Generating Cities from the Bottom-Up:

Using Complexity Theory for Effective Design

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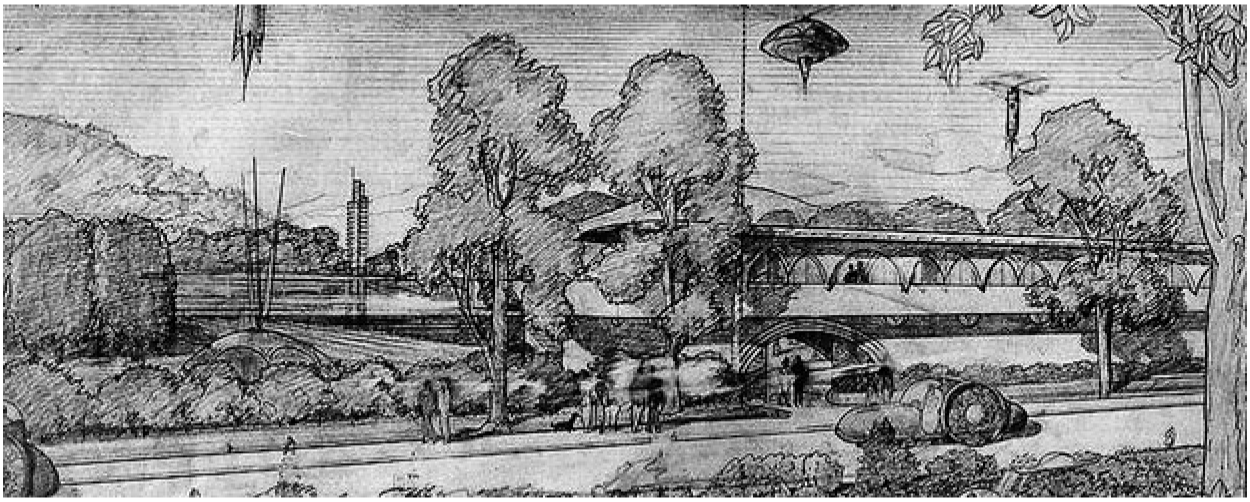


This essay introduces the idea that cities evolve from the bottom up, that patterns emerge as a global order from local decisions. As the future is unknowable, cities must be planned according to this type of complexity. We begin by introducing the idea of hierarchy and modularity as the basis of a generative process that leads to patterns that are self-similar over many scales, patterns that are fractal in their structure. We then present a simple model of growth that generates such patterns based on a trade-off between connecting to the growing structure and seeking as much free space as possible around any location within it. These are the tensions that exist in real cities through the quest by individuals to agglomerate. Once we have sketched the model, we demonstrate how this generative process can be simulated using cellular automata which allows us to think of the logic in terms of rules that represent how existing development takes place. By changing the rules, we can introduce optimality into the process, developing the logic to enable certain goals to be pursued. We conclude with various demonstrations of how idealised plans might be conceived within this complexity which is generated from the bottom up.

1 A New Paradigm for City Planning

Cities are built from the bottom up. They are the product of millions of individual decisions on many spatial scales and over different time intervals, affecting both the functioning and form of the city with respect to how it is structured and how it evolves. It is impossible to conceive of any organisation that can control such complexity and thus the very question of the extent to which the city might be 'planned' is thrown into a new light. Throughout history, plans for cities have been proposed as a top-down response to perceived problems and the realisation of ideals but there are few examples where control has been sufficiently strict to enable their complete implementation. Most development in cities occurs without any central planning yet cities continue to function, often quite effectively without any top-down control. Cities, as part of societies and economies, not only hold together without any top-down control but actually evolve their own coordination from the bottom up, their order emerging from these millions of relatively uncoordinated decisions which express Adam Smith's characterisation of the economy as being managed by an 'invisible hand'.

Fifty years ago, cities were first considered to be systems whose functioning was based on many interacting parts and whose form is manifested in a relatively coordinated hierarchy of these parts (or subsystems). Yet systems in these terms were conceived of as being centrally controlled. As the paradigm developed, there was a subtle shift to the notion that the order in many systems and their resulting hierarchies emerged from the way their parts or elements interacted from the bottom up rather than from any blueprint imposed from the top down. The complexity sciences developed to refresh this systems paradigm with the focus changing from an analogy between cities as machines to one based on evolving biologies, whose form was the resultant of subtle and continuous changes in their genetic composition at the level of their most basic component parts. This shift in thinking is wider than cities per se. It is from thinking of the world in terms of its physics to one based on its biology, from top down to bottom up, from centralised to decentralised action, and from planned forms to those that evolve organically.

In this essay, I will argue that a new paradigm for planning cities is required which takes account of how they are built which is largely but not exclusively from the bottom up. It draws on recent developments in complexity theory which in terms of city planning, draws on the traditions first suggested by Patrick Geddes (1915) in his book Cities in Evolution at the beginning of the last century but taken up in earnest in the early 1960s by Christopher Alexander (1964) and Jane Jacobs (1962) amongst others. This paradigm has taken a century in sensitising us to the need to step carefully when intervening in complex systems. Its message is that we plan 'at our peril' and that small interventions in a timely and opportune manner which are tuned to the local context are more likely to succeed than the massive top-down plans that were a feature of city planning throughout much of the 20th century. To impress this new style of planning, we will proceed by analogy using metaphors about how cities are formed taken from physics and biology. We will first outline the notion of modularity and hierarchy, of self-similarity and scale in the physical and functional form of cities, and then we will present ways in which basic functions generate patterns that fill space to different degrees. Cities develop by filling the space available to them in different ways, at different densities and using different patterns to deliver the energy in terms of people and materials which enable their constituent parts to function. We will demonstrate a simple diffusion model and then generalise it to grow city forms and structures, in silico. We will allude to city plans in history that demonstrate our need to plan with and along side the mechanisms of organic growth rather than against these processes which has been the dominant style of planning in the past century.

2 Modularity, Hierarchy and Self-Similarity

There is wonderful story first told by Herbert Simon (1962) which illustrates the importance of hierarchy and modularity in the construction of stable and sustainable systems. Simon tells of two Swiss watchmakers, Hora and Tempus, who both produced excellent but identical watches, each of 1000 parts. The key difference between the watchmakers was in the processes they used to produce each watch. Tempus, for example, built each watch by simply taking one part and adding it in the requisite order to the next until the whole assembly was complete, Hora however built up his watches in subassemblies, first of 10 parts each. Once he had produced 10 sub assemblies, he added these into a large subsystem containing 100 parts. When he has added all his 10 part assemblies into the larger parts of 100, he completed the whole watch by simply adding the 10 larger assemblies together. It took Hora only fraction longer to add the subassemblies. To all intents and purpose the completed watches took the same time and were no different.

As the fame of the watchmakers grew, they received more and more orders but in this fictional world, the only way they could receive these orders was by telephone. Every time the telephone rang Tempus had to put down the watch and it fell to pieces so he had to start again once he had taken an order. Hora on the other hand simply lost the subassembly he was working on when the telephone rang and he had to put down the watch to answer it. You can see immediately what happened in the long term. Tempus found it more and more difficult to complete a watch as the telephone rang more and more while Hora simply traded off his telephone time for watchmaking for his process was robust. Ultimately Tempus went out of business while Hora prospered and the moral of the story is that sustainable systems which can withstand continued interruptions of this kind are built in parts, from the bottom up as modules to be assembled into a hierarchy of parts.

Modular construction is not simply a functional process of ensuring that component parts of a system are stuck together efficiently and sustainably but a means of actually operating processes that drive the system in an effective way. For example, different functions which relate to how the economy of a city works, depend on a critical mass of population such that the more specialised the function, the wider the population required to sustain it. In short, more specialised functions depend on economies of scale such that the size and spacing of various functions produces a regular patterning at different hierarchical levels. The modules are thus replicated in a way that they change their extent with their scale. We can demonstrate this point using some simple geometry that illustrates how we can scale a physical module, producing a fractal that is similar on all scales. Imagine that we need to increase the space required for planting a barrier along a straight path. If we divide the line of the path into three equal segments, we can take two of these segments and splay them away from the path so that they touch and form an equilateral triangle in the manner that we show in Figure 1 (a). This clearly increases the length of the line L (which has an original length of three units) by one unit, so that the new length of the line becomes (4/3)L. We can further increase the length of the line by subdividing each segment into three and displacing the central portion of each of the original segments to form the same equilateral triangle but at a scale down from the original. If this is done for each of the original four segments, then the length of the second line composed of these four segments increases by 4/3. This in turn is 4/3 the length of the original line L and the new line is now (4/3)(4/3)L. We can continue doing this at ever finer scales and the length of the line at scale n thus becomes (4/3) nL.

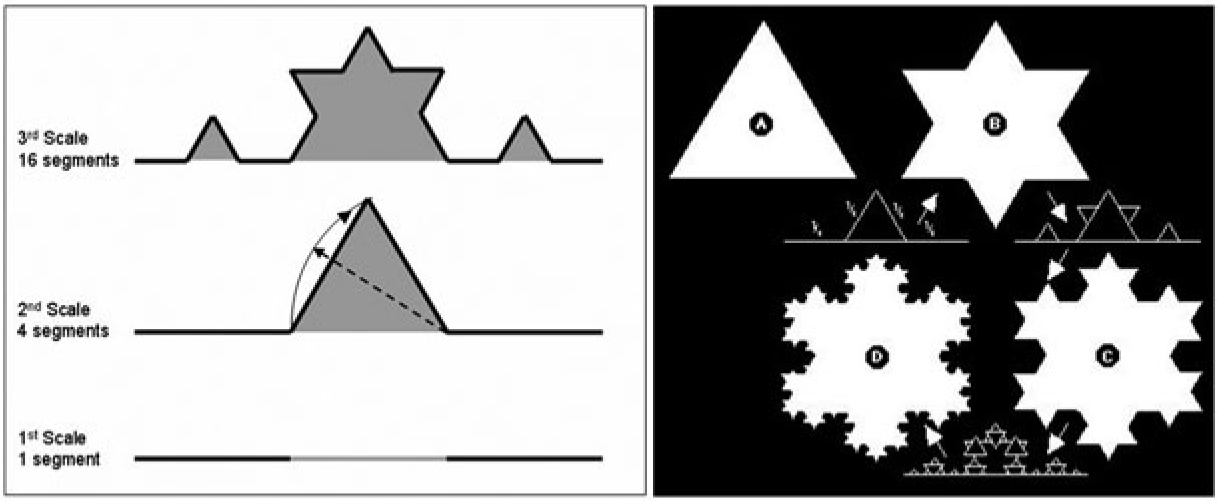


Figure 1: Constructing a Space-filling Curve: The Koch Snowflake Curve

a) left: successive displacement of the central section of a line at ever fine scales
b) right: application of the displacement rule to the lines defining a triangle shape called a Koch Island

This construction is a recursion of the same rule at different scales and it generates a pattern which is self-similar in that the motif – the triangular displacement occurs at every scale and is in a sense the hallmark of the entire construction. The structure grown from the bottom up produces a shape that is a fractal, a regular geometry composed of irregular parts which are repeated on successive scales which is indicative of the same processes being applied over and over again. The process can be viewed as a hierarchy which is clearly present in the pattern itself but in terms of the recursive process, can be abstracted into the usual tree-like diagram which we show in Figure 2.

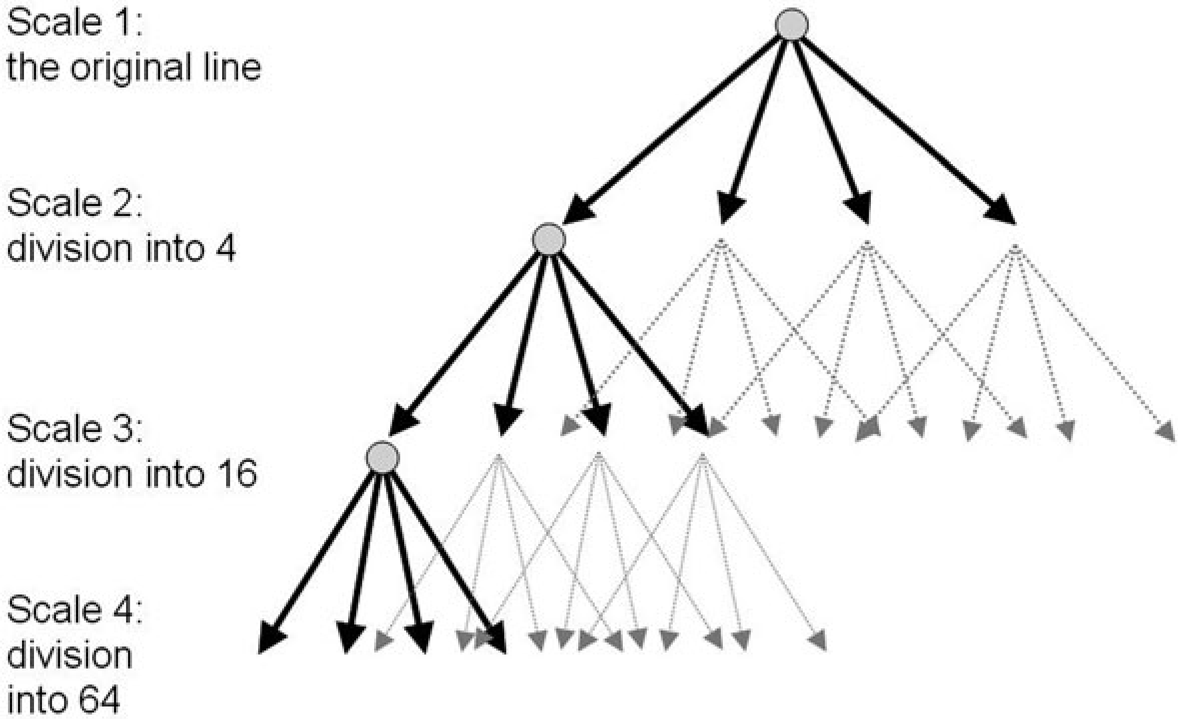


Figure 2: The Hierarchy of Composition in Constructing a Fractal

There are several strange consequences to the process that we have just illustrated. If the process of adding more and more detail of the same kind continues indefinitely, the length of the line increases to infinity but it is intuitively obvious that the area enclosed by the resulting shape either in the Koch curve in Figure 1(a) or the Koch island in Figure 1(b) converges to a fixed value. Second, if the line becomes more and more convoluted in filling the plane, then it would appear that the line which has Euclidean dimension of 1 seems to have the dimension of the plane which is 2. This concept of space-filling can be formally demonstrated to be encapsulated in the idea of fractal dimension. The Koch curve in Figure 1(a) has a fractal dimension about 1.26 while a more convoluted line like a fjord coastline has something like 1.7. Rather smooth curves such as the coastline of southern Australia have a fractal dimension of about 1.1. In fact the inventor of the concept of fractals, Benoit Mandelbrot, wrote a famous paper in Science in 1967 which was entitled "How Long Is the Coast of Britain? Statistical Self-Similarity and Fractional Dimension". To cut a very long story short, objects which are irregular in the way we have shown and which manifest self-similarity are fractals whose dimension lies between the dimension that they are defined by and the dimension of the space that they are trying to fill. In cities, filling the two dimensional pane with particular forms of development from the parcel to the street line and at different densities suggests that their fractal dimension lies between 1 and 2. Thus this dimension becomes the signature of urban morphology which is the outcome of processes that generate fractal shapes (Batty and Longley, 1994).

