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# Biomedia and the Pragmatics of Life in Architectural Design

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In the short animated film, *The Cathedral* (Katedra) (2002), Polish animator Tomasz Baginski presents a vision of cosmic horror in which a man approaches what looks like a medieval cathedral on an unknown, post-apocalyptic planet. As the man explores the inside of the structure, the light of his torch reveals to the viewer that the pillars of the cathedral are living faces. By the end of the film, the sun animates the cathedral, which then consumes the man in its organic outgrowths, turning him into another face in one of its many pillars.



Fig. 1 Tomasz Baginski's *The Cathedral* (2002).

There are certainly many reasons to praise this animated short. Not only did it win Best Animated Short at SIGGRAPH 2002 in San Antonio, but in 2002 it was also nominated for the Academy Award for Animated Short Film. My interest here however is more thematic than technical. I want to suggest that the film presents a model for “living architecture” that is deeply ecological in scope insofar as the structure’s vitality is dependent upon the interpenetration of multiple scales of experience – human, built, cosmic, etc. – the effects of which far exceed what seems possible in the built environment on Earth.



**Fig. 2** Tomasz Baginski’s *The Cathedral* (2002).

This may seem like a strange place to begin an article on architecture. And yet my first introduction to this animation was in an article, “The Cathedral Is Alive: Animating Biomimetic Architecture,” by Dennis Dollens that appeared in the journal, *Animation: An Interdisciplinary Journal* (2006). My enthusiasm for using animation as a model for “living architecture” was eventually dashed upon realizing that Baginski’s piece was used as a way to think about the potentials of biomimetic architecture: the outgrowth of the cathedral is thematically read as a model for biomimetic design, and animation is the appropriate medium for such research. My own disappointment with his reading of the piece has neither to do with Dollens’ explicitly architectural interpretation – he notes that the film is only

“incidentally architectural” (Dollens 2006: 107) — nor does it have to do with the central role he accords to animation — animation should be used to think and visualize living architecture (107-08). Rather, my disappointment is that the life of architecture in this film is reduced to the biological. The interpenetration of environments – organic and inorganic – in a complex ecology is short-circuited by the tyranny of biological life, so that *The Cathedral* is useful to architects insofar as it imitates the “natural world.”

This bio-reductionism should really come as no surprise, however. It’s not as if architecture is a stranger to the concept of biological life, to digital media, and using the latter to promote the former. As I explore in this article, the concept of biological life is intimately connected to architecture through the latter’s experimentation with new media for design. To this end, I suggest that the emergence of what Michael Hensel calls, the “biological paradigm” in architecture, results from a whole series of discursive overlaps and slippages that facilitate the use of computational and biochemical media in architectural design. These media then prepared the way for architecture to become a species of artificial life (ALife), whose aim is to reproduce both the functional and materials properties of life at a “non-standard” scale.

However, by drawing on Alfred North Whitehead’s notion of “importance” from *Modes of Thought*, I expose the biocentric limitation inherent in the importance life acquires for bioarchitecture, and how this contributes to what he calls the “bifurcation of nature” into “primary” and “secondary” qualities. Following Whitehead’s proposal to overcome the bifurcation by constructing a system of general notions as “lures for feeling” the world differently, I ultimately extract a radically ecological, instead of biological, importance for the life of new bioarchitectural media.

## **I. New Modes of Importance**

In his article, “Metabolism and Morphology,” architect and theorist Michael Weinstock notes that, “form has been a central focus in theories and practices of architecture throughout history, and overtime has aligned with many different methodologies and methods of generating the shape of buildings” (Weinstock 2008: 27). Weinstock bemoans, however, that in the history of built architecture

the design of form is most often conceived of as a top-down process in which material realization is a product of a logic or set of criteria (in the mind of the architect) other than the *actual* material conditions within which it finds itself embedded. A structure's relationship to the micro-activities of its environment—wind speed, temperature gradients, landscape, etc.—are accommodated by technologies (environmentally sensitive surfaces—heat generation and transportation systems) only after the generation of form. For Weinstock, this top-down method, exemplified by the modernist discourse on universal space, [1] neglects the range of material and energetic relations a structure can share within its environment, which all must be included in the generation of form when the goal is “performance-oriented design” in a dynamic environment. [2]

Thus, morphology and metabolism—two concepts used to describe the biological world—now articulate an achievable relationship between built form and environment.

In the natural world, form and metabolism have a very different relationship [than in the history of built architecture]. There is an intricate choreography of energy and material that determines the morphology of living forms, their relations to each other, and which drives the self-organisation of populations and ecological systems... The study of natural metabolisms is a significant resource for design as it reveals that shape or morphology is deeply integrated within the means of capturing and transmitting energy. The organisation and morphology of energy systems of the natural world provide a set of models for what will become the new ‘metabolic morphologies’ of future buildings, and ultimately of cities (2008: 27).

In the special issue of *Architectural Design, Techniques and Technologies in Morphogenetic Design*, Michael Hensel describes this trend of turning to notions of morphology and metabolism in design as exemplary of the “biological paradigm” in architecture. This paradigm, thought to describe an amorphous field whose experiments range from computational architectures (e.g., the use of genetic, evolutionary, and parallel algorithms) to biochemical engineering (e.g., creating artificial photosynthesis), is arguably unified by its concern for using the dynamism of the natural world, however that be conceived (neo-Darwinian, symbiotic, etc.), [3] as a model for an architecture capable of a dynamic relationship with its environment.

Of course the connection between the built environment and biological life is far from a new one. As Brian Holland notes in his article, “Computational Organicism: Examining Evolutionary Design Strategies in Architecture,” only four years after the publication of Charles Darwin’s *On the Origin of Species*, the *Revue Générale de l’Architecture* attempted to align built architecture with “the organized life of animals and vegetables” over against the inorganic world of rocks through the concept of “Organic Architecture” (Holland 2010: 486). Whether the editors of the *Revue* were familiar with Darwin’s work seems insignificant compared to the explicit link forged between the inorganic materials of architecture and the living forms of the natural world. Similarly, in her 2006 work, *Architecture, Animal, Human: The Asymmetrical Condition*, Catherine Ingraham notes the deep historical connection between biological life and architecture, but goes somewhat further writing that,

when biology and architecture officially come together—since architectural history and biology are both formed as disciplines during the Enlightenment— they exchange metaphorical terms such as *structure, typology, organization, evolution, and development*. This explicit exchange ceases, after a time, to be noteworthy, but these metaphors subsist beneath both disciplines over the next two centuries” (Ingraham 2006: 23-24).

While Ingraham ultimately sees the relation between life and architecture as asymmetric— “between architecture and life, there is a relation of asymmetry” (1)— the point is that the natural and built worlds have a long and nuanced history of entanglement, far from exhausted by the prevailing “biological paradigm” in design.

Despite this entanglement, there is still something quite different about the biological paradigm in design—at least as Hensel describes it— from much of what has characterized previous entanglements. In his 1979 work, *The Evolution of Designs: Biological Analogy in Architecture and the Applied Arts*, Philip Steadman offers some insight, characterizing architecture’s history of interest in the biological world as follows,

... there are characteristics of designed objects such as buildings, and characteristics of the ways designs are produced ... which lend themselves peculiarly well to description and communication via

biological metaphor. The ideas of ‘wholeness’, ‘coherence’, ‘correlation’ and ‘integration’, used to express the organized relationship between the parts of the biological organism, can be applied to describe similar qualities in the well designed artifact. The adaptation of the organism to its environment, its fitness, can be compared to the harmonious relation of a building to its surroundings (Steadman 1979: 4).

The biological world of morphology, metabolism, coherence, evolution, and so on, were thought of as useful *metaphors* for the built environment. Architectural forms became *analogically* biological. Thus fitness, Steadman goes on to say, becomes a highly effective metaphor for characterizing how certain styles— the modernist style, for example— endure over time, or evolve to meet (cultural and historical) selection pressures. The issue is not whether the modernist structure, as a built entity with its materials and its geometries, achieves evolutionary stability or mutates in concert with the material and energetic exchanges it shares with its environment; but rather, at stake is whether the (abstract) form continues to guide the organization of materials, or evolves, creating new material organizations.

Steadman’s narrative is compelling for a number of reasons, not least of which is the contrast he allows us to draw between the metaphorical use of biology by architects and the more recent bioscientific methods of research employed by designers—the so-called “biological paradigm.” Architectural form is no longer pre-given (in the mind of an architect, for instance) but is itself a product of morphogenesis, thus “paralleling a wider scientific search for a theory of morphogenesis in the natural world” (Frazer 1995: 9).

Given that the life sciences have come to hold such importance for architecture, inquiring into the discursive practices, modes of disciplinary entanglement, and methodological slippages that produced this “mode of importance” is required. Interrogating the conditions for importance will be a more metaphysical investigation than it may initially appear, however. “Importance” is a concept for which Alfred North Whitehead devotes considerable attention in his *Modes of Thought*. He notes that, “we concentrate by reason of a sense of importance, and when we concentrate, we attend to matter-of-fact” (Whitehead 1968: 4). And yet the sense of importance that Whitehead wishes to develop, and to which this essay will ultimately rely, does not bear any of the abstractive ambitions of the

sciences (as in, “this is the most important fact”), but shares in the imaginative “hope” of speculative philosophy, whose ambition, as he ambitiously proposes, is to coordinate every variety of experience (“experience drunk and experience sober...” [Whitehead 1967a: 226]) into a system of general notions in which “no entity can be conceived in complete abstraction from the system of the universe...” (Whitehead 1978: 3). This is why importance, far from signaling the isolation of a fact, actually underscores the relevancy of the totality of experiences (their importance) for that fact. Whitehead explains that,

It follows that in every consideration of a single fact there is the suppressed presupposition of the environmental coOrdination requisite for its existence. This environment, thus coOrdinated, is the whole universe in its perspective to the fact. But perspective is gradation of relevance; that is to say, it is gradation of importance. Feeling is the agent which reduces the universe to its perspective for fact. Apart from gradations of feeling, the infinitude of detail produces an infinitude of effect in the constitution of each fact (Whitehead 1966: 9-10).

