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The Nature of the Artificial: the Contingent and the Necessary in Spatial Form in Architecture

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Abstract: As an explanatory — as opposed to a descriptive — concept, *purpose* has long since been dispensed with in natural science. But recently it has taken up residence in the 'sciences of the artificial' since, it is argued, the form and nature of artefacts can only be understood in terms of the human purposes they serve. The aim of this paper is to show, by examples, that in the case of architecture and urbanism — the largest human artefacts apart from society itself — the argument is fallacious. Architectural and urban artefacts exist to organise and order space for human purposes. But their form and nature cannot be explained in terms of these purposes alone. Explanation requires an understanding of morphological laws of space, within which human purposes work themselves out. The laws are, it would seem, akin to natural laws, and would not justify any special epistemological stance for the 'sciences of the artificial'. *Purpose* should not therefore be given any more privileged status for artefacts than it has for nature. In both areas the role of science is to give an account of the underlying morphological constraints on possibility.

Introduction: Aristotle's Houses

It is often observed that Aristotle's philosophy of nature was based on the assumption that the existence of forms well-adapted to functions in nature was evidence of purposeful design. It is less often observed that his paradigm was architecture.[1] The form of a house, he argued, cannot be explained merely by the process of laying stone on stone, since this 'material cause' needs to be guided by a pre-existing idea of the form the house is to take. Its material form, we might say, needs to be guided by foreknowledge of the spatial form that is required. The argument is unexceptionable. Transferred to nature, it might reasonably be seen as an anticipation of modern genetics.

But Aristotle goes further. The problem, as he sees it, is not simply to explain form, but to account for the adaptation of form to purpose. His answer is immediate. Form and purpose are the same thing. Nature gives form in order to achieve purpose. As with architecture, as he sees it, form is incomprehensible without purpose. 'Final causes', therefore, are purposes. The source of all order in nature is purposeful design. On this architectural foundation the whole fallacious structure of Aristotelian 'science' was erected.

It had one merit. It was the philosophy in the rejection of which scientists would grow strong and wise. In a way, it set the standard. Any theory that could be shown to fall into the Aristotelian error of 'explaining' order in terms of some 'pre-existing order' — an essential requirement of a 'design' theory — could not be counted as a scientific theory. This is why such concepts as inertia in physics and random mutation in biology had such epistemological force, as well as scientific usefulness. They showed how it was possible, and necessary, to set theories of order on a foundation of non-order, thus finally breaking the link between the idea of order and the idea of design. With Aristotle, purpose had been an ultimate explanation. In science the relation of behaviour to form,

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which had given rise to the concept of purpose, became a problem of description. The concept of 'function', perhaps, embodies this descriptive neutrality.

Laws of the Artificial

But the idea of purpose as an explanation of form is not dead. It is alive and well in the area where it began with Aristotle: the artificial. The views of Herbert Simon, inventor of the splendid concept of the 'sciences of the artificial', are pertinent here (SIMON, 1969). Artefacts, according to Simon, are unlike natural phenomena in that they are both contingent — we make them as we wish, rather than as nature makes them according to her laws — and purposeful — in that their form arises from the human purposes they are to serve. More precisely, Simon sees purposes (or 'goals', as he calls them) as links between two kinds of *environment*: the 'inner environment' of the artefact, that is its internal structure; and the 'outer environment', that is the range of circumstances in which these 'goals' must be realised. Purposes or goals are the means by which a selection is made from the contingent possibilities. Purposes are, therefore, the distinctive subject matter of the sciences of the artificial, in contradiction to both inner and outer environments, which belong in the natural sciences.

From this Simon derives a research strategy which can be summarised by his dictum adapted from Alexander Pope: " . . . the proper study of mankind is the science of design" (SIMON, 1969, p. 83). By 'design' he implies a kind of means-end analysis for relating inner and outer environments as favourably as possible, given specified goals. Such a science is possible because:

> "Just as the 'inner environment' of the whole system may be defined by describing its functions, and without detailed specification of its mechanisms, so the 'inner environments' of each of the subsystems may be defined by describing the functions of that subsystem, and without detailed specification of *its* submechanisms (SIMON, 1969, p. 73).

The 'sciences of the artificial' thus become coterminous with the 'science of design'. The two possibilities, Simon asserts, stand or fall together (SIMON, 1969, p. xi).

Now this all sounds very convincing, until we realise that it has the rather bizarre implication that the sciences of the artificial do not exist first and foremost to study artefacts themselves, but to set up processes for designing them which reduce the artefact itself to an abstract representation by way of the notion of 'goal' or purpose. It is all the more bizarre if we reflect that, on a rather broader historical perspective, many sciences of the artificial are well-established and preoccupy themselves precisely with the inner structure — Simon's 'inner environment' — of the artefact. These sciences exist, by and large, where artificial systems are found with the curious property of being both man-made and not understood by man. Languages, cities and societies all come into this category. Moreover, in those areas where design plays a central role — such as urban design — it would seem that the simplification of the artefact itself to a functional description by the designers had been, historically, the means by which all understanding of the artefact was lost.

I have argued elsewhere (HILLIER and LEAMAN, 1974) that design depends on the availability of much more powerful representations of the artefact than would be given by a set of functional abstractions. This is not my theme here. My argument in this paper is more fundamental, and concerns the nature of the alleged differences between artificial and natural systems. I will try to show, by means of examples, that even in the case of spatial form in architecture, Aristotle's starting point on the notion of *purpose* is as devoid of explanatory power as it is in the natural sciences, for more or less the same reasons. The analysis of purposes is, of course, a vital part of the pragmatics of architectural understanding. But it cannot be the basis of a scientific understanding of spatial form in architecture. The object of scientific understanding here, as elsewhere, must be the morphological laws and constraints within which architectural purposes work themselves out. Understanding the relation between purpose (or perhaps we should now use the term 'function') and spatial form depends on a prior understanding of something like the laws of space itself. Or, to put it another way, how function can turn itself into form is severely constrained by the nature of space itself, so much so that an understanding of these constraints and laws is necessary to any non-trivial analysis of the relation of function and form. This implies, of course, that in this particular realm of the artificial there exist morphological laws of the artefact itself which, while not being as powerful and universal as natural laws, are none the less sufficiently akin to them to justify an epistemological parallel between natural science and the sciences of the artificial.

Taking spatial form in architecture and urbanism as my starting point, I will present a series of simple examples to illustrate *three kinds of spatial law*:

1. Laws relating to the generation of spatial patterns by means of walls, apertures, etc., which we might call the *laws for the construction of space*.
2. Laws by which different types of social relations (for example, those which require space to provide segregation or integration) require different types of spatial pattern, which we might call *laws from society to space*.
3. Laws by which spatial structure has its effects back on society, which we might call *laws from space to society*.

