EMERGENT PROCESSES
Tom Wiscombe

This century is going to be about biology. I don't want to confuse architecture with biology. You can take analogies too far of course. But, as Gödel once said in his Theory of Incompleteness, sometimes to solve a problem in a particular discipline, you have to switch to completely different territory.

Architecture and biology at first glance do not appear to be so different—both are materially and organizationally based, both are concerned with morphology and structuring. Both are wound together by multiple simultaneous systems and drives, and probably most important for us here, both are constructed out of parts operating as collectives. While buildings, and to a lesser extent organisms (especially the human kind), may often be laden with content or meaning, that seems to be culturally transient and not particularly informative for either on the level of material dynamics and properties. Nevertheless, despite their parallels, some of the primary terms with which both architecture and biology are concerned turn out to be different in kind rather than degree: what architecture calls function, in the dogmatic sense, biology calls behavior. What architecture calls order, biology calls DNA scripting. Biology, it turns out, defines its processes dynamically and generatively, while architectural processes still tend to be understood as fixed and stable. Recent bio-theories on complex adaptive systems and especially the phenomena of emergence have begun to open up territory that architecture can no longer ignore if it is to have any relevance, and indeed resilience, in the future.

The problem in architecture is the mysterious staying-power of the paradigm of collage (also known as the atomic paradigm), which assumes that all objects and systems in the world are diagrammatically separate and that adjacency is the only possible relation. Relations are indeed often formulated like those tinker-toy sticks connecting colored balls that elementary school physics teachers still use—a virtual, unengaged line between things, where the thing is what counts. Falling out of this logic, architecture still tends to be specialized and categorized, understood as collections of parts and systems in a state of disconnection or even, astoundingly, conflict. Bio-logic however tends away from these kinds of striation and disjunction, toward the smoothness of ecologies, co-evolution, and adaptation, toward the automatic generation of coherences between objects and systems.

In order to move on from the problematics of collage logic, it is necessary to confront two particular assumptions: one, that objects and systems which are not composed from the top-down tend toward chaos, and two, that evolution and iteration (sometimes oversimplified as 'repetition') in architecture are linear, zero-sum operations. The specialization and distribution of the practice of architecture into separate territories-- design, engineering, construction management, etc.-- and the late modern breakdown between design and fabrication creates this climate of disjunction and linearity. We are all familiar with the way a building is generally produced: the architect defines a space plan and sometimes a representative form; structural and mechanical engineers are invited in after the fact to add order and performance but often have to resort to illogical or weak solutions to maintain the design intent. Construction documents are then produced which are only analogous to what will actually be built; contractors are brought in to say how the conflicted contraption might actually be fabricated and erected. There is often no feedback or feedforward, no learning, and certainly no coordination going on at most of those coordination meetings. The question of evolution and complexity never enters the picture.

Emergence isn't interested in parts; it is the science of wholes. In architecture, it opens up a new way of thinking about how various independent agents and disciplines, which have of course not always been independent-- remember the Gothic masterbuilder-- could begin to exhibit generative, collective behavior. Rather than layering discreet systems, the aspiration would be to find points of flexibility and interaction in systems, and determine how the dynamics of one set of material flows can converge with other material flows to create not only improved combined fitness, but also unexpected qualitative effects. The map then becomes the territory in the sense that continuities within the design process could translate into continuities within the construction process. One test of success would certainly be the obsolesence of the 'exploded axonometry' drawing in architecture, which is a machine for unpacking atomic organizations, one to one, into their parts.

Consider again the term 'function'- it is usually used in order to establish a point of fixedness, a datum from which a design can legitimately grow-- a root which, as Deleuze might say, is no better than the tree itself. Function in the Modern sense priviledges use (and the subject) over other material functionings, for instance structural,

mechanical, or atmospheric function. Use, hybrid or not, has the propensity to form an axis, become a kind of fundmentalism in the development of architectural proposals. Behavior, on the other hand, is a dynamic process of feedback between states of formation and adaptation. It does not assume a center, a body; behavior flows between agents and scales. Behavior is not always measured in terms of action and reaction, one to one, but can switch from field to object and back again, creating non-linear patterns of relations between micro and molar states. The wolf is, therefore, also the pack.

