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Built systems, biomimicry and urban food-growing

We might sum up the future paradigm as 'working *with* and *like* nature'. We operate directly with nature, notably in farming and, at the same time, we apply similar principles to systems of our own making, tapping into the free energy of self-organising complex systems. Potentially, *mixed* built-natural systems could therefore encapsulate dis-alienation in an interesting way.

As we have seen, even agriculture at its most non-invasive (closest to deep tradition) is still modified, so in a sense 'built', by us. It could be argued, then, that a city is not *intrinsically* any more anti-nature than farming, and certainly not in comparison to today's mainstream chemical-based farming which needs healing every bit as much as the city does, probably more. Whether or not we accept the term 'anthropocene', this debate at least implies that we are living in a world extensively moulded by humanity: the human/built environment *exists*, we cannot wish it away, but we can/must transform it into something positive by reorganising it on the lines of natural systems.

In reality, biomimicry, self-organisation, evolution and symbiosis increasingly *do* form the paradigm in many areas of design, with the result that today's cutting-edge engineered systems are no longer antagonistic to nature as they once were. Indeed, in many respects, in areas like materials and design, the 'new paradigm' is already there: paradoxically, it is farming – which one might expect to be closest to nature – which lags behind!

The universality of structure

One basis for biomimicry is universality of pattern. Thus, '…the deepest ideas of math, if shown to be true, would almost invariably have

consequences for physics and manifest themselves in nature in general.' (Yau, 2010, p.78). This role of pattern spans both life and non-living organisation: for example, bacteria arrange themselves in similar ways to the quantum arrangements adopted by electrons (Massachusetts Institute of Technology, 2016). A classic instance would be fractals, of which one striking example is the vegetable Romanesco (*Brassica oleracea var. botrytis*), which lays out its fractal pattern along a logarithmic spiral. The separation between art and science is also questioned, since art is sometimes the best way to come to grips with deeper truths. Thus, in cutting-edge research, amino-acid structures have been translated into music, because our ability to listen to them provides the richest way to grasp the 'intrinsic connections between the underlying structures…' (Giesa, et al., 2011, p.159).

In this way, a 'new paradigm for scientific inquiry' (Heylighen, 2008) breaks with the reductionist and mechanistic elements in Newtonian mechanics, in favour of qualities 'such as flexibility, autonomy and robustness, that traditional mechanistic systems lack. These qualities can all be seen as aspects of the process of self-organization that typifies complex systems: these systems spontaneously organize themselves so as to better cope with various internal and external perturbations and conflicts. This allows them to evolve and adapt to a constantly changing environment.' (Heylighen, 2008). Again, as we have seen with plants, evolution *tests* structures. The key is to be is adaptive and self-healing, hence robust.

Understanding the power of self-organisation unleashes astonishing possibilities. Recent research on solar energy storage explores an approach where materials 'self-assemble just by being placed in close proximity'. Its authors point out: 'We worked really hard to design something so we don't have to work very hard' (Science News, 2015). This is a beautiful statement which, although about something artificial, sums up perfectly how permaculture or Fukuoka regard farming: a lot of thinking goes into minimising work because the less we interfere, the more scope for self-organisation. Another nice formulation, by a group of robotics designers, is: 'In nature, complexity has a very low cost…' (University of California-San Diego, 2015).

Physical applications of biomimicry to the sustainable city

If we are to re-engineer the city towards sustainability, a key concept is 'urban metabolism'. Here, we again encounter the contradictory quality of equilibrium.

In nature, internal entropy is removed through a 'balance', whereby flows self-arrange in a way where the only linearity is inflow from the sun and dissipation into space. This faculty is lost in industrial-capitalist-urban systems. De Rosnay's diagrams reveal a striking insight (de Rosnay, 1979): *there is indeed a kind of regulation* within such systems, whereby they generate flows and even a rough-and-ready 'balance', but they can only achieve this at the expense of unsustainable linear flows *at the level of the system as a whole*: fossil fuels coming in, greenhouse gases/pollution going out. Our goal (c.f. Girardet and Mendonça, 2009) is to eliminate this. It seems that complexity is related to this goal *both as cause and effect*: a complex system can self-generate healthy internal flows while, conversely, by reducing linearity and hence entropy, we help complexity to grow . . . so this could become a benign feedback, which has implications at both physical and social levels.