The last of these raises the controversial question of 'architectural determinism'. One consequence of my argument is to show that, in a certain limited sense, such a thing does exist. Spatial design is neither empty nor trivial in its effects on society.

Each of the three types of law will be explained, in turn, by means of real cases. But because the interest here is primarily philosophical, technical explanation will be kept to the minimum necessary to make the cases clear. Readers interested in the full technical details should consult the appropriate texts (HILLIER *et al.*, 1983; HILLIER and HANSON, 1984).

Type 1: Laws for the Construction of Spatial Objects

The first example deals with the structure of certain small settlements. Figures 1a and 1b represent two small settlements in the north of England. Figures 2a and 2b represent two settlements in the south of France. All four are of the kind that would normally be classified as 'irregular' or 'random', since they all lack the kinds of defining features that govern standard classifications: village greens, linear streets, and so on. Yet, oddly, their very irregularity seems to suggest that they might be — at some level — of the same *organic* type.

Careful description can indeed reveal certain common properties. Each settlement is composed of dwellings that define, by their location and orientation, a continuous structure of open space which has a very characteristic form. Firstly there is a continual variation in the width of the open space, so that the fatter areas of space are linked to other fatter areas through thinner spaces, creating an effect rather like irregular beads on a string. Secondly, the structure of open space forms at least one, and maybe several, intersecting rings, which means that there are always alternative routes from every point in the settlement to every other point. Thirdly, although the maps do not show this, empirical inspection will reveal that nearly every distinguishable piece of space — bead or string — is directly adjacent to at least one building entrance, so that the spatial pattern seems to be, in some sense, defined by building entrances.

In short, the four examples all have in common what we call, for want of a better term, a 'beady ring' structure, defined by the orientation of building entrances. What can explain this family likeness? None of the obvious candidates — climate, topography, defence, land tenure systems, and so on — seem able to explain the specificity of the form as I have described it. So perhaps we should explore what might seem, on reflection, a more natural possibility than any of these: that the 'beady ring' form might in fact be the result of some simple process of *organic* growth.

A simple model can suggest such an aggregative process. Let us define an 'elementary unit' for this process as being made up of a simple square dwelling with one entrance and an equal-sized area of open space in front of the entrance side (Figure 3). Now, let us define a process of random aggregation of such units, subject to two rules: each new unit must be joined by its open space with a full facewise join onto an open space already in the aggregation; and while full facewise joins of dwellings are allowed where they occur randomly, the joining of dwellings by their vertices is not allowed (since it is unrealistic).

Figure 4 shows a fairly typical result of such a process of aggregation, carried out by computer and frozen at the average size of an actual 'beady ring' settlement. Figure 5 is a much larger surface generated in the same way. It is clear that all three defining characteristics of the beady ring structure — the formation of variable beads and strings of space, the formation of rings and the relation to building entrances — are all produced in a natural way by this process. Of course, one might object

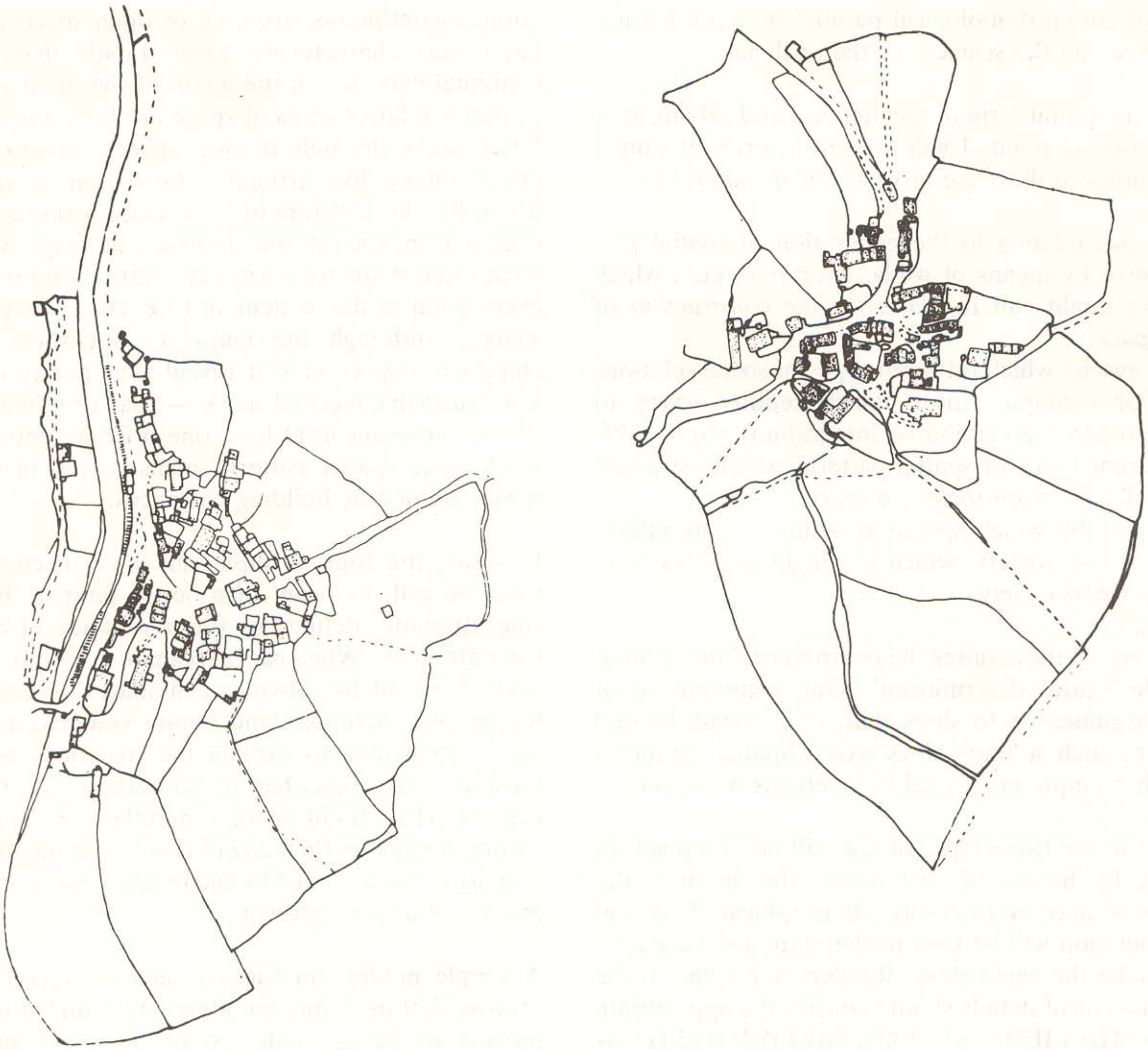


Figure 1. (a) Muker; (b) Middlesmoor.

