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DAVID PIGRAM, IAIN MAXWELL

Supermanouvre

2010 |

2010002470
Original creative work

This essay, composed for the publication *Contemporary Digital Architecture: Design and Techniques*, occupies the field of computational design theory. The text is accompanied by, and serves to position, a series of case study architectural projects designed by the authors.

'Inorganic Speciation' contributes a number of new concepts and analytical frames extending core architectural themes in relation to algorithmic design processes. The concept of typology is combined with that of speciation to understand, describe and model the genesis of architectural form. Similarly, a trajectory of material computation and form-finding, traced through historical projects, is extrapolated to demonstrate the potential of incorporating multiple inputs into computational systems of negotiation. Finally, abstract notational systems are discussed as tools for the meta-analysis of architectural production.

Conceptual and methodological limitations are at least as significant as material limitations in the production of architecture. The three key conceptual apparatus here discussed: typology, form-finding and abstract notational systems each offers both a bridge between contemporary processes and the past and a means towards the accelerated evolution of the discipline.

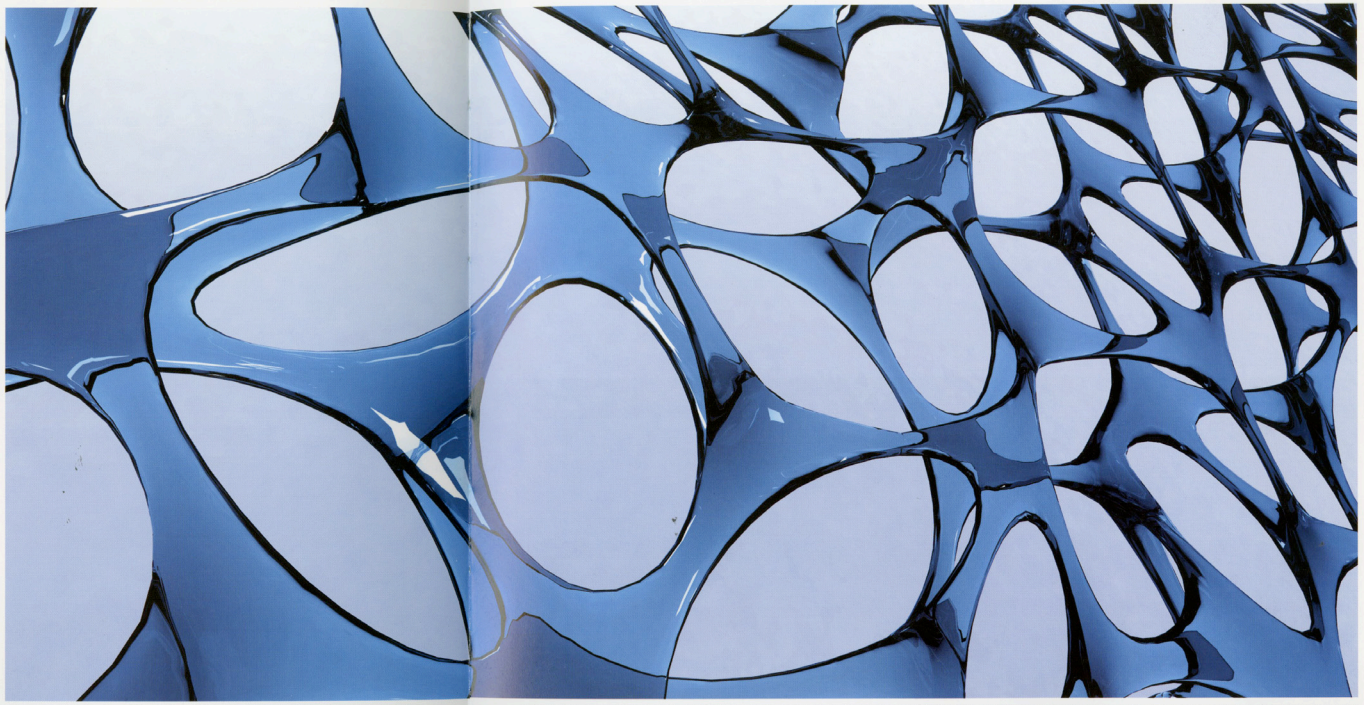
The publication 'Contemporary Digital Architecture: Design and Techniques' is the largest survey to date presenting 'the latest developments in the field of architecture as it has been reshaped by the use of digital technologies'. Over 200 projects are represented. The 20-page section featuring the essay and case study contributions from supermanoeuvre is the largest devoted to any single design practice.

Supermanoeuvre + Kokkugia

Morphogenetic Lattice

A collaboration between supermanoeuvre and kokkugia, this project is an experiment in the effects created by morphogenetic algorithms. These algorithms are designed to generate ornamental distortions within geometry through the internal logic of cellular automata. A technique where a population of self-similar elements in space continually change their state based on the states of their neighbors in a feedback loop, giving rise to emergent patterns. The project is driven by a series of encoded procedures which build a hex-grid cellular automaton and a network of springs which drive the distortion of the more geometrically complex screen. The springs respond to the changing CA states and enable a non-hierarchical distortion of the network through the use of a non-linear physics solver. Accordingly the influence of an individual CA cell trickles through its neighbors influencing the geometry beyond its immediate adjacencies.