What Whitehead is getting at here in these late lectures is of course nothing short of a metaphysical overhaul of what we take to be “important” in any experience; or more specifically, what counts as relevant data in the emergence of “matters-of-fact.” As will be shown, where the definition of life is concerned, the life sciences generally reduce it (life) to an essential set of material and functional properties, relegating all other factors, or experiences, to what are inessential properties. This is not to say that identifying such (material/functional) properties is not necessary for the integrity of the scientific practice (this is why Whitehead is not “Critical” in the Kantian sense of the term, since he does not think we should renounce these abstractions as mere illusions [c.f. Whitehead 1967: 59]). Rather, so long as science neglects how the existence of its matters-of-fact result from the gradation of the totality of environmental factors, or in any case, how the universe is coordinated for them, then it supports the “myth of finite facts” and suppresses the “environmental coordination required for its existence” (Whitehead 1966: 9-10).

It is in this perspective that I wish to broach the importance of life for architecture; although I propose a genealogy in which the former becomes important for the latter by means of the abstractive strategy of the sciences. And yet, just as Whitehead insists that in “[b]oth in science and in logic you have only

to develop your argument sufficiently, and sooner or later you are bound to arrive at a contradiction, either internally within the argument, or externally in its reference to fact" (Whitehead 1966: 10), so too the proposition of a living architecture will exhaust itself, becoming internally and externally conflicted, if its importance is not renewed, as I ultimately propose, under the guise of a different, speculative strategy.

## II. From Computational to Biochemical Media

It is for the purposes of charting the importance of living processes for bioarchitecture that I turn to John Frazer's now seminal work, *An Evolutionary Architecture* (1995). In this work, he boldly claims that, "architecture is considered a form of artificial life, subject, like the natural world, to principles of morphogenesis, genetic coding, replication and selection. The aim of an evolutionary architecture is to achieve in the built environment the symbiotic behaviour and metabolic balance that are characteristic of the natural environment" (1995: 9). But as Frazer attests, it was only with advances outside of architecture (and even biology), in computer science, mathematics, and evolutionary computation that evolutionary architecture could develop into a mature field of speculative research. John Holland's research and development of the genetic algorithm in his 1975 work, *Adaptation in Natural and Artificial Systems*, and its later application by Richard Dawkins in the *Blind Watchmaker* (1986) ("biomorphs"), were two such advancements.

Holland, in many ways the inheritor of John von Neumann's incomplete work on reproducing computers (or programs), once quipped that, "that's where genetic algorithms came from. I began to wonder if you could breed programs the way people would say, breed good horses and breed good corn." (Mitchell 2009: 128). With the genetic algorithm (GA), Holland discovered an effective means for generating solutions to optimization problems. The GA simulates the behavior and adaptation of randomly generated candidate solutions over a period of time. Each generation of "individuals" is evaluated based on a fitness function; it is then selected for, combined with other fit individuals to be parents of the next generation (with the chance of random mutation), and so on until a solution is arrived at (cf. 129; Terzidis 2006: 19). What is critical is that the algorithm performs the process of natural selection irrespective (in principle) of

human invention or concern; the process is thought to exist in nature and the algorithm performs this selection.

Richard Dawkins, for his part, was quick to pick up on this, and developed one of the first well-known experimental applications of artificial, evolutionary design in *The Blind Watchmaker*. By using a GA to evolve a population of “biomorphs”—two-dimensional tree-like structures that graphically represent a set of genes—he established that without a God-designer, extreme complexity can be generated from very simple origins through iterative processes (non-random selection, random mutation, and replication).

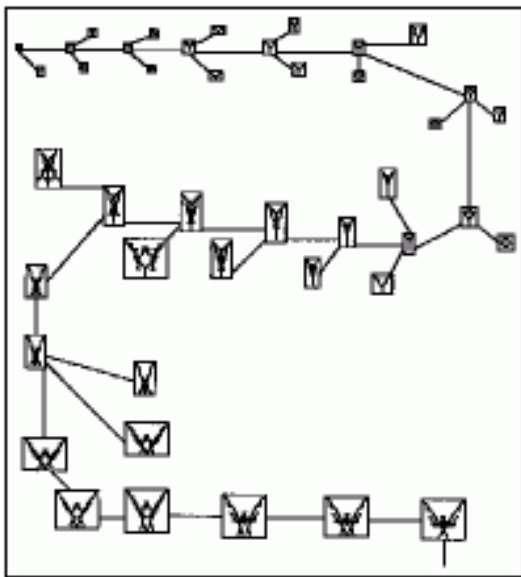


Fig. 3 Richard Dawkins' biomorph in the *Blind Watchmaker* (1987: 58).

The development of the GA by Holland and Dawkins proved extremely useful for evolutionary design. Instead of architects being the agents of design, algorithms that enact the process of natural selection, became the new designers of form. [4] Frazer explains that, “[t]he evolutionary model requires that an architectural concept be described in a form of ‘genetic code.’ This code is mutated and developed by computer program into a series of models in response to a simulated environment” (1995: 65). Frazer also makes important modifications to the original model of “optimization,” however. Instead of finding the best solution to a problem known in advance, following recent work in evolutionary and developmental biology, [5] Frazer argues that environmental

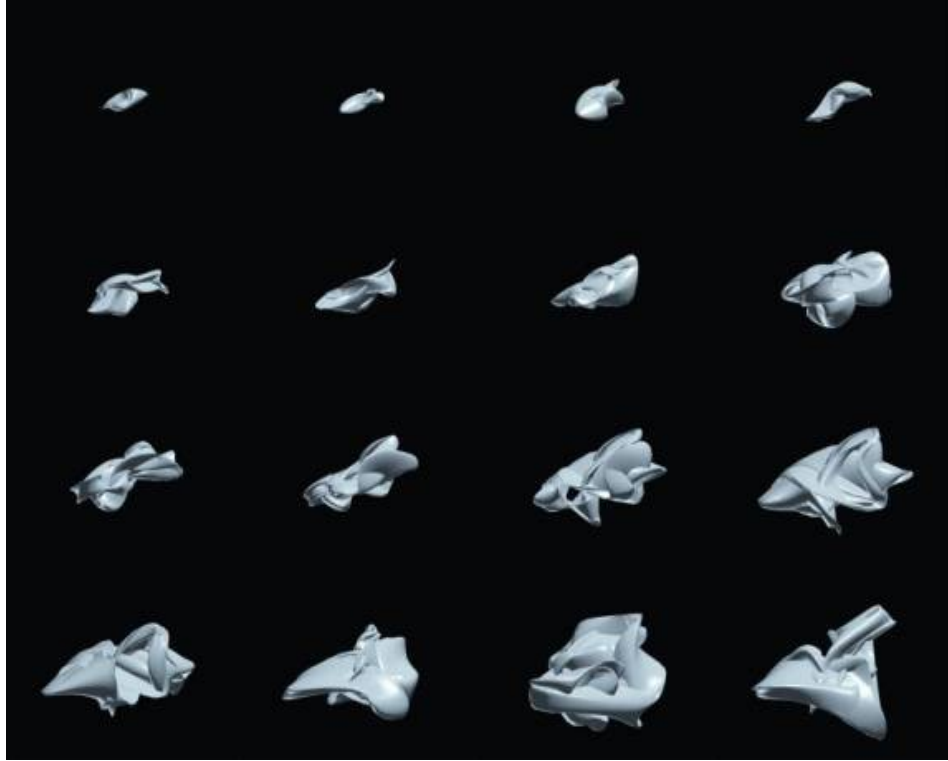
inputs constantly change the nature of the problem in need of a solution. In other words, the changing environment has to be accounted for in the development of a genetic-code script:

It has been emphasized above that DNA does not describe the phenotype, but constitutes *instructions that describe the process of building the phenotype*, including instructions for making all the materials, then processing and assembling them... these are all responsive to the environment as it proceeds, capable of modifying in response to conditions such as the availability of foodstuffs, and so on... This procedure is environmentally sensitive. The rules are constant, but the outcome varies according to materials or environmental conditions" (99).

With Frazer's adjustment, emphasis falls off of the production of one optimal solution, and is redirected onto the "production of a population that has learned to respond in an appropriate way to particular inputs" (59). To facilitate this computationally, "classifier systems" are implemented alongside generic algorithms in order to account for how a system perceives its current environment — as a "structural coupling" (103) [6] — and then generates an output that is positively or negatively fed back into the code-script. [7] Frazer considers this process closer to a living organism's ability to learn and respond to the changing nature problems in the environment than it is to optimization:

A Classifier system receives information from the environment, the information is checked against conditional rules (classifiers), and the rules are acted upon in order to output to the environment. This linking of detection, internal processing of information, and action is regarded as analogous to an organism perceiving information from the environment, thinking about it, and acting on it. If the action produced is effective, the organism receives some pay-off or reward, and this implementation of success is modelled in implementations of classifier systems (59).

Crucially, Frazer thinks that his form-finding algorithms parallel the evolution and development of biological systems so exactly that his "model of architecture exhibits the characteristics of metabolism, epigenesis, self-reproduction, mutability, which are generally agreed to be requirements of life" (1995: 55). [8]



**Fig. 4** *Interactivator*: Networked Evolutionary Design System (John Frazer, Julia Frazer, Mani Rastogi, Peter Graham, Patrick Janssen); image from Frazer, “Digital code scripts for generative and evolutionary design: De Identitate” (2004) (<http://www.generativedesign.com/asialink/de6.htm>).

Frazer therefore devises an evolutionary methodology for architectural design in which biological life is no longer mere inspiration for design (a vague metaphor), but is thought to share its computational logic. And because of this, he makes the strong claim that the architectural species he breeds are “in a limited sense, conscious” and “emerge,” he continues,

on the very edge of chaos, where all living things emerge, and [they] will inevitably share some of the characteristics of primitive life forms. And from this chaos will emerge order: order not particular, peculiar, odd or contrived, but order generic, typical, natural, fundamental and inevitable—the order of life” (1995: 103).