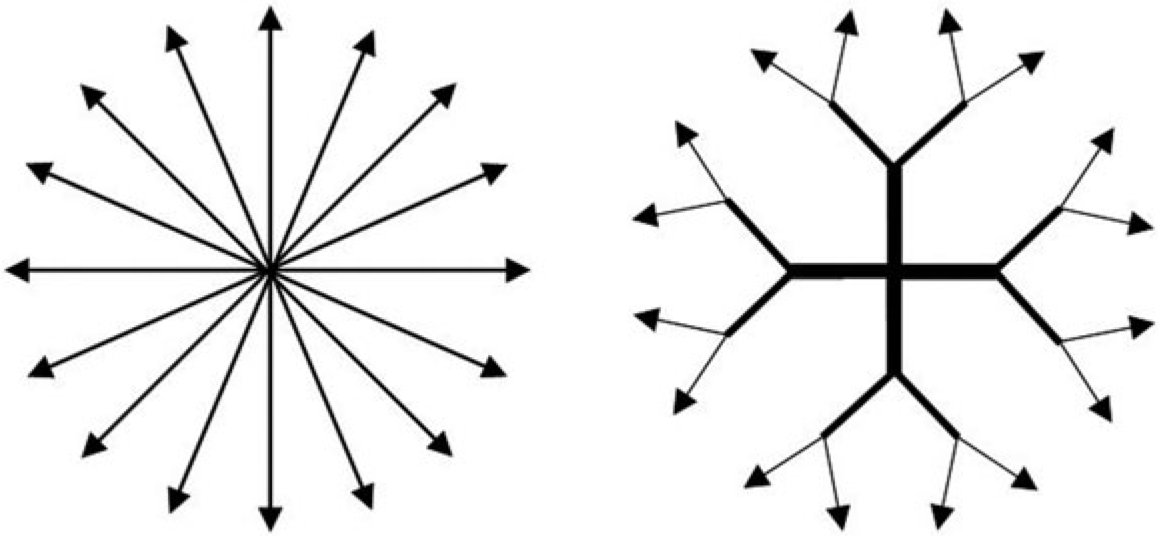


Figure 3: Literal Hierarchies: Transport From a Central Source

a) left: each link is separate b) right: arranging links into a more efficient structure

There is however a much more literal morphology which is fractal and this is the shape of an object or set of linked objects that form a tree or dendrite. If you want to transport energy from some central source to many distant locations, it is more efficient to develop infrastructure that captures as much capacity for transfer as near to the source as is possible. This is rather easy to demonstrate graphically for if there are 16 points arranged around a circle, then rather than build a link between the source and each of these 16 points, it is more efficient to group the links in such a way that the distance to these different locations is minimised. In Figure 3(a), assuming each single link is of distance 1 unit, then the length of the routes needed in total to service these locations ('fill the space') is 16 in comparison with the grouping of these routes into 2, then four, then 8 which is shown in Figure 3(b). The total distance of this arrangement in 3(b) is something between one half and three quarters of the original form in Figure 3(a) depending on the precise configuration although the capacity of the links which take more traffic nearer the source are bigger, and this would incur extra costs of construction. Nevertheless, this demonstrates the important point that where resources are to be conserved (which is in virtually every situation one might imagine), space must be filled efficiently. The tree structures in Figure 3 are fractals with Figure 3(b) illustrating this self-similarity directly while at the same time being a literal hierarchy spread out in space demonstrating quite explicitly the pattern of its construction.

There are many examples of such hierarchical structure in the forms we see in both nature and in made-made systems. Energy in the form of blood, oxygen, and electric signals are delivered to the body through dendritic networks of arteries and veins, lungs, and nerves as we illustrate in the schematic of the central lung system in Figure 4(a). Plants reach up to receive oxygen from the air and down to draw out other nutrients from the soil as in Figure 4(b). Nearer to our concern here and reflecting the discussion of route systems above, Figure 4(c) shows the network of streets in the mid-size English town of Wolverhampton (population circa 300, 000 in 2001). It is clear that the traditional street system has grown organically but the ring around the town centre has been planned, imposed from the top down, thus illustrating the notion that what we observe in cities is a mixture of different scales of decision-making. In Figure 4(d), we show one of the Palm islands off the coast of Dubai developed by the construction company Nakheel. This is a wonderful example of how it is necessary to conserve resources when building into hostile media – in this case by reclaiming land from the sea, where transportation and access become the main themes in the way the resort is formed.

These examples demonstrate that cities are built from the bottom up, incrementally and where they are planned from the top down, the plan is usually a small part of wider organic development. When cities grow at any point in time, we have little idea of what the future holds with respect to new behaviours, values, technologies and social norms and thus it is not surprising that cities grow in an ad hoc manner reflecting the efficiencies and equities that dominate the consensus at the time when development takes place. To illustrate how we can model this process, we can abstract it into two main forces that reflect the desire for space on the part of any individual, developer or consumer which is traded off against the desire to live as close as possible to the ‘city’ composed of other individuals so that economies of scale might be realised. This is a simple model which captures all the ideas we have introduced so far and we will now develop it as a hypothetical simulation.

3 Simulating Space-Filling Growth

Our model is based on two key drivers. First we would all agree that cities exists as machines for enabling us to divide our labour so that we might realise economies of scale, or agglomeration economies as they are increasingly called. Alfred Marshall made the point over one hundred years ago: “Great are the advantages which people following the same skilled trade get from near neighbourhood to one another. The mysteries of the trade become no mystery but are, as it were, in the air.” (quoted in Glaeser, 1996). Our first principle is that individuals must be connected to one another in terms of their proximity to others for the city to exist and this means that new entrants to the city must somehow connect physically to those already there. In contrast, individuals seek as much personal space as possible for themselves and this translates into the notion that they wish to live as a far away from others as possible in the city space. This may translate into living at low densities but as in Manhattan, large apartments in the sky may be another way of realising this quest while there are increasingly innovative ways of meeting this goal by specialising in living in different locations. In our context here, we will embody this second principle as one where people wish to live on the edge of the existing city rather than in the centre, notwithstanding the great variety in these kinds of preference.

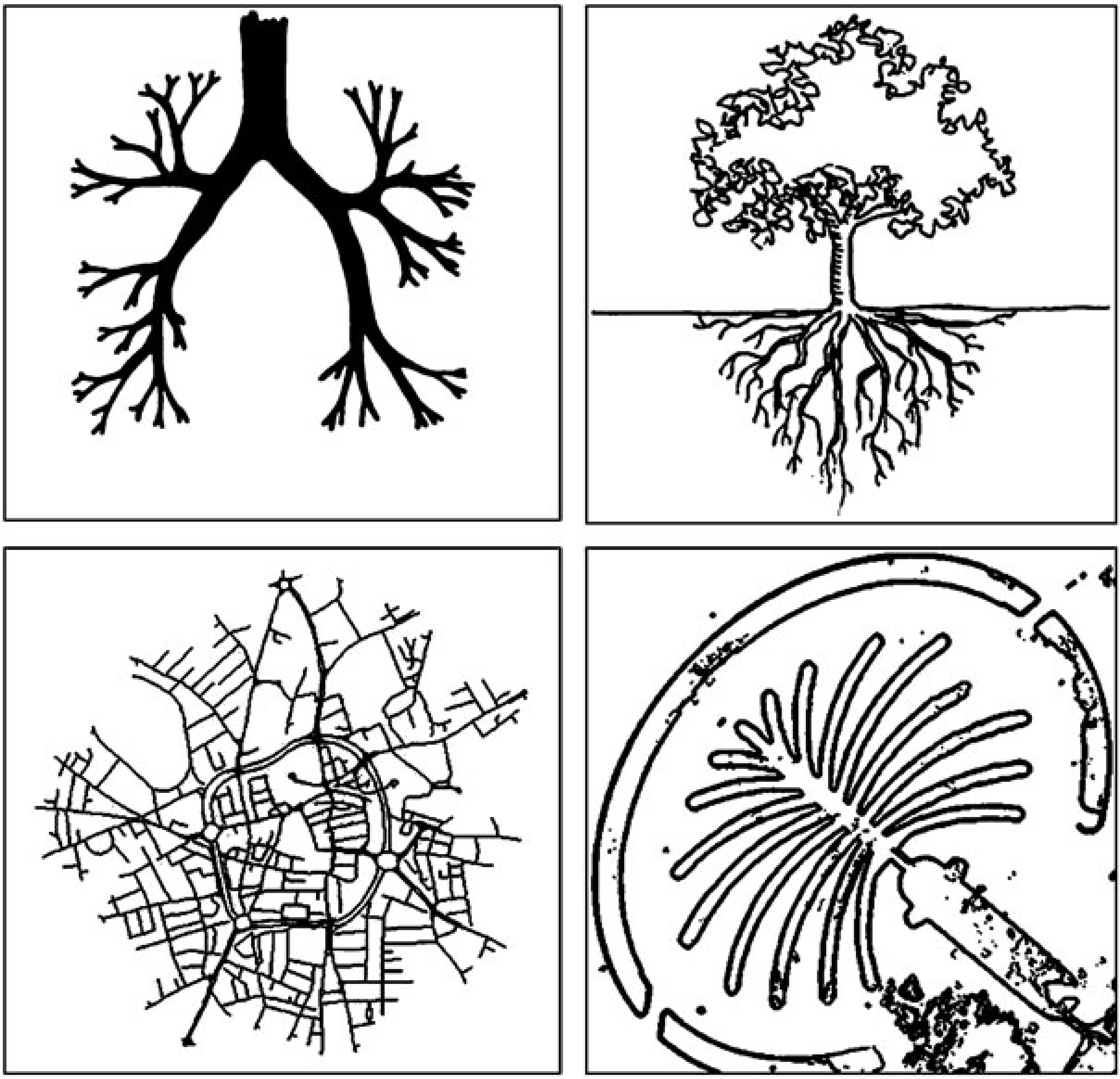
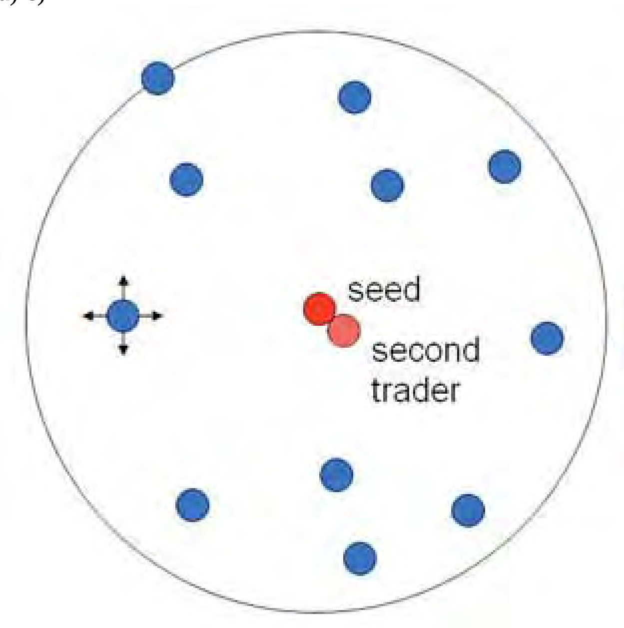


Figure 4: Space-Filling Hierarchies

a) top left: a schematic of the human lung b) top right: a schematic of a tree growing into different media: air above ground and soil below c) bottom left: the road network of a mid-sized English town: Wolverhampton d) bottom right: space-filling in difficult media: Nakheel’s Palm Island in Dubai

Our model can be constructed as follows. Imagine a trader decides to locate his or her base at the intersection of a trading route and a river where the land is fertile and flat. Many cities have grown from such humble origins where comparative natural advantages such as these determine the best location for settlement. Now imagine another individual seeking a permanent location wanders into the vicinity of the lone trader's base. If that trader happens by chance to get within the neighbourhood of the existing trader, that trader decides to locate there although there may be many traders in the wider hinterland who do not enter into the neighbourhood and never find the emergent settlement. However a certain proportion will find the settlement with a certain probability and given enough time and traders, the settlement will grow. From these simple principles, we can demonstrate the form of the growing city. In Figure 5(a), we show a schematic of the location process. The individuals are arranged around a circle well outside the location of the settlement which is fixed at the centre of the circle with the red solid dot. This is where the original trader locates. Each individual is a sold blue dot and they begin the movement in search of the location using a random walk. They decide at each step to move up or down or left or right randomly and in this way walk across the locational plane. If they move to a cell adjacent to the fixed solid red dot, they settle; they stop any further walking and turn red which shows they are now fixed, stable and no longer in motion. The first one to do so is shown by the shaded red dot adjacent to the initial red dot. That is all there is to it. You can see the final form, so you know what will result but if you had not seen this result, then many would guess that the result would not be a tree-like structure but a compact growing mass.

a) c)



b)

