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FORMATION AND VARIATION: WOLTERECK'S CONCEPT OF *REAKTIONSNORM* AND THE POTENTIALS OF ENVIRONMENT

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Throughout the course of man's development of a modern civilization he has had a propensity to seek control of his surroundings, to harness its powers and redirect them for his own use through the invention and implementation of various technologies. In the 1934 book *Technics and Civilization* the historian Lewis Mumford said: "The unwillingness to accept the natural environment as a fixed and final condition of man's existence had always contributed both to his art and his technics: but from the seventeenth century, the attitude became compulsive, and it was to technics that he turned to fulfillment."[1] Mumford's use of the word "technics," as opposed to "technology" or "tools" described not just the mechanical *products* of technological innovation, but also its mechanized *processes* of organization, and perhaps most importantly reflected the underlying change in cultural values that made these advancements possible. This compulsive seventeenth century shift towards technics and away from art went hand-in-hand with a fundamental shift in the physical sciences towards a reductionist, predictable, and mechanically causal experimental method. This resulted in a simplified linear definition of environment and reinforced the idea that it could be rationally controlled. Heightened further by the industrial revolution of the late nineteenth century, this shift saw its most prolific effect on architecture in the development of Modernism, a movement that espoused itself as rational, functional, mechanically driven and totalizing. For Mumford what became most significant in separating modernity from past epochs was the dominance of technics over every aspect of human existence.

Through the design and construction of localized environments intended for human occupation, architecture has effectively become the indispensable product of man's unwillingness to accept the natural world, the synthesis of both art and technics towards the sustainment of the human organism. According to Mumford, the motivation behind all of man's technological development was an attempt "to manufacture outside of the body a set of conditions more favorable toward maintaining its equilibrium and ensuring its survival."[2] In this sense architecture could be thought of as a partial substitute for biological adaptation, an extension of the human organism itself through environmental modification, construction and management. Taken further, by providing direct and deliberate stimuli towards its inhabitants, architecture could become an *active* participant in future human development. If architects are to accept such a role they must redefine their responsibilities and priorities around the human, not just through, or by way of new technics, but also by effectively reincorporating the potentials of art within these human/environment interactions. The artist and architect partnership of Arakawa + Gins have argued that through a closer and more complex alignment of people and architectural surrounds there exists the potential for humans to sustain their lives indefinitely, and that "a procedural constructing of the world will constitute a way for our species to take evolution into its own hands."[3] Producing such a reciprocal relationship between architecture and inhabitant may only be achieved through a re-conceptualization of the linear reductionist model of environment and the evolution of individuals, conceiving them instead as both a part of the same interactive, dynamic series of spatio-historical events.

Although the reductionist model, mutually reinforced by the shift towards technics, has produced substantial scientific advancements towards problems that can be studied in isolation (particularly in the fields of physics, chemistry and molecular biology), it provides only an approximate conception of the world. This "Cartesian method" understands a system through its constituent parts reducing the complexity of interrelationships and representing them inexactly. The population geneticist Richard Lewontin, one of the most prominent and outspoken critics of genetic determinism (a result of Cartesianism in biology) has voiced great concern over the fact that, because of its perceived scientific successes, it has been regarded as more than a method of investigation, but rather an accurate reflection of how things really are. Not simply a representation, but reality itself.[4] The adherence to this reductionist model was for many

1 Lewis Mumford, *Technics and Civilization* (New York: Harcourt, Brace & World, 1934, 1964) 52.

2 Mumford, *Technics and Civilization*, 10.

3 Madeline Gins and Arakawa, *Architectural Body* (Tuscaloosa: The University of Alabama Press, 2002) xv-xix.

4 Richard Levins and Richard Lewontin, *The Dialectical Biologist* (Cambridge, MA: The Harvard University Press, 1985) 2-3.

scientists an opportunistic strategy for more assured scientific "successes." With the implementation of these methods, environment was regarded as something to overcome but, for Lewontin, environmental conditions could not be separated from the definition of the organism as both were actively interrelated throughout the process of evolutionary development.

