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be found alongside the Las Vegas Strip, that Minard's map would meet Archigram's graphic utopias, or that a Parisian *flâneur* would wander into the Olympic Stadium in London. But, after all, the graphic designer who is called upon to work in a wide variety of situations is quite used to unexpected connections. These connections find their *raison d'être* and become part of the structure that design is able to build.

Particularly noteworthy in our view are the similarities hinted at but which remain to be established between the practice of reduction in art and the invention of interfaces transforming the web into modern-day archives. Are we looking at a new kind of encyclopedia? Or it is the case that the role of the visual has been redefined, becoming predominant and replacing in depth the role historically assigned to demonstration, speech and the written word. If so, will it last? These questions bring together ideas of knowledge over the centuries and the work of an Otto Neurath or a Jacques Bertin.

We should perhaps explain the use of the word "provisional" in the first paragraph of this introduction in relation to the conclusion of the research program begun in 2011. This publication, like the two preceding ones, forms part of an exploratory phase, the potential of which is not yet exhausted. Links are created between these contributions, combining their themes – themes that reach beyond the covers of the book. While many connections remain to be identified and examined, here is not their place. A place must be created. It is our hope that the members of the research continuing this work at ESAD Grenoble Valence will, along with other scholars, find this initial stage of use.

REDUCTION INTO ART AND THE VISUALIZATION OF KNOWLEDGE¹

TRANSLATED FROM THE FRENCH
BY CAROLINE HIGGITT

PASCAL
DUBOURG GLATIGNY

¹ P. Dubourg Glatigny and Hélène Vérin, over a period of several years, led a research group investigating "Reduction to art". The results of this work can be read in the joint publication *Réduire en art: la technologie de la Renaissance aux Lumières*, Paris, 2008.

Reduction into art (*ad/in artem reducere/redigere*) is an intellectual system that seeks to rationalize practical knowledge relating to the liberal and mechanical arts. The aim of this ordering of knowledge and skills is to contribute to their diffusion, assimilation and implementation. Like many of the cultural phenomena of the Renaissance, the roots of its principles can be found in Antiquity. In a passage on civil law and, more specifically, the exercise of justice, Cicero writes: "For nothing can be reduced to an art unless the man who has mastered the subject, of which he would organize an art, already possesses the special knowledge requisite to enable him, out of particulars not yet embodied in an art, to construct one.[...] And so a certain art was called in from outside, derived from another definite sphere, which philosophers arrogate wholly to themselves, in order that it might give coherence to things so far disconnected and sundered, and bind them in some sort of scheme"². The instrument with which to carry out this reduction to art is dialectic: an exterior discipline is used as the operator in the organization of knowledge with which it is unconnected.

While there are examples of the use of this expression in the Middle Ages, it is not until the Renaissance that it becomes more widespread, being applied to the majority of human activities. This was a time when the boundaries of knowledge seemed to be expanding rapidly. Sometimes a need was felt to operate choices between apparently contradictory forms of knowledge; the result was the emergence of the question of what is a method.³ At the same time, as printing developed and changed ways of communication, some scholars began to ask questions about not only the quest for and selection of different types of knowledge but also about their arrangement in a hierarchy and their exposition. For the majority of human activities, whether technical or artistic, apprenticeship to a master who passed on ancestral techniques had ceased to be the only source of instruction. The works of Antiquity, gradually being rediscovered at this time, provided a mine of information. Architecture was renewed by the discovery of Vitruvius, hydraulic engineering recovered forgotten techniques from the works of Frontinus and the art of war was reformed along lines suggested by Vegetius. But the texts of the Ancients were not the only sources tapped by the practitioners of the Renaissance: there was in addition an explosion in the numbers of rules

² Cicero, *De Oratore*, vol. 1, ll. 187-187, Cambridge Harvard University Press, trans. Rackham, H and Sutton, E.W. 1942, reissue 1967.

