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SYMMETRY: CULTURE & SCIENCE

AGENTS OF SYMMETRY IN OPERATION

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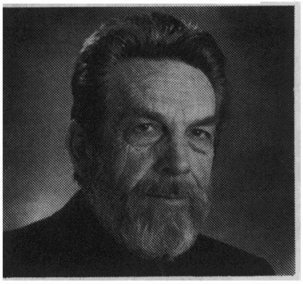
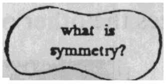


QUESTION 1



Structural systems in the arts span a range from the classical rules of perspective in the Renaissance to serendipitous collage in the 20th century. Symmetry plays a part at both extremes. The rules of perspective were formulated in the 15th century in Italy. The elements for the rules include a baseline for the viewer, a horizon line and a vanishing point where parallel lines converge, as well as vertical lines, horizontal lines, and diagonal lines that establish secondary points. An artist illustrates the illusion of depth by changes in size, changes in distance between images, overlapping, dark to light and sharp to fuzzy changes in the aerial perspective, especially in the edges of images (Fig. 1).

The verticals, horizontals, diagonals, arcs, and spirals that populate a painting are controlled by the artist by imaginary spatial coordinates. The turn of a head, the angle of a table, etc. are all precisely located within the format according to these imaginary points and lines. Of course, this Doppler-like shifting of apparent size and shape with distance is the way we naturally see forms in space. They seem to overlap, reduce in size and get fuzzy and closer together at a distance. Renaissance perspective is formalized observation. A five-year old, upon the occasion of his first airplane ride at ten thousand feet, was heard to ask, “Dad, why aren’t we getting smaller?” We are so used to this single reference frame in binocular vision that we ignore illusions that are involved in everyday observation. The Big Dipper from another angle would not be recognizable as such. The practical use of perspective nowadays is most obvious in architectural renderings, magazine advertising, and photography in general. In the history of art, perspective was still in control of the format well into the 20th century. Just last week I heard someone say that a picture must have a center of interest.

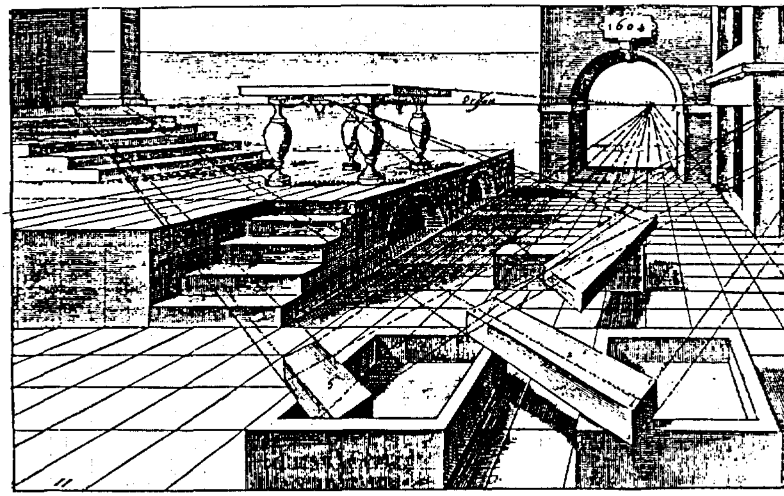


Figure 1: Perspective diagram. de Vries, J. V. (1968) *Perspective*, NYC: Dover, p. 11.

Jackson Pollock is one of the 20th century artists whose approach to structure epitomizes the other organizational extreme. In this kind of organization, serendipity is

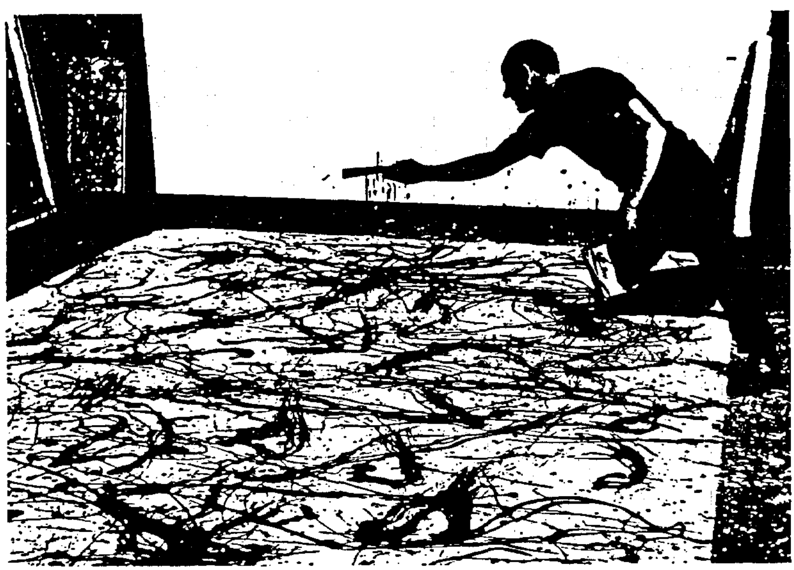


Figure 2: J. Pollock: *Number 32*, 1950. Frank, E. (1983) *Jackson Pollock*, NYC: Cross River, Ltd., p. 69.

at work. There aren't any single elements that need to be located at predestined points. Random systems are superimposed and interwoven into other random systems.

