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A CITY IS NOT A TREE

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The tree of my title is not a green tree with leaves. It is the name of an abstract structure. I shall contrast it with another, more complex abstract structure called a semilattice. In order to relate these abstract structures to the nature of the city, I must first make a simple distinction.

I want to call those cities which have arisen more or less spontaneously over many, many years *natural cities*. And I shall call those cities and parts of cities which have been deliberately created by designers and planners artificial cities. Siena, Liverpool, Kyoto, Manhattan are examples of natural cities. Levittown, Chandigarh and the British New Towns are examples of artificial cities.

It is more and more widely recognized today that there is some essential ingredient missing from artificial cities. When compared with ancient cities that have acquired the patina of life, our modern attempts to create cities artificially are, from a human point of view, entirely unsuccessful.

Both the tree and the semilattice are ways of thinking about how a large collection of many small systems goes to make up a large and complex system. More generally, they are both names for structures of sets.

In order to define such structures, let me first define the concept of a set. A set is a collection of elements which for some reason we think of as belonging together. Since, as designers, we are concerned with the physical living city and its physical backbone, we must naturally restrict ourselves to considering sets which are collections of material elements such as people, blades of grass, cars, molecules, houses, gardens, water pipes, the water molecules in them etc.

When the elements of a set belong together because they co-operate or work together somehow, we call the set of elements a system.

For example, in Berkeley at the corner of Hearst and Euclid, there is a drugstore, and outside the drugstore a traffic light. In the entrance to the drugstore there is a newsrack where the day's papers are displayed. When the light is red, people who are waiting to cross the street stand idly by the light; and since they have nothing to do, they look at the

papers displayed on the newsrack which they can see from where they stand. Some of them just read the headlines, others actually buy a paper while they wait.

This effect makes the newsrack and the traffic light interactive; the newsrack, the newspapers on it, the money going from people's pockets to the dime slot, the people who stop at the light and read papers, the traffic light, the electric impulses which make the lights change, and the sidewalk which the people stand on form a system - they all work together.

From the designer's point of view, the physically unchanging part of this system is of special interest. The newsrack, the traffic light and the sidewalk between them, related as they are, form the fixed part of the system. It is the unchanging receptacle in which the changing parts of the system - people, newspapers, money and electrical impulses - can work together. I define this fixed part as a unit of the city. It derives its coherence as a unit both from the forces which hold its own elements together and from the dynamic coherence of the larger living system which includes it as a fixed invariant part.

Of the many, many fixed concrete subsets of the city which are the receptacles for its systems and can therefore be thought of as significant physical units, we usually single out a few for special consideration. In fact, I claim that whatever picture of the city someone has is defined precisely by the subsets he sees as units.

Now, a collection of subsets which goes to make up such a picture is not merely an amorphous collection. Automatically, merely because relationships are established among the subsets once the subsets are chosen, the collection has a definite structure.

To understand this structure, let us think abstractly for a moment, using numbers as symbols. Instead of talking about the real sets of millions of real particles which occur in the city, let us consider a simpler structure made of just half a dozen elements. Label these elements 1,2,3,4,5,6. Not including the full set [1,2,3,4,5,6], the empty set [-], and the one-element sets [1],[2],[3],C4],[5], [6], there are 56 different subsets we can pick from six elements.

Suppose we now pick out certain of these 56 sets (just as we pick out certain sets and call them units when we form our picture of the city). Let us say, for example, that we pick the following subsets: [123], [34], [45], [234], [345], [12345], [3456].

What are the possible relationships among these sets? Some sets will be entirely part of larger sets, as [34] is part of [345] and [3456]. Some of the sets will overlap, like [123] and [234]. Some of the sets will be disjoint - that is, contain no elements in common like [123] and [45].

We can see these relationships displayed in two ways. In **diagram A** each set chosen to be a unit has a line drawn round it. In **diagram B** the chosen sets are arranged in order of ascending magnitude, so that whenever one set contains another (as [345] contains [34], there is a vertical path leading from one to the other. For the sake of clarity and visual economy, it is usual to draw lines only between sets which have no further sets and lines between them; thus the line between [34] and [345] and the line between [345] and [3456] make it unnecessary to draw a line between [34] and [3456].

Diagrams A & B redrawn by Nikos Salingaros

As we see from these two representations, the choice of subsets alone endows the collection of subsets as a whole with an overall structure. This is the structure which we are concerned with here. When the structure meets certain conditions it is called a semilattice. When it meets other more restrictive conditions, it is called a tree.

The semilattice axiom goes like this: *A collection of sets forms a semilattice if and only if, when two overlapping sets belong to the collection, the set of elements common to both also belongs to the collection.*

The structure illustrated in diagrams A and B is a semilattice. It satisfies the axiom since, for instance, [234] and [345] both belong to the collection and their common part, [34], also belongs to it. (As far as the city is concerned, this axiom states merely that wherever two units overlap, the area of overlap is itself a recognizable entity and hence a unit also. In the case of the drugstore example, one unit consists of newsrack, sidewalk and traffic light. Another unit consists of the drugstore itself, with its entry and the newsrack. The two units overlap in the newsrack. Clearly this area of overlap is itself a recognizable unit and so satisfies the axiom above which defines the characteristics of a semilattice.) The tree axiom states: *A collection of sets forms a tree if and only if, for any two sets that belong to the collection either one is wholly contained in the other, or else they are wholly disjoint.*

The structure illustrated in **diagrams C** and **D** is a tree. Since this axiom excludes the possibility of overlapping sets, there is no way in which the semilattice axiom can be violated, so that every tree is a trivially simple semilattice.

Diagrams A & B redrawn by Nikos Salingaros

However, in this chapter we are not so much concerned with the fact that a tree happens to be a semilattice, but with the difference between trees and those more general semilattices which are not trees because they do contain overlapping units. We are concerned with the difference between structures in which no overlap occurs, and those structures in which overlap does occur.

It is not merely the overlap which makes the distinction between the two important. Still more important is the fact that the semilattice is potentially a much more complex and subtle structure than a tree. We may see just how much more complex a semilattice can be than a tree in the following fact: a tree based on 20 elements can contain at most 19 further subsets of the 20, while a semilattice based on the same 20 elements can contain more than 1,000,000 different subsets.

This enormously greater variety is an index of the great structural complexity a semilattice can have when compared with the structural simplicity of a tree. It is this lack of structural complexity, characteristic of trees, which is crippling our conceptions of the city.

To demonstrate, let us look at some modern conceptions of the city, each of which I shall show to be essentially a tree.