³ M.-D. Couzinet, *Histoire et Méthode à la Renaissance, une lecture de la Methodus de Jean Bodin*, Paris, 1996.



fig. 1 Arbre de Jessé, XII^e siècle, Tree of Jesse, 12th century, *Lambeth Bible*, Londres, Lambeth Palace Library.

formulated by the guilds and corporations, an accumulation of legal directives and the development of professional knowledge in the universities. And they did not confine themselves only to knowledge in books: the collection and preservation of artisan skills formerly transmitted in the workshop, studio or building site now became a new resource.

KNOWLEDGE REDUCED TO ART AND THE INTRODUCTION OF DIAGRAMS

Not all types of practical knowledge described and published in the Renaissance followed the model of reduction to art. Some were organized by *topoi*, or *loci* in Latin. These were stock elements that followed standardized formats in particular rhetorical contexts. Anthologies, collections and *specula principum* ("mirrors for princes") consisted of quotations from the classical authors. They are all, however, based on the written traditions for a particular discipline. The authors that applied the idea of reduction into art, by contrast, were prepared to tackle sources that were much more varied: written or oral, ancient or modern. In many cases, they had no classical model set down for their discipline. While architecture and cookery were more fortunate, this was not the case for dance or painting. The result was that they had to disassociate the disciplinary content from the methods of exposition: Euclid, Vitruvius and Quintilian were often called upon to rationalize the exposition of a branch of knowledge that had originally little to do with mathematics, architecture or rhetoric. Spurred on by an undeniable passion for innovation and invention, these authors were determined to set down their discoveries in writing, their work going far beyond the superficial rejigging of old knowledge. The philosopher Louis le Roy (1510-1577) inveighs against "the perpetual imitators and always translators or commentators concealed in the shadow of others [who] are nothing but slaves, having no generosity and sometimes do not even dare do what they have learned over many years". Conscious of the immensity of the task, he declares: "Great things are difficult and slow to arrive. How many are there still not yet reduced to art?"⁴

The emergence of treatises proposing a reduction to art took place in a context of economic expansion introducing new values of efficiency and productivity. The aim of such books was to place knowledge within the reach of the greatest number possible and

⁴ L. le Roy, *De la vicissitude ou variété des choses en l'univers*, Paris, 1575, fol. 249-250v.

⁵ F. Bacon, *The two books of the proficience and advancement of learning divine and humane*, London 1808, p. 43.

⁶ J. Gisbert, *L'art d'élever un prince*, Paris, 1688, p. 176.

⁷ *Discours préliminaire de l'Encyclopédie*, Paris, 1866, p. 33. English trans. <http://quod.lib.umich.edu>

also to simplify access to scattered sources. A large part of the work of the "reducer to art" consisted in ordering these instructions and enabling a rapid implementation of procedures. Any hesitation between several different formulas or possibilities would naturally delay the execution of the task. Behind the move towards reduction to art lay a desire for standardization together with specialization and division of labour. It could be argued, following Francis Bacon (1561-1626), that this process sometimes stifles inventiveness: "Another error [...], of a diverse nature from all the former, is the over early and peremptory reduction of knowledge into arts and methods; from which time commonly sciences receive small or no augmentation".⁵ He speaks as an upholder of principles. Perhaps the phenomenon, as it becomes more generalized, leads to a certain rigour that could be mistaken for rigidity? It is also true that not everything can be reduced to art, particularly when the matter of the value of talent is involved, a quality understood here not as a predisposition but as sensitivity: "It would not be possible to reduce to art the manner in which one might seek to educate the sentiments of a young prince".⁶

Reduction to art was an idea that lived on well into the eighteenth century, Diderot and d'Alembert's *Encyclopédie* being its most universal and structured example. As a project, the last word that would come to mind about the *Encyclopédie* is "strangling". In the "Preliminary Discourse," published in 1750, the authors of the *Encyclopédie* go so far as to express the wish that it would "reduce to an art the very manner of acquiring information and of reciprocally communicating their own ideas. This art was found and named Logic"⁷. It was also at this period that reductions to art gradually made way for manuals, expressions of skills institutionalized in establishments that specialized in teaching them. Today, *in artem redigere* is only found among certain jurists who still use the expression "*jus in artem redigere*", by which they mean the application of a systematic method to the interpretation of a particular law.