Urban metabolism systems are nested: as well as occurring at whole-city level, self-organisation occurs within each constituent cluster, with the result that the overall structure gains added strength through modularity. One celebrated industrial symbiosis model, that of Kalundborg in Denmark, is seen as a case of self-organised spontaneous order which, in contrast to attempts to build eco-parks from scratch, exhibits greater robustness and resilience (Flint, 2013, p.117). On the one hand, issues around adaptive change (Holling, 2001; Holling, et al., 2002) make urban metabolisms behave like ecosystems. On the other hand, 'Our analysis suggests uniquely human social dynamics that transcend biology and redefine metaphors of urban "metabolism".' (Bettencourt, et al., 2007).

But examples of metabolism arising out of capitalism might – even if they reduce physical linearity – carry certain baggage, notably at a social level. Urban agriculture (UA) could help to redress this, which is one reason for its central importance within the city's re(self)engineering. It brings together several themes: the city *as* a garden; community gardens; wellbeing; meeting, conviviality and neighbourliness; diversity of experimentation, safeguarding free/open space from privatisation and enclosure; plurality against uniformity; common goods; experiencing nature etc. (c.f. Urban Gardening Manifest, 2014).

What has so far *held back* UA from fulfilling its potential in this respect is that it has been *either:*

(a) repressed/excluded;
(b) contained within parameters where it serves the ruling order.

In the global South – where UA would include many types of squatted, informally-occupied land and space – it has been mostly [a] which prevailed. It was despised and rejected by officialdom, at least till fairly recently, and it was relatively chaotic, which has the upside of being creative. In Britain, it was more [b]: through the allotment model, UA received official recognition but, in return, was circumscribed – by several parliamentary Acts spanning the period 1908–50 (UK Govt. 1998) – within a framework of 'food security', as part of national security. More recently there has been progress in breaking down these rigidities, permitting what we might call (in an allusion to evolution) a 'diversification'. Objectively UA *is* part of the metabolism but, by achieving recognition of this fact, we can take it to a new level. This opens up possibilities for a radical re-imagining of greening and food-growing.

At the time of writing, such a project is only embryonic, and much of it is still a vision. This is not of course a criticism, because vision is just what we need and, in fact, the *components* are already real, so our vision is mainly about the ensemble (Biel, 2013). As an aid, we could try to visualise the ensemble, for example digitally (Stuart, 2015), or we could, in the spirit of Eric Olin Wright's notion of 'real utopias' (Wright, 2010), extrapolate from trends which exist now, while remembering that, in our future vision, they'll flourish under new conditions. This will happen not least because they will have been honed and tested, in an evolutionary sense, by the challenges that they will have faced and overcome.

I earlier proposed a threefold analytical division for urban food-growing: the subsistence sector, the urban forest and the ultra-high productivity sector (Biel, 2013). The point was to register that there are several distinct reasons for urban farming, which can potentially interact. However, the distinction should not be rigid: for instance, the ultra-productive sector, though it contains elements of hi-tech, is not necessarily elitist, while its features of biomimicry make it part of the urban forest in some respects. The forest category is particularly interesting, in suggesting an interaction between the following themes:

[1] breaking down dualism between nature and the built;
[2] maximising the 'creative chaos' of self-organisation, in both physical systems and society;
[3] the 'wildness' required for biodiversity.

Where, in conventional plots, we mimic self-formed natural systems up to a point through intercropping, the urban forest takes this to the

next level where farming and built environment cease being sharply separate (Wilson, 2009), with buildings becoming a bit like forests. Partly, the urban forest makes green space productive in food terms: for example, the trees we plant should yield fruit and nuts (Pinkerton and Hopkins, 2009), a process already underway in London (London Orchard Project, n.d.). In a more developed form, trees cohere as an edible urban forest which, once established, acquires its own self-maintaining ecology (Ettinger, 2012). In a social sense too, the process of creating these spaces is itself emergent, a spontaneous encroachment of growing spaces, as already foreshadowed by the squatted community of Bonnington Square, Vauxhall (Self-Help Housing, n.d.). The concept of forest is explicit in the Los Angeles community project L.A. Green Grounds (L.A. Green Grounds, n.d.), while the 'new ruralism' aspires to bring together smart growth, new urbanism and sustainable food/agriculture systems (SAGE, n.d.).

The whole essence of the 'forest' image is diversity, the positivity of the 'wild', getting back/forward to the indigenous principle of robust crops and 'nudged' nature. Hence, it will be important to embrace crops which, from the standpoint of the homogenised mainstream, are considered unconventional. The value of indigenous crops, which are nutritious and resistant, is at last being recognised (Cernansky, 2015), and urban botanical gardens could act as repositories and centres of education to promote these (Michelson, 2015). The author's experience would confirm the urban environment as ideal for experimenting with such crops, which can include native American crops like the tuberous plant oca (*Oxalis tuberosa*), or the achocha (*Cyclanthera pedata*, a climbing cucurbit distantly related to cucumber), as well as the Chinese artichoke or crosne (*Stachys affinis*) and a lettuce-related plant grown in China, celtuce (*Lactuca sativa var. angustana*). All this reveals huge scope for future innovation and creativity.