According to Frazer, computational architecture becomes a new site for the artificial sciences of life: the “functional” processes of life may be reproduced *in silico*. This parallels what philosopher of artificial life, Mark A. Bedau, remarks in his article, “Four Puzzles About Life”: “[l]ife is essentially a certain form of

process. The suppleness of that form makes the process noncomputational, but a computer simulation of life can create real life" (Bedau 1998: 130). This means, as Bedau continues, that life "cannot occur unless it is realized in some material, and although it cannot be realized in just *any* kind of material, the range of materials which *can* realize it seems quite open-ended" (134). It's hard to say whether all architects working under the auspices of "evolutionary" or "bio" architecture using form-finding computation would make the strong claim to artificial life (strong ALife) that Frazer seems to— instead, that is, of the weak claim (weak ALife) that architecture simulates but doesn't synthesize life. [9] What is nevertheless clear is that generative computation allows the reproduction of biological life to become a new horizon for architectural design. [10]

Form-finding computation makes possible a new parallelism between architecture and soft artificial life; but this only tells half of the story of architecture's becoming "alive": advances in mathematics and computer science have more recently been supplemented by advances in biotechnology and synthetic biology. This biotechnological turn responds to what some architects had begun to suspect was merely self-indulgent, digital form-generation that neglected the material pressures of the built environment. Michael Hensel and Achim Menges, for example, are critical of much of what has emerged from computational architectures and insist on the need to return to material and construction logics. They put it this way:

... the current use of CAD- CAM technologies in architecture serves more often than not as the facilitative, and affordable, means to indulge in freeform architecture. Although this may occasionally lead to innovative structures and novel spatial qualities, it is important to recognise that the technology serves merely as an extension of well-rehearsed and established design processes. Particularly emblematic is the underlying impoverished notion of form-generation, which refers to various digitally driven processes resulting in shapes that remain detached from material and construction logics... As these notational systems are insufficient in integrating means of materialisation, production and construction, they cannot support the evaluation of performative effects, and so these crucial aspects remain invariably pursued as top-down engineered material solutions (Hensel and Menges 2008a: 55).

If computationally driven design is capable of digitally simulating the biological world, it has so far been incapable of successfully incorporating material and construction logics into its design programs. CAD-CAM technologies are still driven by a top-down logic: the actual performance and behavior of materials is more of an afterthought than a co-driver in the design process. Matter, for all intents and purposes, is still inert and only given form by “immaterial code.” [11] If bioarchitecture wishes to be more than a species of computer science, then a more dynamic and robust relation between computation and materialization processes is required (cf. 2008a: 56). [12]

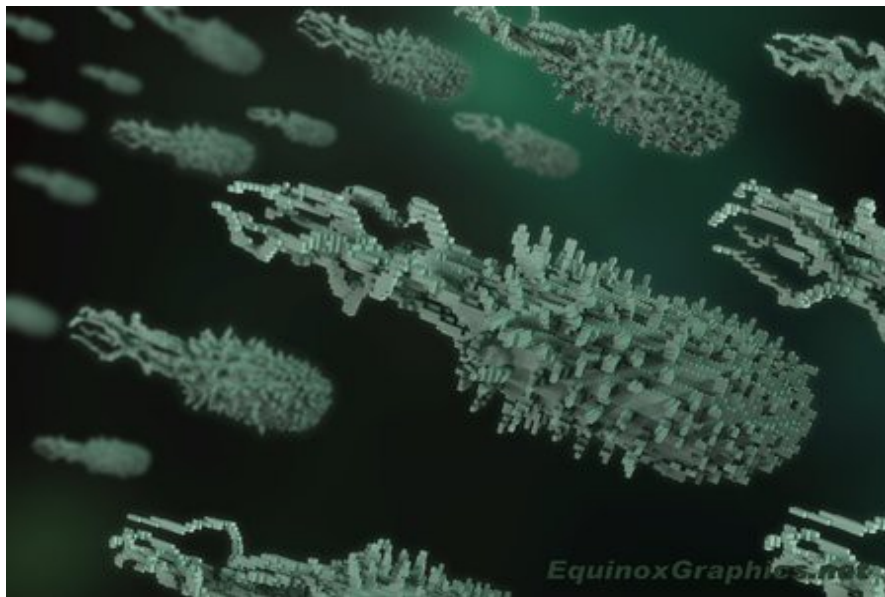
Thus, for many architects working under the banner of bioarchitecture, a “material turn” is underway; a return from what are deemed to be the mere functional performances of life in silico, to its material components, to its wet synthesis using biological materials as new media for design. [13] According to Hensel, this signals a true biological paradigm for architecture. Broadly, the idea is that in order to synthesize life, at whatever scale, one must work from its constituent parts, its “building blocks.” By returning to the molecular materials of life, to its very chemical supports, architecture aims to become biochemical and not simply digital-computational: [14]

It would seem logical and necessary to also include the molecular scale, which promises to yield a functionality of an as yet unrealised extent and to make possible advanced performativity and sustainability. Such an approach would involve biochemistry, the discipline concerned with the study of molecules and their chemistry in reactions that facilitate the processes that make living systems possible (Hensel 2006a: 19).

Hensel argues that recent developments in biotechnology, and especially synthetic biology, provide the means for the material transformation in bioarchitecture. Synthetic biology is itself a highly amorphous field that is hard to pin down. Broadly, it has been associated with the application of engineering design principles to living systems (cf. Carlson 2010: 83-86) according to three different, and not unrelated, models of design, each of which is associated with a scientific spokesperson: device-based standardized construction (“BioBricks”): Drew Endy; problem-focused re-engineering of microbes: Jay Keasling; and whole-genome engineering (the synthesis of an entire genome): J. Craig Venter. [15] A number of architects and designers are now actively using “bioparts” as

media for design, and directly collaborating with engineers and scientists. Projects such as “Synthetic Aesthetics,” jointly sponsored by the University of Edinburgh and Stanford University, and funded by the National Science Foundation (NSF) and the Engineering and Physical Sciences Research Council (UK), promote such “reciprocal collaboration,” fostering, as they boast on their website, the “designing, understanding and building [of] the living world” (<http://www.syntheticaesthetics.org/>).

Experimental architect and co-founder of *The Living* (<http://www.thelivingnewyork.com/>), David Benjamin, has been actively working with synthetic biologists and has been developing architectural pedagogy around such transdisciplinary collaborations. In short, he is thinking about how the standardization of biological parts, or the “BioBricks” model, may be transferred to the architectural context, so that biological parts, such as promoters (e.g. phage promoters), terminators (e.g., bacterial, yeast, and eukaryotic), and so on, may be assembled as systems for architectural application (<http://biobricks.org/>). This is analogous to the way different circuits are constructed in electrical engineering from different parts, following what is known as the “abstraction hierarchy” in engineering: there are parts designers and device and system designers. The application potential of this biotechnology increases substantially using this hierarchy, since you do not need to be a specialist in the chemistry to design an effective system (Cf. 2010: 83-88).



**Fig. 5** An image of LEGO bacteria based on the BioBricks, or LEGO, model of synthetic biology. Image from Equinox Graphics.

Leaving aside, for the moment, the ethico-political stakes of applying the abstraction hierarchy to biological systems, the seeming benefits of this biotechnology are overwhelming. For example, one of Benjamin's architectural students, who, with no previous knowledge of synthetic biology, proposed the redesign of yeast and microalgae by using synthetic biology so that these cells were able to convert sugar and sunlight into fuel, but by generating 80% less carbon than is typical. He was able to reimagine the fuel cycle with vast implications at multiple scales, including architectural. [16]

While using biomedica for design implies an incredible range of new performance capacities for designed systems, what is often sidestepped in this excitement is how life becomes "important" for the design practice. In what way does architecture's use of synthetic biology, along with its concomitant computational practices, make life matter for it? While it would be unfair to say that all architects working with synthetic biology are directly interested in "life definitionism," [17] it would be equally unfair to overlook how advancements in biotechnological application — most notably, BioBricks and its associated synthetic biological practices — have renewed hope in fulfilling Frazer's dream of a living architecture: to grow buildings with biomaterials. While Frazer admits that "it is [their] intention that the form-making process will be part of the system..." (1995: 99), this intention now seems realizable, at least in part, with the incorporation of biochemical materials, the "building blocks" of biological life. Hensel, for example, notes that,

the very notion of architecture that is alive may sound scary to some and blasphemous to others. However, what is proposed here is not a version of Mary Shelley's *Modern Prometheus*. Instead, it involves embedding into buildings the biochemical processes and functionality of life for the advantage of humans, other species and the environment (2006a: 25).

What is often missed in this enthusiasm, however, is how this biotechnological possibility — in which architecture is now biotechnology at a non-standard scale — also affords new limitations with respect to what life must be for architecture. Not only was life "functionally" isolated early on through computational

techniques: as what requires metabolism, reproduction, and self-maintenance; but with new biotechnological tools, life has become “materially” isolated as well: a finite set of biological parts that may be re-purposed for the design of an effective living system. With the twin advances in computation and biotechnology, what architectural design has gained in terms of technological application and flexibility it has also lost in terms of the elasticity of what living systems can be. So while architecture helps to extend the implications of what Melinda Cooper calls the, “destandardization of living systems,” [18] exploring how they may be repurposed at new and exciting scales with surprising functions, life is nevertheless materially and functionally isolated, which introduces objective criteria for what counts as life.

To put the isolation of life in a biopolitical register, it is through the deployment of very specific techniques and strategies (the exact nature of which have yet to be cased out) that computational and biological technologies are mobilized in order for architecture to become a privileged site for reproducing normative content for the living. Without discrediting how various technological interventions facilitate the performance of living processes at non-standard scales (cf., Hensel 2006a; Weinstock 2008), architectural form generation does not escape the normative reproduction of living systems. My concern here, then, is not that architecture borrows from the biological, engineering, and computational sciences. Rather, what worries me is that life acquires “importance” for architecture only insofar as it is normatively reproduced. A number of questions follow from this: does this reproduction exhaust the field of the living? Are there other architectural uses of biotechnology in which life acquires a more robust (or non-normative) sense of importance? Or does life’s importance for biotechnological architecture still require inventing?