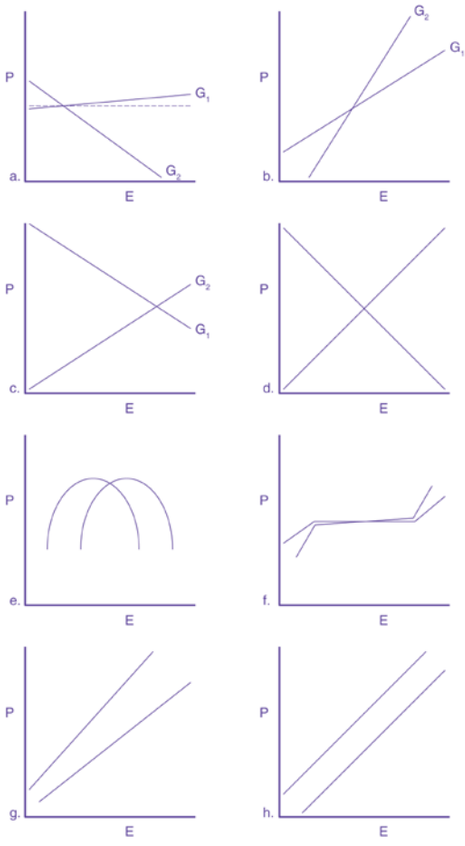
It has been with the steady progress of more advanced twenty-first century technics, particularly in digital computational technologies, that architects have been able to widely acquire the necessary means for investigating this dynamic space of inter-action and development. The architectural historian Antoine Picon has suggested that these "electronic" technologies have begun to change our perception of the relationship between man and machine from one of "dramatic confrontation" to one where technology is "assimilated into a kind of pervasive environment, a kind of landscape."[5] The implementation of these new digital technics by architects reflects a relationship Greg Lynn has characterized as "animate."[6] Lynn describes animate form not as one that displays "motion," but as one "defined by the co-presence of motion and force at the moment of formal conception." For architects this conception is the product of a Leibnizian space of generation (dynamic, viscous and composed of forces), instead of an idealized Cartesian space (static, linear and abstract).[7]

However, as the technics necessary for engaging with animate form available for use by architects has expanded exponentially since Picon's and Lynn's initial speculations, the sophisticated utilization of these technologies towards architectural design has fallen considerably short of their projections. Although the tactical use of these technics is not inherently negative, it is simply limiting, their application has often been towards the production of complex form, geometries, shapes, and/or patterns. From the onset of amorphous blobs,[8] to smooth undulating surfaces of gradual change,[9] to the "style" of parametricism,[10] what we have often been left with is an emphasis on form, its representation and image as the dominant products of architectural production. Unfortunately, it is hard not to place much of Lynn's work since the publication of his book *Animate Form* (1999) into this category.[11]

Despite Lynn's calls for a new type of architectural "contextualizim"[12] and the implementation of these new parametric, scripting and animation tools, the opportunity for the discipline to both "retool and rethink"[13] itself is still necessary, and must be considered beyond the topological surface or digital technique to instead cultivate *active* relationships that are productive, capable of instigating various effects, inhabitations of space and participatory experiences. The architect Sean Lally (Weathers) has made a similar claim in his text "Potential Energies" when he extends Lynn's notion of the 'performative envelope' to consider it not just as a representation of the forces that inform its geometry, but, through the use of simulative digital resources, is able to participate "on" the 'active context' in which it's situated.[14] What may provide architects with more meaningful sophistication of these computational tools is to consider them not as form generating, but form finding; simulators of environmental potentials capable of producing specific effects. In order to speculate further on the effects of these potentials we should examine fully Lewontin's criticism of the reductionist model in genetics and his conception of a less representational active environment.