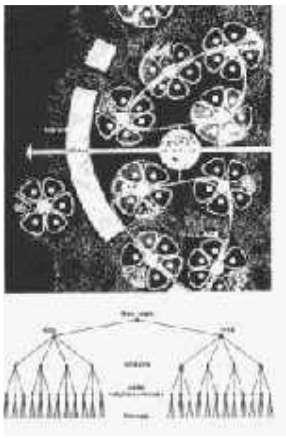


Figure 1. Columbia, Maryland, Community Research and Development, Inc.: Neighbourhoods,in clusters of five, form 'villages'. Transportation joins the villages into a new town. The organization is a tree.

Figure 2. Greenbelt, Maryland, Clarence Stein: This 'garden city' has been broken down into superblocks. Each superblock contains schools, parks and a number of subsidiary groups of houses built around parking lots. The organization is a tree.

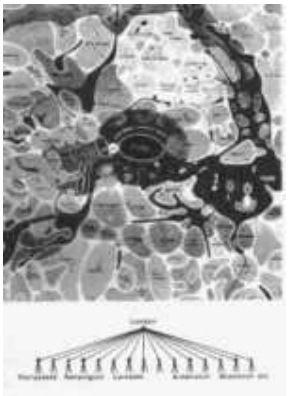


Figure 3. Greater London plan (1943), Abercrombie and Forshaw: The drawing depicts the structure conceived by Abercrombie for London. It is made of a large number of communities, each sharply separated from all adjacent communities. Abercrombie writes, 'The proposal is to emphasize the identity of the existing communities, to increase their degree of segregation, and where necessary to recognize them as separate and definite entities.' And again, 'The communities themselves consist of a series of sub-units, generally with their own shops and schools, corresponding to the neighbourhood units.' The city is conceived as a tree with two principal levels. The communities are the larger units of the structure; the smaller sub-units are neighbourhoods. There are no overlapping units. The structure is a tree.

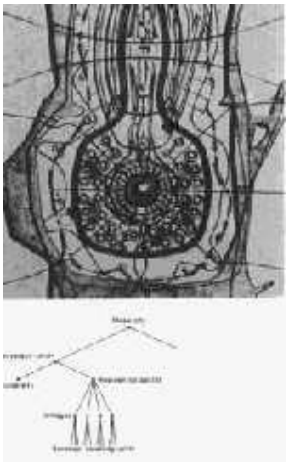


Figure 4. Mesa City, Paolo Soleri: The organic shapes of Mesa City lead us, at a careless glance, to believe that it is a richer structure than our more obviously rigid examples. But when we look at it in detail we find precisely the same principle of organization. Take, particularly, the university centre. Here we find the centre of the city divided into a university and a residential quarter, which is itself divided into a number of villages (actually apartment towers) for 4000 inhabitants, each again subdivided further and surrounded by groups of still smaller dwelling units.

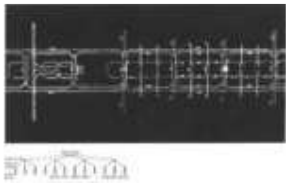


Figure 5. Tokyo plan, Kenzo Tange: This is a beautiful example. The plan consists of a series of loops stretched across Tokyo Bay. There are four major loops, each of which contains three medium loops. In the second major loop, one medium loop is the railway station and another is the port. Otherwise, each medium loop contains three minor loops which are residential neighbourhoods,

except in the third major loop where one contains government offices and another industrial offices.

Figure 6. Chandigarh (1951), Le Corbusier: The whole city is served by a commercial centre in the middle, linked to the administrative centre at the head. Two subsidiary elongated commercial cores are strung out along the maior arterial roads, running north-south. Subsidiary to these are further administrative, community and commercial centres, one for each of the city's 20 sectors.

Figure 7. Brasilia, Lucio Costa: The entire form pivots about the central axis, and each of the two halves is served by a single main artery. This main artery is in turn fed by subsidiary arteries parallel to it. Finally, these are fed by the roads which surround the superbiocks themselves. The structure is a tree.

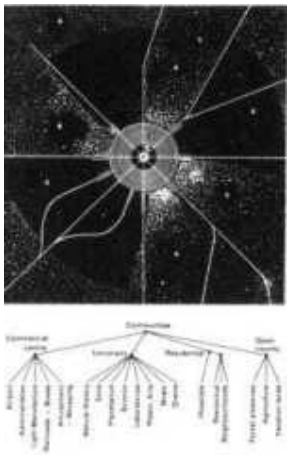


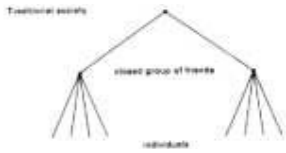
Figure 8. Communitas, Percival and Paul Goodman: Communitas is explicitly organized as a tree: it is first divided into four concentric major zones, the innermost being a commercial centre, the next a university, the third residential and medical, and the fourth open country. Each of these is further subdivided: the commercial centre is represented as a great cylindrical skyscraper, containing five layers: airport, administration, light manufacture, shopping and amusement; and, at the bottom, railroads, buses and mechanical services. The university is divided into eight sectors comprising natural history, zoos and aquariums, planetarium, science laboratories, plastic arts, music and drama. The third concentric ring is divided into neighbourhoods of 4000 people each, not consisting of individual houses, but of apartment blocks, each of these containing individual dwelling units. Finally, the open country is divided into three segments: forest preserves, agriculture and vacation lands. The overall organization is a tree.

Figure 9.The most beautiful example of all I have kept until last, because it symbolizes the problem perfectly. It appears in Hilberseimer's book *The Nature of Cities*. He describes the fact that certain Roman towns had their origin as military camps, and then shows a picture of a modern military encampment as a kind of archetypal form for the city. It is not possible to have a structure which is a clearer tree. The symbol is apt, for, of course, the organization of the army was designed precisely in order to create discipline and rigidity. The photograph on the [left] is Hilberseimer's own scheme for the commercial area of a city based on the army camp archetype.

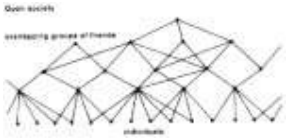
Each of these structures, then, is a tree. Each unit in each tree that I have described, moreover, is the fixed, unchanging residue of some system in the living city (just as a house is the residue of the interactions between the members of a family, their emotions and their belongings; and a freeway is the residue of movement and commercial exchange).

