the common sense the *imaginativa virtus* is shown residing, and somewhat below is written *spiritus sensibiles*. The posterior part of his head is indicated with a line, and divided into three compartments, representing the ventricles. The upper compartment reads *estimativa* (the rest is illegible). The middle compartment reads '*memoria retinat eas*'. The lower compartment is left empty – this was probably a mistake, since memory was always considered the last power. The fantasy, or formative power, is also lacking in this survey. [*See* figure 4.11]. [See also Appendix B.5, page 255, for the labels of this drawing].

The drawing defends the physicians' position on the seat of the intellect. Next to the posterior part of the drawn head, like a title to the drawing, we read that the natural philosophers claim that the common sense is situated in the heart, but that Avicenna and 'Egi' (Giles of Rome?) maintain that it is situated in the brain, in the front part of the first cell.[663] The drawing shows the common sense drawn inside the skull, thus following Avicenna and Giles(?), and ignoring the opinion of Aristotle.

The localization of the ventricles in this cutaway head is, however, odd. The division that places the common sense and the imagination in the forehead, estimation and memory in fixed cells in the back, and something called the *species sensibiles* in the middle, might be interpreted to indicate the transformation of a perception of a particular natural object into an abstract concept (universal *species*) thereof, to then be stored by the memory. Estimation and memory are active functions here, in contrast to the common sense, which just passively receives impressions. The draughtsman distinguished between memory and reminiscence, and also between brutes and men. *Reminiscentia* is usually considered to be a recollection, related to the ratio and therefore only present in human beings. *Memoria*, on the other hand, is a power whose function was held to be separated from the *ratio*, and therefore also present in beings without a *ratio*. The first, in other words, was held to be present only in men, the second also in brutes.[664]

Peter of Dresden did not deal with the question of the location of the soul in his *Parvulus* and the drawing was added on the basis of a later commentary. Its position at the end of a quire seems to suggest that it was not original to the text. Nor is the text above the drawing part of the *Parvulus philosophie naturalis*, since it deals with the human will and distinguishes between *voluntas*, *velleitas* and *voluptas*. Though the *voluntas* is a topic related to the process of intellectual cognition, as we will see below, it was not part of the *Parvulus*. In all likelihood a commentator discussed the topic as an addition to the *Parvulus* and then a

[663] This 'Egi' (Egidius) is probably Giles of Rome, who was affiliated to the University of Paris and who basically agreed with Thomas' position of the classification of the intellect.
[664] H. Anzulewicz, "Memoria und reminiscentia bei Albertus Magnus," in *La mémoire du temps au Moyen Âge*, ed. A. Paravicini Bagliani (Florence, 2005), 163–200, here 187.

student summarized the discourse on the last page, next to the drawing.

In a surviving series of lecture notes on a cycle of lectures of Andreas Brusen at the University of Uppsala in 1486, student Olov Thorstensson illustrated a debate about the internal senses.[665] Brusen, a Swedish master, had studied in Rostock, and was assigned to comment on the *Analytica priora* in the first term of 1481 at the young University of Uppsala.[666] The notes are too elaborate and neat to be the result of dictation by the master, and so his student Olov must have worked them out later, possibly with the help of circulating dictation texts.

Hewing closely to the lecture notes on the *Analytica priora*, Olov wrote a short *questio* on the first book of the *Physica* and it is between these two texts that a figure is inserted, representing a discussion about the internal senses between Aristotle and Albert the Great. The quire in which the figure is inserted consists of the last eight pages of the *Analytica priora*, then the figure, followed by the *questio*, then two blank pages and a last one that is cut out. Thus, we can conclude that the position of the figure, sandwiched between these two texts, is original. [*See* figure 4.15]. A description of the drawing will follow below.

Why was the drawing inserted in this position in the manuscript? Anders Piltz has aptly remarked that the drawing has no relation with the *Analytica priora*, and that consequently it could not have been master Andreas Brusen who showed Olov the picture he consequently drew. In view of this, Piltz suggests that it could have been John of Mechlin who taught Olov the topic, because this master taught on the *De anima* around 1484 in Uppsala, and a commentary in his handwriting is extant there (ms. C601), including a diagram on the same subject.[667] [*See* figure 4.12].

Indeed it seems probable that the figure was intended as a means of understanding a compilation of *questiones* on Aristotle's *Physica*, which was often combined with *questiones* on *De anima*. The text begins with the question «the problem is whether one can obtain *'sciencia'* about natural objects» – «*utrum de rebus naturalibus possit haberi sciencia*». The question is first answered negatively, on the grounds that natural things are mutable and real knowledge can only be obtained from immutable things. The response to the question then argues that there are four grades of science and that man is born with the inherent properties of five senses, which he uses to judge the things around him. The argumentation then tails off, incomplete. [See Appendix B.11, page 261, for a transcription of the *questio*].

Olov Torstensson drew the picture preceding the text and copied the first

665 Uppsala, *Universitetbibliotek*, C599, f. 143r. First published by A. Piltz, "Den äldsta Uppsalapsykologien," *Lychnos. Lärdomshistoriska Samfundets årsbok* 28 (1975): 274–278, here 275.
666 Piltz, *Studium Upsalense. Specimens of the oldest lecture notes taken in the mediaeval university of Uppsala*, 79.
667 Piltz, "Den äldsta Uppsalapsykologien," 276 n. 6.



Figure 4.12 John of Mechlin, *Commentarius in libros De anima*. Dated *post* 1484.

question but never completed the series of *questiones*. The insertion of a drawing about the senses, preceding a question about the possibility of obtaining true knowledge about natural objects, seems more or less appropriate, considering the philosophical weight placed on the senses as means to obtain truths about natural objects.

The possible commentator in the case of the C629-copy is master John of Mechlin, who taught on the *De anima* around 1484 in Uppsala. John of Mechlin also wrote a commentary on *De anima*, held today in Uppsala (Ms C601), and it includes a figure about the powers of the soul.[668] Olov Johansson of Gotland, who studied from 1477 to 1486 at Uppsala, wrote out this commentary copy of John's work. The same commentary is also found in Munich, *Bayerische Staatsbibliothek*, clm 5947.[669] Olov Johansson also wrote out the majority of another manuscript (Ms C599), recording the lectures of master Andreas Brusen on the *Analytica priora*. In this manuscript, he or his comrade Olov Thorstenson drew a third figure, dealing with the powers of the soul.

It is reasonable to think that all three illustrated manuscripts were based on the same cycle of lectures by John of Mechlin, since all three were written out in about the same year. One (Ms C629) of them is drawn in a copy of the *Parvulus philosophie naturalis* (of which in total five copies are extent [*See* figure 4.11], another (Ms C601) is drawn in a commentary on the *De anima* by John of Mechlin [*See* figure 4.12], and a third (Ms C599) is drawn in a *questio* about the *Physica* [*See* figure 4.15]. In total, there are three comparable diagrammatic representations of the soul and five copies of the *Parvulus philsophie naturalis*. The other two drawings associated with Uppsala will be described below.

The University of Leipzig

In yet another manuscript copy, the drawing of the powers of the soul is again not an integral part of the *Parvulus*-text.[670] This copy is almost entirely written in the hand of Johann Lindner (1440–1524), later known as a historiographer, who studied in Leipzig, where he took his master's degree about 1474. Lindner wrote down his copy of the *Parvulus philosophie naturalis* in 1473 in Leipzig, while preparing his master's exams.[671] The manuscript is a study volume of sev-

[668] Piltz, "Den äldsta Uppsalapsykologien," 276 n. 6. With many thanks to Lars van Wezel who helped me out in reading this Swedish article.
[669] Piltz, *Studium Upsalense. Specimens of the oldest lecture notes taken in the mediaeval university of Uppsala*, 128.
[670] London, *Wellcome Historical Medical library*, ms. 55, ff. 93r-99v (incomplete), dated 1473. Figure on f. 93r. First published by Clarke and Dewhurst, *An illustrated history of brain function. Imaging the brain from antiquity to the present*, 31 fig. 42.
[671] S.A.J. Moorat, *Catalogue of western manuscripts on medicine and science, vol. 1. Manuscripts written before 1650 AD* (London, 1962), 40–41. In this catalogue, the *Parvulus* text has been

eral learned texts, including the *Isagoge*, *Dialectica*, *Parvulus philsophia naturalis* and *De anima*.

A drawing that fills half a page precedes the *Parvulus* text. The other half of the folio is used here as scratch paper, covered with several small schemes concerning the nature and principal causes of movements: the elements, the eras, qualities, winds, seasons and 'latitudes of being'. The many versions of the incipit of the text *Natura est principium* also seen here suggest that Johann used this space to practise his handwriting. [*See* figure 4.13].

The drawing of the cutaway head makes explicit that it is for use as a tool to help the memory. It is stated that the head, which hews to the text, should be memorized immediately: «*Item illud capud dicit statim sequi illum textum memorativa ponatur est et cetera*». The five letters SIFEM seen in the man's head are a contraction of the first letters of each power: *Sensus communis, Ymaginatio, Fantasia, Estimativa,* and *Memoria*. The word SIFEM is therefore a mnemonic to help the student remember the order of the powers.

But much more had to be remembered in addition. The drawing represents a man down to his chest, looking to the right, with his tongue sticking out of his mouth. In the cutaway head we see the internal and external senses and also, in the upper part of his chest, some organs. Next to the tongue it is recalled that one has five external and five internal senses. Inside the skull, meanwhile, five small circles are drawn: the cells. The first cell assembles all the lines from the five external senses and transfers them further into the head.

Lindner explained the functions of these five cells in inscriptions surrounding the head. They read clockwise, and the first few are therefore written upside down. The positioning of the texts around the head reminds us of the image of the *'Krankheitsmann'*, in which the names of diseases but also the external senses were grouped around the head. See 4.3.1 *Pathological labelling*, page 180.

The lines of text are clearly written in black and in red, with black ink giving the base text, as if it were a *littera*, and the red ink providing commentary on these original lines. The opinions of Thomas, contrary to those of the great Avicenna, are thus clearly distinguishable and ready for memorization. The text passages are connected to the corresponding cell by means of brackets ending in a knot.

The first cell in the forehead, between the eyes, is the *sensus communis*, which is considered here to be humid in nature and does not perceive objects that are not really there. In red ink we read that Thomas thought the common sense was situated in the heart because it was the sense of touch that communicated intentions. Avicenna, however, as is noted in the commentary, placed the common sense in the brain, in the first cell, because particulars were perceived and processed here.

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wrongly ascribed to Albert the Great.

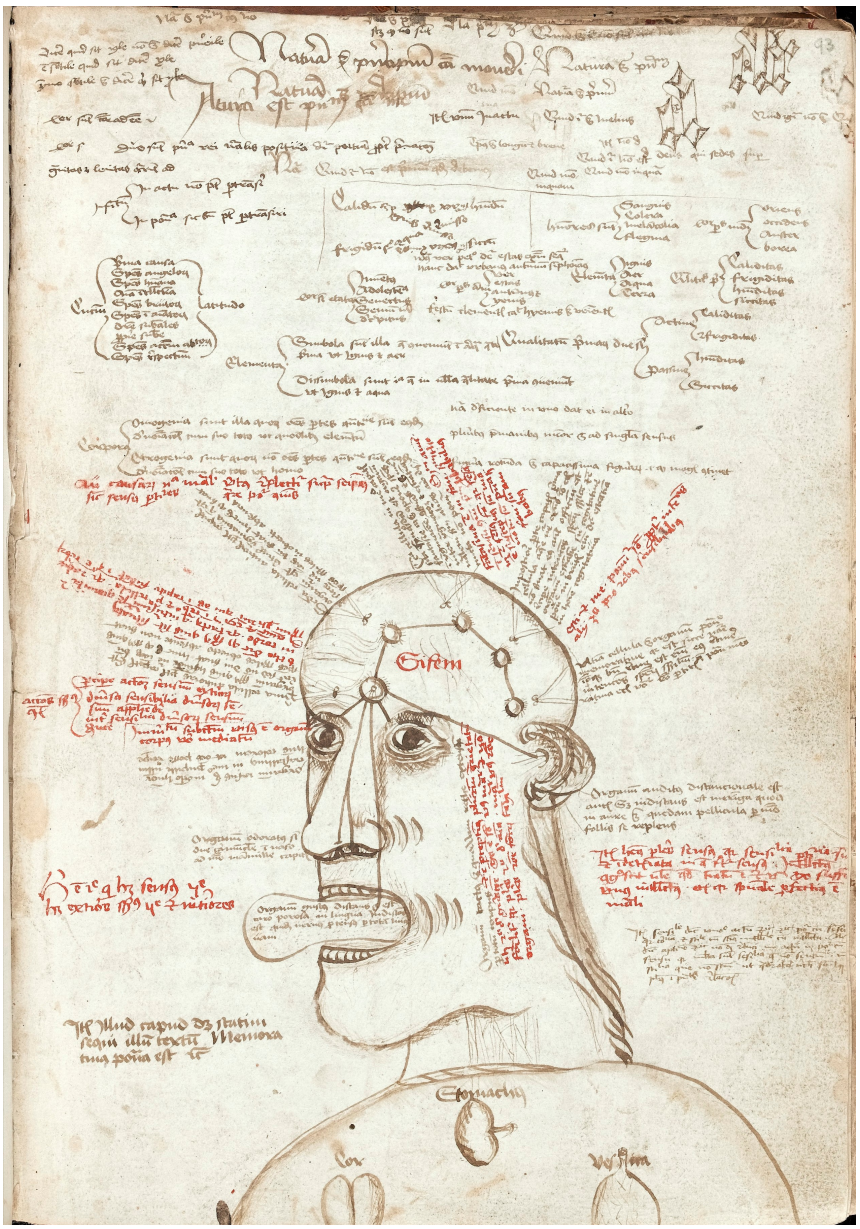


Figure 4.13 Peter of Dresden, *Parvulus philosophie naturalis*. London, *Wellcome Historical Medical library*, ms. 55, f. 93r. Dated 1473.

The second cell in this illustration contains the imagination, which is dry in nature, so that it can sense particulars even when the objects of sensation are no longer present.

The third cell, in the middle of the head, is the organ of fantasy, which was held to constitute species of the various particulars by means of imagination. It is situated here between imagination and estimation, in accordance with some opinions, but according to others, as is stated in red ink, it cannot be distinguished that clearly from its neighbours. Thomas had placed the fantasy within the common sense, but Avicenna had attributed to it a place of its own and the commentator here decides that Avicenna's view is the more probable, because fantasy operates without the use of sense material or principles.

The cell in the back of the head, on the other hand, is held to be watery in nature, its function being to retain intentions. It is called the *estimativa* or the cogitative power. In brutes, we learn, one calls this power *estimativa* and in men one calls it *cogitativa*.

The last cell shown in this illustration is devoted to memory, which is dry in nature to aid retention. Memory stores intentions associated with sensible particulars (*species*) and the author called these intentions the *ratio particularis*. The common sense is represented as a knot, assembling the data (shown as lines) arriving from the different external senses. Each external sense is also described.[672] [See Appendix B.7, page 257].

An identical drawing to this last one was made by a student from Külsheim named Fabian Wachter, while he was studying at Leipzig University around 1488. Fabian matriculated into the university in 1483, got his *baccalaureatus* in 1486 and his *magister* in 1489.[673]

The drawing in his case is inserted into a copy of the *Parvulus* dated 1480 and now preserved in the *Stadsbibliotek* in Norrköping, Sweden.[674] In this volume

[672] About hearing, for example, it is said that the distant organ is the ear, but that it is the *meringa* in the ear whose thin skin fills itself with a follicle. The organ of sight is situated in the eye, which owns the humour *cristallinus*. The middle of the pupil has no colour, so that it can receive everything. The smelling organ consists of two small pieces of flesh, which are like the nipples of the head. The distant organ of taste is a porous flesh on the tongue, while the nearby organ is held to be a nerve that senses throughout the whole tongue. Touch, finally, extents all over the body.

[673] Piltz, *Studium Upsalense. Specimens of the oldest lecture notes taken in the mediaeval university of Uppsala*, 19. See: G. Erler, *Die Matrikel der Universität Leipzig*, 3 vols. (Leipzig, 1895–1909), here vol. 3, 905.

[674] The figure has been reproduced by: Piltz, "Den äldsta Uppsalapsykologien," 277; A. Piltz, *The world of medieval learning*, (Originally published as Medeltidens lärda värld. 1978) (Oxford, 1981), 207, fig. 33; O. Pluta, "On the matter of the mind. Late-medieval views on mind, body, and imagination," in *Imagination in the later middle ages and early modern times*, ed. L. Nauta and D. Pätzold, Groningen Studies in Cultural Change, 12 (Leuven–Paris–Dudley, 2004), 21–34, here 34.

we find two copies of the *Parvulus* inserted, one integral copy and one composed of two fragments, which latter pair probably belong together since one of the fragments contains the *incipit* and the other contains the *explicit*. More study is needed to decide whether the two copies are of two different commentaries. The latter fragment ends with two drawings, on fol. 63r and 63v.[675] The Norrköping manuscript is somewhat younger than the *Wellcome Institute* copy by Johann Lindner, dated to 1473.

Fabian Wachter's study volume contained all his required texts, including an anthology of philosophical texts mainly about the *Parva naturalia* of Aristotle, but also some texts by Thomas Aquinas, *questiones*-collections and tracts by Gerard de Monte, Peter of Dresden, and John Tinctor.

It also includes the regulations for baccalaureate and master exams, set under the rectorship of master Johannes Parverburger, who has been identified as a master of the University of Leipzig.[676] Following Piltz, who alone has written about this manuscript, we can say that these regulations are a copy of an original *cedule actuum*.[677] A *cedule actuum* is a written note whereby a student declared that he had fulfilled the demands by attending compulsory lectures and exercises, in order then to be granted admission to examinations.[678] With three months of required lectures on *De anima* the student would have been well introduced to the matters of the soul. The lecture notes in the manuscript broadly correspond with the compulsory lectures required for subsequent admission to the examination.

Wachter's drawing is almost exactly the same as Lindner's one and a detailed description is therefore unnecessary.[679] [*See* figure 4.14], Appendix B.8, page 258. Compare this figure with [*See* figure 4.13] and AppendixB.7, page 257.

Wachter, just like his fellow student Johann Lindner, draughtsman of the diagram previously discussed, mentioned the abbreviation SIFEM in the middle of his head illustration, thus capturing the first letter of the names of the internal senses. With the mnemonic SIFEM Fabian would have been able to recall with

675 My provisional foliation, since the manuscript has not been foliated.

676 «*Lectiones pro gradum baccelaureum. Pro gradu magisterio lectos. Exercitia ad eminus gradus. In titulatus sub rectoratum venerablis viri magistri Johannis Parverburger*». Piltz, *Studium Upsalense. Specimens of the oldest lecture notes taken in the mediaeval university of Uppsala*, 19.

677 ibid., 19.

678 For his baccalaureate exam (*lectiones pro gradyu baccalaureus*) the student heard lectures on the work of Peter of Spain (that is, probably, on the *Tractatus*), and also on the *De anima* – both for three months. To obtain the grade of master (*pro gradu magistro lectiones*) one read, among others, the *Perspectiva communis* (John Peckham) and the *Parva naturalia*, respectively for three and four months. Among the *exercitia ad eminus gradus* are summed up: <*libri*> *Physicorum, Nova loyca* (logica), *Parvulum naturalium*, and *De generatione, De celo, Ethicorum* and others. Norrköping, *Stadsbibliotek*, ms. 426 fol., (my foliation f. 38r).

679 The Norrköping figure is previously reproduced in: Piltz, *The world of medieval learning*, 207.

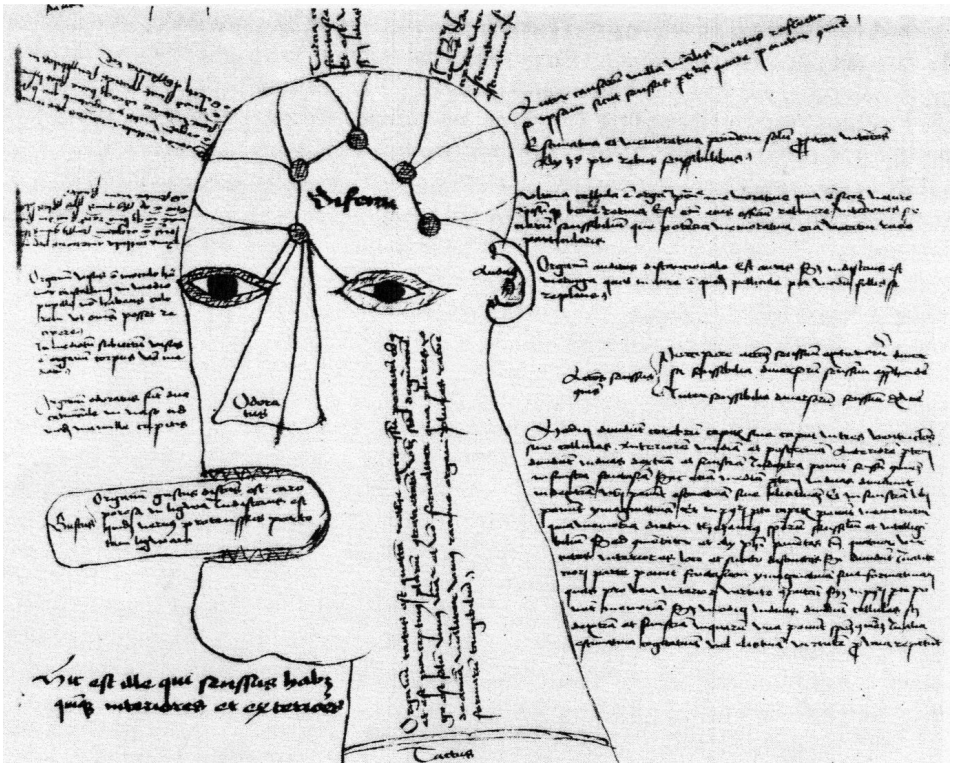


Figure 4.14 Peter of Dresden, *Parvulus philosophie naturalis*. Norrköping, *Stadsbibliothek*, 426, f. 62r. Dated 1480.

ease the names and order of the internal senses.[680]

A peculiarity, however, which is not visible in its 'twin' copy, is that Wachter states that physicians (*medici* in Latin) think that the head is divided into three ventricles or cells: an anterior one, a middle one and a posterior one. The anterior cell is in turn divided into a right-hand part, where the common sense resides, and a left-hand part, hosting fantasy. The middle cell, equally, is divided here into a right and a left-hand part containing, respectively, the estimation and the imagination. The posterior cell, by contrast, is not divided and is entirely given over to the memory. The memory is considered here as a thesaurus of sensible and intelligible objects, sensible objects being understood as objects in the real world perceived by the senses and intelligible objects as the objects of intellect. The memory is therefore called a storehouse of forms, fantasies of sensible things created when the latter are no longer sensible to the external senses, and also a storehouse for universals (the absolute forms of species, stripped of their individual bodily matter).

> «physicians (*medici*) divide the brains in the head or the head itself into three ventricles or cells: an anterior one, a middle one and a posterior one. They divide the anterior part in two, a right-hand part and a left-hand part. In the right-hand part they place the common sense, in the left-hand part fantasy. They divide also the middle cell in two, a right-hand part where they put the estimation or fantasy and a left-hand part where they put imagination. And in the posterior cell they place memory, for memory is considered the thesaurus of sensible and intelligible species».[681]

It is stated that Averroes and other unspecified philosophers had acknowledged only four internal senses. They thought fantasy and imagination were in the anterior part of the head and memory in the posterior part. This posterior part was divided into a left and a right-hand part to house different kinds of judgment, one applied to common species and the other to the distinctive virtues realized by estimative cogitation.[682]

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[680] Piltz, *The world of medieval learning*, 206.

[681] Norrköping, *Stadsbibliotek*, 426 fol. 62r: «*Medici dividunt cerebrum capitis sive caput in tres ventriculos sive cellulas: anteriorem, mediam et posteriorem. Anteriorem partem dividunt in duas, dextram et sinistram. In dextra ponunt sensum communis, in sinistra fantasiam. Sed etiam mediam partem in duas dividunt, in dextram ubi ponunt estimativam sive fantasiam, et in sinistram ubi ponunt ymaginativam. Et in posteriori parte capitis ponunt memoriam quia memoria dicitur thezaurus specierum sensibilium et intellegibilium […]*».

[682] Norrköping, *Stadsbibliotek*, 426 fol. 62r: «*[…], sed Commentator et alkii philosophi ponentes (MS: ponentas) tantum quattuor virtutes interiors loco et …. distinctas si<c> dividunt : in anteriori parte ponunt fantasiam ymaginativam sive formativam quas pro una interiori viortute computant, sed in posteriori parte ponunt memoriam. Sed medici in duas dividunt cellulas secundum dextram et sinistram, in quarum una ponunt speciem communem (MS: communam ?), in alia estimative<m>, cogitativam vel eectivam*».

The strong resemblance between the Norrköping's *Stadsbibliotek* copy and London's *Wellcome Institute* copy implies a direct relationship between these two manuscripts. They have both been copied by Leipzig-students to illustrate the *Parvulus philosophie naturalis* of Peter of Dresden. Johann Lindner probably took his copy with him to England. In fact, the Uppsala-copy (C.629) we encountered above also relate back to the University of Leipzig around the year 1480 for it includes a *cedule actuum* of Leipzig University.