Having been originally conceived as a one-to-one correspondence between gene and trait, the specificity of gene action (genetic determinism) was a presumption since the inception of genetics and persisted, though increasingly mitigated, through-

5 Antione Picon, "Architecture, Science, and Technology," in *The Architecture of Science*, ed. Peter Galison and Emily Thompson (Cambridge, MA: The MIT Press, 1999) 325-326.
6 See Greg Lynn, *Animate Form* (New York: Princeton Architectural Press, 1999), 9-43.
7 Lynn, *Animate Form*, 9-15. He goes on to make the point that it has only been possible through the invention of new technologies for modeling and animating space that notions of *topology*, *time* and *parameters* may be used by the architect to finally produce animate forms.
8 See Frank Gehry's Experience Music Project in Seattle, WA (2000); Peter Cook and Colin Fournier's Kunsthaus Graz in Graz, Austria (2003); Future System's Selfridges Department Store, Birmingham, UK (2003) and various projects by Hernan Diaz Alonso and Tom Wiscombe.
9 See Reiser + Umemoto's West Side Convergence Competition Entry in New York, NY (1999); Peter Eisenman's City of Culture of Galicia in Santiago de Compostela (1999-2011); Zaha Hadid's MAXXI – National Museum of the 21st Century Arts, Rome, IT (1999-2010) and the Heydar Aliyev Cultural Center in Baku, Azerbaijan (2007-2012).
10 See Patrik Schumacher's writing "Parametricism as Style – Parametricist Manifesto" (2008)
11 One example would be Lynn's design for the Ark of the World Museum (2003) located in the Costa Rican rainforest. It's composed of a series of attenuated 'vegetative' blobs which turn up to support a tensile fabric roof structure. Here the eco-center adopts the image of the ecology through the use of botanical floral elements and forms.
12 Lynn, *Animate Form,* 42, endnote #2.
13 Lynn, *Animate Form,* 41.
14 Sean Lally, "Potential Energies" in *Softspace: From a representation of form to a simulation of space,* ed. Sean Lally and Jessica Young (London: Routledge, 2007), 25.



Examples of different forms of reaction norms. In each case the phenotype (P) is plotted as a function of the environment (E) for different genotypes (G1 , G2). Credit: *American Journal of Human Genetics,* 26, Richard C. Lewontin, "The Analysis of Variance and the Analysis of Causes," 400-411, Figure 1, a-h, Copyright Elzevier (1974).

out the twentieth century.[15] The strongest form of genetic determinism claims that the phenotype[16] shows no response to environmental variation, only that in order for a trait to develop *an* environment is needed, but it does not matter *which* environment; a second "more moderate form of genetic determinism claims that genetic and environmental factors interact additively."[17] The continued persistence of genetic determinism prompted Lewontin to publish a paper titled "The analysis of Variance and the Analysis of Causes" (1974), perhaps the most influential contribution to the literature concerning the interpretation of behavioral genetics,[18] in which he challenged the supremacy of additive causal relationships between genotype, environment, and phenotype. Through an alternative analysis of variance in the performance of specific genotypes under a single well ordered, but changing environmental stimuli (such as temperature), Lewontin demonstrated that genotypic performance at one point in time is not necessarily an accurate predictor of performance at any future moment.

The perception of a general cause and effect relationship between genes

15 Sahotra Sarkar, "From Genes as Determinants to DNA as Resource," in *Genes in Development: Re-reading the Molecular Paradigm,* ed. by Eva Neumann-Held and Christoph Rehmann-Sutter (Durham: Duke University Press, 2006), 79.

16 Phenotype is the physical and psychological traits of an organism, both its appearance and its behaviors, from: Neil A. Campbell, *Biology* Third Edition (New York: Benjamin Cummings Publishing Company, Inc., 1993) 263.

17 Paul E. Griffiths, "The Fearless Vampire Conservator: Philip Kitcher, Genetic Determinism, and Informational Code," in *Genes in Development: Re-reading the Molecular Paradigm,* ed. by Eva Neumann-Held and Christoph Rehmann-Sutter (Durham: Duke University Press, 2006)178-179.

18 Griffiths, "The Fearless Vampire Conservator," 179.

and environment was demonstrated to be only an illusion. Lewontin's analysis showed that "the sensitivity of phenotype to both environment and genotype is a function of the particular range of environments and genotypes" resulting in a dynamic interactive relationship between them.[19] From this understanding it is not possible to separate out genetic factors and environmental pressures and every attempt to do so is founded upon a mistaken view of biological and environmental interaction.[20]