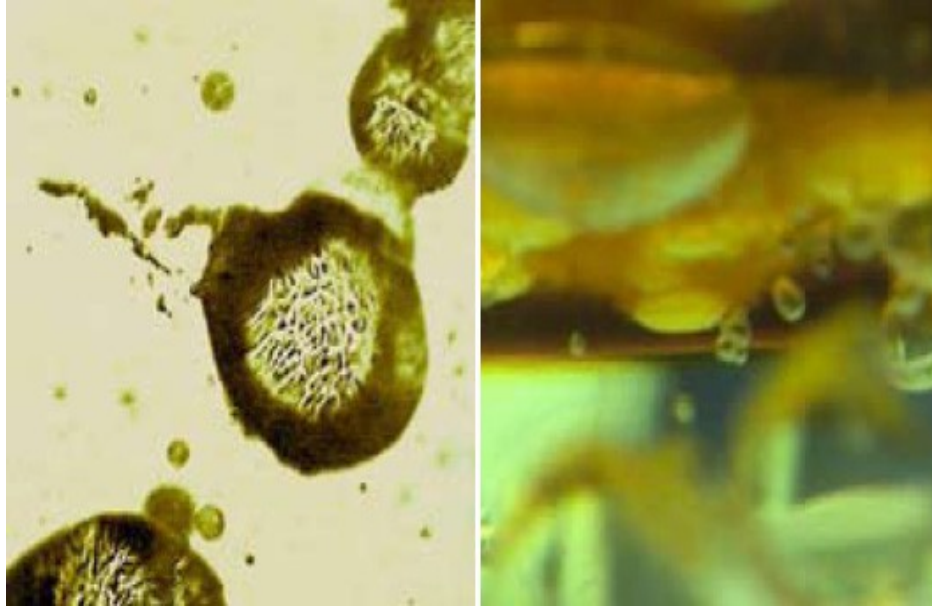
### **III. Life, “Out There” or “In Here”?**

To address these concerns, we should note that in the last decade a number of debates within speculative scientific communities — including the origins of life, astrobiology, and extremophile communities — have drawn considerable attention to how isolating a set of functional and/or material conditions for life is based on known, terrestrial chemistries that limit the possibilities for discovering

truly “weird” forms of life (Cleland and Chyba 2007; Sterelny and Griffiths 1999), from Earth-bound extremophiles (Rothschild and Mancinelli 2001), to other, non-terrestrial, living chemistries. In other words, the constant conjunction of life and biomaterials and functionalities is inherently limited by human perspective. In this view, any attempt at reproducing life — via biotechnological mediation, for example — based on a biocentric metric cannot help but reproduce anthropocentric criteria for the living, and may capture certain living processes associated with biological systems, but certainly not life as such.

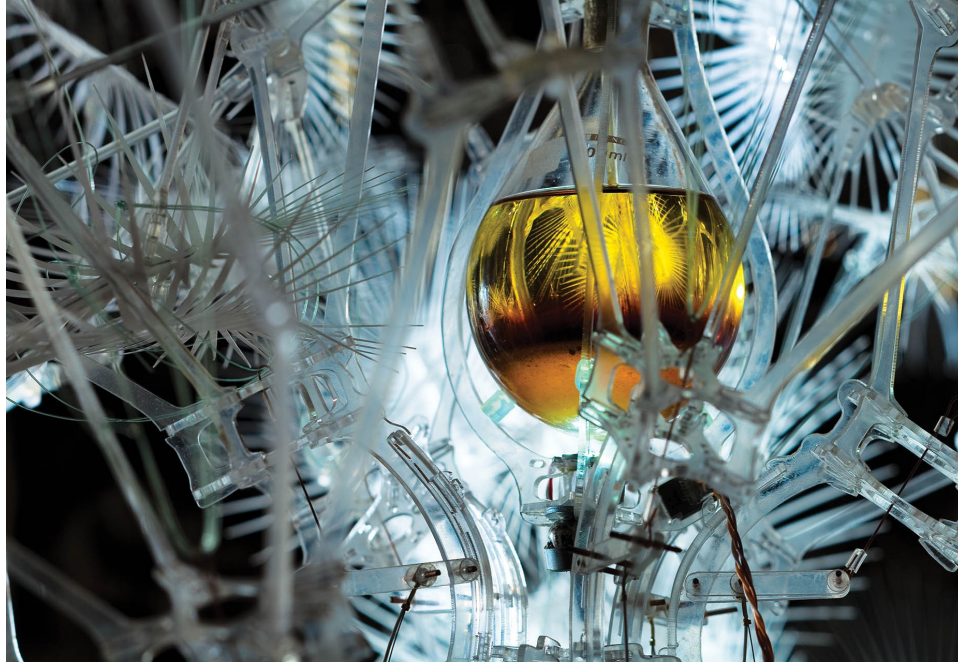
Simply stated, this consensus among speculative scientists of life is a damaging blow to the synthetic-life architecture described above. It’s important to note, however, that there are a host of architects and scientists using “living technologies” (Bedau *et al.* 2010) who are decidedly less concerned with biological-life synthesis, and far more interested in designing new potentials for living systems. The question of course is whether these technological mediations truly offer a non-biocentric conception of life for architecture.

In a recent issue of *Architectural Design*, Neil Spiller and Rachel Armstrong advocate the use of protocell technology for architectural research and development (Spiller and Armstrong 2011). While protocell technology is often associated with bottom-up synthetic biology, or wet ALife, whose goal is the synthesis of life *de novo* (Rasmussen *et al.* 2009; Bedau and Parke 2009), as an applied science in architecture, there is decidedly less emphasis on the synthesis of biological life as such, and more on the exploration of living processes. To this end, Spiller and Armstrong are indebted to the protocell research of Martin Hanczyc in his lab at the Institute for Physics and Chemistry at the University of Southern Denmark. In 2007 Hanczyc and his colleagues created a protocell using oil and water based chemistry that achieves dynamic motility (chemiotaxis) by remodeling its own chemical environment to generate the conditions (PH gradient) for motility (Hanczyc *et al.* 2007). These protocells are thought to be primitive metabolisms, sensing and transforming their environments.



**Fig. 6** Image of Protocells from Rachel Armstrong, “Self-Repairing Architecture” (2010) (<http://www.nextnature.net/2010/06/self%E2%80%93repairing-architecture/>)

There are a number of different species of protocells in existence now, and it is even possible to chemically “program” them to perform different tasks. [19] In this regard, they have even been thought of as “material computers” capable of rebuilding their environment (Armstrong 2011). It is no surprise that protocells have become an important new media of speculative design; they are a form of low-cost biotechnology, according to Spiller and Armstrong, that function as environmentally sensitive computing units capable of building their environment from the bottom-up. Armstrong, for her part, has been actively involved in promoting protocell technology as a way of generating an artificial reef to stop the sinking of Venice, Italy. [20]



**Fig. 4** Protocells in flask at the Venice Architectural Biennale 2010.

And yet there is no doubt in the minds of these researchers that these molecular globules are not living. Hanczyc *et al.* (2007) and Ikegami and Hanczyc (2009) affirm that their protocells possess some, but certainly not all of the properties of life. In this regard, their research modifies much of the extant protocell research (Rasmussen *et al.* 2009), since it advocates that protocells do not have to be alive to exist; they exist as the “first cell,” an achievement on the way to synthesizing life (Ikegami and Hanczyc 2009). Similarly, Armstrong notes that, “protocells are the transition stage towards the creation of fully artificial cells...” (2011: 18). In fact, Armstrong and Spiller are insistent that they are *not* building synthetic-life architecture: “Protocells do not operate within the realms of biological processes that are associated with living systems...” (21). Their technology is based on a chemistry and physics that opposes the tyranny of the DNA molecule. At times, they even speak with understandable disdain about the dogma of the natural world, and propose what they call the *unnatural* evolution of protocells.

For our purposes, it is significant that protocell architecture opposes the reproduction of the biological world, and seeks, in its place, a terrestrial chemistry with an unnatural history. But insofar as it opposes bio-materials and — functionalities, it also opposes life in their view; their terrestrial agents are

decidedly not alive. But this logic, I would suggest, reinforces a tyranny at another level: the constant conjunction of life and biology. While their research acknowledges that protocells explore processes “associated with life,” life itself is nevertheless a *state*, and it is one that their protocells do not fully achieve — they are “semi-living,” at best. [21] In this regard, protocell architecture promotes, in spite of itself, the same biocentric conception of life that synthetic-life architecture advocates. In setting itself against biology, protocell architecture reinforces the stronghold of biology over life.

It is no wonder, then, that some theorists, such as Evelyn Fox Keller, question whether there is any definition of life that will not be inherently limited by human perspective (Keller 2002: 265-294). Edouard Machery has recently argued that the sciences of life will always come up short on the problem of “life definitionism,” and so it is useless to continue trying to define it (Machery 2012). And in a slightly different register, by drawing on the philosophy of life from Aristotle to Kant, but also including the neo-vitalisms of Deleuze and Guattari, among others inspired by Spinoza, Eugene Thacker compellingly argues that life is a contradictory concept, and so what we need now more than ever is a “critique of life” (Thacker 2010). Thacker’s recent efforts have been touted as contributing to the popularity of speculative realism, materialism, and even nihilism in the continental tradition, arguably united by a critique of what Quentin Meillassoux identifies as “correlationism,” or the idea according to which, ever since Kant, we never have knowledge of an object as it is in-itself, our knowledge is always correlated to a subject. [22]

In this register, all definitions of life are fundamentally limited by their correlation to a subject, and so any architecture that commits itself to either the biotechnological reproduction or non-reproduction – as in the case of protocell architecture – of life by means of objective criteria is bound to run up against the conditions (whatever they may be – subjective, cultural, historical, etc.) for the emergence of the criteria. Of course Whitehead had already warned us that our scientific abstractions are fated to become contradictory when pushed to their limit: recall that “in science you have only to develop your argument sufficiently, and sooner or later you are bound to arrive at a contradiction, either internally within the argument, or externally in its reference to fact.” And that sufficient limit is a reference to “the myth of the finite fact”: that there could be a matter-of-

fact without larger environmental coordination is a myth. The significance of Whitehead's observations become particularly apparent with those practices that isolate life (limit it to a set of properties), but then continually run up against its wider conditions for isolation.

