BioIntelligent Beehive as Architectural Data

#1: What a Beehive Can Teach Architecture

The Transparent Beehive by Annemarie Maes.
See: http://annemariemaes.net/presentations/bee-laboratory-presentations-2/sensorial-skin-at-resonances-ii-ispramilano/

For most of the past decade, Annemarie Maes has been growing, hacking, digitizing, building, and thinking about beehives — particularly those in urban areas. Her constructed, prototyped, and grown hives are not immediately recognizable in classic forms of basket or wooden-box apiaries. Collaborating with a team of biologists, she is reconceptualizing what a beehive is and what it can be. Through the beehive she is addressing urban ecology, politics, and social systems. In this sense, what she builds or grows is recognizable as belonging to the realm of biological growths, found in nature and culture, and known in theory as animal, extended phenotypes.

Animal extended phenotypes are built structures biologically instigated (sometimes thought of as instinctual), physically built — extended — from the animal's individual or collective genotype/phenotypes. Such constructions demonstrate adaptability to manipulate environmental conditions, geography, and available materials to result in shelters or to lure mates or prey. They are defended, maintained, adaptive, and (sometimes) social spaces establishing architectural adaptability by intelligent species other than our own. In the natural world, extended phenotypic structures — spider webs, bird nests, termitaries, cricket burrows, etc. — represent, before their materialization, constructions built using intelligence related (but not equivalent) to our own realms of sensory, perceptual, responsive cognition — and this holds, in varying degrees, across all living organisms: animals, plants, microbes, and in special conditions, to AI and what Alan Turing called thinking machines.

This article is looking into Annemarie Maes's research, exhibitions, and thinking as environmentally applicable to biodigital architectures.

#2. The Republic of Urban Pollination

The Intelligent Guerrilla Beehive. 2017. Annemarie Maes.

I came to Maes's work because her experiments connect living, intelligent systems and technology/biosciences with social (colony/urbanism) architectural and technological prototyping and experimentation. Her work illustrates radical and necessary ecological searches for sharing urban life. Equally, her toolset and research trajectory crosses paths with my own investigations, positing microbial life and algorithmic generation for bioremedial buildings — both, with the use of technology and instruments, such as scanning electron microscopes (SEM), sensors, and computation.

Today, I'm considering the captions and images in Maes's The Transparent Beehive (TBH) (https://issuu.com/annemariemaes/docs/transpbeehive2), and reading them in relation to her project called: Sensorial Skin at Resonances II, ISPRA/Milan (http://annemariemaes.net/presentations/bee-laboratory-presentations-2/sensorial-skin-at-resonances-ii-ispramilano/). The Transparent Beehive book functions for this blogpost as an introduction to how Maes's research operates between experimental urban horticulture, scientific research, and metabolic architectures. It's a guide to her artistic vision and ways she evolves processes to realize forms, materials, and biological monitors. Particularly important to me, is her analyses of bees and pollen from SEM images because they depict relational form/material assembly in overlapping complexity with artistic sensibilities. By engaging complexity, Maes builds into the project first-hand observation, laboratory probes, and digital monitoring for testing in research gardens, overgrown urban lots, and rooftop apiaries.

In this view, the SEM images feed morphological development and idea generation. The book prepares us for current work witnessed in Sensorial Skin (Museum for Science and Technology, Milan. 21 September – 22 October 2017). For the exhibition, her project called, "The Intelligent Guerrilla Beehive," deploys the word/concept — guerrilla — as the operand-framework for urban beekeeping — an undertaking of environmental action and ecological mindset, participatory with municipal, wild, scientific, and artistic life. As readers and viewers, we are confronted both with works of art and a political statement supporting the integration of nature as a social/sensory/phenomenal (living) matrix. Such a matrix is imaginable in collaboration with bees and their foraging and honeymaking — from which species justice and ecological survival become dialectical urban activities and concerns. The resulting practice/theory, emphasizes fairness to nature represented amid species. Specifically, it draws attention to fragile affinities between humans, bees, bacteria, and the urban neighborhoods they symbiotically inhabit. From my perspective — looking from metabolic architectures, AI, and living technology — practice/theory is foundational for recognizing species' intelligence and ways of collectively communicating them into the domain of intentionally designed processes for bioremediating climate change. Consequently, TBH may be read and viewed as a handbook for action plotted between species cohabitation.

