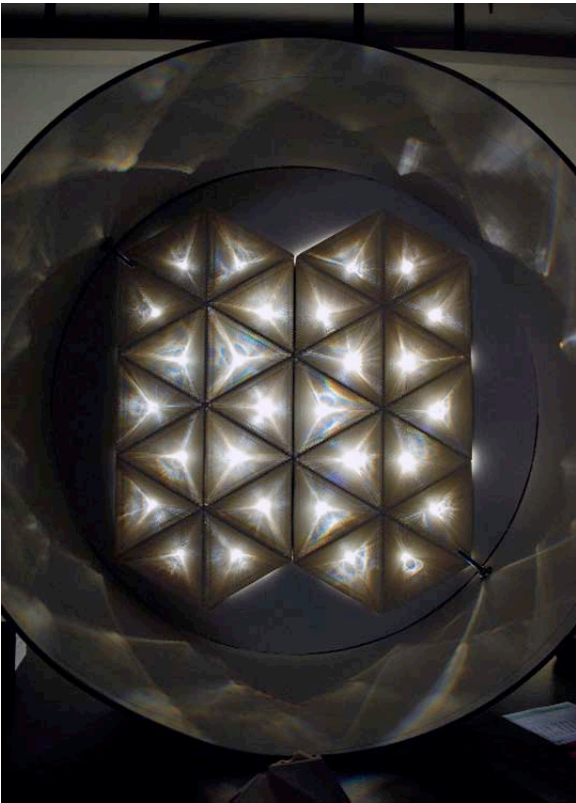


Emerging Materials

Álvaro Malo



1. From *Sensitive Apertures*, Ben McDonald, M.Arch./EMT '08.

For the Renaissance Reality was Soul: for the Romantics, reality was Nature. Now then, as our knowledge cannot exceed the limits of Soul and Nature, the New Renaissance (let's call it that) has no other basis for Reality...The result, then, is that for the New Renaissance there must be a *fusion of Nature and Soul*...That is, for the New Renaissance, *Nature will be understood as Soul*. There is no other conceivable hypothesis...To say that matter is material and spirit is spiritual is not false, but it is more true to say that matter is spiritual and spirit, material.

Fernando Pessoa¹

Not long ago, I was asked, "Why did you want to be an architect?" Pondering that question, I thought that the desire was perhaps inevitable, or genetic. Searching for possible answers, I went back up the incline of time to a region of innocence — back to my childhood. I was born in the city of Cuenca, in a high mountain valley between two parallel Andean cordilleras — its pre-Columbian, or Inca, name was Tumipampa. My father, who was a physician, was nevertheless engaged in never ending building activities. When excavating the foundations for the house where I grew up, he uncovered several geometrically precise monoliths perfectly cut of *andesite* — a very hard igneous rock typically formed at convergent tectonic plate margins in the Andes of South America. The stones were left unaltered in the garden, at the perimeter of the building, as silent mementos and question marks. In their enigmatic presence they

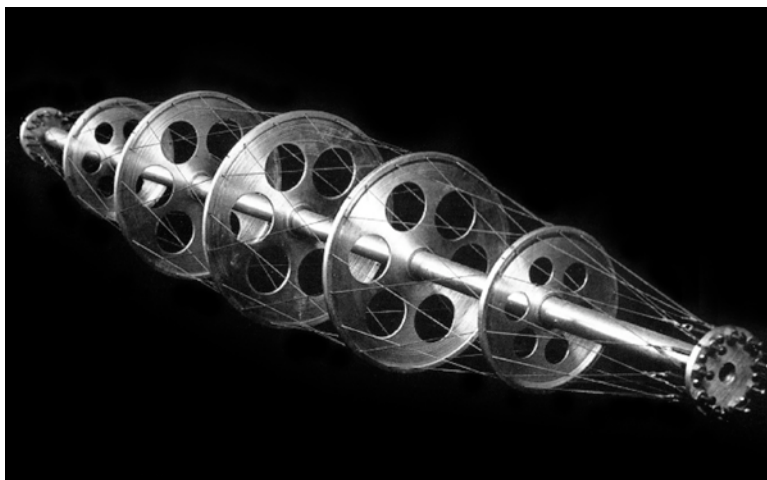
¹ Fernando Pessoa, "On Sensationism," *Always Astonished*. San Francisco: City Lights, 1988.

were a subliminal witness to my rudimentary consciousness of the world. Today, their images must be somewhere deep in myself, shuttling as units of information in the circuit between the pineal gland and the solar plexus — and, I rationalize that they must have played a part in my forming *entelechia*. Now, as a weathered soul, I blend them with the mysterious monoliths that appear at the beginning of Clarke/Kubrick's *2001: Space Odyssey* and with Piaget's hypotheses in *The Child's Conception of Space*.