In many ways, this is the contradiction that Thacker articulates in his compelling, *After Life*: life is at once "out there," or "in-itself" and "in here, or "for us." Life is a contradiction, in Thacker's estimation, and so demands a "critique," which results in an ontology of life that is radically *nihil* (Thacker 2011: 266). Of course Whitehead is aware that you cannot separate what's in-itself from what's for-us in our consideration of natural phenomena. It is the denial of their constant conjunction, in fact, that produces what he spent the majority of his career trying to overcome: the bifurcation of nature. But whereas Thacker calls for the revival of radical nothingness, in *The Concept of Nature*, Whitehead takes the opposite tack by adding to our abstractions. He endeavors to construct a concept of nature that accounts for all that we are aware of in perception, both primary and secondary qualities, in order to resist the tendency of modern thought to bifurcate nature "into two systems of reality, which, insofar as they are real, are real in different senses . . ." (Whitehead 1964: 30). Although the demands of such a project have yet to be cashed out (and transform throughout his career), what's significant for us here, in any case, is that Whitehead takes on board precisely what Thacker claims cannot be: the subjective and objective nature of phenomena, in order that "all we know of nature is in the same boat, to sink or swim together" (1964: 148).

What's compelling is that Whitehead and Thacker seem to find very different solutions to a similar problem: the contradiction that pervades "nature" does not warrant its wholesale rejection, for Whitehead, but rather demands deeper "interpretation" (1978: 3). Where Thacker's nihilism may have once seemed like a bold gesture, surprisingly, Whitehead's proposal, now more than seven decades old, to move beyond contradiction and construct a concept that can put "all of nature in the same boat," seems more daring, or at any rate, involves more risk. Whitehead knew this, of course, and even embraced the all but certain "failure" of his project by noting that, "the aim at generalization is sound but the estimate of success is exaggerated" (Whitehead 1978: 7). And yet Whitehead's fallibilism does not spell metaphysical ruin or weakness, but is a hallmark of his

method: “there remains the final reflection,” insists Whitehead, “how shallow, puny, and imperfect are efforts to sound the depths in the nature of things. In philosophical discussion, the merest hint of dogmatic certainty as to finality of statement is an exhibition of folly” (1978: xiv). This helps explain why he claims, much later in *Process and Reality*, that “[i]t is more important that a proposition be interesting than true” (1978: 259).

This, at any rate, is the constructivist method to which I now turn in order that life may acquire a new mode of importance for biotechnological architecture. The challenge for this new strategy, of course, is resisting the “habit of thought” that divides life into essential and inessential properties, and thus reproduces the bifurcation of nature that Whitehead’s constructivism sought to avoid. As Isabelle Stengers insists in her *Thinking With Whitehead*, this bifurcating habit is insidious and is certainly not restricted to the sciences but pervades all modern thinking, from the inaccessibility of Kant’s “thing-in-itself” to Bergson’s duration that replaces science’s spatializing abstractions; in each of these cases, “philosophy destroys its usefulness,” according to Whitehead, by “indulg[ing] in brilliant feats of explaining away” (1978: 17). Thus, if life is going to acquire a rigorous sense of importance for biotechnological design, it will have to do so by means of a non-bifurcating mode of valuation. It is in order to understand the means for constructing this mode that I now turn to the specifics of Whitehead’s philosophic method.

#### **IV. Living Abstractions**

In *Modes of Thought* Whitehead writes that the “aim of philosophy is sheer disclosure” (Whitehead 1938: 49). But disclosure here cannot be confused with “unveiling” what is concealed, as if the latter always existed behind the veil. [23] For Whitehead, disclosure is more like the production of a “solution space,” as Isabelle Stengers describes it, that is inseparable from the problem to which it responds; there is no disclosure separated from its philosophical problem (Stengers 2011: 15-17, 112). [24] Although Whitehead’s problem transforms from his early work in *The Concept of Nature* to his later metaphysical reflections in *Science and the Modern World*, *Process and Reality* and *Adventure of Ideas* he is arguably consistent in his efforts to create a solution space that resists the

bifurcation of nature. The poet's musings about his or her experiences of the sunset are no more and no less essential to experience than the physicist's explanations of why s/he has these experiences. We tend to bifurcate all that we are aware of in experience by over-exaggerating the importance of certain abstractions at the expense of others; this is a modern habit of thought that Whitehead calls the "Fallacy of Misplaced Concreteness" (Whitehead 1967: 51).

Whitehead, though, is careful not to confuse our overvaluation of certain abstractions with the need to overcome all abstractions — as is the case with Bergson's "method of intuition," for example. "We cannot think without abstractions," Whitehead explains in *Science and the Modern World*, so we must be "vigilant in critically revising [our] *modes* of abstraction" (1967: 59). He places emphasis on our *modes* of abstraction here, not in order to "critique" abstraction as such — there are no unmediated experiences for Whitehead [25] — but in order to critique how we regard our abstractions, that is, the importance we give to them, so that "all we know of nature is in the same boat, to sink or swim together" (1964: 148). To do this, speculative philosophy must create abstractions, or "speculative propositions," that "lure" us into feeling our world differently (1978: 187,197), that lure us into experiencing our abstractions in such a way that there are no abstractions that are reduced to irrelevancy, or merely explained away. [26] Each item of experience "shall have the character of a particular instance of a general scheme" (1978: 3).

Thus, by the time of his metaphysical writings, Whitehead has become increasingly concerned with the *real transformation* of our modes of thought, so that in *Process and Reality* he famously likens speculative philosophy to the flight of an airplane:

The true method of discovery is like the flight of an aeroplane. It starts from the ground of a particular observation; it makes a flight into the thin air of Imaginative generalization; and it again lands for renewed observation rendered acute by rational interpretation (Whitehead 1978: 5).

Metaphysical abstractions find their verification, not in their depiction of a pre-existent world, but in their ability to transform our habits of thought according to the problem posed: resist the bifurcation of nature. Philosophic abstraction needs to land from the "thin air" of imaginative rationalization in order to verify itself,

to determine its success. [27] The importance of William James on Whitehead's thought cannot be overstressed at this point. Isabelle Stengers, for her part, makes the connection explicit writing that,

This is why the question raised by Whitehead will never be that of knowledge faithful to the truth of that experience. From this view point, Whitehead is, after William James, one of the very rare philosophers of the twentieth century to have faithfully envisaged the consequences of the Darwinian evolution for the classical problems of philosophy, that is, to have situated questions of truth not on the side of right, legitimacy, or authenticity, but on the side of its consequences (Stengers 2011: 112).

In his series of lectures, *Pragmatism*, James notes that, "the truth of an idea is not a stagnant property inherent to it. Truth *happens* to an idea. It *becomes* true, is *made* true by events. Its verity is in fact an event, a process..." (James 2008: 87). To see the James in Whitehead means to see how the latter's well-known, though no less troubling, proposition that actual occasions are the "Final Realities, or *Res Verae*" (1987: 22) is not a pre-existent truth [28]; its truth is an event determined by the experience produced. Speculative concepts are abstract materials that individuate experiences, generate them, so that a notion's truth is a consequence of the production of an experience that resists the bifurcation of nature. Thus, if "life," as Whitehead will claim in *Process and Reality*, "is the name for originality, and not for tradition" (1978: 104), then this must become true; its verity rests, in other words, on its capacity to produce a non-bifurcating experience, and not on whether it represents a life that pre-exists it.

Of course, Whitehead's association of life with novelty is far from a new one. Didier Debaise, for example, sees resonances in Whitehead's construction with C.S. Pierce's proposal that life is ubiquitous because novelty is ubiquitous in "The Doctrine of Necessity Examined (1892)." [29] Although the important difference is that Whitehead is not doing "Nature philosophy," where life and nature are identified (in *physis*). In this register, what requires explanation is not so much life, but its derivations, or stabilizations in such a way that? "it should be possible to explain novelty as well as repetition by the same principle" (Debaise 2007: 58). This is decidedly not what Whitehead is up to. "Life" and "tradition" are distinguished in his metaphysical scheme; but the challenge is to do so without letting nature bifurcate, as if there was inert "tradition," on the one hand, and creative "life," on the other. In what follows, then, I'd like to unpack

Whitehead's mysterious claim that, "life lurks in the interstices of each living cell, and in the interstices of the brain" (1978: 105-6), and suggest that this succinctly characterizes the differentiation of life and tradition without reintroducing an unnecessary division in nature. For this, however, we need to consider Whitehead's metaphysical scheme in more detail.

According to Whitehead, in order to remedy the modern "fallacy" of thought that produces the bifurcation of experience, an ultimate, generic principle is required; this is not in order to delimit the absolute limits of thought, but it is in order to constrain thought productively so that it may construct only according to what is exemplified by *all experiences*; without this obligation, philosophy once again "indulges in brilliant feats of explaining away." For Whitehead, "creativity is the universal of universals characterizing ultimate matter of fact," and is what explains the transition between the "many" and the "one"; "it is the ultimate principle by which the many, which are the universe disjunctively, become the one actual occasion, which is the universe conjunctively" (1978: 21). With the constraint of creativity, one of the oldest dualisms in Western thought – the "many" and the "one"—is overcome: every one, even the most repetitious one, is the coming together of the disjunctive many into a novel one, so that the many are then increased by one. "Creativity, many, one," these are the notions that "complete the Category of the Ultimate" in Whitehead's thought; all "more special categories" in his general scheme presuppose the Category of the Ultimate (21).