We can safely conclude that, by the end of the fifteenth century, the *Parvulus philosophie naturalis* of Peter of Dresden was used in university education and was commented on in the University of Leipzig and also in the University of Uppsala, where the curriculum was based on Leipzig's. The drawing was not only copied within the text tradition of the *Parvulus*, but also influenced similar textbooks on the *De anima*.

The University of Cologne

This situation is not unique to Leipzig. In Cologne, similar drawings were sketched into 'competing' study volumes. For, two rival schools were based in Cologne: the *Bursa montana* of Lambertus de Monte (d. 1499), and the *Bursa laurentiana*, governed by Gerard of Harderwijck (d. 1503).[683]

The former wrote *Copulata super libros de anima Aristotelis*, who composed it as a lecture on *De anima*. The text circulated in student notes, was corrected and improved, and was eventually printed. Of this *Copulata* on *De anima* only two manuscripts are extant, and five printed editions.[684]

The Berlin manuscript copy, dating from the second half of the fifteenth century, was written hastily. It has been suggested that these were notes on a formal lecture given by Lambertus in Cologne, since its phrasing is free and variable in comparison to printed versions.[685] The student responsible for these notes was probably Johannes Parsow, who copied also the texts notes and added a drawing.[686]

The printed editions of Lambertus' text, on the other hand, were not illustrated with a woodcut. Instead, some purchasers decided to draw in a picture themselves. For instance, a drawing similar to Parsow's was added to a copy of the 1498 edition of the *Copulata* now preserved in the *Nardona in universitetna*

[683] Hoenen, "Late medieval schools of thought in the mirror of university textbooks. The Promptuarium argumentorum (Cologne 1492)," 333.
[684] Lohr, "Medieval Latin Aristotle commentaries," here 307–310.
[685] Rose, *Die Handschriften der Kurfürstlichen Bibliothek und der Kurfürstlichen Lande*, no. 983, 1249. Rose added, as proof for this hypothesis, the end of the text written by Parsow in order to compare it with the end of the printed version made in Cologne in 1494 (Hain 1713).
[686] It is now kept in Berlin, *Staatsbibliothek*, theol.lat.247: «*Ad conventum Brand pertinet totum quod contestor ego frater Johannes Parsow manu mea*».

Knjižnica (Llubljana, Slovenia).[687] In a Paris copy of the same edition, a copy of the woodcut from the *Margarita Philosophica* of Reisch is drawn in [*See* figure 4.1].[688] The poor quality in both copies suggests, again, that the purchaser himself took his pen and added the picture.

In Harderwijck's *Epitomata seu reparationes totius philosophie naturalis Aristotelis*, printed by Heinrich Quentell in Cologne, a comparable pen drawing is found about the powers of the soul. A description of this drawing will be given below in section 4.4.3.

4.4.3 Teaching polemics

Studying the opinions of others remained the methodological mainstream for centuries. Medieval scholars were convinced that knowledge of nature was given, once and for all, in the works of Greek thinkers. Their awe for authorities was however combined with the use of their own ratio.[689] We should understand medieval text criticism therefore not only as an attempt to recover this knowledge, but also as an attempt to improve the original text.[690]

Text analysis and disputes were founded on the same broad convictions. Students were trained to process texts and opinions in a certain way to think in terms of factions and controversies, notions that shaped the minds of young students from the first years of their training. They studied and reproduced the arguments belonging to particular traditions.

The dispute, moreover, was not only a means of analysis but also a means of examination. It was considered the most appropriate way to gain knowledge and of course also to put one's ingenuity to a test. Teaching meant preparing students for their transitional rite from student to licentiate able to teach. Therefore, they had not only to repeat what authorities or their masters opined on a topic, but also had to make a proper deduction themselves, starting from several pros and cons. They were also prepared in such a way as to give them the resourcefulness to defend flawed positions.

In a series of lecture notes on a cycle of lectures of Andreas Brusen, Olov Thorstensson illustrated a debate about the internal senses.[691] Olov drew Aris-

[687] Ljubljana, *Nardona in universitetna Knjižnica*, Ti 468. (Cologne 1498 by Heinrich Quentell. Hain 11585).
[688] Paris, *Bibliothèque nationale*, Res. 516. Figure on f. 84b. (Cologne 1498 by Heinrich Quentell. Hain 11585).
[689] L.M. de Rijk, *Middeleeuwse wijsbegeerte. Traditie en vernieuwing* (Assen, 1977), 132.
[690] Crossgrove, "Textual criticism in a fourteenth century scientific manuscript," here 57. See also: Marrone, "Medieval philosophy in context," here 35.
[691] Uppsala, *Universitetbibliotek*, C599, f. 143r. First published by Piltz, "Den äldsta Uppsalapsykologien," 275.

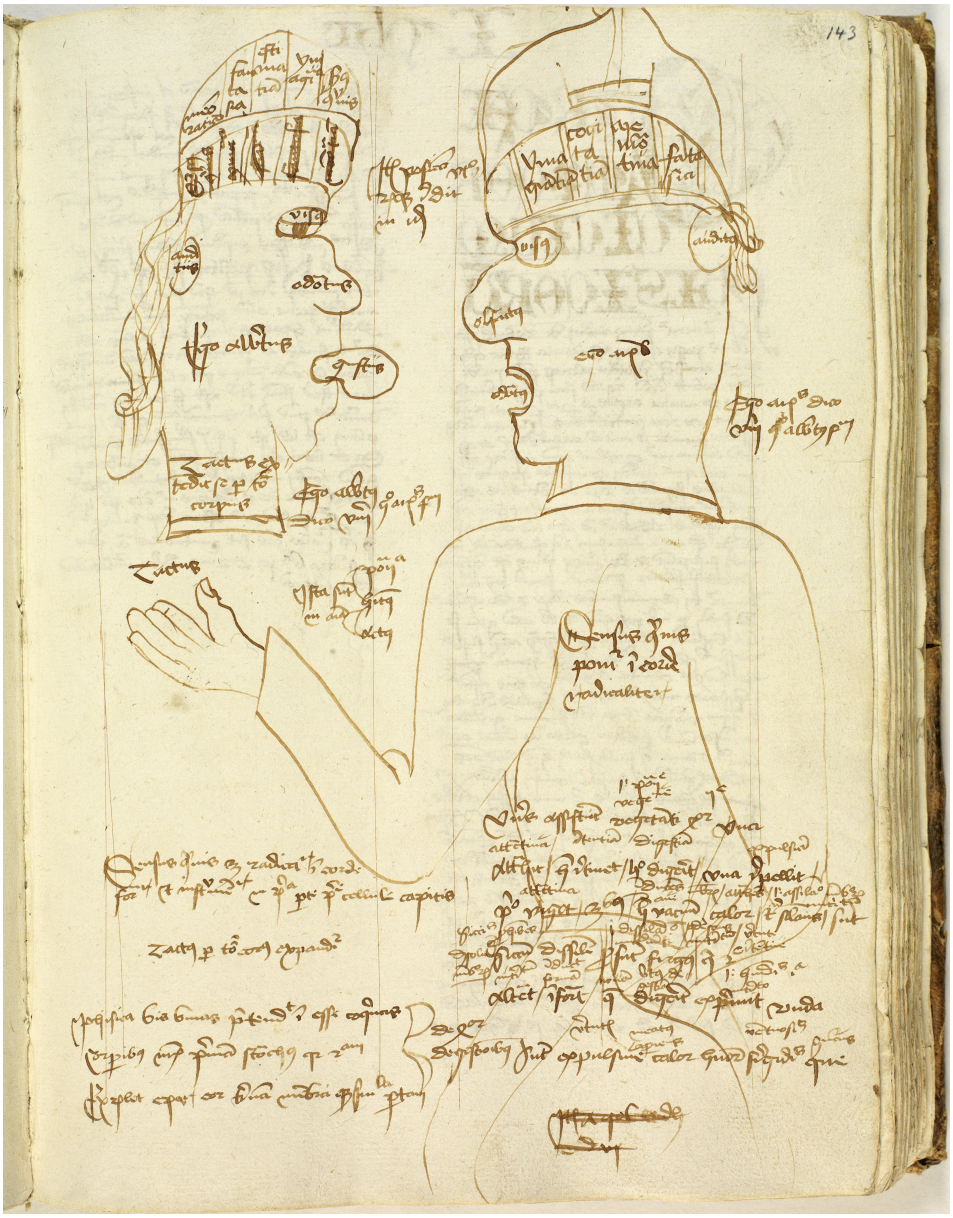


Figure 4.15 Anonymous, *Circa exercitium physicorum*. Uppsala, *Universitetbibliotek*, C599, f. 143r. Dated 1486.

totle on the right and his medieval commentator Albert the Great on the left, as if they are disputing with one another. [*See* figure 4.15]. The man on the left says: «I am Albert and I am telling the truth, in contrast to Aristotle». The man on the right duly responds: «I am Aristotle and I am telling the truth, in contrast to Albert». The two philosophers are drawn wearing a sort of hat, in which the senses are inscribed. Olov first made a careless mistake by reversing the order of the senses in Albert's hat, but corrected this error quickly by drawing a second tier onto the hat.

According to Albert, as shown in the diagram, the five senses consisted of common sense, imagination, an estimative power, fantasy and memory. The common sense in the front of the brain receives all sense impressions and then forms real objects, based on the sensory material provided by vision, hearing, smell, taste and touch. Olov also inscribed these five external senses near the corresponding organ in the drawing.

For Aristotle, the right-hand figure, the internal senses consist of imagination, a cogitative power, memory and fantasy. Common sense is conspicuously lacking in the head of the figure of Aristotle, with the front section left overtly empty. The common sense is placed in the area of the heart, instead of the head: «the common sense is rooted in the heart» – «*sensus communis ponitur in corde radicaliter*». This explains why the right figure had to be drawn fully, while for the left figure only the head was needed.

In the drawing, the common sense is shown as a general (common) root and principle of the external senses. The lines in the drawing running up from the external senses to the common sense represent the relationship of dependence between the senses and the common sense. Aristotle himself was rather vague on the issue, but he is generally considered to maintain that the common sense resides in the heart. Albert the Great classified the common sense in one instance as the first of the internal senses, and elsewhere, when speaking about the externally apprehensive powers, placed it next to the five external sense, merely because it knows its object only when the latter is materially present.[692] For a full description of this figure, see [Appendix B.9, page 260].

Controversies led not only to methodological dispute, but also fostered rival schools in the later Middle Ages, the point being to settle the question in favor of one of the opinions. In Cologne, for instance, two rival factions competed: in the *Bursa montana* school the books in the Arts faculty were studied and lectured upon with the help of he writings of Thomas Aquinas, while in the *Bursa laurentiana* one explained the books with the help of Albert the Great.

Lambertus de Monte Domini (from 's-Heerenberg) was the regent master of the *Bursa montana* in Cologne, the school of the followers and defenders

[692] Steneck, "Albert the Great on the classification and localization of the internal senses," 198–200.

of Thomas Aquinas.[693] He matriculated in 1450 at the University of Cologne and obtained his master's degree there four years later. In 1455 he became a professor in the Arts faculty, then dean of the theological faculty, rector and regent of the *Bursa Montana*. He wrote several compilations of Thomas Aquinas' commentaries of the *Physica*, *De physico auditu* and *De anima* of Aristotle.

The text that concerns us here, dealt with in passing in the previous pair of sections, is called the *Copulata super libros De anima Aristotelis cum textu iuxta doctrinam doctoris sancti Thome de Aquino*. The copy in question was done by Johannes Parsow around the end of the fifteenth century and is equipped with a drawing by him.

Johannes Parsow's study volume (Berlin, *Staatsbibliothek*) was typical of the *Bursa Montana* in containing mainly texts by Thomists teaching in Cologne: Gerard de Monte (compendium *De ente et essentia*), is followed by the *Parvulus philosophie naturalis* by Peter of Dresden, with a commentary (item 2), then the *Copulata super libros de anima Aristotelis* of Lambertus de Monte (item 3, 107r-247r), then three drawings, a *specula inmaterialia*, a *specula materialia* (247v), and an ink drawing of a man down to his waist (248r), followed finally by the *Copulata circa octo libros Physicorum Aristoteles* (item 4, 249r-446r), also from Lambertus de Monte.

Parsow's picture shows an overview of the three souls: the rational soul with the agent intellect, possible agent and the will; the sensitive soul with the internal and external senses; and finally the nature of the vegetative soul, with its functions and locations in the heart, stomach, lungs, spleen, and liver. The diagram is described in section 4.3.2. [*See* figure 4.9]. [See also Appendix B.3, page 253].

The rival school to the Lambertus' *Bursa montana* was called the *Bursa laurentiana*, also based in Cologne. The *Bursa laurentiana* consisted of the followers and defenders of Albert the Great and was governed by Gerard of Harderwijck, whose teachings followed Albert's.[694] In his *Epitomata seu reparationes totius philosophie naturalis Aristotelis*, printed by Heinrich Quentell in Cologne in the year 1496, a drawing is found about the topic at hand here.[695] Though

[693] Hoenen, "Late medieval schools of thought in the mirror of university textbooks. The Promptuarium argumentorum (Cologne 1492)," 333. On the *Burse* in Cologne, see: E. Meuthen, "Die Artesfakultät der alter Kölner Universität," in *Die Kölner Universität im Mittelalter*, ed. A. Zimmerman (Berlin–New York, 1989), 366–393. On Lambertus de Monte, see: P. Leeuwenberg, "Lambertus van 's-Heerenbergh (de Monte Domini) (d. 1499). Een Nederlands geleerde aan de Universiteit van Keulen," *Tijdschrift voor geschiedenis* 85 (1972): 325–349.

[694] Hoenen, "Late medieval schools of thought in the mirror of university textbooks. The Promptuarium argumentorum (Cologne 1492)," 333.

[695] London, *Wellcome Historical Medical Library*, no. 283, figure on KK6. See, for a reproduction of this figure: F.N.L. Poynter, *A catalogue of incunabula of the Wellcome Historical Medical Library* (Oxford, 1954), plate 8; K.D. Keele, *Anatomies of pain* (Oxford, 1957), plate II; W. Pagel, "Medieval and Renaissance contributions to knowledge of the brain and its functions," in *The history*

this text was copied by printing, it nevertheless contains hand written marginal notes and a pen drawing. The pen drawing is positioned before the treatise *De sensu*.

In it, three male figures are drawn, representing three competing views. [*See* figure 4.16]. [See Appendix B.10, page 261]. The two on top are depicted in discussion. The figure on the left represents the teachings of Galen and Avicenna, since it reads: «*Distinctio et locatio sensuum interiorum Galieni et Avicenne*». The figure on the right represents the position taken by Thomas Aquinas and Albert the Great: «*Distinctio et locatio sensuum interiorum sancti Thome et Alberthe*».

The dialogue therefore contrasts the physician's position regarding the sense with the philosophers' position. The physicians posit four senses, of which fantasy and common sense reside in the first ventricle, a cogitative power in the middle ventricle and memory in the posterior ventricle. The physicians agglomerated several working processes in the cogitative power, instead of differentiating between imagination and estimation, while the philosophers maintained five senses: the common sense in the first ventricle, the imagination, estimation and fantasy in the middle ventricle, and memory in the last ventricle.

Comparison between the physicians' and philosophers' heads shows a divergence in the location of the several grades of abstraction, and especially regarding the position of fantasy. The physicians asserted that the front ventricle of the brain was divided into two parts, one for the common senses and one for the fantasy. The drawing gives the unfortunate impression that fantasy was, according to physicians, a grade of abstraction preceding the working of the common sense. For philosophers the fantasy was crucial to the apprehension of the essence of things because it created abstractions out of sense impressions, while the common sense discerned between phantasms found in the imagination and those in external reality. Fantasy, cogitation and memory therefore all worked to prepare the phantasm and process it further for the intellect.

The drawn head of the philosophers' point of view in this image, however, is not clearly Thomist or Albertist in spirit. Albert had classified the common sense sometimes as a power of the sensible soul, alongside the external senses, and sometimes (following Avicenna) as one of the internal senses. Thomas' grades of abstraction, from sense perceptions to universals, went from common sense, to imagination or fantasy, to cogitation and finally to memory.

A third view is drawn in this image as the lower figure of the three. It is not explicitly labelled, but clearly visualizes the Aristotelian point of view about the location of the internal senses. The head is divided into three sections, with labels around the head explaining its contents. The first cell in the forehead con-

and philosophy of knowledge of the brain and its functions: an Anglo-American symposium. London, July 15th-17th, 1957, ed. F.N.L Poynter (Oxford, 1958), 95–114; fig. 1; Clarke and Dewhurst, *An illustrated history of brain function. Imaging the brain from antiquity to the present*, 16, fig. 14.

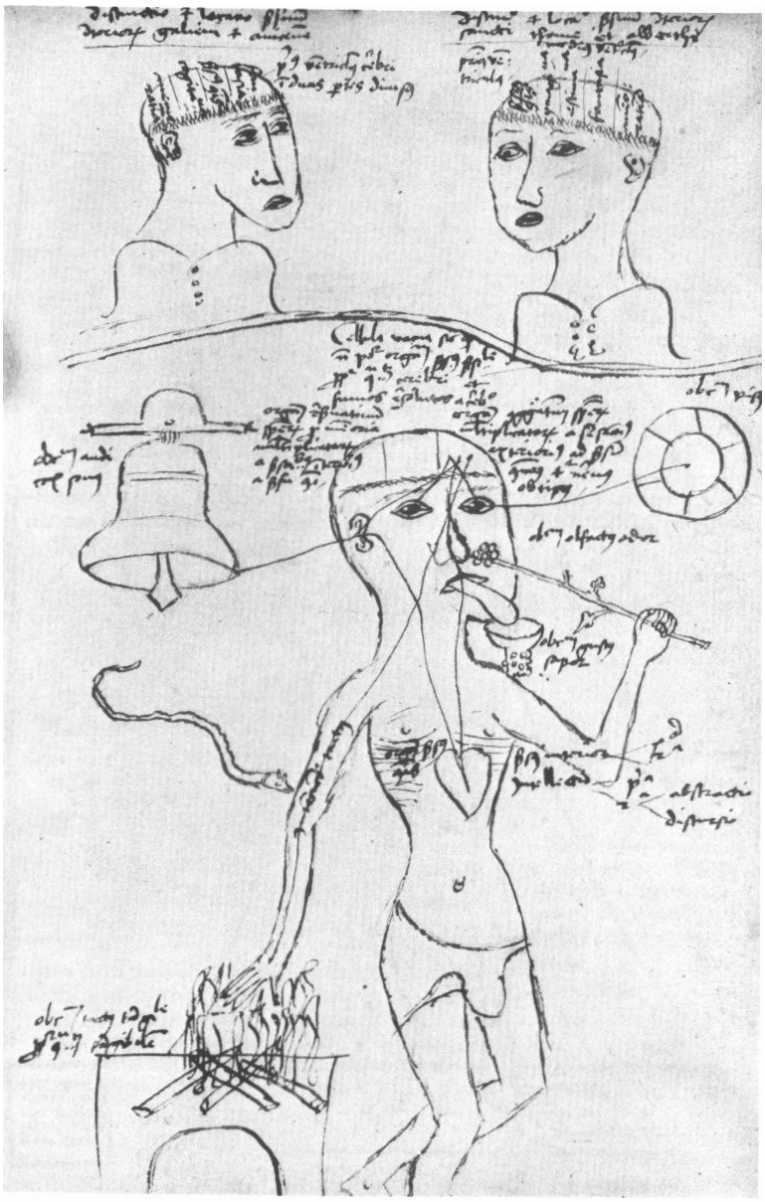


Figure 4.16 Gerard of Harderwijck, *Epitomata seu reparationes totius philosophie naturalis Aristotelis.* London, *Wellcome Historical Medical Library*, no. 283, KK6. Dated 1496.

tains an organ (*organum congregationis*) that assembles many *species* perceived by the external senses and then transports them to the common sense. The middle cell is multifaceted (*cellulla varia*), while the back of the head is shown to store an organ that is capable of retaining *species* through the use of memory.

The common sense assembled, according to this image, the impressions received by the external senses. Gaudy objects visually represent the five external senses: a bell for sound, a snake and fire for touch, the sun for vision, a flower for smell, and a cup for taste. These objects seem to have been common attributes given to the different senses in medieval literary and artistic sources.[696] The objects are related to their respective senses here by means of a drawn line and from the senses the line continues on, to the anterior part of the brain, where the common sense resides. We should note in addition that hearing is also related to the lower part of the body, as a line runs down from the ear to the heart. Next to the heart is written *organum sensus communis*.

Aristotle considered the heart the principal organ of the body, and the importance given to this organ in the lower body suggests that his point of view is explicitly represented by this image. The common sense, however, is confusingly shown to reside in two different places: the brain and the heart.

Although the text of Gerard of Harderwijck's *Epitoma* is Albertist in its tenets, the drawing discussed here deals explicitly with the debate between physicians and philosophers, and also the debate among philosophers. The drawing gives a summary of the divergent positions, without many subtleties.

Conflicts between opposing schools of thought therefore found their way into the disputation hall, the classroom and the textbook. Many drawings explicitly showed debates by presenting rival opinions and a striking feature of these diagram-debates is that the pictures did not necessarily illustrate the diagram-makers' own opinions, but showed the range of existing opinions united in one drawing.

The drawings usually expressed two or even three opinions held by competing authorities, giving them each a different face. Olov's drawing shows a dialogue between Aristotle and Albert the Great. Harderwijck's dialogue unfolds between physicians (Galen and Avicenna) and philosophers, among whom were Thomas Aquinas, Albert the Great and Aristotle. The drawing in Lambertus de Monte's *Copulata* shows Aristotle's *De anima* and Thomas Aquinas' commentary, and defends Thomas's conception that every man has powers of his own.

Tendencies in late medieval thinking were closely interwoven with the primary level of teaching and this pedagogical weave was then codified in books.

[696] See the artistic examples in, for example: Sears, "Sensory perception and its metaphors in the time of Richard of Fournival."

As we have seen above, the very literary genres of commentary, exercises, *questiones*, textbooks and the like, bear witness to the way in which pedagogical knowledge was processed. A plethora of compendia summarized and discussed books, highlighting the conditions needed to pass the examination, in particular the disputation, which was one of the required elements for earning the baccalaureat degree.

The diagram, in short, gives a clear overview of what the students were expected to retain for their future disputations.

4.5 Conclusion: Training instruments

The very picture that prompted Vesalius to revolt is an invaluable source for research on medieval teaching practices, and on the exchange and diffusion of popular natural philosophical manuals among students, masters and universities.

The iconographic histories of the cutaway head written before now did not reveal the shifting role of the diagram from the anatomical to the philosophical realm. Sudhoff found the predecessors of the incunabula's cutaway head, but described them as a 'servile' pictorial tradition. In this chapter I have made a case for the cross section of the head,to consider it not as a servile but a successful diagram. The cross section became standardized, after replacing the circular diagram that had conformed to contemporary convictions about harmony in the cosmos.

Taking the intellectual scenery into consideration also makes one realize that the anatomist Vesalius was complaining about a philosopher's diagram, but also that that diagram was indeed first conceived in the medical domain. Centuries of debate between physicians and philosophers, and among philosophers, lay between this moment of conception and Vesalius' complaint.

The earliest pictures, in which the powers of the soul had a role, were in the surgical domain. The powers of the soul were, however, only a secondary aspect of the representation of the anatomy of the skull. Later physicians dealt with the powers of the soul as part of pathology or in their own right in a learned discourse, and depicted the cross-section of the head. The philosophers borrowed this picture and extended it by including a torso and its organs. For them, the powers of the soul were intimately related to the entire body. This fitted into their debate about the physical seat of the soul in the heart or in the skull.

A strong residue of the physicians-against-physicists debate persisted in the later medieval cross sections of the head, as seen in the textual tradition of the *Parvulus philosophie naturalis*. But the debate expanded and became a debate

within philosophy. All parties eventually used the same convention of the cutaway to convince readers and thereby recruit supporters. The cutaway head full of functions was the winning diagram and lasted until at least the sixteenth century, when a new wave of 'surgical' representations were drawn into Vesalius' work.

This chapter also showed that the *Parvulus philosophie naturalis*, written by Peter of Dresden before 1414, played an important role in the dissemination and canonization of the picture under consideration. The *Parvulus* was composed as an aid for students by synthesizing the original authorities and the main commentaries in physics, among which figured the question of the soul. Peter's was one of the earliest manuals on natural philosophy and enjoyed great influence in Central Europe. The academic atmosphere at Prague in the early years of the fifteenth century had an enormous impact, as I have shown, on the dissemination and therefore the canonization of Peter's text and its figure. After the Kutná Hora decree, Peter's local manual traveled to Leipzig, Uppsala, Cologne and other towns, following the itinerary of masters and students to other universities.

The drawings dealt with here were part of the commentary and not part of the original texts of the *Parvulus philosophie naturalis* of Peter of Dresden or the *Copulata* of Lambertus de Monte, or the *Epitoma* of Gerard of Harderwijck. The position of the drawings, always at the beginning, (London's *Wellcome Institute* copy), or end of the text, (Norrköping and Uppsala C629 copies, and the Berlin copy of the *Copulata*), either full page, or even in the margin, but never in the text itself, suggests this assumption to be true.