Design: Dave Pigram, Roland Snooks
Thanks to: Cory Clarke



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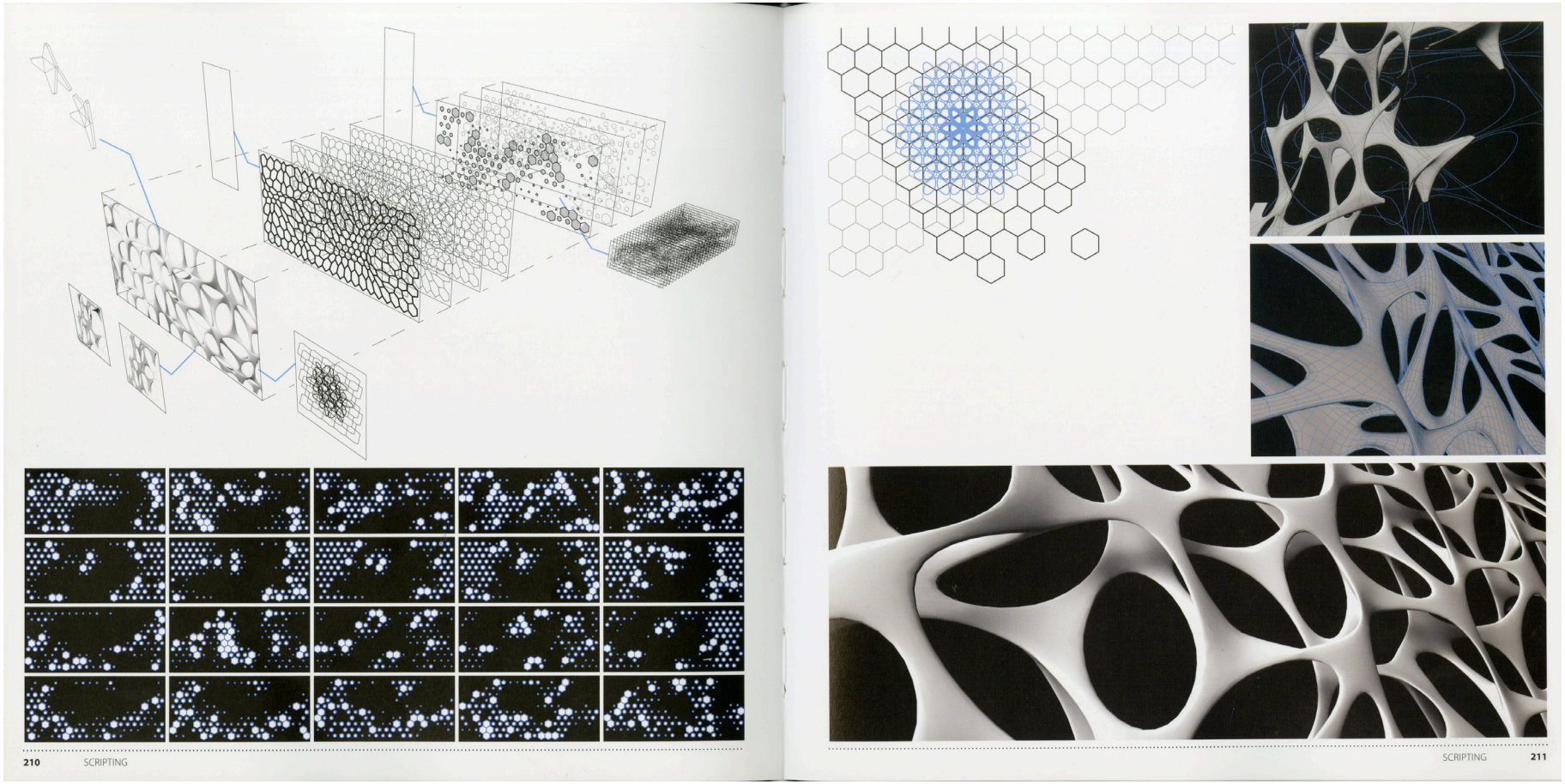

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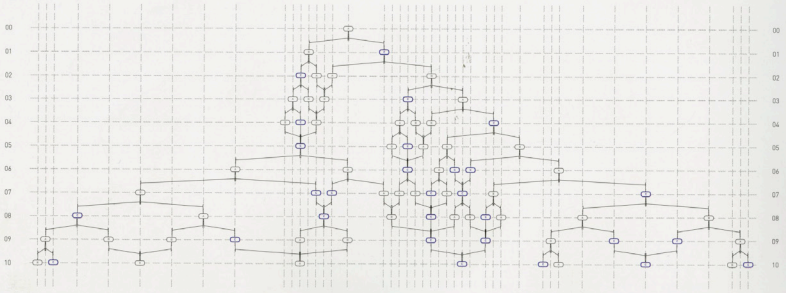
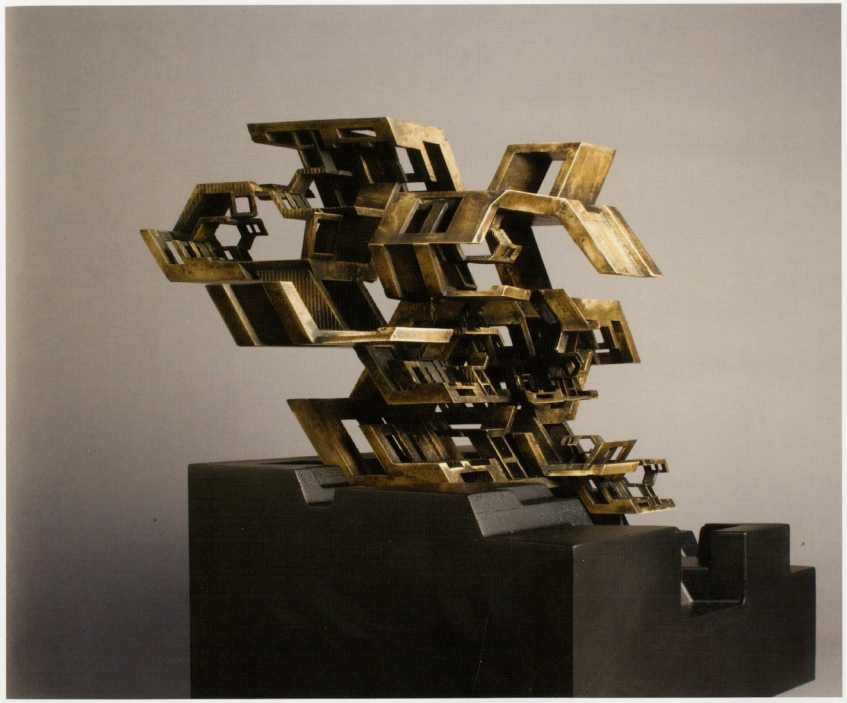
Supermatter