Reduction to art is a cultural phenomenon that has found expression not only in language and written texts. Authors have sometimes applied the system, based as it is on heterogeneous material, to visual representation of types of knowledge in an attempt to simplify their acquisition. At first, they set out the distribution of branches of knowledge in diagrammatic form,



fig. 2 Arbre de Jessé, XV^e siècle, Tree of Jesse, 15th century, Fra Angelico, *Armadio degli argenti*, Florence, Museo nazionale di San Marco.

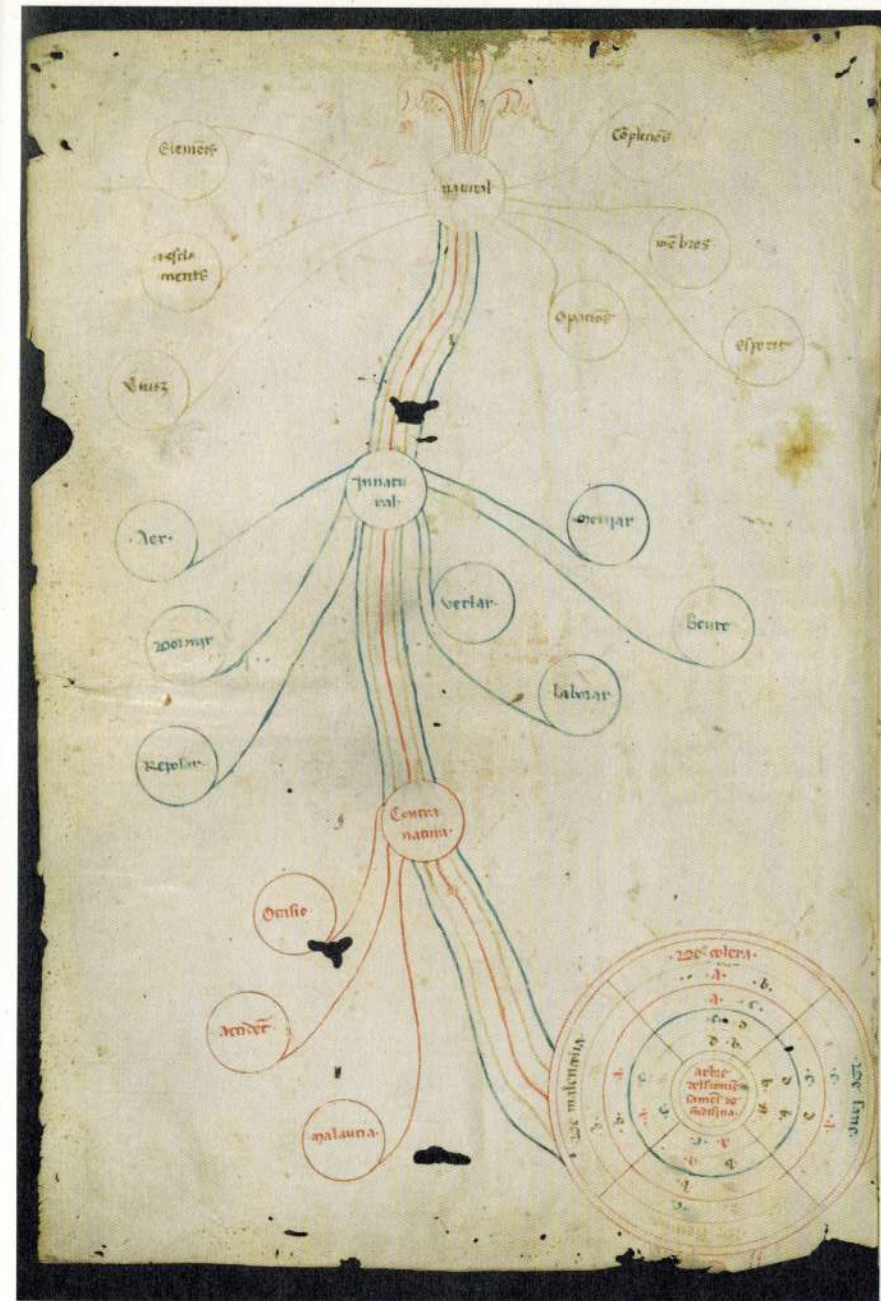


fig. 3 Un arbre de médecine dans un manuscrit de la fin du XIII^e siècle, A medicine tree from a late thirteenth-century manuscript, Ramon Llull, *Començaments de medicina*, Dublin, University College.

showing the links between them. It was not long, however, before they began using these diagrams to provide an effective description of complex procedures not easily explained in words. As they tried to give an account of physical operations they came up against the problem of how to express clearly the spatial and temporal aspects of an operation without going into unnecessarily long descriptions. How could they express motion, the movement of a body in space and the succession of actions? It was here that images took over from text.