Although the drawing was not integral to the *Parvulus* text, however, it was closely related to this textbook. Many teachers wrote their commentaries while using the *Parvulus* for teaching, and the positioning of the drawing as part of the commentary assigns a relationship between commentator and drawing. We cannot know for sure, of course, in what situation the students sketched this drawing. Did their master make them copy a drawing during class, as Vesalius had to, or did he refer the students to the library, in which they could find a neat version to copy from, or did he even provide dictation, which students used to correct their notes and to add the diagram? The exact relationships between the drawings, the *Parvulus* and its commentaries, as well as the exact stage at which the drawing became related to the *Parvulus*: all this remains to be studied.

An ordinary text like the *Parvulus philosophie naturalis* was meant as a textbook for beginner students in Central-European universities, to help them discover the basic notions, arguments and positions of several authors. The three parts of the treatise presented a collection of basic theses and the third part focused on the soul. Peter of Dresden relied on material written by others, but rearranged it to form a new whole. In this process, he joined forces with

the original authors and by systematizing their thoughts he helped to produce meaning, translating several bodies of thought into a whole that students could comprehend. The system of views presented was visually represented as diagrams in numerous student copies and the diagrams, like the book as a whole, give an overview of several opinions. Also like the text as a whole, the diagrams served memory.

A rather minor product like the *Parvulus philosophie naturalis* played therefore a key role in the dissemination of the picture under consideration. Students copied these texts and diagrams directly during or after attending lectures or dictations. Teaching therefore conditioned the production of diagrams by students and helped to standardize the textbooks and commentaries that supported everyday teaching. The text as well as the picture became normalized and canonized by the masters and students using them.

The cross section of the head became even more firmly canonized than the textbook it accompanied. Although the figure was not developed in and for the *Parvulus philosophie naturalis*, it became associated with this text, and was standardized by association with it. The cutaway head was also employed by many other adaptations of, and expositions on *De anima*. The same cutaway head was even used to illustrate the competing views of rival schools in Cologne, as demonstrated this chapter. In Cologne competing manuals were written, such as those by Lambertus de Monte and Gerard Harderwijck and in the same city Gregor Reisch printed, somewhat later, a manual that would be used in the *Pedagogium Castrense* in Louvain University, where Vesalius studied.

The *Parvulus* and its diagram became canonized, but the enormous spread of the *Parvulus* must also have contributed to its normalizing influence. Textbooks in general fulfilled a fixative role in canon forming, which was a long process of consolidation and normalization of doctrines and questions, eventually responsible for the achievement of consensus. The exact mechanisms by which the *Parvulus philosophie naturalis* played a role in canonizing the opinions of physicians and the philosophers such as Thomas Aquinas, Albert the Great, and Avicenna remains to be studied.

The diagrams reflected the methods of analysis, examination and didactics. They were used to convey and systematize existing knowledge and to present, in orderly fashion, the different positions of a polemical dispute between authorities. Although common opinion in the fifteenth century held that the five internal senses were placed in the head, it was still necessary to learn the opposing opinions. Likewise, students were not only to remember and argue for a given 'winning' theory, they were also supposed to be able to reproduce the counterarguments on the subject and then refute them one by one.

The cross section of the head, then, not only offers the common opinion, but also the way in which students achieved these opinions, in dialogue with

authoritative philosophers. The contradiction between these different opinions was part of the discourse, and helped students to set out the various different lines of argumentation, which was a required feature in students' final exams. The student was trained to reproduce the dialogue between different authorities, even when the drawings with the help of which he learned did not literally show him a dialogue between two men – though this latter iconography was not uncommon either, as we have seen.

The sources of this chapter turned out to have been made for the most part by students who copied the texts and also executed the drawings found in the manuals and lectures. I thereby demonstrated that visual representations are to be found in poor medieval masters' and students' schoolbooks, contrary to Bolton's claims.[697]

The quality of these drawings is usually poor, supporting the thesis that it was mostly students who added the drawings, using their limited artistic skills. It is probable that students copied the drawings, after lectures, from copies that were used as examples, for the different types of drawings still stuck quite faithfully stuck to certain texts. Perhaps these students were made to copy the pictures onto their own scratch paper, as was Vesalius in the early sixteenth century. He complained about the average skill of student draughtsmen, the product of which we have seen in this chapter.

Vesalius would do things differently - and thereby give a decisive boost to descriptive anatomy. He employed a professional draughtsman, who mastered a perfected naturalism for the anatomical pictures that went alongside Vesalius' descriptions. These new images were based on texts and then rectified with the help of a verification *de visu* (by sight) of cadavers.[698]

[697] See also the Introduction of this book, page xi. Bolton, "Illustrations in manuscripts of Boethius' works," here 430.

[698] M.D. Grmek, ed., *Histoire de la pensée médicale en Occident*, vol. 2: De la Renaissance aux Lumières (Paris, 1997), 8–9.

CHAPTER 5

RESULTS AND CONCLUSIONS

Bruno Latour wrote that '*the earlier we go back in the history of science, the more attention scholars paid to the setting and the practice, and the less to the visual representations of data*'.[699] He meant that today's scientific publications depend on flashy graphs and colourful photos to obtain relevance and attract allies in the scientific competition. This craftsmanship of the image is specific to our modern scientific culture. In former days, science was not yet a rat race, and Latour claims scientists - like Johannes Kepler, Galileo Galilei and others - could concentrate honestly on their laboratory work and research. Much other scholarly literature about scientific and scholarly diagrams also starts with the early modern period and while this period is indeed very interesting for the history of science, the unidirectional focus on the early modern period ignores the fact that many diagrams have predecessors in the preceding centuries.

The objective of this book is therefore to enlarge our understanding about how diagrams worked as a form of scientific practice at the Arts faculties from 1200 to 1500. This was a period in which the institution of the university developed and the complete oeuvre of Aristotle came to be studied in depth.

DIMENSIONS OF INVESTIGATION

Several themes structured my investigation. A first theme questioned the congruency between text and diagram (chapter 2). The degree of symbiosis and play between text, underlying idea and an image might grant insight into the objectives enfolded in diagrams. A second theme centred on the question of the responsiveness of diagrams to scientific tradition and renewal (chapter 3). This question is of special importance in a period of scientific change, when visual notation is put to the test. And a third theme turned to the practices that may take possession of scientific books and thereby produce differentiated uses

[699] Latour, "Visualization and cognition: thinking with eyes and hands," here 16–17.

and meanings. The focus in this latter instance was directed onto the place of diagrams in their institutional context, with special attention to transmission, normalization and dissemination (chapter 4). These three themes correspond to different layers of the investigation: from a text-image comparison, to the diagram and scientific development, to the diagram in its actual context of use.

To deal with these three themes, three case studies of diagrammatic representations from the Arts faculties have been designed. Case studies permit a careful examination of a selection of diagrams. They are therefore an apt method with which to approach the relatively unexplored, large and dynamic area of medieval scientific diagrams. The case studies for this book were selected according to available material in the manuscript copies on the following topics: the Tree of Porphyry, the four elements, and the powers of the soul.

The case study of the so-called Tree of Porphyry dealt with a diagram in logic, inserted mainly into manuscripts containing Boethius' works in logic and the *Tractatus* of Peter of Spain, which were introduced at the University of Paris in the 1260's (chapter 2).

A second case dealt with primary qualities and the structure and change of substantial matter (the four elements). The main sources used for this case were the encyclopaedic work *De natura rerum* by Isidore of Seville, Nicole Oresme's *De configuratione* (*College de Navarre* in Paris) and the fourteenth-century *Termini naturales* of William Heytesbury, written in Merton College at Oxford University (chapter 3).

A last case study dealt with the rational power of the soul, commonly considered in this period to reside in the head. This last case study rests mainly on the fifteenth-century *Parvulus philosophie naturalis* of Peter of Dresden, probably written in the circle around the University of Prague, and its adaptations, but the case study starts with several medical treatises dealing with the topic and dating from the High Middle Ages (chapter 4).

These three cases cover the three main areas of medieval investigation: logic (language and truth), the inanimate world (nature and the visible world) and the animate world (the human being and his cognition). The texts used were all discussions of the major works of Aristotle, (respectively: *Categorie*, *De generatione et corruptione* and *De anima*), which had been introduced in the twelfth century and systematically studied in Arts faculties from the thirteenth century onwards. The three themes mentioned above were applied to all three case studies, but each case study turned out to be especially telling for an individual theme.

Considering figures and pictures

Chapter 1 - *About the sources* – described, in greater detail than the introduction, the complex character of the sources used for this book. It described the

entry of the new corpus of Aristotelian texts and those texts' reflection in the curricula of the Arts faculties. The new corpus of Aristotelian texts was translated in the middle of the twelfth century and by the end of this century it was systematically studied in schools and the universities developing out of these schools, as witnessed by their curricula. In the curricula of the Arts faculties we read that the *De generatione et corruptione*, the *Categorie* (and the *Isagoge* of Porphyry), and the *De anima*, were usually compulsory literature for the bachelor and master exams. These texts, along with the rest of the New Aristotle, were frequently studied by means of study-aids, written by masters to help students to process the large amounts of literature.

This chapter also dealt with the medieval statements about *figura* and *pictura*, the most common designations for the sort of diagrams I discuss. The roles medieval scholars had in mind for figures did not coincide with the roles modern scholars attribute to medieval diagrammatic representations. The two groups use concepts differently and interchangeably. Medieval writers, for their part, accentuated the didactic role and function of a *figura* and described a *pictura* as an (inferior) externalization of a true thing (which it depicts). Modern scholars, meanwhile, often consider medieval diagrams as models and accentuate the role figures can play in mnemonics (the double function of storage and recollection).

Congruency between trees

Chapter 2 - *Form, content and the Tree of Porphyry*- is devoted to the supposedly congruent relationship between figure and text and the play of complexity, reduction and concretization. The very structure of the Tree of Porphyry, known in its early forms since Boethius, was designed to convey the technique of definition. The Tree of Porphyry shows how students were to proceed from a general genus down through a series of successively less general genera to obtain a definition of the human being. The diagram demonstrates, thereby, the method of definition by taking the example of the move from substance to human being. At the same time it was not functional as a tool, for the student could hardly apply the method to concepts other than substance.

A careful examination of the tree-structure in the Tree of Porphyry revealed that the synchronization between theory and diagram was not flawless, and that many inferences failed. The application of the metaphor of the tree caused a degree of incoherence between the image of an actual tree and the inferential scheme of the tree-structure. There was a real tension between the image and the logic when the tree metaphor was added, as some draughtsmen showed in their attempts to solve the problem. The logical theory demonstrated proved not necessarily to require the form of the Tree of Porphyry. The tree-metaphor was also applied to the logic diagram only quite late in its iconographical history. Even if some forms seem more apt than others, then, there was no inherent

sense in this choice. Its sense lay elsewhere.

By becoming a tree, the Tree of Porphyry could fit into a repertoire of other trees. This repertoire of trees enabled masters, students, preachers, or anyone else, depending on his memory, to construct and recollect data for the oral discourses he gave. The Tree of Porphyry did not encounter any new scientific demands, because it was designed to illustrate the definition of species and genera as Porphyry presented it. But it turned into a pictorial tree in order to comply with new demands in scholarly culture and in order to collate theories into an arboreal structure that would facilitate spoken discourse. Once the Tree of Porphyry became a tree it was much easier to collate the knowledge of one domain with the other, and therefore make parallels with other domains, enriching one's discourse.

The transformation of the logic diagram into a tree does fit perfectly, however, into the synthetic conception of the world, put in terms of coherence and harmony, that was still prevalent in the thirteenth century. Theories were considered combinable and open to collation in tree-structures because this structure resembled the foundations of the sublunary realm. This suggests that the possibility to collate and affiliate was considered more relevant than the specific congruency, integrity and coherence between text and diagram. The relevance and truth of collation relied on the prevalent view of a coherently created universe.

As an example of collation and 'pulling' I dealt with the *Clavis Physice* that leans on the diagrammatic structure of the Tree of Porphyry. The similarities in shape plus the dissimilar data permitted a careful comparison of these data, allowed the production of new discourses and the easy memorization and reproduction of these latter.

VISUALIZING SYNTHESES AND ANALYSES

In Chapter 3 - *Changing matters: Elements, qualities and scientific interests* - I examined how diagrams dealing with theories about 'qualities' and 'elements' were affected by new interests, new approaches and demands in science. The focus on diagrams is thereby placed in the context of the intellectual developments in which scientific practices are embedded. This case study dealt in particular with the variability of phenomena in the physical world, about which new ideas and approaches were developed in the fourteenth century.

First, I dealt with the most important theories about the elements and qualities that came down to the fourteenth century, especially Aristotle's logical, physical and chemical thinking and Plato's cosmological accounts, as interpreted or adapted up to the later Middle Ages by in particular Avicenna, the Oxford Calculators and Nicolas Oresme. The most current earlier medieval (ninth to the twelfth century) diagrams of the elements and qualities represented

the combinations of qualities in the element and their possible transformation. They illustrated thereby the antique theories of change by opposites. At the same time they reflected the synthetic conception of the world in terms of coherence and harmony. The diagrams of the four elements with their qualities were supposed to demonstrate the unity and regularity of creation, preferably in the form of parallels, quadrupled structures and circle diagrams in order to sustain the coherence of the system's foundations. The reader would sense the symmetry by means of these diagrams, which acted as physical backdrops claiming the perfection of creation.

As a contrast I examined how fourteenth-century scholars from Oxford and Paris approached substantial matters in terms of quantities of qualities. They were interested in the analytical treatment of particular problems, instead of creating comprehensive syntheses. Instead of demonstrating coherence and stability, they studied mutability in substantial matter. The new fourteenth-century mathematical-geometrical and logical approach to the question of the mutability of matter confronted medieval draughtsmen with the challenge of demonstrating how the structure of matter in the physical world surrounding them was actually changing.

The 'configuration' diagrams of Nicolas Oresme described the change in *intensio* (elevation) or *remissio* (decrease) of a quality by means of a geometric figure with a latitude and a longitude. The resulting graph approaches the coordinate system through which the intensity of quality is related to an extent (time, distance or other measurable dimension). The configuration diagram is not only an illustration, but also a tool and a geometric proof (of the mean-speed theorem). Several students tried to articulate the Aristotelian opposites with the changing qualities and quantities in a square figure by forcing an 'old' diagrammatic structure onto it, in the manuscripts of the *Termini naturales*. The attempt ran aground and shows the struggle to adapt diagrams to comply with the new demands of science. Odington's alchemical square of elemental oppositions is likewise based on the diagrammatic structure of an older diagram, but adapts it cleverly to his need to represent the relationships of augmenting and weakening qualities.

Odington's diagram and Oresme's graphs reflected the new approach differently. Walter Odington effectively invented a tool by means of which the reader could read off the behavior of the qualities when the elements transformed. The description of the behavior of the qualities is thus reduced to the weakening or augmenting intensity of the qualities. Nicolas Oresme indicated not just intensity but also extent (say volume, quantity, time) of a subject. The quantity of quality of a given form was visualized by Oresme as a latitude, representing the degrees. The extent was visualized by a longitude. His graph was thus a geometric volume. The square of elemental opposition, by contrast, failed to reflect

the new approach but instead gives a traditional overview of the (im)possible combinations of qualities.

Some of these new diagrammatic structures helped scholars and students to understand or solve the problem of transformation in substantial matter. The configuration graphs provided an overview of the mechanism and the effect of changing qualities in the elements, and applied the new insights about the quantity of quality to the composition of compounds. The configuration graphs helped readers understand the internal configuration of physical phenomena. In the case of the mean-speed theorem, the graph helped to solve the problem of acceleration. The graph gave the solution for the measurement of the total distance traversed in a given acceleration: the surface of the resulting figure represented the distance traversed. Odington's diagram helped in calculating the degree of qualities present in a compound. And though it does not give an immediate understanding of the formulae used, one could deduce these, with some effort, from the accompanying table. The diagram equally illuminated what happens to the configuration of qualities when elements change, but did so somewhat more abstractly than in Oresme's geometrical graphs, because Odington's representation does not operate by analogy to a real thing.

THE CANON OF MULTIPLE OPINIONS

Chapter 4 - *The powers of the soul in intellectual and institutional context* - considered diagrams from a third point of view. In this chapter the perspective employed captured diagrams in the context of their particular scientific culture and practices, especially didactics, transmission and the dissemination of knowledge. In all three case studies, the diagrams played a clear role in education at the Arts faculty. The case study of the visual representations showing the powers of the soul, however, turned out to be of special interest, for nearly all the consulted diagrams found in the fourteenth- and fifteenth-century manuscripts sources were drawn by students in written lectures or textbooks.

Examination of the iconographical history demonstrated that the first cross sections of the head were found in treatises compiled by and for physicians in the first half of the fourteenth century. Some of these 'physicians' heads' were drawn into a composite manuscript of medical, historical and Arts texts, while others were written in the context of higher medico-arts education. By the second half of the fifteenth century, the natural philosophers dealing with *De anima* had borrowed the same visual representation. In one instance, it was labeled the 'physicist's head', so as to overrule the physician's claim. For use in the psycho-philosophical field, the diagram was visually elaborated with the addition of the rational soul, the (recent) debate about the intellect, and the vegetative soul.

The 'adoption' of the cut-away head by natural philosophers was facilitated,

as I argued, by the wish to represent a debate, including argumentation and refutation. Several divergent (even contrasting) opinions were thereby easily combined in one sole diagram. The labels comprised mainly annotations of arguments by Thomas Aquinas and Avicenna. Aristotle's solution - placing the powers of the rational soul in the heart region - was however overruled in favour of the head.

The cut-away heads drawn in textbooks that addressed the *De anima* therefore confronted their readers with a staged dispute between the physicians' discourse and the philosophers' one. The dispute was concerning the classification of the internal senses, and the location of the rational soul in the head or in the heart. In some manuscripts, students drew several cutaway heads of philosophers discussing with one another, thus quite literally showing a debate.

Successful and extensively used textbooks have the effect of normalizing and canonizing the scientific ideas and authors mentioned in them. These books translated research into something readers could comprehend. Not only did the ideas at work in the *Parvulus philosophie naturalis* become canonized, but also the figure itself - and even more firmly than its textbook, for the figure became not only associated with the *Parvulus*, but was also employed in many other adaptations and expositions on the *De anima*. The cutaway head standardized the main arguments of Thomas Aquinas, Albert the Great and Avicenna in particular. The same cutaway head was even used by competing views of rival schools in Cologne, as demonstrated in chapter 4.

Processing the New Aristotle

On the basis of the results of the four chapters in this book, a complex view emerges of how diagrams interact with the scientific text, with new scientific approaches, with a discipline's characteristics and with its institutions. The choice of several case studies in several different domains had the advantage that similarities and dissimilarities in the results can be compared. This might reveal insights that remain concealed if only one in-depth study was undertaken. The three different themes employed in the three case studies also shed different kinds of light on diagrams as a form of scientific practice.

One thing predominated in all the chapters: the fact that medieval diagrams enjoyed an important role in the *processing* of the textual corpus of the New Aristotle. Diagrams were used as an explicative tool to appropriate, process, recycle and assimilate the many different texts and to collate medieval commentaries on them. These diagrams were inserted *per exemplum*, to clarify, express, show, visualize, in short to externalize something, *breviter* or *generaliter*. Diagrams, then, were used to objectify the ideas, problems and solutions at work in the text.

This book has demonstrated that my selection of diagrams from the Arts

faculty are mostly encountered in texts with the purpose of explaining the Aristotelian text. *Tractatus* or *summule*, *parvulus philosophie*, *expositio*, *copula*, *termini naturales*: the names of the sources used for this book indicate that we are dealing with a literary genre developed for medieval university education, though each text had its own specific character. These literary genres are captured here under the name 'study-aids'. Learning occurred in the Middle Ages more and more often by means of textbooks, which consequently enjoyed a larger place in daily lectures. These textbooks provided cheaper and shorter texts, used as an aid for assimilation and for revision of the material. These study-aids are still very much undervalued as a source, despite the fact that most students in the later Middle Ages became acquainted with the Aristotelian corpus by means of them.

Not all sub-genres of study-aids were considered apt for illustration. Diagrams turned out to be especially used in commentaries, *expositiones* and in abbreviated adaptations like *abbrevationes, summule, compendia*, and *epitomata*, which indicated briefly the contents of individual works. Other genres, like *conclusiones, tabule, flores* and *auctoritates*, giving short entries or excerpts of the Aristotelian base text, on the one hand, and *questiones* on the other, for the advanced, proved unlikely to be accompanied by a diagram.

The distinction between these two sets of study-aids has to do with the fact that commentaries, expositions and comparable texts all originated in the lectures given by masters. Abbreviations and the like were sometimes used in lectures instead of reading the required section of base text, but were also used by students to revise. The expository character of these genres might well have promoted the insertion of visual material. As for *lexica, tabule, flores* and *auctoritates*, they do not provide for explanations, but instead summarize and compile arguments and citations, and were considered therefore less apt for illustration. *Questiones* are text for the advanced and deprived of pictures.

Exceptions to this view are Walter Odington's alchemical square and the configuration diagrams of Nicolas Oresme. These both feature in original medieval work (chapter 3), that is to say that these diagrams were not designed to process the textual corpus of the New Aristotle by means of a study-aid, but illuminated new work.

How do diagrammatic representations help to 'process' the text? From the results here we learn, firstly, that diagrams are closely related to the text they accompany, but that they hardly form a sound symbiosis with it. There is play between the meaning and the role of the diagrammatic representation in the text, which transcends the role of 'mere' illustration. In the case of the Tree of Porphyry (chapter 2), the diagram takes several sections together and compresses these data into a single picture. Besides, pictorial elements are added to the design, which then obstructed a 'proper' reading. The Tree of Porphyry

participates in and appeals to the intellectual skill of saving and recalling knowledge from (mental) structures, for the purpose of composing and elaborating of oral discourses. This observation could be more broadly supported by studying in more detail how tree-structures were used to combine data and to compose new discourses.

Odington's alchemical square of qualities and elements (chapter 3) was an instrument by means of which readers could train themselves in the application of the functional relationships between the qualities he described. The process is described in the text and ordered in a table. The diagram showed an example and the reader was supposed to substitute the degrees in the example with others so as to experience the transformation of qualities shown in the figures and so as to be able to work with the relationships himself.

Many of Oresme's configurations (chapter 3) were more like illustrations of the behavior of qualities in a compound. He described the figures in the text and then visualized them geometrically to help the reader understand how qualities behave when intensified or weakened. Oresme explicitly announced his book as a tool for training and for organized study. As a tool for training it was meant for students who were to familiarize themselves with the rules and principles for measuring qualities. The manual drawing and mental visualization of the configuration would help the reader to understand and sense what happened in a transformation. The configuration diagram representing the mean-speed-theorem gives, in addition, a geometrical proof to the claim. The diagram thereby functions as the verification of what is asserted in the text.

The diagrams of the rational soul (chapter 4) reflected the methods of analysis, examination and didactics used at the time. They were used to convey and systematize existing knowledge and to present, in orderly fashion, the different positions in a polemical dispute between established scholars.

Local teaching, local textbooks

Diagrams have a role in transmitting knowledge from masters to students. This is demonstrated in all the case studies: the Tree of Porphyry was designed to initiate children to the concepts of logic; Oresme's configurations are meant for training students; the square of elemental opposition was conceived by a young and confused Arts-student who began his studies in natural philosophy; and most diagrams of the *Tractatus philosophie naturales* were likewise drawn by students and added to their lecture notes. In this way I have demonstrated that visual representations were to be found in poor medieval masters' and students' schoolbooks, contrary to Bolton's claims.[700]

[700] See also the introduction of this book. Bolton, "Illustrations in manuscripts of Boethius' works," 430.

The cut-away diagrams of the powers of the rational soul reflected, then, methods of analysis, examination and didactics. The opinions of several established scholars were systematized and ordered in a visual survey. These diagrams summarized, in a single image, the different elements of the entire discourse then current on the subject of the soul.

These diagrams played a mediating role between science and social culture in that they translated science into something the reader understood. Teaching has been considered as the vulgarization of knowledge for a larger public but the reverse is also true. Diagrams, and the textbooks they are drawn in, play a role in the normalisation and consolidation of scientific ideas. However, the exact mechanisms by which the *Parvulus philosophie naturalis* played a role in canonizing the opinions of physicians and the philosophers Thomas Aquinas, Albert the Great and Avicenna remain to be studied.

Teaching also proved to be highly progressive, especially in the case of the structure of matter (chapter 3). Teaching in fourteenth-century Oxford was very responsive to recent developments in science. Thus the rather insignificant textbook for Oxford students called *Termini naturales* indicates that the new Terminist approach to quantifying qualities in physics was immediately transmitted in textbooks for undergraduate students.

Some textbooks with diagrams were exclusively of a local character, and thereby related to local habits and local current ideas. The dissemination of the *Parvulus philosophie naturalis* was in particular related to the history of the University of Prague (chapter 4). It spread as a consequence of the exodus of masters after the Kutná Hora decree. The booklet travelled along with these masters and students to their new habitats. The *Parvulus philosophie naturalis* thus had a market as big as Central Europe, from Cologne to Wrocław, Uppsala to Prague. This dissemination pattern shows that the *Parvulus* had a strong local tradition, attached to the specific masters and students working with it.