Integration of urban farming with the hi-tech sector

So how can/should this fit with the rest of the metabolism? Consistent with the rise of biomimicry in industrial design, a key issue could be the interaction between the hi-tech sector and the urban forest. Thus, the model of sustainable urban drainage systems (SUDS), in which planting is a key ingredient (Dover, 2015, p.40 ff.), is totally different from old-style urban water management: it introduces permeable pavements,

vegetation and a subsurface of micro-organisms degrading pollutants (c.f. Dover, 2015, p.93 ff.) and is another way in which the city can be 'invaded' by green.

In particular, the new solar technology looks increasingly, and respectfully, at natural photosynthesis for inspiration. Progress is now being made along lines either inspired by the way plants use nanoscale structures to pull apart positive and negative charges (Science News, 2015), or drawing upon principles of symbiosis where, for example, 'artificial forests' of nanowires work together with bacteria, using solar power to sequester carbon and manufacture useful products in the process (Liu Chong, et al., 2015). These advances suggest great possibilities as a pattern for rooftops which symbiotically combine solar power and greening, using common principles of biomimicry.

Such an approach is already starting to be explored in a notion of 'biosolar roofs'. If we consider first the green-roof side of this model, we find a great case of spontaneous self-organisation: in place of the sedums which used to dominate (and homogenise) old-style green roofs, practitioners have now learned merely to lay a substrate, let nature take its course and watch the results (Gedge, 2013). What we find is that native plant species spontaneously appear, soon followed by rare birds, insects and arachnids (Kadas, 2006). Given that in a rural context biodiversity is heavily depleted by factory farming, monocropping and pesticides, the city actually becomes a sanctuary of biodiversity. If we now add the solar component, shade-loving wild plants spontaneously occupy niches beneath the raised and inclined solar panels in a manner reminiscent of agroforestry, while lowering ambient temperatures to increase the efficiency of solar photovoltaics (Gedge, 2013). Once again, it takes much knowledge to create systems where these things just 'happen' by themselves, but this is exactly what design communities are starting to acquire. The missing element in the biosolar model at the moment is, in the author's view, food growing. However, this could readily be incorporated.

Then we can add the social element of creating employment and education, something which again already exists as a developing practice. The hi-tech aspect of sustainable cities is not per se elitist or top-down, but has strong potential for community empowerment. A community-based rooftop solar power project already exists in an urban context in Brixton, South London (Rabagliati, 2014), and it is important that the paradigm for such experiments is the Social Work and Research Centre (commonly known as Barefoot College) in Tilonia, Rajasthan, India (Barefoot College, n.d.), which works with some of the most oppressed and marginalised rural women.

This in turn suggests an interesting notion: if, as we argued, the indigenous principle is about self-organisation and complexity, and cutting-edge design is about the same thing, can the two be brought together?

In practice, this *is* happening, and the back/forward dialectic has immense promise in urban contexts. The international Slow Food movement has a strong theme of 'Indigenous Voices' (Slow Food International, 2016), while it is interesting that cutting-edge, hi-tech, Sweden-based vertical-farming company Plantagon is chaired by veteran Native American activist Oren R. Lyons, Faithkeeper of the Turtle Clan, Onondaga Nation, part of the Haudenosaunee (Iroquois) confederacy (Plantagon, n.d.). In Canada, First Nations people are similarly a major driver in UA projects (Yves Cabannes, personal communication). Brafman and Beckstrom, in their argument for resilient systems where power is diffuse and modular, in fact reference the survival capacities of North American indigenous populations (Brafman and Beckstrom, 2006), specifically the Iroquois. This emphasises resilience, not just in the more superficial sense of readiness to bounce back after shocks, but in the profounder sense of readiness to embrace *dis*equilibrium as a vector for system change.

From the above, we can well envisage – using already verifiable components – a composite model comprising self-organised society, biomimicry in physical built systems, and an urban wing of agroecology. It would offer the robustness of self-engineered systems, while the indigenous component resists co-optation by the ruling order.