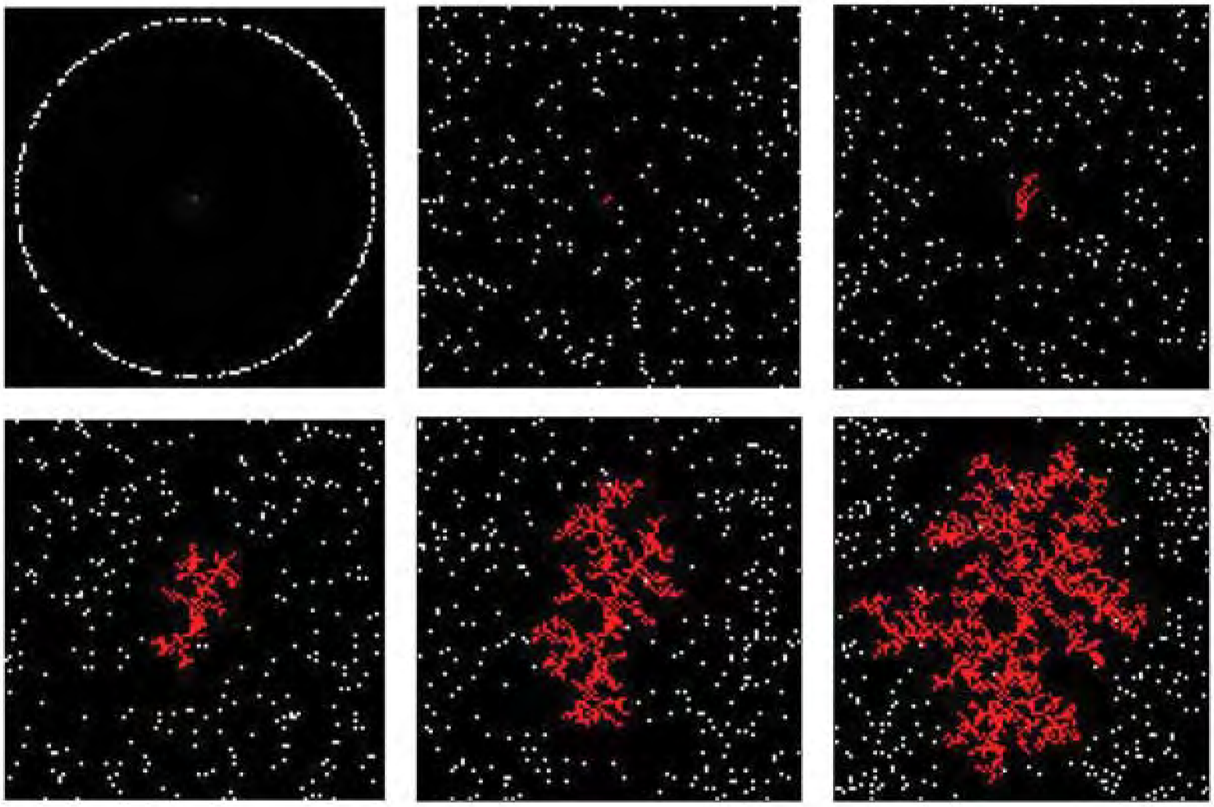


Figure 5: Generating Clustered City Growth Using Diffusion-Limited Aggregation

We show the progression of this in Figure 5(b) and to talk this through, what happens is that as soon as a trader settles next door to the existing red dot, the chances of another trader finding that new trader settlement as opposed to any other one increase just a fraction. As time goes by, the linear edge pattern that is characteristic of the growing tip of the cluster begins to emphasise itself and increasingly a trader finds it impossible to penetrate into the fissures in the growing cluster. Traders then are more likely to find the growing cluster at its edge and in this way, the cluster begins to span the space. If this were to produce a growing compact mass then it would have dimension nearer to 2 – the Euclidean dimension but in fact it has a fractal dimension between 1 and 2, about 1.7 so empirical work in many fields has determined. This like any dendritic structure, is a fractal, and it is easy to see the self-similarity that is contained in its form. Break off any branch and you can see the entire structure in the branch just as you can usually see the entire structure of a tree or a plant in its leaf. As we increase the resolution of the grid or lattice on which this walk takes place, then we get finer and finer tree-like structures where the fractal structure is readily apparent as we show in Figure 5(c).

This form is generated by a process which is called diffusion-limited aggregation (DLA) which has been found and used extensively in physics to grow crystal-like structures and to examine ways in which one media penetrates another, such as oil diffusing into water. In fact you can see similar patterns if you pour concentrated liquid soap into ordinary bath water and this is also reminiscent of the way the Dubai palm island resort has been ‘forced’ into the sea. It is a general principle that a substance with a higher density creates such patterns when infused into a substance of a lower density. A model of course is only as good as its assumptions but it is possible to tune this DLA model to produce many different shapes, some of which bear an uncanny resemblance to those that we find in real cities. For example, we can ‘tune’ the DLA to produce sparser structures if we relax the criterion that the individual who settles must exactly touch the already settled structure. We could, for example, set a distance threshold for this, or we could insist that more than one individual must already have settled. In this way, we can change the density, growing structures that are very heavily controlled in their dependence to what has gone before, generating linear structures all the way to compact ones where the degree of control over where traders are allowed to settle is very weak. Some of these extensions are illustrated in my book Cities and Complexity (Batty, 2005).

4 Real World Cities and Patterns of Complexity

There are many examples at different scales of the way cities are structured along dendritic lines mirroring the lines of energy that serve their distant parts. We glimpsed an idea of this in Figure 4(c) where we abstracted the street network of Wolverhampton but cities are not pure dendrites. Different networks are superimposed on one another for different kinds of transport ranging from different modes requiring different networks through to social and electronic networks which underpin the way people trade and communicate. In Figure 6, we show a map of inner London where the streets are coloured according the energy they transport, in fact using the proxy of road traffic volumes which give some index of both capacity and congestion or saturation. This is also highly correlated with patterns of accessibility which mirror the proximity of places to each other.

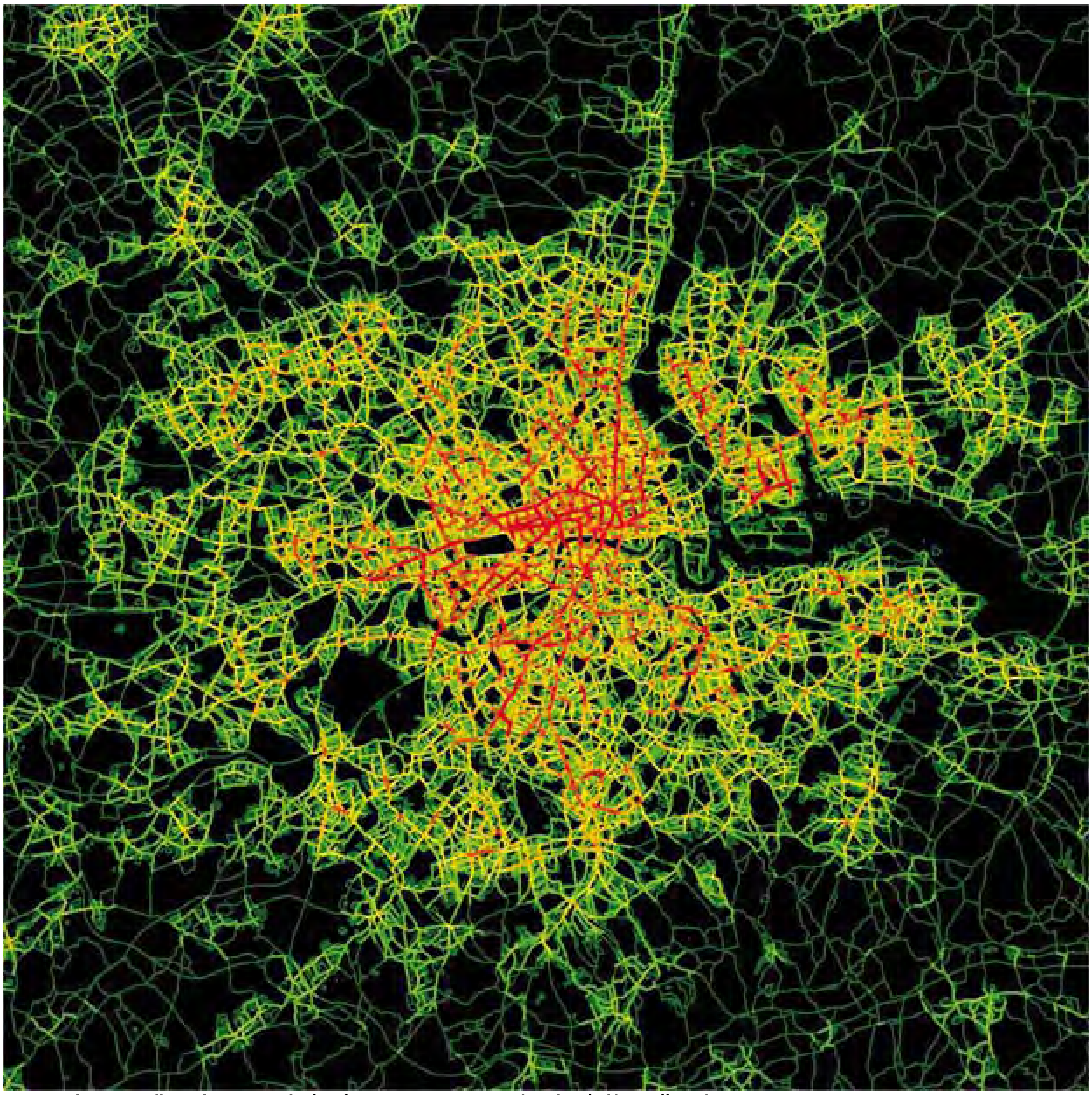


Figure 6: The Organically Evolving Network of Surface Streets in Greater London Classified by Traffic Volume

Street networks are excellent examples of how cities grow from the bottom up for they represent the skeletal structure on which all else in the city hangs. As we can see from the way cities grow, transport and land use are intimately related. Indeed, in the 1930s as urban sprawl first became significant in Britain, 'ribbon' development became the pattern of transport linked to land use that was the subject of fierce control in the quest to contain urban growth. It is possible to see this connectivity in many patterns of urban growth. The picture of the way the eastern US city of Baltimore in Maryland has grown over the last two hundred years that we show in Figure 7 is a clear illustration of the way development proceeds along radial routes from the traditional centre, particularly at the turn of the last century when streetcars, bus and railways systems dominated. Although this pattern is breaking down as cities become more polycentric and specialised in their parts and as new kinds of central business district such as 'edge cities' become established, it is still significant.

These patterns recur at different scales although the notion of them being faithfully reproduced at every spatial scale needs to be tempered with the obvious fact that individuals are diverse in their tastes and values and thus heterogeneous in their actions. Moreover the sort of similarity that occurs in cities is statistical self-similarity rather than the rather strict self-similarity that we saw for example in the construction of the Koch snowflake curve in Figure 1. In fact, although the pattern of transport routes in cities is generally radial, focussing on significant hubs, and organised according to a hierarchy of importance which mirrors different transport technologies, capacities and speed of transmission, street systems illustrate the space-filling principle quite clearly. At the local level, there is more conscious planning and design of street systems particularly in developments which are self-contained for purposes of the actual construction themselves as well as their financing and sales. For example, residential areas are often formed as small single entry streets into houses arranged around cul-de-sacs for purposes of containment, traffic management as well as security. We will return to these ideas in the next section when we speculate on how such structures can be formed in a more conscious sense through explicit design and planning but it is important to note that these patterns do recur across different scales as can be seen in their statistical distributions as well as their physical self-similarity.

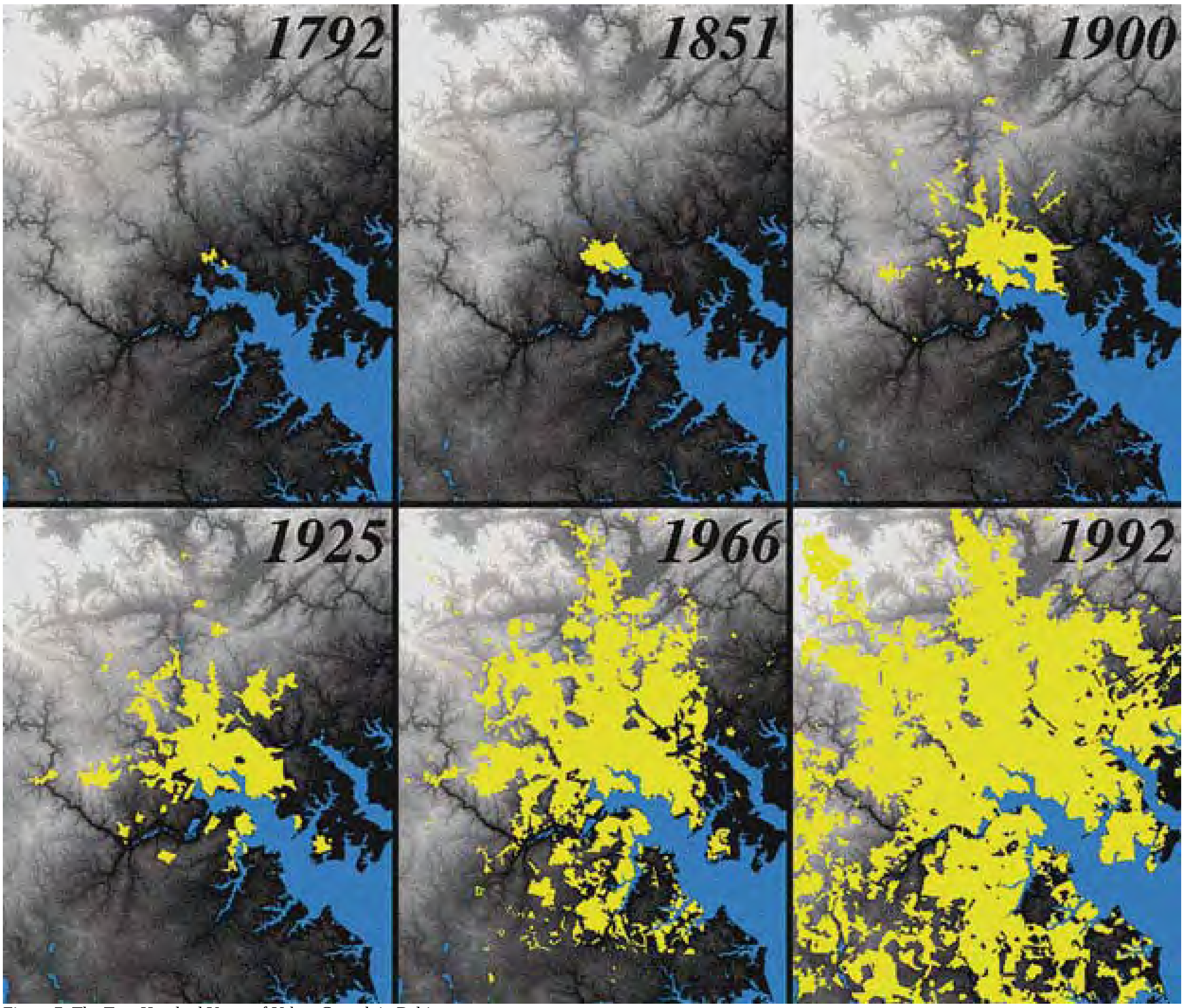


Figure 7: The Two Hundred Years of Urban Growth in Baltimore

From http://landcover.usgs.gov/LCI/urban/umap/pubs/asprs_wma.php

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The obvious question is how far can we get with the diffusion-limited aggregation model of the last section in generating simulations of real structures that we see in the transport development of London in Figure 6 and urban development of Baltimore in Figure 7? This kind of model is of course a demonstration of how two principles or forces interact to produce a structure that resembles certain features of the modern city. It is not intended as anything other than a graphic way of impressing the notion that bottom up uncoordinated change leads to highly ordered structures – fractals – which emerge from this comparatively simple process. One can begin to illustrate how one might make this more realistic but it is a far cry from the kinds of operational models that are used routinely for strategic planning by government and other agencies. The model is made more realistic simply by planting it into a space or terrain that has real features. In Figure 8, we show four different simulations of development in the town of Cardiff, Wales which takes the coastline and rivers which define that area. We set two seeds, one at the historic centre and one at the dockside and let the DLA model operate in the manner we have shown in Figure 5. From this, we realise quite quickly that the river cutting the town in two makes a difference to the rate of growth in parts of the town while the fact that Cardiff has two centres shows how difficult it is to generate a pattern that gives the right historical balance to each. This is not surprising because none of the factors that affected this competition between the two centres is contained in the model. A more detailed discussion of the simulation is presented in our book Fractal Cities (Batty and Longley, 1994). The model however can only simulate patterns that are a consequence of its assumptions. Yet these kinds of simulation also provide a means of demonstrating and testing various future hypotheses about urban form. By way of providing some sense of closure to this essay, we will show how such models can be used to help to generate effective designs.