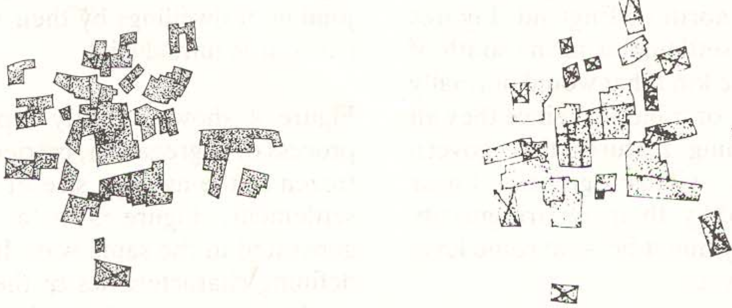


Figure 2. (a) Perrotet; (b) Les Yves.

(a) (b) (c)

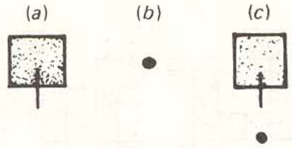


Figure 3. (a) Elementary unit with one entrance; (b) open space; (c) elementary unit with open space in front of entrance side.

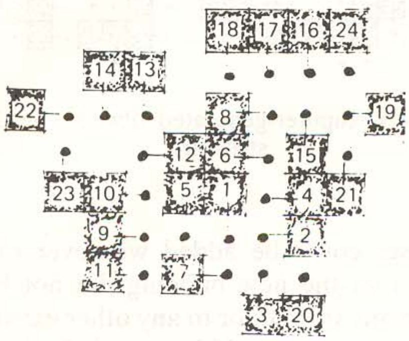


Figure 4. Computer-generated 'beady ring' surface. The numbers refer to the sequence of aggregation.

that the result is influenced by carrying out the process in an over-regular way. But this is not so. Figure 6 is a 'de-geometrised' computer-generated village layout (by Paul Coates of UCL) that simulates some rather more linear beady ring forms that can be found in the North of England. The general characteristics of the beady ring process are robust enough to appear in many variations.

What about the variation between the settlements in Figures 1 and 2? The main difference seems to lie in the size and number of clumps of buildings — the settlements in Figure 1 having several such clumps, and therefore several rings, while those in Figure 2 have a more dominant major clump and a dominant ring of open space. Again, a simple change in the formal model can generate this difference. In the process I described, the question of whether or not two 'houses' joined onto each other was settled randomly. If the process generated it, then it happened. Suppose, then, we lessen the randomness of this type of join by specifying a higher probability of contiguous houses than would occur randomly. Obviously the effect would be to increase the size and decrease the number of clumps. This is, in fact, the main difference between the settlements

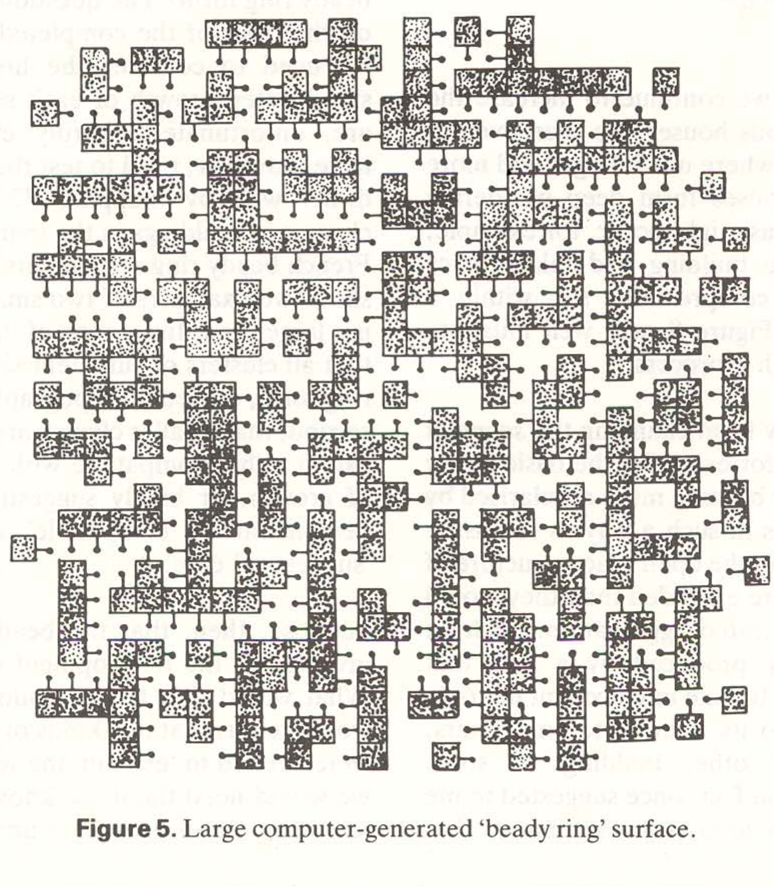


Figure 5. Large computer-generated 'beady ring' surface.

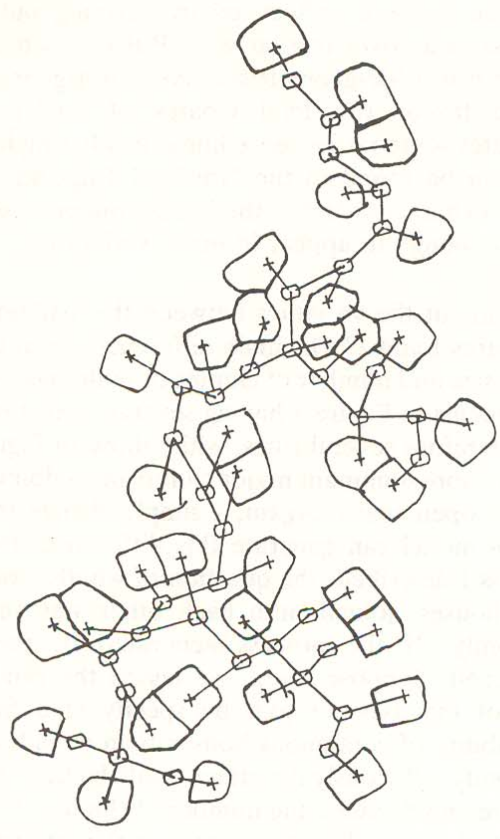


Figure 6. 'De-geometrised' computer-generated village layout.

