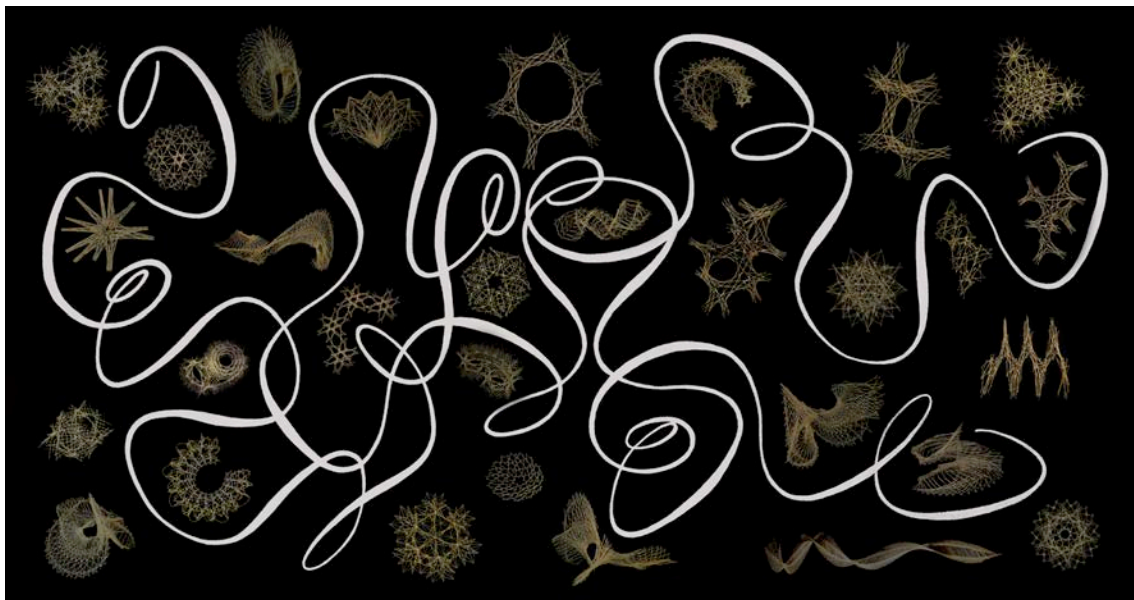


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## **Resonant Matter: Pattern Correlates of Process-In-Formation**

## **Materia Resonante: Patrones que Correlacionan con Modelos-In-Formativos**

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### **Abstract**

Through the aid of ever advancing technology, the analysis of complex phenomena offers us more comprehensive insights regarding the intricate inner workings of Nature's dynamic processes. Through such digital simulations (i.e., of fluid, aero, neuro and vibratory dynamics), the *operations* and *flow of energy* are revealed as highly patterned *process-structures* of activity. These vivid configurations often resemble and correlate with the patterns and motifs found at different scales throughout Nature and in a myriad of cultural artifacts. As intricately braided cellular relationships, these fertile processes evolve into highly integrative systems with re-generative, shape-shifting and re-structuring capabilities. Moreover, they are robust coalitions of *event-filled-processes*, highly responsive and fluently encoded with information. This embodied potential of generative kinetic *in-formation* and related patterns have been explored and offer more comprehensive insights regarding the resonances between self-organization, pattern generation and emergent complex morphology. At the heart of this lies the nature of *process-structures* and their elaborations into multi-dimensionally entrained kinetic *patterns of patterns-in-formation*. We are experientially embodied with and inextricably embedded within this interplay of ubiquitous metapatterns with reciprocally related cultural artifacts and motifs offering insightful resonances as analytical tools advance and probe further into the inner workings of the human mind and the nature of embodied consciousness.

### **Keywords:**

Body/Mind, Complexity, Emergence, Patterns, Self-Organization, Technology

### **Resumen**

Con la ayuda de una tecnología en constante desarrollo, el análisis de los fenómenos complejos nos ofrece una visión más completa sobre el funcionamiento interno de los procesos dinámicos que suceden en la Naturaleza. A través de simulaciones digitales (por ejemplo, la neurodinámica o la de fluidos, gases y vibratorias), las operaciones y el flujo de energía se revelan como procesos-estructurales de actividad que se ajustan a un modelo. Estas intensas configuraciones a menudo se asemejan y se correlacionan con los patrones y motivos encontrados en distintas escalas a través de la Naturaleza y en numerosos artefactos culturales. De forma similar a relaciones celulares enmarañadamente trenzadas, estos procesos fértiles evolucionan en sistemas altamente integradores con capacidades regenerativas, cambiantes de forma y restructuradoras. Más aún, son robustas coaliciones procesos-eventos-completos, altamente sensibles y con gran información codificada. Esta encarnación del potencial de in-formación cinética generativa y los patrones relacionados, al explorarse, ofrecen amplios puntos de vista con respecto a las interrelaciones entre la autogestión, la generación de patrones y el surgimiento de una morfología compleja. En esto radica la naturaleza de los *procesos-estructurales* y sus elaboraciones en patrones de los *modelos-in-formativos*, entrelazados cinéticamente y multidimensionalmente. Estamos experimentalmente encarnados y complejamente inmersos en este juego de meta-patrones ubicuos, recíprocamente relacionados con artefactos y motivos culturales, que ofrecen unas resonancias profundas como herramientas analíticas de avance y sondeo que van más allá del funcionamiento interno de la mente humana y de la naturaleza de su conciencia.

**Palabras Clave**

Cuerpo/Mente, Complejidad, Emergente, Patrones, Auto-Organización, Tecnología.

## 1. INTRODUCTION

*“You who speculate on the nature of things, I praise you not for knowing the processes which Nature ordinarily effects of herself, but rejoice if so be that you know the issue of such things as your mind conceives.”*

Leonardo Da Vinci (MacCurdy, p.70)

*“Think not of form, but of the act of forming.”*

Paul Klee (Guse, 1991)

The patterns generated by nonlinear dynamic processes are, intrinsically, highly ordered cellular coalitions of kinetic information, that incessantly self-modulate and are themselves modulated in ways comparable to improvised musical structure with variable leitmotifs. From an overall perspective they appear to be static configurations, but closer inspection reveals multi-layered fluctuations of *in-forming* kinetic energy as the underlying scaffolding sustaining the configuration in *suspended animation*. This rolling, coiling, and intermingling scaffolding is comparable to the undulations and twisting of threads that are woven into brocade fabrics. As inter-actively encoded *patterns-of-potentiality*, they offer multiple alternative “*readings*” of the embodied *in-formation* (Klee’s “act of forming,” thus, the splitting of the word to emphasize the current understanding of *information* as a verb). Intrinsically, these pattern-ing resolutions to dynamic activity are composed of encoded cellular units with the innate characteristics of the versatile processes that generate them. This complexity of metapatterns, when compared to less evolved diagrams, was metaphorically evoked by the physicist Erwin Schrödinger when he compared the difference between information contained in aperiodic (irregular) and periodic crystals: “The difference in structure is of the same kind as that between an ordinary wallpaper in which the same pattern is repeated again and again in regular periodicity and a masterpiece of embroidery, say a Raphael tapestry, which shows no dull repetition, but an elaborate, coherent, meaningful design...” (Schrödinger, 1967, p. 5).

Understanding such elaborate patterns and how they can be generated, modulated and appropriated, offers new avenues for innovative research. Historically, for example, conceiving and comprehending the potential of woven patterns eventually led to the cultural and technological evolution of weaving techniques and to the early conception and development of the loom. Through further expanded and insightful “*readings*” of woven *processes of in-formation*, the automated mechanical loom evolved, starting from earlier versions in Lyon, France, by Basile Bouchon in 1725, Jean Baptiste Falcon in 1728, Jacques Vaucanson in 1740, eventually culminating with the Jacquard Loom, invented by Joseph Marie Jacquard in 1801. By then, abstractly encoded *information* on cards with punched holes allowed for sequential instructions that could be manipulated and modulated to weave a myriad of intricately rich patterns. The encoded process was now contained within an abstract pattern of instructions that would need to be, at its most basic fundamental level, as simple and efficient as possible in order to accommodate as much variability of information as possible. In a similar comparable fashion, as a result of 19<sup>th</sup> century industrialization and mechanization, music boxes, player pianos and tabulating devices were controlled through encoded instructions on rolls of paper with punched hole patterns or through

metal cylinders with brass pin patterns. These new insights concerning other possible means of storing and encoding information regarding sequential processes would have immense repercussions in future technological developments.

Similarly, we are composed of and by highly versatile encoded cells (i.e., stem cells and pacemaker cells) and hierarchically organized multi-cellular structures and organisms that are inextricably embedded within a rich and complex matrix of biological and physical phenomena. Investigating the inherent attributes of this pro-creative matrix can lead to insightfully understanding and appreciating the correlations between developmental processes, growth, form and reciprocally related multi-cellular configurations, patterns and metapatterns. This embodied-mind and environmentally embedded-body matrix offers a wealth of possible “readings” through its reciprocal relationship with the nature of the material world. The sheer complexity of this intricately layered interplay inspired the neurophysiologist Sir Charles Sherrington to rely on layered and interweaving metaphors centered around Jacquard’s Loom as a way to envision and describe the inner working of the human mind: “The brain is waking and with it the mind is returning. It is as if the Milky Way entered upon some cosmic dance. Swiftly the head-mass becomes an enchanted loom where millions of flashing shuttles weave a dissolving pattern, always a meaningful pattern though never an abiding one; a shifting harmony of sub-patterns. Now as the waking body rouses, sub-patterns of this great harmony of activity stretch down into the unlit tracks of the stalk-piece [spine] of the scheme. Strings of flashing and traveling sparks engage the lengths of it. This means that the body is up and rises to meet its waking day.” (Sherrington, p. 178).