Lewontin argued that a more accurate description of this relationship was expressed through the concept of the *Reaktionsnorm,* or the Norms of Reaction (NoR), which graphically illustrates performance not at a single moment in time, but rather multiple moments, reflecting the *total* potentials of the genome and not only at an ideal, or selective instance. The historian of genetics Raphael Falk has credited Lewontin with reviving the concept of *Reaktionsnorm* from its early twentieth century originator Richard Woltereck, emphasizing the unpredictability of individual phenotypic responses once the genotype-environment interaction was considered over a wide range. Lewontin was able to effectively demonstrate "the fallacy inherent in the hopes of analyzing causes through linear models embodied in the analysis of variance, covariance, and path analysis."[21] This conceptualization of the individual suggests a dialectical relationship between organisms and the spaces they inhabit; environmental niches are not preexisting waiting to be filled by better adapted individuals, but instead they exist only in relationship to the organisms that occupy them, where both are constantly shaping and reshaping one another.[22] If we consider architectural spaces as localized environments for human inhabitation then, like the biological niche, they too may can not be defined separately from the individuals who occupy them. A closer examination of the concept of *Reaktionsnorm* may help us better understand this active relationship and the possibility for architecture to engage directly with human evolutionary potentials.

19 Richard C. Lewontin, "The Analysis of Variance and the Analysis of Causes," *American Journal of Human Genetics* 26 (1974): 400-411.

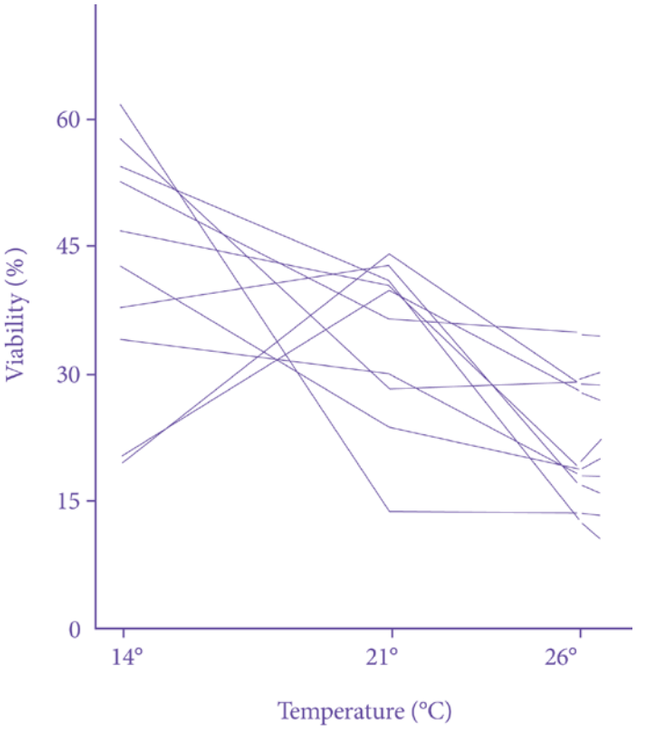
20 Michael Ruse, *The Evolution Wars: A guide to the Debates* (New Brunswick, NJ: Rutgers University Press, 2000) 223.

21 Raphael Falk, "Can the Norm of Reaction Save the Gene Concept?" in *Thinking About Evolution: Historical, Philosophical, and Political Perspectives,* ed. Rama S. Singh, Costas B. Krimbas, Diane B. Paul, and John Beatty (New York: Cambridge University Press, 2001), 131.

22 Michael Bradie, "Epistemology from and Evolutionary Point of View," in *Conceptual Issues in Evolutionary Biology,* ed. Elliott Sober (Cambridge, MA: The MIT Press, 1994) 466.