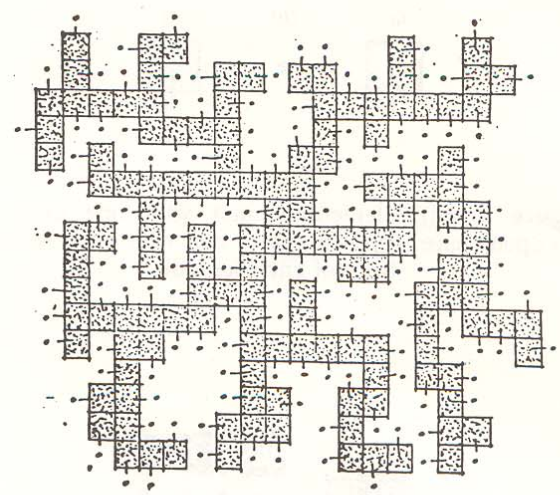


Figure 7. Computer-generated 'obverse' beady ring structure.

in Figures 1 and 2. If we continue to increase the probability of contiguous houses, we then eventually arrive at a pattern where much larger and more irregular clumps of houses form deep wandering courtyards (Figure 7), as might occur, for example, in a settlement where building had taken place under severe spatial compression, say within a restrictive town wall. Figure 8 may well illustrate the end product of such a process.

Other variations follow from changing the *scope* of the rules. In Figure 9, for example, the basic beady ring process has clearly become more regularised by arranging the dwellings in such a way as to ensure that lines of sight (within the open space structure of the settlement) are more extended than they would be in a randomly generated aggregation. Such an effect could be easily produced by a rule that required each new unit to take into account not only how a house relates to its immediate neighbours, but also relations to other buildings at some distance away. It was, in fact, once suggested to me by a local builder in the area of this settlement that new houses could be added wherever one liked, provided that the new building did not block the view from any front door to any other existing door. Such a spatial rule would have exactly the effect of increasing the linear (or, perhaps, 'axial', to anticipate a later term) organisation of space.[2]

Can we say, then, that the process 'explains' the beady ring form? The question is difficult to answer on the basis of the completed forms, since clearly we need to consider the historical data on the step-by-step growth of each settlement. Such data are, unfortunately, hardly ever obtainable. We have, however, tried to test the proposition in a less direct way by mapping 77 apparently random clusters of buildings in the immediate vicinity of the French beady ring settlements. Figures 10a and 10b show two examples of two small clusters. Figure 11 is a larger one. Inspection of the sample shows first, that all clusters of sufficient size take a clear beady ring form, subject to topographical constraints, and second, that smaller clumps are to an overwhelming extent either compatible with a beady ring process of growth, or highly suggestive of it. Figure 10a demonstrates a 'compatible' case and Figure 10b a 'suggestive' case.

Suppose, then, that the beady ring process were involved in the development of these settlements. What would that tell us philosophically? Surely it would tell us that *two* kinds of knowledge, not one, were needed to 'explain' the settlement form. First, we would need the usual knowledge of real historical events and economic and social processes in

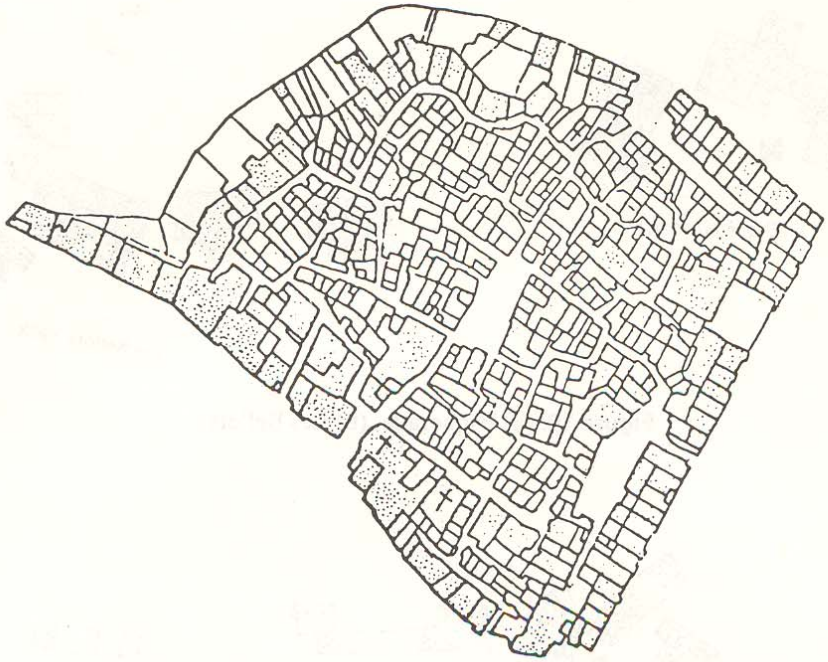


Figure 8. The walled town of Cisternino in southern Italy.

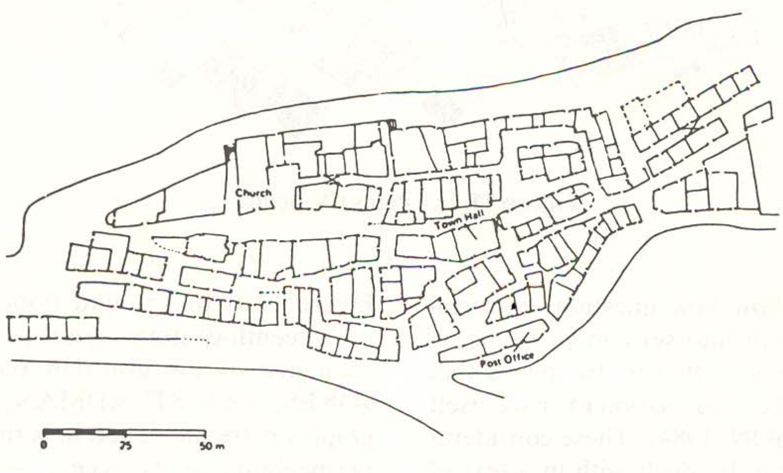


Figure 9. The town of Gassin in Southern France.

which they were embedded. But this, on its own, would never truly 'explain' the special morphological invariants we have described. For this we need a second kind of knowledge; knowledge that included the principle that the local rule of 'open space contiguity' applied to an otherwise random aggregation process would lead *by itself* to the global form. This knowledge of the relation of implication between a local rule and a global form would be at the very least indispensable to a proper *explanation* of the form. In other words, we could not explain the form without knowledge of certain quite autonomous 'laws of space' which, in this case, are to do with how some well-formed global properties could arise from the consistent application of a purely localised rule of aggregation.

This argument is taken forward in more extended texts to show both how a form of analysis of settlement space can be developed in order to identify 'genotypical' patterns in settlements (which appear to vary quite systematically with the type of

Figure 10. (a) Esquerade. (b) Les Bellots.