At an equally complex scale, our understanding of the nature of matter in its varied states (i.e., gas, liquid, plastic, crystal, liquid-crystal, etc.) and their inner workings has required that we again re-conceive creative and revealing analogies and metaphors as we try to comprehend the degree of complex behaviour encountered at the micro scales. This re-conceptualization occurred during the first decades of the twentieth century regarding, at the most elementary level, our comprehension of the nature of matter and the principles involved in its organizing and structuring processes. “What we observe as material bodies and forces,” according to Erwin Schrödinger, “are nothing but shapes and variations in the structure of space.” (Schrödinger, 1989, p. 327) Thus the measurable and numerically quantifiable states and locations of the most basic elements of matter were intrinsically and inextricably related to the dynamic inter-actions of energy and its variable complex coordination and structuring as vibrant fields. Nature’s processes revealed that at this most basic level of organization, static and precise measurements for analysis and prediction were not possible. Instead, three-dimensionally complex fields, networks or patterns-of-probabilities emerge through the evolving dynamic self-organization within the processes involved. “We still share the belief,” writes the mathematician Hermann Weyl, “of a mathematical harmony of the universe. It has withstood the test of ever-widening experience. But we no longer seek this harmony in static forms like regular solids, but in dynamic law.” (Weyl, p.77) Regarding this new conception, Weyl’s description of matter in the crystal state is most revealing and relevant to what follows: “In the crystalline state atoms oscillate about positions of equilibrium as if they were tied to them by elastic bands. These positions of equilibrium form a fixed regular configuration in space.”

(Weyl, p.28) This description of a vibrant yet “fixed regular configuration,” or pattern, where the “atoms oscillate” in suspended animation as if held in place by “elastic bands,” offers us a clue as to how to possibly investigate the nature of this realm of matter and its emergent properties.

The work that follows is produced through an investigation into the nature of these vibrant processes and their reciprocally related fluent patterns. With the overall title *The Phenomenological Garden*, the comprehensive project seeks to investigate the morphological and integrative versatility of the complex *processes-in-formation* lurking within Sherrington’s “enchanted loom” with its “shifting harmony of sub-patterns.” Work produced in research workshops incorporating educational methods and procedures derived from the research will also be covered. The dynamics of spin and the complex motion and angular momentum that emerges from multiple combinations of spin through, for example, hinging, folding and pivoting will be the primary focus. At an elementary level, including related emergent variations, spin is the simplest motion that is commonly found within the myriad of dynamic processes referred to above. Furthermore, spin is simultaneously robust and variable in scope through its specific axis or point of rotation and variable distance from that location, thus also including variable leverage. The entrained spin within the structure of atoms, the encoded spiral structure of DNA, the inherent complex rolling interactions induced through heat and fluid motion, the sequential structural folding of protein molecules, the dynamic interplay between the ball-and-socket joints in our hands and body, the complex dynamics of the earth’s environment due to multiple spin, and beyond to the spiral galaxies, should sufficiently attest to the ubiquitous presence of spin, its related emergent properties, and hierarchical structuring capabilities.

Overall, the evolving research is a systematic exploration of the versatility and generative potential of these complex processes along with the kinetic nature of their encoded *in-formation*. As part of Crossings Interdisciplinary De-Formation Research at the Azrieli School of Architecture and Urbanism at Carleton University, the work seeks to investigate how complex structures, forms and possible experientially resonant spaces can be conceived, produced and developed from initially simple and/or random processes that can specifically evolve into morphologically rich, integrated and integrating relationships. The rich diversity and potential of *in-formation* as revealed through more comprehensive interdisciplinary awareness and understanding, offers new insights and directions into the expressive versatility lurking within matter and Nature’s processes as these developments continue to be embraced for conceptual and metaphoric inspiration.

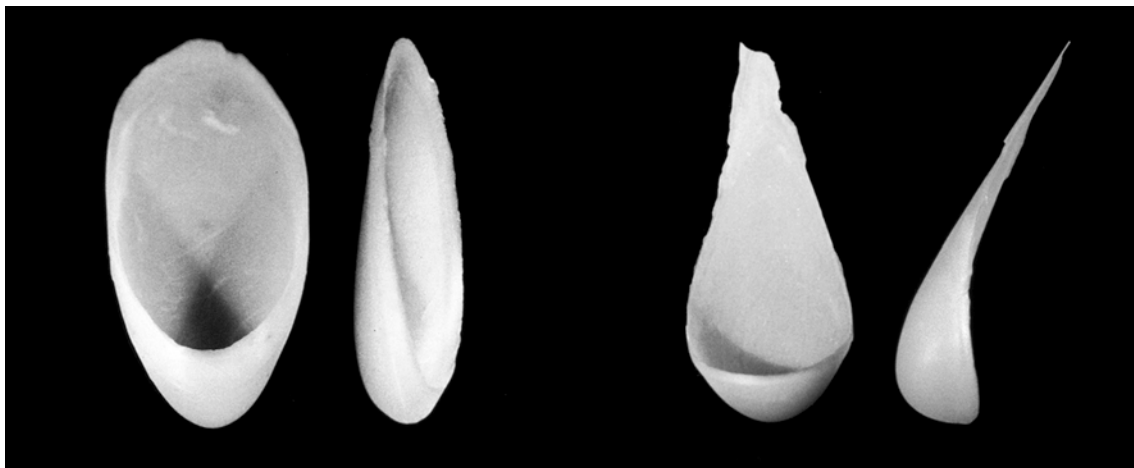
## **2. A FREE-WHEELING POTTER WORKS-IN-PROCESS**

### **2.1. Whirling Form-Work**

Spin was first incorporated into the investigative process through the use of a simple Potter’s wheel. The whirling vortex generated by the spinning wheel was used as kinetic formwork (or scaffolding) for casting possible forms. First, a wooden frame was constructed and secured to the wheel. This frame allowed for a 3-inch diameter by 9-

inch high metal cylinder to be secured at any desired angle relative to the horizontal surface of the wheel. Hot water, followed by melted wax, was then poured into the cylinder and sealed with a cap. This set-up was spun for a period of time, allowing for the water and wax to cool. Subsequently, the cylinder was released from the frame and the water poured out leaving only the wax cast of the top surface of the vortex generated by the un-mixing fluids. Through this process, several forms were cast reminiscent of seashells and biologically sensual shapes. Figure 2 shows two of these wax forms with two views of each.

Materially, through the form and texture of the surface, these wax casts are clear records of their dynamic self-organizing and making process. Similarly, for example, seashells are encoded records of their dynamic *in-forming* process, offering vivid information regarding Nature's inner workings that can be deciphered, interpreted and expanded upon in ways comparable to those mentioned above regarding woven patterns. In his seminal 1917 publication, *On Growth and Form*, the biologist D'Arcy Thompson emphasized the importance of these growth and developmental traces found throughout Nature, referring to such patterns from self-organizing processes and fields of stress as a "diagram of forces" that generate the form of an object (Thompson, 1942).

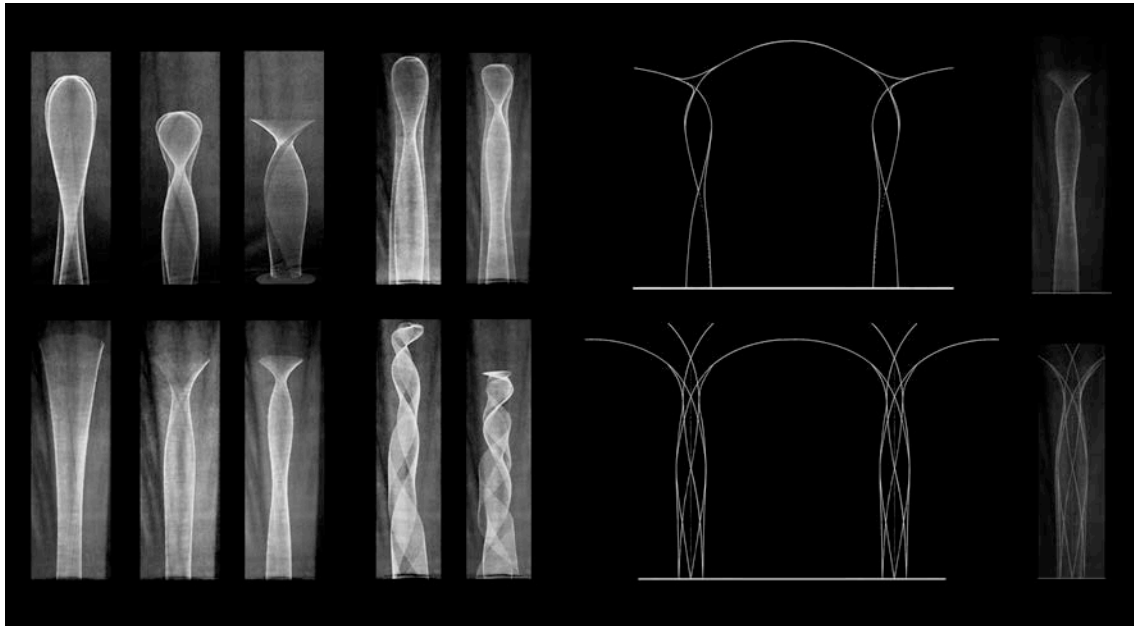


**Figure 2:** ©M. Báez, *Wax Forms Studies*, cast with a potter's wheel and metal cylinder. Both wax forms are approximately 7-inches high by 3-inches wide.