'Supermatter' is both a continuation of supermanoeuvre's broader research interest into systemic processes of formation, and an assessment of the capacity of contemporary prototyping technologies to elaborate thousand-year-old processes of fabrication.
Conceived as a family of objects cast in bronze, Supermatter explores the algorithm as a geno-typical morphology, where similarity across the collective is instilled through the instructions of assembly embedded within the algorithm as it operates on a discrete set of geometric aggregates. The input of geometry enables a speciation of each resultant object as the rules of growth and assembly are applied to the specific geometric constraints and potentials of connection particular to each aggregate primitive. Through changing either one or all of the primitives, or the generative rules of the Lindenmayer (L-System) combinatorial algorithm itself, differentiation across the population can be instantiated. The resultant objects, are indexed to both the rules and geometric laws of aggregation, and as such the character of similitude is enacted.

To this end, the project facilitates a shift to a new definition of the architectural model to be inclusive of comprehensive methodologies of spatial, formal and material distribution.
In realizing the final cast objects,samples of the computational process were selected for rapid prototyping (SLS). These 1:1 outputs were then used as positive forms in the preparation of casting moulds, a process which combined an accurate translation of the formal character and intricate detailing of the digital model with the specific material behavior of first molten and then thawed bronze.

Project team: Dave Pigram, Wes McGee, Iain Maxwell, Paulis Austrins, Zack Jacobson-Weaver, Brandon Clifford





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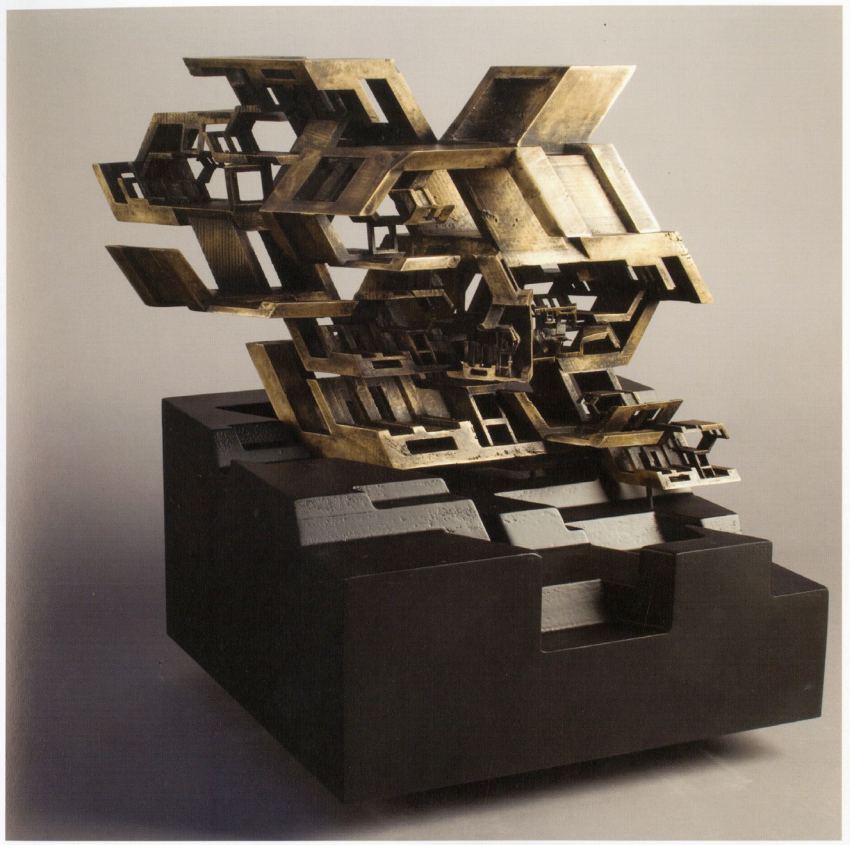