FROM THE GENEALOGY OF CHRIST TO TREES OF KNOWLEDGE

The authors who pursued the idea of reduction to art developed a variety of visual devices to get round this difficulty. The way was paved for them by a long tradition of the use of diagrams in particularly bookish branches of knowledge. One of the most interesting examples is the development of the iconographic scheme of the genealogy of Christ into trees of knowledge. It is of particular relevance to our argument because it marks the transition from the illustration of a narrative to the representation of a system of knowledge.

The *New Testament* contains two genealogies of Christ that differ in some points from David onwards. The version in Matthew (I, 1-14) begins with Abraham and institutes a periodization, with a break at the time of the deportation of the Hebrews of Judea to Babylon. The version in Luke (III, 23-28) starts at the very beginning with Adam, the son of God and sets out the names of the ancestors in a linear manner. While Matthew names them in descending order ("X begat Y"), Luke arranges them in ascending order ("Y son of X"). Two opposing ways of seeing time are offered, one turning towards the future, the other looking back to the past. Many representations of this genealogy exist, dating from the eleventh century onwards, often arranged along the lines of the passage in the *Old Testament* relating to the Dream of Jesse: "And there shall come forth a rod out of the stem of Jesse, and a Branch shall grow out of his roots" (Isaiah 11:1-3). Jesse, father of David, marks the exact moment where the two Gospels diverge before arriving at Christ. This bifurcation was to give rise to many theological discussions over the course of time.⁸ The majority of the representations that have come down to us from the Middle Ages

⁸ S. Legasse, "Notes et critiques: les généalogies de Jésus", *Bulletin de littérature ecclésiastique*, 99, 4, 1998, pp. 443-454.

entered into this debate by their choice of patriarchs, and their decisions as whether to contextualize them or represent them as icon-like portraits, with or without a more extensive network of genealogies involving a more or less complex arrangement of branches. The representation of the Tree of Jesse posed the question of the historicity of Christ's genealogy and the anagogical reading that can be deduced from a simple chronological list. The frequent inclusion of the figure of the Virgin Mary on the trunk of the tree itself is an indication of the serious nature of this questioning. This figure, standing outside the patriarchal lineage, calls the viewer, through the series of mysteries of every kind, to the contemplation of Christ's genealogy. [fig. 1, p. 129]

At the same time, certain iconographers felt the need to introduce a system of classification that could be understood from the representation. This can be clearly seen, for example, in the works produced by Fra Angelico and his entourage between 1451 and 1453 for the cabinet housing the precious ex-votos offered to the church of the Santissima Annunziata in Florence.⁹ One of the panels, part of the *Life of Christ* cycle, shows icon-like portraits of each of Christ's ancestors; in addition each one of them holds a scroll referring to the missions of the Church. The tree has been replaced by a seven-branched candelabrum, archetype of the celestial sphere with its seven planets. The element of "vegetable nature" (the tree), now no longer required to act as the image's vertebral column, is now visible in the background of this representation where narrative and symbol are intermingled. In an evocation of the universe, the central stem of the candelabrum displays the stages of Christ's life as spiritual stations in the life of the faithful. [fig. 2, p. 130] Here there is no attempt to provide a chronological direction for the story or a narrative extension to be allocated to each of the ancestors. In Angelico's panel, we find, on the one hand, nature and the cosmos placed in relation to one another and, on the other, a clear link made between the literal, historical plane and the tropological meaning, intended to lead to moral elevation.