## 2.2 Ariadne's Thread Whirling in Rumi's Ocean

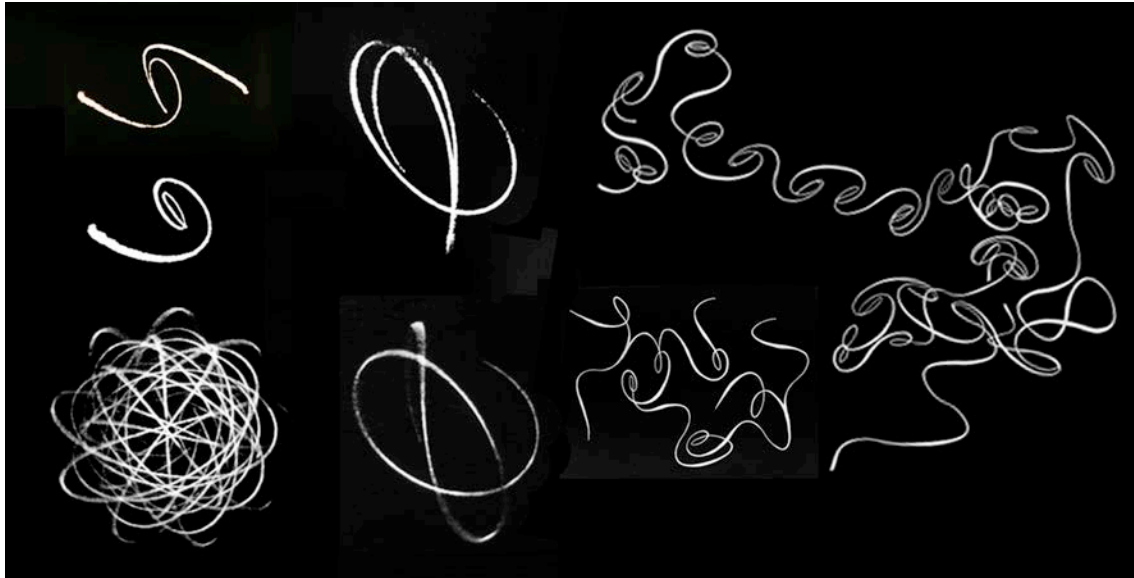
In another exploration of spin as an *in-forming* process, the potter's wheel was secured upside down to the ceiling, thus inverting the relationship of the wheel to the pull of gravity and allowing for cotton threads (as one example) to be suspended and spun. Single threads hanging freely from one or two end points on the wheel were spun, generating sequential and highly sensitive wave formations as the speed of rotation was changed and modulated. Stable wave-formations gradually would transform with increasing turbulence as the speed increased. Titled *Ariadne's Thread/Rumi's Ocean* (1), this on-going series of explorations were recorded from several vantage points:

from below, centered on the axis of spin; from within, with the camera mounted to the wheel and centered on the axis of spin; and from random locations and exposures around the generated forms. This generated a myriad of morphological formations and generative working procedures, shedding insight, relative to a frame of reference and motion, into the correspondence between generated forms, emergent patterns and perception. Figures 3-7 show the full scope of this project along with the myriad of possibilities — see also the calligraphic line shown in the Cover image (2).

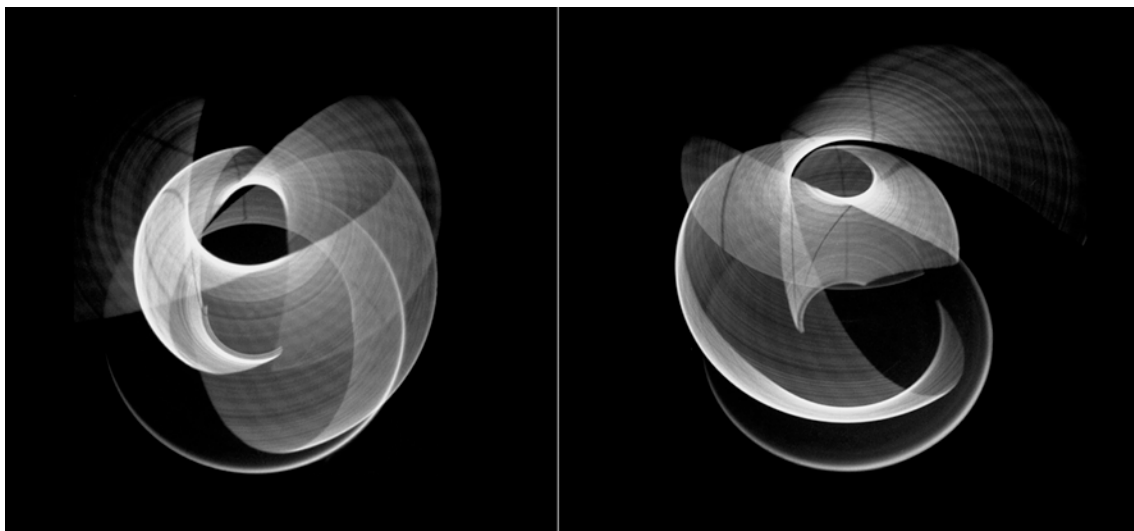


**Figure 3:** ©M. Báez, *Ariadne's Thread/Rumi's Ocean*, String & Potter's Wheel, 1993-present. Left side: Single string and looped string formations, shown up-side down, with the speed of rotation increasing to the right. Right side: Two single string formations (on right) shown as possible connected columns on the left.

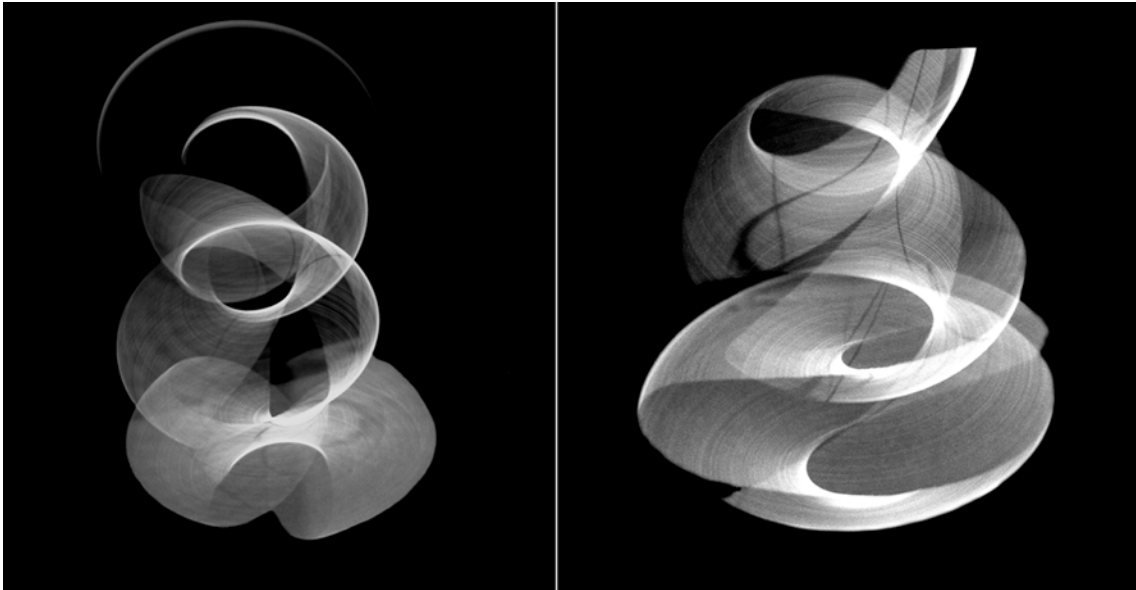




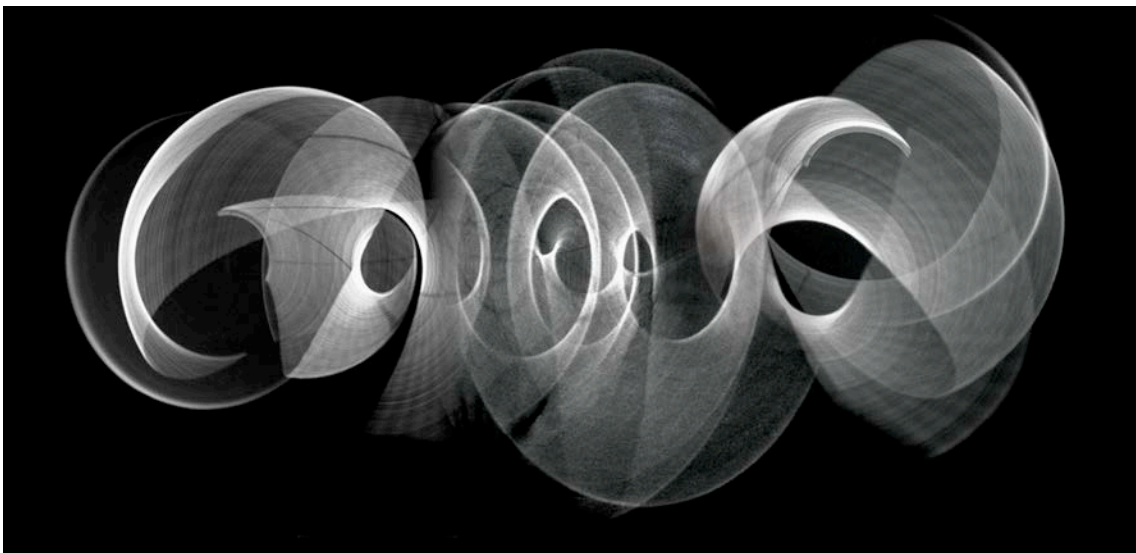
**Figure 4:** ©M. Báez, *Ariadne's Thread/Rumi's Ocean*, String & Potter's Wheel, 1993-present. Upper left: Single and looped string images of the spinning string recorded with the camera mounted to the Potter's wheel. Lower left: Multiple exposure image of the spinning string recorded from below, recalling "*Ariadne's Ball of Thread*." Middle: Calligraphic Lines of the spinning looped strings, still images recorded from below. Right: Collaged multiple still images of the spinning string generate fluidly undulating calligraphic lines. The cover image shows another of these improvised calligraphic lines.



**Figure 5:** ©M. Báez, *Ariadne's Thread/Rumi's Ocean*, String & Potter's Wheel, 1993-present. Two swirling and undulating surfaces are shown generated by the spinning string, recorded from different arbitrary angles, exposures and rates of rotation.



**Figure 6:** ©M. Báez, *Ariadne's Thread/Rumi's Ocean*, String & Potter's Wheel, 1993-present. Two additional swirling and undulating surfaces are shown generated by the spinning string, recorded from different arbitrary angles, exposures and rates of rotation. Of special note here is how the image on the right shows the string casting its shadows on the surface that it generates. Both these images evoke the circular dance of the Whirling Dervishes.



**Figure 7:** ©M. Báez, *Ariadne's Thread/Rumi's Ocean*, String & Potter's Wheel, 1993-present. Collaged multiple images of the spinning string, as shown in figure 5, generate spatially swirling and undulating surfaces that evoke fluidly dynamic turbulence while also offering spatial possibilities.