Later, in my education at the University of Pennsylvania, I came under the ægis of a teacher who had a profound respect for materials; it was Louis I. Kahn, who said, "I sense Light as the giver of all presences, and material as spent light." It was customary that most of the students in Kahn's Master's Studio also enrolled in Robert le Ricolais' "Laboratory of Experimental Structures." The lab was well furnished with equipment: a Bridgeport milling machine, a six-foot lathe, bench top drill presses and band saws, and a wet metal saw for cutting heavy stock. There was also acetylene and arc welding equipment, an air compressor, a complete array of portable power and hand tools, and a more than sufficient supply of raw stock: assorted gauges of rods, tubes, cables and plate metals.

My affection for technology and equipment was aroused in my high school days when during the summers I became the self-appointed mechanic who kept things running in a sugar cane plantation and distillery that my family owned in South America. But the experience at le Ricolais' laboratory was an induction into a higher order of workmanship, putting manual dexterity on an equal footing with logical precision — or 'precisation,' to use Gregory Bateson's term. I felt confident with the fine points of operation and calibration of the machines, particularly the Bridgeport mill, which was new in my experience and induced the greatest appeal in my imagination as an instrument of three-dimensional metal milling. It was by all accounts a well-run laboratory, balancing tacit and explicit knowledge.²

After working for three weeks in minor variations of a couple of models that I chose from the existing repertoire of structural concepts, I began work on a new variant of the lemniscate, or funicular polygon of revolution. The stock materials used in fabrication were: 3/4 inch diameter aluminum tubing for the central compression post, 3/16 inch thick aluminum plate for the circular diaphragms, 1/32 inch stainless steel aircraft cable for the funicular tensile strands, and 3/4 diameter stainless steel ball bearings for the ends. The contour of the spatial volume was the revolution of a parabolic segment, intentionally adjusted by the diameter and spacing of the five diaphragms. The diaphragms were milled to 1/16 inch thickness and perforated by six proportionately sized portholes — heeding to le Ricolais' maxim: "The art of structure is where to put the holes" — to lighten their physical and visual weight, remaining thicker at the outer perimeter, acting as compression rings, and at the inner circumference in contact



the center tube. The ball bearings, whose function was to eliminate torsion and to allow self-adjustment, were installed at both ends over bushings that protected the tube walls from crushing. Two small diameter plates were installed over the ball bearing to allow the array of the tension strands, which were eighteen in total and rotated one full revolution from end-to-end, alternately clockwise and counterclockwise. On judgment day, the mechanical performance of the model was more than satisfactory: its weight to span ratio was very economical, and the deflection

2. Funicular polygon of revolution, manufactured by Á. Malo. Philadelphia, 1969.

² Richard Sennett, *The Craftsman*. New Haven: Yale U. Press, 2008.

under load was minimal, maximizing its dependence on the tensile network. Le Ricolais was quite pleased with the results; I remember clearly his sober smile. He made an intuitive assessment and jotted some numbers, which he probably knew by heart, on a piece of paper and the test was finished. This model was still far from his dictum, “Zero weight, infinite span...” Nevertheless, it has stayed in my cerebral cortex an example of what the Greek called “entelechy” — the actualization of form-giving cause and an inherent regulating and directing force in the development and functioning of a system.

At Penn, I was introduced to a powerful and peculiar dialectic oscillation between *nature* and *mind*, between materials and ideas. Out of many others, two books provided a fundamental matrix for this research: D’Arcy Thompson’s *On Growth and Form* and Kenneth Boulding’s *The Image: knowledge in life and society*. Thompson’s work has been a font of inspiration and a model of precision in the geometric and poetic analysis of natural morphologies and specimens, providing clear methods of reference through analogy — similarity of function — and homology — similarity of structure. I have continuously brought it to light in my own meditations on teaching and have worn out several copies, which came apart at the spine. Boulding’s work has come back to my attention, after a long hiatus, particularly chapter 2, “The Image in the Theory of Organization,” where he identifies seven levels of complexity: the jigsaw puzzle, the clockwork, the thermostat, the cell, the plant, the animal, and the human being.

Since time immemorial, buildings have been designed to function as jigsaw puzzles, even some of exquisite intricacy, such as the Alhambra. One may find clockwork attributes in the building methods of Brunelleschi, a foremost architect-engineer of the Italian Renaissance, considering that his construction machines were fundamental to his architecture. The thermostat as a device has been part of the mechanical equipment of buildings, as the governor is a regulating part of the operation of an engine; but buildings as whole thermodynamic systems are still experimental and rare. Current investigations on “biomimetism” and “intelligent buildings” are of great promise, but ubiquitous use of these terms in the academic language and the advertisement of ambitious practices are in many cases unabashed self-indulgence.