The systematic process in the structure of a Pollock painting differs from the structure in a classical painting by the way the elements fit together. In a Renaissance painting, the elements are fitted in place one by one and in a Pollock painting, they fall in place as superimposition of pattern upon pattern. In a Pollock painting, an overall pattern of a certain kind of paint splash is balanced out with the other elemental patterns. Each element – drops, runs, drips, etc. – exists within the pictorial format as an overall pattern as opposed to a single element that exists in one place at a time. The collage method does not depict single static objects held together within a preset grid of perspective lines. In the collage system, the whole is conditioned by the parts which generate the whole. There is no center of interest; therefore, everything is of equal importance. The abstract lines that regulate the space in a Renaissance picture are camouflaged by the illusion of recognizable images. Most art historians dwell upon the recognizable images and very little is said about the significance of methods of organization. In works like Pollock's, you see everything. There are no illusions. Every element is exactly what it is. The elements, randomly superimposed, organize themselves as they go. There is no preset order. In one way, experiencing a Pollack painting is like sitting under a big oak tree and observing the patterns on the ground – leaves, twigs, mud cracks, moss, shadows, etc. They all balance each other as they evolve randomly. Nothing is static. Today, the patterns are dry; tomorrow, wet. The next day insect trails may appear. Even broken glass is absorbed into the patterns. Serendipitous collage and Renaissance perspective represent two different systematic approaches to structure.

What is the procedure for making a systematic collage? To begin, toss a handful of coins, all at once, upon a given format. After the toss, if the coins pile up into a clump and the random placement of the coins does not account for all of the given space, remove all of the coins and toss them again. Do not interfere with any of the random coin locations by moving one or more of the coins to a new location. This would counterfeit the process and lead to chaos. Continue to remove and toss the same handful of coins until an arrangement is thrown that does account for the space. Obviously, the coins will not be either all in one clump or exactly equidistant. Secure the coins in place, choose a second element, say nails, and toss a handful of those into the fixed arrangement of coins. As before, if you do not like the way the nails have adjusted themselves within the coins, remove all of the nails, and toss them again and again into the coins until both elements do complement each other. Of course, it is your personal decision, there are no predetermined scenarios. You may then choose to stop or to introduce a third element. In fact, you may introduce as many elements as you feel you can cope with, one handful at a time, providing you operate under the same consistent set of limitations. In this collage process, no previous experience is necessary and failures are not possible. Even if each handful of elements vary in size, color and texture, the continuity brought about by superposing system upon system guarantees a successful intelligible collage. Within the process of making a collage, the compositional elements lose their original identity to a new abstract set of relationships. The continuous change of identity among the elements in the form evolution provides the most important distinction between the classic and the collage approaches to structure.

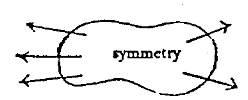
Classical elements in a Renaissance composition retain their original identities all the way through from the beginning to the finished composition.

The difference in the mechanics between the elements in a man-made collage and the continuously changing phenomenon under the oak tree is that there are no second throws for the natural elements. Man-made collages are formed by choice and collages in nature are formed by chance. Like the view from an airplane or through a microscope, the state of 20th century art is manifest in *systematic serendipity*. As shown by Herbert (1985, p. 248), "The source of all quantum paradoxes appears to lie in the fact that human perceptions create a world of unique actualities – our experience is inevitably 'classical' – while quantum reality is simply not that way at all. Quantum reality consists of simultaneous possibilities, a 'polyhistoric' kind of being absolutely incompatible with our merely one-track minds .... Since physics assures us that our lives are imbedded in a thoroughly quantum world, is it so obvious that our experiences must remain forever classical?"

A systematic approach in the quest for structural information ensures against the chaos of entropy. Symmetry establishes a base of equilibrium in this endeavor. As shown by Pagels (1982, p. 294), "The mathematician Emmy Noether discovered the full consequences of symmetry in physics only in this century. She showed that for every symmetry of physics – like the translational symmetries of space and time – there is a conservation law."