### 2.3. Whirling Surfaces and Catenary Spins

*Ariadne's Thread/Rumi's Ocean* is an on-going investigation that kinetically speculates on, and expands upon, the ruled surfaces traced by a moving line and the catenary curves that a hanging chain, cable, rope, or cord, when supported at the ends, acquires due to its own weight being uniformly pulled by the force of gravity. Inspired by his extensive study of Nature, Antoni Gaudí incorporated ruled surface forms and their complex combinations and intersections throughout his architecture. The full extent of this can be seen and experienced in his masterpiece, the Sagrada Familia. According to Gaudí, "paraboloids, hyperboloids and helicoids, constantly varying the incidence of light, are rich in matrices themselves, which makes ornamentation and even modeling unnecessary." (Puig i Boada, 2004)

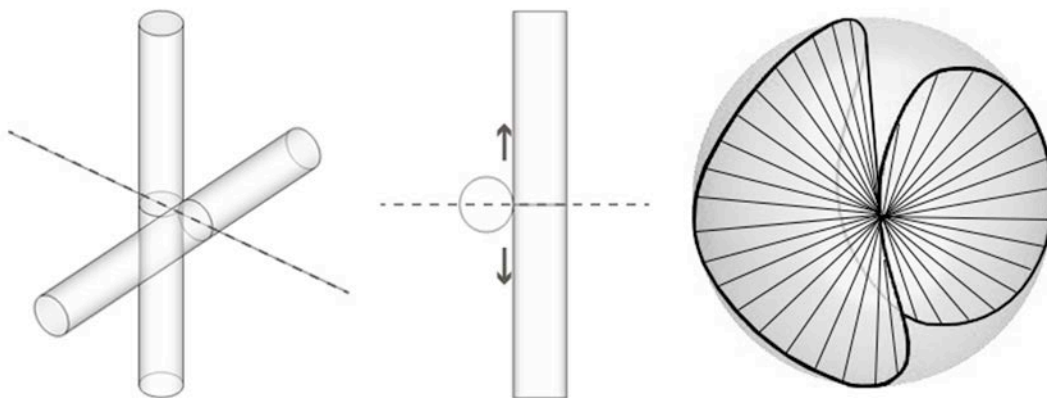
First analyzed by the natural philosopher and architect Robert Hooke in the 1670s, the catenary curve was eventually incorporated by Hooke into the construction of inverted catenary arches. This structural simplicity of the inverted catenary was later incorporated by Antoni Gaudí in such works as the Casa Milà, throughout its roof support structure and, more extensively, in the iconic structural study model for the church of the Colonia Güell and the Sagrada Familia. The straight line and catenary curves acquired by the suspended cord (metaphorically referred to as *Ariadne's thread*) are now subjected to the emergent complexities of spin (the labyrinth in *Rumi's Ocean*) and its associated "ruled," warped, twisted and sculpted surfaces. The catenary curves are also distorted to an extreme with the length of thread within the kinetics of spin. In both instances (the initially straight line and catenary curve), guided by the various trajectories of the spinning thread, the tension forces can be imagined as "inverted" into compression (as shown on the right in Figure 3). How the un-inverted tension trajectory could be structurally conceived and maintained in this *suspended animation* can be visualized as a tensioned cable that's embedded within the dynamic interplay of the invisible vortex-matrix. Such speculations bring to mind the question: What kind of comparable or analogous physical membranes could one conceive that could possibly mimic such dynamic structural interplay? This would offer new formulations of the work by Hooke and Gaudí, referred to above, as well as that of such notable architects/engineers as Buckminster Fuller, Félix Candela, Eduardo Torroja, Emilio Pérez Piñero, Eladio Dieste and Frei otto.

### 3. METAPHORIC INTER-WEAVINGS IN SUSPENDED ANIMATION

With the ultimate goal of applying the results of the research, further analysis and development of the working methods, processes and concepts described above eventually led to exploring ways of possibly constructing the generated forms and complex surfaces. In this regard, the anthropologist Gregory Bateson advises us to "discard the magnitudes [or scales] in favour of shapes, patterns, and relations." (Bateson, p.11) At this fundamentally nascent stage, the relationships between components and scale-less shapes and patterns should thus be the guiding principles. Elemental cellular diagrams and shapes, such as a triangle, square, pentagon, etc., and their combined configurations as multi-cellular fields were

considered as 3-dimensionally encoded dynamic relationships instead of static patterns or arrangements.

Early on in the process it was clear that a critical item would be how the assembled components would be held together or constrained while simultaneously allowing for a certain degree of freedom. Eventually, a joint detail was conceived consisting of linear elements (specifically, 1/8-inch bamboo dowels or shish kebab sticks) that were held together, at this initial exploratory phase, with elastic bands. Comparable to Hermann Weyl's dynamic conception of how oscillating atoms are held in their positions, this allowed for a high degree of flexibility as a result of the constrained rolling action between the dowels. The dynamics of this tangential interaction between cylinders is the generative and interactive kinetic-cell or joint of the process. Through the emergent choreography of these interacting joints, in different basic geometric relationships that are then assembled into increasingly complex cellular configurations, there emerges a very fluent, tangible, experiential and malleable field with highly generative and informing properties. By analyzing the overall behavior of these membranes and their kinetic properties, while simultaneously being aware of the reciprocally corresponding and very specific behaviour of the individual joints, the shape-shifting and form-finding capabilities of the assembly can be grasped, deciphered, modulated and expanded upon for specific applications. Figure 8 shows the kind of virtual undulating surface that can be experientially visualized and defined by the dynamic interactions between the two cylinders.



**Figure 8:** ©M. Báez. Details of the two opposing cylinders rolling against each other (left and middle), the elastic band joining them together is not shown. Right: 3-dimensional image of the undulating virtual surface that's defined by the kinetic interactions between the cylinders (their possible locations are indicated with the dashed and solid lines).

Many parallels can be drawn between the virtual surface shown on the right side in Figure 8 and the emergent kinetic properties of the possible membranes. This also serves as an example of how self-similarity comes into play through this generative process at the scale of the individual cellular joints and that of the broader more complex combinations. This will become apparent in the sections that follow. At this

stage, a more thorough comprehension of the kinetics within the joint and between the joints is needed.

As the two cylinders roll against each other, they both define reciprocally related surfaces, similar to the kind of ruled surfaces defined by the traced movements of a line referred to earlier. Through this point of contact between the cylinders there are two constantly aligned and opposing axes (see left-side of Figure 8) held in place and in compression by the tension through the stretched elastic band (not shown in the figure). This relationship is constant as the point of opposing contact kinetically rolls and spirals around the two cylindrical surfaces. Driving this constrained dynamic interplay is the resulting and relatively constant tangential movement rolling around the cylinders, constantly at right angles to the aligned and opposing axes between them (see middle of Fig. 8).

By 3-Dimensionally leveraging this kinetic joint action through various multiple combinations of joints, an emergent transformable membrane is generated with great shape-forming and shape-shifting potential. Thus, a kind of *suspended animation* is achieved through self-similar tensegrity at the scale of the joint, intermediate configurations and overall membrane. This robust, emergent, tactile and generative *event-filled moment-of-inertia* can be experienced, “listened” to, guided and expanded upon through its inherent kinetic momentum. Overall, this woven propagation of wave motion through the membrane is constrained at the joints by corresponding spiraling kinetic torques. As observed by Hermann Weyl, “The most general rigid motion in three-dimensional space is a screw motion... combination of a rotation around and axis with a translation along that axis.”(Weyl, p.71) This robust rotational motion, occurring here at the joint and leveraged throughout the membrane, has great generative potentiality that has been technologically appropriated throughout history as its complex simplicity has been deciphered and applied. At its most elementary level, Nature has incorporated this in the simultaneously simple and yet complex structure of DNA.

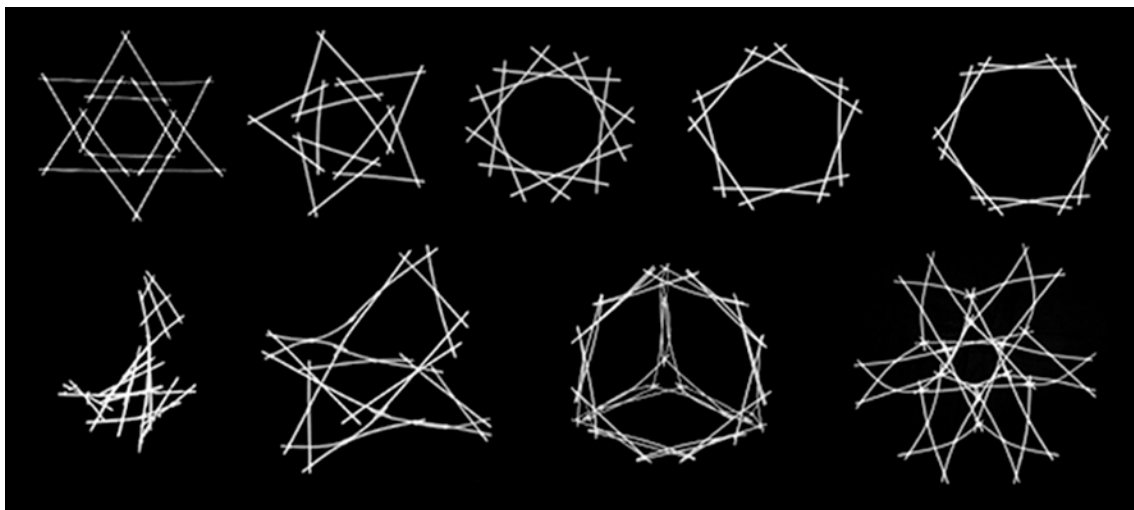
### **3.1 Multi-Cellular Inter-Weavings of Variable Shapes, Patterns and Relations**