The quest to reconcile the *difference* between nature and mind, between materials and ideas, eventually finds a smooth and continuous flow that in its logical pattern is *similar* to the paradoxical geometry of the Möbius strip. The quest becomes a question of continuity and reciprocity, of asymptotic convergence between the artificial and the natural; a question of similarities and differences, or better yet in terms of David Bohm’s rheology, of *similar differences* and *different similarities*.³

In “Form, Substance, and Difference,” Gregory Bateson has articulated this as a question of evolutionary epistemological necessity.⁴ He proposes it as two intertwining ecologies, or one ecology with two faces: one is called *bioenergetics* — the economy of energy and materials, which is composed of units and sets with specific boundaries and operates with an additive-subtractive budget of inflow and outflow of energy tending toward entropy; the second, I will call *ecosophy* — a term used by the Norwegian philosopher Arne Næss, also called deep ecology, which corresponds precisely to Bateson’s proposition — the economy of information, ideas, and communication that deals with budgeting of pathways and probability in a fractionating-multiplicative mode tending towards negentropy. The two ecologies are braided in a continuum of exchange. Hard material forces and energy surround us, sometimes shelter us; they are a condition of life. Sensation filters energies, encodes and passes on information: it transforms hard into soft. *Hardware* becomes *software*, *force* becomes *meaning*.⁵

In my current research on Emerging Material Technologies, I find that the work of learning and teaching is also a never-ending rheology, for ultimately we are the prime material of our own experiment, we are an *emerging material*. As such, we cannot operate in a one-way relationship, but continuously exchange roles in a reciprocal convection loop — again similar to the kinetics of the Möbius strip.

³ David Bohm, *On Creativity*. London: Routledge, 1996.

⁴ Gregory Bateson, *Steps to an Ecology of Mind*. Chicago: U. of Chicago Press, 1972.

⁵ Michel Serres, *The Five Senses: A Philosophy of Mingled Bodies*. London: Continuum, 2009.

A prime example of this was my recent interaction with Ben Ari McDonald, whose hypothesis was to study light as a material, then fine-tune the experiment to focus on light at dawn and dusk, when photoreceptive cells in our eyes, cones and rods, reach a crossover point of equal efficiency. This perceptual phenomenon within the ‘mesopic vision range’ marks a unique moment of visual awareness and the threshold for a possible search for the ‘right’ kind of light.

It begs the question: Right kind of light for ‘what’? Initially, McDonald hypothesized that light affects our consciousness ‘of space,’ of being ‘in space,’ and eventually our self-consciousness — therefore our ‘state of mind.’ He went further in search of a particular quality of light that provokes a heightened sense of perceptual awareness, “After several sessions of twilight observation, my personal experience was that I began to sense my eyes feeling light the way we feel with our touch. This new sense then produced a stimulated awareness of and focus to my mental state. I don’t want to get carried away here or sound mystical; I did not have any epiphanies or revelations. I was simply in a kind of light rapture.”⁶

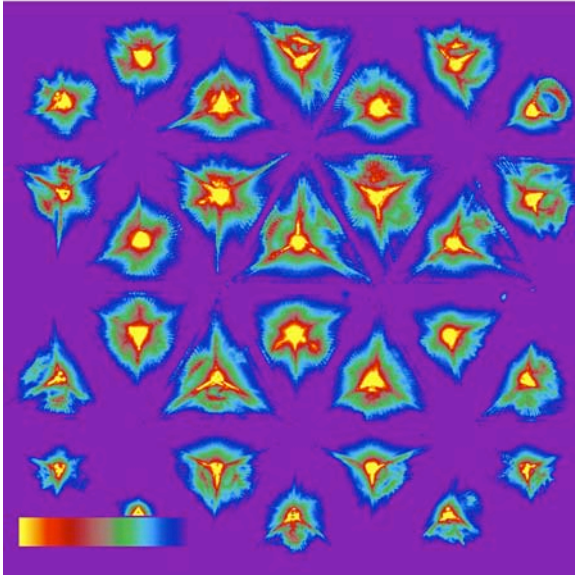
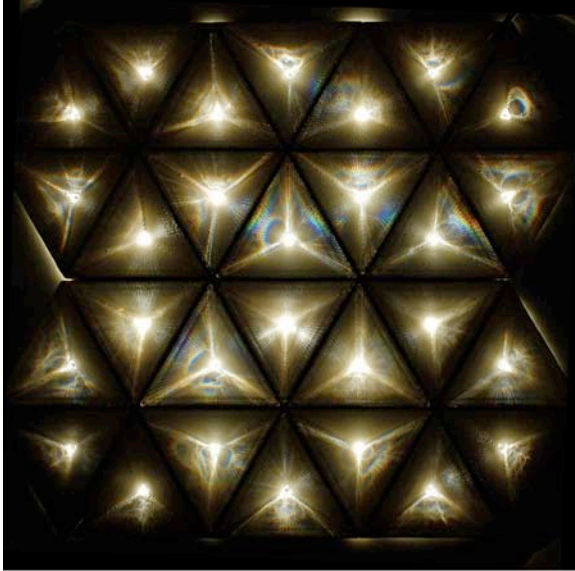
It happens that there are precedents for these phenomena, but they are often concealed under the current of everyday occurrences. “To become sensitive to their quality as actual events, to become competent in listening to their sound underneath silence or noise...requires at the very least a high degree of refinement in the perception of small differences.” It requires a fine-tuning of the body and relaxation of the senses to induce paradoxically a kind of *indifference*, or ‘peace of mind’: the Epicurean *ataraxia*, the Stoic *apatheia*, the extreme Stoic *adiaphora*, the Zen not-thinking, the Taoist nothingness, etc.⁷ And there is a precedent for favorable occurrence at precise moments of the day, namely the *matins* and the *vespers*, the first and the sixth canonical hours that are celebrated in prayer or song by many cloistered monastic orders: Benedictines, Cistercians, etc. Whether he knew this, or not, McDonald had the right intuition.