If The Transparent Beehive is studied as a forerunner to Sensorial Skin, a common thread will likely stich together thinking supporting urban-oriented agriculture and multispecies cohabitation. In fact, the introduction to the TBH, by Luc Steels, is titled: "Creating Ecological Corridors in Cities." Ecological corridors in a living/working urban jungle, are a huge and valid concept — a cartography of intelligence that maps bee-demographics wherein bees are shareholders in the landscape of cognition — prime citizens in the Republic of Pollination. In this realm, Maes speaks of urban awareness and learning:

I organize bee-friendly botanical walks through the city center to raise awareness about the plant diversity in our urban ecosystem. . . And, if necessary, the city is made greener by acts of guerrilla gardening: vacant lots are bombed with seedballs filled with a flower seed mix for pollinating insects (TBH 2013 p168 Fig 74).

Two pages on, she writes:

Honeybees are good bio-indicators. Biological indicators are species that are used to monitor the health of their ecosystem. . . . honeybees are generally doing well in the city. City honeybees have more food diversity, and less problems with pesticides and monocultures (TBH 2013 p172 Fig 76).

These statements are four-years in advance of Sensorial Skin, but compatible with the Milan show's developmental trail where the beehive becomes a site of metabolic architectural bioremediation and genetic transmission — maintaining hive functions while embedding biological actions to assist colony inhabitants resist Varroa destructor mites. As we learn, Maes and team are evolving a radically new beehive as a:

. . . mobile shelter for swarming honeybees . . . designed for urban environments. It supports the bee colonies in their pollination tasks. . . . The research and development of the device have also been a starting point for exploring possible futures through artistic experiments in materials science and biotechnology.

The team collaborating with Maes includes biologist/computer scientist Núria Condé Pueyo, microbiologist Laura Gribaldo, and environmental engineer Paulo Rosa. Maes frames their experiments for bacterial biofilms, where, of special interest, insect/microbe architectures, bee nature, and urbanisms/architectures interface. Here we encounter techniques and ideas with wide spectrum potential, focused toward bees and hives, but this focus also applies to experimental bioarchitectures and bioreactive materials. The interface Maes explores is open — nature-to-technology and species-to-hive, -nest, -house, or –skyscraper expressed in biological theory as extended phenotypes. Elsewhere, I theorize machine-to-building intelligences (Can buildings think?) and how to organize them involving species (animal, plant, microbe, machine) as Extended Autopoiesis (Dollens 2017). In following posts, I return to some specific junctures involving biofilms as hybrid living components to discuss implantation of living organisms into architectural composites for roles, in Steels's words as, ecological corridors in cities — advanced in Maes's biofilms.

Dollens, Dennis. (2017) Metabolic Architectures: Turing, Sullivan, Autopoiesis, & AI. ESARQ & SITES Books.

Post #3. Biofilms & Robobees

Biofilm from Sensorial Skin. Annemarie Maes.

Maes writes that an, “aspect of the Transparent Beehive [is] to challenge how the relation between nature and technology is understood” (Alchimia Nova p2). Her intention to refocus nature-to-technology in debate not only tracks through the Transparent Beehive, it continues to test materials in her works surrounding, “The Intelligent Guerrilla Beehive.” Her ongoing research reminded me of a comparison John Markoff made in 2014 between AI and bees. He wrote in the New York Times about an IBM project called TrueNorth, involving “electronic ‘neurons’” and neural nets for computational intelligence, saying the chip:

[T]ries to mimic the way brains recognize patterns, relying on densely interconnected webs of transistors similar to the brain’s neural networks. . . [to function as] electronic “neurons”. . . (Markoff 2014).