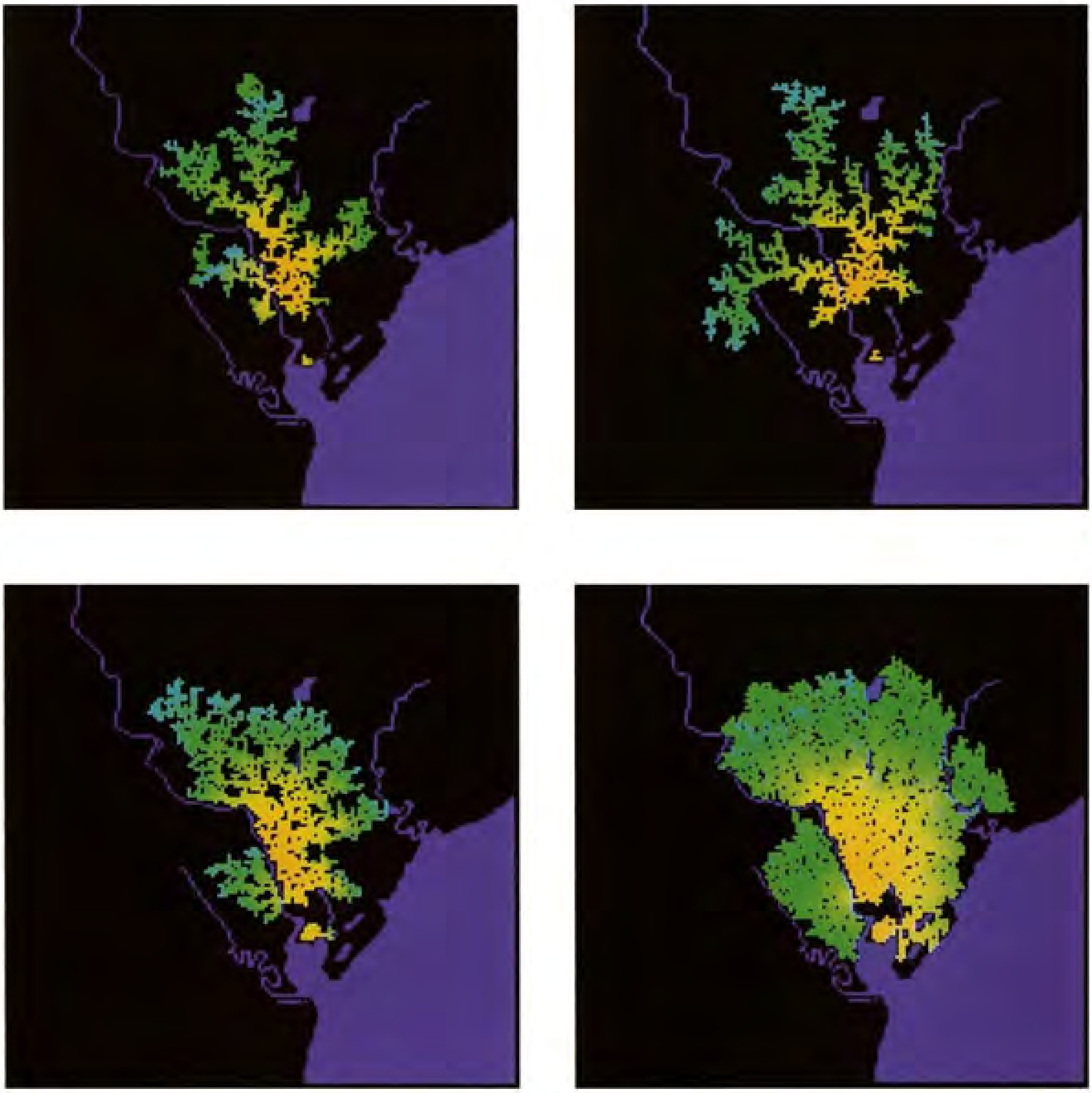

Figure 8: Simulating Growth Using DLA in the Spatial Landscape
Centred on the City of Cardiff

The control over the development is tuned to decrease systematically through the simulations from the top left to bottom left in clockwise order

5 Generating Idealised Cities

We need a greater degree of control over our simulation process than that provided by the diffusion-limited aggregation model or its variants. In fact the way we generated the previous clusters is using a generative algebra that lies at the basis of many pattern-making procedures called automata. An automata is usually defined rather generally as a finite state machine driven by inputs which switch the states of the machine – the outputs – to different values. The outputs from the machine may then be used as inputs to drive the process of state transition through time and this generative process can be tuned to replicate the sorts of patterns that we have been discussing in this essay. For example, the input to the DLA model is an individual who moves in a cell space and if certain conditions in the space occur, the individual changes the state of the cell from undeveloped to developed. This is of course is done in parallel for many individuals. The idea that the space might be characterised as a set of cells simply gives some geometric structure to the problem and although we have taken for granted the fact that cities are represented in this way in these simulations, for automata in general, and spatial automata in particular, they can be any shape and in any dimension.

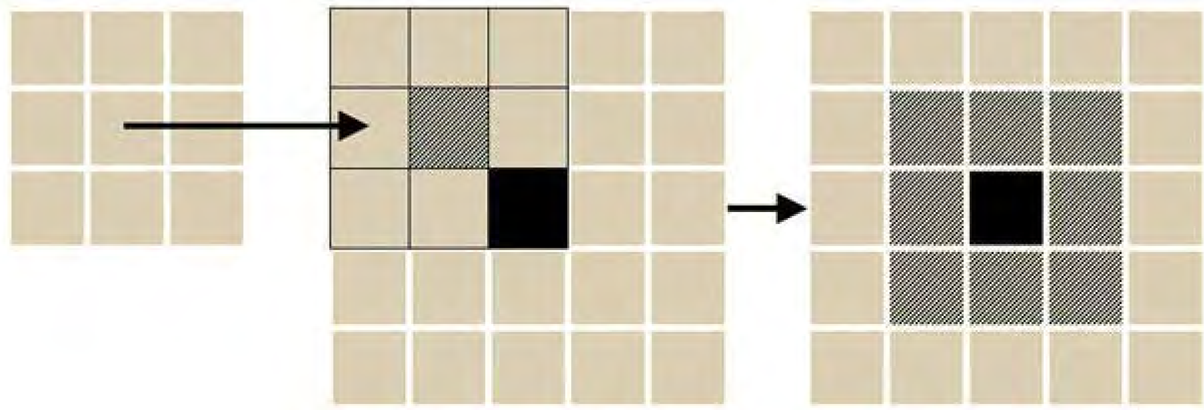

Figure 9: How Cells are Developed

a) left: an 8 cell neighbourhood around a central cell in question is applied to b) middle: each cell in a lattice. If one or more cells in the lattice is of a particular state, in this case developed (black), the state cell in question in the neighbourhood (black hatch) changes to developed. If this rule based on one of more cells in the neighbourhood is applied to every cell in the lattice, the result is c) right: the set of cells around the central cell (black) become developed (black hatch).

The automata we use here to generate physical development are called cellular automata (CA) where we assume a regular lattice of (square) cells in which development takes place by changing the state of each cell from undeveloped to developed as long as certain rules apply. The elements of CA are thus: a set of cells which can take on one of several states, in this case developed or undeveloped, extendable to different kinds of development; a neighbourhood of 8 cells in the N-S-E-W-NE-SE-SW-NW positions around each cell in question; and a set of transition rules that define how any cell should change its state dependent upon the configuration and state and possibly attributes of cells that exist within the neighbourhood of the cell in question. Now if we apply this model starting with the initial condition of one cell in the centre of the lattice being switched on – developed – and apply the rule that if there is exists one or more cells in the neighbourhood of any cell, this will generate a diffusion around the initial cell which mirrors the process of successive spreading of the phenomena, just as a physical substance with some motion might diffuse. The diffusion is square because the underlying lattice is square but we can easily develop versions where the diffusion is circular if we so configure the lattice. We show this diffusion and the rules of engagement in Figure 9. If we then modify the rules by noting that the number of cells in the neighbourhood of an undeveloped cell must be only one, then we generate the diffusion in Figure 10(a) and if there are one or two, then the simulation generates Figure 10(b). There are literally millions of possibilities and the trick is of course to define the correct or appropriate set of rules. Wolfram (2002), in his book A New Kind of Science, argues that such automata represent the fundamental units on which our universe is constructed. Although we have more modest ambitions here, this kind of automata can be tuned to replicate many different generative phenomena which characterise many different forms of city.

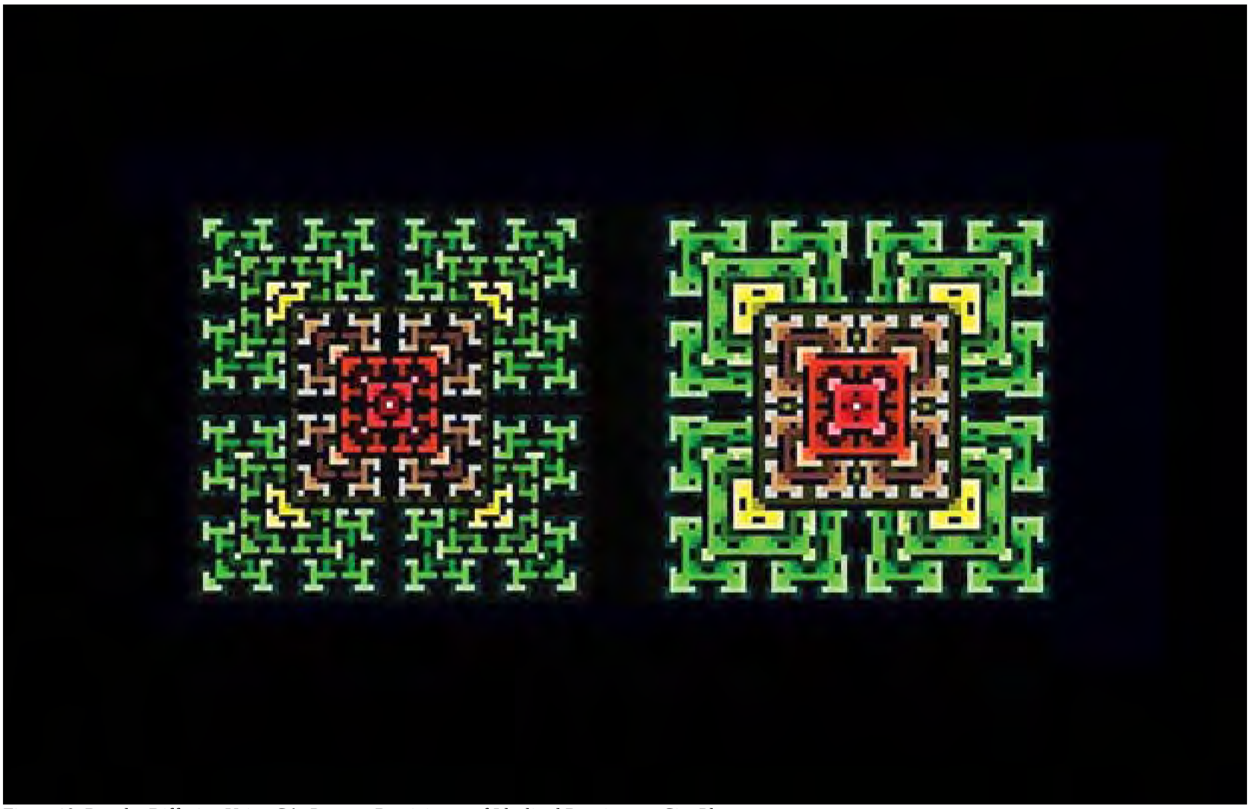

Figure 10: Regular Diffusion Using CA: Patterns Reminiscent of Idealised Renaissance City Plans

a) left: with only one cell in the neighbourhood b) right: with one or two cells developed

To generate ideal cities using such automata, it is necessary to begin with a set of realistic rules for transition. Ideal cities are often designed to meet some overriding objective function, to minimise density as in Frank Lloyd Wright's BroadAcre city, to maximise density as in Le Corbusier's City Radieuse, to generate formal vistas and garden squares as in Regency London, to generate medium density new towns with segregated land uses as in the first generation of British New Towns, and so on. A rather good example which can be generated using cellular automata principles is the plan for Georgian colony of Savannah in the New World. Developed in 1733 by General James Oglethorpe, we show the plan in Figure 11; the CA rules might be imagined in analogy to the way we generate development in Figures 9 and 10.