Although largely unknown to historians of biology,[23] the German zoologist Richard Woltereck (1877-1944) preceded Lewontin in providing an earlier conception of the individual as the product of genotype-environment interaction and is credited with the conception of the NoR as the comprehensive graphical and material representation of these interactions. In his 1909 publication *Weitere experimentelle Untersuchungen uber Artveranderung, speziell uber das Wesen quantitativer Artunterschiede bei Daphnien*[24] he came to the conclusion, after years of experiments conducted on morphologically distinct pure strains of Daphnia and Hyalodaphnia species,[25] that the genotype of an individual was less of a deterministic force and more of an enabling agent in the developmental process of phenogenesis.[26] Woltereck's experiments were designed specifically to address the debate of the day concerning the evolutionary mechanism responsible for species formation, "particularly to counter the mutationists' salutatory model with evidence of evolution as a continuous process which was guided, whether directly (neo-Lamarckianism) or indirectly (selection), by environment."[27] In his many experiments each pure line of individuals maintained their phenotypic traits (such as head length) consistently over several generations; however when the line was subjected to changes in environmental variables, varying phenotypic outcomes of these previously stable traits were routinely observed. The interrelationship of genotype and environment towards the production of the phenotype "was best represented, not as a constant, but as a curve which demonstrated the degree of the trait's development in a range of environments."[28] In order to fully visualize the phenotypic potential of the line's genome, Woltereck superimposed the series of curves onto a single comprehensive graph. As each curve described the phenotypic outcome of an individual genotype as it was influenced by a specific environmental stimulus these curves were not flat, but fluctuated unpredictably in relationship to the particular environmental factor being considered. It was apparent that the influences of external forces were vital

23 Jonathan Harwood, "Weimar culture and biological theory: A study of Richard Woltereck (1877-1944)," *History of Science* 34 (1996): 348. Harwood proposes that this might have been because he never attained a full professorship at a German University or because much of his later biological writings were primarily philosophical.
24 Translation: "Further investigations on change of species, specifically on the nature of quantitative species-differences in Daphnides," in Falk, "Can the Norm of Reaction Save the Gene Concept?" 119.
25 Sarkar, "From the *Reaktionsnorm* to the Adaptive Norm," 235.
26 Sarkar, "From the *Reaktionsnorm* to the Adaptive Norm," 238.
27 Jonathan Harwood, "Weimar culture and biological theory," 349.
28 Jonathan Harwood, "Weimar culture and biological theory," 350.



The viability of ten different genotypes of *Drosphilia* when tested at three different temperatures. Plotted and overlaid together they visually describe the potentials held within the Norm of Reaction. Credit: Reprinted by permission of the publisher from THE TRIPLE HELIX by Richard Lewontin, p. 25, Cambridge, Mass.: Harvard University Press, Copyright © 1998 by Gius, Laterza & Figli Spa, Copyright © 2000 by the President and Fellows of Harvard College.

to the developmental process of each individual, additional phenotypic outcomes were an almost direct corollary to the degree of variability in those environmental conditions.[29] As there are potentially an infinite number of environmental factors that may interact with a given genotype, there are as many phenotypic curves (*Phänotypen-kurven)* that result if one could document all potential variables.[30] In order to effectively express the totality of the relationships embodied within an individual organism, Woltereck conceived the concept of *Reaktionsnorm* in order to describe the locus of these various phenotypic potentials. He argued that what was inherited were the NoRs themselves "as wholes"[31] and not as individual genes. Hereditary changes were thus understood as a modification of that norm and could not be localized to single gene expressions.[32] In evolutionary develop-

29 Sarkar, "From the *Reaktionsnorm* to the Adaptive Norm," 235.
30 Richard Woltereck, "Weitere experimentelle Untersuchungen uber Artveranderung, speziell uber das Wesen quantitativer Artunterschiede bei Daphnien" *Verhandlungen der deutschen zoologischen Gesellschaft* 19 (1909): 135.
31 Jonathan Harwood, "Weimar culture and biological theory," 352.
32 Sarkar, "From the *Reaktionsnorm* to the Adaptive Norm," 236.

ment what's ultimately being selected for is not a *specific reaction*, but rather the NoR's ability to produce *a range of reactions* in response to a range of conditions, its evolvability.[33] In the NoR model environmental variation is an integral *constructive* constituent of the individual phenotype and not an unavoidable nuisance to be overcome as Woltereck's contemporary Wilhelm Johannsen later portrayed.[34] Johannsen's genocentric interpretation, which lasted well up to the time of Lewontin's decisive 1974 paper, was reinforced by the pursuit of genetic determinants which sought to explain away variations derived from genotype-environment interactions.[35] These variations, although usually appearing insignificant, are often the qualities that impact the survival of the individual most profoundly, serving as the fuel for speciation and evolution. In this sense human development is not the final result of a long progression, but rather a *continuous* re-actualization within a particular local environment.