It was only a small step from this usage of an iconographic scheme in the area of theology to that of natural philosophy, from spiritual learning to that of the material world. This phenomenon can be seen at work in the writings of the thirteenth-century Catalan scholar Ramon Llull. Llull travelled throughout Europe

⁹ E. Casalmi, *Il Beato Angelico e l'Armadio degli Argenti della SS. Annunziata di Firenze*, Florence, 2007.

propagating his logical doctrine of preaching and conversion. The technique he called the *Ars Magna* brought together philosophical and theological arguments, presenting them in a fixed geometrical form. Different kinds of knowledge emerging from different disciplinary contexts were to be selected and compared and examined by means of intellectual operators applicable to any case. The resultant knowledge could then be translated into action. One of Lull's works, the *Arbor scientiae* (*Tree of Science*), shows knowledge as being divided into sixteen different trees of knowledge.¹⁰ They bring together profane and sacred knowledge, uniting them in a coherent whole moved by a natural principle. Each tree is made up of seven parts: the roots contain the elemental principles, the trunk displays the nature of the knowledge, the branches represent the different components or aspects — bodily or spiritual, the twigs the attributes of these components, the leaves the accidental characteristics, the flowers the operations carried out on this material by humankind, and the fruits the individuals who make up this type. Lull's trees show in diagrammatic form the components of knowledge according to an order believed by Lull to be natural and hence divine from the moment of its definition and its identification right through to the maturing of the intellectual fruits it produces. [fig. 3 et 4, p. 131-132] From then on, Lull was to be famous for having tried to organize his ideas using graphic means that put forward an alternative conceptual flow than that suggested by a written text. By contrast, the majority of manuscripts of his time, transcribed and copied by scholars more interested in language than in images, rarely included such visual representations of trees of knowledge.

An interesting fourteenth-century miniature is evidence of the difficulty that scholars found in having their visual explanations accepted. A pupil of Lull's, Thomas Le Myésier (died 1336), presented a large compilation of his master's works with the aim of encouraging the use of these theories in universities, and particularly at the Sorbonne where he taught. One of the versions of the *Breviculum* contains several illustrations showing the life of Lull, including a scene where the master and his pupil are shown talking. [fig. 5, p. 132] Ramon indicates a box filled with books and says: "Here are a hundred and fifty books, small, medium and large...". Thomas answers: "Such a large number of books may cause confusion and upset the human intellect". Higher up, on the

¹⁰ Raimundi Lullii Opera latina - *Arbor scientiae*, P. Villalba Varneda (ed.), Turnhout, 2000. For the Tree of Science, see *Arbor scientiae. Der Baum des Wissens von Ramon Llull*, F. Domínguez Reboiras, P. Villalba - Varneda, P. Walter (eds.), Turnhout, 2002.

right hand side of the image, Thomas is saying: "The moderns love conciseness and (...) I have devoted myself to abbreviating (...) the text of your books with the aim of simplifying study and relieving eye fatigue because of the complexity of the signs and of its sixteen figures which oppress the mind". Despite these remarks, the miniature represents intellectual operations according to the Lullien system of alphabetical classification. They are to be found in the top and left-hand borders, their meaning being: "A: God, B: memory, C: understanding, D: will, E: the combination BCD ...". The alphabetization of the faculties is followed by brackets linking three or four notions together, indicating the logical links with a higher level.

It is hard to recognize in this medieval universe the paradigms of the reduction to art as adopted in the early Renaissance. And yet, several elements were already in place: accumulated knowledge was destined for action, Thomas was moving towards an essential choice from a mass of scattered information, he was writing about these subjects according to a new and more concise order. Ramon's earlier attempts were informed by the same concerns. By means of logic trees and diagrammatic alphabets, he reformulated theories developed in his texts so that they could be remembered visually.

A GEOMETRY REDUCED TO TABLES

Several disciplines fed into reductions to art, contributing to the structuring of written rules applicable to other activities. This operation was not without symbolic significance. By using the written word, as found in recognized disciplines such as rhetoric, these activities were promoted from the rank of "activities" to that of "disciplines". In many cases, it was mathematics — and particularly geometry — that filled this function.