However, in every city there are thousands, even millions, of times as many more systems at work whose physical residue does not appear as a unit in these tree structures. In the worst cases, the units which do appear fail to correspond to any living reality; and the real systems, whose existence actually makes the city live, have been provided with no physical receptacle.

Neither the Columbia plan nor the Stein plan for example, corresponds to social realities. The physical layout of the plans, and the way they function suggests a hierarchy of stronger and stronger closed social groups, ranging from the whole city down to the family, each formed by associational ties of different strength.



In a traditional society, if we ask a man to name his best friends and then ask each of these in turn to name their best friends, they will all name each other so that they form a closed group. A village is made up of a number of separate closed groups of this kind.



But today's social structure is utterly different. If we ask a man to name his friends and then ask them in turn to name their friends, they will all name different people, very likely unknown to the first person; these people would again name others, and so on outwards. There are virtually no closed groups of people in modern society. The reality of today's social structure is thick with overlap - the systems of friends and acquaintances form a semilattice, not a tree (**Figure 10**).

In the natural city, even the house on a long street (not in some little cluster) is a more accurate acknowledgement of the fact that your friends live not next door, but far away, and can only be reached by bus or car. In this respect Manhattan has more overlap in it

than Greenbelt. And though one can argue that in Greenbelt, too, friends are only minutes away by car, one must then ask: since certain groups *have* been emphasized by the physical units of the physical structure, why are just these the most irrelevant ones?

Part II

The units of which an artificial city is made up are always organized to form a tree. So that we get a really clear understanding of what this means, and shall better see its implications, let us define a tree once again. Whenever we have a tree structure, it means that within this structure no piece of any unit is ever connected to other units, except through the medium of that unit as a whole.

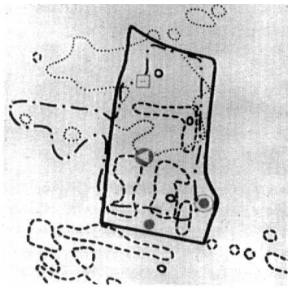
The enormity of this restriction is difficult to grasp. It is a little as though the members of a family were not free to make friends outside the family, except when the family as a whole made a friendship.

In simplicity of structure the tree is comparable to the compulsive desire for neatness and order that insists the candlesticks on a mantelpiece be perfectly straight and perfectly symmetrical about the centre. The semilattice, by comparison, is the structure of a complex fabric; it is the structure of living things, of great paintings and symphonies.

It must be emphasized, lest the orderly mind shrink in horror from anything that is not clearly articulated and categorized in tree form, that the idea of overlap, ambiguity, multiplicity of aspect and the semilattice are not less orderly than the rigid tree, but more so. They represent a thicker, tougher, more subtle and more complex view of structure.

Let us now look at the ways in which the natural, when unconstrained by artificial conceptions, shows itself to be a semilattice.

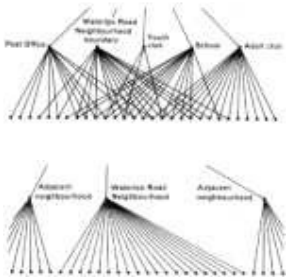
A major aspect of the city's social structure which a tree can never mirror properly is illustrated by Ruth Glass's redevelopment plan for Middlesbrough, England, a city of 200,000 which she recommends be broken down into 29 separate neighbourhoods. After picking her 29 neighbourhoods by determining where the sharpest discontinuities of building type, income and job type occur, she asks herself the question: 'If we examine some of the social systems which actually exist for the people in such a neighbourhood, do the physical units defined by these various social systems all define the same spatial neighbourhood?' Her own answer to this question is no. Each of the social systems she examines is a nodal system. It is made of some sort of central node, plus the people who use this centre. Specifically she takes elementary schools, secondary schools, youth clubs, adult clubs, post offices, greengrocers and grocers selling sugar. Each of these centres draws its users from a certain spatial area or spatial unit. This spatial unit is the physical residue of the social system as a whole, and is therefore a unit in the terms of this discussion. The units corresponding to different kinds of centres for the single neighbourhood of Waterloo Road are shown in **Figure 11**.



The hard outline is the boundary of the so-called neighbourhood itself. The white circle stands for the youth club, and the small solid rings stand for areas where its members live. The ringed spot is the adult club, and the homes of its members form the unit marked by dashed boundaries. The white square is the post office, and the dotted line marks the unit which contains its users. The secondary school is marked by the spot with a white triangle in it. Together with its pupils, it forms the system marked by the dot-dashed line.

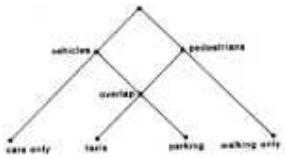
As you can see at once, the different units do not coincide. Yet neither are they disjoint. They overlap.

We cannot get an adequate picture of what Middlesbrough is, or of what it ought to be, in terms of 29 large and conveniently integral Chunks called neighbourhoods. When we describe the city in terms of neighbourhoods, we implicitly assume that the smaller elements within any one of these neighbourhoods belong together so tightly that they only interact with elements in other neighbourhoods through the medium of the neighbourhoods to which they themselves belong. Ruth Glass herself shows clearly that this is not the case.



Next to Figure 11 are two representations of the Waterloo neighbourhood. For the sake of argument I have broken it into a number of small areas. **Figure 12** shows how these pieces stick together in fact, and **Figure 13** shows how the redevelopment plan pretends they stick together.

There is nothing in the nature of the various centres which says that their catchment areas should be the same. Their natures are different. Therefore the units they define are different. The natural city of Middlesbrough was faithful to the semilattice structure of the units. Only in the artificial-tree conception of the city are their natural, proper and necessary overlaps destroyed.



Consider the *separation of pedestrians from moving vehicles*, a tree concept proposed by Le Corbusier, Louis Kahn and many others. At a very crude level of thought this is obviously a good idea. Yet the urban taxi can function only because pedestrians and vehicles are not strictly separated. The cruising taxi needs a fast stream of traffic so that it can cover a large area to be sure of finding a passenger. The pedestrian needs to be able to hail the taxi from any point in the pedestrian world, and to be able to get out to any part of the pedestrian world

to which he wants to go. The system which contains the taxicabs needs to overlap both the fast vehicular traffic system and the system of pedestrian circulation. In Manhattan pedestrians and vehicles do share certain parts of the city, and the necessary overlap is guaranteed (**Figure 14**).