As re-presented by Lewontin the relationships expressed in the NoR have been routinely accepted, however there has been some criticism regarding its actual usefulness in the field. Although the NoR is empirically derived, it's also approximate because what's being represented often reflects only a specific environmental condition. While the definition of the "total" environment[36] is perhaps a very real necessity for the geneticist, the value of the NoR as a conceptual model for understanding development still maintains incredible potency for use by architects. Rethinking human development in this way suggests an architecture not only conceived as the functional extension of the phenotype, but through the production of *active* environmental subjectivities, capable of direct engagement it may be possible to facilitate and even direct future human development.

The architectural historian David Gissen has argued for a new conception of architecture as "producers of nature," that building technologies not only adjust spaces to the needs of particular chemical and physical metabolisms, but "they also produce conceptualizations of the natural: ideas of comfort, performance, and health…" understood as both material and discursive processes.[37] If, as Gissen claims, "all nature is laced with human agency and structure"[38] and given our understanding of the influence of local environment on evolutionary development conceived in the NoR model, then is it really so difficult to also include humans as part of the "nature" produced by architecture? What's needed in order to instigate change is the architect's conscious decision to engage with these active environmental factors as the motivators of design. This potential may certainly be observed in the effects on other species. One example cited by Reynar Banham in his text "The Environmentalist" (1962) was the *Victoria Regia* house of Chatsworh (ca. 1849), a greenhouse designed and built specifically to accommodate the most environmentally demanding species of giant water lily, the *Victoria Regia*. Through the design of "the structure of the roof, the form of the pool with its marginal shallows and central deep, and the network of four-inch heating pipes…all these combined together to create the environment in which *Victoria Regia* was to flourish as it never did elsewhere outside its native habitat."[39]

While Paxson's design mitigated the effects of the lily's transplantation from its native context by augmenting the interior space to more suitable environmental conditions, there are a variety of contemporary architects and artists working today who have extended these potentials, engaging with the human sensorium in order to produce physiological and psychological effects.[40] The Swiss architect Philippe Rahm has described his

33 The systems biologists Marc Kirschner and John Gerhart have extended Lewontin's observations, claiming that an organism's characteristics are only remotely connected to the DNA sequence through the complex processes of development, growth and metabolism. A change in DNA sequence is only indirectly correlated with change in the anatomy and physiology of the organism. These core processes are conserved precisely because they have within their mechanism the greatest ability to produce a variety of possible states in response to environmental stimuli or genetic mutations, allowing them to readily facilitate meaningful variation with only minimal direct genetic modification. John C. Gerhart and Marc Kirschner, *Plausibility of Life: Resolving Darwin's Dilemma* (New Haven: Yale University Press, 2005) 34-35.

34 Raphael Falk, "Can the Norm of Reaction Save the Gene Concept?" 123.

35 Johannsen's interpretation of Woltereck's concept of the NoR in his 1911 paper "The Genotype Conception of Heredity," *The American Naturalist* Vol. 45, No. 531 (1911): 133, regarded it as "nearly synonymous with 'genotype'" and according to Raphael Falk this interpretation ultimately "provided the framework for the conceptual isolation of the genotype as the blueprint in the vault that determines development, function, and behavior of creatures and yet is protected from any (adaptive) modification by its carriers." See: Raphael Falk, "Can the Norm of Reaction Save the Gene Concept?" 124-125.

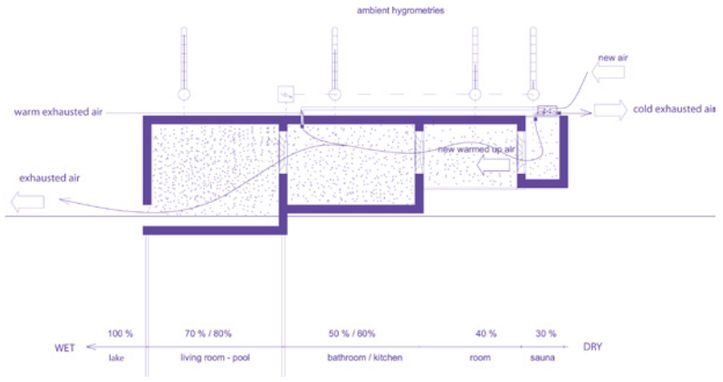
36 Total environment refers to the correspondence between environmental interactions, genomic makeup and developmental noise - the random events within cells at the scale of molecular interactions. Despite this noise being comparatively small in relationship to the whole organism, it is often responsible for producing many observable phenotypic variations amongst individuals of the same species or even between individuals of the exact same genetic makeup. See: Anurag A. Agrawal, "Phenotypic Plasticity in the Interactions and Evolution of Species," in *Science* 294 (2001): 321-326.