There has been a lot of talk about emergence since it was 'discovered' as a subset of complexity theory in the 1980s, that discovery linking back to the emergence of systems theory in the 1920s. Beyond the journalistic definition, ie. 'to arise' or 'come to being', as in 'emerging artists', emergence refers in fact to a very particular scientific phenomenon: the indivisibility and irreversibility of wholes-- be they structures, organizations, behaviors, or properties. In particular, emergence refers to the universal way in which small parts of systems, driven by very simple behaviors, will tend toward coherent organizations with their own distinctly different behaviors. The natural world gives us the most vivid, real-time examples-- the hive, swarming, flocking-- where independent parts snap into formation and take on complex emergent behavior, behavior which is not traceable back to the behavior of the parts. Nevertheless, emergent phenomena are natural in a broader sense, and have been proven to be equally useful in describing the complex behavior of cultural, political, economic, and urban organizations. Even the organization of conciousness into what is often loosely referred to as 'intelligence' turns out to be best modelled from the bottom-up as a swarm of neurons exhibiting emergent behavior. More interesting still, paradigm shifts, or changes of collective mind, appear to also be best understood as sudden coherences emerging from multitudes of independent feelings about the world. Growth and evolution, and the drive toward more complex forms of organization, therefore, are never additive and linear, but rather consistently based on the dynamics and transformative potential of emergence. As Kevin Kelly says: more is different.[1]

As emergence has begun to make its foray into the world of architectural thought, it has begun to raise conciousness of models of simultaneity, continuity between part and whole, and the new and strange issue of "effects", which are not understood as the result of design intention, but rather of interaction between parts or systems in complex arrangements. This trajectory, begun by Jeff Kipnis, Greg Lynn, Reiser & Umemoto, Mark Goulthorpe, Karl Chu, Sanford Kwinter, and Manuel DeLanda in the 1990s is now being refined and brought to market by younger groups such as Ocean North and the 'Emergent Technologies and Design' program faculty at the Architectural Association, as well as Servo, Marcelo Spina, and the list goes on.

Mathematics are certainly at the heart of this discussion: the question is to what extent hard math should to play a part in generating architectural emergences in the laboratory. Hollywood, to which architecture owes many of its tricks, has figured out the use-value of swarming algorithms in producing complex formations and coherences in such films as the Matrix and Lord of the Rings. Architecture is just now beginning to sublimate the possibilities. The digital revolution in architecture began with a romance with modelling and animation tools which made new forms possible, but has recently developed into a more specific control of geometry and the application of more complex parameters, both in types of morphodynamic diagram-based work and morphogenetic autocatalysing work. At the same time, academic currents have begun to refine the differences and overlaps between the concepts of hydridity (testing the limits of the categorical and combinatorial), and emergence (generation of collectives and coherent systems). Mathematics, whether understood literally, where the architect engages in programming scripts, or working indirectly through a software interface, is however only part of the story. Purely mathematical experiments in architecture assume that all information required for the generation of buildings can be coded in a way that make it available for calculation, and that such calculations can be expected to create real material complexity, rather than simply representing it.

It is interesting to imagine a path to an emergent architecture which includes, in addition to application of abstract algorithms to geometry and the generation of pattern-based organizations, the complexities of engineering and the building industry. This means setting multiple processes and techniques in motion, with the express aim of generating feedback between performance envelopes and calculation systems rather than focusing on a singular formal solutions. This model transforms the 'design process' from a purely artistic, and often private venture within the architects studio, into a collective enterprise of actors, systems of analysis and visualization, fabrication restraints, and materialities operating in an unpriviledged space. The question of computation becomes not simply one of searching for the ultimate auto-generative design software and the best of all possible starting conditions (a conundrum possibly better suited to cosmology than architecture), but rather one of evolution

through the feedback of various parts and systems. The computer is certainly key in this equation, because of its natural potential for dealing with multiple sets of information simultaneously and its capability of iteration and feedback, preconditions for any kind of emergence. Productive work is for instance already going on at the Engineering Design Centre (Cambridge, UK), by Kristina Shea, who has, in her eifForm software, begun to set up an iterative relation between structural loading patterns and geometrical behavior.[2] Such tools are pioneering and uncover a latent field of expertise and development for architecture, leading away from expressionism toward emergence.

Consider the following analogy from outside architecture: Biosteel. Biosteel is a spinoff of multiple industries and processes which generates a new product with emergent properties, and also points beyond industrial specialization toward what might be called emergent manufacturing. Biosteel, presented at a trade conference in 2003 by Dr. Jeffrey Turner of Nexia Biotechnologies, is an effect of the feedback between the agricultural industry, the textile industry, the genetic engineering industry, and the military industry.[3] Simply, it is a meta-fiber based on spider silk. It works like this: since spiders cannot be domesticated, cultured spider genes are injected into goats, the goats are milked and transgenetic spider protein is extracted, which is spun into silk fibers lighter than aluminum and with the strength of steel. This material has potential applications as wide ranging as aircraft hulls, helicopter blades, and artificial ligaments and sutures for the human body. Affiliations and feedback between agents and industries creates a distinct pattern, an emergent species with exceptional and unexpected properties.