These other categories, then, elaborate the coherence of Whitehead's philosophical system (through generic notions such as actual occasions, eternal objects, prehension, and so on), and specify how "the many become one, and are increased by one" (1978: 21). For the purposes of our discussion, what matters is that an actual occasion (the first of the eight categories of existence) is what it is because of its integration of other actual entities. "It lies in the nature of things," writes Whitehead, "that the many enter into a complex unity" (31). And yet each occasion, as a space-time quantum of experience, doesn't simply repeat the past but *is* a definite and unique integration of the totality of the past. Whitehead must therefore explain how an actual entity is able to integrate all other entities—the many *becomes* one—while also becoming a novel one.

According to Whitehead, the actual entity decides on how it will integrate, or “prehend,” each perspective into the constitution of itself becoming a subject as a determinate “concrecence” of these perspectives. However, this concrecence is neither a fusing nor aggregation, but a *patterning*, such that each perspective in the manifold is woven into the oneness of a concrecing subject becoming itself without losing its unique character. For Whitehead, all entities become what they are through their prehensions of other entities. Prehension itself has a complex structure, consisting of three aspects: “(a) the subject which is prehending ... (b) the datum which is prehended [and] (c) the subjective form which is *how* subject prehends the datum” (1978: 23). The subject feels the datum in a particular way. The many data then grow together into a realized “perspectival harmonization.” This unity is privately felt as a “satisfaction” that withdraws from all future relation, as it perishes instantly, becoming objective datum — a “superject” — for future occasions to incorporate into their own becoming— “the many become one, and are increased by one.” [30]

And yet, for all the creative advance Whitehead affirms, an occasion cannot become anything at all. An occasion cannot completely outgrow its own environment, since *it is* an outgrowth of its environment. The antecedent world, the objectified world of past occasions, determines, to a large extent, what an occasion can become. There is order in the world of the occasion that limits its possible satisfaction. Order does not necessarily have a negative connotation in Whitehead’s view, though: in the right proportion, it allows the occasion to have a greater intensity of satisfaction for itself and for the future. [31]

Social order is not, then, an “add-on” to Whitehead’s theory of actual occasions that produces a bifurcation at another level (occasions and societies). [32] Rather, it offers an account of a particular kind of relatedness among actual occasions that explains the world of semi-stable objects we encounter in everyday experience—trees, rocks, bacteria, humans, etc. Social order arises when there is a common element of form, or a “defining characteristic” (a complex eternal object), [33] positively felt by occasions in a nexus, so that their diversity of satisfaction becomes “relevant diversity,” or contrast, unified by a defining characteristic. The common element of form, however, is not imposed from without, but is reproduced throughout the nexus of occasions “due to the genetic relations of the members of the nexus among each other, and to the additional

fact that genetic relations include feelings of the common form. Thus the defining characteristic is inherited throughout the nexus, each member deriving it from those other members of the nexus which are antecedent to its own concrescence" (1978: 34). [34]

"Tradition" is the name Whitehead gives to the inheritance of a common form in a nexus of occasions. It is the insistence of "efficient causality" in an occasion's concrescence. But within any social order, there is no one occasion that does not take a unique stand on its relation to the rest of the universe. Each occasion experiences a privacy that is unable to be shared by any other occasion, which is why Whitehead argues that all occasions are "essentially bipolar, physical and mental, and the physical inheritance is essentially accompanied by a conceptual reaction partly conformed to it, and partly introductory of a relevant novel contrast..." (1978: 108). Social order emerges from a shared relation among its members, but this is indissociable from the novelty immanent to the inheritance of a common form. Disorder is not opposed to order, then, it is in its interior, "lurking" within in it. Life is the name Whitehead gives to this disorder, so that "life lurks in the interstices of each living cell, and in the interstices of the brain" (105-6). [35] If life is "a bid for freedom," it is a freedom from tradition, from efficient causality, and is the insistence of final causality (104). [36]

What follows from this is that a society, a biological society for example, "is only to be termed living in a derivative sense," since it depends upon "the prevalence in it of living occasions" (1978: 102). But since there are no occasions that do not introduce some degree of novelty into the world, an "occasion may be more or less living according to the relative importance of novel factors in its final satisfaction" (102). This means that, "there is no absolute gap between 'living' and 'nonliving' societies" (102); there is always life lurking within social orders. It is true of course that some social reproductions require more inventiveness than others. The fact that the *Triops cancriformis*, or the tadpole shrimp, one of the oldest living species, has reproduced itself for so long in an ever-changing environment, testifies both to the insistence of a tradition, but also to its incredible capacity for adaptation, for originality, for the inventiveness of life. But to use biological life as the criteria for life is to introduce a difference in kind or nature between social orders, when there is, for Whitehead, only a difference in degree – "more or less 'living'" (102).

## V. Life, It's Important

The point of this excursion into Whitehead is not to generate a new concept of life itself that could see life in the materials of the built environment; Whitehead does not offer us such a concept. Life is an abstraction from experience, not a representation of it, whose aim is to transform our habits of thought. Recall that the “aim of philosophy is sheer disclosure” (1938: 49), and it is the disclosure, and not the concepts themselves, that “always will have the last word” (2011: 17). Concepts are necessary for the transformation, they are what generate it, but it is the transformation that is most important. To propose that life lurks in the interstices of each order is pragmatic: can it generate different habits of thought?

Whitehead's concept of life offers us a non-bifurcating way to characterize biological systems: they are no longer defined by a difference that makes all the difference. While the biological sciences have tended to privilege biological systems because their “defining characteristic” is “life,” Whitehead challenges us to regard life, not as defining characteristic, or a tradition, but precisely as the interstice that lurks within tradition. With this transformation, biological systems may possess incredible degrees of flexibility and inventiveness (when compared to non-organic systems, for example), but they are not of a different nature or kind from other ordered systems; their defining characteristic is not life.

For biotechnological architecture, specifically, life is no longer an objectively defined property (a tradition) that may be more or less reproduced within material systems. Rather, life acts as “lure for feeling” (as Whitehead calls all speculative propositions, cf. 1978: 25) the material systems designed and engineered by biotechnological architecture (biomaterial systems) as embedded within a much larger ecology of systems (biological, chemical, technological, social, political, etc.) that each have their own relative degrees of flexibility, capacities for adaptation, and so on. So although biomaterials may be extremely useful media for architectural design (including phage promoters, yeast, genetically engineered bacteria, and the inorganic chemistries of the protocell), to isolate them because they possess a defining property called “life,” is to reproduce, I would even say, a politically suspect hierarchy (an exclusionary tactic that resonates with the thanatopolitical declensions of biopolitics – cf.

Roberto Esposito's *Bios*) [37] because it fails to see how these materials themselves nest and are nested within vital environments that all pervade and require each other for their existence. It's not difficult to see, then, how Whitehead's metaphysics is a "philosophy of the organism," but in such a way that each social environment is pervaded by, and therefore dependent on, all the others (cf. 1978: 90).

To return, if only briefly, to the short film that I used to introduce this article, organic interdependency is precisely what biomimetic interpretations of the *Cathedral* miss: whatever vitality the cathedral may possess does not derive from a singular property that it possesses, but from an entire ecology of nested environments (from the travellers staff to the planetary movements) that are anything but passive. Dollens may be right that *The Cathedral* is an important model for thinking about "bio" architecture, but it is "important" only insofar as its "bio" materials participate in a complex ecology in which vitality is distributed throughout.

Of course in Whiteheadian terms, every system has its unique way of incorporating other environments. The way a protocell society maintains itself nested within the incredibly diverse societies of an architectural site is, for example, different from the way a staphylococcal (*Staph*) species of bacteria sustains itself within the larger society of the human body. These are differences we should celebrate in Whitehead's view, but without reducing them to differences in nature or kind as a consequence of exaggerating the impact of any one set of abstractions. [38] In this respect, there is not an isolatable Bio- or Nature- Thing in Whitehead since all systems are "instances of a general scheme" (1978: 3). [39] Whiteheadian philosophy is a critique of "Nature" in this regard. What this also means is that the "Natural" order is not something that could be differentiated from, as protocell architecture often tries to do. "Unnatural" evolution is only justified to the extent that it is a critique of over exaggerating the importance of the "Nature" abstraction ("mistaking the abstract for the concrete" (1967: 51)), not because it has produced a more "accurate" abstraction; to assume this, according to Whitehead, would enfeeble thought yet again.

Accordingly, to propose that life "lurks" within each order challenges much of what has passed as "living" or biotechnological architecture in the last few

decades. But this is not a challenge that generates a more exhaustive concept of life itself; rather, it is a challenge to our habits of thought. “Life is novelty” is a speculative proposition in Whitehead’s view. Its “importance” derives from the fact that it is a “lure for feeling” that is neither true nor false in itself; rather, it is a mediation capable of transforming the way the world is felt (1978: 191, 197). The proposition of life transforms our habits of thought, our thinking societies, and introduces interstices within these well-worn habits. Living architecture does not therefore signal a thought-independent state of affairs, a pre-existent world, or even a speculative project that could one day be built. Rather, life’s importance derives from its capacity to “lure” us into regarding architecture’s biomedica as immanently connected to all other singular achievements of order-disorder. In this way, life is abstract media that encourages us to regard the biomaterials of biotechnological design ecologically framework; but this is only on condition that thought can itself be “lured” into injecting a different dosage of disorder, or life, into its habits.

This is a very interesting article, on the necessity of a broader definition of the concept of life, and of the attention for what we define, and do not define, as life, particularly in relation to the emerging form of architectural design that relies on biotechnologies or biomedica. I am taking this occasion to suggest a few points that could help the author clarify and strengthen their already original, well researched and theoretically significant piece of work. The points that need correction or clarification are marked in the text. Basically there are just a few points that might gain from a better explanation or clarification and, more in detail, I think the text would gain in linearity and fluidity if the use of commas could be more carefully considered.

Particular attention should be given to the reading of Whitehead’s philosophy. I would like to clarify that my suggestions on this are not meant to be taken as explanations or guides on how to proceed in this reading, but simply as occasions to identify points that might generate critique or discussion, or as ways to indicate other possibilities of interpretation.

## Notes

[1] Cf. Michael Hensel and Achim Menges, "Designing Morpho-Ecologies: Versatility and Vicissitude of Heterogeneous Space" (2008).