37 David Gissen, "APE" in *Design Ecologies: Essays on the Nature of Design* ed. by Lisa Tilder and Beth Blostein (New York: Princeton Architectural Press, 2010) 63.

38 Gissen, "APE," 64.

39 Reynar Banham, "The Environmentalist," in *Program* 2 (Spring 1962): 63.

40 One could include such diverse practices as the artist Olafur Eliasson in projects such "The Weather Project" at the Tate Modern, London (2001) and the "360 degree room for all colors" shown at the MoMA (2002), the research of David Benjamin's Living Architecture Lab, AMID (cero9)'s oxygen rehydration project for Pine Grove Park (2008), R&Sie(n)'s curtain wall system for the B_mu Tower (2005) and much of the work of Philippe Rahm and Arakawa + Gins.



Route of the air ventilation and repartition of the vapor. Design diagram Mollier Houses by Philippe Rahm Architects, (2007). Credit: Reprinted, by permission, from Philippe Rahm Architects.

approach as adopting an extreme openness towards reality, referring to "relative humidity levels, the temperature gradient, light intensity, and spectrality [as] the elements of architectural language that are called into question in producing an architectural project." This approach no longer adheres to spatial requirements as the motivation for designing architecture, but rather human physiology.[41] Rahm's design of the Mollier houses (2005) observes that various human activities both require, and result, in the presence of various levels of water vapor (relative humidity), adopting this as the major design parameter he reorganized the spaces of the house into strata, from the driest to the most humid, disregarding the traditional individualization of rooms and functions. The design doesn't program the spaces functionally, but rather according to the inhabitant's physiological needs, effectively creating new programmatic correspondences and alternative domestic possibilities.

Additionally the architect Sean Lally (Weathers) often manipulates the internal environment, leveraging physiological potentials as primary design elements, to produce new social inhabitations of space. These potentials are embedded within the architectural design through the active

41 Philippe Rahm, "In Architecture, Precisely" in *Precisions: Architecture between Sciences and the Arts,* ed. by Ākos Moravānszky and Ole W. Fischer (Berlin: Jovis Verlag, 2008) 171. An example of this would be "The Hormonorium," designed and built in collaboration with Jean-Gilles Décosterd, in the Swiss Pavilion at the Venice Biennale (2002). It recreated the environment of the "high mountains" by adjusting nitrogen levels and light intensity effectively reducing the percent of oxygen in the air to 14.5%, causing slight hypoxia, characterized by states of confusion, disorientation, and/or slight euphoria due to increased endorphin production.

mobilization of responsive sensory gradients both generated and simulated byway of advanced digital technics.[42]

The artist and architect partnership Arakawa + Gins, instigated by a perceived ethical obligation and a call to action,[43] argues for a more radical approach towards designing architecture that aspires to effect humans not laterally through physiology, but directly through continued physical engagement. Their projects are both playful and artistic; they are overtly stimulating, dealing with the body as a physical participant and demanding direct interaction through climbing, balancing, traversing and maneuvering within them. Their project *Site of Reversible Destiny – Yoro* (1993-95) is a park-like terrain of steep inclined surfaces and small pavilions that produce "nonsensical discrepancies in scale and arrangement of familiar objects and images." It strives to destabilize occupants, challenging them to keep their balance and training their bodies to become more physically and mentally agile.[44]