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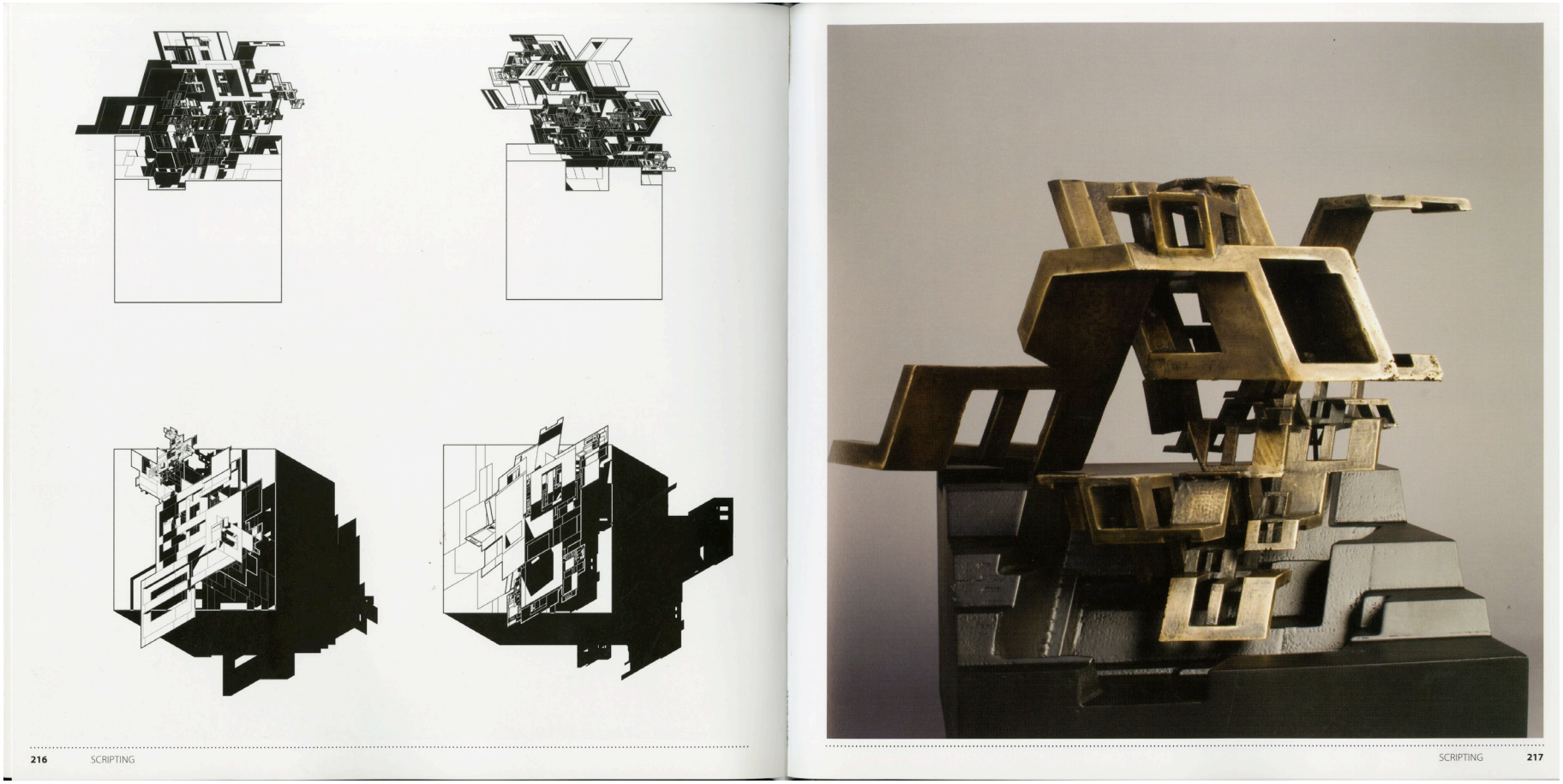

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Proto-Synthesis & Trabeculae

The two projects, Proto-synthesis and Trabeculae, are here presented as a pair and respectively illustrate the genotypical and phenotypical aspects of supermanoeuvre's design approach.

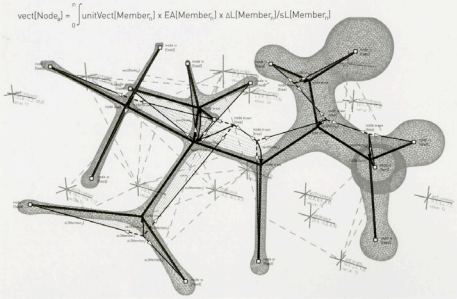
Proto-synthesis (the genotype) is not a singular design project or curated artefact; rather it is an algorithmic strategy for the elaboration of a topologically rich and highly networked architecture. It is also the genome or operative-framework for the latter architectural project – Trabeculae. But here, Proto-synthesis has not been encoded with specific programmatic protocols to engender a specific programmatic effect and therefore remains typologically-free, and capable of multiple possibilities. Within the system, the very construction of architecture; position, scale, displacement, density, thickness, length and so on, are deeply embedded within the decision-making mechanisms of the algorithm, and are stimulated through both internal logics, and the discrete sampling and feedback of stimuli within the local environment.