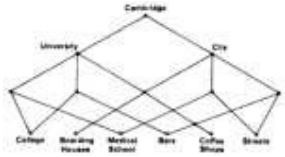
Another·favourite concept of the CIAM theorists and others is *the separation of recreation from everything else*. This has crystallized in our real cities in the form of playgrounds. The playground, asphalted and fenced in, is nothing but a pictorial acknowledgment of the fact that 'play' exists as an isolated concept in our minds. It has nothing to do with the life of play itself. Few self-respecting children will even play in a playground.

Play itself, the play that children practise, goes on somewhere different every day. One day it may be indoors, another day in a friendly gas station, another day down by the river, another day in a derelict building, another day on a construction site which has been abandoned for the weekend. Each of these play activities, and the objects it requires, forms a system. It is not true that these systems exist in isolation, cut off from the other systems of the city. The different systems overlap one another, and they overlap many other systems besides. The units, the physical places recognized as play places, must do the same.

In a natural city this is what happens. Play takes place in a thousand places it fills the interstices of adult life. As they play, children become full of their surroundings. How can children become filled with their surroundings in a fenced enclosure! They cannot.

A similar kind of mistake occurs in trees like that of Goodman's Communitas or Soleri's Mesa City, which separate the university from the rest of the city. Again, this has actually been realized in the common American form of the isolated campus.

What is the reason for drawing a line in the city so that everything within the boundary is university, and everything outside is nonuniversity? It is conceptually clear. But does it correspond to the realities of university life? Certainly it is not the structure which occurs in nonartificial university cities.



There are always many systems of activity where university life and city life overlap: pub-crawling, coffee-drinking, the movies, walking from place to place. In some cases whole departments may be actively involved in the life of the city's inhabitants (the hospital-cum-medical school is an example). In Cambridge, a natural city where university and city have grown together gradually, the physical units overlap because they are the physical residues of city systems and university systems which overlap (**Figure 15**).

Let us look next at the hierarchy of urban cores realized in Brasilia, Chandigarh, the MARS plan for London and, most recently, in the Manhattan Lincoln Center, where various performing arts serving the population of greater New York have been gathered together to form just one core.

Does a concert hall ask to be next to an opera house? Can the two feed on one another? Will anybody ever visit them both, gluttonously, in a single evening, or even buy tickets from one after going to a performance in the other? In Vienna, London, Paris, each of the performing arts has found its own place, because all are not mixed randomly. Each has created its own familiar section of the city. In Manhattan itself, Carnegie Hall and the Metropolitan Opera House were not built side by side. Each found its own place, and now creates its own atmosphere. The influence of each overlaps the parts of the city which have been made unique to it.

The only reason that these functions have all been brought together in Lincoln Center is that the concept of performing art links them to one another.

But this tree, and the idea of a single hierarchy of urban cores which is its parent, do not illuminate the relations between art and city life. They are merely born of the mania every simple-minded person has for putting things with the same name into the same basket.

The total separation of work from housing, started by Tony Garnier in his industrial city, then incorporated in the 1929 Athens Charter, is now found in every artificial city and accepted everywhere where zoning is enforced. Is this a sound principle? It is easy to see how bad conditions at the beginning of the century prompted planners to try to get the dirty factories out of residential areas. But the separation misses a variety of systems which require, for their sustenance, little parts of both.

Finally, let us examine the subdivision of the city into isolated communities. As we have seen in the Abercrombie plan for London, this is itself a tree structure. The individual community in a greater city has no reality as a functioning unit. In London, as in any great city, almost no one manages to find work which suits him near his home. People in one community work in a factory which is very likely to be in another community.

There are therefore many hundreds of thousands of worker-workplace systems, each consisting of individuals plus the factory they work in, which cut across the boundaries defined by Abercrombie's tree. The existence of these units, and their overlapping nature, indicates that the living systems of London form a semilattice. Only in the planner's mind has it become a tree.

The fact that we have so far failed to give this any physical expression has a vital consequence. As things are, whenever the worker and his workplace belong to separately administered municipalities, the community which contains the workplace collects huge taxes and has relatively little on which to spend the tax revenue. The community where the worker lives, if it is mainly residential, collects only little in the way of taxes and yet has great additional burdens on its purse in the form of schools, hospitals, etc. Clearly, to resolve this inequity, the worker-workplace systems must be anchored in physically recognizable units of the city which can then be taxed.

It might be argued that, even though the individual communities of a great city have no functional significance in the lives of their inhabitants, they are still the most convenient administrative units, and should therefore be left in their present tree organization. However, in the political complexity of a modern city, even this is suspect.

Edward Banfield, in his book *Political Influence*, gives a detailed account of the patterns of influence and control that have actually led to decisions in Chicago. He shows that, although the lines of administrative and executive control have a formal structure which is

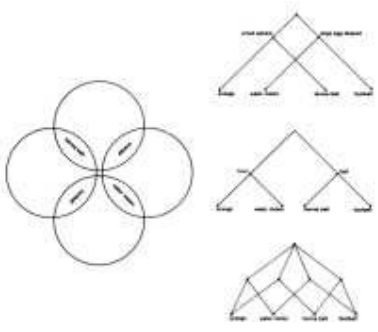
a tree, these formal chains of influence and authority are entirely overshadowed by the ad hoc lines of control which arise naturally as each new city problem presents itself. These ad hoc lines depend on who is interested in the matter, who has what at stake, who has what favours to trade with whom.

This second structure, which is informal, working within the framework of the first, is what really controls public action. It varies from week to week, even from hour to hour, as one problem replaces another. Nobody's sphere of influence is entirely under the control of any one superior; each person is under different influences as the problems change. Although the organization chart in the Mayor's office is a tree, the actual control and exercise of authority is semilattice-like.

Now, why is it that so many designers have conceived cities as trees when the natural structure is in every case a semilattice? Have they done so deliberately, in the belief that a tree structure will serve the people of the city better? Or have they done it because they cannot help it, because they are trapped by a mental habit, perhaps even trapped by the way the mind works - because they cannot encompass the complexity of a semilattice in any convenient mental form, because the mind has an overwhelming predisposition to see trees wherever it looks and cannot escape the tree conception?

I shall try to convince you that it is for this second reason that trees are being proposed and built as cities - that is, because designers, limited as they must be by the capacity of the mind to form intuitively accessible structures, cannot achieve the complexity of the semilattice in a single mental act.

Let me begin with an example. Suppose I ask you to remember the following four objects: an orange, a watermelon, a football and a tennis ball. How will you keep them in your mind, in your mind's eye? However you do it, you will do it by grouping them. Some of you will take the two fruits together, the orange and the watermelon, and the two sports balls together, the football and the tennis ball. Those of you who tend to think in terms of physical shape may group them differently, taking the two small spheres together - the orange and the tennis ball and the two large and more egg-shaped objects - the watermelon and the football. Some of you will be aware of both.