What does the invariance of physical law have to do with the structure of a painting? In the application of paint to the surface under the collage method, the amount of force used, distance travelled to the surface, density of the paint and kind of tool, all have an effect on the species of splash, drip or run that one might expect. Control of the elements, either by intuitive or analytical means, according to this information, amounts to principles of conservation. The Chinese painters have certain brushes for certain images – a certain brush for bamboo leaves, another for pine boughs, etc. One learns to predict what images will be generated from the combination of certain forces at certain distances along with certain densities of the medium and kinds of tools employed. In Renaissance paintings, the conservation laws that insured the classical continuity of structure were imbedded in the rules of perspective.

QUESTION 2



The process of observing or producing a work of art is comparable to the measurement process in the uncertainty principle of particle physics. At the subatomic level, the concepts of momentum and position of a particle cannot be known simultaneously with accuracy. This problem is not caused by the inferiority of the measuring equipment, it is because of a limitation of principle.

The parallel concepts in the art world are structure and quality. Like momentum and position in particle physics, structure and quality in the arts are two concepts that are interrelated but cannot be comprehended simultaneously. The structural analysis interferes with the qualitative sense and the qualitative sense interferes with the structural analysis. The closer the structure is attended to by the artist or observer, the more uncertain the quality becomes and vice versa. For both concepts to be fully functional, regardless of whether a person is born into an analytical concept or into a qualitative concept, he must piece-by-piece and day-by-day gravitate toward the other.

Whether in the arts or in the sciences, symmetry is involved in this process of documenting information. In the process, the information converts from its observed form at the source and reforms in a new medium or material – wood, paint, words, numbers, etc. The documentation of structural information requires a systematic method of conversion for intelligibility. This sets up a certain kind of conservation between the elements of the source and the elements of its new form.

My structural information comes from direct observation of nature and progresses to a kind of natural history which I found recorded in the anatomy of polyhedra. Complex natural patterns are reduced to simple lines and junctions. In my study, the spatial coordinates of angular source polyhedra are conserved in the structure of new curvilinear configurations. The new configurations are continuously connected rings of twisted loops. The new circular orbits of the loops replace the angles in the vertex and edge junctions of conventional polyhedra. This conversion method generates a hierarchy of twisted loop configurations in tabular form. There are two kinds of loop elements in the foundation of the generating process. There are single loops that either twist right or twist left individually, and there are double loops that twist right and twist left simultaneously.

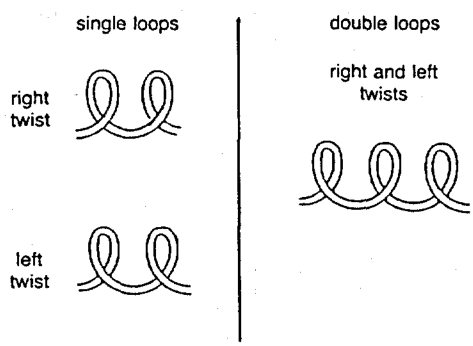


Figure 3: Loop elements.

A continuously connected string of four preformed double loops on a vertical translation axis, closed into a ring, will generate a meandering, spherical orbit. The unique phenomenon in the loop dynamics is in their ability to produce both an exostructural and endostructural mode by simply changing the direction of closure into a ring. In Figure 4, close the four double loop string (center) into a ring to the left and it will produce an exostructural mode like the suture in a tennis ball or baseball cover. Close the same double loop string into a ring to the right and it will produce an endostructural spool-like inverse mode. The exo twisted loop pathway orbits the perimeter of the ring from the outside-in and the endo pathway orbits the ring from the inside-out. It is this outside-in/inside-out flip/flop oscillatory capability that produces the exo/endo resonance.

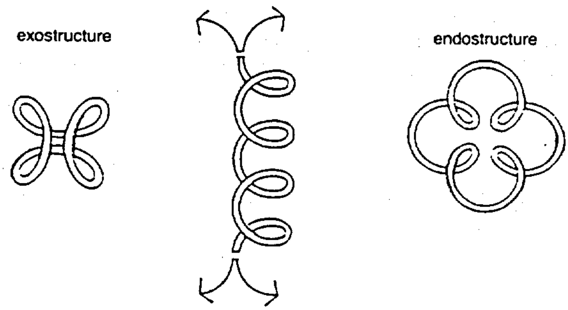


Figure 4: Exo/endo resonance.

With a single twist upon a given neutral ring, the Figure 5 twisted loop hierarchy begins. Double loops generate full-blown spherical orbits. A single loop orbit is more shallow because its over and under pathway is plaited and it interferes with itself. All of the configurations in the loop hierarchy are nothing more than complex circular orbits composed of right and left twists. All twisted loops may be untwisted back to their original ring shape. None of the loops wind through each other and, therefore, knots do not exist in the table. In the branch of mathematics called knot theory, they are known as unknots. Further, the loop configurations require neither vertices nor polar caps (defined in part 3) for their completion, as polyhedra do. They orbit around and thereby conserve all of the same spatial coordinates that regulate polyhedra. The rings of loops are not topologically equivalent to polyhedra. This is true because wire models of the loop configurations dipped in liquid soap will not produce any minimal surface substructures.