The next question may be: Why would we seek this kind of light, this peace of mind? What may we get out of it? A simple answer is that the benefit of such self-discipline, or asceticism, may have profound ethical and aesthetic consequences. It is an approach to imagination and sensitivity delineated in Kant’s *Critique of Judgment*, and a reflection of the cognitive function analyzed in the “Transcendental Aesthetic” of the *Critique of Pure Reason*. Kant differentiates three kinds of syntheses that are supposed to be necessary to present objects to knowledge: synthesis of apprehension in intuition, of reproduction in the imagination, of recognition in the concept — or logical form in reason. There are two movements in the initial synthesis: one is to seize or touch, which is the inflow of the sensual manifold; the other is to bring together, to mix, the comprehension of this flow, as instantaneous intuition. The second is a fastening onto, a withholding of this intuition, and this occurs as a diachronic reproduction in the imagination. Finally, it is possible for the intuitive ‘object’ to be grasped out of the diachronic flow and captured through a final synthesis of recognition, a synthesis that opens the way to knowledge proper.

A final question may be: How did McDonald carry out the sensual, empirical and logical testing of the hypotheses? He did this through an examination and understanding of the physiology of vision; he did this through direct personal observations and photography that captured luminance and was analyzed with software (Photosphere); he did this through analysis of refractive indexes of materials and fabrication of refractive apertures in acrylic and glass; he did this through analysis of refraction and reflection of light in space as a function of spatial geometry and material properties; he did this through a laborious, complex and precise fabrication of ‘light containers,’ a series of tetrahedral slip-cast ceramic cells; he did this by throwing himself in the mix and flow of the materials. If his initial hypotheses had a sense of possibility and his initial intuitions were ‘right,’ his knowledge now is truer and more durable, it is a heuristic product acquired and confirmed through his own body~mind experiences. In the ensuing rheology, he became a prime material of his own experiment: a sensating, imagining, reasoning, emerging material — and so did I, bearing direct testimony as a witness.

⁶ Ben McDonald, *Sensitive Apertures*. Tucson: U. of Arizona Electronic Theses and Dissertations Library, 2008.

⁷ Jean-François Lyotard, *Peregrinations: Law, Form, Event*. New York: Columbia U. Press, 1988.



3 . HDR composite and false color luminance. Sensitive Apertures. Ben McDonald, M.Arch./EMT '08.

Now, I am reminded that, “While we talk,” — and I write — “the sun is getting older. It will explode in 4.5 billion years. It’s just beyond the halfway point of its expected lifetime...With the sun’s death your insoluble questions will be done too. It’s possible they will stay unanswered right up to the end, flawlessly formulated, though now both grounds for raising such questions as well as the place to do this will no longer exist.”⁸

*Ariel was glad he had written his poems.
They were of a remembered time
Or of something seen that he liked.*

*Other makings of the sun
Were waste and welter
And the ripe shrub writhed.*

*His self and the sun were one
And his poems, although makings of his self,
Were no less makings of the sun.*

*It was not important that they survive.
What mattered was that they should bear
Some lineament or character,*

*Some affluence, if only half-perceived,
In the poverty of their words,
Of the planet of which they were part.*

Wallace Stevens⁹

⁸ Jean-François Lyotard, “Can Thought go on without a Body,” *The Inhuman*. Stanford: Stanford U. Press, 1992.

⁹ Wallace Stevens, “The Planet On The Table,” *The Palm at End of the Mind*. New York: Knopf, 1971.