Let us make a diagram of these groupings (**Figure 16**). Either grouping taken by itself is a tree structure. The two together are a semilattice. Now let us try and visualize these groupings in the mind's eye. I think you will find that you cannot visualize all four sets simultaneously - because they overlap. You can visualize one pair of sets and then the other, and you can alternate between the two pairs extremely fast, so that you may deceive yourself into thinking you can visualize them all together. But in truth, you cannot conceive all four sets at once in a single mental act. You cannot bring the semilattice structure into a visualizable form for a single mental act. In a single mental act you can only visualize a tree.

This is the problem we face as designers. While we are not, perhaps, necessarily occupied with the problem of total visualization in a single mental act, the principle is still the same. The tree is accessible mentally and easy to deal with. The semilattice is hard to keep before the mind's eye and therefore hard to deal with.

It is known today that grouping and categorization are among the most primitive psychological processes. Modern psychology treats thought as a process of fitting new situations into existing slots and pigeonholes in the mind. Just as you cannot put a physical thing into more than one physical pigeonhole at once, so, by analogy, the processes of thought prevent you from putting a mental construct into more than one mental category at once. Study of the origin of these processes suggests that they stem essentially from the organism's need to reduce the complexity of its environment by establishing barriers between the different events that it encounters.

It is for this reason - because the mind's first function is to reduce the ambiguity and overlap in a confusing situation and because, to this end, it is endowed with a basic intolerance for ambiguity - that structures like the city, which do require overlapping sets within them, are nevertheless persistently conceived as trees.

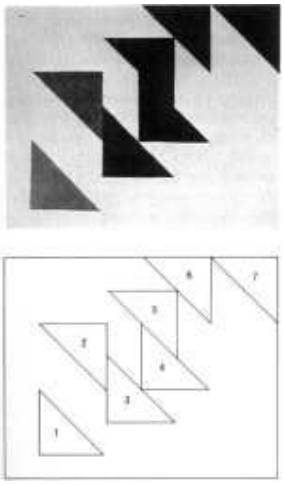
The same rigidity dogs even perception of physical patterns. In experiments by Huggins and myself at Harvard, we showed people patterns whose internal units overlapped, and found that they almost always invent a way of seeing the patterns as a tree - even when the semilattice view of the patterns would have helped them perform the task of experimentation which was before them.

The most startling proof that people tend to conceive even physical patterns as trees is found in some experiments of Sir Frederick Bartlett. He showed people a pattern for about a quarter of a second and then asked them to draw what they had seen. Many people, unable to grasp the full complexity of the pattern they had seen, simplified the patterns by cutting out the overlap. In **Figure 17**, the original is shown on the left, with two fairly typical redrawn versions to the right of it. In the redrawn versions the circles are separated from the rest; the overlap between triangles and circles disappears.

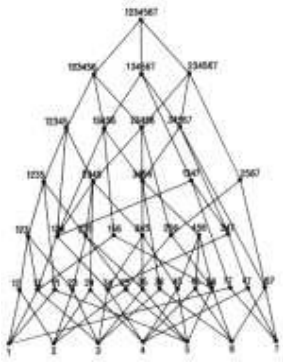
These experiments suggest strongly that people have an underlying tendency, when faced by a complex organization, to reorganize it mentally in terms of non-overlapping units. The complexity of the semilattice is replaced by the simpler and more easily grasped tree form.

You are no doubt wondering by now what a city looks like which is a semilattice, but not a tree. I must confess that I cannot yet show you plans or sketches. It is not enough merely to make a demonstration of overlap - the overlap must be the right overlap. This is doubly important because it is so tempting to make plans in which overlap occurs for its own sake. This is essentially what the high- density 'life-filled' city plans of recent years do. But overlap alone does not give structure. It can also give chaos. A garbage can is full of overlap. To have structure, you must have the right overlap, and this is for us almost certainly different from the old overlap which we observe in historic cities. As the

relationships between functions change, so the systems which need to overlap in order to receive these relationships must also change. The recreation of old kinds of overlap will be inappropriate, and chaotic instead of structured.



One can perhaps make the physical consequences of overlap more comprehensible by means of an image. The painting illustrated is a work by Simon Nicholson (**Figure 18**). The fascination of this painting lies in the fact that, although constructed of rather few simple triangular elements, these elements unite in many different ways to form the large units of the painting - in such a way indeed that, if we make a complete inventory of the perceived units in the painting, we find that each triangle enters into four or five completely different kinds of unit, none contained in the others, yet all overlapping in that triangle.



Thus, if we number the triangles and pick out the sets of triangles which appear as strong visual units, we get the semilattice shown in **Figure 19.**

Three and 5 form a unit because they work together as a rectangle; 2 and 4 because they form a parallelogram; 5 and 6 because they are both dark and pointing the same way; 6 and 7 because one is the ghost of the other shifted sideways; 4 and 7 because they are symmetrical with one another; 4 and 6 because they form another rectangle; 4 and 5 because they form a sort of Z; 2 and 3 because they form a rather thinner kind of Z; 1 and 7 because they are at opposite corners; 1 and 2 because they are a rectangle; 3 and 4 because they point the same way as 5 and 6, and form a sort of off-centre reflection; 3 and 6 because they enclose 4 and 5; 1 and S because they enclose 2, 3 and 4. I have only listed the units of two triangles. The larger units are even more complex. The white is more complex still and is not even included in the diagram because it is harder to be sure of its elementary pieces.

The painting is significant, not so much because it has overlap in it (many paintings have overlap in them), but rather because this painting has nothing else in it except overlap. It is only the fact of the overlap, and the resulting multiplicity of aspects which the forms present, that makes the painting fascinating. It seems almost as though the painter had made an explicit attempt, as I have done, to single out overlap as a vital generator of structure.

All the artificial cities I have described have the structure of a tree rather than the semilattice structure of the Nicholson painting. Yet it is the painting, and other images like it, which must be our vehicles for thought. And when we wish to be precise, the

semilattice, being part of a large branch of modern mathematics, is a powerfu1 way of exploring the structure of these images. It is the semilattice we must look for, not the tree.

When we think in terms of trees we are trading the humanity and richness of the living city for a conceptual simplicity which benefits only designers, planners, administrators and developers. Every time a piece of a city is torn out, and a tree made to replace the semilattice that was there before, the city takes a further step toward dissociation.