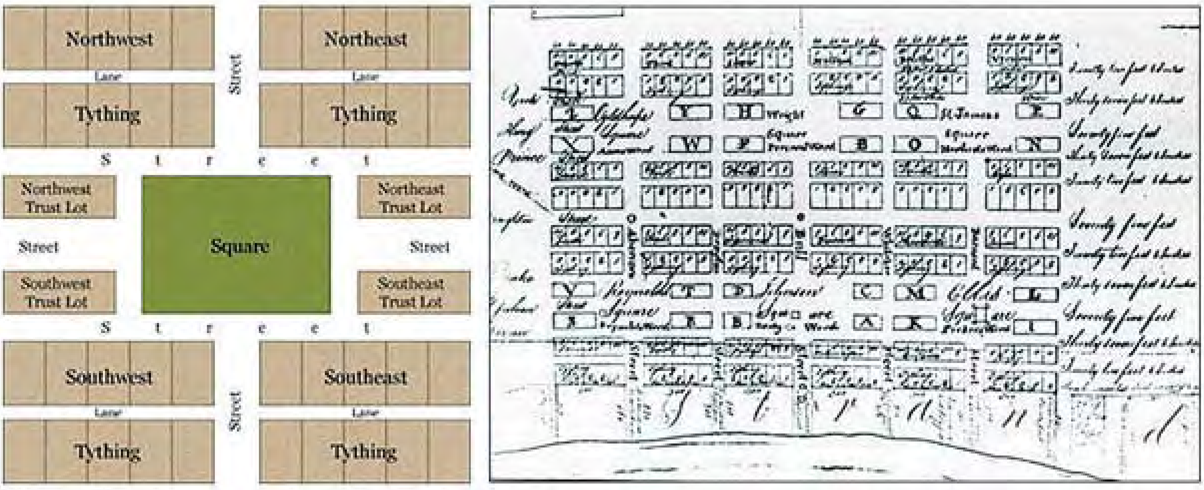

Figure 11: The Colonial Plan for Savannah Georgia

a) left: the original neighbourhood plan b) right: the plan in 1770
From http://en.wikipedia.org/wiki/Squares_of_Savannah,_Georgia

Usually plans for ideal cities are not grown using a generative logic because plans are conceived of all-in-one-piece so-to-speak and the notion of an uncertain future is never in the frame. However CA allows us to generate plans that evolve through time and we can continually change the rules so that the idealisation is a shifting vision. In a sense, the plans which are grown in Figures 9 and 10 have stable rules which may or may not be considered as ideal objectives to be attained. To conclude our demonstration of this kind of logic and the intrinsic complexity of cities in that their ideal form is never certain, we will return to the DLA model and tweak the rules a little so that a system-wide objective might be met. Imagine that the agents in our model move randomly in the manner we described earlier, that is to all points of the compass; this can be simulated using CA by assuming that where the state of the cell is an agent, then the cell changes state according to the movement. If an agent is at cell i, j, and it moves to cell i+1, j in the next time period, then the cell state switches accordingly, from the cell where the agent is located to the cell where it is newly located. Our first rule then is simply cell state switching from the place where the agent was located to its new location. But we also have a rule that says that if the agent is located at cell i, j and there is another agent fixed at a cell in the neighbourhood of i, j, then the agent remains fixed and the cell on which it sites changes to the stable state. Note in this version of the CA, the cells contain mobile or fixed (stable) agents or have no agents within them at all. The cells have three possible states which are appropriately coded but this is still a CA with two sets of rules.

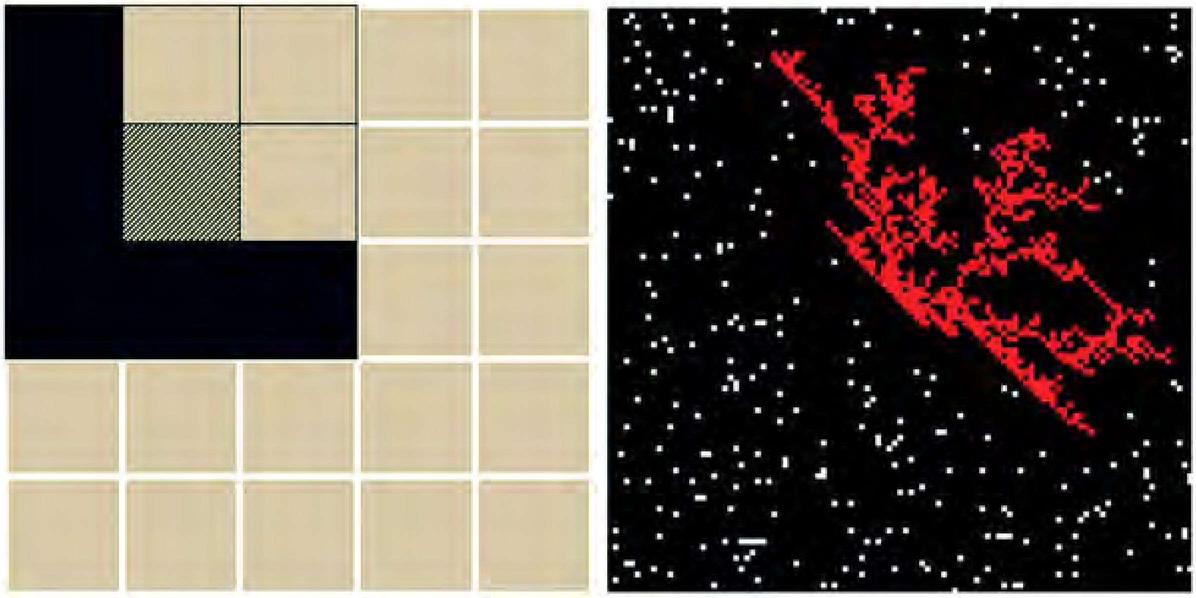

Figure 12: Optimising Growth by DLA: New Development on Leeward Side of Existing Development

a) left: if cells in black on the windward side are developed, the central neighbourhood cell is developed b) right: a typical outcome of the generative process

Now imagine that there is a strong wind blowing from south west to north east and therefore any agent which is on the windward side of an occupied cell will not fix themselves there. So whenever an agent comes within contact of an agent already fixed on its leeward side, it continues to be mobile. Thus the development moves continually away from the point where the first agent locates and what happens is that a line of cells is established across the space. In fact it is quite hard to guess what happens and it is necessary to run the simulation to see what the ultimate form the model might be. We show this in Figure 12 which is the picture of the city formed when the two principles of contact to the existing agglomeration and the need for as much space as possible are linked to the general objective of locating on the leeward side of already existing development. CA shows how this objective might be met.

6 Next Steps

There is much still to say about how cities are formed and evolve, how we might best understand and then simulate them, and most importantly, how we should design plans which enable them to function in more efficient and equitable ways. This essay has broached the idea that cities evolve into an unknowable future that is always uncertain. Therefore any goals that we might have for the future city are contingent on the present, hence continually subject to revision and compromise. In the past, cities have been designed in a timeless future where sets of objectives have been defined to be achievable as if the city were cast in timeless web, and it is of little surprise that few cities have ever achieved the aspirations set out in their plans. Complexity theory broaches the problem of the unknowable future and the way cities evolve from the bottom up, incrementally as the products of decisions that might be optimal at any one time but always subject to changing circumstances. This would appear to be a far more fruitful and realistic way of generating cities that meet certain goals with the goals continually under review as the city emerges from the product of decisions which might be optimal in the small but whose global effects are unknowable in the large, until they emerge.

There are ways in which the processes that we have introduced here might be steered in more centralised ways and it is the challenge of thinking in these terms that the complexity sciences are attempting to grasp: how control and management, planning and design which traditionally have been configured and treated from the top down might best be meshed with systems that grow and evolve from the bottom up. The answers probably lie in notions about hierarchy and the extent to which we might intervene and manage processes that generate hierarchies organically from the bottom up (Batty, 2006). As we learn more about how cities evolve in these ways, it is my contention that we will learn to plan less as we identify points of pressure and leverage. There, effective intervention and design in small, incremental ways might lead to large and effective changes that go with the flow, and do not fight against the grain. Such planning through incremental evolution has not been the history of most city plans hitherto but our science is evolving to meet this challenge.

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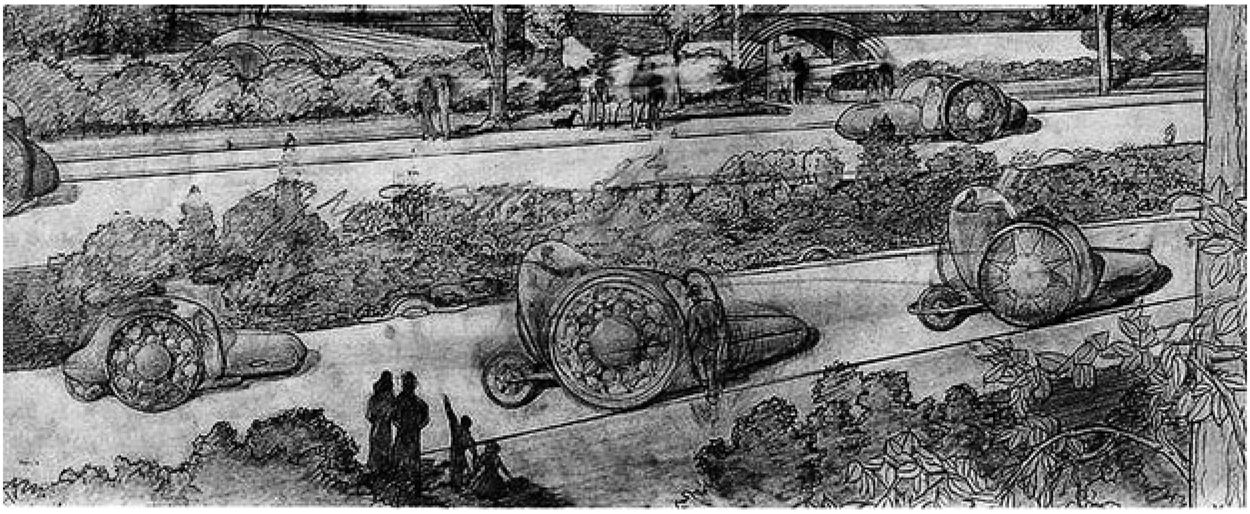
Creare la Città dal Basso in Alto:

Uso della Teoria della Complessità per un Design Efficace

Michael Batty



1 Un Nuovo Paradigma per la Pianificazione della Città

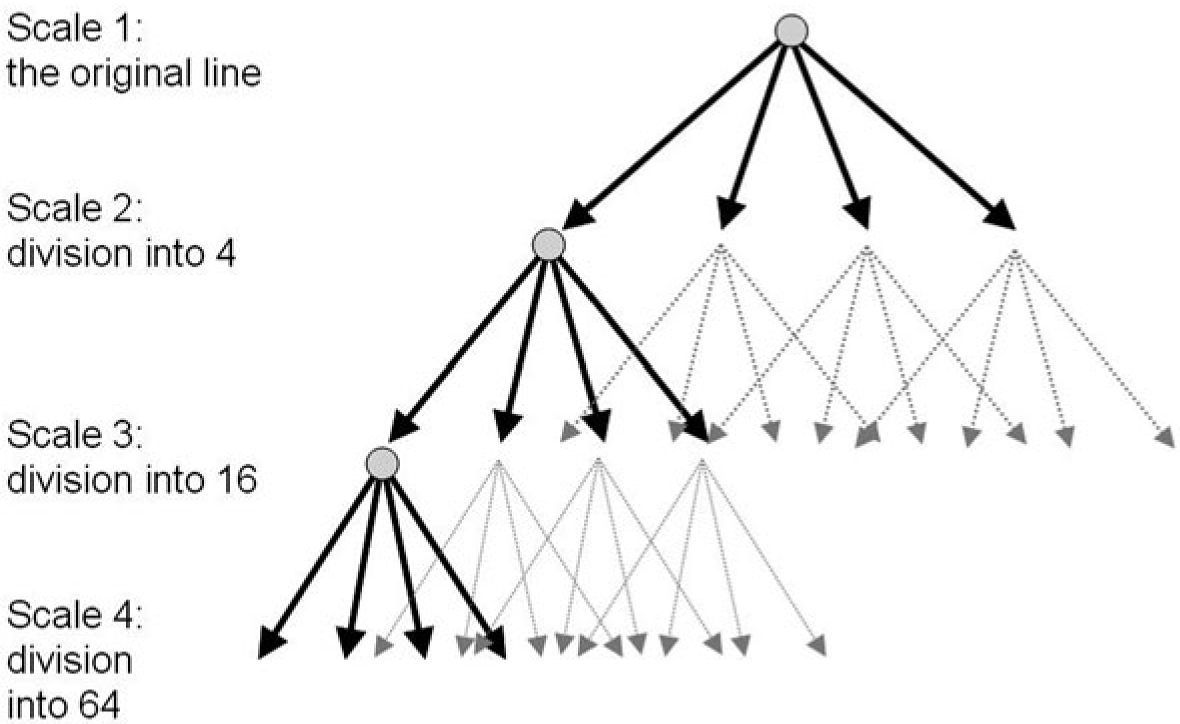
Le città crescono e si sviluppano dal basso verso l'alto. Sono la risultante di milioni di decisioni singole, in diversi ambiti spaziali, in molteplici intervalli temporali e che influiscono su ogni aspetto della città, su com'è strutturata e come si evolve. È impossibile immaginare una qualsiasi organizzazione che possa essere in grado di controllare tale organizzazione. Nei secoli sono stati generalmente proposti progetti dall'alto verso il basso ma esistono ben pochi esempi in cui il controllo sia stato sufficientemente rigoroso, al punto da consentire la loro completa attuazione. Nelle città, gran parte dello sviluppo avviene senza pianificazione e tuttavia le città continuano a funzionare, spesso in modo abbastanza efficace e, soprattutto, senza alcun controllo dall'alto. Le città, come parte di società ed economie, non solo stanno insieme, ma arrivano addirittura a coordinarsi automaticamente, come se fossero gestite, come teorizzava Adam Smith nella sue analisi economiche, da una "mano invisibile".

Cinquanta anni fa, le città erano ritenute sistemi il cui funzionamento era basato su sottosistemi che interagivano fra loro e la cui forma si manifestava attraverso una gerarchia relativamente coordinata; i sistemi erano immaginati come diretti da una sorta di controllo centrale. Man mano che il paradigma si è andato ampliando, c'è stato un sottile mutamento, arrivando al principio che l'ordine di molti sistemi emerge dal modo in cui le parti interagiscono dal basso. La scienza della complessità si è sviluppata dando una nuova veste a tale paradigma sistemico, con un conseguente cambiamento di obiettivi e spostando l'analogia da "città come macchine" a "biologie in evoluzione" la cui forma era la risultante di sottili e costanti cambiamenti nella loro composizione genetica al livello delle componenti più basilari..

É necessario un nuovo paradigma che tenga conto di come le città sono state costruite e che sia, tendenzialmente, dal basso verso alto. Questo paradigma, secondo noi, si basa sui recenti sviluppi nella teoria della complessità che, in termini di pianificazione della città, è fondata sulle tradizioni suggerite da Patrick Geddes, prima, da Christopher Alexander (1964) e Jane Jacobs (1962), poi. Il tema centrale è che pianifichiamo "a nostro rischio e pericolo" e che piccoli interventi effettuati in modo puntuale ed opportuno, in piena armonia con il contesto locale, hanno maggiori probabilità di buon esito rispetto ai progetti calati dall'alto, caratteristica della pianificazione urbanistica del XX secolo. Le città si sviluppano riempiendo lo spazio a loro disposizione in vari modi, con densità differenti e utilizzando schemi diversi, consentendo alle loro parti di funzionare.