Trabeculae (the phenotype) is an instantiation of the Proto-synthesis algorithms, achieving specialization enabled through embedding qualitative programmatic, situational and environmental design aspirations toward the reimagining of the central atrium office tower. Replacing the traditional operation of repetitive extrusion, the heliotropic branching system actively seeks out those areas within the zoning envelope with greatest access to daylight. Forking and swelling in response to varying light conditions the atrium is thus conceived as a site-specific network that traverses intelligently and freely from one façade to another. The atrium becomes the defining element of differentiation within otherwise normative floor plates.

Within the atrium a second order proliferation of the same system at a finer scale develops a structural meshwork - the Trabeculae. The swellings and coagulations of this topologically free structural network-within-a-network accommodate meeting & function rooms, bridges and communication stairs as well as supporting the atriums glazing.

Project team: Dave Pigram, Iain Maxwell, Brad Rothemberg, Ezio Blasetti, Jared Olmstead, Matthew Hall, Susan Teal

$$vect[Node_n] = \int_0^n unitVect[Member_n] \times EA[Member_n] \times \Delta L[Member_n]/sL[Member_n]$$



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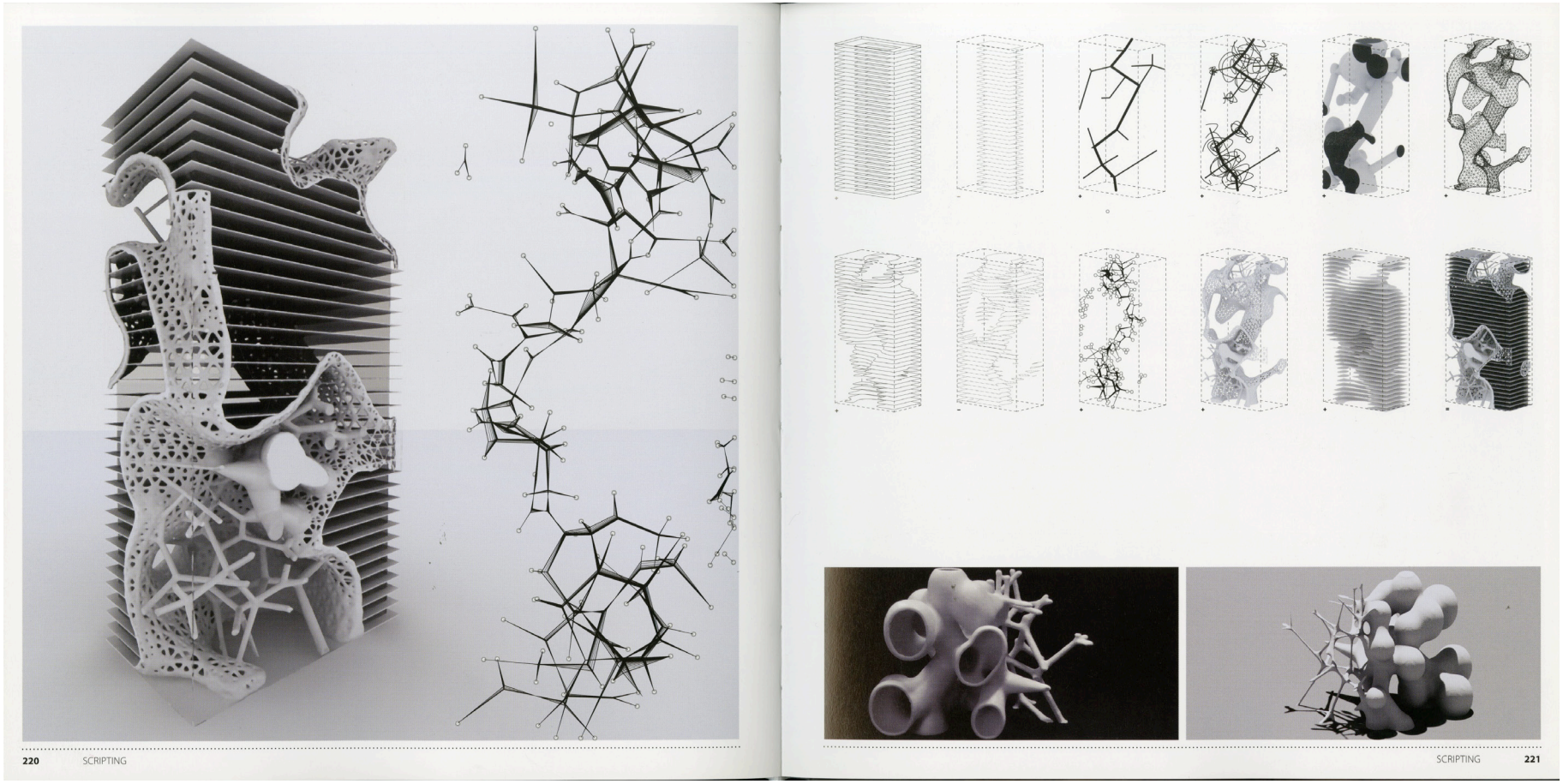