In the early Renaissance period, the ordering of mathematics was very different from that which we know today. It evolved out of texts by Euclid that were progressively perfected and completed. Different versions of Euclid, of which the most important was that by Campanus of Novara, offered various structures and arrangements of his *Elements*, depending on which tradition they followed — Arab-Latin or Greek-Latin.¹¹ In either case, the texts were often accompanied by illustrations, taken from the original source or elaborated on by copyists. Thus the manuscripts, or at least those concerned with geometry, frequently contained large

¹¹ H. L. Busard, M. Folkerts (eds.), *Robert of Chester's Redaction of Euclid's Elements, the so-called Adelard II Version*. Basel, 1992.

numbers of diagrams. Mathematics in the Middle Ages was often taught with a specific, frequently theological, aim in mind and it was not until the Renaissance that it could be properly described as a speculative science. In these conditions, Euclid's teachings are frequently mixed in with other sources, each compiler making a particular selection with specific and practical goals in mind. The fifth-century Berber writer Martianus Capella, for example, represents the seven liberal arts, including geometry and arithmetic, as the servants of philology.¹² The sixth-century compilation for Roman land-surveyors *Corpus Agrimensorum Romanorum*, influenced by the work of Boethius, describes the techniques of geometrical land measurement relating them to Roman property laws.¹³ Gradually, in the course of the sixteenth century, a more reliable and complete version of Euclid's text became available, establishing the notion of starting from the simple and progressing to the complex. The thirteen or fourteen books were selected and arranged with the types of exposition separated out into definitions, postulates, axioms, lemmas and scholia. A relative consensus was reached with the edition prepared by the Jesuit scientist Clavius and published in 1574. The thoroughness and precision of this work put an end to many earlier mathematical debates.

The construction of the canonic text of the *Elements*, a *summa* of mathematical knowledge, did not, however, directly fit the needs of practical mathematicians. Knowledge is one thing, practice is another. Clavius himself attempts to remedy this by adding onto the end of many of the propositions a short paragraph setting out the *praxis* (practice), explaining the application of a particular piece of knowledge. These paragraphs only occur in Book I and the schemas found throughout the work are no more than illustrations of entirely verbal mathematical formulations. We need to turn to other authors to find broader approaches, still based on the early modern text but applying the idea of reduction to art through the use of images.

Among the numerous rewritings and summaries of the Euclidian texts to appear during the Renaissance, that of Giovanni Pomodoro is of special interest. In a series of 44 tables, his work offers visual lessons in geometry. It was not published until after his death in 1599, by the mathematician Giovanni Scala who, faithful to the tradition of explaining mathematics verbally, adds a

¹² Martianus Capella, *De nuptiis Philologiae et Mercurii* (On the Marriage of Philology and Mercury). Book VI: *Geometry*, English trad. by William Harris Stahl, Columbia University Press, 1992. ¹³ C. Thulin, *Die Handschriften des Corpus agrimensorum romanum*, Berlin, 1911.

¹⁴ Vitruvius, *De Architectura*, Book 4, Preface. Vitruvius: The Ten Books on Architecture. Morris Hicky Morgan. Cambridge: Harvard University Press. London: English trans. Humphrey Milford. Oxford University Press, 1914. Perseus Digital Library <http://www.perseus.tufts.edu/hopper>.

summary of the relevant Euclidian text to accompany the plates. Highly influential during the whole of the seventeenth century, the work is addressed to "soldiers, architects, bombardiers, engineers, cosmographers and teachers of general geometry". Scala states that here geometry is "set out in figures and explained with statements", with the text clearly subordinate to the images. [fig. 6, p. 133] The first few plates show the instruments used in the practice of geometry: compasses, set squares, rulers, pencils, knife... Next come basic definitions: the point, the different kinds of lines, the distinction between surfaces and volumes, regular and irregular. Following that come a succession of procedures for calculating proportions and transforming figures, all conforming to Euclid's work. After that are the applications appropriate for the particular skills the book aims to teach. In other words, Pomodoro has used Euclid as a basis to which he adds other types of knowledge as well as drawing on the experience of practitioners. It is, strictly speaking, an example of reduction to art, but here formulated entirely in images.