Through a series of explorations, starting with different combinations of 1/8 inch bamboo rods held together with the joint described above, a series of cellular units were conceived and combined in a progressive sequence of increasing cellular size, complexity and combinations. This would eventually lead to overall complex assemblies of cellular units that perform as deformable membranes. Different intermediate stages of this assembling process are shown in Figure 9. The top row shows cellular units that are made with combinations of the initial cells (triangles, squares, pentagons, etc.). These cellular units are themselves combined into more complex units through the progressive sequence (as shown on the bottom row). This process would continue while maintaining a degree of malleability within the overall 3-dimensional assembly. Gradually, the emergent, transformative and organizing properties of the integrated assembly reach a very fertile and specifically robust informing phase. Often, these emergent properties re-generate the inherent

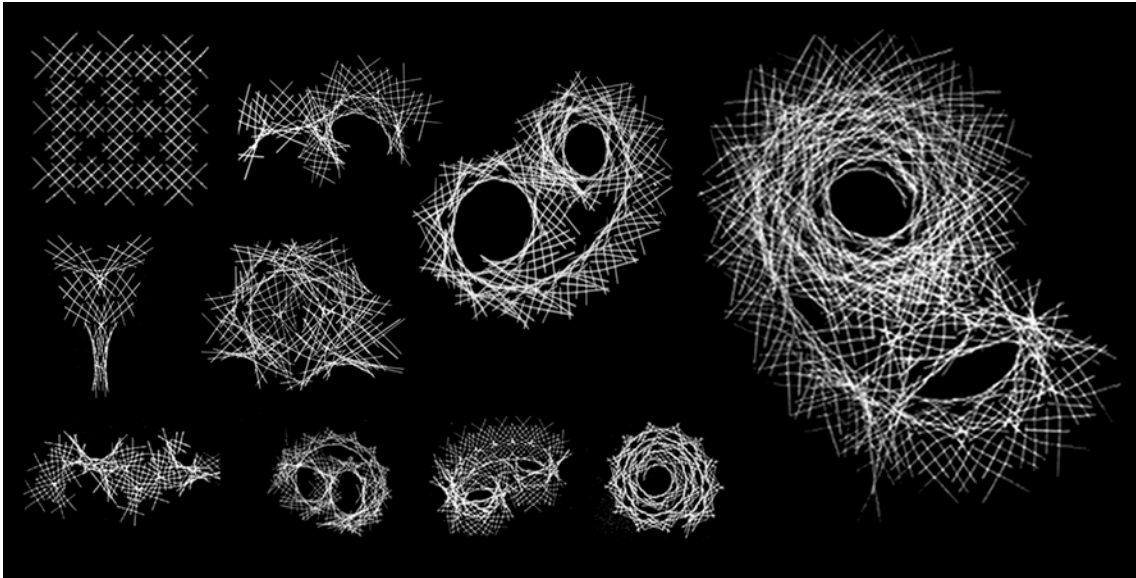
characteristics of the processes that inspired their conception or those of the original cellular joint (as discussed previously and illustrated in Figure 8).

The emergent properties of the constructed membranes are explored through an experiential process that leads to an ability to selectively differentiate portions of the membranes as a way of determining the forms and structures that could be revealed, combined and developed. This tactile participatory experience engages a process through which one senses, follows, and guides the versatile form-generating and self-organizing properties (the encoded *in-forma-tion*) within the membrane. The experiential process has many parallels with weaving, the evolution of weaving techniques and involves a comparable degree of intricate complexity, recalling Sherington's "enchanted loom" with its overall shifting, meaningful and un-abiding pattern(s).

The initial cellular explorations eventually focused on the robust versatility of a square geometric relationship. Compared to a triangular arrangement, the square is the first that is inherently deformable. Figure 10 offers a summary of this sequential process with a portion of the membrane shown on the upper left-hand corner. What appears as gaps within the membrane allow for opposite corners in the gaps to be joined (always with elastic bands) thus warping the planar surface. Improvised explorations through this process are shown at intermediate stages of development. As stated earlier, the possible forms and structures revealed and developed through the experiential process are determined by how the initial membrane is probed, segmented and differentiated into deformable sub-patterns. An inherently coiling structure, approximately 30 feet in overall length and 3 feet wide, is shown in the middle and right side. This construction has been exhibited in several different configurations as shown in Figure 11.

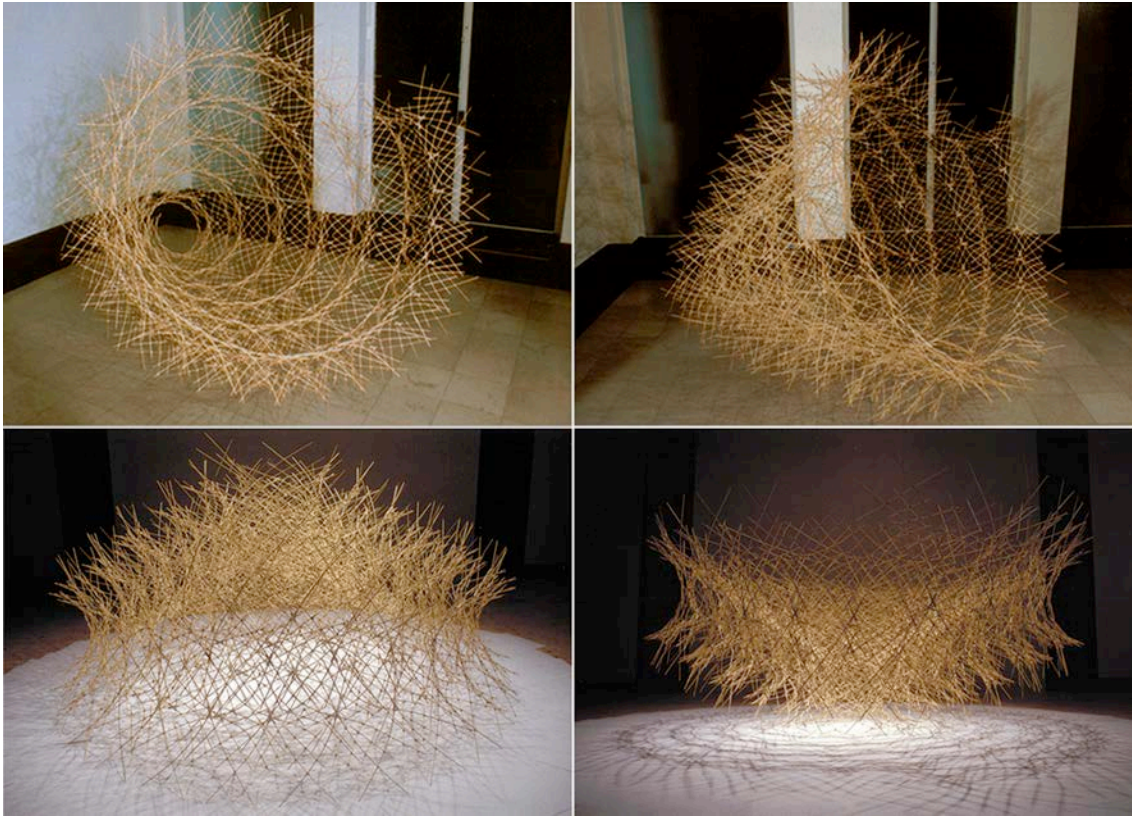


**Figure 9: ©M. Báez, Crossings Workshop, *Phenomenological Garden/Suspended Animation Series*.** Cells and cellular arrangements: 12" bamboo dowels joined together with elastic bands (joint detail is shown in figure 8). These initial cells and cellular arrangements are joined together into flexible membranes or fabrics. Different cut-out patterns of the membranes will generate different forms and structures through the inherent flexibility of the integrated assemblies.



**Figure 10:** ©M. Báez, *Phenomenological Garden/Suspended Animation Series, 1994 – Present*. Form Studies with a transformable membrane construction made with square cellular units using 12" and 6" bamboo dowels & elastic bands. Upper left: assembled membrane; left to right: improvised assemblies with full constructions of a coiling structure shown on the right.

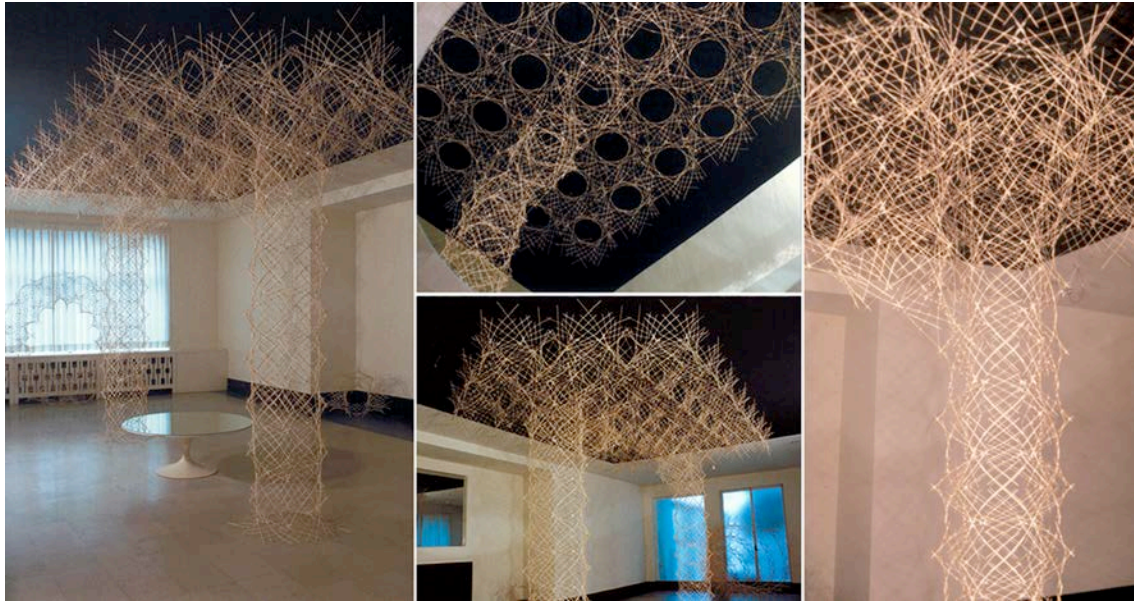
As previously discussed, the 3-dimensional joint and intermediate cellular configurations, as integrated assemblies, contain innately encoded *inter-active in-formation*. Through increasing experiential awareness of this *in-formation* and familiarity with the working process, more expressive forms and intricate structures can be conceived. There is a literal sensing of the stresses within the membrane and its inherent *in-forming* potential. Initially random explorations would eventually selectively focus and differentiate combinations that lead to the discovery of unanticipated configurations and patterns. In turn, the specific generative properties of these emergent patterns can then be probed further, allowing for the development of even more complex combinations.