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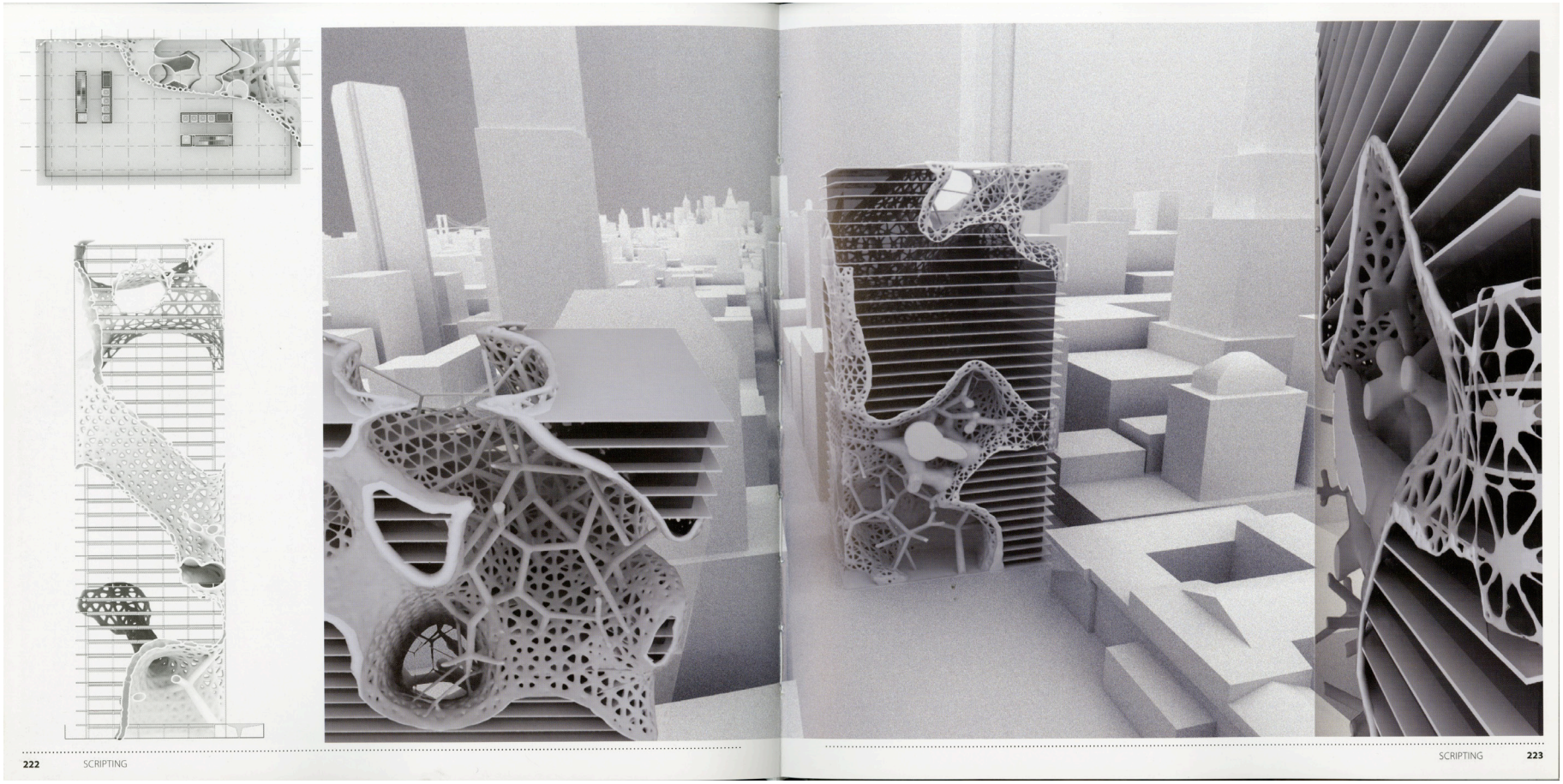

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Inorganic Speciation: Matter, Behaviour and Formation in Architecture

Form is the primary instrument through which architecture engages with the world. It is this firmly held position that motivates supermanoeuvre to develop custom methodologies of formation that allow for the explicit and open-ended negotiation between multiple architectural intentions and the complex milieux within which they will operate. These methodologies are algorithmic in nature, primarily digitally enacted, and extend the capacities of the form-finding tradition within architecture through a decoupling of its processes from the limits of physics, enabling a broader examination of the number and nature of negotiable inputs. The abstract notation underlying these algorithms enables a meta-analysis of the formational processes, which has an accelerating influence on their evolution, as experienced within other fields of intellectual and artistic endeavour. Through the application of algorithmic notation, the conception of form-production within design shifts from object-centric applications of typology, to the speciation of mutable architectural models.

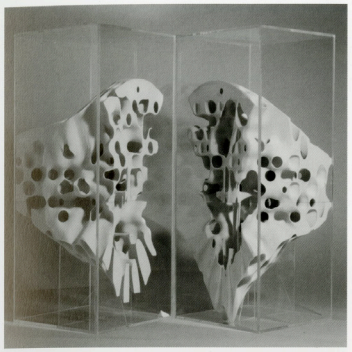
Architectural form is concerned with organization across multiple scales (programmatic, material and structural) enmeshed in a complex feedback loop with the forces, events and behaviors that simultaneously drive and are driven by them. The description of 'formation' through causal processes (morphogenesis) has been convincingly articulated by D'Arcy Thompson. He posited that 'form' could no longer be understood as an isolated, inert, or solely genetic event; but rather a generative process of transformation negotiated through an organism's internal constitution (DNA) and its adaption to a situation via the sampling of environmental, physical or material forces (feedback). The gift of form is both a *"diagram of the forces"*[1] that gave rise to it, and a critical, selective and adaptive process through which morphology sheds its 'generic' nature and attains a higher order of specialization. The more stable or recurrent of these specializations can be understood to have achieved the level of 'speciation'.