The *Tractatus* (chapter 2) was *the* logic textbook used to elucidate the *Isagoge*, a compulsory reading in the Arts faculty since the mid-thirteenth century. The *Tractatus* was therefore read everywhere on the continent. The *Tractatus* and the *Parvulus* were particularly sought after, while the Oxford treatise *Termini naturales* (chapter 3) appeared to be less successful, probably because this treatise belonged to a local set of logical and natural philosophical material in the Oxford tradition. The book is therefore associated with a specific local Oxford compilation.

Setting and practice

These results show late-medieval scientific diagrams differently than does the picture sketched in the existing secondary literature, which is primarily based on early-modern scientific illustrations. The views expressed in recent publica-

tions on the role of scientific diagrams are varied indeed, but emphasize in all cases the reception of diagrams in a research context.

Indeed the scholarly literature dealing with scientific visual material from the early-modern period onwards represents this visual material essentially as the results of research. The examples Eisenstein and Latour wrote about, for instance, are used by them to demonstrate how scholars in the modern period managed to fix, transport and rationalize (natural) phenomena in diagrams. Their examples include mapped coastlines, industrial drawings of buildings and instruments, stuffed animals, geological layers and economic statistics. Baigrie, as editor, dealt with scientific illustrations that played a role in the creation of scientific knowledge. Lefèvre, Renn and Schoeplin, meanwhile, directed their focus to the cognitive functions diagrammatic representations possessed for engineers in the domain of the mechanical arts and the Arts faculty.

In most of these cases, the diagrammatic representations are understood and described as conceived by and for other scholars, scientists or engineers. But the meaning of early modern diagrammatic scientific material has so far not been found, or sought, in education. It would be of great interest to take the educational aspect of diagrams into consideration for the modern period and to analyze these diagrams, especially the relationship between diagrams made for peers and those made for students. Such research would accentuate the differences and similarities between diagrams in the light of the early-modern development of scientific research and education. It would be also be of great interest to gather and analyze the medieval diagrams produced in the mechanical arts practiced outside the university, and compare them to those produced in the Arts faculties.

Medieval scientific diagrams reflect another form of scientific practice. Latour wrote that the earlier we go back in the history of science, the more attention scholars paid to the setting and the practice, and the less they paid to the visual representations of data. The medieval scientific diagrammatic representations studied in this book do not stand in this continuum and instead had their prime role in processing masses of new ideas.

This didactic role fits the character of the medieval university as the institution where undergraduates acquired learning from masters. Students learned primarily by engaging in verbal disputations. And diagrams were instrumental in developing the intellectual habits used to develop lines of thought.

Under the impact of the New Aristotle, new modes of relating language and images were devised, and promoted a kind of visual thinking. The earlier, monastic, meditative use of images was amplified and became more complex because of their function in collating vast and diverse domains of knowledge.

The diagrams dealt with in this dissertation were therefore drawn by and for students, and not so much to convince peers. The Burney-miniature, with

which we started this book, was also, in its content, a diagram for students. Only its expensive execution reveals that it was made for the Chancellor of the University of Paris.

APPENDIX A

MASTER ALBERT, *Termini physicales**

SIGLA

P	Paris, *Bibliothèque nationale*, nal. 566, ff. 49r-58r
A	Assisi, *Bibl. Sacro Convento fondo antico comunale*, ms. 690, ff. 314r-319r
Pc , Ac	the corrector of ms P, A.
om.	*ommitit (ommitunt)*
add.	*addit (addunt)*
inv.	*invertit*
sup.	*supralineavit*
. . .	until
< . . . >	insertion by the present editor
[. . .]	marginal note
instanti: instans A	of the two manuscripts P reads *instanti*, and A reads *instans*
ac: Pc 1(ut P)	the corrector of P gives *ac*, while in P *ut* is deleted
(. . .)	deleted
(..?..)	unreadable

*With many thanks to Bert Bos, who helped me out with the illegible parts of the text.

MASTER ALBERT, *Termini physicales*

/(MS P, f. 49r)/ Termini physicales editi per magistrum albertum. Natura est principium motus et quietis eius in quo est primo et per se et non per accidens. Istam

1 Termini physicales: Termini naturales seu physicales A [Natura] Pc 1–2 principium] motus *add.* A

diffinitionem ponit Philosophus et Commentator secundo *Physicorum*, et in quinto *Methaphysice*. Unde natura est principium motus et quietis diversimode. Nam natura est principium eius in quo est quando ipsum ponitur extra locum suum naturalem, et natura est principium quietis eius quando ipsum existit in loco suo naturaliter, ut si terra ponatur versus aerem nisi impediatus statim movetur descendendo, et hoc naturaliter. Ideo natura est principium eius motus. Similiter si terra ponatur in suo loco naturali ibi quiescit naturaliter ideo natura est principium quietis eius.

Motus dicitur duobus modis, scilicet motus subitaneus et motus successivus. Motus subitaneus est ille qui causatur sine aliqua resistentia, ut inductio luminis. Nam luminosum inducitur lumen in aliquod medium quia non invenit resistentiam, ideo subito indicat lumen: sed talis motus sed mutatio non est proprie dictus sed mutatio quadam. Unde non potest esse motus proprie dictus. Motus successivus est qui causatur ex certa proportione potentie a re ipsa, et talis motus vocatur motus proprie dictus. Unde non potest esse motus proprie dictus nisi sit successivus, et non potest esse successio in motu nisi sit partibilis, et non potest esse partibilis acquisitio nisi sit ibi resistentia. Patet igitur quod non potest esse motus verus sine resistentia. Motus a Philosopho sit diffinitur: motus est actus entis in potentia. A Commentatore diffinitur sic: motus est acquisitio partis post partem illius termini ad quem tendit res mota. Prima diffinitio dicitur formalis. Secunda materialis et per secundam diffinitionem satis patet quod oportet quod sit partibilis acquisitio et successio in motu proprie dicto.

Duo sunt termini in motu, scilicet terminus [49v] a quo etterminus ab quem. Terminus a quo est ille terminus a quo incipit motus et deperditur per motum. Terminus ad quem est ille terminus ad quem tendit res mota terminatur actu et ultimate acquiritur per motum ut si quis iret ex Venetiis Florentiam, tunc esset ex Venetiis terminus a quo, et Florentiam ad quem, et sic de aliis.

Decem sunt predicamenta, scilicet substantia, quantitas, qualitas et cetera. In quatuor istorum conceditur a Philosopho esse motus, scilicet in substantia, in quantitate, qualitate et in ubi. In predicamento substantie sunt due species motus contrarie, scilicet generatio et corruptio. Unde generatio est mutatio de non esse ad esse. Corruptio est mutatio ab esse ad non esse. Unde generatio et corruptio non sunt proprie dicti motus quia non sunt successivi. Similiter ad hoc quod in aliquo predicamento sit motus proprie dictus, requiritur quod subjectum immediatum recipiens formam acquisitiam per illum motus sit in actu de se, et compositum ex materia et forma, sed nichil est subiectum immediatum recipiens formam substantialem que acquiritur per motum generationis, nisi materia prima que de se non est in actu, nec est composita ex materia et forma.

Generatio est duplex scilicet generatio simplex et generatio secundum quid. Gen-

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6 in suo loco *inv.* A 8 loco suo *inv.* A 9 quiescit] et hoc *add.* A quietis eius: eius quietis *inv.* A 10 [Motus] Pc scilicet] motus *om.* A subitaneus: subitus Pc: subitus A successivus motus *inv.* A 11 subitaneus: subitus Pc: subitus A 12 aliquod: quoddam A medium] subito *add.* A 12–13 (ideo subito indicat lumen) A 13 proprie] motus *add.* A (dictus) A 14 (Unde . . . dictus) *sup.* A 18 [Motus] Pc 19 in potentia] sed que impossibile *add.* A 23 [Terminus in motu] Pc et: ad A ab: ad A 27 et] ly *add.* A Florentiam] terminus *add.* A 28 [predicamenta] Pc qualitas] acto et paxris <sic>, situs, habitus, ubi, quando et relatio *add.* A In] quorum *add.* A 29 (istorum) A 29–30 in qualitate, in quantitate *inv.* A 30 (in) A due sunt *inv.* A 31 (contrarie) A [Generatio] Pc [Corruptio] Pc 33 (dicti) A 39 [Duplex] Pc scilicet (generatio) simplex et (generatio) secundum A

eratio simplex est generatio substantie et generatio secundum quid est generatio accidentis. Sic est de corruptione. In predicamento qualitas reperitur motus proprie dictus qui dicitur alteratio. Unde alteratio est transmutatio ab una qualitate in aliam eodem subiectum manente a principio usque in finem. Cuiusmodi est calefactio, frigefactio, albefactio et consimiles. In alteratione est una successio quia in alteratione est resistentia que causatur a qualitate contraria qualitati inducende.

In predicamento quantitatis reperiuntur due species motus proprie dicti, scilicet augmentatio et diminutio. Augmentatio est motus de minore quantitate ad maiorem quantitatem. Diminutio est e converso. [50r] Ad veram augmentationem tria requiruntur. Primum est quod subiectum recipiens illam augmentationem maneat a principio usque ad finem talis augmentationis. Secundum est quod quelibet pars aucti sit aucta. Tertium est quod illa augmentatio fiat per aliquod corpus de novo adveniens. Et si deficiat aliqua istarum trium conditionum, non est augmentatio proprie dicta. Et sic de diminutione. Ideo nulla augmentantur nisi animalia vel animata. Ideo, si inanimata augmentur, hoc non est proprie, scilicet quanto rarefiunt vel condensantur. Rarefactio est partium remotio inter se sine aliqua novi corporis acquisitione. Nam rarum est tale, cuius partes remote iacent ut Philosophus ponit in *Predicamentis* capitulo *De qualitate*. Condensatio est partium ad invicem constrictio, vel comprehensio sine alicuius corporis deperditione. Nam condensum est tale cuius partes propinque iacent ut patet in *Predicamentis*, capitulo quinto.

Quantitas dicitur duobus modis, scilicet quantitas continua et quantitas discreta. Quantitas continua est cuius partes copulantur ad terminum communem et tales sunt quinque, ut patet in*Predicamentis* in capitulo *De quantitate*, scilicet linea, superficies, corpus, locus et tempus. Linea est longitudo sine latitudine et profunditate cuius extrema sunt duo puncta. Superficies est longitudo et latitudo sine profunditate cuius extrema sunt due linea. Corpus est quoddam longum, latum et profundum cuius extrema sunt due superficies. Ideo de numero istorum solum corpus est perfectum quia sibi non deficit aliqua dimensio. Tres sunt dimensiones, scilicet longitudo, latitudo et profunditas. Locus est ultima superficies corporis continentis locatum. Tempus est mensura motus secundum prius et posterius prout ab anima mensuatur ut habentur in quarto *Physicorum*, capitulo *De tempore*. Quantitas discreta est talis cuius partes ad nullum terminum communem copulantur, et tales sunt due scilicet numerus et oratio. [50v] Numerus est quadam quantitas discreta resultans ex collectione unitatum ad invicem. Oratio est vox significativa etc. Tempus et motus dicuntur res successive. Unde est quedam res permanens et quedam successi totova. Res permanens est talis cuius omnes partes permanent simul in actu cum suo toto, ut homo, domus et huiusmodi. Nam quelibet pars domus manet simul in actu cum tota domo. Res successiva est illa cuius non omnes partes manent simul in actu cum suo toto, ut dies, hora et huiusmodi. Nam

41 Sic: Similiter A 42 [Alteratio] Pc de] ab Pc [Alteratio] Pc 43 (subiectum manente) A usque] in: ad A 47 [Augmentatio] Pc [Diminutio] Pc 48 Diminutio] non *add.* A 52 sic: similiter A 53 (vel animata) A 54 hoc non est] in *add.* A condensantur: condenpsum A [Rarefactio] Pc 57 [Condensatio] Pc 58 condensum: condenpsum A ut patet] utque *add.* Pc 60 [Quantitas continua] Pc (quantitas) continua et (quantitas) discreta A 61 ad] (..?..) A 62 (in) A [Linea] Pc 63 sine] (et) Pc 64 [Superficies] Pc latitudo et longitudo *inv.* A 65 [Corpus] Pc 67 [Dimensio] Pc Dimensiones sunt tres *inv.* A 68 [Locus] Pc [Tempus] Pc 70 [Quantitas discreta] Pc 71 [Numerus] Pc [Oratio] Pc 73 (etc) A 74 [permanens] Pc (totova) A 76 [Successiva] Pc

non quelibet pars dici esse simul in actu cum die. Nam existente prima hora diei dies est, sed tunc secunda hora non est. Et, tamen esse talius successivorum est simul cum eorum fieri, unde bene sequitur 'dies est in fieri, ergo dies est'. Sed esse permanentium presupponit eorum fieri, unde prius est domus in fieri quam in facto esse. Unde non sequitur 'domus est in fieri, ergo domus est', sed potius sequitur oppositum. Nota quod punctus est quoddam indivisibile in linea ad quem terminantur partes linea. Puncta extrinseca vocantur in linea omnia puncta prilicet primi et ultimi, scilicet primus et ultimus, vel extrema que eadem sunt.

Puncta intrinseca in linea vocantur oratio puncta inter extrema. Sic est de instanti respectu temporis. Nota etiam quod non sunt plura puncta in linea centis pedali quam in linea bipedali. Ymmo, tot sunt in linea minori quot sunt in linea maiori, et in qualibet linea quantumcumque modica sunt infinita puncta, et nullum infinitum est alio infinito maius ut minus. Nec aliqua infinita sunt aliis infinitis plura nec panciore.

In predicamento ubi reperitur motus proprie dictus qui dicitur loci mutatio vel motus localis quod idem est. Motus localis est motus de uno loco in alio eodem subiecto manente a principio usque ad finem. [51r] Iste motus solum competit corporibus ut habetur per Auctorem *Sex principiorum*, capitulo *De actione* ubi dicit sic: Solus corpus est quod de loco in locum transit et movetur. Corpus dicitur duobus modis, scilicet corpus simplex et corpus mixtum. Corpus simplex est tale quod non componitur ex contrariis ut elementa que solum componuntur ex materia prima et forma elementali. Materia prima est maxime simplex que non componitur ex materia et forma priori. Unde materia est illa quod est prima materia corporis et ultima via resolutionis, et est in potentia ad omnes formas, et nullam determinat sibi certam.

Corpus mixtum est illud quod componitur ex contrariis et ex elementis, et vocatur etiam corpus elementatum, ut lapides, et alia huiusmodi. Adhuc corpus mixtum dicitur duobus modus, nam quoddam est animatum, quoddam inanimatum. Corpus inanimatum est illud quod non actuatur per aliquam animam ut aurum, lapis et huiusmodi. Corpus animatum est cuius forma per quam actuatur est anima, et hoc potest esse tripliciter. Aut eius forma per quam actuatur est anima vegetativa, et sic est arbor, vel herba, et huiusmodi. Aliomodo cuius forma est anima sensitiva, et sic est asinus, vel equus et huiusmodi. Tertia cuius forma est anima intellectiva et sic est homo.

Sex sunt differentia positionis, scilicet sursum, deorsum, dextrorsum, sinistrorsum, ante et retro. Unde omne quod movetur motu recto aut monetur sursum aut retrorsum aut sinistrorsum, aut dextrorsum, aut antrorsum aut retrorsum. Unde omne corpus corruptibile naturaliter movetur solum secundum unam differentiam positionis, et hoc loquendo de natura elementi. Et hoc est verum tam de corpore simplici quam de corpore mixto, tam de animato quam de inanimato. Nam ignis est corpus simplex et movetur naturaliter versus sursum, et terra ver[51v]sus deorsum et inmista animata moventur versus unam differentiam positionis. Omne mixtum movetur ad motus el-

83 Punctum Pc 84 (prilicet) A 86 instanti: instans A 87 resptu: respectu Pc 90 ut: vel A 92 [Motus localis] Pc alio] loco add. A 94 sic dicit *inv.* A [Corpus] Pc 97 [Materia prima] Pc 99 materia] prima add. Pc, A materia corporis: via compositionis A 101 mixtum est: mixtum vocatur A 102 [Corpus elementatum] Pc lapides] ligna *add.* A 103 animatum] et *add.* A 103–104 [Inanimatum] Pc 104 aptuatur: actuatur Pc animam ut: formam seu animam A 105 [Animatum] Pc 106 [Vegetativa] Pc (vel) A 107 Aliomodo: Aut A (cuius) A [Sensitiva] Pc 108 Tertia: Aut A (cuius) A [Intellectiva] Pc 109 [Positio Pc 110–111 retrorsum: deorsum A 112 [Corruptibile] Pc 114 [Ignis] Pc 115 [Terra] Pc 116 [Mixtum] Pc

ementi dominantis in eo, ut mixtum in quo dominatur ignis movetur ascendendo et mixtum in quo dominatur terra, movetur descendendo, et sic de mixto animato. Nam animalis secundum quid est grave, movetur versus deorsum solum naturaliter loquendo de natura elementi. Tamen de natura animalis animal est mobile versus diversas differentias positionis. Unde omne corpus quod movetur movetur proportione potentie ad suam resistentia. Unde resistentia est duplex scilicet resistentia intrinseca et extrinseca. Resistentia intrinseca est illa que est in re mota, et causatur ex compositione contrariorum. Et illa resistentia invenitur in corporibus mixtis et non in simplicibus. Unde si sit mixtum ex igne et terra, in quo dominatur terra, tunc illum mixtum movetur versus deorsum. Tamen non movetur illa velocitate sicut movetur terra per se quia ignis in illo mixto qui contrariatur illi terre, nititur moveri motu contrario motui illius mixti resistendo in quantum potest, et ista est resistentia intrinseca.

Resistentia vero extrinseca est illa que est extra res motam et causatur ex difficultate divisionis medii ut aeris vel acque et huiusmodi, ut si mixtum movetur et descendat, tunc difficultas seu densitas aeris sibi resistit extrinsece, et elementum sibi dominans resistit intrinsere. Unde si mixtum movetur in pleno, vel in medio (quod idem est) illud movetur ex proportione potentie ad suam resistentiam extrinsecam quia corpus simplex non habet resistentiam intrinsecam.

Sed si imaginaretur aliquod vacuum et mixtum movetur in illo vacuo, moveretur ex proportione potentie ad resistentiam intrinsecam solum. Sed simplex in vacuo non posset moveri quia nullam resistentiam haberet. Motus localis [52r] dicitur duobus modis, scilicet modus naturalis et motus violentus. Motus naturalis est ille motus qui procedit a principio rei intrinsece ut descensus terre et ascensus ignis. Motus violentus est ille qui a principio rei extrinsece causatur ut si terra iactaretur versus sursum ille ascensus est motus violentus. Motus naturalis tempore intenditur versus finem sic quod in quolibet instanti posteriori est motus velecior quam in instanti priori. Motus violentus semper remittitur versus finem id est: fit tardior. motus rectus est motus mediante quo motu describitur linea recta et est motus elementorum existentium extra loca sua naturalia. Motus circularis est ille motus, mediante quo describitur linea circularis ut motus celi. Nota quod nullus motus potest esse perpetuus nisi motus circularis. Tria requiruntur ad veritatem motus scilicet unitas motoris, unitas mobilis, unitas temporis. Motus reflexus non potest esse unus motus, nec continuus cum inter omnes motus contrarios cadat pars media, et omne quod movetur successive movebatur et movebitur, ita quod non est dare primum instans motus successivi, nec ultimum et ideo generaliter si Sortes incipit moveri per remotionem de presentio et positionem de futuro. Similiter si desit moveri, desit per remotionem de presenti et remotionem de futuro. Et omnis motus successivus est temporalis et mensuratur tempore. Sed motus subitus est qui per instans mensuratur, et ideo talium est dare primum instans et ultimum.

Gradus summus est ille gradus qui non est mixtus cum suo contrario, et est ita intensus in eius natura quod nullus gradus illius nature est illo intensior continens sub

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121 movetur] movetur *add.* Pc 122 [Resistentia] Pc intrinseca resistentia *inv.* A 124 si(c) Pc 125 illum: illud A 126 (non) A 127 moveri] moveri Pc 129 vero: autem A 133 [Simplex] Pc 137 [Motus localis] Pc 138 naturalis] tempore *add.* Pc est: esset A 139 (Motus) violentus A 143 [Rectus] Pc motus: ille A 145 [Circularis] Pc ille] (motus) A 146 [Nota] Pc circularis] nota quod *add.* A 147–148 [Reflexus] Pc 150 ulti: ultimum Pc 151 [Ipse incipit moveri] Pc 153 [Successivus] Pc [Subitaneus] Pc subitus: subit(ane)us Pc 156 eius] (siam) Pc [Gradus] Pc

naturaliter omnem gradum possibilem illius nature ut gradus summus albedinis est ille gradus qui nullo modo est inmixtus cum nigredine. Nam gradus summus est pura privatio albedinis sicut nigredo summa que [52v] nichil habet albedinis latitudo albedinus est tota natura albedinus continens in se omnes gradus albedinus dispositos secundum remissius et intensius a non gradu albedinus usque ad gradum summum, et sic est de aliarum qualitatum latitudine unde in omni latitudine sunt infiniti gradus, sic in omni tempore sunt infinita instantia, et inter omnes duos gradus cadit latitudo media, sicut inter quecumque duo instantia cadit tempus medium.

Unde gradus dicuntur intensi vel remissi penes participationem cum suis contrariis secundum magis et minus. Ideo albedo dicitur intensa eo quod modicum habet de suo contrario secum admixto, et dicitur remissa eo quod multum habet. Unde, si sunt duo gradus qualitatis puta albedinis, tunc quanto magis unus illorum habet de nigredine sibi admixta quam alter eorum. Tunc illa est remissior quam alia, et quanto minus habet tanto dicitur intensior. Et si nichil habeat de suo contrario, dicitur intensissima vel summa, quod idem est.

Alio modo dicuntur gradus intensi vel remissi penes propiequitatem a non gradu. Unde gradus dicitur intensus quia per magnam distantiam distat a non gradu, et dicitur gradus remissus eo quod per modicam distantiam distat ab non gradu, est dicitur intensior gradus ille qui per maiorem latitudinem distat ab non gradu. Et dicitur gradus remissior qui per minorem latitudinem distat a non gradu. Sed quilibet gradus quo aliquis gradus est remissior, dicitur intensus. Ideo quilibet gradus inter non gradum et summum aliquis est gradus intensior et aliquis remissior. Nullus est gradus intensus inter non gradum et summum, quin ille sit intensus et remissus, et gradus summus est intensus et non remissus.

Intendere est per aliquam latitudinem gradum perfectiorem [53r] adquirere. Remittere est per aliquam latitudinem gradum perfectiorem deperdere. Intendere adhuc aliquem gradum est duplex, scilicet inclusive et exclusive. Intendere aliquem gradum inclusi est per latitudinem mediam illum gradum acquirere. Intendere ad aliquem gradum exclusive est latitudinem mediam acquirere terminatam ad illum gradum non acquirendo illum gradum. A non gradu intendere est pura privatione illius qualitatis aliquem gradus acquierere.

Remittere ad aliquem gradus est duplex scilicet exclusive et inclusive. Inclusive remittere ad aliquem gradum est totam latitudinem suam et illum gradus habitus dependere et infimum. Illius remissionis secundum illum gradum non existere. Remittere ad aliquem gradum exclusive est totam superficiem, vel latitudinem graduum deperdere non deperdens illum gradum et sub illo infimum remissionis existere secundum illum gradum. Remittere est totam latitudinem usque ad puras privationes illius qualitatis deperdere.

Intendere ad aliquem gradum sive inclusive sive exclusive est dupliciter scilicet uniformiter et difformiter. Uniformiter intendere motum est tantam latitudinem acquirere in una parte temporis, sicut in alia sibi equali. Difformiter intendere est maiores latitudinem deperdere in una parte temporis quam in alia sibi equali. Difformiter remittere

159 summa] est *add.* A [Latitudo] Pc 161 intencius: intensius Pc 162 latitudine] unde in omni latitudine *add.* Pc 168 gradus] ille *add.* A 169 (eorum) A 172 (p) Pc 174–175 gradus intensior *inv.* A 175–176 remissior gradus *inv.* A 176 Sed: Unde A quo gradus *inv.* A 181 [Intendere] Pc 181–182 [Remittere] Pc 191 latitudinem vel superficiem *inv.* A

est maiorem latitudinem deperdere in una parte temporis quam in alia sibi equali. Uniformiter remittere est tantam latitudinem deperdere in una parte temporis quam in alia. Unde si quis intendat motum suum sive uniformiter, sive difformiter, sive remittat motum suum, sive uniformiter sive difformiter movetur difformiter et non uniformiter. Nam qui uniformiter movetur continue eodem gradu motus movetur nec acquirendo latitudinem, nec deperdendo sicut in aliqua sibi equali. Sed quicuiusque intendit vel remittit [53v] motum suum, acquirit vel deperdit latitudinem motus, et sic aliquando movetur gradu intensiori aliquanto aliis remissiori. Ideo quicumque intendit vel remittit motum suum difformiter movetur et non uniformiter.