2 Modularità, Gerarchia ed Autosomiglianza

La costruzione modulare non è solo un processo funzionale atto a garantire che le componenti di un sistema vengano messe insieme in un modo efficiente e sostenibile, bensì un mezzo per far funzionare processi in grado di gestire il sistema efficacemente. Ad esempio, le varie funzioni economiche di una città dipendono da una massa critica di popolazione al punto che, più è specializzata la funzione, maggiore è la quantità di popolazione necessaria per sostenerla. Le funzioni maggiormente specializzate dipendono talmente da economie di scala che le dimensioni e le distanze fra varie funzioni producono una schematizzazione regolare a livelli gerarchici diversi. Questo porta ad una replica di moduli uguali ma di estensione diversa a seconda della rispettiva scala. Siamo in grado di dimostrare il quanto appena affermato utilizzando qualche semplice nozione di geometria, così da illustrare come possiamo produrre un modulo fisico, dando luogo ad un frattale che risulta simile a qualunque scala.
Il processo può essere visto come una gerarchia, chiaramente presente nello schema stesso, ma che, in termini di processo ricorsivo, è visibile diagramma ad albero (Figura 2).



Scala 1: la linea originale
Scala 2: suddivisione per 4

Scala 3: suddivisione per 16
Scala 4: suddivisione per 64

Figura 2: La Gerarchia della Composizione nella Costruzione di un Frattale

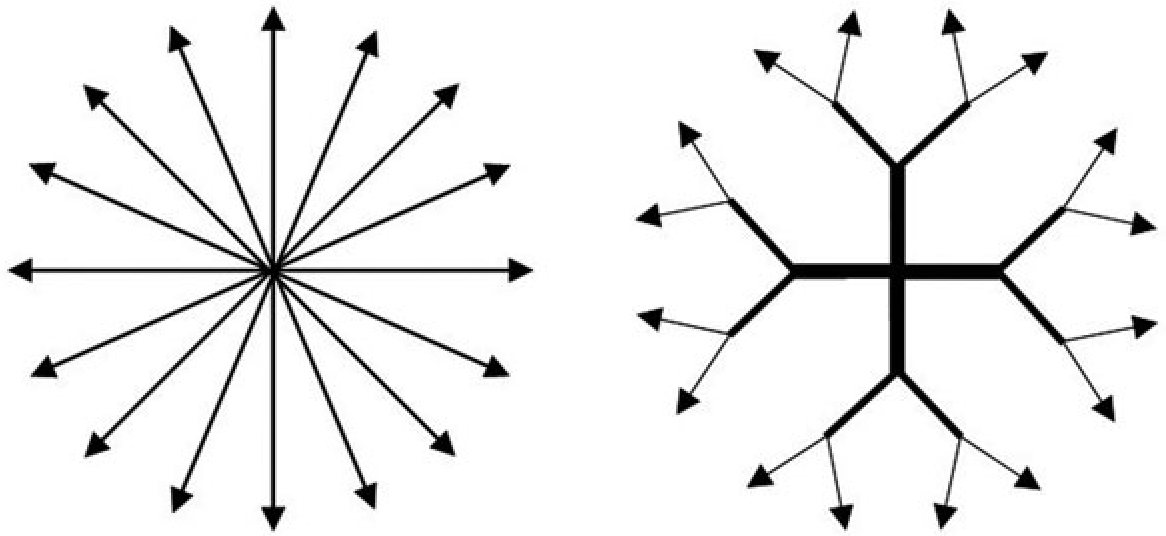


Figura 3: Gerarchie Precise: Trasporto da una Sorgente Centrale

a) a sinistra: ogni collegamento è separato
b) a destra: disposizione dei collegamenti in una struttura maggiormente efficiente

Esiste una morfologia precisa, frattale: è la forma di una serie di oggetti collegati fra loro a formare un albero, o un dendrite. Se si vuole trasportare energia da una sorgente centrale a punti posti ad una certa distanza, risulta maggiormente efficiente sviluppare un'infrastruttura in grado di catturare la massima capacità di trasferimento e che sia il più vicino possibile alla sorgente. Disponiamo, ad esempio, 16 punti intorno ad un cerchio ed ipotizziamo 2 schemi di connessione tra la sorgente e i 16 punti. Il primo con collegamenti diretti -Figura 3(a)-, il secondo con collegamenti raggruppat -Figura 3(b)-. Nel primo, ipotizzando che ogni singolo collegamento corrisponda ad una distanza di 1 unità, la lunghezza complessiva dei percorsi necessari per servire tali postazioni è quindi pari a 16. Nel secondo, dove i collegamenti sono stati raggruppati, è dimostrato che la distanza complessiva dei è un numero che sta tra la metà e i tre quarti della forma originale. Questo dimostra che lo spazio deve essere riempito in modo efficiente. Le strutture della Figura 3 sono frattali e nella Figura 3(b) l'autosomiglianza è palese mentre e una gerarchia precisa viene protesa nello spazio.

Esistono molti esempi di tale struttura gerarchica in forme osservabili sia in natura sia in sistemi artificiali. L'energia, sotto forma di sangue, ossigeno e impulsi elettrici, viene trasmessa al corpo attraverso reti dendritiche fatte di arterie e vene, polmoni e nervi (Figura 4(a)) e le piante si estendono verso l'alto, per ricevere ossigeno dall'aria, e verso il basso, per trarre altre sostanze nutritive dal terreno (Figura 4(b)). Allo stesso modo nella Figura 4(c) è illustrata la rete stradale di Wolverhampton, UK (circa 300.000 abitanti nel 2001): il sistema stradale tradizionale è cresciuto organicamente dal basso, ma l'anello intorno al centro della città è stato, invece, pianificato ed imposto dall'alto. Ciò che osserviamo, quindi, è una miscela di diversi processi decisionali.
Nella Figura 4(d) è illustrata una delle isole a forma di Palma al largo della costa di Dubai. Si tratta di un esempio straordinario di come sia necessario preservare le risorse quando si costruisce in un ambiente ostile.

Le città si sviluppano dal basso verso alto in modo incrementale e dove sono pianificate dall'alto, il progetto risulta essere piccola parte di uno sviluppo organico più ampio. Quando, in un qualsiasi momento della loro storia, le città crescono, ci sono poche idee su quel che ci si potrà aspettare a livello di nuovi comportamenti, valori, tecnologie e norme sociali, pertanto non è affatto sorprendente che le città crescano "ad hoc", rispecchiando l'efficienza e l'equità che predominano nel consenso unanime al momento in cui ha luogo lo sviluppo. Per illustrare come sia possibile modellare questo processo, possiamo cercare di riassumerlo in due forze principali che incarnano sia il desiderio di spazio da parte di ogni singolo individuo, sviluppatore di progetti o consumatore, sia il desiderio di vivere il più vicino possibile alla 'città' composta di altri individui. Si tratta di un modello semplice, una simulazione ipotetica, in grado di raggruppare tutto quanto fino ad ora esposto.

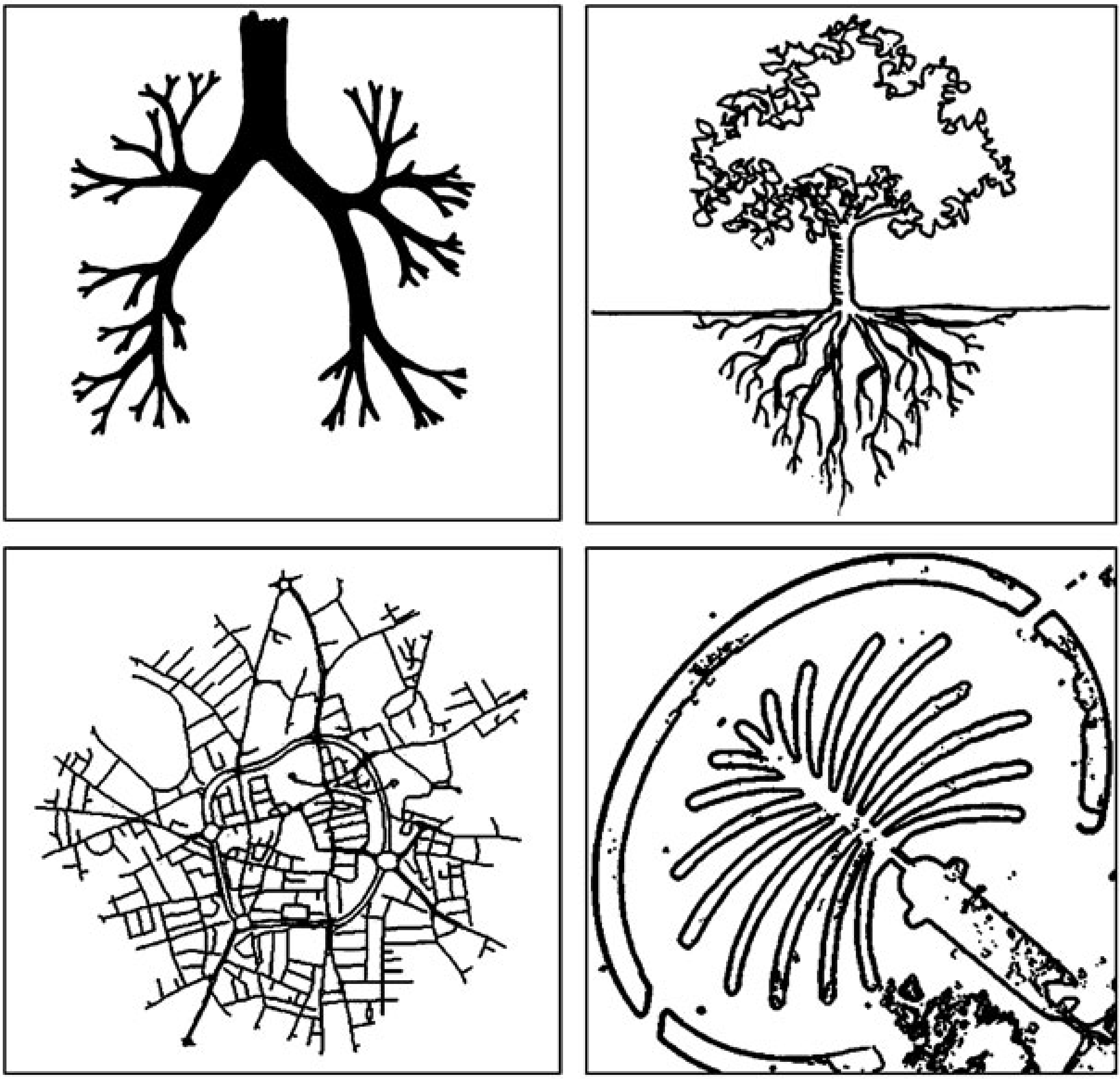
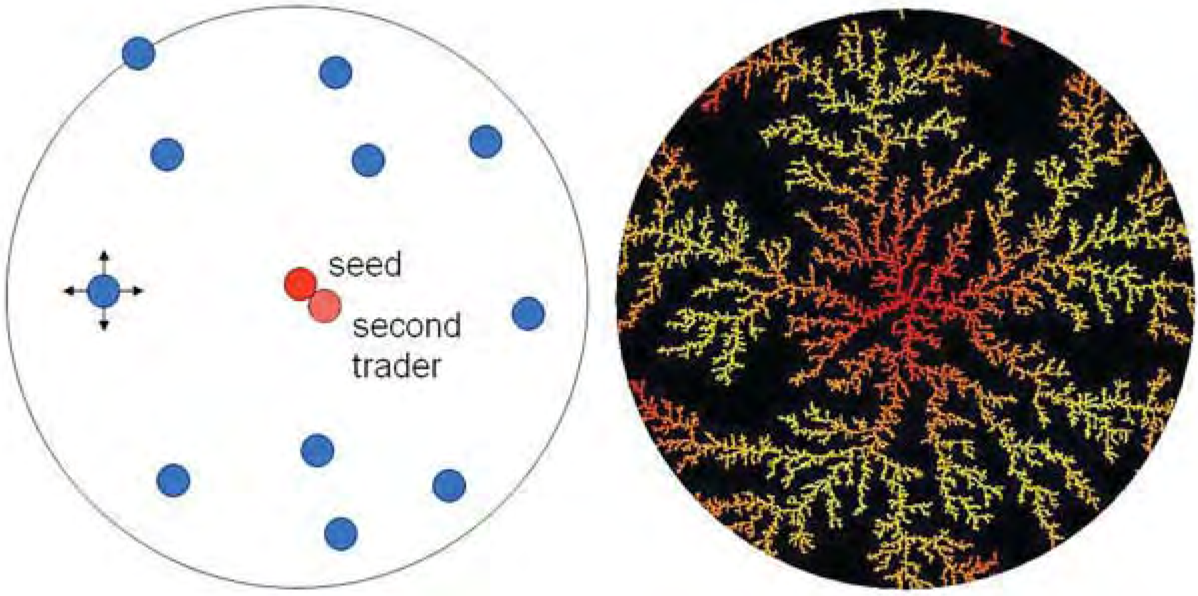


Figura 4: Gerarchie di Riempimento dello Spazio

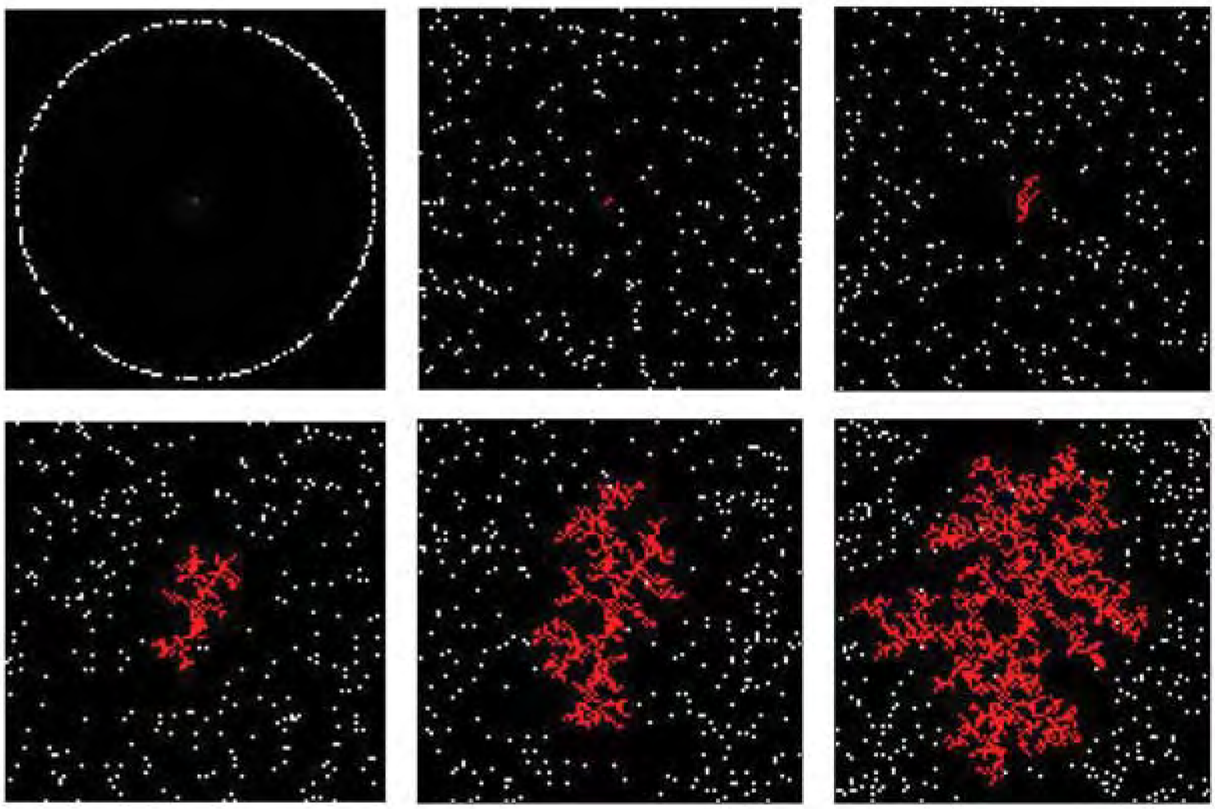
a) in alto a sinistra: schematizzazione di un polmone umano; b) in alto a destra: schematizzazione di un albero che cresce in ambienti diversi: nell'aria e nel terreno sottostante; c) in basso a sinistra: la rete stradale di una cittadina inglese di medie dimensioni: Wolverhampton; d) in basso a destra: riempimento dello spazio in un ambiente difficile: Isola a Forma di Palma a Dubai, realizzata da Nakheel.