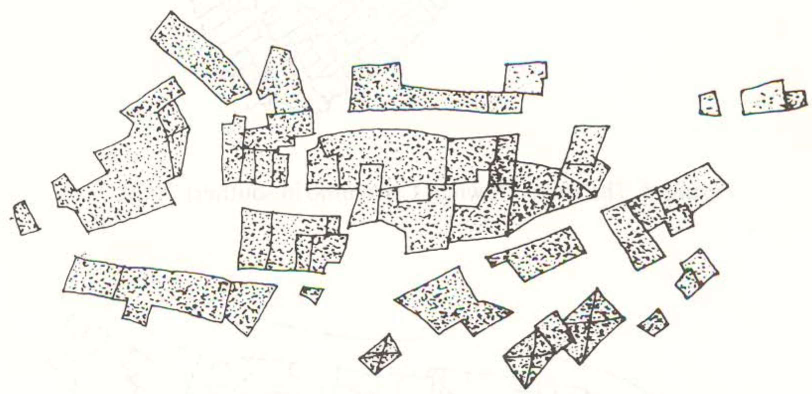


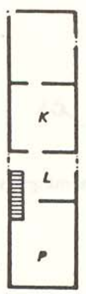
Figure 11. Les Petits Clements.

society) and also to show how questions of social 'meaning' might be built into settlement forms by purely 'syntactic' means — that is, by means that have to do *only* with the organisation of space itself (HILLIER and HANSON, 1984). These considerations are too complex to be dealt with in a text of this length, but in any case, the idea that rules generating forms might have social meaning belongs to the second type of law.

Type 2: Laws from Society to Space

To illustrate laws of type 2 we can return to Aristotle's paradigm case: the spatial structure of the house. For this we need a little methodology: a representation and a measure. The representation employed is what we call a 'justified graph', while the measure is one of the degree to which a particular space *integrates* — or fails to *integrate* — a spatial complex.

Figure 12 is the ground floor plan of an English seventeenth-century house, one of a sample examined by the historian Wood-Jones (WOOD-JONES, 1963: STEADMAN, 1983, Ch. 12). The graph we are interested in is that of the relations of permeability — or access — from one space to another in the house. To make this graph we simply represent each space in the house by a small circle and each relation of direct access by a line, as shown in Figure 13a. To 'justify' this graph, we simply start from a point we are interested in — say, the space outside the house, as shown in Figure 13b — and align the graph up the page, so that spaces directly connected to the point of origin (the outside) are aligned immediately above this space on the first row, those two spaces away on the second row, and so on. This graph at once clarifies a property that we call *depth*. Depth exists to the extent that to go from one space to another it is necessary (i.e. not merely possible) to pass through intervening spaces. We can say, then, that the space marked K, for



K kitchen
L living area
P parlour

Figure 12. Ground floor plan of an English seventeenth-century house.

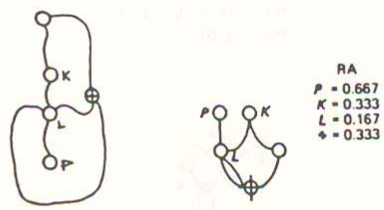


Figure 13. (a) Graph of permeability relations in the house shown in Figure 12; (b) 'justified' graph of the permeability relations from the space outside the house. The figures refer to the 'integration' values of the rooms.

example, is 'two deep' from the space marked P. Or that the space marked P is the 'deepest' from the outside. Or that the space marked L is the 'shallowest' on average from all other points.

Now consider the ground floor plans and respective justified graphs in Figures 14a–e. In each case P stands for 'parlour' or 'best room'; k for kitchen, or a space where food is prepared; and h for the space where most everyday living takes place. The justified graphs immediately show that all the statements I have made about the first case can be made about all these examples. P is always deepest from outside. K is never directly linked to P. H is shallower on average from all other spaces than either P or K.

Now, of course it would be reasonable to expect that these 'invariants' are in some sense a product of the geometry of the house, or simple functional or technological constraints of some kind.[3] So let us look at some more difficult cases. Figures 15a–d are a set of quite different English houses: a Victorian cottage; an up-market conversion of a Georgian house; a 1950s local authority house; and a lower ground floor flat conversion of unknown date. The positions of P, K and L have, it would seem, been juggled around quite considerably. For example, P is by the front door in two cases, on the top floor in another and the 'deepest' on the main floor in another. K is at the front in two cases and at the back in the others. Is there any underlying pattern in these cases?

To show that there is, let us first go back to the original house (Figure 12) and reverse our idea of the justified graph. Instead of looking at how 'deep' spaces are from the outside, let us begin from each space of interest — that is, P, K and L — and use the graph to show how deep all other spaces are from that particular space. Figure 16 shows justified graphs whose 'root' (starting point) is, respectively, P, L and K. These graphs show that, considered from the point of view of depth, each label has a different relation to the spatial complex as a whole. Other spaces are on average deeper from P than they are from K or L, and deeper from K than from L. Conversely, we can say that the complex as a whole is shallowest from L. Another way of saying this is that L *integrates* the complex more than other labelled spaces: integrates in the sense that it draws the complex closer to itself, whereas P, as it were, pushes it farthest away.

Now we have developed a way of measuring the degree to which any space *integrates* a complex in this way (see HILLIER *et al.*, 1983; HILLIER and HANSON, 1984, Ch. 3). This allows comparisons to be made across complexes of different sizes, the 'mean integration' of different complexes to be calculated, comparisons to be made between individual spaces in different cases, and so on. Readers should refer to the above texts for further details. What is important here is that on the basis of this measure of 'integration' we can make statements about the relation between room functions and spatial arrangements of the kind: L integrates more than K, which integrates more than P; or, to put it more briefly, L > K > P.

We can now return to the four apparently heterogeneous plans shown in Figure 15 together with the 'integration values' of the different spaces (plus the value from the outside and of the complex as a whole). Here we have to negotiate one little