Ad hoc quod aliqua sint activa et passiva ad invicem duo requiruntur. Primum est quod illa sint similia quoad materiam, et sint communicative in materia. Secundum est quod illa sint contraria quoad formam, et quod forme earum sint contraria. Unde ad actionem requiritur similitudo materiarum et contrarietas formarum. Ad hoc quod sit actio, requiritur dominium agentis supra suum passum, et qui patiatir ab ipso agente. Unde omne agens se habet ad suum passum a proportione maioris inequalitatis et requiritur quod forma agentis excedat resistentiam illum passi. Proportio dividitur in proportionem maioris in equalitatis et in proportionem minoris inequalitatis.

Proportio maioris inequalitatis est habitudo maioris qualitatis ad minorem, ut duo ad unum. Proportio minoris inequalitatis est habitudo minoris quantitatis ad maiorem, ut duo ad quattuor. Proportio equalitatis est habitudo duarum qualitatum equalium ad invicem ut quattuor ad quattuor. Sed solum ex proportione maioris inequalitatis provenit motus vel actio. Aliquid potest agere in aliquid dupliciter, scilicet ex proportione totius ad totum vel ex proportione totius ad partem. Tunc agens agit in passum ex proportione totius ad totum quando totum agens agit in passum totum, et sic agit maius in minus, et hoc proprie vocatur agere vel actio. Tunc agens agit in partem passi ex proportione totius ad partem quando non dominatur supra totum passum, sed supra aliquam eius partem, quia tunc est actio ex proportione totius agentis ad illam partem passi, et hoc vocatur reagere vel reactio, et talis reactio invenitur inter magis et minus et inter due inequalia.

Similiter aliquid potest pati dupliciter, scilicet secundum se [54r] totum et secundum partes suas, et tunc dicitur repati, et sic omne agens communicam cum passo in agendo repatitur. Unde partes elementales sunt active et passive, sed omnia elementa in suis speris sunt equalis virtutis. Ideo inter elementa in suis speris est reactio et passio, et continue agunt ad invicem et patiuntur secundum partes immediatas.

Quattuor sunt elementa, scilicet ignis, aqua, aer et terra. Quattuor sunt qualitates primes : caliditas, humiditas, frigiditas et siccitas, secundum quarum combinationes resultat numerus elementorum naturalium. Sex sunt combinationes qualitatum primarum, quarum due sunt impossibiles et tantum quatuor sunt combinationes possibiles earundem, et quot sunt combinationes qualitatorum primarum possibiles, tot sunt elementa, et sic investigantur a Philosopho in libro *De generatione et corruptione*. Quod tantum sunt elementa quattuor proprie. Prima combinatio est calitas et siccitas, cui combinationi correspondet ignis. Est namque ignis calidus et siccus, in quo caliditas se

199 maiorem: tantam A alia] sibi equali *add.* A 204 sic] (el P) 206 intensiori] aliquanto *add.* (vel) Pc 208 [Activa] Pc [Passiva] Pc qui] passum add. A 212 ab ipso agente: a suo agentis A 213 [Proportio] Pc 217 aiorem: maiorem Pc 218 quatuor: quattuor Pc 219 solum: tamen A 226 reactio: actio A 230 [Elementales partes] Pc 233 Quatuor: Quattuor Pc [Elementa] Pc [Qualitates] Pc 234 primes] scilicet *add.* A [Combinationes] Pc 240 [Ignis] Pc

habet in predominio ad aliam. In omni namque elemento sunt due qualitates, quarum una se habet in predominio ad aliam. Secunda combinatio est caliditas et humiditas cui correspondet aer, qui est calidus et humidus, in quo dominatur humiditas. Tertia combinatio est humiditas et frigiditas cui correspondet aqua, que est frigida et humida in qua dominatur figiditas. Et quartum combinatio est frigiditas et siccitas, cui correspondet terra, que est frigida et sicca, in qua dominatur siccitas. Quinta combinatio est caliditas et humiditas <sic>, et isti non correspondet aliquid elementum quia ista combinatio est impossibilis quia caliditas et frigiditas sunt qualitates contrarie, et qualitates contrarie non possunt esse simul vere eidem, et hoc denominative. Sexta combinatio est humiditas et siccitas, et isti combinationi non correspondet aliquod elementum propter causam predictam, ut patet in sequenti figura. [54v] <*figura in textum*: ignis, siccitas; terra; aqua, frigiditas>.

Ignis est elementum nobilissimum, rarissimum, levissimum, subtilissimum. Ideo collocatur in supremo loco regionis elementalis, scilicet in concavo orbis lune, et sub igne inmediate est aer, et sub aere est aqua, et sub aqua est terra, quod est elementum gravissimum et vilissimum. Ideo collacatur in infimo loco. Similiter est ignis decuplo maioris quantitatis quam aer, et in decuplo rarior. Ideo aer est in decuplo maioris quantitatis quam terra, et ideo est rarior illa et aqua est in decuplo maioris quantitatis quam terra et ideo est maior illa. Unde elementum in quanto est maioris quantitatis, in tanto est rarius, et in quanto minoris quantitatis tanto densius est.

Quedam sunt elementa Symbola, et quedam dissymbola. Illa sunt elementa symbola que conveniunt in aliqua qualitate prima ut ignis et aer, aer et aqua, aqua et terra et ignis. Elementa dissymbola vocantur illa quem nulla qualitate prima conveniunt, ut ignis et aqua, aer et terra. Inter elementa symbola facilis est artio, ut patet in libro *De generatione*.

Elementa sunt corpora homogenia. Corpora homogenia sunt illa: quorum omnes partes sunt eiusdem nature, et eiusdem nominis cum suis totis, ut elementa, nam quelibet pars aque est aqua, et sic de aliis elementis. Alia corpora vocantur etherogena, quorum non omnes partes sunt eiusdem nominis, sive rationis, cum suis totis ut Sortes, homo, asinus, leo et sic de aliis, nam non quelibet pars hominis est homo etcetera. De numero qualitatum primarum quedam dicuntur active, et quedam passive, sicut caliditas et frigiditas, et quedam passive sicut siccitas et humiditas, et sic de elementis in quibus predominantur. Non tamen dicuntur active, quia non sint passive, quia hoc est falsum sed sunt principliter active, et ex [55r] contingenti passive, et sic de aliis.

Qualitates prime sunt ille ex quibus resultant omnes alie, et non ille ex aliis non resultant. Qualitates secunde sunt ille que resultant ex certa proportione primarum ad ininitem, ut albedo, nigredo, amaritudo, dulcedo, etcetera, quarum quelibet sunt uniformes vel difformes, sicut et prime. Qualitas uniformis est illa cuius quelibet pars est eque intensa cum suo toto, ut si sit qualitas uniformis, tunc nulla pars illius est intensior

243 [Aer] Pc 244 [Aqua] Pc 246 [Terra] Pc 247 humiditas: frigiditas Pc 249 simul in esse *inv.* A (vere) A eidem] natura *add.* A 251 sequenti figura: figura primum A <*Square of elemental opposition. Not completed* P> 254 supremo] gradu seu *add.* A 256 ignis est *inv.* A 257 quam] (terra A) aer, et] ideo est *add.* A 261 [Elementa] Pc [Symbola] Pc [Dissymbola] Pc 262 aqua] aqua add. Pc 266 [homogenia] Pc 268 aqua] et sic add. Pc [etherogena] Pc etrogena: etherogena Pc 270 leo] et sic de aliis add. Pc sic de aliis: similia A 275 [Qualitates] Pc Qualitates prime] De numero qualitatum primarum quedam dicuntur active et quedam passive ut dictum esse et *add.* A ille non inv. A aliis] (non) A 277 etcetera] de aliis add. A

altera alica tamen in qualitate uniformi una pars est maior alia, sed non intensior. Unde non eadem de causa una albedo dicitur intensior alia albedine, et maior alia, nam albedo dicitur inferior alia, quia per maiorem latitudinem distat a suo non gradu, sed albedo dicitur maior alia que per magis extendit subiectum quam in alia. Unde intensio qualitatis est ratione distantie a suo non gradu, sed magnitudo qualitates est ratione subiecti. Unde intensum et remissum sunt proprie differentis qualitatis. Ideo qualitas dicuntur intensa vel remissa per se. Sed magnum et parvum sunt proprie differentis qualitatis proprie. Ideo quantitas dicitur magna et parva per se ratione sine dimensionis. Tamen aliquando qualitas magna et parva, sed non est per se, sed per accidens, quia ratione alterius, puta subiecti, vel qualitatis. Et quantitas etiam dicitur intensa et remissa, non tamen per se, sed per accidens, quia ratione alterius, puta qualitatis.

Qualitas difformis est talis cuius una pars est intensior alia. Qualitas difformis est duplex, scilicet qualitas uniformiter difformis et qualitas difformiter difformis. Sed qualitas difformiter difformis est talis cuius alique partes que sunt immediate secundum extensionem multum distant secundum intensionem [55v] id est cuius partes quia terminantur ad eundem punctum in quantitate et non terminantur ad eundem gradum in qualitate, ut si 'a' sit unum corpus cuius una medietasit alba gradu summo secundum se totam et alia medietas sit alba gradu medio, inter gradum medium et gradum summum secundum se totam. Tunc est tota albedo difformiter difformis, et hoc corpus album est difformiter difforma cuius alique partes secundem extensionem vel secundem quantitatem non distant, quia terminantur ad eundem punctum, puta ad punctum medium ipsius, et tamen ille medietates multum distant secundem intensionem vel secundum qualitatem, quia non terminantur ad eundem gradum albedinus. <figura uniformis marginalis>. Aliqua duo esse immediata dupliciter dicuntur secundum extensionem et secundum intensionem. Illa sunt immediata secundum intensionem, que terminantur ad eundem gradum in qualitate. Illa dicuntur esse immediate secundum extensionem que terminantur ad eundum punctum ub quantitate. Qualitas uniformiter difformis est illa cuius omnes partes sunt immediate secundum extensionem, et sunt immediate secundum intensionem que terminantur ad eundem gradum, et gradus ille ad quem sic terminantur est intensus magis, quia non est in parte intensiori et remissus minus. Quia non est in parte remissiori. Nam ille gradus ad quem terminantur tales partes immediate non est in parte intensiori et quilibet intensior illo est in parte intensiori. Ideo ille est intensissimus que non est intensior ille qui est in parte remissiori circa centrum, ideo est remissior qui non est in parte remissiori. Et etiam omnis qualitas uniformiter difformis terminatur ad duos gradus quorum neuter est summus, terminatur ad unum gradum secundum extremum sui intensius,et ad aluim gradum secundum extremum sui remissius. <quinque figure marginalie : uniformiter difformiter /ignis, aqua, terra, aer/ a:b>. Ideo [56r] ad quem terminatur talis latitudo secundum extremum intensius, dicitur remissius qui non est in illa latitudine et quelibet remissior illo circa centrum est in illa. Et ille gradus ad quem terminatur secundum extremum remissius dicitur remissius qui non est in illa latitudine. Quelibet qualitas uniformiter difformis terminatur

280 (alica) A 282 inferior: in repsio A 284 distantie: substantie A 285 proprie sup. Pc 288 aliquando: aliis A qualitas] dicitur *add.* A 299 difformis: difforma P 302–303 diagram in margin, inscribed 'uniformis' Pc, *not in* A 314 gradus] quoddam gradus exclusive vel ad gradum vel ad non. Unde qualitas latitudo terminata ad duos gradus add. Pc 315 intensius: remissius A 315–316 (et ad aluim . . . remissius) A 316–317 [quinque figure marginalie: uniformiter difformiter /ignis, aqua, terra, aer / a:b] Pc, *not in* A

ad gradus ad quos terminatur exclusive. Sed qualitas difformiter difformis aliquando terminatur ad gradum exclusive, et aliquando inclusive. Sed qualitas uniformis non terminatur, sed potuis terminat, quia qualitas uniformis se habet per modum termini. Quelibet qualitas uniformiter difformis sive latitudo quod idem est correspondet gradui suo medio, et erit equalis intensionis cum suo medio gradu, et minus intensa quam medietas eius intensior, et minus remissa quam medietas eius intensior. Unde latitudo a gradu ad non gradum est equalis intensionis cum qualitate uniformi, ut quatuor ad tria et sic de aliis.

Motus dicitur duobus modis, scilicet motus uniformis et motus difformis. Motus uniformis est ille qui in omnia tempore equali equale pertransit spacium. Unde moveri uniformiter est tantum de latitudine spacium pertransire in una parte temporis quantum in alia sibi equali. Motus difformis est quando in tempore equali pertransit spacium inequale. Moveri difformiter est plus de spacio pertransire in una parte temporis quam in alia sibi equali. Motus difformis est plus de spacio pertransire in una parte temporis quam in alia sibi equali. Motus difformis est duplex, scilicet motus uniformiter difformis et motus difformiter difformis. Motus uniformiter difformis est ille quo uniformiter acquiritur latitudo motus vel uniformiter deperditur latitudo motus. Moveri uniformiter difformis est uniformiter acquirere latitudinem motus. Motus [56v] difformiter difformis est ille quo acquiritur difformiter latitudo motus ut difformiter deperditur latitudo motus. Ideo moveri difformiter difformis est difformiter acquirere latitudinem motus, vel difformiter deperdere latitudinem motus. Et quot modis dicitur motus, tot modus dicitur intensio, et etiam remissio motus. Sicut motus se habet ad spatium extra se, sic se habet intensio motus ad latitudinem motus, quia sicut per motum acquiritur spacium extra se sic per intensionem motus acquiritur latitudo eius motus. Ideo intentio motus est acquisitio latitudinis motus, et intendere motum est acquirere latitudinem motus.

Remissio motus est deperditio latitudinis motus, et remittere motum est deperdere latitudinem motus. Ideo intensio dicitur duobus modis scilicet uniformiter et difformis. Intentio motus uniformis est quando in tempore equali aquiritur motus equalis. Intendere motum uniformiter est tantum de latitudine motus acquirere in uno tempore sicut in alio equali sibi. Uniformis remissio est illa in qua tempore equali latitudo motus equalis deperditur. Ideo remittere motum uniformiter est tantum de latitudine motus deperdere in uno tempore sicut in alio sibi equali. Intensio motus difformis est illa qua in tempore equali latitudo motus acquiritur inequalis. Unde intendere motum difformiter est plus de latitudine motus acquierere in una parte temporis, quam in alia sibi equali. Remissio difformis est illa qua in tempore equali latitudo motus deperditur inequalis. Unde remittere motum difformiter est plus de latitudine deperdere in una parte temporis quam in alia sibi equali.

Intensio uniformiter difformis est illa qua in tempore equali latitudo motus intensioris acquiritur inequalis. Uniformiter difformis intendere motum est tantum plus de latitudine intensioris. <due figure marginalie>. Intensioris motus acquirere in uno tempore quam in alio sibi [57r] equali. Remissio uniformiter difformis est illa qua in

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321 aliquando: aliis A 322 (terminatur ... aliquando) A 325 gradu medio *inv.*A 329 [Motus] Pc scilicet] (motus) A et] (motus) A 332 Motus] (non) A 334 Motus difformis est plus de spacio pertransire in una parte temporis quam in alia sibi equali sup. Pc 335 equali sibi) *inv.* A 342 remissio] motus *add.* A 359–360 intensioris] motus *add.* Pc 361 intensioris *sup.* Pc <*due figure marginalie*> P intensioris] motus *add.* A

tempore equali latitudo motus intensioris deperditur inequalis. Unde remittere motum uniformiter difformem est plus de latitudine intensioris deperdere in uno tempore quam in alio sibi equali. Intentio difformiter difformis est illa qua in tempore equali latitudo intensioris motus acquiritur inequalis. Unde difformiter difformis intendere motum est plus de latitudine motus intentionis acquierere in una parte temporis quam in alia sibi equali. Remissio difformiter difformis est illa in qua equali tempore latitudo intensioris motus deperditur inequalis. Unde difformiter difformis remittere motum est plus de latitudine intensionis motus deperdere in una parte temporis quam in alia sibi equali. Et adhuc aliquid moveri uniformiter est duplex, scilicet quoad tempus, et quoad subjectum. Illud movetur uniformiter quoad tempus cuius punctus velocissimi motus uniformiter movetur, et illud movetur uniformiter quoad subjectum cuius quelibet pars movetur eque velociter cum suo toto. Et sic est difformiter moveri, et solus motus succesivus est velox vel tardus. Motus subitaneus non est velox, nec tardus.

Quatuor modi dicitur causa, scilicet causa materialis, causa formalis, causa efficiem, causa efficiem finalis. Causa materialis est illa qua componitur res et manet in re. Unde causa materialis et materia idem sunt. Causa formalis est illa per quam res est talis, qualis ipsa est, qua posita ponitur una res, qua ablata aufertur res. Causa efficiens est illa que componit et efficit eandem. Causa finalis est illa propter quam fit res illa primo et principaliter ut ligna et lapides sunt causa materialis domus et figure resultant ex compositione partium ad intrincem est causa formalis domus. Ipse carpentarius est causa efficiens domus. Sed servatio compositorum a nocivis extra scilicet ab ymbribus, frigoribus et huiusmodi, est causa finalis domus. Due illarum sunt cause intrinsece scilicet materialis et formalis, et due extrinsece, scilicet [57v] efficiens et finalis. Unde primo Physicorum traduntur tria principia intrinseca rerum naturalium, scilicet materia, forma et privatio sed prima si duo sunt per se, tertium per accidens.

Corpus columnarum est longum figuratum ad modum columne et ad modum postis. Corpus piramidale vel piraminon est corpus figuratum ad modum piri cuius extremum est acutum, et dicitur corpus piramidale extremum obtusum, et vocatur basis. Corpus circulare est illud spericum rotundum in cuius medio est unus punctus a quo omnes linee ad circumferentiam sunt equales, et ille punctus vocatur centrum spere, vel circumferentia circuli vel spere et est extrema superficies illius extra quam non est illiud. Dyametrum circuli est una linea existens ab uno puncto circumferentie in punctum oppositum qui transiens per centrum dividit circulum in duos semicirculos. Dyametrum circuli est una linea recta existens ab uno puncto circumferentie in punctum oppositum. Semidyameter est linea recta triangularis vel triangulum corpus habens tres angulos vel tria latera. Corpus quaterlaterum vel quadrangulum est corpus habens quatuor latera equalia vel quatuor angulos. Corpus penthagonium est corpus habens quinque angulos vel latera. Corpus sexagonum est corpus habens sex angulos, et sic de aliis. Angelus rectus quando una linea recta perpendiculariter cadit supra lin-

364 intensioris] motus *add.* A 373 [Motus uniformiter] Pc 375 subitaneus: subitus Pc 376 [Causa] Pc 377 efficiem finalis *sup.* Pc 381 materialis domus] et figure resultant ex compositione partium ad intrincem est causa formalis domus add. Pc 385 [Materia] Pc [Forma] Pc 387 [Privatio] Pc sed . . . accidens: prime due sunt cause per se sed tertia est cause per accidens *add.* A 388 colupnarum: columnare Pc [Columnare] Pc 389 [Piramidale] Pc 390–391 [Basis] Pc 391 [Circulare] Pc illud] quod est *add.* A [Spericum] Pc 392 linee] ducte add. A [Centrum] Pc 393 [Circumferentia] Pc 394 [Diameter] Pc existens: exiens A 397 [Semidiyameter] Pc 398 [Quadrilaterum] Pc 399 [Penthagonum] Pc 400 [Sexagonum] Pc 401 [Angelus rectus] Pc

eam rectam. Angulus acutus est quilibet angulus minor recto. Corpus planum est illud cuius superficies est plana et nichil asperitas tenet ut tabula. Angulus obtusus vocatur quilibet angulus minor recto, nam cum aliquo alio aliquid fit. Forma est quedat esse rei et seruat eam in esse.

Quanta est proportio medii ad medium, tanta est proportio motus ad motum, et temporis ad tempus. Duplex est actus. Unus est ad esse, alius est qui est ad operari. Quare motus non potest esse in instanti propter incompossi-[58r]bilitatem terminorum quia termini motus non sunt compossibilis ut terminus a quo et terminus ad quem. Secunda ratio proprie limitationem rei vel mobilis que nominatur regula intrinseca quia licet non sit regula, semper est intrinseca. Ideo motus non potest esse in instanti. Nota quod instans est finis preteriti et initium futuri.

<quattuordecim figure marginalis:> corpus piramidale; corpus columnare; angulus; dyameter; angulus rectus; basis; angulus acutus; corpus circulare; penthagonum; angulus obtusus; corpus quadrangulare; angulus acutus.

Expliciunt termini naturales. Deo gracias.

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402 [Acutus] Pc [Corpus planum] Pc 403 [Obtusus] Pc 404 [Forma] Pc rei] (et servat eam in esse) A 407 [Acutus] Pc 408 [Instanti] Pc 410 una P: regula Pc 412 futuri.] Amen *add.* A 413–415 Fourteen drawn geometrical figures, inscribed : corpus piramidale; corpus columnare; angulus; dyameter; angulus rectus; basis; angulus acutus; corpus circulare; penthagonum; angulus obtusus; corpus quadrangulare; angulus acutus P, not in A 416 (Expliciunt termini naturales. Deo gracias) A

Appendix B

Transcription of diagram labels*

*With many thanks to Bert Bos, who helped me out with the illegible parts of the text.

B.1 Munich, *Staatsbibliothek*, Cod. lat. 527, f. 64v.

Bertold Blumentrost, Compilation of *De sensu, Questiones* etc. Dated 1350.
[*See* figure 4.7]

Legend : Ista est anathomia capitis pro medicos

Internal senses : sensus communis | fantasia | ymaginativa | cogitativa seu estimativa | memorativa primus cellula | secundus cellula | tertius cellula

External senses : visus | olefactus | gustus | tactus | auditus

Ducantur omnes linee post angulum occuli, et non ante visus nasum

B.2 Norrköping, *Stadsbibliotek*, cod. 426 fol., (my f. 62v).

Peter of Dresden, *Parvulus philsophie naturalis*. Fragment. Dated 1480.
[*See* figure 4.8]

On top : Sensus communis dicitur quia iudicat de speciebus vel de objectis omnium sensum exteriorum.

Cogitativa cognoscit substantiam particularem ut hec est vel agnus ex specie sensibili scilicet ex colore in lupo iudicat lupum esse inimicum.

Non est potentia passiva cui non correspondet activa prima celi.

Lucretius dicit quod fantasmata sunt in fantasia, sed beatus Thomas dicit quod sunt in sensu communi. Primum est probabilius.

Item Aristoteles dicit quod sensus communis sit situatus in corde. Sed Avicenna et Egidius dicunt quod in cerebro, et perceptiva in prima parte cellule prime.

Quidditas rei naturalis et facta autem (..?..) (..?..) autem prima intencio quidem idem est.

Intellectus { agens / possibiles } Divident (..?..)

Circles : Tres potentie separate

Voluntas sive liberum arbitrium. Caritas, iustitia, spes sunt ibi. Objectum bonum universale et bonum ad intellectum.

Intellectus possibilis fides, sapientia, intellectus, scientia, patiencia, ars, sinderesis, species intelligentes

Intellectus agens. Lumen.

Interior sense : Sensus communis appetitus concupiscibilis. Objectum bonum pure delectabile in quo sunt sex passiones scilicet amor, desiderium, delectatio, odium, fuga, tristitia et sex virtutes morales scilicet temperantia, liberalitas, philotimia, anteopolia, affabililitas et veracitas. Illa cellula est aque nature et ergo illa sensus nihil retinet.

Virtus ymaginativa. Species sensate.

Objectum sensibile per se sensatum in quam reservabile organum supra sinistrum oculum, et est ignee nature ergo bene retinet.

Cogitative vel estimative et appetitus irascibilis.

Virtus cogitativa elicit species elicitivas et iudicat aliquem esse amicum aut inimicum ex rebus sensatis.

Estimativa at memorativa ponuntur solum pro intentionibus, sed alii tres pro rebus sensibilibus.

Virtus memorativa.

Objectum sensibile per actus impressiones reservabile organum in prius sunt parte capitis et est ignee nature, ergo illa retinet interiores elicita et reservat ad longum tempus.

Lines in head : Objectum sensibile se per sensatum inquantum cognoscibile.

Intentiones

External senses : Visus : Visio fit per (..?..) per animam sensitivam tamquam per primum principium videndi (..?..) visivam tamquam per principium proprium oculum instrumentaliter. Speciem visibilem formaliter. Objectum color. Organum nervus opticus. Medium: aer, aqua.

Odoratus : Objectum odor. Organum: interior pars naris. Medium: aer, aqua.

Auditus : –

Gustus : Objectum sapor. Organum: interior pars lingua. Medium: cutis lingue et humor salivalis. In ore non fit digestio sed potius masticatio.

Tactus : Tactus per totum corpus. Objectum: quatuor qualitates prime. Organum vena contexta per totum corpus ad modum rethe. Medium: caro exterior.

Veins : Vena lata per quam retinetur cibus et potus in stomachum.

Vocalis arteria per quam intrat aer.

Organs : Stomachus qui est cocina cibi et potus in quo fit prima digestio.

Pulmo per aere refrigerat cor et est causa vocis.

Splen

Cor habet moveri secundum { gibbosus, id est extensionem / Concavum, id est constructionem

Virtus motiva sive vitalis a qua spiritus vitalis.