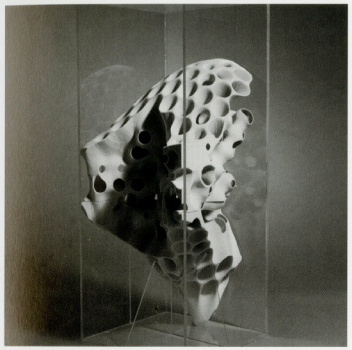
Matter, like architecture, is traditionally conceived of as benign, an underestimation that generally extends to all things lacking the motivations for life. In accordance with the contemporary understanding of formation, as exhibited in soap-film aggregations, snowflake crystals, and bee-cell morphologies, the property of 'body' is in fact driven by the action, or 'agency', of one molecule upon another while simultaneously negotiating internally produced (surface tension) and externally imposed (surface pressure) influences. Formalness is therefore not a latent property of the single molecule, but a collective and intelligent behavioural event. Thus, *"matter can no longer be seen as passive and 'dead.' it can sense and respond, in unpredictable ways, to its own condition and to external influence. The intimacy of the interaction of material with these fields is forcing a revision of the conception of matter and form as a separable duality."*[2] Supplant the term 'matter' with 'architecture' to yield a framework for supermanoeuvre's approach to design.

Collaboration with matter's computational abilities is a well-established trajectory within architecture; Gothic Cathedrals, Antonio Gaudi's hanging-nets and Frei Otto's seminal work on minimal surfaces all serve as preeminent examples. Similarly, traditional design methodologies frequently take advantage of the positive formal constraints of specific design mediums. Charcoal sketches, clay models and procedural methods such as folding, cutting or weaving, all provide a consistency of character via a delimited 'phase-space of possibility'. However, the limitation of analogue modes of computation in relation to broader architectural speculation is precisely their fixed relationship to immutable physical laws and material properties. Without the ability to expand, intervene-in or tune the parameters of form-finding techniques, architects are either forced into subservience to imperfect analogies between these factors and a larger set of extrinsic design intentions, or, must remain content to limit themselves to structural and material investigations. When executed digitally however, form-finding processes enable a greater incorporation of architectural constituency; programmatic as well as material design goals in negotiation toward the elaboration of architectural effect; spatial experience, ornament and performance.

Digital techniques, specifically algorithmic as opposed to parametric (associative) processes, allow for the non-hierarchical and non-linear (feedback) negotiation between multiple factors; the topology of the system, its network of connections (physical, virtual or both), remains open and is able to self-organize. The conception of architecture as a collective organization driven through multiple agencies is more akin to the dynamics of complex natural systems than to conventional modes of design. For this reason, supermanoeuvre is consciously drawn to the modelling of the algorithmic processes that underlie biological and chemical phenomena, as opposed to the emulation of pre-existing geometries found within nature. Such fixed references, serve only to limit the capacity of the design process before it has even begun. Our interest therefore, rests firmly in the description of behaviors such as growth and change, mechanisms of feedback, and the transformative agencies such entirely syntactical models elaborate. This is a critical and conscious departure from graphical systems of representation, toward an active engagement with the protocols of 'making' that exist deep within all complex behavioral systems. The algorithm becomes the operative medium (descriptive environment) through which intentions are first encoded, then negotiated and ultimately enacted.

The application of algorithmic processes presents architecture with a set of descriptive and accelerating possibilities akin to those embedded within mathematics via its systems of abstract notation. Similarly, music enjoys rapidly enhanced evolution with each successive creation of new symbolic notational systems. As John Holland has observed, *"anyone with a bit of effort can appreciate quite complicated music, but there are musical subtleties that are difficult to convey without notation. The sophisticated compositions of Bach, Beethoven, and Prokofiev depend on the discipline that produces that musical notation. To know musical notation is to enrich one's understanding of the music and of the process of composition."*[3] Here the delimiting frame of syntactical protocols, enables rather than inhibits the space of formal possibility. The 'fugue', *"a type of contrapuntal composition or technique of composition"*[4], famously adopted by Bach, is a prime example of cultural production literally inconceivable without symbolic grammar. Thus, notation enables a medium for the systematic meta-analyses not only of the artefact (theorem, composition or building), but also of the processes that have brought it into being. In short, it enables the creation of theories of making, which can then form a foundation for the elaboration of a design methodology. Within architecture, it is our precise ability to relay, quantify and query design speculation and aspiration through computable terms, that allows *"architectural concepts [to be] expressed as generative rules so that their evolution may be accelerated and tested."*[5]





Iain Maxwell, Marga Busquets, Sebastien Delagrange
Adaptive Ecologies. AADRL. 2008
Housing protoype realized through reverse-engineering the planning, spatial and circulation logics of Unite d'Habitation. Increasing the proto-systems internal and context sensitive behaviours, enables an expansion of the systems capacity to produce more diverse apartment outcomes, whilst embedding Le Corbusier's circulatory heirachies.