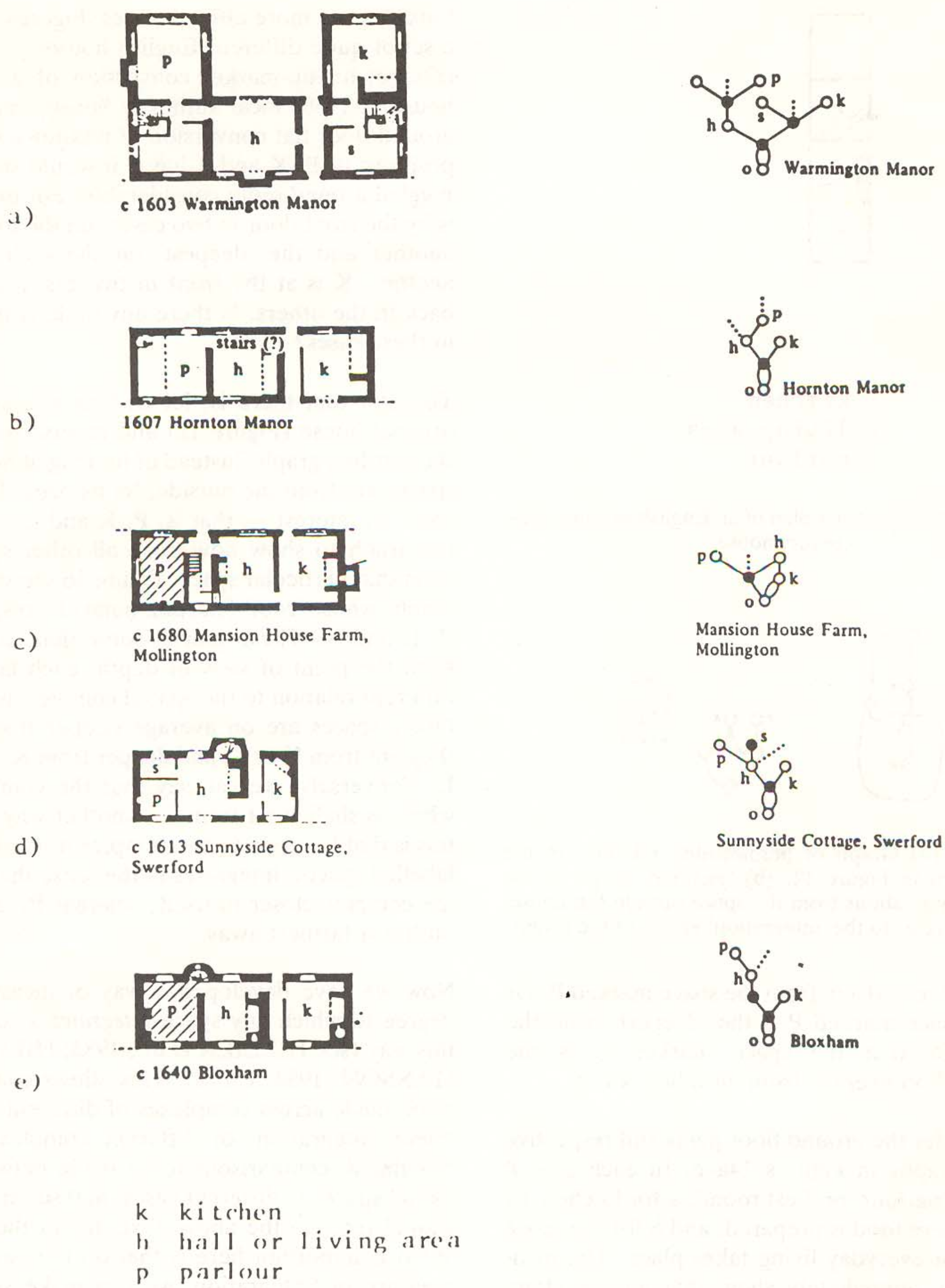


Figure 14a–e. Five seventeenth-century regional house plans from the area around Banbury in England (from WOOD-JONES, 1963).

difficulty: a low value (i.e. close to 0) indicates high integration and vice versa, since the value reflects the amount of depth the complex has from a particular space. It is then easy to see that in each case the following pattern exists: L integrates more than K, which integrates more than P; or L > K > P for all cases. This is called an 'inequality genotype', meaning that certain inequality relations between the function and spatial arrangement are invariant across a sample.

What does this mean? It means surely that to the

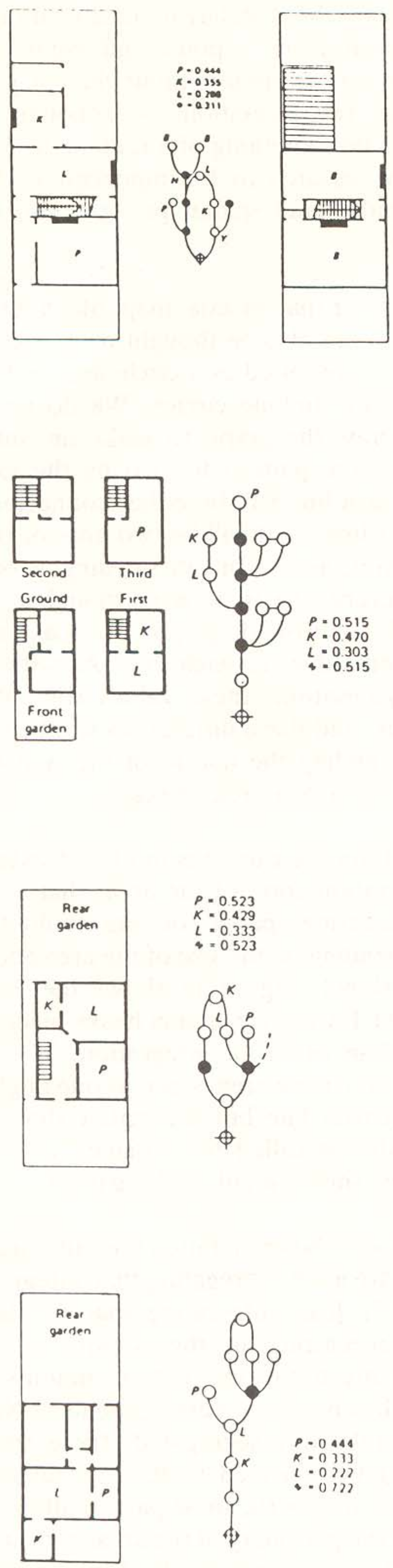


Figure 15. (a) Plans of a Victorian cottage; (b) plans of a converted house in Camden Town, London; (c) plan of a 1950s local authority house; (d) plan of a converted flat in Islington, London.

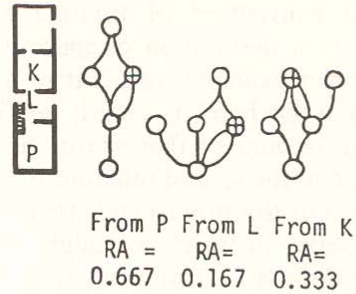


Figure 16. Plan of house shown in Figure 12 with 'justified' graphs from P, L and K.

extent that such 'genotypes' can be shown to exist, then we have identified some kind of cultural principle for giving different social relations and activities a spatial form with respect to a whole complex of spatial relations. But if these *functions* are expressed through spatial invariants, then surely what we *mean* by a 'house' is a spatial complex in which these necessary differences can be related together in a way that preserves the 'genotypical' spatial relationship of each. Within the idea of an 'inequality genotype', the notions of functional patterns and spatial arrangement become, in a sense, the same thing.

Now we are *not*, of course, suggesting that the pattern we have identified is a cross-cultural pattern. On the contrary, we have presented a methodology for identifying one aspect of whatever cultural pattern exists (for other aspects of the methodology, again, readers should consult the referred texts). What is clear from our studies is that such patterns often exist and, while being markedly different from each other, nevertheless seem to follow certain underlying principles. Increasing the average depth from a particular space to all other spaces is a common means of achieving the relative segregation of important categories of spaces in buildings: front parlours, professor's rooms, chief's quarters, and so on. On the other hand, varying the occurrrence of 'rings' (or cycles) in the spatial arrangement is a normal means of varying the degree of control that particular spaces have with respect to the whole. Although cultures vary in their domestic space genotypes, the morphological means by which these genotypes are constituted are invariant.