Multe venule proceduntur a iecore ad omnia membra per quas membra nutriunt<ur> (..?..)

Epar virtus naturalis sive nutritiva

B.3 BERLIN, *Staatsbibliothek*, THEOL.FOL.247, F. 248R.

Lambertus de Monte, *Copulata super libros De anima Aristotelis cum textu iuxta doctrinam doctoris sancti Thome de Aquino* or *Copulata circa VIII libros Physicorum Aristotelis cum textu iuxta doctrinam doctoris sancti Thome de Aquino*. Dated end 15th century.
[*See* figure 4.9]

Legend at the bottom : Caput physicum.

Sunt etiam multoplure in corpore quorum declaratio magis spectat ad medicos

Legend on top : Tres potentie separate:

Circles : Voluntas sive liberum arbitrium (..?..) in qua sunt iustitia, caritas et spes.

Objectum bonum universale est bonum intellectum.

Intellectus possibilis in quo } et { practicus / speculativus } objectum: quidditas rei naturalis ut facta verum intelligibile aut prima intentio quia idem sunt quodammodo

sunt sapientia prudentia intellectus scientia spes, sinderesis, fides, species intelligibiles.

Intellectus agens qui est lumen.

Objectum: quidditas rei naturalis in quantum factibilis

Interior senses : Organum sensus communis. Appetitusque concupiscibilis species sensate.

Objectum sensibile per se sensatum in quantum cognoscibile.

Objectum bonum particulare delectabilis in quo appetitu sunt sex passiones: amor, desiderium, delectatio, odium, fuga, tristitia, et sex virtutes morales sunt: temperantia, liberalitas, philotomia, enteopolia, affabilitas et veritas

Organum virtutis ymaginativa species sensate.

Objectum sensibile per accidens in quantum est sensabile (?).

Organum virtutis cogitative vel estimative sunt appetitus irascibilis. Interiores chete.

Objectum sensibile particularium in quantum cognoscibile.

Objectum bonum particulare ardum, in quo appetitu sunt quinque passiones scilicet timor, audacia, spes, desperatio, ira, et quattuor virtutes morales scilicet fortitudo, magnificentia, magnaminitas, mansuetudo.

Organum virtutis memorative intentiones elicite.

Objectum sensibile per se sensatum inquantum cognoscibile.

Exterior senses : Visus. Objectum: color et lumen. Organum: nervus opticus. Medium: aer, aqua.

Auditus. Objectum: sonus. Organum: aer connaturalis in meringa. Medium: aer et aqua.

Olefactus. Objectum: odor. Organum: interior pars narum. Medium: aer, aqua.

Gustus. Objectum: sapor. Organum: interior pars lingue. Medium: cutis lingue et humor salivalis.

Tactus. Objectum: quattuor qualitates: prime: calidum, frigidum etcetera. Organum: vena contexta per totum corpus ad modum retis. Medium: cutis.

Veins : Vena lata per quam cibus et potius crepit in stomachum.

Vocalis arterea per quam intrat aer.

Organs : Pulmo. Per aerem { est causa vocis / refrigerat cor

Stomachus qui est cocus cibi et potus a quibus ascendunt vapores ad caput et (..?..) (..?..) (..?..) fuerunt perturbans et generatur sompuus prima digestio.

Epar. Virtus naturalis sive nutritiva et etiam augmentativa et generativa. Secundo digestio. Objectum: (..?..), potentia, (..?..).

Cor habet moveri secundum { gibbosus id est extensionem / concavum id est constructionem

Virtus motiva sive vitalis a qua procedunt spiritus vitale. Tertia digestio.

Splen: quod plenus spectat ab medicos.

Multe venule proceduntur ab epate ad omnia membra per quam membra nitrituntur.

B.4 PRAGUE, *Universitní Knihovna*, IV.F.18, F. 143V.

Henricus Plattenberger, *Questiones de philosophia naturali*. 1449–1450.
[*See* figure 4.10]

In the heart : Cor seu sensus communis

cognitio | intellectio | sensatio | ymaginatio | estimatio | memoratio | fantasia | sensus communis

intentio | objectiva cognitio | elicicio | abstractio | discursus | compositio divisio | volicio | acceptatio | nolicio | refutatio

In the head : cerebrum | congregatio specierum | organum reservativum |

Channels : Appetitus per quem species interiores descen<dunt> a sensatione exteriori et veniunt ad cor descendendo.

Intentiones mediantibus quibus causantur sensationes per species respiratus, venula per quam ascendunt species.

External senses : Sensatio exterior | olefactus | gustus | tactus | nervus obticus <sic>.

Objectum: pyramidis.

Oculus.

B.5 UPPSALA, *Universitetbibliotek*, C. 629, F. 89V.

Peter of Dresden, *Parvulus philosophie naturalis*. Dated post 1482.
[*See* figure 4.11]

Above the figure : [701] *(manus 1)* Differentia inter voluntatem et velleitatem:

Velle dicitur habere voluntatem qui vult finem, et etiam habere media ad illum finem tendentia. Sed iste dicitur habere velleitatem qui vult finem sed non vult media tendentia ad illum finem. Si quis vult esse doctus sed tamen non vult se aggravari studio ut si fiat(?), iste habet velleitatem sed non volluntatem.

Differentia inter voluptatem et velleitatem.

Differentia est inter voluntatem et voluptatem.

Voluntas est medium adopte rei desiderum.

[701] (not part of the *Parvulus philosophie naturalis*)

Voluptas est rei concepte boni vel mali delectato.

Internal senses : Sensus communis | imaginativa retinet species | spiritis sensibiles | estimativa irascibilis et (..?..). Memoria retinet eas.

External senses : visus organum | organum odoris | auditus | gustus |organum tactus | est expansum per totum corpus.

Organs : stomachus | cor

Next to the posterior part of the brain : Naturalis philosophus. Et dicit quod sensus communis sit situatus in corde, sed Avicena et Egi dicunt in cerebro et precipere in prima parte prime cellulle.

Estimativa et memorativa ponuntur solum pro intentionibus

Memoria

Brutis, hominibus

Reminiscentia

Next to the eye : Visio sit per ocului instrumentaliter, per sensum visibilem formaliter

Below the figure : *(manus 2)* Maximianus. Dulce mori miseris sed mors optata recedit

non est habita nisi sine. (..?..) figura nisi,

per cuius vescendo percussimus (..?..) bibendo

egro (..?..) datur (..?..) se abstineatur

vel phisicus putat (..?..) de morte levatur

demisus esto (..?..) de (..?..) (..?..) misi

B.6 UPPSALA, *Universitetbibliotek*, C. 601, F. 2V.

John of Mechlin, Commentary on *De anima*. Dated post 1484.
[*See* figure 4.12]

Circles : Voluntas sive liberum arbitrium

Intellectus possibilis sinderesis intellectis (..?..) Qui (..?..) materialis est objectum

Intellectus agens

Internal senses : Sensus communis | Ymaginativa | Cogitativa | Memoria

External senses : Tactus est per totum corporis

Veins : Vocalis arteria

Vena per quam defereruntur cibi et potus in stomachum

Organs : Vena | Vena

Virtus naturalis est nutritia.

Epar. Secunda digestio et ab epate procedunt multe vene per quas deferuntur nutritia ad singula membra.

Stomachus est cocina cibi et potii ubi primus sit digestio.

B.7 LONDON, *Wellcome Historical Medical library*, MS. 55, F. 93R.

Peter of Dresden, *Parvulus philosophie naturalis*. 1473.
[*See* figure 4.13]

About the internal senses : *(manus 1)* Prima cellula anterioris partis capitis est organum sensus communis humide nature. Ideoque bene recipit, sed non diu servat. Hinc est quod sensus communis species sensibiles obiecto absente non servat.

(manus 2) Beatus Thomas dicit quod sensus communis sit situatus in corde quia tactus qui intrinsecus se communitatur. Sed Avicenna et Egi in cerebro et prima cellula, quia radix sensuum particularium qui omnes in capite fundantur in quo est cerebrum.

(manus 2) Secunda cellulla anterioris partis capitis organum est virtutis ymaginative que est sicce nature. Ideoque bene servat. Hinc est quod servat species sensibiles in objecti absentia.

(manus 1) Tertia cellula in medio capitis sita secundum quosdam est organum fantasie cuius est componere species in ymaginacione conservandas et est media inter ymaginationem et estimationem naturalem. Secundum alios vero distincta non ponitur.

(manus 2) Secundum Avicennam fantasiva est in fantasia. Secundum Thomam in sensu communi. Primum probabilius inest sensus fantasie, quia sensus est susceptivus sine materia, non tamen sine presentia sed fantasia sine anibobus.

(manus 1) In posteriori parte capitis prima cellula aquane (?) nature existens; ideo etiam non servat. Cuius autem officium est recipere intentiones speciorum sensibilium et est organum estimative sive cogitative potentie. In brutis enim dicitur estimativa, in homine cogitativa.

(manus 2) Estimativa et memorativa ponuntur solum propter intentionem. Alii tres pro rebus sensibilibus.

(manus 1) Ultima cellula est organum potentie memorative quia est sicce nature. Ideoque bene retinet. Est enim eius retinere intentiones specierum sensibilium, que potentie memorativa etiam vocatur ratio particularis.

About the external senses : *(manus 2)* Actiones sensus communis: percipere actionem sensuum exteriorum Diversa sensibilia diversorum sensuum apprehendere, inter sensibilia diversorum sensuum distinguere.

Organum auditus distantionale est auris, sed indistans est meringa quod in aure est quedam pellicula per modum follis se replens.

Organum visus est in oculo humor cristallinus in medio pupille nullum habens calorem ut omnes posse<t> recipere.Immediatum subiectum vi-

sus est organum corpus vero mediatum.

(manus 1) Organum odoratus sunt due caruncule in naso ad modum mamillarum capitis.

Organum gustus distans est caro porosa in lingua; indistans est quidam nervus protendens per totam linguam.

Organum tactus est quoddam rethe extensum per totum corporis et est perceptivum plurium, secundo *De generatione*; ergo est materialiter solum unus, et non formaliter quia Philosophus, secundo *De anima*, materialiter unus ratione organi, plures ratione formarum tangibilium.

Lines on the right : : *(manus 2)* Item, habemus plures sensus, quia sensibilia particularia sunt indeterminate in que fertur (?) sensus; intellectus cognoscit universale, quod terminatum est et unum intellectus, etiam quia spirituale perfectius est materiali.

Item, sensibile dicit uno modo actum, et sic ponitur cum sensu quia copulativa, et sensibile cum sensu, intelligibile cum intellectu. Aliter dicit aptitudinem, et sic non debet reduci in actum nec ponitur cum sensu quia multa sunt sensibilia que non sciuntur et scibilia que non sciuntur ut quadratura circuli sicut habet Philosophus in predicamento relationis [7 b 31].

Lines on the left : Hec ille qui habet sensus quinque habet exteriores sensus quinque et interiores.

Illud capud dicit statim sequi illum textum memorativa ponatur est et cetera.

Labels of organs : cor, stomachus, vesica

B.8 NORRKÖPING, *Stadsbibliotek*, COD. 426, NOT FOLIATED (MY F. 62R).

Peter of Dresden, *Parvulus philosophie naturalis*. Fragment. Dated 1480.
[*See* figure 4.14]

Lines on the left : Hec est ille qui sensus habet quinque interiores et exteriores.

About the internal senses : Prima cellula anterioris parte capitis est organum sensus communis humide nature ideoque bene recipit sed non diu servat. Hinc est quod sensus communis, species sensibilis objecto absente non servat.

Beatus Thomas dicit quod sensus communis sit situatus in corde quia tactus qui intrinsecus se communitatur, sed Avicenna et Egi in cerebro et prima cellule quia radix sensuum particularium qui omnes in capite fundantur in quo est cerebrum.

Secunda cellulla anterioris parte capitis est organum virtutis ymaginative que est sicce nature. Ideoque bene servat. Hinc

est quod servat species sensibiles in objecti absentia rei.

Tertia cellula in medio capitis sita secundum quosdam est organum fantasie cuius est componere species in ymaginacionem conservandas et est media inter ymaginationem et estimationema naturalem. Secundum alios vero distincta non ponitur.

Secundum Avicenna fantasiva est in fantasia. Secundum Thomas in sensu communi. Primum probabilius inest sensus fantasie quia sensus est susceptivus sine materia non tamen sine potentia sed fantasia sine anibobus.

In posteriori parte capitis prima cellula aque habite existens; ideo etiam non servat. Cuius autem officium est recipere intentiones speciorum sensibilium et est organum estimative sive cogitative potentie. In brutis enim dicitur estimativa in homine vero cogitativa dicitur.

Lutor causarum milla naturalis virtus reflectitur supra se ipsam sicut sensus potentias quare ponitur communis.

Estimativa et memorativa ponuntur solum propter intentionem. Alii secundum pro rebus sensibilibus.

Ultima cellula est organum potentie memorative quia est sicce nature. Ipsum que bene retinet. Est enim eius officium retinere intentiones specierum sensibilium, que potentie memorativa etiam vocatur ratio particularis.

About the external senses : Organum auditus distancionale est auris, sed indistans est meringa quod in aure est quedam pellicula per modum follis se replens.

Organum visus est in oculo humor cristallinus in medio pupille non habens calorem ut omnes posset recipere. Immediatum subiectum visus est organum, corpus vero mediatum.

Organum odoratus sunt due carnuncule in naso ad modum mamillarum capitis.

Gustus. Organum gustus distans est caro porosa in lingua indistans est quidam nervus per sensum protendens per totam linguam.

Organum tactus est quaddam rethe extensum per totum corporis et est perceptivum plurium contrarietum etatum virtus, secundo *De generatione*; ergo est solum unus materialiter et non formaliter quia Philosophus secundo *De anima*, materialiter unus ratione organi, plures ratione formarum tangibilium.

Lines on the right : Lectiones sensus communis:

percipere actum sensibilium exteriorem diversa sensibilia diversorum sensibilium apprehendere

Inter sensibilia diversorum sensum (..?..)

Medici dividunt cerebrum capitis sive caput in tres ventriculos sive cellulas: anteriorem, mediam et posteriorem. Anteriorem partem dividunt in duas, dextram et sinistram. In dextra ponunt sensum communis, in sinistra fantasiam. Sed etiam mediam partem in duas dividunt, in dextram ubi ponunt estimativam sive fantasiam, et

in sinistram ubi ponunt ymaginativam. Et in posteriori parte capitis ponunt memoriam quia memoria dicitur thezaurus specierum sensibilium et intellegibilium *sed Commentator et alii philosophi* ponentes tantum quattuor virtutes interiores loco et (..?..) distinctas. Sed dividunt in anteriori parte ponunt fantasiam ymaginativam sive formativam, quasi<i> pro una interiori virtute compositam, sed in posteriori parte ponunt memoriam, sed medici iudicas(?) dividunt cellulas scilicet dextram et sinistram, in quarum una ponunt species communis et alia estimativa, cogitativa vel distincta virtutem pro una reputans.

Labels of organs : [702]

stomachus. (..?..) cibus lege artem in de (..?..) principium. (..?..) sicitrix

cor

vesica

visem

auditus

odoratus

B.9 UPPSALA, *Universitetbibliotek*, C. 599, F. 143R.

Figure preceding the *Questio in librum primum physicorum*. Dated post 1486. [*See* figure 4.15]

Internal senses : Left: memorativa | fantasia | estimativa | ymaginativa | sensus communis

Right: ymaginativa | cogitativa | memorativa | fantasia

Item positio utrorumque reddit in idem

Ego Albertus. Ego Albertus dico verum, ergo Aristoteles falsum

Ego Aristoteles. Ego Aristoteles dico verum, ergo Albertus falsum

External senses : Visus | auditus | odoratus | gustus | tactus extendit per totum corpus

Ista sunt in anima: potentia, habitus, actus

Sensus communis ponitur in corde radicaliter

Sensus communis est radicaliter in corde, formaliter et instrumentaliter in prima parte prime cellula capitis

Tactus per totum corpus expanditur.

Physica bis binas pretendit in esse coquinis
Corporibus nostris prima stomachus quia secundam
Explet par cor tertia membra, que secundum partem

} de quattuor digestionibus sunt expulsive, calor, humor, frigiditas que <...>(?)

[702] (not visible in [*See* figure 4.14]

Virtus assistiva vegetam quattuor: una attrahit, hec retinet, hoc digeret, una repellit, primo arges, hec vacuum, calor et silans sunt siccus dissimilem prosunt frigus que alleret infert que digeris exprimit unda.

B.10 LONDON, *Wellcome Historical Medical Library*, NO. 283, KK6.

Gerard of Harderwijck, *Epitomata seu reparationes totius philosophie natualis Aristotelis*. Henri Quentell. Cologne, 1496.
[*See* figure 4.16]

Distinctio et locatio sensuum interiorum Galieni et Avicenne
prior ventriculus cerebri in duas parte divisus
fantasia | sensus communis | cogitativa | memorativa
Distinctio et locatio sensuum interiorum sancti Thome et Alberthe
prius ventriculus
medium ventriculum
sensus communis | ymaginativa | estimativa | fantasia | memorativa
Organum congregationum specierum multiplicatorum a sensationes exteriores ad sensum communem (..?..) (..?..) obtisus
Cellula varia sic quod non ponitur organum sensus sensibile propter quantitater cerebri et sumos (..?..) a cerebro
Organum reservativum specierum pro memoria multiplicatorum a sensibus (..?..) a sensus communis
Objectum auditus: sonus
Objectum visus: (missing in copy, often: color)
Objectum olfactus: odor
Objectus gustus: sapor
Objectus tactus: tangibile propriam qualitatem tangibilem
In nervus tactus
Organum sensus communis
sensus interior { prima / secunda
intellectio { prima / secunda { abstractio / discussio

B.11 UPPSALA, *Universitetbibliotek*, C. 599, F. 143VA-B.

***Questio in librum primum Physicorum.* 1486.**

Incipit: Primum Phisicorum
Circa exercitium Physicorum

Queratur primo utrum de rebus naturalibus possit haberi sciencia.

Huic quidem questioni[703] occasionem prestiterunt plerique philosophi qui de ullis rebus certum aliquid

sciri posse ostendeba, ut narrat *Aristoteles* quarto *Metaphysice*. Permoti autem fuerunt ex rerum mutatione. Cuncta namque assidue moveri[704] et mutari arbitrabantur eo quod celum continuo movetur. Cuius alternatio omnium inferiorum est commutatio, quia mundus iste inferior contiguum est lationibus superioribus, et tota eius virtus ab alto gubernatur, ut scribitur primo *Metheorum*.[705]

Huic autem rationi inferius videbitur istud igni. (?) Ante omnia consideranda <*sic*> quod entia naturalia sunt que[706] quomodolibet mutationem suscipiunt, et res naturales prius/primus est que quamvis sit celo sublimior secundum omnem scientiam phisicum, dicitur tamen ab ymaginibus rerum et de inherentia ad scientiam per (..?..)

Post hunc est totum celum quod in se loci translationem admittit nullam, quamquam aliam sustinet vicissitudinem; ideo inter res naturales computatur.

Post hoc sunt quattuor elementa, et omnia ex hiis constantia impressiones metheorici, metalla, lapides (..?..) et queque (..?..), et universali sermone concludatur universa linea subiecta glebo res naturales appellantur, quia hec singula suas habent intentiones. Illud etiam prenotandum est iuxta Lincolniensem.

Scientiarum quattuor (..?..) sunt gradus.

Primus est minutissimus et talis. Quedam noticia rerum ad utrumlibet contingentium.

Secundus gradus est aliquanto firmior. Verumptamen nota adhuc perfecta est scientia que est apprehensio rerum cintingentium frequenter (..?..) frequentie et intermissionis.

Tertius gradus est quedam notitia firma credulitas et adhesio rei sed nec du. est vera scientia que causas exposcit, igitur.

Quartus gradus et summus est apprehensio rei incontinuitatis per totam (..?..) (..?..), et hec est vere scientia de qua tam multa describit Philosophus primo [707] *Posteriorum*. Iuxta hunc igitur multiplices inveniuntur proprietatis rerum naturalium. Ita sunt quedam ad utrumlibet se habentes, ut hominem nasci fortunatum vel infortunatum, album vel nigrum. Sunt alie que frequenter quibusdam inherent, sed interdum destruuntur ut hominem nasci cum quinque sensibus frequenter accidit, interdum autem aliter fit dum surdus aut cecus quis nascitur. Tertie sunt proprietates inseperabiliter inherentes, ut hominem nasci disciplisibilem <*sic*>. Iste autem tam diverse proprietates in diversos insidunt <*sic*> gradus scientiarum (..?..).

Hiis positis sit conclusio responsalis: de rebus naturalibus certa potest haberi scientia. Probatur conclusio auctoritate omnium phisicorum qui de naturalibus ediderunt tractatus, in quibus preclaras ediderunt sententias, et demonstrabilium scientiam relinquerunt. Ratione sic ostenditur fieri (?) quo <modo> potest eligi firma demonstratio de (..?..) habere scientiam, certum est, sed de rebus naturalibus demonstrabiles possunt fieri demon-

[703] questionis MS.
[704] movere MS.
[705] Methenorum (*sic*) MS.
[706] eque MS.
[707] pos *add. necnon del.* MS

strationes, ergo (..?..) quia plenus est liber iste *Phisicorum* firmissimis demonstrationibus, sed et libri alii eiusdem phisice et membrorum similium (..?..) redundant.

Arguitur primo sic: de rebus naturalibus nulla certa potest haberi scientia. Probatur quia scientia non est in rerum immutabilium (?), sed res naturales omnes sunt mutabiles. A primo *Posteriorum*; minor patet. Quia idcirco naturales dicuntur quod mutationi.

APPENDIX C

CONSULTED MANUSCRIPTS

Author, *Title*
Nr of diagrams (in nr of consulted mss) (out of nr of mss preserved, excerpts and fragments included) * Consulted manuscripts.[708]

C.1 CONSULTED MANUSCRIPTS FOR CHAPTER 2

Anonymous (various), *Commentary on Isagoge*

1 (3) (?) * Munich, *Bayerische Staatsbibliothek*, Clm 14.564; Paris, *BN*, nouv. acq. lat. 1374; *Idem*, nouv. acq. lat. 1374

Avicenna, *Logica*

0 (6) (7) * Bruges, *Stedelijke Bibliotheek*, 510, Vatican, *Biblioteca Apostolica Vaticana*, Vat. lat. 2186 (2x); Zwettl, *Zisterzienserstift*, 89; Graz, *UB*, 482 (40/51 Fo.) (2x)

Boethius, *Commentary on Isagoge*

3 (6) (34)[709] * Firenze, *Biblioteca Medicea-Laurenziana*, San Marco, 113; Munich, *Bayerische Staatsbibliothek*, Clm 14516; Paris, BN, lat. 12957; *Idem*, lat. 12958; *Idem*, lat. 13955; St. Gallen, *Bibl. Abbat.*, 831

Boethius, *Isagoge translatio*

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[708] Unless otherwise mentioned, the numbers of preserved manuscripts are based on: Weijers, *Le travail intellectuel à la Faculté des arts de Paris: textes et maîtres (ca. 1200-1500)*; Lohr, "Medieval Latin Aristotle commentaries"; 24 (1968) 194–245; 26 (1970) 135–216; 27 (1971) 251–351 and 28 (1972) 281–396; 29 (1973) 93–197; 30 (1974) 119–144.
My research for Chapter 4 on the manuscipts dating from the Carolingian period (manuscript-copies of the texts of Isidore of Seville, Boethius, Cassiodorus and Macrobius) is based on the selection of manuscripts consulted by B. Obrist, and not enlisted here. See: Obrist, *La cosmologie médiévale. Textes et images. I. Les fondements antiques*.
[709] Minio-Paluello, *Categoriarum supplementa. Porphyrii Isagoge, Translatio Boethii, et Anonymi Fragmentum vulgo vocatum 'Liber sex principiorum'*.