A critical view of technocentrism

While affirming the power of imagination, we should still ask a critical question about the viability of certain solutions. This question is not just technical, because it carries wider implications around the arrogance of technocentrism which, if not corrected, could keep us stuck in the old paradigm. A key case is the notion of growing food inside buildings. There is a few years of experience in this field (Despommier, 2013), and the world's first publicly-owned, open-data, crowdfunded, vertical farm research and education campus was recently established at Pasadena, Texas (Indoor Harvest Corp., 2015). Despite this, concrete successes so far are hardly enough to justify the grandiloquence of some claims. Critics – even those generally supportive of urban food growing – question

the viability of indoor growing, notably on the grounds of energy cost (Cox, 2016).

I would say that the problem of energy cost is maybe not the main constraint, given extremely rapid progress in the efficiency of light emitting diodes (LEDs); and significant research *is* being conducted into LED application to food-growing (for example, Olvera-Gonzalez. et al., 2013). However, a deeper criticism of non-soil-based growing in general may need to address how far we can reproduce, *in an artificial growing medium,* the issues addressed in Chapter 4: natural complexity, in both the soil itself and surrounding ecosystem services.

This is a genuine question: the multi-layer aquaponic greenhouse system pioneered by Will Allen in Milwaukee, USA, does supply some reasonably convincing responses (Allen, 2013), in that it does constitute a spontaneously self-regulating system. Nevertheless, the weakness of 'visionaries' is often to sweep such awkward questions under the carpet. Thus, the Cairo-based rooftop aquaponics organisation, Shaduf, writes: 'as soil in natural conditions serves only as a reservoir for water and nutrients, water containing crucial minerals and adequate aeration let plants thrive on the rooftops without a grain of soil' (Climate Heroes, 2014). This statement is pure nonsense and goes counter to the whole notion of the soil as a complex system, in symbiosis with which plants have evolved.

Right now, some large-scale vertical projects appear viable commercially. Nevertheless, certain of their protagonists propagate the model with a weird line of reasoning which looks intuitively wrong. To cite a typical example (Shedlock, 2016), the argument is all about *eliminating risk and unpredictability*: proponents boast that there are no dodgy bacteria because sterility is monitored, the system is insulated from weather, etc. To cap it all, it is robotised so you do not have to worry about workers!

This kind of approach touches upon ideas signalled in Ulrich Beck's well-known critique of a 'risk society' (Beck, 1992). Beck himself framed his argument in what I would see as a deeply incorrect (i.e. Eurocentric and classist) way, by asserting that society has already *transcended* material want. In reality, want is still very much there (indeed increasing), but the point is, *risk-aversion is diametrically the wrong way to redress it*. On the contrary, the only way to surmount ecological crisis is to allow crops to strengthen themselves under testing conditions (including the messy world of bacteria). It is moreover not a virtue to exclude workers: the future universe of knowledge will come into being *through* the farmer, not by eliminating her/him.

The role of food-related networks

Despite these caveats, we do indeed witness a new ecosystem of initiatives, which recall a striking observation made by Holling in discussing points of system-change: 'reshuffling in the back loop of the cycle allows the possibility of new system configurations and opportunities utilizing the exotic and entirely novel entrants that had accumulated in earlier phases. The adaptive cycle opens transient windows of opportunity so that novel assortments can be generated.' (Holling, 2001, p.397). In the decade and a half since he wrote, so much has happened and many novel entrants now exist. The crisis of the old paradigm opens the window of opportunity for a new one, as an emergent assemblage of these components.

Clearly the urban metabolism cannot just represent *objective* self-organisation, independent of human will. What conveys and embodies the loops and flows are actually socio-institutional mechanisms: i.e. networks (these function in some sense as the social equivalent of the networks conveying information in the soil system). Here, the city can make a strong contribution to the strategic task of restructuring *rural* agriculture for sustainability. One key way this happens is through an interaction with the peri-urban area and, in this, networks play a big role. The best-known form is community supported agriculture (CSA), i.e. building stable links with peri-urban farmers, in order to offer predictability (in a good sense) to both consumers and producers.

Here again, we encounter the duality of risk: stability in an ecological sense is a false goal if we seek to attain it by artificially simplifying and homogenising systems, robbing them of their capacity to evolve in response to shocks. However, security in the sense of livelihoods – and hence the minimisation of risk to those livelihoods – is something we *should* always seek to attain. This seems to pose a dilemma for policy, but the solution will become clear if we understand the connection between the two definitions. The simplified and artificially stable systems, built in a futile attempt to banish risk from capitalism's urban-industrial future, are also very conducive to class dominance, thereby allowing privileged interests to manipulate the system's flows. Hence the risk, which is supposedly being eliminated from the system as a whole, is actually exported onto the oppressed and vulnerable (social classes, districts). It is futile to imagine we can improve the *distribution* of risk within such a system while leaving the system itself intact. Conversely (and this is

where the argument becomes positive and optimistic), if we change the ecology of a system to make it more diverse, modular and robust – and hence *less artificially 'stable'* – this will also remove the power-nexus which reproduces insecurity at a livelihood level.