THE ORDERS OF ARCHITECTURE DIAGRAMMATICALLY EXPRESSED

During the Renaissance, architecture was a discipline in its own right. It already had its treatise from Antiquity, Vitruvius's *De Architectura*, which brought together a large number of precepts and prescriptions relating to the art of building. This material had already been organized according to a rational sequence by its author who had "to reduce the whole of this great art to a complete and orderly form of presentation, and then in different books to lay down and explain the required characteristics of different departments"¹⁴. The theoreticians were, however, presented with another fund of knowledge — Roman monuments and ruins. They found that these two sources, very different in nature, did not always agree, often on account of changes over time. Architects were thus compelled to compare one with the other and then make a choice. A further problem with Vitruvius's work — at least as it had come down to them — was that it had no illustrations. The reconstruction of these images was to give rise to a lively and conflicting debate that was to continue for many centuries. This was why practitioners of architectural theory were obliged to undertake a double reduction to art. The first consisted of selecting

those things that enriched and complemented Vitruvius's text from the mass of knowledge from other sources as well as that from the oral tradition of the science of building. The second, corresponding to the other meaning of "*reducere*", related to methods of restoration, renewal and reinstatement.

At the heart of the debate lay the theory of orders, describing and regulating the appearance of columns, essential elements in any architecture. More than any other part of architecture, columns and capitals were often to be found dismembered and scattered on the sites of ruins, their link with the function of the buildings they had belonged to now severed. According to Vitruvian theory, each order had an appearance that was anything but merely decorative: this was the Humanist notion of *ornament*. The system governing the relationships between the base, the shaft and the capital of the column was to undergo ramifications with the entablature and, more generally, in the building as a whole. Each order was, furthermore, intended for particular types of buildings, according to a classification system with its origins in Antiquity.

The work on the orders of architecture set down by the architect Vignola in 1562 was, in succeeding centuries, to be one of the most published books on architecture. Unlike many other contemporary publications, the text is very short and omits Vitruvius's commentary. The author announces his intention to draw on the work of "all the Ancients" and to add nothing but a modular grid diagram, based on a system of proportions between the elements making up the different columns. With this, he avoids giving measurements for the various "individual members", information based on observation that was frequently provided by other authors but which was of little use in the design of new projects where the dimensions were naturally unpredictable. In the plates illustrating capitals, Vignola draws an elevation including the entablature and provides, to one side, a scale of proportions of the different elements on particular buildings mentioned in the short explanatory text. [fig. 7, p. 133] He proceeds, therefore, with an archeological intent, the information he provides coming from the observation of the buildings of ancient Rome, but with a mind still influenced by Vitruvian ideals in that he seeks to establish a rule that can be applied to different types of columns. Vignola is dealing with a purely architectural area — the theory of orders — but Vitruvius does not, strictly speaking,

provide him with the material for his account. It instructs him, though, in how to proceed and how to bring together knowledge that is scattered, heterogeneous and sometimes contradictory. It offers a model for the diagrammatic presentation of this knowledge.

ARCHITECTURE, A STRUCTURING DISCIPLINE

Vitruvius states at the beginning of his treatise that architecture is a multidisciplinary activity and that the architect stands at the centre of a discipline that requires the contributions of specialists drawn from many other areas. Central to his writing is the matter of the construction to be built — the contract — and the importance of the ability to project oneself into an unknown situation and turn it to account. Thus, Vitruvius's work is not merely a collection of different types of knowledge about the science of building, it also describes a method for the acquisition and organization of skills required for action, and indicates the order of operations to be followed. Architecture is not only a discipline in the sense of the doctrine of building, it is also a discipline in the sense of a rule of conduct for intellectual operations. Thus it is that Vitruvius's *De Architectura*, like Euclid's *Elements* and Quintilian's *Institutes of oratory*, served as a model for other areas of knowledge. But Vitruvius's text was not the only one to play a role in this process. Through archaeological discoveries, the first tangible reality of the culture of the Ancient world in the Humanist period, material architecture made an equally important contribution to the structuring of the conception of a knowledge brought to a complete and useable form, establishing an analogy between the static stability of buildings and the logical force of intellectual constructs.