Nella Figura 5(a) è illustrata una schematizzazione base del processo di localizzazione. Liberamente in movimento, una serie di individui si dispone quasi secondo un cerchio ma, dopo l'insediamento di un primo operatore, (operatore originario o "seed"), gli individui che vogliono insediarsi in seconda istanza (puntini blu sul grafico) iniziano a muoversi alla ricerca della loro ubicazione, seguendo un percorso casuale. Decidono ad ogni passo decidono, in modo casuale, attraversando il "piano di localizzazione". Se si spostano verso una cellula adiacente al puntino rosso fisso, s'insediano: si fermano e diventano rossi (secondo trader). Ora sono stabili.
Potete vedere la forma finale e, di conseguenza, sapere quale sarà il risultato definitivo; se, però, non aveste seguito il processo e visto il risultato, avreste potuto pensare che il risultato fosse una massa crescente in modo compatto.

a) c)



b)



Germe iniziale
Secondo operatore

Figura 5: Generazione di Crescita Agglomerata di una Città tramite Aggregazione a Diffusione Limitata

Nella Figura 5(b) illustriamo una progressione e ciò che accade è che, non appena un operatore s’insedia a fianco al puntino rosso esistente, la conformazione muta. Man mano che passa il tempo, lo schema a bordo lineare, caratteristico della punta di crescita della massa iniziale, inizia ad enfatizzarsi e ad un operatore risulta sempre più impossibile penetrare nelle fessure della massa in crescita. Gli operatori si ritrovano, così, ai bordi della massa e, in questo modo, tale massa inizia ad espandersi nello spazio. Se ciò dovesse produrre una massa crescente compatta, dovrebbe avere dimensioni prossime a 2, ma in realtà ha dimensioni frattali di circa 1,7, come stabilito da studi empirici. Anche questa, proprio come qualunque struttura dendritica, è un frattale ed è facile vedere l’autosomiglianza che è insita nella sua forma. Distaccatene una diramazione e potrete vedere, all’interno del segmento staccato, l’intera struttura come. Man mano che andiamo ad aumentare la risoluzione della griglia o del reticolo su cui avviene tale cammino, otteniamo strutture ad albero sempre più fini, in cui la struttura a frattali è assolutamente evidente -Figura 5(c).

Questa forma è generata da un processo denominato “aggregazione a diffusione limitata (DLA)” che è stato riscontrato ed ampiamente utilizzato in diversi ambiti della fisica.

3 Città del Mondo Reale e Schemi di Complessità

Esistono molti esempi, a diverse scale, del modo in cui le città sono strutturate intorno a linee dendritiche che rispecchiano le linee di energia, funzionali alle loro parti più distanti. Ma le città non sono dendriti puri: ci sono reti diverse, sovrapposte l’una sull’altra, espressione di modi con cui le persone operano e comunicano. Nella Figura 6 si vede una mappa del centro di Londra, in cui le strade sono colorate in funzione dell’energia che trasportano, utilizzando con approssimazione i volumi di traffico stradale.

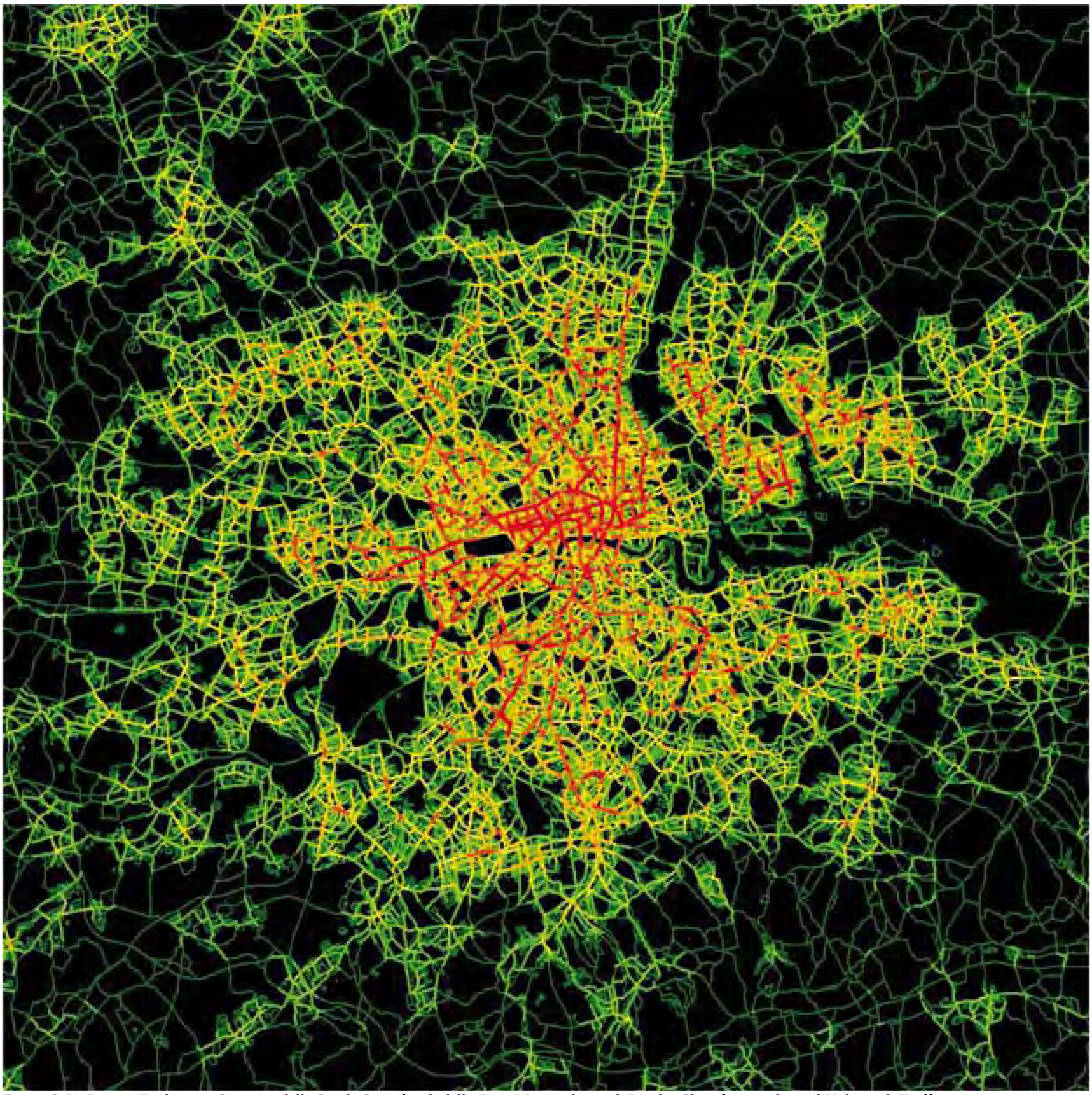


Figura 6: La Rete in Evoluzione Organica delle Strade Superficiali della Zona Metropolitana di Londra Classificata in base al Volume di Traffico

Le reti stradali sono esempi eccellenti di come le città crescono dal basso in alto, poiché rappresentano lo scheletro su cui si agganciano tutte le altre strutture. Come possiamo osservare, i trasporti ed il territorio sono strettamente correlati.

4 Generazione di Città Idealizzate

Abbiamo bisogno di un maggior grado di controllo sul nostro processo di simulazione rispetto a quello fornito dal modello d’aggregazione a diffusione limitata o dalle sue varianti. In effetti, il modo in cui abbiamo generato le masse precedenti fa uso di un elemento algebrico, denominato “automa”, che sta alla base di molte procedure di definizione di schemi. Un automa, di solito, viene definito in modo abbastanza generico come una macchina a controllo limitato attivata da immissioni che commutano gli stati della macchina – le emissioni – su valori diversi. Le emissioni provenienti dalla macchina possono poi essere utilizzate come immissioni per attivare il processo di transizione fra i vari stati nel corso del tempo e questo processo generativo può essere messo a punto in modo da replicare i tipi di schemi su cui abbiamo discusso nel presente saggio. Ad esempio, l'immissione nel modello DLA consiste in un individuo che si muove in uno spazio fatto di cellule e, qualora si verifichino determinate condizioni nello spazio, l'individuo cambia lo stato della cellula da non sviluppata a sviluppata. Ovviamente, ciò viene fatto in parallelo da molti individui. L'idea che lo spazio possa essere rappresentato come un gruppo di cellule, conferisce semplicemente una determinata struttura geometrica al problema e, malgrado abbiamo dato per scontato il fatto che le città siano rappresentate in questo modo, per quanto riguarda gli automi in generale, e gli automi spaziali in particolare, essi possono assumere qualunque forma ed essere di qualsiasi dimensione.

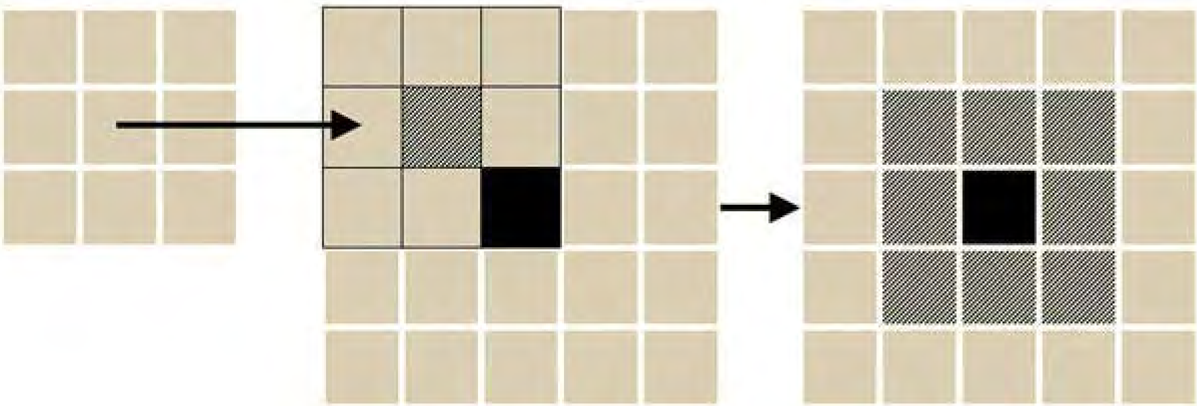


Figura 9: Modalità di Sviluppo delle Cellulea) a sinistra: un contorno di 8 cellule disposte intorno alla cellula centrale in questione viene applicato a b) al centro: ogni cellula in un reticolo. Se una o più cellule nel reticolo si trova in uno stato particolare, in questo caso sviluppata (nero), lo stato della cellula in questione nel contorno (ombreggiata) cambia in sviluppata. Se questa regola, basata su una o più cellule nel contorno, viene applicata ad ogni cellula nel reticolo, il risultato è c) a destra: il gruppo di cellule intorno alla cellula centrale (nera) diventano sviluppate (ombreggiatura).

Gli automi utilizzati in questo caso per generare lo sviluppo fisico sono denominati "automi cellulari (CA)" e presuppongono la presenza di un reticolo regolare di cellule (quadrate) in cui lo sviluppo avviene, nel momento in cui risultano applicabili determinate regole, proprio cambiando lo stato di ogni singola cellula da non sviluppata a sviluppata.
Gli elementi dei CA sono quindi: un gruppo di cellule in grado di assumere uno stato fra vari stati diversi, in questo caso sviluppate o non sviluppate, estensibile a vari tipi di sviluppo; un contorno di 8 cellule che occupano le posizioni N-S-E-W-NE-SE-SW-NW intorno alla singola cellula in questione ed un gruppo di regole di transizione che definiscono come una qualsiasi cellula possa cambiare il proprio stato in funzione della configurazione, dello stato e degli eventuali attributi delle cellule esistenti nell'ambito del contorno della cellula in questione. Applichiamo ora questo modello partendo dalla condizione iniziale di una cellula accesa (sviluppata) al centro del reticolo. Applichiamo la regola che: se esistono una o più cellule intorno alla prima si genererà una diffusione intorno alla cellula iniziale dando vita al processo espansione del fenomeno, proprio come potrebbe diffondersi una sostanza fisica provvista di una qualche sorta di movimento.
La diffusione risultante sarà a quadrati, in quanto il reticolo a maglie quadrate, ma possiamo sviluppare facilmente versioni in cui la diffusione è circolare, semplicemente configurando in tal modo il reticolo.
Questa diffusione, e le sue regole basilari, sono illustrate nella Figura 9.
Se si modificano le regole di partenza dicendo, ad esempio, che, intorno ad una cellula non sviluppata, ce ne deve essere solo un'altra cellula, allora si ottiene il tipo di diffusione illustrata nella Figura 10(a). Se, invece, il numero di cellule intorno sia pari ad una o due, allora la simulazione genera quanto illustrato nella Figura 10(b). Esistono letteralmente milioni di possibilità ed il trucco sta, ovviamente, nel definire il corretto od opportuno gruppo di regole. Wolfram (2002), nel suo libro Un Nuovo Tipo di Scienza, afferma che tali automi rappresentano le unità fondamentali su cui è costruito il nostro universo. Malgrado le nostre ambizioni in questo caso siano ben più modeste, questo genere di automi possono essere adattati per replicare molti fenomeni generativi diversi che caratterizzano svariate forme diverse di città.