**Figure 11:** ©M. Báez, *Phenomenological Garden/Suspended Animation Sculpture Series*. Top: for the *Metaphoric Inter-Weavings Symposium*, Cranbrook Academy of Art and the Sybaris Gallery, 1998. Bottom: at the Network Gallery, Cranbrook Academy of Art, Bloomfield Hills, Michigan, USA, 1999. Views of two different sculptural installations of the coiling structure shown on the right side of Figure 10, 12" and 6" bamboo dowels & elastic bands.

The sculptural forms shown in Figure 11 are constructed variations of the membrane and coiling structure shown in Figure 10. More thorough experiential awareness of the potential of this membrane eventually led to the intricate installations shown in Figures 12 and 13. The almost limitless expressive potential of the membrane and working process had, by then, become apparent. The installation in Figure 12 was part of a symposium, titled *Metaphoric Interweavings*, that was based on the overall themes of the research. It explored the interrelationships and similarities between weaving, basketry, musical composition and architecture through the use of a modular or cellular composing process. Invited artist Lissa Hunter lectured on her work, basketry and weaving, while classical pianist Marina Korsakova-Kreyn delivered a lecture/performance on the intricate structure of musical compositions by J. S. Bach. Professor of architecture Gulzar Haider lectured on the intricate use of *mugarnas* in Islamic architecture. *Mugarnas* is a modular system of corbelled projecting niches used for spatial transition zones and for architectural decoration.

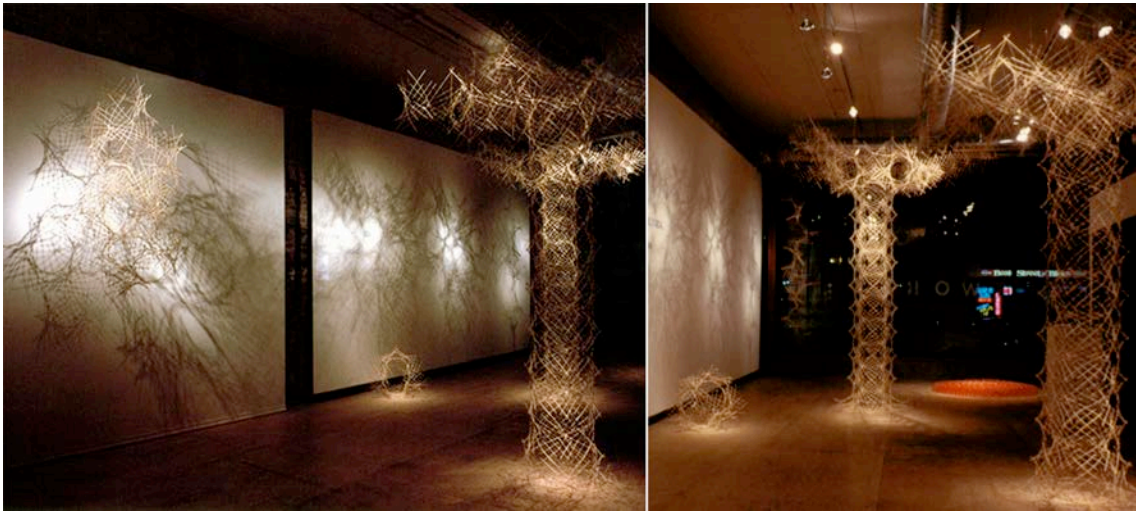




**Figure 12:** ©M. Báez, *Phenomenological Garden/Suspended Animation* installation for the *Metaphoric Inter-Weavings Symposium*, Cranbrook Academy of Art and the Sybaris Gallery, 1998. Transformable membrane constructions using a square cellular unit made with bamboo dowels and elastic bands (as shown in Figure 10). Middle and left side: Images of the overall installation where two columns are transformed into an intricately patterned ceiling structure. Emergent patterns are revealed throughout the installation and, as shown in the upper-middle, as one looks into the mirrored central table (seen in the left image). Right: Close-up of column structure and ceiling which can appear as highly structured or chaotic depending on where it is viewed from.

The *Phenomenological Garden* project was initiated with the installation in Figure 12. Two supporting columns are gradually transformed into an intricately patterned ceiling as sculptural forms (visible on the left side and lower middle) are displayed throughout the exhibition. The close-up of one of these columns on the right shows the transition into the ceiling as well as the unanticipated fluid lines and patterns that emerge. The rich variety of these patterns and lines are revealed as one walks around the installation or looks into the mirrored central table (see upper-middle image). Different vantage points reveal entirely different patterns, at times regular, chaotic, and unexpected.

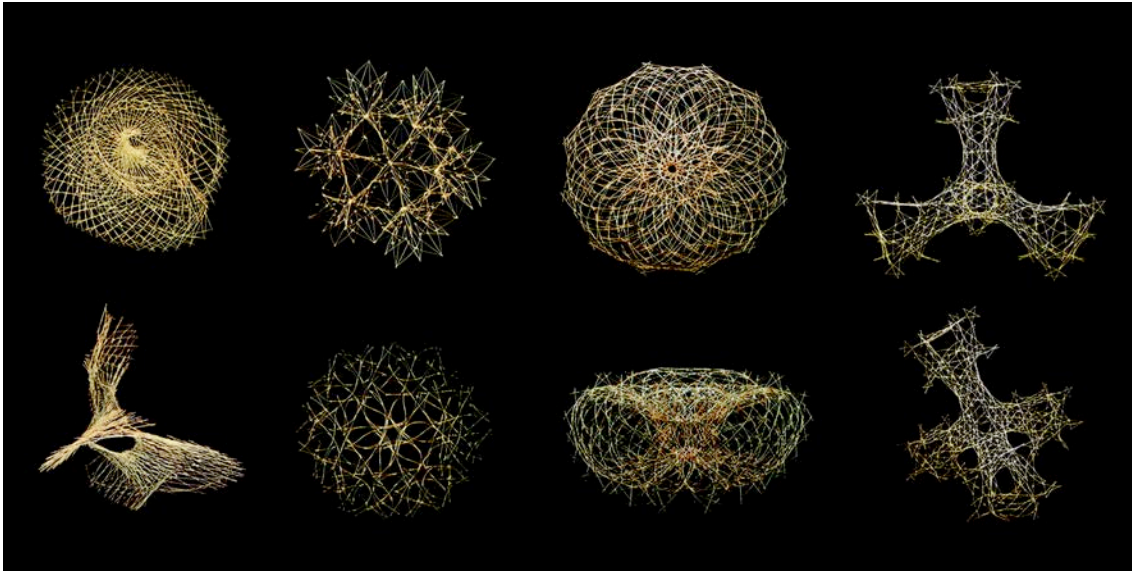
Through the evolution of the *Phenomenological Garden*, the intricate shadows cast by the constructions have become increasingly more relevant to the themes of the research. The installation in Figure 13 was developed from the one shown in Figure 12. Here shadows played a major role in addition to the 3-dimensional sculpting possibilities of the working process. A series of improvised woven sculptures and freestanding structures cast their shadows on the walls and floor throughout the exhibition. The sculptures along the walls are inspired by Leonardo Da Vinci's *Deluge* drawings of dynamic natural phenomena and his reflections on the inherent dynamic potential of geometry. Again, throughout the installation, different vantage points would reveal highly ordered and at times chaotic patterns within the overall woven constructions. Thus, to a certain extent, the intricacies of the experiential construction process are revealed and experienced throughout the installation.



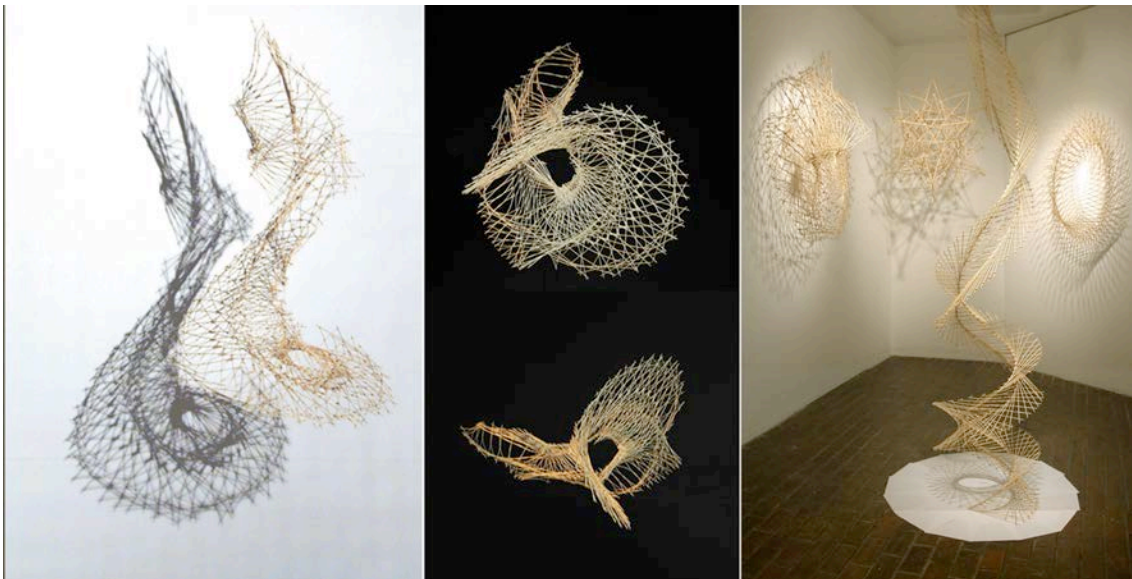
**Figure 13:** ©M. Báez, *Phenomenological Garden/Suspended Animation Series*, installation at the Network Gallery, Cranbrook Academy of Art, Bloomfield Hills, Michigan, USA, 1999. Developed from the installation shown in Figure 12. Improvised sculptural weavings and freestanding constructions cast shadows on the gallery walls and floor.