In any organized object, extreme compartmentalization and the dissociation of internal elements are the first signs of coming destruction. In a society, dissociation is anarchy. In a Person, dissociation is the mark of schizophrenia and impending suicide. An ominous example of city-wide dissociation is the separation of retired people from the rest of urban life, caused by the growth of desert cities for the old like Sun City, Arizona. This separation isonly possible under the influence of treelike thought.

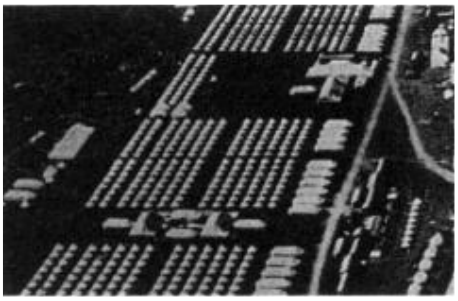
It not only takes from the young the company of those who have lived long, but worse, it causes the same rift inside each individual life. As you pass into Sun City, and into old age, your ties with your own past will be unacknowledged, lost and therefore broken. Your youth will no longer be alive in your old age - the two will be dissociated; your own life will be cut in two.

For the human mind, the tree is the easiest vehicle for complex thoughts. But the city is not, cannot and must not be a tree. The city is a receptacle for life. If the receptacle severs the overlap of the strands of life within it, because it is a tree, it will be like a bowl full of razor blades on edge, ready to cut up whatever is entrusted to it. In such a receptacle life will be cut to pieces. If we make cities which are trees, they will cut our life within to pieces.

http://www.rudi.net/pages/8755

'A City is not a Tree'
by Christopher Alexander

A CITY IS NOT A TREE



CHRISTOPHER ALEXANDER

The tree of my title is not a green tree with leaves. It is the name of an abstract structure. I shall contrast it with another, more complex abstract structure called a semilattice. In order to relate these abstract structures to the nature of the city, I must first make a simple distinction.

I want to call those cities which have arisen more or less spontaneously over many, many years *natural cities*. And I shall call those cities and parts of cities which have been deliberately created by designers and planners artificial cities. Siena, Liverpool, Kyoto, Manhattan are examples of natural cities. Levittown, Chandigarh and the British New Towns are examples of artificial cities.

It is more and more widely recognized today that there is some essential ingredient missing from artificial cities. When compared with ancient cities that have acquired the patina of life, our modern attempts to create cities artificially are, from a human point of view, entirely unsuccessful.

Both the tree and the semilattice are ways of thinking about how a large collection of many small systems goes to make up a large and complex system. More generally, they are both names for structures of sets.

In order to define such structures, let me first define the concept of a set. A set is a collection of elements which for some reason we think of as belonging together. Since, as designers, we are concerned with the physical living city and its physical backbone, we must naturally restrict ourselves to considering sets which are collections of material elements such as people, blades of grass, cars, molecules, houses, gardens, water pipes, the water molecules in them etc.

When the elements of a set belong together because they co-operate or work together somehow, we call the set of elements a system.

For example, in Berkeley at the corner of Hearst and Euclid, there is a drugstore, and outside the drugstore a traffic light. In the entrance to the drugstore there is a newsrack where the day's papers are displayed. When the light is red, people who are waiting to cross the street stand idly by the light; and since they have nothing to do, they look at the papers displayed on the newsrack which

they can see from where they stand. Some of them just read the headlines, others actually buy a paper while they wait.

This effect makes the newsrack and the traffic light interactive; the newsrack, the newspapers on it, the money going from people's pockets to the dime slot, the people who stop at the light and read papers, the traffic light, the electric impulses which make the lights change, and the sidewalk which the people stand on form a system - they all work together.

From the designer's point of view, the physically unchanging part of this system is of special interest. The newsrack, the traffic light and the sidewalk between them, related as they are, form the fixed part of the system. It is the unchanging receptacle in which the changing parts of the system - people, newspapers, money and electrical impulses - can work together. I define this fixed part as a unit of the city. It derives its coherence as a unit both from the forces which hold its own elements together and from the dynamic coherence of the larger living system which includes it as a fixed invariant part.

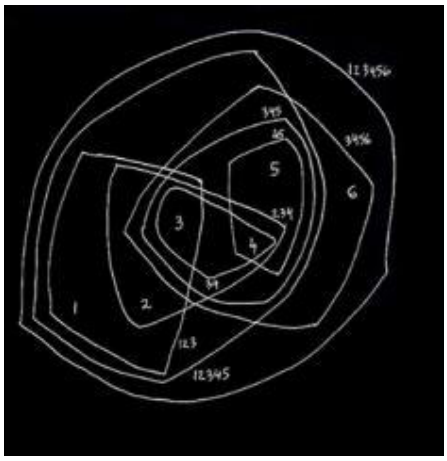
Of the many, many fixed concrete subsets of the city which are the receptacles for its systems and can therefore be thought of as significant physical units, we usually single out a few for special consideration. In fact, I claim that whatever picture of the city someone has is defined precisely by the subsets he sees as units.

Now, a collection of subsets which goes to make up such a picture is not merely an amorphous collection. Automatically, merely because relationships are established among the subsets once the subsets are chosen, the collection has a definite structure.

To understand this structure, let us think abstractly for a moment, using numbers as symbols. Instead of talking about the real sets of millions of real particles which occur in the city, let us consider a simpler structure made of just half a dozen elements. Label these elements 1,2,3,4,5,6. Not including the full set [1,2,3,4,5,6], the empty set [-], and the one-element sets [1],[2],[3],C4],[5], [6], there are 56 different subsets we can pick from six elements.

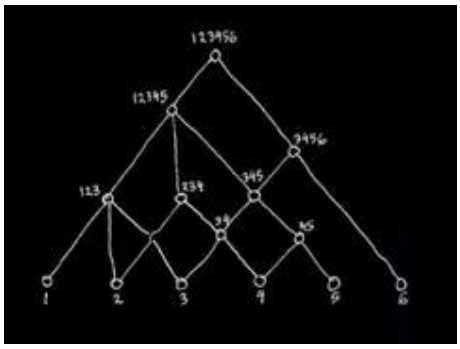
Suppose we now pick out certain of these 56 sets (just as we pick out certain sets and call them units when we form our picture of the city). Let us say, for example, that we pick the following subsets: [123], [34], [45], [234], [345], [12345], [3456].