In addition to the nature-to-cognition-to-technology ontology consistent with Maes’s intention, Markoff drives home his description saying, “TrueNorth has one million [electronic] ‘neurons,’ about as complex as the brain of a bee.”

Markoff’s comparison suggests trade-offs we make when discussing nature vis-à-vis technology, regardless of mitigating factors and liminal conditions. If a reader infers that IBM's breakthrough (circa 2014) chip was as intelligent as a bee — a vast realm of mitigating factors would be overlooked. The chip is not sentient, it's not perceptive, it doesn't see, feel, navigate, communicate in the language of a dance, collect plant matter to make honey, or participate in communal architecture (hive) building. The chip may have a neural net that in some realms is comparable to that of a bee's brain, and even be able, when toggled to an array of other digital sensors, simulate performative intelligence, it is, nevertheless, not animate and therefore only metaphorically beelike. My point here, is that simple expectations of biological performance in human-made objects/tools/machines ought to be seen in a context of full-spectrum cognition/intelligence. A microchip and a bee are differently intelligent — this distinction quietly underpins Maes's exhibition, Sensorial Skin (See Post #2 for website).

While Maes does not emphasize robotics her experiments with performative properties for materials establishes areas of overlap. Herein, my interjection of robobees is a device for comparison between biorobotic actions and biomaterialized environmental performance. Efforts to build robotic intelligence and bioactions into biorobotic bees — robobees — for one example, is machinic and presents some cross-logic considerations between say a biofilm enactive beehive vs. a biorobotic machine. In the robobee's case, a programmed, AI is tasked to pollinate in manners like bees and other pollinating insects. Its intelligence is of a limited, performative sort, more closely related to a smartphone than to a living organism.

Robobees are thus a response to potentially catastrophic events that would necessitate supplementing insects as pollinators — without question robobees lack bee dynamics used in collaboration with nature for making honey, supporting hive society, and reproducing (nor were they ever intended to participate in such activities). I support the goals of research involved in AI, and see in biorobotics, steps urban architecture must take to engage the environment. For this post, robobees specifically illustrate a case distinction, the binary of nature/machine. And, because Maes's project vision suggests that, while recognizing, valuing, and incorporating machine intelligence, her use of technology and analysis transcends machines as inanimate and allopoietic, to arrive at complex visions. The vision incorporates bacteria as contributing agents enabling her Guerilla Beehive to autonomously interact with the bees, mites, humans, and urban environment.

In a relational analogy, if a building is a machine, why isn't a beehive or a spider web or a bird nest also a machine? In Maes's research, the resulting beehive prototype is only in name and scale, different from an experiment for a tall building's cladding. Under the conditions of her investigations, I find analogies for building and neighborhood materialization following precedents she demonstrates in the bacterially-aided, bioremedial beehives. In my mind's-eye, they serve as engines-of-thought, as well as physical models, for biological actions in conjunction with technological fabrication appropriate to envisioning metabolic architectures.

The trajectory of Maes research then expands beyond the simple binary machine/nature, to unfold as machine intelligence partnering biological intelligence. It is more A Thousand Plateaus multiplicity recognizing various types of existent intelligences (including AI) with the task of theoretical synthesizing urban environments and wild nature. In this instance, the design brief is against mites and neonicotinoid pesticides while also promoting goals of multiplicity recognizing the urban role for bees as citizens living in urban proximity with humans.