The best way to achieve this is through social movements. Applying such an approach to peri-urban farmers, the problem can be framed in the following way. The ecological argument to achieve resilience is diversity (in the way agroecology works with the soil system, in the range of crops and strains grown). Nevertheless, this will not automatically solve the problem in a livelihoods sense because, even in a good year, farmers suffer since there will be a glut, and supermarket chains can force prices down. Therefore, against the bad networks of capitalist value chains, we deploy the good ones of CSA, reducing farmers' insecurity through box schemes, which offer a guaranteed market. So, in this way, risk is magically dissipated (the main risk for consumers is having to consume seasonal produce, which is a good thing anyway!). An interesting way of concretising this, explored in Hackney Growing Communities in London (Growing Communities, n.d.), might be where UA focuses on those crops which must be consumed quickly – either because (like salads) they would wilt or, as in the case of peas, the sugars begin to convert to starch when they are picked – whereas other crops are sourced more from the peri-urban area.

And then, we may need to explore further steps, taking us beyond farmers' markets and CSA. Urban food-related network-formation is already beginning to generate its own literature (Cleveland, et al., 2014). It has been argued that the next step is *food hubs*, which can collect produce from many different producers and distribute it to many consumers. Through this process, farmers 'can plan together with the food hub to focus extra production in areas that minimize competition and maximize cooperation and collective benefits' (Wharton, 2016, p.144). There is a strong element of inclusivity. Although it is often assumed that people with low income will be forced to accept nutritionally worse diets, this is not necessarily the case: using the approaches we have discussed, good-quality food can be made available cheaply (Lifespan, 2016) while, similarly, farmers' markets do not just appeal to better-off people but can have a strongly positive impact on the less advantaged (Sadler, 2016). This is not just a building of food, but of society: studies suggest that such linkages carry a strong theme of moral values (University of Iowa, 2015).

Urban composting – the case for qualitative intensification

Supporting peri-urban farmers, distribution hubs, etc. – all this is vital. However, it still leaves the question of how meaningful a contribution can be made by food production *within* the city. We must always bear in mind where we began in Chapter 1: if the old paradigm is unsustainable, we must produce – in a new way – a *lot* of food. The reason for high-intensity UA is that, if the city can partially feed itself, this will buy crucial time to convert to wider food systems.

Some efforts at quantification which have been undertaken, particularly in the global North, suggest that the amount of food currently grown in urban agriculture is small. Thus the contribution of community food gardens is small when assessed for yield (though they can be important for other reasons) (Tomkins, 2014). A report on the campaign Growing a Million Meals for London revealed that 160 community food growing spaces produced 21 tonnes of food, estimated value £150,000, with a potential increase to about ten times as much (Sustain, 2014). This is billed as an 'achievement', but how many people would this really feed? Using a US estimate of 188 kg of vegetables per person per year (The Week, 2012), or alternatively the author's calculation of production on a home plot providing most of a person's fruit and vegetable needs (210 kg p.a.), a ballpark figure could be 200 kg. On this basis, the above-mentioned 'achievement' would impact the food security of only about 100 out of London's 8.5 million population.

So if conventional UA does not currently deliver, what can be done? For reasons just discussed, there are question-marks over the hi-tech sector, and although the latter undoubtedly supplies part of the solution, we should not be over-reliant on it. This suggests the goal of what we might call a 'qualitative intensification' of urban gardening.

In our earlier argument about rural agriculture we critiqued a narrow 'input-output' model which neglects the free energy of self-organisation available inside the 'black box' of farming methods themselves. The Malthusian error of Caldwell (1977) was to assume we cannot feed the global population if there are insufficient sources of nitrogen (N) (and we could make a similar argument about water for example).

Now, transposing this to the urban sector, there is a risk of making – on the same conceptual basis – an opposite error. Here, the confusing

factor is not the paucity of inputs *but their abundance*: practically unlimited supplies of organic compostable waste and grey water are available through the urban metabolism.

Am I saying this is a bad thing? Not necessarily, but it is important that UA exercise a critical function with respect to the metabolism. While it is true that *some* metabolism will self-organise, it must be remembered that the high-entropy capitalist/industrial model is still dominant and, consequently, whatever loops and flows emerge are not *per se* guaranteed to be benign. Notably, UA might be treated as a sink or dumping-ground for whatever other sectors want to get rid of. We could then get lazy by relying on abundant inputs as an excuse for not correcting the farming system itself, and this would probably translate into entropy output.