What are the possible relationships among these sets? Some sets will be entirely part of larger sets, as [34] is part of [345] and [3456]. Some of the sets will overlap, like [123] and [234]. Some of the sets will be disjoint - that is, contain no elements in common like [123] and [45].



We can see these relationships displayed in two ways. In **diagram A** each set chosen to be a unit has a line drawn round it. In **diagram B** the chosen sets are arranged in order of ascending magnitude, so that whenever one set contains another (as [345] contains [34], there is a vertical path leading from one to the other. For the sake of clarity and visual economy, it is usual to draw lines only between sets which have no further sets and lines between them; thus the line between [34] and [345] and the line between [345] and [3456] make it unnecessary to draw a line between [34] and [3456].

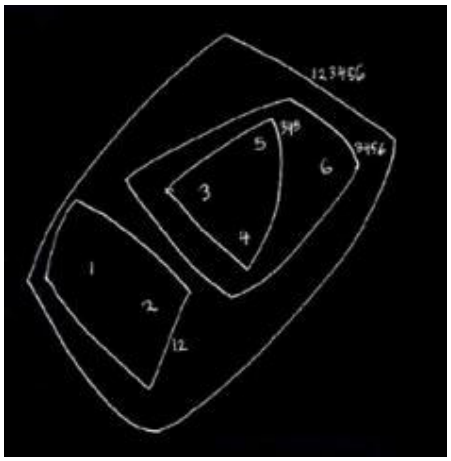
Diagrams A & B redrawn by Nikos Salingaros



As we see from these two representations, the choice of subsets alone endows the collection of subsets as a whole with an overall structure. This is the structure which we are concerned with here. When the structure meets certain conditions it is called a semilattice. When it meets other more restrictive conditions, it is called a tree.

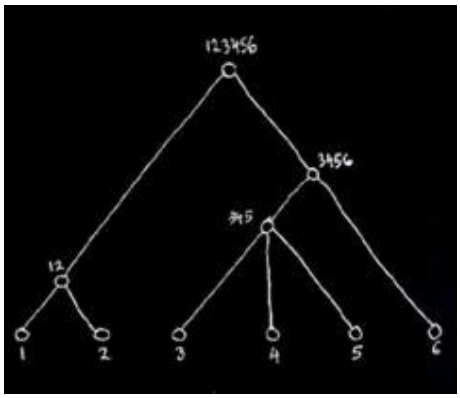
The semilattice axiom goes like this: *A collection of sets forms a semilattice if and only if, when two overlapping sets belong to the collection, the set of elements common to both also belongs to the collection.*

The structure illustrated in diagrams A and B is a semilattice. It satisfies the axiom since, for instance, [234] and [345] both belong to the collection and their common part, [34], also belongs to it. (As far as the city is concerned, this axiom states merely that wherever two units overlap, the area of overlap is itself a recognizable entity and hence a unit also. In the case of the drugstore example, one unit consists of newsrack, sidewalk and traffic light. Another unit consists of the drugstore itself, with its entry and the newsrack. The two units overlap in the newsrack. Clearly this area of overlap is itself a recognizable unit and so satisfies the axiom above which defines the characteristics of a semilattice.) The tree axiom states: *A collection of sets forms a tree if and only if, for any two sets that belong to the collection either one is wholly contained in the other, or else they are wholly disjoint.*



The structure illustrated in **diagrams C** and **D** is a tree. Since this axiom excludes the possibility of overlapping sets, there is no way in which the semilattice axiom can be violated, so that every tree is a trivially simple semilattice.

Diagrams A & B redrawn by Nikos Salingaros



However, in this chapter we are not so much concerned with the fact that a tree happens to be a semilattice, but with the difference between trees and those more general semilattices which are not trees because they do contain overlapping units. We are concerned with the difference between structures in which no overlap occurs, and those structures in which overlap does occur.

It is not merely the overlap which makes the distinction between the two important. Still more important is the fact that the semilattice is potentially a much more complex and subtle structure than a tree. We may see just how much more complex a semilattice can be than a tree in the following fact: a tree based on 20 elements can contain at most 19 further subsets of the 20, while a semilattice based on the same 20 elements can contain more than 1,000,000 different subsets.

This enormously greater variety is an index of the great structural complexity a semilattice can have when compared with the structural simplicity of a tree. It is this lack of structural complexity, characteristic of trees, which is crippling our conceptions of the city.

To demonstrate, let us look at some modern conceptions of the city, each of which I shall show to be essentially a tree.

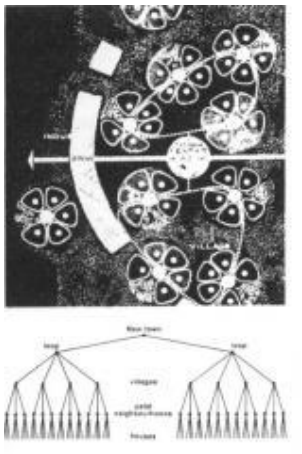


Figure 1. Columbia, Maryland, Community Research and Development, Inc.: Neighbourhoods,in clusters of five, form 'villages'. Transportation joins the villages into a new town. The organization is a tree.

Figure 2. Greenbelt, Maryland, Clarence Stein: This 'garden city' has been broken down into superblocks. Each superblock contains schools, parks and a number of subsidiary groups of houses built around parking lots. The organization is a tree.

Figure 3. Greater London plan (1943), Abercrombie and Forshaw: The drawing depicts the structure conceived by Abercrombie for London. It is made of a large number of communities, each sharply separated from all adjacent communities. Abercrombie writes, 'The proposal is to emphasize the identity of the existing communities, to increase their degree of segregation, and where necessary to recognize them as separate and definite entities.' And again, 'The communities themselves consist of a series of sub-units, generally with their own shops and schools, corresponding to the neighbourhood units.' The city is conceived as a tree with two principal levels. The communities are the larger units of the structure; the smaller sub-units are neighbourhoods. There are no overlapping units. The structure is a tree.

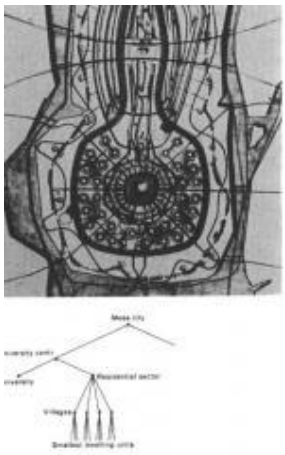


Figure 4. Mesa City, Paolo Soleri: The organic shapes of Mesa City lead us, at a careless glance, to believe that it is a richer structure than our more obviously rigid examples. But when we look at it in detail we find precisely the same principle of organization. Take, particularly, the university centre. Here we find the centre of the city divided into a university and a residential quarter, which is itself divided into a number of villages (actually apartment towers) for 4000 inhabitants, each again subdivided further and surrounded by groups of still smaller dwelling units.