Here then, Maes's work remixes the cultivation of Urban Nature. It emphasizes that intelligence and responsiveness are species relative. It recognizes a topology of intelligence where — once types of intelligence are categorized — AI and ALife may come into focus as genuine behavioral attributes collaboratively deployable. Consequently, parts of Maes's project is extendable to biorobotic and architectural where technology manifested, say as robobee pollinators, may enact genuine (if limited) bee behavior. Clearly, I do not suggest that robobees have equivalence with the wide-spectrum intelligence of Apis mellifera — but I do suggest, biofilms and biorobotics have conceptual, behavioral, and machinic similarity, and that they align machines and AI with us and with bees as biointelligent agents. Related in this context of AI and life/intelligence, Christopher Langton wrote:

. . . living organisms are nothing more than complex biochemical machines. . . A living organism is not a single, complicated biochemical machine. Rather it must be viewed as a large population of relatively simple machines. The complexity of its behavior is due to the highly nonlinear nature of the interactions between all of the members of this polymorphic population. To animate machines, therefore, is not to “bring” life to a machine; rather it is to organize a population of machines in such a way that their interactive dynamic is “alive” (Langton 1988/1989 5).

Between nature and technology, Maes’s investigations take on precise types of intellectual scaffold building, calling into question not only machine-to-insect intelligence, but questioning how we deal with biological performance in hybrid materials. The question is delicate since material-hosted actions, like those involving bee intelligence, may be supplemented by microbial and bacterial intelligences producing new, sometimes unlikely, hybrids. Materialization aspects of artistic production then enter realms of science where collaborative investigations mentioned in Post #2 (below), engage as composite realms anchored by Maes’s research. Hereafter, in nature populated by intelligences of bees and plants and machines and buildings, a collective matrix emerges requesting recognition and cultivation in order for behaviors of organisms (beehives) and machines (also beehives) to be understood as genuine attributes of physical intelligence, where, in Langton’s sense of ALife and AI, intelligence requires us to “organize a population of machines in such a way that their interactive dynamic is “alive.”

Deleuze, Gilles. & Guattari, Félix. Massumi, Brian. Tr. (1987) A Thousand Plateaus: Capitalism and Schizophrenia. Minneapolis. University of Minnesota Press.
Langton, Christopher G. (1988/1989) “Artificial Life.” In: Langton, Christopher G. (1989) Artificial Life. Santa Fe, NM. Addison Wesley & The Santa Fe Institute. 6:1-47.
Markoff, John. (2014) “IBM Develops New Computer Chip Designed to Work Like the Brain.” The New York Times. 7 August 2014.
https://www.nytimes.com/2014/08/08/science/new-computer-chip-is-designed-to-work-like-the-brain.html

Robobees see: https://wyss.harvard.edu/technology/autonomous-flying-microrobots-robobees/

Post #4: Sustainable Skins in Urban Metabolic Architectures.

Biofilms and Sustainable Skin : http://urbanbeelab.okno.be/doku.php?id=grow_your_own_beehive
AnneMarie Maes and Núria Conde Pueyo

Chitosan Matrix as part of the biomaterialization for intelligent beehives.

Thinking of building intelligent beehives with living substances, Maes and Conde initiated laboratory experiments involving the growth of bacterial and yeast skins (scoby skins), with "leather-like celluloses" properties, for prototype constructions. Matrix-like, these striated biofilms are projected to function as environmental sensors while providing the bees with antibiotic resistance to fight-off mites. From this process, resulting hives are envisioned as integrating, "skin cells as programmable material," thus transporting their biological attributes to bioactive structures. By extension, similar bio-research processes are in line with designing materials and infrastructures, pertinent to metabolic architectures. As Maes demonstrates, her research process is already environmentally engaged, taking place as beehive-architecture investigated at urban levels and intended for distribution at urban scales. Potentially, such investigations dovetail with fablab procedures engrained in current design practices, so that the introduction of living cells in architectural subsystems materially incorporate, in Maes's words: "living exoskeleton cells from Apis mellifera." She suggests such cells, "be used as raw material for growing an artificial exoskeleton/skin on a 3D-printed scaffold of bacterial cellulose."

Potential, 3D-printed scaffolds are depicted first in the formulation of printable compounds and their constituent raw ingredients as prototype matrices testing solutions of cellulose for bacterial growth membranes and then chitosan solutions for pre-3D printing. Details of these experiments with comments are the focus of http://urbanbeelab.okno.be/doku.php?id=grow_your_own_beehive and procedures from them are applicable to biomaterial development for metabolic architectures.