Most obviously, we might input too much nitrogen (N). A project involving the author (*Closing the waste-energy-food loop – applying anaerobic digestate to urban agriculture*, University College London, 2015–16) showed that, while anaerobic digestion can produce plenty of high-quality fertiliser, the latter is high in N and, as we know, N pollution is one of today's main problems, which would presumably apply even if its source is organic. Crucially, the damage is not just in the form of the polluting effects of N runoff, but even more because of its knock-on effect on CO_2 emission (e.g. Zhang, et al., 2013). Now we come to a striking revelation of recent research: this is not just a rural problem; urban soils too emit very significant CO_2 (Decina, et al., 2016).

This strongly suggests that a major emphasis be placed on the *qualitative* character of land-management in cities, and particularly on converting land from emissions-source into carbon sink. This in turn implies a close examination of exactly how we farm in the city and, notably, what we use compost *for*.

The first point is that, in principle, composting is more about conserving soil structure than an input to raise fertility. The centrality of compost in this sense was established by Howard (1943), and has been carried forward in subsequent low-input methodologies (Dowding, 2007). Among practitioners, there is an aura of mystery around compost, which even has its own 'Da Vinci Code': a twelfth century manuscript of the Order of the Knights Templars discovered in an attic above a Spanish priory (Dailliez, 1981), which provides magical recipes for *composte de broussaille* gathered from the surrounding nature. In today's rural contexts large quantities of compostable material might be difficult to find,

but in an urban context it is very easy. The key role of compost in this model is as a mulch, i.e. a layer protecting the soil and maintaining aeration, moisture and constant temperature (Dailliez, 1981, p.37).

Now we come to the issue of intensification. Once we have secured the minimum goal of maintaining soil structure and reversing greenhouse gas emission, it should then be possible to go one step further, into a high-intensity system where we maximise yield, for example, by mostly eliminating fallows and sowing another crop as soon as we have harvested the previous one. In this way, we might usefully absorb more compostable waste without causing runoff. Let us therefore consider a quantification. Literature on organic agriculture typically calls for a 40 mm mulch (Corbalan, 2005), which does not sound much. However it is surprisingly rare for authors to multiply this by the surface area to get a real idea of the volume required, so let us attempt this. Taking the traditional British allotment (250 m^2), converted to a no-dig method with paths between beds and allowing for compost bins and sheds etc., our cultivable surface is about 150 m^2. Spread over 150 m^2 this gives a figure of 6 m^3 required in a given year. It can be estimated that about half is internally generated from the plot. This gives a figure of 3 m^3 per 250 m^2 of cultivable surface required from outside the plot's closed system, which in the author's practice, provides the basis for a truly intensive UA.

What precedents exist? We referred earlier (Chapter 3) to the French Physiocrat model, which could in a way be seen as a 'sustainable intensification', and the early nineteenth century saw an extremely interesting peri-urban experiment in the form of the *maraîchers* surrounding Paris: an ultra-intensive organic system, employing masses of compost and focussing solar energy through the use of cloches. It is, as always, important to understand the political subtext. As Jacobsohn importantly points out, the *maraîcher* project was a deliberate slap in the face to Malthusianism (Jacobsohn, 2016). Most obviously, the anti-Malthusian position is to demonstrate that human ingenuity *can* produce a lot of food, but there is more to it than that. To achieve this we must unleash the initiative of direct producers. For the utopian socialists, the way to prove Malthus wrong was the co-operative and associative principle. The Physiocrats failed because they did not challenge dispossession and, in fact, much of today's organic movement, permaculture, etc. are similarly blinkered in failing to unite with radical social causes. If our food-related networks can be linked to working-class associative traditions and indigenous traditions – *and if we can use these as a counterweight to accumulation and dispossession* – we can make it work!

The troubled legacy of modernism

The problem of a laissez-faire metabolism, which might reproduce the bad loops of capitalism, arises in both physical and social forms, and we must critique both in tandem: this is crucial to a meaningful political ecology, bridging nature and society. Hence the relationship of the new UA with notions of 'insurgent planning', activist scholars supporting social movements, and a re-definition of space. One example is a new approach to architecture which intrinsically incorporates food-growing, as in the AgroCité project in the cité of Colombes, suburb of Paris (Uncube, 2014). The issues around biomimicry and the universality of structure, with which we began this Chapter, are definitely not just technical, but intrinsically political.