17 (40) (295)[709] * Augsburg, *Bayerische Staats-, Kreis- und Stadtbibliothek*, 20. ms. 328; Bamberg, *Staatsbibl.*, Class. 24; Barcelona, *Ripoll* 134; Basel, *UB*, F I 1; Bruges, *Openbare Stadsbibliotheek*, 510; Cambridge, *Library of Corpus Christi College*, 206; Darmstadt, *Hessische Landesbibliothek*, 2282; Cologne, *Dombibliothek*, 191; Leiden, *UB*, BPL 139 B; *Idem*, BPL 1925; Leipzig, *UB*, 1351; London, *BL*, Burn. 275; *Idem*, Royal 8AXVIII; Milan, *Biblioteca Ambrosiana*, L. 60 Sup; Munich, *Bayerische Staatsbibliothek*, Clm 14516; *Idem*, Clm 4621; *Idem*, Clm 14564; *Idem*, Clm 16.123; Oxford, *Balliol College*, 253; *Idem*, *Trinity College*, 47; Paris, *Bibliothèque de l'Arsénal*, 727, *Idem*, 728; *Idem*, 811; Paris, *BN*, lat. 6288; *Idem*, lat. 6289; *Idem*, lat. 6291; *Idem*, lat. 6291A; *Idem*, lat. 7730; *Idem*, lat. 15089; *Idem*, lat. nouv. acq. lat.1611; Reims, *Bibliotheque Municipale*, 870; St. Petersburg, *Publichnaja Biblioteka*, Class. lat., F. V. N. 7; Vercelli, 138; Vienna, ONB, 2374; *Idem*, 5199; *Idem*, 235; Rome, *Bibl. Angelica*, cod. 953; Vatican, BAV, 2114; *Idem*, 10683; Venice, *Bibl. Marciana*, Zanetti lat. 273

Gilbert de la Porrée, *De sex principiis*

0 (7) (233) * Paris, *BN*, lat.16080; *Idem*, lat.16092; *Idem*, lat.16595; *Idem*, lat, 16598; *Idem*, lat.16611; *Idem*, lat.15088; *Idem*, lat.14697

John Damascene, *Logica*

2 (2) (13) [709] * Paris, *BN*, lat. 14700; *Idem*, lat. 16598

Peter of Spain, *Tractatus*

25 (71) (ca. 400)[709] * Augsburg, *Bibliotheca Augustana*, 40 12 (K.451); Bamberg, *SB*, H.J. IV 30 (Philos. 7); Barcelona, *Archivo de la Corona de Aragón*, Ripoll 216; *Idem*, *Biblioteca Central*, 711; Basel, *UB*, F V 9; Berlin, *SB*, 981 (Lat. Qu 87); Carpentras, *Bibliothèque Inguimbertine*, 289; *Idem*, 280; Cordoba, *Biblioteca del Cabildo*, 158; Edinburgh, *UL*, 138 (Laing 48); Erfurt, *Bibliotheca Amploniana*, Q 245; *Idem*, Q 271; Erlangen, *UB*, 394; Florence, *Biblioteca Riccardiana*, 730 (L II in 40 VI); *Idem*, 1223; *Idem*, *BN*, F. Conv. Soppr., H. IX. 1520; *Idem*, *Biblioteca Medicea Laurenziana*, F. Fiesolano 145; *Idem*, F. Ashburnham 170 (102; 96); Graz, *UB*, 1039; Ivrea, *Biblioteca Capitolare*, 79 (XIV); Krakau, *Biblioteka Jagiellonska*, 3292 (DD XI 25); *Idem*, 2045 (BB XXVII 17); *Idem*, 2084 (BB VII 11); *Idem*, 2093 (BB XVIII 3); London, *BL*, Add. 16386; Oxford, *Bodleian Library*, lat. misc. e. 100; Metz, *BM*, 638; *Idem*, 642; Monte Cassino, *Archivio dell' Abbazia*, 791 lit. TT; *Idem*, 362 VV; Munich, *SB*, Clm 7205; Clm 7658; *Idem*, Clm 8401; *Idem*, Clm 12304; *Idem*, Clm 14458; *Idem*, Clm 7733; Napoli, *BN Vittorio Emanuele II*, F. Principale VIII F 24; *Idem*, F. Principale VIII F 29; Novacella (Neustift), *Convento dei Canonici Regolari* (Augustiner Chorherrenstift), 605; Padova, *BU*, 647; Paris, *BN*, 6657; *Idem*, 16611; *Idem*, nouv. acq. lat. 219; *Idem*, nouv. acq. lat. 258; *Idem*, nouv. acq. lat. 892; *Idem*, *Bibliothèque Mazarine*, 3795 (587 A); Pavia, *BU*, F. Aldini 450; Prague, *Národní Knihovna Ceské Republiky*, 2605; *Idem*, 2567; Ravenna, *Bibl. Classense*, 293; Rome, *Biblioteca Casanatense*, 804; *Idem*, 806; Saint-Dié, *BM*, 69; Toledo, *Archivo y Biblioteca Capitular*, 94, 28; Vatican, *BAV*, Chis. E V 148 (1178); *Idem*, Pal. lat. 995; *Idem*, Vat. lat. 4537; *Idem*, Regin. lat. 1205; *Idem*, Vat. lat. 10044; *Idem*, Regin. lat. 1731; *Idem*, Vat. lat. 3051; Venice, *BN Marciana*, lat. VI 38 (3214) (Val. X 55); *Idem*, lat. VI 198 (2602) (Val. X 184); Vienna, ÖNB, 5199; *Idem*, 5196; *Idem*, 4698; *Idem*, 2389; *Idem*, 5148; *Idem*, 4996; *Idem*, 5248; *Idem*, 5162

William Ockham, *Commentary on Isagoge*

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709 Minio-Paluello, *Categoriarum supplementa. Porphyrii Isagoge, Translatio Boethii, et Anonymi Fragmentum vulgo vocatum 'Liber sex principiorum'*, xvi-xxii.

709 Thomson, *The writings of Robert Grosseteste, Bishop of Lincoln, 1235–1253*, 45, 47.

709 Rijk, *Peter of Spain (Petrus Hispanus Portugalensis). Tractatus called afterwards Summule logicales*.

o (7) 12 * Assisi, *Biblioteca comunale*, 293; Bruges, *Stedelijke Bibliotheek*, 499; Florence, *Biblioteca Nazionale Centrale*, F. Conv. Soppr., G. III. 803; Oxford, *BL*, Canon. Misc. 558; Paris, *BN*, 14721; Vatican, *BAV*, Burgh. 151; *Idem*, Pal. lat. 998

C.2 CONSULTED MANUSCRIPTS FOR CHAPTER 3

Adam of Buckfeld, *Commentarium in Aristotelis Physicam*
o (1) (18) * Paris, *BN*, lat. 6319

Albert the Great, *De causis proprietatum elementorum*
o (3) (40) [709] * Paris, *BN*, lat. 6510; *Idem*, lat. 6512; *Idem*, lat. 6523

Galen, *Tractatus de elementis*
o (11) (?) * Paris, *BN*, lat. 14005; *Idem*, lat. 544; *Idem*, lat. 7749; *Idem*, lat. 16198; *Idem*, lat. 6556; *Idem*, lat. 7015; *Idem*, lat. 11860; *Idem*, lat. 14389; *Idem*, lat. 15456; *Idem*, nal. 343; *Idem*, nal. 1482

Guillaume of Colllingham, *Questiones naturales*
o (1) (3) * Paris, *BN*, lat. 6559

John Dumbleton, *Summa logice et philosophie naturalis*
o (3) (21) * Paris BN, lat. 16146; *Idem*, lat. 16621; Paris BU, 599

John Garisdale, *Libellus de terminis naturalibus sive termini naturales*
o (1) (4) [709] * Oxford, *New College*, 289

Master Albert, *Termini physicales*
1 (2) (2) * Asissi, *Bibl. Com.*, 690; Paris, *BN*, lat. nal. 566.

Nicolas Oresme, *De configurationibus*
8 (14) (14) [709] * Paris, *BN*, lat. 14579; *Idem*, lat. 14580; *Idem*, lat. 7371; Paris, *Arsenal*, 522; Groningen, *Universiteitsbibliotheek*, 103; Brugge, *Stadsbibliotheek*, 486; Vatican, *Bibl. Vat.*, Chigi E. IV. 109; Vatican, *Vat. Lib.*, 3097; Erfurt, *Stadtbibliothek*, Ampl. Q. 298; *Idem*, Ampl. Q. 150; Florence, *Bibl. Med. Laur.*, Ashburnham 210; Florence, *Bibl. Naz.*, F. Conv. Sop. J.IX.26; London, *Brit. Mus.*, Sloane 2156; Basel, Öffentl. Bibl. d. Univ., F.III.31

Philip de Vitry, *Compendium philosophia*
o (3) (27) [709] * Paris, *BN*, lat. 3430; *Idem*, lat. 14938; *Idem*, lat. 15879

Ps.- Robert Grosseteste, *Summa in VIII libros Physicorum*

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[709] W. Fauser, *Die Werke des Albertus Magnus in ihrer hanschriftlichen Überlieferung*, vol. 1: Die echten Werke (Münster, 1982).

[709] Weisheipl, "Repertorium Mertonense," 216–217; Thorndike and Kibre, *A catalogue of incipits of mediaeval scientific writings in Latin. Revised and augmented edition*, 902; Antolín, *Catálogo de los códices latinos de la Real biblioteca del Escorial*, here vol. 2, 1911, 297.

[709] I base myelf on: Clagett, *Nicole Oresme and the medieval geometry of qualities and motions: A treatise on the uniformity and difformity of intensities known as Tractatus de configurationibus qualitatum at motuum*, 146–155.

[709] Not to be confused with Philip de Vitry, bishop of Meaux, clerc of Charles IV et musician. See, also for literature about this author: Weijers, *Le travail intellectuel à la Faculté des arts de Paris: textes et maîtres (ca. 1200-1500)*, here vol. 7, 30, 250.

0 (2) (12) * Paris, *BN*, lat. 6749C; Cambridge, *Trinity College*, O.2.11

Ps.- Robert Grosseteste, *Summa philosophie*
0 (3) (5) * Oxford, *Merton College* 310; *Idem*, *Digby* 220; Cambridge, UL,1783 (J.i.III.19)

Thomas Aquinas, *De mixtione elementorum*
0 (7) (109) * Paris, *BN*, lat. 14546; *Idem*, lat. 3899; *Idem*, lat. 6443; *Idem*, lat. 14719; *Idem*, lat. 16153; *Idem*, lat. 16195; *Idem*, lat. 16607

Thomas Netter of Walden, *Termini physicales / De terminus naturalibus*
2 (2) (2) * Oxford, *Bl.*, Digby 75; *Idem*, Bodley 676.

Walter Odington, *Icocedron*
1 (2) (4)[709] * London, *BM*, Add. 15549; Oxford, *BL*, Digby 119.

William Heytesbury, *Termini naturales*
3 (9) (21)[709] * London, *BM*, Royal 8 A XVIII; Oxford, *New College*, 289; Paris, BN, lat. 6673; Padua, *BU*, 1123; Munich, *St.B.*, CLM 8997; *Idem*, 5961; Vatican, *Vat.*, lat. 5132; Vienna, *Dom.*, 93/57; *Idem*, *Nat. Bibl.*, 4698.

C.3 Consulted manuscripts for chapter 4

Questiones sextaginta sex in libros De anima
1 (1) (1) * Uppsala, *UB*, C602

Adam of Bocfeld, *Commentarium in Aristotelis De anima*
0 (1) (12) * Paris, *BN*, lat. 6319

Egidius of Rome, *Sententia super libro de anima*
0 (5) (42) * Paris, *BN*, lat. 15005; *Idem*, lat. 16121; *Idem*, lat. 16616; *Idem*, BU 121; Mazarine, 3497.

Albert of Orlamunde, *Summa naturalium*
0 (7) (106) * Paris, *BN*, lat. 6523A; *Idem*, lat. 6524; *Idem*, lat. 6749C; *Idem*, lat. 16222; *Idem*, lat. 16635; *Idem*, nouv. acq. lat. 157; London, *BM*, Arundel 344

Albert the Great, *De animalibus*
0 (9) (110)[709] * Paris, *BN*, lat. 6517; lat. 6518; *Idem*, 6518A; *Idem*, lat. 6519; *Idem*, lat. 6520, *Idem*, lat. 14727; *Idem*, lat. 14728; *Idem*, lat. 17156, *Idem*, BU 41

Albert the Great, *De anima*
0 (4) (66)[709] * Paris, *BN*, lat. 6509; *Idem*, lat. 6530; *Idem*, lat. 14711; *Idem*, lat. 16944

Albert the Great, *De intellectu et intelligibili*
0 (2) (73)[709] * Paris, *BN*, lat. 14712; *Idem*, lat. 16170

Albert the Great, *De memoria et reminiscentia*

[709] Skabelund and Thomas, "Walter Odington's mathematical treatment of the primary qualities"
[709] Weisheipl, "Repertorium Mertonense," 216–217.
[709] Fauser, *Die Werke des Albertus Magnus in ihrer hanschriftlichen Überlieferung*.
[709] ibid.
[709] ibid.

0 (3) (44)[709] * Paris, *BN*, lat. 6512; lat. 6523; lat. 14729

Albert the Great, *De natura et origine anime*
0 (5) (52)[709] * Paris, *BN*, lat. 6512 (2x); *Idem*, lat. 14712; *Idem*, lat. 16170; *Idem*, lat. 16607

Anonymous notate, *Circa exercitium physicorum*
1 (1) (1) * Uppsala, *UB*, C599

Anonymous, *Questiones super librum De anima*
0 (1) (1)[709] * Paris, *BN*, lat. 16170

Anonymous, *De quaternario*
1 (1) (1) * Cambridge, *Gonville and Caius College*, 428/428

Berthold Blumentrost, *Questiones disputate circa tractatum Avicenne de generatione embryonis et librum meteorum Aristotelis*
1 (1) (1) * Munich, *St.bibl.*, Cod. lat.527

David of Dinant, *Questiones naturales*
0 (1) (4) * Paris, *BN*, lat. 15453

Guido Vernani Ariminensis, *Expositio liber de anima*
0 (1) (2) * Paris, *BN*, nouv. acq. lat. 1739

Guido da Vigevano (de Papia), *Anatomia*
1 (2) (5)[709]

Guillelmus de Valle Rovillonis, *Liber de anima*
0 (1) (3) * Paris, *BN*, lat. 16585

Guillelmus of Colllingham, *Questiones naturales*
0 (1) (3) * Paris, *BN*, lat. 6559

Henricus Plattenberger (Platerburger), *(Fundamentum) philosophia(e) naturalis*
1 (1) (2) * Prague, *Univ. Knihovna*, IV.F.18

Henry of Mondesville, *Anatomia*
1 (1) (?) * Berlin, *St.Bibl.*, lat.fol.219

Jacobus Lombardus, *Supra librum De anima*
0 (1) (1) * Paris, *BN*, lat. 16125

Jacobus de Blanchis (de Alexandria), *Compilatio super totam philosophiam naturalem et moralem*
1 (1) (21) * Paris, *BN*, lat. 15450

Jacobus of Douai, *Questiones super libro De anima*
0 (1) (3) * Paris, *BN*, lat. 14698

Johan Yperman, *Cyrurgie*

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[709] ibid.
[709] ibid.
[709] M. Giele, F. van Steenbergen, and B.C. Bazàn, eds., *Trois commentaries anonymes sur le Traité de l'âme d'Aristote* (Leuven–Paris, 1971), 377–385.
[709] Wickersheimer, *Anatomies de Mondino dei Luzzi et de Guido de Vigevano*.

1 (2) (4)[709] * Ghent, *Universiteitsbibliotheek*, 1263; Cambridge, *S. John's College Library*, A 19

John Buridan, *Questiones super librum De anima secundum tertiam lecturam*
0 (1) (10) * Paris, *BN*, lat. 15888

John Peckham, *Perspectiva communis*
3 (7) (62)[709] * Wien, *Öst.Nat.*, 5210; Basel, *Univ.Off.Bibl.*, F.IV.30; Cracow, *Bibl.Jagiellonska*, 1929 (Czechel); Paris, *BN*, lat. 7368; *Idem*, lat. 7378A; Berlin, *St. Bibl*, lat.qu.514; *Idem*, lat.qu.530

Magister Zacharias of Salerno
9 (2) (?) * London, *BL*, Sloane, 981; Paris, *BN*, lat. 6988

Mondini dei Luzzi, *Anatomia Mundini*
1 (1) (32)[709] * Wolfenbüttel, *Herzog.Aug.Bib.*, 42.1.fol.

Nicolaus Bertrucius, *Betruccii collectorium in parte practica medicine*
1 (1) (?) * Munich, *St.Bibl.*, CLM73

Paulus Nicolettus Venetus, *Lectura super librum de anima*
0 (3) (14) * Paris, *BN*, lat. 6433; *Idem*, 6530; *Idem*, 6547

Petrus Gerticz de Dresden, *Parvulus philosophie naturalis*
4 (12) (57) * London, *Wellcome Inst.*, 55; Berlin, *St.Bibl.*, theol.fol.247; *Idem*, lat.qu.71; *Idem*, lat.fol. 40; Uppsala, *UB*, C601; *Idem*, C622; *Idem*, C629; *Idem*, C231; Norrköping, *Mun. Lib.*, 426 fol.

Pierre d' Ailly, *Tractatus de anima*
4 (4) (16) * Paris, *BN*, lat. 15173; *Idem*, lat. 14579; Paris, *Arsenal*, 521; *Idem*, 522

Radulphus Reginaldi Britonis, *Questiones super librum De anima*
0 (2) (7) * Paris, *BN*, lat. 12971; *Idem*, lat. 14705

Roger Bacon, *De scientia perspectiva*
3 (6) (39) * Paris, *BN*, lat. 2598; *Idem*, lat. 7378A; *Idem*, lat. 7434; *Idem*, lat. 10260, London, *BL*, Harley 80; *Idem*, Sloane 2156

Walter Burley, *De potentiis anime*
1 (4) (40)[709] * Leipzig, *UB*, ms. 426; London, *Lambeth Palace*, 74; *Idem*, 70; Paris, *BN*, lat. 16195

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[709] Van Leersum, *De cyrurgie van meester Jan Yperman*, xxv-xxxv.

[709] D.C. Lindberg, *John Pecham and the science of optics: Perspectiva communis* (Madison, 1970), 14–18.

[709] Wickersheimer, *Anatomies de Mondino dei Luzzi et de Guido de Vigevano*, 69–70.

[709] M.J. Kitchel, "The 'De potentiis animae' of Walter Burley," *Mediaeval Studies* 33 (1971): 85–113, here 85.

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CUP: *Chartularium Universitatis Parisiensis: sub auspiciis consilii generalis facultatum Parisiensium ex diversis bibliothecis tabulariisque collegit et cum authenticis chartis contulit Henricus Denifle, O.P. in arvhivo apostolicae sedis romanae vicarious, academiae scientiarum vindobonensis socius auxiliante Aemilio Chatelain, bibliothecae universitatis in Sorbona conservatore adjuncto*. Edited by H. Denifle and A. Chatelain. Paris, 1889–1897.

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SAMENVATTING-ANALYSE

De Franse wetenschapssocioloog en -filosoof Bruno Latour schrijft dat hoe verder we teruggaan in de wetenschapsgeschiedenis, hoe meer aandacht wetenschappers besteden aan de achtergrond en de praktijk van onderzoek, en hoe minder aan de visuele presentatie van hun onderzoeksgegevens.[1] Daarmee beschouwt hij '*imaging craftsmanship*' (beeldende bekwaamheid) specifiek aan onze moderne wetenschappelijke cultuur. De uitvinding van de drukpers, lineair perspectief tekenen en naturalisme in de vroegmoderne periode worden door hem beschouwd als de drijvende kracht voor de intellectuele revoluties van deze periode. Deze instrumenten verbeterden de wetenschapsbeoefening, in het bijzonder door de vermeerdering van de kwaliteit en kwantiteit van teksten en presentatie van onderzoeksmateriaal.

Deze claims zonderen op voorhand de betekenis van getekend beeldmateriaal in handgeschreven teksten in de middeleeuwen uit. Latour heeft dan ook nooit onderzoek naar handschriften gedaan. Dat geldt ook voor Elisabeth Eisenstein die al in 1979 publiceerde over de materiële cultuur van wetenschap, in het bijzonder over de beslissende rol van de drukpers voor de ontwikkeling van de wetenschappen. Nieuwere publicaties (Baigrie, Freeland and Corones, Kemp, Lefèvre, Renn and Schoeplin) op dit terrein laten veel subtielere resultaten zien, maar nemen in het merendeel eveneens als beginpunt de wetenschappelijke revolutie, als 'uitwerking' van de drukpers, het perspectief tekenen en naturalisme.

Andere publicaties doen vermoeden dat er een schat aan wetenschappelijk beeldmateriaal ligt in de overgeleverde middeleeuwse fondsen in (universitaire) bibliotheken. Dit boek wil de werking onderzoeken van diagrammen als een manifestatie van wetenschappelijke theorie en praktijk. Een gedeelte van dit beeldmateriaal is ontsloten in anthologieën (Murdoch, Weijers), anderen hebben deelstudies ondernomen naar een set van gerelateerde diagrammen in bijvoorbeeld de anatomie (Sudhoff, Clarke en Dewhurst, Violé O'Neill), of natuurfilosofie (Obrist) om zo de stand van wetenschap en de ontwikkelingen daarvan beschrijven. Dit boek heeft een ander doel. Het doel van dit boek is om onze

[1] Latour, "Visualization and cognition: thinking with eyes and hands", hier 16–17.

kennis te verdiepen van de dynamische wisselwerking tussen wetenschappelijke diagrammen en wetenschap aan de *Artes* faculteit in de periode van 1200 tot 1500.

Wetenschappelijke diagrammen staan in verband met de actuele tekst en de ideeen die zij presenteren, maar ook met de geschiedenis van deze tekst, die van het totale boek en zijn gebruik. Een diagram is immers geen autonome entiteit, geabstraheerd van ideologische factoren, persoonlijke ideeën, geabstraheerd van het boek. Diagrammen in wetenschappelijke teksten staan dan ook noodzakelijkerwijs in verband met een complex van factoren die de intellectuele atmosfeer uitmaken waarin het diagram is getekend, beschouwd, verworpen, opnieuw getekend en vormgegeven, enzovoort. Factoren die de atmosfeer bepalen zijn bijvoorbeeld de doelgroep, didactiek, theoretische inbedding en ontwikkelingen, disseminatie van ideeën, onderzoekspraktijk en financiële omstandigheden.

In de onderzochte periode voltrokken zich grote institutionele en wetenschappelijke veranderingen door de ontwikkeling van universiteiten en de bestudering van het nieuw geïntroduceerde Aristotelische corpus. De vele voornamelijk natuurfilosofische en logische teksten daagden geleerden uit tot reflectie over de stand van kennis en de wijze waarop kennis vergaard diende worden. De jaren 1200 en 1500 markeren de handschriftelijke verbreiding en verwerking van dit enorme corpus van teksten.

Door verbanden te leggen tussen diagrammen en enkele essentiële factoren die middeleeuwse wetenschappelijke activiteit kenmerken, worden verschillende betekenisvolle functies van diagrammen in wetenschappelijke handschriften onderzocht. De analyse van het probleem hoe diagrammen en middeleeuwse wetenschap op elkaar inwerken, vindt plaats aan de hand van vier vragen:

1. Waar worden diagrammen aangetroffen en hoe worden ze beschouwd?
2. Hoe verhouden diagrammen zich tot de corresponderende wetenschappelijke tekst en onderliggende theorie?
3. Hoe verhouden diagrammen zich tot de nieuwe wetenschappelijke ontwikkelingen in het betreffende vakgebied?
4. Hoe verhouden diagrammen zich tot de institutionele samenhang waarin zij opereren?

Deze vragen corresponderen met verschillende dimensies binnen welk licht de diagrammen worden beschouwd:

1. het diagram als visuele bron, 2. het diagram als onderdeel van een tekst, 3. het diagram in wetenschappelijke ontwikkeling, 4. de praktische implementatie van het diagram. Op deze wijze wordt beoogd een historisch begrip te verkrijgen van de visuele productie van kennnis.

Om deze bovenstaande vragen te beantwoorden zijn drie *case studies* ontworpen, geselecteerd op basis van beschikbaar materiaal:

a.) de Boom van Porphyrius,

b.) de vier elementen en kwaliteiten,

c.) de vermogens van voornamelijk de rationele ziel (cognitie).

Deze drie gevallen omvatten drie belangrijke studieterreinen van de *Artes* faculteit: logica, natuurfilosofie en psychologie. Gezamenlijk bestrijken ze het domein van de taal en de redenering (het denken), de onbezielde natuur van het ondermaanse (materie), en de bezielde natuur (mens). Centraal in de studie van deze drie gebieden staan de vraagstukken genereerd in respectievelijk de Aristotelische teksten *Categorie* (en de *Isagoge* van Porphyrius), *De generatione et corruptione*, en *De anima*.

Bovengenoemde vier vragen worden behandeld in vier hoofdstukken.

Hoofdstuk 1 *About the sources* bespreekt het bronnenmateriaal in meer detail dan mogelijk was in de inleiding. Het complexe karakter van de voor dit boek geselecteerde bronnen maakte deze opsplitsing noodzakelijk. Dit hoofdstuk beschrijft de herintroductie van het Aristotelische corpus en haar reflectie in het curriculum van de *Artes* faculteit. Het corpus van Aristotelische geschriften werd rond het midden van de twaalfde eeuw vertaald en maar langzaam, tegen het einde van de eeuw, systematisch bestudeerd. De curricula van de Sorbonne en andere colleges in Parijs tonen aan dat het geselecteerde bronnenmateriaal werd bestudeerd in het kader van de *Artes* faculteit vanaf het begin van de dertiende eeuw. De *De generatione et corruptione*, de *Categorie*, de *Isagoge* van Porphyrius en de *De anima*, de kernteksten van de gekozen *case studies*, behoorden tot de verplichte literatuur voor de graad van 'bachalarius' en 'magister'. Een uitzondering vond plaats in de perioden 1210–1231 en 1277, waarin een verbod op onderwijs van deze werken gold.

Het eerste hoofdstuk bespreekt vervolgens het karakter van de teksten waarin de diagrammen zich bevinden. De bestudering van de opgegeven literatuur verliep vaak door middel van leerboeken. Deze leerboeken zijn geschreven door magisters om het studenten te vergemakkelijken de hoeveelheid literatuur te verwerken. Naast het gemak, dienden deze tekstboeken ook de portemonnee doordat deze samenvattingen en opsommingen goedkoper waren dan de uitgeschreven tekst.