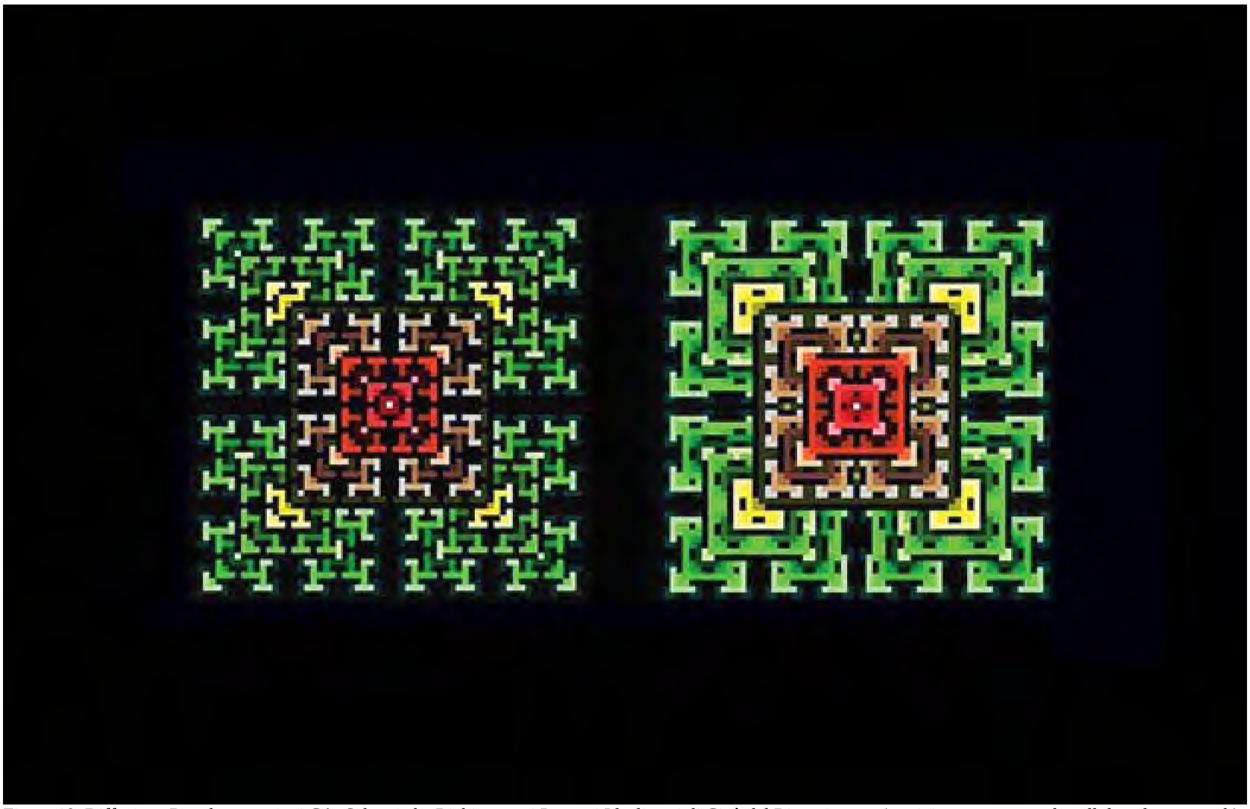


Figura 10: Diffusione Regolare tramite i CA: Schemi che Richiamano i Progetti Idealizzati di Città del Rinascimentoa) a sinistra: con una sola cellula nel contorno b) a destra: con una o due cellule sviluppate

Per generare città ideali utilizzando i suddetti automi, è necessario iniziare con un gruppo di regole realistiche. Le città ideali vengono spesso progettate per soddisfare alcune funzioni oggettive prevalenti: per ridurre al minimo la densità, come nella BroadAcre City di Frank Lloyd Wright, per aumentare al massimo la densità come nella Ville Radieuse di Le Corbusier, per generare prospettive formali e piazze-giardino, come a Regency a Londra, per generare nuove città a media densità con un uso segregato del territorio, come nella prima generazione delle Nuove Città Britanniche, e così via. Un esempio piuttosto valido che può essere generato utilizzando i principi degli automi cellulari è il progetto per la colonia Georgiana di Savannah nel Nuovo Mondo, sviluppato nel 1733 dal Generale James Oglethorpe e illustrato nella Figura 11; le regole dei CA potrebbero essere immaginate analogamente al modo in cui abbiamo generato lo sviluppo nelle Figure 9 e 10.

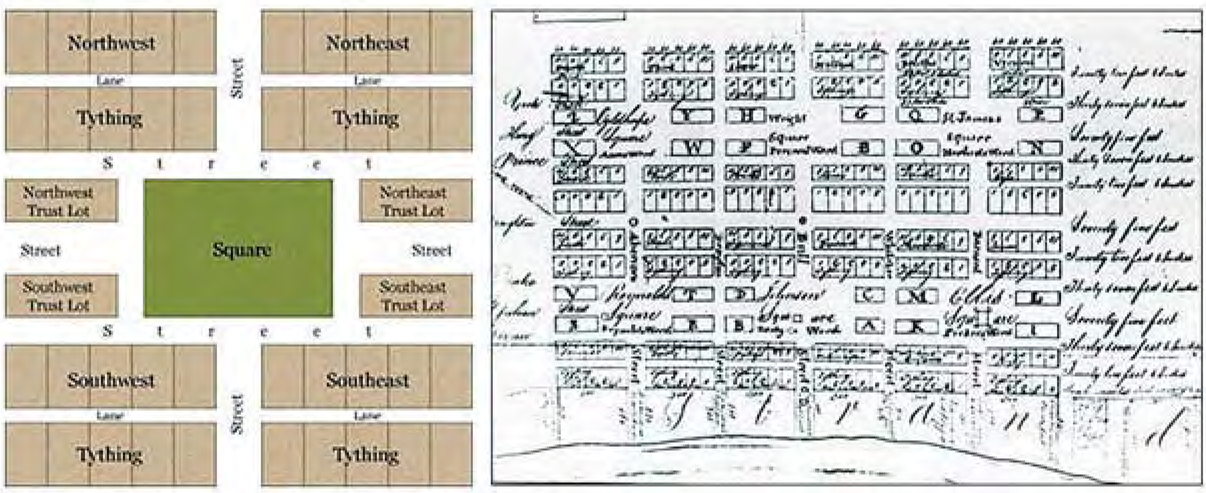


Figura 11: Il Progetto Coloniale per Savannah, in Georgiaa) a sinistra: il progetto originario dei dintorni b) a destra: il progetto nel 1770
Da http://en.wikipedia.org/wiki/Squares_of_Savannah,_Georgia

Di norma, i progetti per le città ideali non nascono utilizzando una logica generativa, in quanto concepiti, per modo di dire, in blocco unico e la nozione di futuro incerto non viene mai presa in considerazione. Tuttavia, i CA ci consentono di generare progetti che si evolvono nel tempo e possiamo cambiare costantemente le regole, al punto che l'idealizzazione diventa una visione mutevole. In un certo senso, i progetti che vengono creati nelle Figure 9 e 10 presentano regole stabili che possono essere ritenute, o meno, degli obiettivi ideali da raggiungere. Per concludere la nostra dimostrazione a supporto di questo tipo di logica e della complessità intrinseca delle città, così complessa che la loro forma ideale non è mai certa, andremo a riprendere il modello DLA, apportando lievi modifiche alle regole, affinché possa essere ottenuto un risultato vasto quanto un sistema. Immaginiamo che gli agenti del nostro modello si muovano in modo casuale, proprio come avevamo indicato in precedenza, ossia verso tutti i punti alla loro portata; ciò può essere simulato utilizzando i CA, presupponendo che, nel caso in cui lo stato della cellula sia un agente, allora la cellula cambia di stato in conformità con il movimento. Se un agente si trova nella cellula i, j e si sposta nella cellula i+1, j in un lasso di tempo successivo, allora lo stato della cellula si commuta di conseguenza: dalla cellula in cui si trovava l'agente alla cellula in cui si è appena insediato. La nostra prima regola, quindi, è semplicemente che lo stato della cellula passa dal luogo in cui l'agente si trovava, alla sua nuova posizione. Ma abbiamo anche una regola che dice che, se l'agente si trova nella cellula i, j e c'è un altro agente insediato in modo fisso in una cellula nei dintorni di i, j, allora l'agente rimane insediato in modo fisso e la cellula su cui si è insediato cambia il proprio stato diventando stabile. Va sottolineato che, in questa versione di CA, le cellule possono presentarsi unicamente in tre situazioni: o contengono agenti mobili, o contengono angenti fissi (stabili) oppure non contengono affatto agenti. Le cellule, quindi, presentano tre stati possibili opportunamente codificati, ma si tratta ancora di un CA con due gruppi di regole.

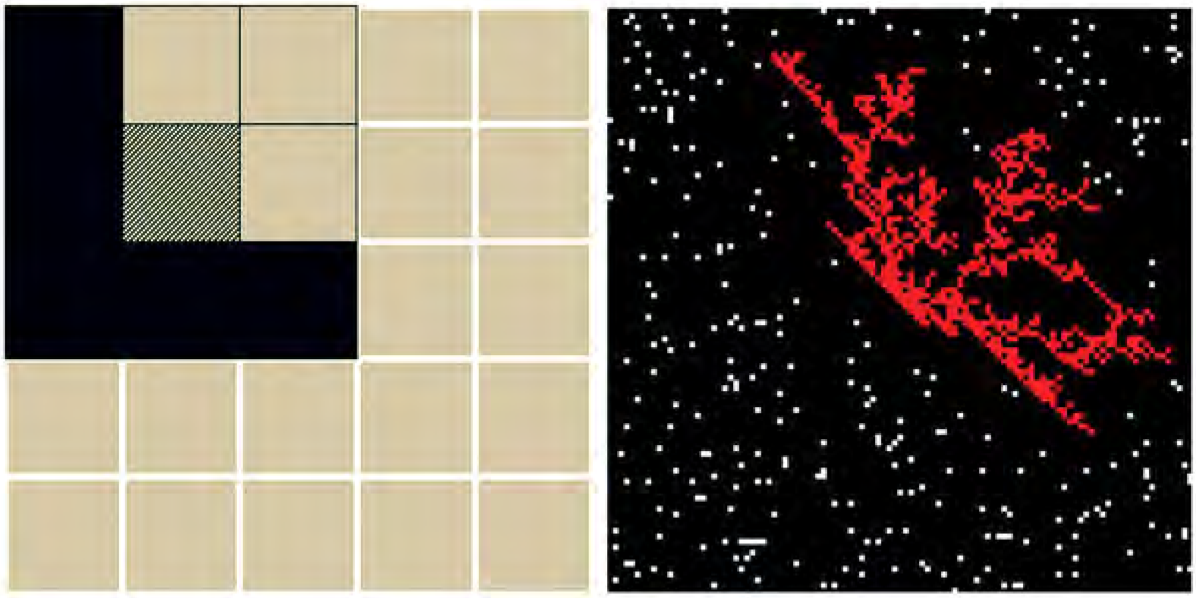


Figura 12: Ottimizzazione della Crescita tramite DLA: Nuovo Sviluppo, dal lato Sottovento, dello Sviluppo Esistentea) a sinistra: se le cellule in nero, situate sopravento, sono sviluppate, la cellula centrale del contorno risulta sviluppata b) a destra: risultato tipico del processo generativo

Immaginiamo ora che esista un forte vento che soffia da nord-ovest a sud-est: di conseguenza, ogni agente che si trova nella parte sopravento di una cellula occupata non si insedierà in quel luogo. Pertanto, ogni volta che un agente entra in contatto con un agente già insediato in modo fisso nel proprio lato sottovento, il suddetto continua ad essere mobile. Lo sviluppo, quindi, si sposta continuamente, allontanandosi sempre di più dal punto in cui si è insediato il primo agente. Ciò che avviene è che si crea una linea di cellule nello spazio. Nonostante tutto, però, è abbastanza difficile indovinare che cosa potrà accadere alla fine e risulta, pertanto, necessario portare avanti la simulazione fino alla ipotetica forma definitiva del modello. Ecco cosa accade nella Figura 12: la raffigurazione della città che viene a formarsi quando i due principi, di contatto con l'agglomerato esistente e la necessità di avere più spazio possibile, sono orientati verso l'obiettivo generale di insediarsi sul lato sottovento dello sviluppo già esistente. Il CA dimostra come tale obiettivo possa essere raggiunto.

6 Passaggi Successivi

Rimane ancora molto da dire in merito a come le città si formano e si evolvono, a come potremmo capirle meglio e farne una simulazione ed, ancora più importante, a come andrebbero concepiti i progetti per consentire loro di funzionare in modo più efficiente ed equo. Con questo saggio, si accenna all'idea che le città si evolvono verso un futuro ignoto e sempre incerto. Pertanto, qualunque obiettivo si possa avere per le città future dipende dal presente che è, quindi, costantemente soggetto a revisioni e compromessi. In passato, le città sono state progettate per un futuro senza tempo, in cui gruppi di obiettivi erano stati definiti raggiungibili, come se le città fossero sparse su una rete senza tempo. Per questo non sorprende il fatto che siano state ben poche le città in grado di raggiungere effettivamente le aspirazioni prestabilite dai loro progetti. La teoria della complessità intavola il problema del futuro ignoto e del modo in cui le città si evolvono dal basso, in modo incrementale, come frutto di decisioni che potrebbero essere ottimali in un determinato momento ma sempre soggette a circostanze mutevoli. Questo potrebbe sembrare un modo assai più vantaggioso e realistico per generare città che possano raggiungere determinati obiettivi, sottoponendo costantemente a revisione tali obiettivi man mano che la città emerge, come frutto di decisioni che potrebbero essere ottimali nel loro piccolo, ma i cui effetti globali sono ignoti su vasta scala, finché non emergono.

Esistono modalità attraverso cui i processi che abbiamo presentato potrebbero essere più focalizzati e la scienza della complessità sta cercando di cogliere la sfida data proprio dal pensare in questi termini: come possono controllo e gestione, pianificazione e design, che tradizionalmente sono stati configurati e trattati dall’alto verso il basso, essere intersecati, in modo ottimale, con sistemi che crescono e che si evolvono dal basso verso alto. Le risposte, probabilmente, sono insite nelle nozioni di gerarchia e nella misura in cui dovremmo intervenire e gestire i processi che generano le gerarchie, organicamente, dal basso verso alto (Batty, 2006). Man mano che apprendiamo di più su come le città si evolvono secondo le suddette modalità, è mia opinione che impareremo anche a pianificare meno, identificando i punti di pressione e di influenza. In questo caso, interventi e progetti efficaci, realizzati a piccoli passi, in modo incrementale, potrebbero portare a vasti ed efficaci cambiamenti in grado di seguire il flusso senza andare a contrapporsi alle tendenze. La pianificazione che avviene tramite l’evoluzione incrementale, sinora, non ha certamente delineato la storia dei progetti di città, ma la scienza si sta evolvendo proprio ai fini di superare questa sfida.

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