In exploring this, an important insight is offered by the work of Alexander Kluge (Kluge, 2008). Kluge embarked on the realisation of a project which had once been initiated (and abandoned, because it seemed unrealisable) by Sergei Eisenstein: that of filming Marx' *Capital*. In a deep sense, we might view his work as an exploration of political ecology and a critical interrogation of biomimicry, conducted through art. Thus, describing Marx as 'the poet of our crisis' (Frankfurter Allgemeiner Zeitung, 2011), Kluge explores among other things the affinity between Marx and Ovid, the poet of metamorphoses. Here again, art can provide the best understanding of structure at a profound level.

On this topic, the legacy of modernism harbours an interesting ambiguity. The positive side is that modernism opened up respect for natural forms, and did have a core of political radicalism. We find both aspects in the work of Iannis Xenakis who was at the same time both composer and architect. His musical work *Metastasis*, closely inspired by his experience in the war as an anti-fascist partisan (c.f. Service, 2013), and which formed the inspiration for a notable building at the 1958 Brussels Expo on which he collaborated with Le Corbusier, draws also on the golden ratio inscribed by the same logarithmic spiral which we encountered in the vegetable Romanesco. The score of *Metastasis* (Xenakis, 1955) suggests a succession of phase transitions similar to Holling's model or to those (in the international political economy) set out in Figures 4.1 and 4.2 (Chapter 4). For the modernists, nature was key to healing the disjunction between form and function and, for Le Corbusier, furnished an inspiration for order (Dummet, 2007).

On the other hand, there was a rationalist distrust of *spontaneously* accreted cities, as they actually exist. While aspects of the 'green' were

central to modernism, it was a very structured rather than spontaneous/messy green. Even the garden city movement was in many ways strongly rationalist: Ebenezer Howard's model (Howard, 2012 [1902]), a very interesting attempt to re-integrate cities with their food system, is nevertheless rather the antithesis of an order self-formed out of chaos. In the London context, the Abercrombie Plan – a stunning vision of fingers of green connecting the centre to the Green Belt – also involved demolishing whole areas of the messy, accretive built city to make way for what looks like a rather un-natural and artificial green space.

This is the questionable side of rationalism. Accordingly, Austrian architect Friedensreich Hundertwasser (1928–2000) strongly critiqued modernism as an artificial imposition, not in any way truly emergent: 'When rust sets in on a razor blade, when a wall starts to get mouldy, when moss grows in a corner of a room, rounding its geometric angles, we should be glad because, together with the microbes and fungi, life is moving into the house and through this process we can more consciously become witnesses of architectural changes from which we have much to learn.' As cases of the good alternative to rationalism, he cited – alongside the work of Gaudí and *very few* other examples of architecture – workers' allotment garden-houses (Hundertwasser, 1964 [1958]). This is really about the creative facet of chaos, connecting with the arguments from Prigogine cited earlier.

Historically, the structure of many cities objectively *has* in fact self-assembled out of non-order, certainly in Britain and very much in the global South too. It is this which the bad side of modernism wanted to destroy. More specifically, the hostility to informal, messy and uncontrolled self-organisation was unsurprisingly manifested in hostility to UA, most notably in the global South. Thus, in a conventional narrative (e.g. Gore, 2008, p.55), UA, having already been repressed by colonial urban legislation, suffered still worse repression under modernising post-colonial regimes.

Indeed, to understand fully the modernist repression of UA, we have to place this in a wider context of demolitions, evictions, 'slum clearance' and social cleansing, all of which reflect a similar mind-set. The global South saw an atrocious legacy of destruction of informal settlements, in defiance of the right to the city. Even in London – if we take the case of a self-assembled and functional town centre like Brixton, South London – the intention in the 1960s and 1970s was simply to raze *everything* and start with a blank slate. A key element in this was the 'master plan', whose resonances are quite patriarchal and phallocratic.

The result would be to expunge complexity and cut short the ongoing adaptive process. There are crucial resonances here with our earlier argument about evolutionary plant breeding and in general the point that oversimplified systems are brittle and weak: if you do not embrace the creative side of chaos, you are left vulnerable to system-collapse higher up the panarchy. At the same time, whoever prescribes the recipe for a simplified system enjoys power over it: again, the intrinsic link between physical resilience and social justice.

This helps explain why struggles for the right to the city connect with urban food-growing at many levels. One of the most inspiring UA projects, which achieved a world-wide resonance, was the Garden of Eden, constructed behind 184 Forsyth Street, New York, by activist Adam Purple. The garden was destroyed in 1986 as part of an all-out attack on community gardens waged by Mayor Giuliani (for details see Reynolds, 2008, p.69; Carlsson, 2008, p.63). This is not to say that the spontaneous, emergent city is necessarily just because, after all, it emerged under capitalism; nevertheless, demolitions and 'slum clearance' have without question frequently occasioned still worse injustices.