The design of the *Reversible Destiny* Lofts (In memory of Helen Keller) completed in Mitaka, Tokyo (2005), reorganizes the actions of body and mind within domestic spaces. The lofts are each composed of a group of separate "shape defining elements" (cube, sphere and cylinder) rotating around a sunken centralized open space that functions loosely as the kitchen. All of the interior surfaces are either painted a variety of bright colors, or are composed of various textured materials. The design of the lofts is intended to prompt inhabitants to pay closer attention to their actions and "recalibrate their equanimity and self-possession, causing them to doubt themselves long enough to find a way to reinvent themselves."[45] Similarly the design for

42 Lally's design for the SIM Residence (2006) leverages the internal environment to incorporate latent "potential energies" capable of producing a multiplicity of responses to various conditions of living. He describes these living scenarios as being instigated through "elastic and networked structures of organization (systems of display, illumination and air flow and temperature)." These systems are fully integrated into the project's ceiling design which provides the loose spatial and formal configuration of the house. It was imperative for Lally to utilize advanced softwares able to simulate and visualize the fluid dynamics of air temperature and air movement, to help provide feedback as to how these networked environmental systems behaved in relationship to various formal configurations and material properties. See: Lally, "Potential Energies," 26-29.

43 Through the development of the term "reversible destiny" Arakawa and Gins have proclaimed a war on mortality citing that any ethics that puts the preserving of life as the highest value must take a stand against death. See their book *Architectural Body*.

44 Michael Govan, *Reversible Destiny – Arakawa / Gins* (New York: Guggenheim Foundation Publications, 1997) 9.

45 "*Reversible Destiny* Lofts (In Memory of Helen Keller)," Arakawa + Gins, Reversible Destiny Foundation, (2005) accessed September 14, 2013, [http://www.reversibledestiny.org/#!reversible-destiny-lofts-mitaka-%e2%96%91%e2%96%91-in-memory-of-helen-keller]

the *Bios*cleave House (Lifespan Extending Villa), completed in East Hampton, NY (2008) is a more extreme version of the Mitaka lofts adopting the same basic organizational strategy, but manipulating the main floor surface of the house even more radically into a rolling moonscape of textured mounds. Traversing the floor to make a cup of tea or use the bathroom becomes a test of physical agility and mental focus. Slender columns become points of contact for regaining one's balance and recalibrating movement. Interior spaces flow out to the exterior around the house in various forms providing a totalizing local environment of interaction. For A+G comfort instigates stagnation and leads to mortality, they regard architecture as the greatest tool available to humans in order to subvert death. Through sentient interactions with architectural surrounds the inhabitant must remain "tentative," forcing one to continuously redefine him/herself effectively extending life indefinitely.

Although A+G's optimistic and imaginative proposition of cheating death through architectural inhabitation may be disregarded by many as fantastical aspiration, the potential to combine their participatory architectural environments of physical/mental stimulation, with the development of physiologically responsive environmental systems capable of instigating social re-compositions of inhabitation, architects might be able to fully engage with the NoR model of development. However, in order to effectively design within the dynamic space of interaction between individual development and environment posited by the NoR, architects must also utilize advanced technics able to effectively simulate and evaluate the complex relationships necessary to facilitate specific phenotypic outcomes.[46] For architects, adopting this strategy of evolvability through the design of actively engaging local architectural environments is the type of radical reorientation of priorities that may provoke actual change in humans.

46 This conceptualization of technics is similar to what the contemporary philosopher Manuel Delanda (in discussion of Deleuze and Guattari's BwO) might refer to as a "blind probe-head," a specific type of abstract machine that is the result of a sorting device coupled with the ability to replicate with variation, "or a searching device capable of exploring a space of possible forms." See Manuel Delanda, "Immanence and Transcendence in the Genesis of Form," *The South Atlantic Quarterly*, 96:3 (Summer 1997): 499-514.

View of the *Bios*cleave House (Lifespan Extending Villa) living room showing the mounded terrain of the interior floor and the stabilizing vertical poles. Designed by Arakawa + Gins, completed in East Hampton, NY (2008). Credit: ©Eric Striffler, all rights reserved.

View of the Site of Reversible Destiny parkscape showing sloped surfaces and destabilizing terrain. Designed by Arakawa + Gins (1993-95). Credit: scarletgreen, reproduced from flickr creative commons.