[2] In their introduction to *AD Versatility and Vicissitude: Performance in Morpho-ecological Design*," Menges and Hensel suggest that we replace the tired rhetoric of "sustainability" with a more dynamic set of concepts, such as *versatility* and *vicissitude*: the former describing the behavior and performance of an organism, or building, in a context, the latter describing the "differentiation of the object and the dynamic of the environment" (Hensel and Menges 2008: 7). And 'ecology' captures the dynamic relation between organism/building and environment — hence a new paradigm: morpho-ecological design.

[3] In her fascinating article, "Symbiotic Architecture: Prehending Digitality," Luciana Parisi charts two major trends in bio-algorithmic architecture: the use of serial algorithms — genetic and evolutionary algorithms— associated with Neo-Darwinian thinking (Dawkins); and parallel or symbiotic algorithms, based on the logic of symbiotic parasitism, closely associated with Lynn Margulis' theory of endosymbiosis (Parisi 2009).

[4] See Parisi 2009.

[5] It is important to note that despite Frazer's indebtedness to Richard Dawkins, who pioneered the "selfish gene theory"—a gene-centered view of evolution—he is deeply committed to recent trends in evolutionary and developmental biology—e.g., Autopoiesis, Developmental Systems Theory, Evo Devo— that challenge the gene-centric view. In contrast to Dawkins, the gene is seen as only one among many factors that contribute to development and inheritance. Tim Jachna characterizes Frazer's understanding of the gene in the postscript to *An Evolutionary Architecture* as follows: "the notion of an ideal gene is useless. The merits of genetic information are revealed only in the process of their immersion in the context through the interface of the organism. Their meaning is purely relational" (1995: 115). For a thorough overview of the recent work in evolutionary and developmental biology, see Susan Oyama's *The Ontogeny of Information: Developmental Systems and Evolution*; Richard Lewontin's *The Triple Helix: Gene, Organism and Environment*; Eva Jablonka and Marion J. Lamb's *Evolution in Four Dimensions: Genetic, Epigenetic, Behavioral, and Symbolic Variation*

*in the History of Life*; and Sean B. Carroll's *Endless Forms Most Beautiful: The New Science of Evo Devo*.

[6] Although Humberto Maturana and Francisco Varela's theory of autopoiesis is not discussed at any length in Frazer's work, he characterizes the future of evolutionary architecture as autopoietic. He also speaks of the co-evolution of system and environment, which suggests connections to current work in Developmental Systems Theory (1995: 83, 103).

[7] Cf. D.E. Goldberg, *Genetic Algorithms in Search, Optimisation and Machine Learning* (1989).

[8] There are three generally agreed upon *minimal* functionalities of life: metabolism (or some form of resource transformation), inheritable information, and self-maintenance (or identity over time). Please see *The Nature of Life: Classical and Contemporary Perspectives from Philosophy and Science*.

[9] Proponents of strong ALife believe that artificial life systems, whether soft, hard, or wet, are *actually* alive (Langton 2003), while proponents of weak ALife believe that the systems merely simulate life processes. For a thorough analysis of the differences through the lens of 'functionalism' in philosophy of mind, see Elliot Sober's "Learning from Functionalism: Prospects for Strong Artificial Life" (2003). Bioarchitects themselves seem divided on this point. Following Frazer, Una-May O'Reilly, Ian Ross, and Peter Testa of MIT's Emergence and Design seem to make the case for a *strong* ALife program: cf., "Emergent Design: Artificial Life for Architecture Design" (2000); while designers and theorists such as Greg Lynn, Alisa Andrasek, Jenny Sabin, Roland Snooks, among many others, would simply make the case that they use biocomputing to explore living processes and not necessarily that they're synthesizing life as such.

[10] MIT's Emergent Design Group, once headed by Una-May O'Reilly, Peter Testa, and Devyn Weiser, has taken the opportunity to develop a number of experimental design tools that incorporate genetic/evolutionary computation and environmental modeling into different software packages; and in doing so they have brought architectural and artificial life research programs into new proximity. "Morphogenetic Surface Structures," or MoSS, and "Generative Form

Modeling and Manufacturing,” or *Genr8*, are two such experimental design tools. See Testa and Weiser, “Emergent Structural Morphology” (2002).

[11] Frazer confirms Hensel and Menges’ thesis, namely, that matter is only an afterthought, a passive receptacle for form: “[e]ventually it is our intention that the form-making process will be part of the system, but for the moment our model works by describing the process of processing and assembling the materials. The actual processing and assembly is external to the model” (1995: 99).

[12] Hensel and Menges go on to suggest that the “logic of computation strongly suggests such an alternative, in which the geometric rigor and simulation capability of computational modeling can be deployed to integrate manufacturing constraints, assembly logics and material characteristics” (2008a: 56). This means that the potentials for biological design, or even (artificially) living design, are extended further still, from digital form generation, to actual building performance and behavior. The logic of this digital-material biodesign unfolds, then, not by trading one for the other, the immaterial world of digitization for the concrete world of material sciences, but through a synthesis of the two; a design program “that derives morphological complexity and performative capacity without differentiating between form-generation and materialization processes” (56).

[13] Very broadly, there are parallels between the “material turn” in architecture and the “material/real turn” in recent continental philosophy. In philosophy, the return to the real and/or material is associated, most commonly, with a move away from what Quentin Meillassoux has called, “correlationism,” or the idea according to which, since Kant, there is no object without a subject— they are correlated (cf. Meillassoux 2008). In architecture, there is also a move away from computation as sole media of generative design (purely in silico), and an embrace of the complex material ecologies of design. See for instance, Michael Hensel, Defne Sunguroglu, and Achim Menges’ “Material Performance” in which they consider the performance capacities of wood and argue that it should be considered a “smart material.” Also consider Neri Oxman’s work on what she calls the “material ecology” of architecture in “Structuring Materiality: Design Fabrication of Heterogeneous Materials.” There have also been a number of

conferences that suggest such an overlap between philosophical and architectural materialisms. For example: “Proto/e/co/logics: speculative materialism in architecture” (<http://www.genware.org/agentware/blog/?p=85>) in 2011; and the “Leper Creativity: Cyclonopedia Symposium” on Reza Negerastani’s *Cyclonopedia: Complicity with Anonymous Materials*, also in 2011.

[14] “To pursue seriously the proposition of synthetic-life architectures it is important to take a close look at biological processes and materials, all the way down to the molecular scale, involving biochemistry in the understanding of the advanced functionality and performance capacity of biological organisms” (2006a: 19).

[15] For an overview of the field of synthetic biology, see Robert Carlson’s, *Biology is Technology* (2010); Paul Rabinow and Gaymon Bennett’s, *Designing Human Practices: An Experiment with Synthetic Biology* (2012); and Andrew Balmer and Paul A. Martin’s, *Synthetic Biology: Social and Ethical Challenges* (2008).

[16] See David Benjamin’s interviews with Metropolis here: [http://www.azuremagazine.com/newsviews/blog\\_content.php?id=1732](http://www.azuremagazine.com/newsviews/blog_content.php?id=1732). And yet, such innovation is not uncommon in the field of synthetic biology. The yearly undergraduate (and now including high school) synthetic biology competition, iGem (International Genetically Engineered Machine), testifies both to the ubiquity of innovation (not simply professional scientists), and the potential for far-reaching impacts of this technology. That iGem exists at all, that high school students are so easily able to manipulate DNA, raises any number of ethical questions about how to manage the risks of biohacking, bioterrorism, and national security with the rise of “amateur” or “citizen” scientists (<http://diybio.org/>), without being alarmist and needlessly impeding innovation.

[17] For example, Christophe Malaterre argues that, in the main (save bottom-up synthetic biology), synthetic biologists are unconcerned with life definitionism, or even the related question of the origin of life. See Malaterre, “Can synthetic biology shed light on the origin of life?” (2009).

[18] In her monograph, *Surplus Life: Biotechnology and Capital in the Neoliberal Era*, Melinda Cooper makes the case that the destandardization of life is inseparable from neoliberal investment in biological futures of flexibility and regeneration. She shows how the birth of genetic engineering, as a practice, is inseparable from the Regan administration's need for a political tool to denounce the environmental regulations of the Carter-era. She suggests that Regan created the economic conditions for recombinant DNA technology (rDNA) to flourish—through a series of reforms that made investment in biotech easier— as a basis for denouncing the Carter-era rhetoric of post-Fordist, economic and environmental “crisis.” If life could be “destandardized,” then there would be a foundation for the neo-conservative rhetoric whereby the biosphere was far from depleted, as was previously thought from industrialism, but could be turned into a new opportunity for investment – a post-industrial economy of flexibility, a *bioeconomy* (Cooper 2008: 25-29).

[19] The majority of the articles in the special issue of *AD Protocol Architecture* 2011 are devoted to speculating about what this technology can do. See especially, Philip Beesley and Rachel Armstrong's “Soil and Protoplasm: The Hylozoic Ground Project” (2011) and Neri Oxman's “Proto-Design: Architecture's Primordial Soup and the Quest for Units of Synthetic Life” (2011).

[20] Cf., “Self-Repairing Architecture” (2010): <http://www.nextnature.net/2010/06/self%E2%80%93repairing-architecture/>

[21] The question of the “semi-living” is something for which Oron Catts and Ionat Zurr's explore in their Tissue Culture and Art Project (<http://tcaproject.org/>).

[22] See Quentin Meillassoux's *After Finitude* (2008) and Ray Brassier's *Nihil Unbound: Enlightenment and Extinction* (2010), especially Chapter 3, for a thorough explanation of correlationism.

[23] This is a point that cannot be overstressed. *Pace* what a good deal of recent commentary from the speculative realist community may suggest, Whitehead is not discovering a pre-existent, thought-independent reality. Recent work in object-oriented ontology, for instance, seems to overlook this fact (cf. Harman

2002: 231-233). Although Whitehead claims that actual occasions are the “*Res Verae*” (Whitehead 1978: 22), this is not to say that occasions are the new subatomic particles, that is to say, the new ultimate bits of reality that we may one day discover; this would bifurcate nature, relegating certain experiences to irrelevancy. Occasions do not pre-exist their philosophic construction. They are abstractions from experience that serve the purpose of transforming experience. In this regard, Whitehead is far indeed from the pre-Kantian dogmatism of which he has often been accused. Isabelle Stengers has done important work dispelling this myth in her *Thinking with Whitehead* (2011).