Here, the work of Jane Jacobs (1916–2006) played an importantly positive role in a fightback against modernism's destructive face. Jacobs affirmed *both* an ecosystem approach to cities, and (in a socio-political sense) solidarity with popular struggles against neighbourhood destruction: it's precisely the link between ecology and politics which is key to her stance on self-organising complexity (c.f. Hirt and Zahm, 2012).

Jacobs' legacy led to a more holistic approach to the city, as an emergent, complex system in which built and ecosystemic elements interact. If we first recognise that this interaction is an objective reality anyway, we can then begin to operate in a new way which embraces and reinforces these faculties. On this basis, a new literature on urban systems (for example, Pinderhughes, 2004), could approach the city differently, as something which objectively *is* a kind of ecosystem where built and natural elements co-evolve. If we see cities 'as hybrid phenomena that emerge from the interactions between human and ecological processes' (Alberti, 2008, p.6), the issue becomes not the 'impact' of humans *upon* the environment but rather the emergent collective behaviours occurring through an interaction between the two. Since, importantly, complex systems do not follow a single trajectory to a single point of equilibrium, the goal of planning is not to impose a futile stability on dynamic systems, but rather to encourage resilience (c.f. Alberti, 2008, p.24). This perspective is obviously an urban-planning expression of the attitude to farming which we explored in earlier chapters, and

therefore seems to supply the conceptual basis for a new, close integration of UA and urbanism.

Although all this is great, we must nevertheless be aware that the critique of modernism smuggled in some dangerous tendencies amongst its baggage. Notably, we must be careful not simply to laud spontaneous order in an unthinking way.

Perils of the neo-liberal city

The argument that spontaneous order equals best order is a neo-liberal one: exactly the argument for laissez-faire proposed by the high priest of neo-liberalism, Friedrich von Hayek (Hayek, 1964). The two linked flaws with this argument are:

(a) it makes abstraction of the overarching dominance of capitalism's circuits, and more broadly norms, which tends to channel any emergent social phenomena in a direction which reproduces these circuits/norms;
(b) it repudiates the visioning function – embodied in that form of emergence associated with consciousness, c.f. Chapter 6 – which is intrinsically human.

In this sense, the defeat of modernist rationalism could unleash new threats. A few examples can be given:

Firstly, while the spontaneous organic forms of the city have been vindicated, they are now vulnerable to place-marketing and gentrification. However much urban greening may play a good role in challenging binary town/country divisions, even a 'green' city can easily be co-opted as a market value. It is crucial, therefore, that the movement against gentrification and social/ethnic cleansing (c.f. Hancox, 2016) be a movement in defence of space, and an urban manifestation of the land struggle.

Secondly, the self-ordering of the city could reproduce inequalities rooted in the fabric of its structures. Thus, as Heynen points out, there is a bad metabolism through which today's city somehow reproduces the divisions of colonial city, as analysed by Fanon, into a well-fed white town and a hungry native town (Heynen, 2015). For this reason, urban political ecology, if it is to signify something real, must situate itself in the continuum of struggle against slavery and colonialism, and the issue of food deserts is one manifestation of this. African-American activists in the

US have pinpointed many of these issues: Will Allen strikingly places the contemporary food struggle within the context of slavery, its aftermath and legacy (Allen, 2013). So we cannot just worship emergent process which might be channelling exactly the metabolism which entrenches exploitation!

Thirdly, the conventional narrative of UA in cities of the global South (for example, Gore, 2008) rather misses the point about *why* the hold of modernism increased after independence. In reality, colonial powers had usually been quite clever at exploiting informality, and indeed imprisoning their subjects in a truncated limbo, stuck between a simulacrum of 'tradition' and an impossible aspiration for full admission to the capitalist core. This explains why post-colonial national and municipal authorities of the 1960s–1970s, only too relieved to have the oppressor off their backs, felt at last free to push modernisation. In this sense, neo-liberalism can be considered a kind of turning-back-the-clocks to the colonial era. As soon as the *global* rulers found themselves at last able – in the 1980s – to launch a revanchist dance of death on the grave of the modernist national project, it is natural that they would rediscover a 'tame' version of co-opted colonial informality. Although there are many positive aspects to the more enabling attitude to UA over the past few years, it is essential to remain aware of these co-optive dangers.

The answer to these dangers is again to emphasise the centrality of radical movements.