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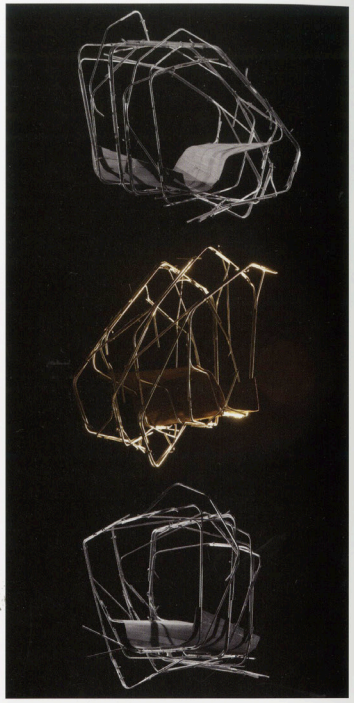
Advocating architectural form as a synthesis of internal motivations and their response to situation requires an expansion of the framework through which it is theorized. Analysis of commonalities across and between architectural forms is critical to their generation, evaluation and positioning. Historically, typology has been both a practical and theoretical apparatus to this end. Premising architectural organization upon established typologies, however, can be a reductive and external practice that unnecessarily pre-conditions and limits the act of design. The difficulty is that established typologies have conventionally been viewed as fixed, and are primarily articulated in programmatic and/or semantic terms without explicit reference to the forces and processes that generated them. There are exceptions; Zaera-Polo, Tschumi, Kipnis and Frampton have each articulated models of typology that are active to various degrees. What such models do not provide however, is an adequate meta-analysis or operative grammar through which a productive and empowering design methodology could be structured.

It is within this context that we advocate the adoption of an alternate conceptual framework, speciation: *"the evolutionary process by which new biological species arise."*[6] When applied to architecture, speciation offers a series of analytical tools and terms that redress the aforementioned deficiencies of typology and as such it presents a more open and robust vehicle through which to qualify architectural formation. Of particular value is the conceptual distinction between genotypical and phenotypical variation. Analyzing formational processes and internal motivations separately to formal characteristics and context sensitive behaviours enables the discernment of a much larger and richer set of affiliations between projects. This in turn allows for more sophisticated systems of evaluations of fitness, both for purpose (the traditional domain of type), and of adaptability to a host environment. Fitness is here measured not against assumed global orders, but is evidenced through the realization of a persistent, entirely local, and specialized instantiation of the genome. By advocating speciation over typology we do not seek to abandon the organizational diagrams of type, rather to enrich and elaborate them through their exposure to additional influence and the establishment of operative meta-models.

As a design practice, supermanoeuvre implicitly values richness and diversity and privileges complex and aperiodic forms of order; the heterogeneity and flux of the outside world are welcomed collaborators in the design process. Organizational, spatial and material characteristics arise from a synthesis of their own network of internal logics and their environmental,



"Pipe Dreams" by Nicolas Rebeck and Kendra Byrne.
1:2 scale prototype fabricated with custom-built pipe bending attachment to KUKA 6.5 axis robot arm utilizing custom written software.
Research into Robotic Fabrication directed by David Pigram and Wes McGee, University of Michigan, Taubman College of Architecture and Urban Planning

social, political, cultural and technical contexts (both existent and desired). Architecture, seen in this way, is neither a neutral substrate, mapping external influence without resistance, nor is it an inert exercise in the explicit production of shapes without reference to their environment. Instead it is an active participant with agency across multiple domains. Algorithmic techniques enable non-hierarchical, non-linear and explicit negotiations between an enlarged set of architectural intentions. Computation is employed to extend the form-finding traditions of architecture beyond the limitations of material substrates, while abstract notational systems enable a meta-analysis of the processes of form generation allowing them to be better understood, tuned and deployed, thus accelerating their evolution. Through the conceptual apparatus of speciation, fitness can be qualified through the persistence of specific formal differences, attained through the mutability of deeply embedded architectural logics. Supermanoeuvre's work is dedicated to the critical exploration and invention of strategies, methodologies and grammars of architectural formation.

1. Thompson, D'Arcy. Edited J T Bonner. *On Growth and Form.* Cambridge University Press, UK, 1961. p11
2. Jachna, Tim. Postscript Essay. in; *"An Evolutionary Architecture"* by Frazer, John. Architectural Association Publications. 1995. p110.
3. Holland, John H. *Emergence: From Chaos to Order.* Oxford University Press, UK, 1998. p 15
4. http://en.wikipedia.org/wiki/Fugue.
5. Frazer, John. *An Evolutionary Architecture.* Architectural Association Publications. 1995. p 9.
6. http://en.wikipedia.org/wiki/Speciation

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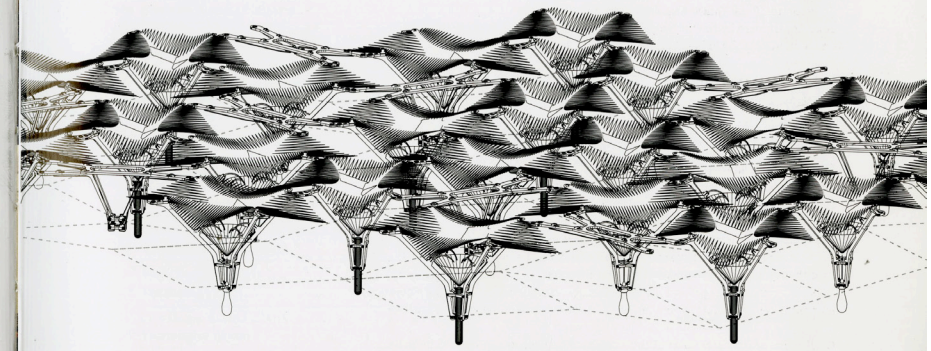

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