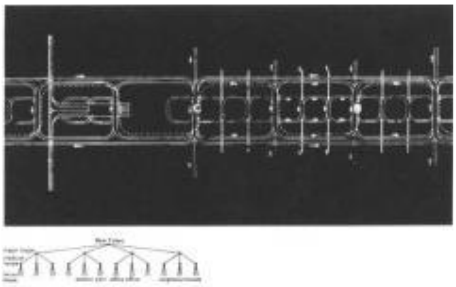


Figure 5. Tokyo plan, Kenzo Tange: This is a beautiful example. The plan consists of a series of loops stretched across Tokyo Bay. There are four major loops, each of which contains three medium loops. In the second major loop, one medium loop is the railway station and another is the port. Otherwise, each medium loop contains three minor loops which are residential neighbourhoods, except in the third major loop where one contains government offices and another industrial offices.

Figure 6. Chandigarh (1951), Le Corbusier: The whole city is served by a commercial centre in the middle, linked to the administrative centre at the head. Two subsidiary elongated commercial cores are strung out along the maior arterial roads, running north-south. Subsidiary to these are further administrative, community and commercial centres, one for each of the city's 20 sectors.

Figure 7. Brasilia, Lucio Costa: The entire form pivots about the central axis, and each of the two halves is served by a single main artery. This main artery is in turn fed by subsidiary arteries parallel to it. Finally, these are fed by the roads which surround the superbiocks themselves. The structure is a tree.

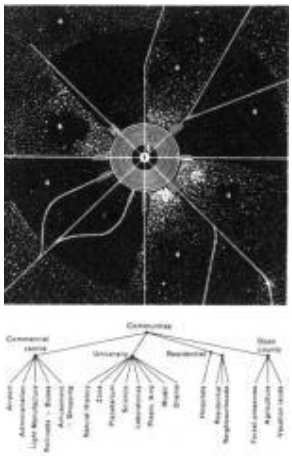


Figure 8. Communitas, Percival and Paul Goodman: Communitas is explicitly organized as a tree: it is first divided into four concentric major zones, the innermost being a commercial centre, the next a university, the third residential and medical, and the fourth open country. Each of these is further subdivided: the commercial centre is represented as a great cylindrical skyscraper, containing five layers: airport, administration, light manufacture, shopping and amusement; and, at the bottom, railroads, buses and mechanical services. The university is divided into eight sectors comprising natural history, zoos and aquariums, planetarium, science laboratories, plastic arts, music and drama. The third concentric ring is divided into neighbourhoods of 4000 people each, not consisting of individual houses, but of apartment blocks, each of these containing individual dwelling units. Finally, the open country is divided into three segments: forest preserves, agriculture and vacation lands. The overall organization is a tree

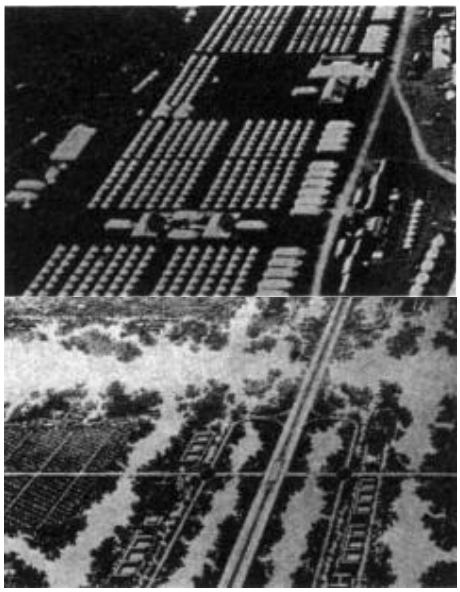


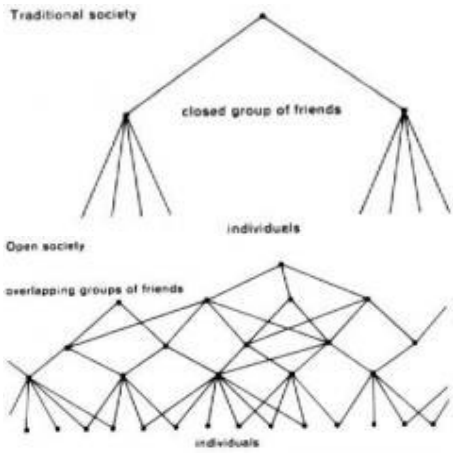
Figure 9. The most beautiful example of all I have kept until last, because it symbolizes the problem perfectly. It appears in Hilberseimer's book *The Nature of Cities*. He describes the fact that certain Roman towns had their origin as military camps, and then shows a picture of a modern military encampment as a kind of archetypal form for the city. It is not possible to have a structure which is a clearer tree. The symbol is apt, for, of course, the organization of the army was designed precisely in order to create discipline and rigidity. The photograph on the [left] is Hilberseimer's own scheme for the commercial area of a city based on the army camp archetype.

Each of these structures, then, is a tree. Each unit in each tree that I have described, moreover, is the fixed, unchanging residue of some system in the living city (just as a house is the residue of the

interactions between the members of a family, their emotions and their belongings; and a freeway is the residue of movement and commercial exchange).

However, in every city there are thousands, even millions, of times as many more systems at work whose physical residue does not appear as a unit in these tree structures. In the worst cases, the units which do appear fail to correspond to any living reality; and the real systems, whose existence actually makes the city live, have been provided with no physical receptacle.

Neither the Columbia plan nor the Stein plan for example, corresponds to social realities. The physical layout of the plans, and the way they function suggests a hierarchy of stronger and stronger closed social groups, ranging from the whole city down to the family, each formed by associational ties of different strength.



In a traditional society, if we ask a man to name his best friends and then ask each of these in turn to name their best friends, they will all name each other so that they form a closed group. A village is made up of a number of separate closed groups of this kind.

But today's social structure is utterly different. If we ask a man to name his friends and then ask them in turn to name their friends, they will all name different people, very likely unknown to the first person; these people would again name others, and so on outwards. There are virtually no closed groups of people in modern society. The reality of today's social structure is thick with overlap - the systems of friends and acquaintances form a semilattice, not a tree (**Figure 10**).

Christopher ALEXANDER: *A city is not a tree*