Is Aristotle right, then, in this case? Does purpose give form? I would suggest in a descriptive sense not exactly, and in an explanatory sense not at all. In a descriptive sense it is clear that to follow the usual architectural convention of treating function *as though it were* a description of space is obviously inadequate. For example, to point to a space and say "this is a kitchen" is clearly an inadequate architectural account of that space, since it omits any reference to the spatial relations of a kitchen in that culture. On the other hand, there could be a reasonable sense in which we might say that the 'purpose' of the spatial arrangement as a whole was to achieve a certain pattern of integration and segregation of functions.

But at an explanatory level such an account disregards the fundamental fact that the relation of form to function in such cases depends, firstly, on what space has to offer by way of combinatorial possibilities (i.e. laws of type 1), greater or less average depth being one such possibility; and, secondly, on the fact that these combinatorial possibilities offer a family of *structural analogies* for different kinds of relationships among social categories and activities. For example, a 'semi-sacred' space like the 'best room' in a house can only be preserved as such if it has marginally greater *segregation* than the spaces of everyday activity. The social concept, as it were, already implies a 'genotypical' spatial requirement.

The relation of form to function thus passes through two types of morphological laws: those prescribing the lawful possibilities of combination in the first place; and those by which social relations give spatial meaning to such terms as 'integration' and 'segregation'. Obviously the task of an explanatory science must be to give an account of these types of morphological laws, not simply to *re-present* the problem by another functional description that takes these morphological pre-conditions for granted. All this can be made clearer, however, by looking at laws of type 3.

Type 3: Laws from Space to Society

To introduce laws of type 3 we will move from domestic space to the larger scale of urban space, since it is here that the *effect* of the pattern of space on its use by people can be most clearly discerned. Once again we can make use of the notion of *integration* and its measure. Figure 17a is the plan of Barnsbury, an urban area in inner London, and Figure 17b is what we call its 'axial map', meaning the least set of straight lines that cover the open space of the area (HILLIER *et al.*, 1983). We might think of these lines as having to do with both what can be seen from a point and what is directly accessible from a point without changing direction. This axial representation — although it seems initially to be something of a reduction — has been shown by research to be important to both how people understand spatial patterns and how they use them.

Now it is clear that an axial map, like a set of rooms and doors, can also be thought of as a graph, with each line represented as a circle and each intersection as a line linking circles. We do not need to actually draw the graph to make an 'integration' analysis of the pattern formed by the axial lines. Clearly, each line will be either connected directly to another line, or it will be two lines or three lines deep from it, and so on. Proceeding as before and treating every line in turn as though it were the 'root' of a justified graph, we can assign an 'integration value' to each line. As with domestic space organisation, these values will differ from each other, and these differences will be significant in understanding the nature of the spatial pattern and how the urban area works.

The first thing we can do is to identify what we call the 'integration core' of the area; that is, the 10% most integrating spaces (or one could take 2 or 25%, depending on the size of the area and what we want to show). Figure 18 shows the 'integration core' of the Barnsbury area in heavy black lines and numbered in order of integration. The most integrating line in the area is not, as one might expect, a long, central line but the rather short line that defines what is called the 'village', on which one finds a few shops, a pub and a garage.

Figure 18 also shows in dotted lines the spaces in the area that are more segregating than integrating; that is, the 50% least integrating spaces. These quite clearly concentrate in the squares — a rather unusual pattern but one quite commonly found in nineteenth-century redevelopments. Note that although relatively segregated, these squares are still strongly connected to the surrounding urban fabric, and are for the most part 'shallow' from the spaces on the periphery of the area that, in this case, is defined by the main roads. The arrangement of integrated and segregated lines does, however, show a rather common 'genotypical' pattern. The integration core links certain fairly central lines to some peripheral areas in all directions. The core has, in effect, the shape of a deformed wheel, with a

Figure 17. (a) Plan of the area of Barnsbury in north London; (b) axial map of Barnsbury.

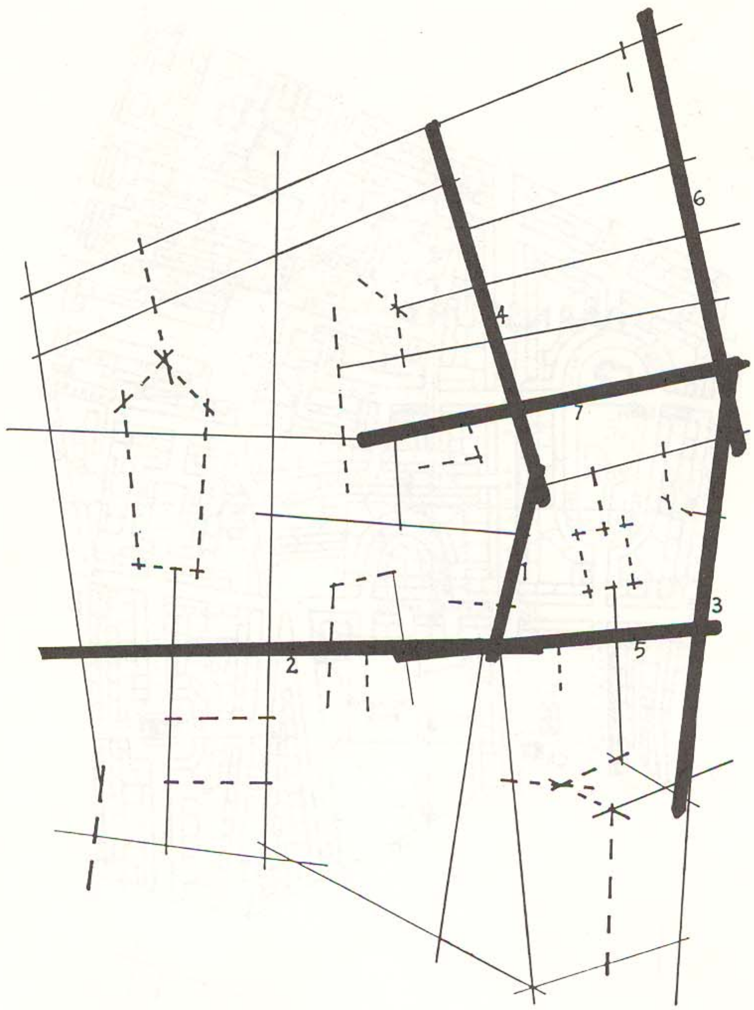


Figure 18. Integration map of Barnsbury.

central hub and spokes radiating towards the rim and reaching it in several directions. A similar deformed wheel would have been found if we had subjected the settlement in Figure 9 to the same analysis, showing again that 'genotypical' patterns can be identified underneath considerable surface differences. Nonetheless it must be emphasised that this particular pattern is far from being the only type that exists. On the contrary, the structure of the integrating core and the distribution of the more segregated areas are usually major clues to the type of culture that created the spatial pattern.