### **3.2 Inter-Disciplinary Structural Morphology: The Crossings Workshop**

As illustrated above, the generative potential of a membrane constructed with a square cellular unit has been extensively explored. The inherent possibilities and emergent properties of other cellular units have also been systematically explored. Figures 14 and 15 show several constructions produced by students in the Crossings Workshop. Through this workshop and related seminar, the educational potential of the research is explored by introducing students to the inherent possibilities of the working process and the interdisciplinary developments that have inspired their conception.



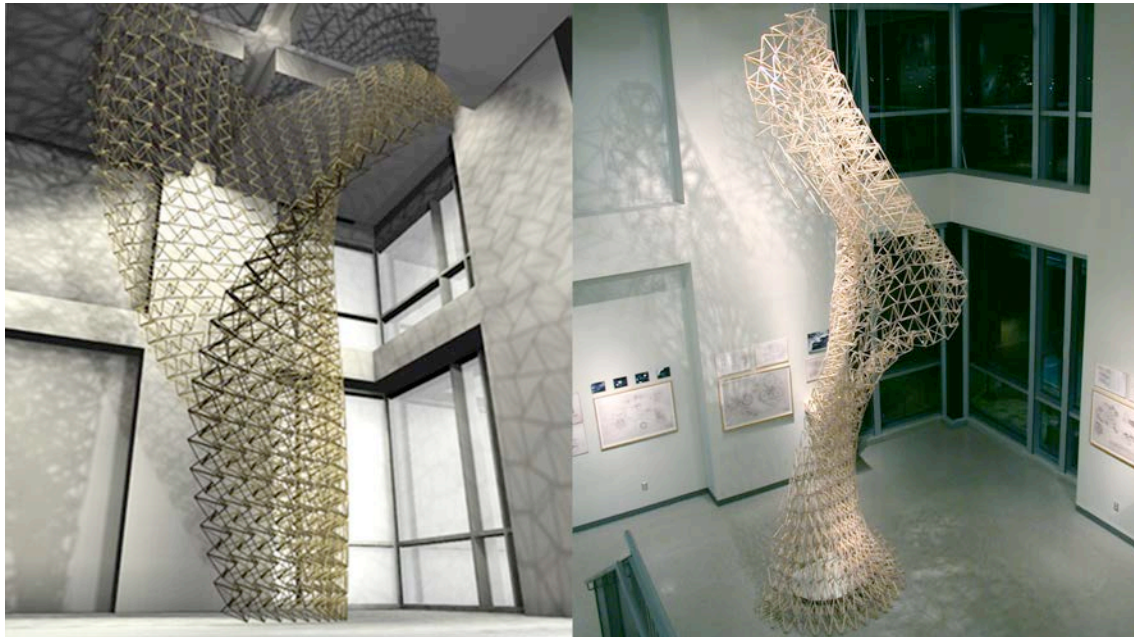
**Figure 14:** ©M. Báez, *Crossings Workshop Suspended Animation Series*, Cellular forms Studies, bamboo dowels and elastic bands, 2001-05. Works by Diana Park, Daniel Cronin, Sharif Kahn, Natalia Kukleva and Nathan Dykstra. From left to right: 1<sup>st</sup> structure on top and bottom, with heptagonal cells; 2<sup>nd</sup> top, with pentagonal cells; 2<sup>nd</sup> bottom, with square cells; 3<sup>rd</sup> top and bottom, with square cells; 4<sup>th</sup> top and bottom, with pentagonal cells.



**Figure 15:** ©M. Báez, *Crossings Workshop Suspended Animation Series*, Cellular forms Studies and Workshop exhibition, bamboo dowels and elastic bands, 2001-05. Works by Diana Park, Mariam Shaker, Sherin Rizkallah and Raymond Chow. Left and middle: same structure (with heptagonal cells) in different configurations, casting its shadow on the wall. Same structure is also shown on the left side of Figure 14. Right: Crossings Workshop exhibition.

The left side of Figure 14 shows two different configurations of a woven membrane constructed with a seven-sided (heptagonal) initial cellular unit. Figure 15 shows other

configurations of this membrane (see the left-side and middle). Of special interest here is the organic looking shadow that it casts on the wall. Elsewhere, the gradual effect of gravity is clearly demonstrated in the subtle undulations of the structure shown on the right side of Figure 15 (in the foreground). Other constructions shown in Figures 14, 15 and throughout the initial cover image were assembled with different units and reveal the rich diversity of the working process. The assembling procedures, derived from the encoded *in-forma-tion*, lead to unexpected patterns and dynamic configurations that generate new and diverse developmental directions for the evolving process.



**Figure 16.** ©M. Báez, *Complex Simplicity* installation (as part of the exhibition on the work of Canadian Architect James W. Strutt) at the David Azrieli Gallery, Carleton University, 2006. Wooden dowels w/plastic tubing. Left: digital study. Right: Installation view. Research assistants Adam Fingrut, Patrick Bisson, and Elie Nehme.

### 3.3 Folding as an Emergent and Generative Hinging Process

The installation shown on the right of Figure 16 is another project derived from the concepts and themes of the *Phenomenological Garden*. It was developed from explorations of the structural and architectural potential of a membrane derived and developed with a hexagonal cellular unit. By subdividing the hexagon, the structural stability of the equilateral triangle was incorporated into the generative cellular process. As with the others, inherent folding patterns encoded within the evolving combinations generated very specific, versatile and transformable 3-dimensional membranes (or space-frames). Hyperbolic paraboloid (hypar) surfaces, referred to earlier, can be generated through this process, with simple folds incorporated and developed as hinges. Due to the increased flexibility (or *degrees of freedom*) of the 3-dimensionally folded or hinged patterns, these particular curved surfaces are far more deformable than when they are derived as ruled surfaces from linear elements. More complex and

versatile undulating capabilities can be achieved by introducing other simple degrees of folding from the pattern. Prior to the exhibited installation shown in Figure 16, the potential of the membrane was explored both digitally, as shown on the left, and in the actual space of the gallery. The architectural potential of this membrane is being explored and developed through applied research projects such as the one shown in Figure 17.



**Figure 17.** ©M. Báez, Major's Hill Park Pavilion proposal, Ottawa Tulip Festival, 2009. Application of a malleable membrane structure, allowing for different thematic pavilions to be designed each year using the same kit-of-parts. Special thanks to Research Assistants Przemyslaw Myszkoski, Tom Svilans and Mitch Counsell.

### 3.4 Resonant Currents of Local and Global Inter-Weaving Agency

The installation shown in Figure 18 is the latest project from the *Phenomeno-logical Garden*. Currently in-progress, the project is a response to an invitation to propose an installation at the headquarters of HUB Ottawa, one of several non-profit co-operative organizations located in major cities throughout the world. This global network of organizations is focused on community engagement initiatives and relationships that address social and environmental global challenges. The project is inspired by the parallels between the underlying themes of the research and those of the global and local HUB initiative. It has been developed along with students in the Crossings Workshop. Titled *Resonant Currents*, it is also inspired by global commonalities, connections and their expressions through human cultural artifacts (i.e., weaving traditions, calligraphy, basketry and mosaic patterns). Envisioned as an integrative network and support structure, the installation would be in resonance with the open concept and inclusiveness of its environment. As a woven structure with bands of birch plywood as the generative cellular unit, the interwoven network reflects its material

capabilities and properties while simultaneously responding and adapting to its setting. Linear combinations of the bands are woven together through their inherent twisting and bending material properties. Once again, spin through twisting is incorporated into the assembly process due to the more versatile and complex possibilities. The overall collective weave will also have highlights using wire mesh fabric at significant locations within the space. The modulating patterns, with their configurations and interconnected parts, are envisioned as metaphors for the HUB's collective social initiatives and their equivalent parallels within the multicultural diversity of the Canadian setting.



**Figure 18.** ©M. Báez, *Resonant Currents* installation (in-progress), HUB Ottawa, 1/8"x4"x5' Birch plywood (with wire mesh highlights - not shown), 2013. Woven ceiling construction envisioned as an interconnected network and support structure mirroring the HUB's vision and Canada's ethnic cultural diversity. Special credit goes to Crossings Workshop students: Kaveh Baradaran, Ming Fu, Melhik Gebremichael, Arron Griffioen, Macy Laporte, Mark Madera, Stephanie Murphy, Mateusz Nowacki, Maria Olmedo Franco, Aigerim Shakanova, and Robin Woollacott.

#### 4. THE RESONANT MIND-FIELD OF METAPHORS AND META-PATTERNS

*"The universe is built on a plan the profound symmetry of which is somehow present in the inner structure of our intellect."*

Paul Valery (Sautoy, p.1)

*"El universo se basa en un plan de la simetría profunda de lo que es de alguna manera presente en la estructura interna de nuestro intelecto."*

Paul Valery (Sautoy, p.1)

This insightful observation by the French essayist and philosopher Paul Valery regarding, essentially, a correlative and reciprocal relationship is similar and

comparable to Leonardo Da Vinci's words of wisdom that served to initiate the introduction to the journey summarized above. In both, one more direct than the other, reflective introspection regarding the nature of our intellectual, creative and imaginative abilities is referred to as a very revealing way of acquiring perceptive and intrinsic knowledge regarding the inner workings behind the theatre of the mind and its relationship to the material world. Any artistic and cultural tradition, or scientific, biological and technological process that innately resonates with and, therefore, propagates through this vast and fluent matrix, can be acutely expressive, fertile, meaningful and insightful. The evolution, development, significance and metaphorically fluid structure of both language and music are certainly examples of such profound processes (if not the primary ones) that mirror the nature and structure of their boundless source. Equally as significant is how they are both written or encoded in order to thoroughly communicate the depth of the linguistic or musical information. Sir Charles Sherrington's evocative and metaphoric vision, previously cited, certainly comes to mind as an appropriately resonant and evocative description of this intricate and remarkable phenomenon.