[24] There is an important overlap between Whitehead’s problem-based constructivism and the constructivism of Deleuze and Deleuze and Guattari. In *What is Philosophy?* (1994) Deleuze and Guattari write that, “a concept lacks meaning to the extent that it is not connected to other concepts and is not linked to a problem that it resolves or helps to resolve” (79). Also see Isabelle Stengers marvelous discussion of the relation between Whitehead and Deleuze-Guattari on the construction of an “image of thought” in her *Thinking with Whitehead*. She writes that, “[s]peculative propositions [Whitehead’s] do not designate a world that exists prior to them, but, quite the contrary, they bring into existence what Deleuze and Guattari call an ‘image of thought,’ in the sense that such an image coincides with a ‘thought without images,’ that is, without a stopping point that makes words and things coincide in a satisfactory way” (2011: 267).

[25] In this regard, despite the sympathies Whitehead has for Henri Bergson, noting that, “[o]ne of my great preoccupations has been to rescue their [Bergson’s, James’, and Dewey’s] type of thought from the charge of anti-intellectualism...” (1978: xii), Bergson’s method of intuition seeks to be “transported into the interior of an object in order to coincide with what there is unique and consequently inexpressible in it” (Bergson 1968: 190). For Whitehead, by contrast, philosophic concepts are speculative abstractions that leap into the “thin air of Imaginative generalization” (1978: 5). For a careful discussion of Bergson’s intuition and Whitehead’s abstraction see Didier Debaïse’s “The Emergence of Speculative Empiricism: Whitehead Reading Bergson” (2009).

[26] In *Process and Reality* Whitehead writes that, “Philosophy destroys its usefulness when it indulges in brilliant feats of explaining away” (1978: 17).

[27] This is the “empirical side” of rational systematization: the adequacy and applicability of the system. Whitehead writes that, applicability “means that some items of experience are thus interpretable, and [adequacy] means that there are no items incapable of such interpretation” (Whitehead 1978: 3). Suffice it to say here that the rational requires experience for its verification; its truth is dependent on whether it can transform experience so that any item of experience is affirmed in terms that do not reduce any experiences to irrelevancy.

[28] This is the great relevance of Whitehead’s work on the speculative proposition. In contrast to his early work with Bertrand Russell in the *Principia Mathematica* (1910, 1912, 1913), by the time of *Process and Reality* Whitehead suggests that a proposition is neither true nor false, but is more importantly, a “lure for feeling,” a way the world could be felt. The truth of a proposition is an additional qualification that depends on whether the predicate is actually realized in the nexus physically felt (Whitehead 1978: 187-188).

[29] See Didier Debaise’s, “Life and Orders—A Speculative Approach to Life” (2007) for a thorough discussion of the relation between nature, order, and life in Whitehead.

[30] Whitehead’s three-fold doctrine of prehension counters the tradition of substantialist metaphysics. Whitehead asks: “how can ... other actual entities, each with its own formal existence, also enter objectively into the perspectival constitution of the actual entity in question? ... The classical doctrines of universals and particulars, of subject and predicate, of individual substances not present in other individual substances ... alike render this problem incapable of solution. The answer given by the organic philosophy is the doctrine of prehensions, involved in concrescent integrations, and terminating in a definite, complex unity of feeling” (Whitehead 1978: 56). See Judith A. Jones’ *Intensity: An Essay in Whiteheadian Ontology* (1998), for one of the best available works on the interpenetration of actual entities in Whitehead’s metaphysics; it challenges much of the classical Whiteheadian scholarship (Leclerc, Christian, Ford) in which a sharp, ontological distinction exists between subject and superject, by proposing a more “ecstatic interpretation,” where there is no absolute distinction—or ontological dualism—between superject and subject.

[31] If, for example, the world of the occasion is excessively diverse, displaying no coordination among the datum, then in Whitehead's words, the synthesis of the datum will be "trivial," arising from "lack of coordination in the factors of the datum, so that no feeling arising from one factor is reinforced by any feeling arising from another factor" (1978: 111). But if, on the other hand, there is an excess of coordination among the datum, so that there is too much identity in the world of the concrescing occasion, then there is "vagueness," or an excess of narrowness over width in the data synthesized, so that "the contrasts between the various objectifications are faint, and there is deficiency in supplementary feeling discriminating the objects from each other" (111). An intense satisfaction therefore arises from the proper *dosage* of order and disorder in the world of the occasion: too much order, the satisfaction is too narrow and has vagueness; too much disorder, the satisfaction is too wide and has trivial value. The right dosage of order and disorder is the condition for intensity of satisfaction.

[32] That "societies" may be an unnecessary, or even bifurcating, "add-on" to Whitehead's scheme is a common critique among object-oriented ontologists.

[33] Very basically, an eternal object is meant to account for the potential forms of definiteness that are actualized in an occasion's concrescence. In other words, in one occasion's prehension of another, there is no direct causal transfer (efficient causality); the occasion must select from the infinite ways of *potentially* feeling another entity enter in its own constitution. These "pure potentials" are called "eternal objects," precisely in order to emphasize how potentials are never exhausted by their actualization in temporal occasions (cf. 1978: 22). For more an extensive account of the significance of Whitehead's notion of eternal objects, please see Stengers 2011, 206-217.

[34] What's important to remember here is that there are no self-contained societies of occasions. Every society participates in wider societies, providing larger environments of order. In this sense, every society requires other societies for its support; the wider society provides the more general characteristics required for the maintenance of more specialized instances of order – e.g. molecule, cell, organ, nervous system, etc. The most appropriate way to think about this is terms of nested environments that penetrate each other (hence the

“organic model”), so that any given occasion of experience willprehend all environments it includes and is included within. The existence of a specific order – biological, physical, and so on— requires an extended network of support, which means that any a disruption in a wider environment could be detrimental for a more specialized one. According to Whitehead, “the doctrine that every society requires a wider social environment leads to the distinction that a society may be more or less ‘stabilized’ in reference to certain sorts of changes in that environment” (1978: 100).

[35] Stengers writes that, “[o]ne will not oppose living societies and novelty, habit and freedom, conformism and autonomy. Rather, one will ask the question of what social belonging makes possible... Living societies are not opposed to life; they are what ‘shelters’ the interstices in which life lurks...” (2011: 323).

[36] Whitehead writes that, “[e]xplanation by ‘tradition’ is merely another phraseology for explanation by ‘efficient cause.’ We require explanation by ‘final cause.’ Thus a single occasion is alive when the subjective aim which determines its process of concrescence has introduced a novelty of definiteness not to be found in the inherited data of its primary phase” (1978: 104). See Steven Shaviro’s excellent discussion of Whitehead’s use of efficient and final causality in his *Without Criteria: Kant, Whitehead, Deleuze, and Aesthetics* (2009: 86-89).

[37] In Roberto Esposito’s, *Bios: Biopolitics and Philosophy*, he argues that in order to reverse the thanatopolitical declensions of biopolitics throughout the twentieth century (that saw its most intense articulation in Nazism) there can be no form of life that does not express life (Esposito 2008: 194); there can be no normative criteria for exclusion. There are many problems with this suggestion, one of which is that Esposito uses Gilles Deleuze’s concept of “a life” from his last essay, “Immanence: A Life,” without adequately distinguishing between “life” and the “living.” What Esposito misses, then, is that a life is radically indifferent to individual lives (it is the immanence of immanence, according to Deleuze), and cannot be used in the service of lefting lives. But as such, a life is indifferent to any absolute distinction between organic and inorganic, and so on this basis, a life is immanent to all orders – organic and inorganic. Thus, the biological order reintroduces another criteria of exclusion. I would argue that this is deeply similar to Whitehead’s thesis that life is a “bid for freedom” from “tradition,”

and that life *as such* is wholly indifferent to the maintenance of any specific order, including biological; in fact, it is precisely what works against it.

[38] It may seem that the Whiteheadian argument for life is subject to what Cary Wolfe, in his monograph, *Before the Law*, identifies as the problem with the radical “equality” of life – from humans to microbes – that is prevalent in the affirmative biopolitics of Roberto Esposito. On Wolfe’s reading, insofar as the principle of life functions as an equalizing force that forbids any normative criteria of exclusion—since every form of life expresses *a life*, or as Esposito writes, “every life is a form of life and every form refers to life” (Esposito 2008: 194)—there is no essential basis on which to found exclusion. There is radical equality in the plurality of expressions – from microbes to humans. The problem with this view, especially when framed in these terms, is on the hand, philosophical: *a life* is not itself “living,” it is never “Life-in-itself” (a criticism that invokes Eugene Thacker’s critique of Deleuze’s vitalism, where life is never “in itself”); and on the other hand, practical: it rehearses all those tired debates of deep ecology that, in Wolfe’s view, exposes the problem of placing equal value on all forms of life: “As Tim Lukes notes, if all forms of life are given equal value, then we face questions such as the following: ‘Will we allow anthrax or cholera microbes to attain self-realization in wiping out sheep herds or human kindergartens?’” (Wolfe 2013: 59). And even if there were those who proclaimed, “Yes! Let cholera express itself, even if it means human death,” this still doesn’t resolve the biopolitical problem since, demographically, poor populations of colour would be the ones to suffer the most, producing, yet again, a non-equivalence in life. This is precisely the kind of criticism that Whitehead avoids, since life is not in the service of valuing organisms – or societies – but is precisely what lurks within them, and is what even “robs” from them. Hence, Whitehead’s famous proclamation, “life is robbery” (Whitehead 1978: 105), is far indeed from valuing every form of equally.

[39] In this regard, certain aspects of Whitehead are compatible with the work Timothy Morton is doing on ecology without Nature. See his *Ecology without Nature* (2007) and *The Ecological Thought* (2012).

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