Why this might be so can be seen from Figure 19, which is a scattergram plotting integration against the numbers of people observed moving along different axial lines for a sample of spaces in the internal area of Barnsbury. I emphasise internal area because the peripheral spaces really form part

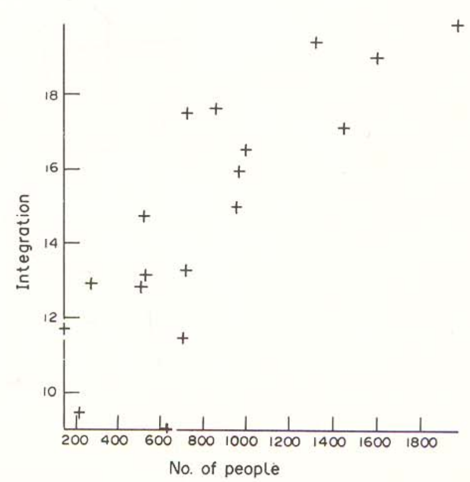


Figure 19. Scattergram plotting integration against the numbers of people observed in the Barnsbury area.

of a larger system (also, however, with systematic properties at that level), and if they are taken into account as part of this local area they tend to obscure the clarity of the relationship between spatial structure and patterns of movement. This relationship for the interior of the system is quite clear: there is a very powerful correlation between integration value and the tendency for people to use that line for pedestrian journeys.[4]

The curious thing is that if we then try another measure, one which measures the degree to which each axial line features on all shortest (i.e. fewest axial steps) journeys from every point to every other point in the area, and which therefore should give the ideal distribution of moving people in the system, then we get a weaker correlation. Integration (rather than 'choice', which is the name we give to this second parameter) is the strongest predictor of movement, and this result can be duplicated for several urban areas that have been analysed and systematically observed in a similar way.

The reason is not hard to find, and it has to do with the shape of the integration core. The reason integration predicts movement so strongly is because many of the people observed are not moving only within the system but across or through it from origins or to destinations outside the system. However, the shape of the core makes it clear that the structure of integration in the system is arranged in such a way to facilitate movement from outside the area as far as possible. The core, by linking centre to edges in all directions, makes it easy for 'strangers' to enter and cross the system, while controlling it by making sure that the axially shortest journeys will concentrate on the most integrating lines. At the same time, the distribution of the core with respect to the interior of the system ensures that the more segregated destinations in the system are nevertheless in all cases 'shallow' from the integrating core.

At the same time, the existence of a strong correlation between 'choice' (which governs internal movement patterns) and integration (which governs global movement patterns into and across the system) ensures that a continuous *interface* is maintained between strangers entering the system and 'inhabitants' who are already within it. In other words, integration and other properties of the spatial patterns are used to produce that natural and unforced field of potential encounter between inhabitants and strangers — as well as between inhabitants themselves — that seems to be the hallmark of many traditional urban street patterns. It need perhaps hardly be added that it is exactly this global structuring of urban space, with its concomitant effects on the encounter field of people in the system, that is so often lost in pathological cases of modern urban estates and redevelopments (see HILLIER *et al.*, 1983).

Is this effect from space to people an example of a 'purposive' artefact? Again, in a trivial sense we might say it is, since the 'purpose' of the arrangement of space seems to be to structure the pattern of movement. But once again this does not *explain* the nature of the pattern itself. As with beady rings and domestic space, the effect of space on movement depends on pre-existing morphological laws that relate space to movement, and it must be these laws which are the main objects of an explanatory theory.

In fact, the ways in which real environments work — either well or pathologically — are as often as not the *unintended* by-products of declared 'purposes' which designers have attempted to realise in a way that disregards these morphological constraints and laws. Most typically, designers have tried to design 'community' by using exactly those morphological means that most limit the possibilities of its development.[5] It may well be that history will eventually judge modern architecture in terms of this disjunction between purposes and realities — a disjunction that arises in the main from a concept of design in which a language of purposes and functions obscures the need for objective morphological knowledge.

Conclusion

So where does this leave Aristotle? In a way my analysis confirms the distinction between a *material* process (or 'cause', as he would call it) and an *immaterial* one, since in all three types of cases that I have considered, something like abstract rules appear to intervene in a material process. But regularities in spatial form and socio-spatial behaviour do not arise *only* from those rules, but from their conjunction with the independent laws of material processes. Moreover, the rules themselves have a 'social logic' in that they are physical analogues to social ideas and relations. The relation of rules to forms is, therefore, neither direct nor simple. It passes through autonomous material laws, without a knowledge of which any explanatory understanding of the situation is probably impossible.

Nor is it the case that these rules are, in themselves, akin to purposes. On the contrary, they are the *means* by which social processes can be expressed in spatial form. Without them the relation of function to form must necessarily be arbitrary. In a sense it is neither function nor form which should be the object of an explanatory theory, but the means by which one turns into the other. It follows that the attempt to analyse spatial forms in terms of purposes can never be more than a superficial commentary on the obvious. So far as architecture and urban design are concerned, therefore, the language of purposes can offer little more to the 'sciences of the artificial' than it did to the natural sciences. 'Sciences of the artificial' must, after all, pursue the more orthodox path of uncovering the laws that govern the artefacts themselves — the laws of the artificial.

Notes

1. MCKEON (1941). The two most important references to the 'architectural paradigm' in Aristotle are probably the *Physics*, Book 2, Ch. 8, pp. 250–252, in the McKeon edition; and the *Parts of Animals*, Book 1, Ch. 5 and Book 2, Ch. 1, pp. 657–659, also in the McKeon edition. But the idea is pervasive throughout his writings, as shown by the conceptual importance given to it in the two references cited.
2. This approach to the understanding of morphology seems exactly analogous, philosophically, to Rene Thom's adaptation of C. H. Waddington's 'chreodic' processes, as set out in Thom's *Structuralism and Biology* in WADDINGTON (1972) The analogy between approaches to describing natural and artificial morphologies illustrates perfectly the central thesis of this paper.
3. In fact the difficulty of explaining these spatial features by technological or other factors is explored in HANSON and HILLIER (1979) and HILLIER and HANSON (1982a, b).
4. These results are based on research carried out in 1983 by the Unit for Architectural Studies at the Bartlett School of Architecture which involved the systematic observation of patterns of pedestrian movement and occupancy in the Barnsbury area.
5. See, for example, the ideas and layouts presented in ALEXANDER (1977).

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