More recently, the biologist Gerard Edelman has offered a less poetic and succinct description, in its own technical way equally as compelling as Sherrington's: "I conclude that the human brain itself operates as a selectional system with highly variant repertoires of circuits. Subsets of these circuits are selected to match signals from the world of complex events."(Edelman, p.82) Elsewhere he adds, "The important point is that this selective system allows enormous combinatorial freedom for thought and imagery, and even for logic and mathematical calculation."(Edelman, p.103) These insights emerge from, and are reinforced by, the current technological advances that are allowing for more comprehensive simulations and analysis of complex processes, such as those associated with mental activity. Edelman also relies on musical metaphors, again recalling Sherrington, as an appropriate means of describing and evoking his conceptual understanding and complex vision regarding how modulating and modulated mental patterns or "maps" interact throughout the brain. These intricate descriptions and advances also confirm and add credence to the insightful observations of Leonardo and Valery regarding the mind, Nature and the physical universe.

This is a truly fertile realm for creative inspiration, ideas and directions, and has served as fuel for the research and work summarized above. Throughout the explorations and developmental processes, an initial wide-ranging investigative phase is subsequently selectively focused on a specific and highly versatile direction. The experiential and tactile working methods involved, inherently correlate with our latent embodied potential, thus allowing for heightened and engaged participation, interactions and awareness of the possibilities. Through our interweaving sensorial capabilities and their equivalent combinatorial patterned-mappings encoded within our brain, there is latent proportional resonance that allows for specific related manifestations to be activated, unveiled and realized. This reciprocal relationship between the nature of the explorer and that which is being explored, mirrors our relationship with the world of natural phenomena and how it is deciphered, recorded, visualized and modulated through a richly layered matrix of variable patterns and metapatterns.

Interestingly enough, we are now reflectively “reverse engineering” the generation of these innate patterns through our current technological advances and their simulation capabilities. The resonances that these vibrant images have with ancient and traditional cultural artifacts and motifs cannot be over emphasized. Perhaps the acute and reflective lessons that these modern advances are revealing are that ancient intuitive traditions, through their artistic and cultural artifacts, offer equally as profound and comprehensive insights, or perhaps even more so, than those currently being technologically unveiled. The neurologist Oliver Sacks has explored this subject and the profound resonances that certain patterns can evoke, including those that correlate with the geometric swirling hallucinations associated with migraine auras. Having had migraines throughout most of his life, Sacks’ observations come from direct personal experience as well as those of his patients. He speculates on whether this personal experience and the resonance triggered by certain patterns and artistic motifs are actually indicative of a much broader and perhaps more universal experience. “Migraine-like patterns, so to speak,” observes Sacks, “are seen not only in Islamic art, but in classical and medieval motifs, in Zapotec architecture, in the bark paintings of Aboriginal artists in Australia, in Acoma pottery, in Swazi basketry — in virtually every culture. There seems to have been, throughout human history, a need to externalize, to make art from, these internal experiences, from the decorative motifs of prehistoric cave paintings to the psychedelic art of the 1960s. Do the arabesques in our own minds, built into our own brain organization, provide us with our first intimations of geometry, of formal beauty?”(Sacks, 2008) These observations offer us a much broader and humanist framework from which to re-evaluate, re-analyze and appreciate the offerings of artistic and cultural traditions that initially evolved through unconsciously reflective processes, engaging, in a sense, “emergence,” “self-organization,” “self-similarity,” and “mirror neurons” long before their scientific and technological “discovery.”

## **5. CONCLUSION: ON THE RESONANT NATURE OF THINGS**

Modern science and related technology has once again reached a level of development and comprehension whereby the offerings of ancient traditions, initially discarded as meaningless superstitions during the Enlightenment in the 17<sup>th</sup> century, seem to resonate with their latest findings. As previously cited, this initially occurred during the first decades of the 20<sup>th</sup> century and these recent developments are, essentially, more expansive and in-depth elaborations of those findings. The nature of matter as revealed then at its most fundamental level led the physicist Werner Heisenberg to declare: "The world thus appears as a complicated tissue of events, in which connections of different kinds alternate or overlap or combine and thereby determine the texture of the whole."(Heisenberg, p.107) This dynamic “tissue of events” certainly resonates and corresponds, again, with Sir Charles Sherrington’s “enchanted loom” where vibrant patterns of patterns dissolve, intermingle and interweave into “a shifting harmony of sub-patterns.” Such speculations on *the nature of things* and their interrelationships have a long tradition and usually mirror the contemporaneous understanding and conceptions regarding the nature of the physical world.



The concept of the *Book of Nature* is certainly within this tradition and incorporates the *Book's* potential, structure, readability and comprehensibility as an appropriate poetic metaphor with, perhaps, the longest tradition in modern times. Such individuals as Galileo Galilei and Antoni Gaudí often referred to their work as being inspired by “reading” and interpreting the information offered through the *Book of Nature*. As we have seen, other metaphors and analogies, as an essential means of communicating and evoking intricate and/or paradoxical *information*, have been used throughout history, influenced by how prevalent, significant, and influential the impact of their source has been on the human imagination.

To the earliest known civilizations, awe inspiring and mysterious events occurring in the natural world, the characteristics of animals, and the properties of natural elements were the source for imaginative interpretations and mythologies, enduring considerably much longer, in comparison, than the more modern *Book*. Closer to our present time, in the 19<sup>th</sup> century such initially scientific devices as the Kaleidoscope (invented in 1816), the “modern” zoetrope (1833), and other related devices leading to the motion picture camera (1888), offered glimpses and clues into the possible inner workings of vision and how the eye and brain could possibly merge, or blend, still images in order to convey the illusion of continuous motion or depth. The prevalence of such then new devices, often having their most impressionable, direct and significant impact on the younger budding generation, would eventually provide vibrant metaphors and analogies regarding the theatre of the mind to such notable individuals as the French novelist Marcel Proust, the philosopher and psychologist William James, and the French philosopher Henri Bergson. This was not limited to only the visual realm: The technological, cultural and social impact of sound recording and transmission through the phonograph (1877) and wireless transmission (1901) must also be taken into consideration.

Presently, through the initial revolutionary stirrings in the early 20<sup>th</sup> century that led to an unprecedented comprehension and ability to manipulate *matter*, energy and, subsequently, reciprocally related information, the scientific and technological realms are offering what seem to be the most impressionable and inspiring experiences. The virtual *World Wide Web* and *Cloud*, and the digital devices providing fluid access to those and other realms of manipulated and seamlessly structured information, these are the new awe inspiring innovative concepts and experiences. They provide and will continue to offer a rich experiential source for vibrant metaphoric speculations on *the nature of things*. Here, Leonardo's introductory words of wisdom remind us that we need to reflect on our human nature as revealed by these innovations and by other “such things as our mind conceives.”(MacCurdy, p.70) What these conceptions and speculations all have in common is that they come from the same explorer, participant and experiential interpreter. Thus, the commonalities, parallels and self-similarities between these speculations are what is perhaps most revealing about their source, and they are offered throughout history by a myriad of vibrant metaphors that mirror our very nature.

“Our view of Nature,” writes Oliver Sacks, “has changed... we have come to recognize nonlinear dynamical processes, chaotic and self-organizing processes, in a vast range of natural systems, and to realize that these play an essential part in the evolution of

the universe. But we do not need to go far afield for examples... we have a natural laboratory, a microcosm, in our own heads.” (Sacks, 1999, p. 297) In other words, we do not need to “look out there,” as we’ve primarily done due to deceptive and seamless illusions, and can now re-evaluate the myriad of speculative evidence that history provides us with from within our built-in mental “laboratory,” and see the latent creative potential within the heart of Nature itself as reflected through our very own sense of self.

An excerpt from the ancient epic philosophical poem by Titus Lucretius Carus (c. 99 BC – 55 BC), conveniently titled *The Nature of The Universe* (*De Rerum Natura*, also translated as *On the Nature of Things*), will serve as an appropriately resonant conclusion to the reflective, reciprocal, and combinatorial ideas and concepts covered above regarding the human mind, its creative potential and the nature of its embedded and embodied consciousness:

“Let me now explain briefly what it is that stimulates the imagination and where those images come from that enter the mind. My first point is thus: There are a great many flimsy films from the surface of objects flying about in a great many ways in all directions. When these encounter one another in the air, they easily amalgamate, like spider’s web or gold-leaf. In comparison with those films that take possession of the eye and provoke sight, these are certainly of a much flimsier texture, since they penetrate through the chinks of the body and set in motion the delicate substance of the mind within and there provoke sensation... The fact is that the films flying about everywhere are of all sorts: some are produced spontaneously in the air itself; others are derived from various objects and composed by the amalgamation of their shapes... Since, as I have shown above, these delicate films move with the utmost nimbleness and mobility, any one of them may easily set our mind in motion with a single touch; for the mind itself is delicate and marvelously mobile.” (Lucretius, p.113-114)

## FOOTNOTES

1. Ariadne’s Thread/Rumi’s Ocean: Ariadne is the mythological Greek guide to the winding labyrinth of chaos and the individual life. The labyrinth design is credited to Daedalus, meaning the “clever worker” and is the first architect in Greek mythology. Jalai al-Din Rumi (1207-1273) is the great Persian mystic poet of the thirteenth century and the creator of the whirling circular dance of the Mevlevi dervishes. The dance involves spinning ones body while simultaneously spinning around in space as a way to be in harmony with the revolutions of all things in Nature.

2. Cover image: The calligraphic line is from the *Ariadne’s Thread/Rumi’s Ocean* project shown in Figures 3-7. Shown throughout the image are cellular form studies from the Crossings Workshop *Suspended Animation Series* (also shown in Figures 14 and 15). Works by Chloe Allin, Manuel Báez, Joyce Baddour, John Blais, Mei Ling Chow, Raymond Chow, Daniel Cronin, Karam George, Sharif Kahn, Sahar Kubba, Natalia Kukleva, Dan Linda Liu, Diana Park, Sherin Rizkallah, Maraim Shaker, and Titania Truesdale.

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