Enkele subgenres van het leerboek blijken meer geschikt voor de invoeging van diagrammen dan andere. In *florilegia, conclusiones, questiones*, en *auctoritates*, bijvoorbeeld, worden geen diagrammen aangetroffen. In *tractatus, summe, expositiones*, en *copulata*, bijvoorbeeld, echter wel. Dit onderscheid is het gevolg van het karakter van elk van deze genres. De tweede groep van genres biedt een exposé, een commentaar of een uitleg op de grondtekst en is dus verklarend van karakter, waar de eerste groep een opgave biedt van citaten en argumenten en dus opsommend van aard is. Diagrammen sluiten zodoende aan bij het verklarende karakter van de teksten die ze bijstaan.

De diagrammen worden in deze tekstboeken meestal benoemd als *figura*

of *pictura*. De laatste paragraaf van dit hoofdstuk behandelt de draagwijdte en betekenis van de concepten *figura* en *pictura* in middeleeuwse tekstbronnen. Het beeld dat hieruit ontstaat, is vervolgens vergeleken met het beeld dat moderne auteurs toeschrijven aan middeleeuwse diagrammen. Samenvattend kan gezegd worden dat de betekenis van de termen *figura* en *pictura* niet onderscheidend en zelfs dubbelzinnig gebruikt werd. De middeleeuwse geleerden benadrukken het belichamende karakter van *figure* en *picture*, en omschrijven hun functie in termen van verheldering, illustratie, uitleg en voorbeeld. De diagrammen zijn gebruikt om zich de stof toe te eigenen, te verwerken, te hergebruiken, en er commentaren aan vast te hechten. Diagrammen werden gebruikt om te verklaren, uit te drukken, te laten zien op verkorte of samenvattende wijze. Ze zijn gemaakt om ideeën te objectiveren en te belichamen.

In hedendaagse literatuur worden middeleeuwse *figure* en *picture* veelvuldig beschouwd als modellen, met een mnemotechnische functie. De toegekende betekenis door beide partijen komen niet altijd overeen, mar sluiten elkaar ook niet uit. Hieruit volgt we nog niet voldoende kennis bezitten over de werking van middeleeuwse diagrammen, en dat we bovendien alert moeten zijn op het variërende gebruik en perceptie van diagrammen in de Middeleeuwen.

Hoofdstuk 2 *Form, content and the Tree of Porphyry* is gewijd aan de veronderstelde gelijkvormige relatie tussen diagram en tekst, en de complexiteit van herleiding en concretisering van gegevens in beeld.

Dit hoofdstuk beschrijft in eerste instantie hoe de zogenaamde 'Boom van Porphyrius' ontstond. De Boom van Porphyrius is ontworpen om een methode van definiëring over te brengen. Het toont de definitie van 'mens' door het ontleden van substantie in genera en soorten. De iconografische geschiedenis van het diagram verklaart hoe de Boom van Porphyrius is samengesteld uit de verbeeldingen van diverse tekstpassages bij Boethius' commentaar, en uiteindelijk terecht komt in zijn vertaling van de *Isagoge*. In deze fase is de Boom van Porphyrius nog niet getekend als een boom.

De benaming van de Boom van Porphyrius als 'boom' komt voor het eerst voor in Peter van Spanje's *Tractatus*, een tekst geïntroduceerd in het Parijse universitaire milieu rond 1260. In de dertiende eeuw verschijnen ook de eerste Bomen van Porphyrius uitgedost als boom, met wortels, takken en bladeren. Met de verbeelding als een boom relateert het diagram aan allerlei metaforen zoals hiërarchie, vertakking, groei, bloei, enzovoort. Een ander, eveneens veelvuldig voorkomende verbeelding, is de antropomorfische structuur van de *syndesmos*. De antropomorfische samenstelling uit ledematen, romp en hoofd is in de traditie van dit diagram minder uitgebaat dan de componenten van de boom.

Een nauwgezette vergelijking tussen de tekst en de Boom van Porphyrius toont aan, dat de boommetafoor conflicten genereert in de leesrichting van de boom. Samenvattend kan gezegd worden dat de gegevens in de boom omge-

keerd staan genoteerd, dat de takken van de boom omlaag groeien in plaats van omhoog, en dat de structuur de gesuggereerde laterale lezing niet toestaat. Door het gebrek aan gelijkvormigheid tussen het diagram en de tekst, staat de betekenis van de Boom van Porphyrius als 'boom' onder druk.

Wat is dan het nut voor het logische diagram om het de Boom van Porphyrius te noemen en om er wortels, takken en bladeren aan te tekenen? In dit hoofdstuk wordt onderbouwd dat de boomstructuur van de Boom van Porphyrius aansluit bij een brede beweging in het gebruik van boommetaforiek die gangbaar was in de twaalfde en dertiende eeuw. Door zich te voegen bij het boomrepertoire, deelt de Boom van Porphyrius in de didactische, in het bijzonder de mnemotechnische, voordelen, die kleven aan de gelijkvormigheid van boomstructuren. Als voorbeeld is de vorm van een diagram uit de *Clavis Physice* uitgewerkt, die sterk leunt op de structuur van de Boom van Porphyrius. De gelijkvormigheid van ongelijkvormige gegevens staat een precieze vergelijking toe van gegevens, die door middel van de boomstructuur tamelijk eenvoudig ingeprent en gereproduceerd kon worden.

Er bestaat dus geen sluitende gelijkvormigheid tussen de Boom van Porphyrius en de tekst in de *Isagoge*, Boethius' commentaar of Peter van Spanje's *Tractatus*. De rol van dit diagram ligt dan ook niet louter besloten in de illustratie van een tekstpassage. De vroegste diagrammen tonen het doel om een samenvatting van meerdere paragrafen te comprimeren in een enkel beeld. De dertiende-eeuwse Bomen van Porphyrius-als-boom participeren bovendien in en appelleren aan een veel bredere intellectuele vaardigheid waarin oraliteit en mnemotechniek een rol spelen.

Hoofdstuk 3 *Changing matters: measuring qualities* behandelt de vraag hoe diagrammen inwerken op nieuwe benaderingen in de wetenschap, met als doel inzicht te verwerven in de rol van diagrammen in de middeleeuwse wetenschappelijke praktijk.

In de eerste paragrafen passeren op samenvattende wijze de belangrijkste theorieën over elementen en bijbehorende diagrammatische voorstellingen die tot in de late middeleeuwen een rol speelden. De vroegste elementendiagrammen (achtste eeuw tot en met de twaalfde eeuw) reflecteren de antieke theorieën van verandering door opposities en intermediairs. Ze manifesteren een opvatting van de vier elementen geïntegreerd in een synthetische beschouwing van de wereld in termen van samenhang en harmonie. Deze elementendiagrammen tonen de vier elementen in relatie met de vier kwaliteiten, soms in verband met de vier seizoenen, humoren en de windstreken, toegewijd aan de demonstratie van samenhang, eenheid en regelmaat van de Creatie in parallelle, vierdelige circulaire en kubusachtige structuren.

Vervolgens is onderzocht hoe veertiende-eeuwse geleerden uit Oxford en Parijs substantiële materie benaderden in termen van *kwantiteit*. In de veertiende

eeuw, betuigen de zogenoemde Terministen van een bezieling voor taalfilosofie en kwesties van logische vorm, gecombineerd met een wending naar een analyse naar de aard van kwantiteit en met pogingen tot kwantitatief redeneren. De leden van deze beweging ontwikkelden een groeiende interesse in een analytische behandeling van veranderlijkheid en het vatten van singuliere dingen.

De mathematische, logische benadering van veranderlijkheid daagde vervolgens laatmiddeleeuwse tekenaars uit de veranderlijkheid van substantiële materie uit te beelden. In dit hoofdstuk passeren de diagrammatische structuren van substantiële materie van de 'alchemist' Walter Odington en William Heytesbury, beiden verbonden aan Merton College in Oxford, en Nicolaas van Oresme aan het College van Navarre te Parijs. Alle drie waren actief in de eerste helft van de veertiende eeuw.

Verschillende studenten poogden de antieke Aristotelische theorie van oppositie uit te breiden met het denken in kwantiteiten van kwaliteiten. Ze gebruikten hiervoor de bekende diagrammatische structuur van het 'Vierkant van opposities' en transporteerden eveneens de terminologie die de modaliteiten van proposities uitdrukt, om veranderingen in kwaliteit en kwantiteit te beschrijven. Dit elementendiagram toont de strijd om het beeldmateriaal aan te passen aan de vernieuwingen in wetenschap. De overplaatsing van begrippen liep vast in het diagram in de zogenoemde *Termini naturales* van de Oxfordiaanse William Heytesbury.

Odington's diagrammatische structuur is eveneens gebaseerd op dit 'Vierkant van opposities', maar zonder de rigide transpositie van de terminologie, slaagde hij erin het model aan te passen en om variabele verhoudingen tussen kwaliteiten weer te geven. Hij ontwierp daarmee een diagram waarmee de lezer het gedrag van kwaliteiten kon bepalen door de regels (formules) van de functionele relaties toe te passen.

De bekende configuratie-diagrammen van Nicolaas van Oresme zijn een typische veertiende-eeuwse vinding. Deze configuratie-diagrammen beschrijven de verandering in intensiteit van een kwaliteit door middel van een geometrische figuur bestaande uit een latitude en een longitude. Er zijn verschillende vormen van deze geometrische figuur die diverse configuraties illustreren. De configuratie van het theorema van de gemiddelde snelheid is in de geschiedenis het meest vermaard, omdat het niet alleen acceleratie verbeeldt maar het theorema ook bewijst. Het diagram functioneert in dit geval zowel als een verificatie instrument als de bewijslast. De configuratiediagrammen zijn niet alleen te vinden in *De configuratione* van Nicolaas van Oresme maar ook in bijvoorbeeld het bovengenoemde werk *Termini naturales*.

Sommige van deze nieuwe diagrammen helpen het probleem van transformatie in substantiële materie te begrijpen of op te lossen. Oresme ontwikkelde een geometrische figuur dat (een variabele) intensiteit (kwaliteit) op de ene as,

van een bepaald subject, op de andere as, representeert. De interne configuratie van het subject is daarmee aanschouwelijk maakt. Het volume van het figuur representeert de totale kwantiteit van de configuratie. In het geval van het theorema van gemiddelde snelheid, helpt het corresponderende diagram het probleem van het meten van acceleratie op te lossen. Odington's diagram helpt in het berekenen van de graad van intensiteit van een kwaliteit in een samenstelling. Het biedt geen onmiddellijk begrip van de formules, maar deze zijn met wat moeite af te leiden uit de bijgegeven tabel. Odington's diagram is een instrument, en representeert geen subject in de werkelijkheid. Oresme's configuraties representeren het werkelijke subject met behulp van beeldende analogie.

Hoofdstuk 4 *The powers of the soul in teaching* beschouwt vervolgens de plaats van diagrammen in een nog omvangrijkere dimensie, namelijk de wetenschappelijke praktijk van kennisoverdracht, verspreiding, didactiek, en normalisatie van doctrines. De onderzochte *case studies* speelden alle drie een sterke rol in onderwijs, maar het geval van de hersendiagrammen (of liever de diagrammen van de vermogens van de ziel) blijkt in het bijzonder interessant voor dit perspectief. De meerderheid van de geconsulteerde diagrammen in veertiende- en vijftiende-eeuwse handschriften zijn getekend door studenten in hun tekstboeken en college-aantekeningen en functioneerden dus aantoonbaar in een onderwijspraktijk.

Onenigheid tussen Galenus en Aristoteles over de groepering van functies in de ziel, de locatie en volgorde van de rationele vermogens, alsmede het takenpakket van de verschillende vermogens, creëerde veel onduidelijkheid.

Enkele medische teksten tonen diagrammen (bijvoorbeeld afb. 4.2 en 4.3 van ideologisch in vieren gedeelde cirkeldiagrammen, alsook een horizontale dwarsdoorsnede van het hoofd.

De vijftiende-eeuwse tekeningen over dit onderwerp tonen een heel andere soort, namelijk een dwarsdoorsnede van het hoofd, dat door middel van deze conventie de ventrikels in het hoofd alsook de externe zintuigen aan de buitenkant van het hoofd toont. De iconografische geschiedenis van deze dwarsdoorsnede wijst op een medische ontstaanscontext. De vroegst overgeleverde verticale dwarsdoorsneden van het hoofd zijn getekend in pathologische teksten, die te midden van een opsomming van ziekten ook de functies van de vermogens van de rationele ziel benoemen. Uit het midden van de veertiende eeuw dateert een diagram in een medisch-filosofisch georiënteerde verzameling teksten, dat expliciet het 'hoofd van medici' is genoemd.

In de tweede helft van de vijftiende eeuw blijkt het diagram van de hersenfuncties te verschuiven naar het natuurfilosofische domein waarin *De anima* werd besproken. De discussie over de locatie van de ziel en de taken van de vermogens in het hoofd, werden uitgebreid met een discussie over het intellect en de vegetatieve en sensitieve ziel. Deze diagrammen zijn getekend in handboeken

die de overeenkomstige problematiek in *De anima* van Aristoteles behandelen. Het diagram komt bijvoorbeeld standaard voor bij de vroeg vijftiende-eeuwse tekst de *Parvulus philosophie naturalis* van Peter van Dresden, dat geschreven is in de omgeving van de Universiteit van Praag. Het diagram is vaak gekopieerd in aanverwante tekstboeken van de magisters Lambertus de Monte en Gerard de Monte in Keulen, Henri Plattenberger, Gerard van Harderwijck, en Johannes van Mechelen in Uppsala. In één van de vijftiende-eeuwse bronnen wordt de dwarsdoorsnede kenmerkend vernoemt als het 'hoofd van filosofen'.

De verspreiding van dit diagram verloopt zoals het tekstboek waarmee het verbonden is: via de universitaire infrastructuur. Vele studenten en magisters, zoals Peter van Dresden, verlieten Praag na de uitvaardiging van het Kutná Hora decreet. Zij streken vervolgens neer in andere Centraal-Europese universiteitssteden, zoals Leipzig, Heidelberg, Erfurt, Keulen en Uppsala. Ze namen een kopie van de *Parvulus* mee, en gebruikten deze, eventueel in een adaptatie, opnieuw bij studie en onderwijs.

De vijftiende-eeuwse natuurfilosofische diagrammen van de cognitieve functies zijn uitgebreid gelabeld, als korte commentaren, in de *Parvulus philosophie naturalis* en verwante natuurfilosofische tekstboeken. Deze labels beschrijven de verschillende argumenten van hoofdzakelijk Avicenna, Thomas van Aquino en Albert de Grote. De polemiek tussen de auteurs weerspiegelt de gebruikelijke wijze van wetenschappelijke onderzoekingen naar het rechte eind, in een gefingeerd debat tussen auteurs. Het past ook in de stijl van het literaire genre van *questiones* en de georganiseerde disputen van de faculteiten. Enkele diagrammen tonen het debat tussen auteurs op een bijzonder wijze door meerdere getekende 'hoofden' met elkaar te laten discussiëren. Hetzelfde diagram werd in Keulen gebruikt om rivaliserende argumenten van twee scholen uit te drukken.

Diagrammen spelen een rol in de kennisoverdracht van magister naar student, maar ze spelen ook een onderhandelende rol tussen wetenschap en sociale cultuur. De argumenten in het getoonde debat zijn geconsolideerde elementen in de bespreking van *De anima*. Tekstboeken zoals de *Parvulus* spelen een belangrijke rol in de normalisatie van wetenschappelijke ideeën en daarmee de opname ervan in een canon van denkbeelden, doordat ze een selectie van kennis op vereenvoudigde wijze presenteren. De diagrammen in deze tekstboeken polemiseren de argumenten eveneens, en spelen daarmee ook een rol in consolidatie van wetenschappelijke ideeën.

Op basis van de resultaten van deze vier hoofdstukken ontstaat een divers beeld over de werking van diagrammen als vorm van wetenschappelijke praktijk in de artes faculteit in de periode van 1200 tot 1500. De keuze voor een analyse van meerdere *case studies* verspreid over drie domeinen heeft als voordeel gehad dat de overeenkomsten en verschillen in resultaten nieuwe inzichten kunnen genereren die bij de bestudering van een enkele *case study* onzichtbaar blijven.

Zodoende kunnen enkele algemene observaties worden gemaakt op basis van de drie *case studies*.

Zo spelen alle gebruikte bronnen voor dit boek een rol in de verwerking van het nieuwe Aristotelische corpus. De Boom van Porphyrius ontworpen om jonge studenten in de logica te initiëren; Oresme's configuraties zijn bedoeld om studenten te trainen; het Vierkant van elementaire opposities in de *Parvulus* was geconcipieerd door een jonge en ongeoefende *Artes*-student die net begon met zijn studie in de natuurfilosofie; en de diagrammen in de *Tractatus philosophie naturales* zijn eveneens alle getekend door studenten en toegevoegd aan hun college-aantekeningen.

De literatuur waarin diagrammen zich het meest voordoen zijn handboeken die een samenvatting, exposé, of een uitleg geeft op de basistekst, vaak van Aristoteles. Dit genre van studiemateriaal sluit goed aan bij de observatie dat diagrammen een belangrijke rol spelen in de verwerking van het nieuwe Aristotelische corpus, en dus primair zijn ontworpen voor een onderwijsomgeving.

De algemene conclusies plaatsen de laatmiddeleeuwse wetenschappelijke diagrammen op een nieuwe wijze in het beeld van wetenschappelijke beeldmateriaal geschetst in de secondaire literatuur. De bestaande literatuur omvat voornamelijk onderzoek naar vroegmodern wetenschappelijk materiaal. Het opgeroepen beeld van wetenschappelijke diagrammen in deze publicaties is weliswaar divers, maar benadrukt in nagenoeg alle gevallen de receptie van wetenschappelijke diagrammen in een *onderzoeksomgeving*. Vroegmoderne wetenschappelijke diagrammen worden beschouwd als onderzoeksresultaten die ontvangen en gebruikt werden door collega-wetenschappers en ingenieurs. Een betekenis van vroegmoderne wetenschappelijke diagrammen is tot dusver niet gevonden, of gezocht, in een *onderwijsomgeving*.

Middeleeuws wetenschappelijke diagrammen hadden hun primaire rol in de verwerking van de grote hoeveelheden nieuwe teksten. De diagrammen zijn daarbij getekend voor en door studenten om de stof te verwerken en niet om collega-wetenschappers te overtuigen. Hun didactische rol past goed in het karakter van de middeleeuwse universiteit als instituut voor onderwijs. Studenten moesten leren disputeren en argumenten weerleggen. De diagrammen waren daarbij behulpzaam om verschillende gedachtelijnen te onderscheiden en deze in bouwstenen te analyseren. De 'collatie'-mogelijkheden tussen diagrammen vergrootte het bereik van toepassing en de verknoping van de verschillende gedachtelijnen.

Waar Latour in de vroege wetenschap vooral aandacht voor het onderzoek zelf ziet, en maar een kleine rol voor een aantrekkelijke visuele presentatie van de resultaten, toont dit boek dat er in de dertiende tot de vijftiende eeuw veel aantrekkelijk wetenschappelijk beeldmateriaal bestaat, maar dat deze vooral is ingezet voor onderwijs.

ACKNOWLEDGEMENTS

This Ph.D. thesis has been prepared at Leiden University, in the History department, section of Medieval History, with several sojourns in Paris, to consult manuscript libraries and to stay at the Ecole Normale Supérieure de Paris. Other visits for manuscript research were undertaken in London, Berlin and Uppsala. Large parts of these visits were financed by Leiden University Funds, and by Marie Curie Actions in the framework of Early Stage Training: The European Doctorate in the Social History of Europe and the Mediterranean - Building on the Past (6th FP).

I this paragraph I give the names of those people who, besides the committee, have given me useful comments on parts of my thesis, who have shown me new directions and encouraged me at moments when I did not see the relevance of my work. Of all those who made a valuable contribution to the completion of this doctoral thesis, many will remain martyrs only quorum nomina Deus scit. As to the remaining ones:

Even though I spent a large part of my Ph.D. project abroad, the section of Medieval history in Leiden has always remained my home base. I have learned a lot from everybody: from identities to fishes, staple rights, quarrels, old-boy networks, and pretty books. The atmosphere at work was great, the staff drinks highly stimulating. Thank you all for commenting on my papers and chapters in early drafts, which helped to direction to this study. I want to say special thanks to Robert Stein for his vision about trees and structures and for his encouraging talks. Your directions made this book so much better.

Very valuable was also my contact with colleagues at the History of Philosophy in Nijmegen University. I thank them, also of letting me consult their rich microfilm collection of medieval manuscripts.

I thank François Menant at the Ecole Normale Supérieure de Paris who took care of me during my stay in Paris. Your welcome has been and always is heartwarming. I thank Ian Hacking for having me over to Paris to give a lecture on trees at the Collège de France. The honour of standing there at an early stage of my career was tremendously encouraging. A big thanks to all those, in Paris, who were willing to discuss my work or parts of it, in particular Olga Weijers, Joelle Ducos and Barbara Obrist.

I could never have executed this research without the help of staff members of the *Département des manuscrits (division occidentale)*, *Réserve des livres rares*, and *Bibliothèque de l'Arsenal* of the *Bibliothèque nationale de France*, *La Réserve* of the *Bibliothèque Sainte-Geneviéve*, the *Institut de Recherche et d'Histoire des Textes* in Paris, *Lambeth Palace* in London, the *Department of Manuscripts* at the *British Library*, the *Manuscript Collections* at *Uppsala University Library*, the *Municipal Library* of Norrköping, the *Staatsbib-*

liothek in Berlin, the *Department of western manuscripts* of *Leiden University Library*, and the *Special collections department* of the *Library of the University Amsterdam*.

I also want to mention my friends. Met een kleine groep mede-promovendi deelde ik de beloften, de spanning, maar ook de teleurstellingen van het onderzoek doen, van het leven als onderzoeker, en het leven als zodanig. Ik wil in het bijzonder graag Serge ter Braake, Hans Wilbrink en Esther van Gelder bedanken voor hun vriendschap. Serge, bedankt: je hebt mede de weg gewezen en met opgetrokken wenkbrauw indrukwekkend weinig drukte gemaakt over het schrijven van een proefschrift. Hans, voor een beroepszwartkijker heb je toch aardig wat kleur aan mijn leven gegeven. Dankjewel. Esther: Wat een plezier om met je samen te werken! Samen zijn we Kwik, Kwek èn Kwak.

I would not like to miss the chance to thank lovingly my other history friends for their good advice and practical help: Justyna Wubs-Mrozewicz, Karine van 't Land, Justine Smithuis. Met in Paris but now spread over Europe again: Maike Thier, Barbara Gaspar Bosch, Josep Penades and Ivan Polancec. Gracias, Danke, dankjewel, dziękujè, thank you all for support, smiles, and friendship. Je remercie Margaret Dobby pour avoir passé avec moi de longues journées dans les bibliothèques, pour ta confiance et ton appui, pour l'amitié que tu m'as donnée depuis que je suis arrivée à Paris.

Dan een paar lieve en dierbare vriendinnen buiten de werksfeer, Mariëlle en Marlies, die vaak oprechte belangstelling toonden, maar gelukkig ook gewoon een biertje wilden drinken, lachen en praten over de dingen van het leven. Juist omdat werk niet de boventoon voerde in onze gesprekken, hebben jullie een belangrijk evenwicht in mijn leven aangebracht.

Pap en mam waren altijd trots, ook al werd dat niet hardop gezegd - het betekent meer dan ik doorgaans toon. Ik dank ook de rest van mijn familie die bij gelegenheid altijd met interesse informeerde naar de stand van zaken betreffende het proefschrift.

Et pour finir : mon cher Frédéric. Tu as fait un travail fantastique sur la mise en page de la thèse grâce au logiciel LaTeX, je t'en remercie. Tu m'as permis de me changer les idées en partageant tes lectures sur l'actualité, en me parlant de tes projets, en me tenant dans tes bras. Tu as partagé toutes mes émotions : la joie, le courage, l'assurance, mais aussi la frustration, l'impatience, le doute et l'attente. Merci pour ton appui irremplaçable.

Curriculum vitae

Annemieke Verboon was born November 12, 1975 in Delft, the Netherlands. She grew up in the Dutch regions of the Westland and Twente. In 1994 she started her studies at the University of Amsterdam where she obtained a Masters in Art History in 2001. A year later, in 2002, she obtained a Bachelor in Philosophy at Leuven University. From 2003–2009 she was associated as a Ph.D. candidate to the section Medieval History of Leiden University, where she wrote her doctoral thesis and conducted some teaching. In this period she sojourned for two years in Paris, to consult the manuscript libraries and for a stay at the École Normale Supérieure de Paris, thanks to a Marie Curie – *Early Stage Training* fellowship in 2006. In the Netherlands she co-founded a national platform *Material culture of science* with the objective of uniting scholars, scientists and curators of historical collections of scientific and scholarly material. In past meetings they addressed topics such as the genre of the scientific book, esthetics and science, instruments, anatomical collections, images, diagrams, and research material.