The lesson for architecture goes beyond the generation of new materials (although that is certainly fair game) toward a new understanding of how creating real-time feedback between processes is itself a new design process. The causality of traditional Modern design (form follows function, or stepping: "I did this and then I did that…") is replaced by the richness and beauty of emergent evolutional leaps. After all, emergence never comes piecemeal, it comes all at once, just as H_2O does not evolve linearly from 10% hydrogen/ 10% oxygen to 15% hydrogen/ 15% oxygen, and so on.   Hydrogen and oxygen become water all at once, with the emergent properties of wetness and Brownian motion, neither of which is predictable from observing the qualitative or quantitative properties of the original substances.

Architectures concerned with complexity will certainly find the most fertile ground in explorations of how emergence can become operative rather than theoretical.   That said, this experimentation may be most productive if it involves the application of the logic of collectivities-- of 'agents' and 'behaviors'-- to the methods of architectural practice as well as to geometry.   There exists an immense and untapped potential for generating beauty and coherence not only in the controlled conditions of the studio, but in the field, in terms of connectivity between information-bases, industries, and methods.

3 Projects
The following projects-- the PS1 Urban Beach, the Radiant Hydronic House, and the Micromultiple Tower— involve different applications of emergence in design, from the feedback of structural and mechanical behavior into morphology, to the integrity of cohesive swarm-structures.

The PS1 Urban Beach, realized in 2003 in the PS1 Contemporary Art Center courtyard, was based on 2 distinct but interrelated systems: the Cellular Roof and the Liesure Landscape.   The landscape integrates various programmatic elements such as long lap pools, furniture for sitting and lounging, and promenade catwalks at different heights.   Also, at key points, the landscape begins to adapt into structural supports for the roof.   All of these behaviors are integrated into a coherent gradient of use, spilling out rhizomatically into the courtyard, parsing the space into microclimates and passageways. The design for the Cellular Roof is based on creating a long-span structure through the use of a non-heirarchical structural patterning of small, interlaced units, or cells.   The location and geometry of each cell is determined by local shading requirements, by its required shear and moment reactions, and also by the behavior of neighbor cells.   The interconnected cells operated in alliance, enabling large, clear spans and forming a kind of structural ecology.   A crenellated second skin wrapps these elements into a singular multiplicity, a unified shade structure. At night, however, this provisional body transforms back into an atmospheric light-emitting swarm.

One of the driving goals of this project was to integrate issues of fabrication and erection into the design process.   As a temporary event roof which had to be designed, manufactured, and installed in just two months, the project

team was forced to jump directly from conceptual design to shop drawings-- a feat which was made possible by computation. The key was to avoid designing a fixed shape and concentrate on creating an iterative system which could evolve-in changes in structural requirements, scope, and existing conditions. All five hundred skin panels were generated algorithmically as single-curvature elements making them easy to develop, water-jet cut flat, and transport. The project would not have been feasible or economical had it been defined with traditional construction documents rather than with adaptive geometry and mathematical logic.

The Radiant Hydronic House is based on feeding back various building systems into one another in order to produce emergent effects, both quantitative and qualitative. The house is structured by a set of flexible bands which take on various gradients of behavior-- structural, mechanical, circulatory-- depending on various local requirements but also based on the behavior of adjacent bands.

A central spine, cascading down from the roof, connects the various infrastructures into a monocaulk structure. Ductwork in this spine opportunistically twists up to become structural supports in key locations, and then twists flat to become a ramp or bridge. While each building system performs, it does so only in relation, and in a state of biological epistasis (ie. no one system is optimized but all systems are optimized in relation). This spine contains a reversible hydronic AC system which, in winter, transports liquids from solar pools down to a radiant slab inside the house. On summer evenings, this system also transports cool westerly winds down into a subfloor plenum to chill the thermal mass of the house for the following day.

The Micromultiple Tower began as a research project, examining the options for dissolving the core-and-plate model of the high-rise. The assumption was that the core tends to be an inauthentic simultaneity: sheer economic considerations have stabilized structural, mechanical, and circulatory systems into expedient adjacency-- a collage of systems.

The proposal was to relocate and recombine these systems into a thick adaptive infrastructural skin on the outside of the building, replacing the dematerialized curtainwall of Modernist architecture. This skin inflects and responds to performance criteria such as shear loading and wind forces, supports radiant heating and cooling systems for all floors, and contains naturally ventilated fire exiting and other vertical circulation systems.   In addition, the degree of inflection of the skin is linked to maximum economical floor plate spans, enabling the complete obsolescence of any column grid.

Notes:

1   Kevin Kelly, Out of Control, Chapter 2: The Hive Mind
        (Massachusetts: PerseusPress, 1994)
2   Kristina Shea, Directed Randomness, published in Neil Leach (ed), Digital Tectonics
        (London: Wiley-Academy, 2004)
3   Dr. Jeffrey Turner, BioSteel Performance Fibers: Military Applications of Recombinant Spider Silk
        (CTI-DND Conference Lecture, April 3, 2003)