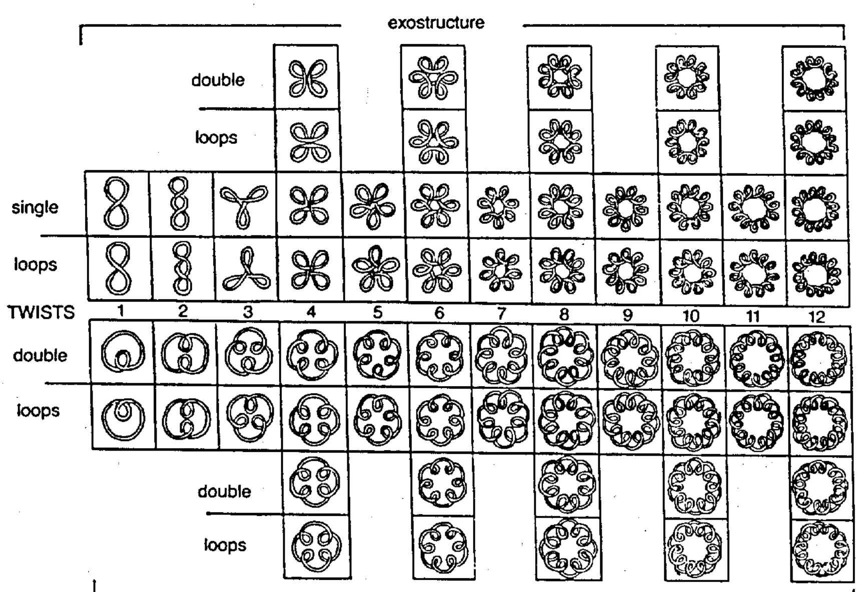


Figure 5: Table of loops.

Perhaps the loop diagrams would be easier to comprehend in their angular forms. Figure 6 shows angular loops circumnavigating the exo/endo orbital pathway around the spatial coordinates of the five regular polyhedra. These diagrams show that in the loop conversion process the vertices of the conventional polyhedra have been split in order to accommodate the continuously looping orbits.

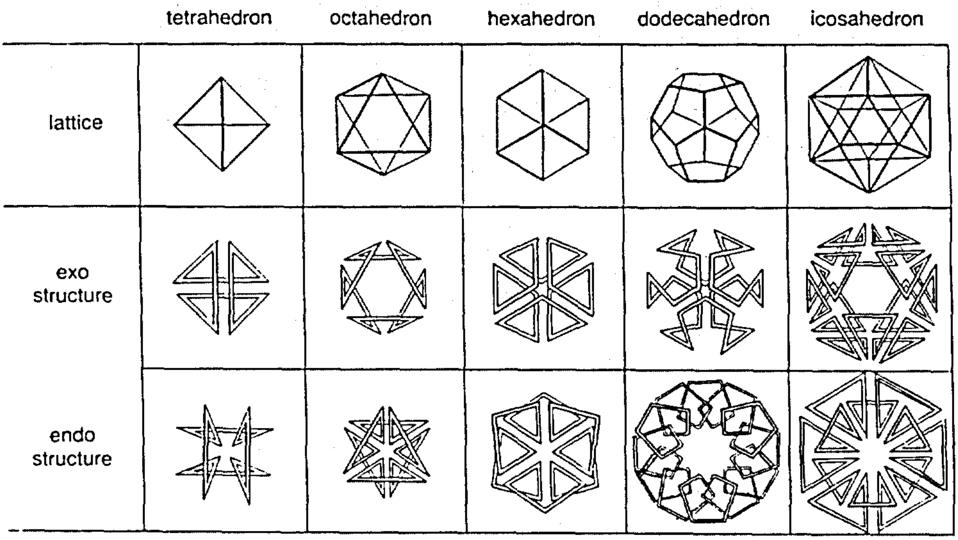


Figure 6: Angular loops.

In quantum physics, all particles have a definite spin. They must have discrete increments that are not arbitrary. Evidently, there are only two spin families. One family has whole integer spin and the other has one-half integer spin. Even numbers belong with integer spin and odd numbers belong with one-half integer spin. Whole integer spin requires a regular 360-degree rotation for symmetrical rotational coincidence with itself. A one-half integer spin particle must loop twice around, 720-degrees, for rotational coincidence with itself. As shown by Misner, et al., (1971, p. 1203), "Attempts to find a place for spin one-half in Einstein's standard geometrodynamics founder because there is no natural way for a change in connectivity to take place within the context of differential geometry. A uranium nucleus undergoing fission starts with one topology and nevertheless ends up with another topology. It makes this transition in a perfectly continuous way, classical differential geometry notwithstanding."

This sounds a lot like the flip/flop resonance in the exo/endo dynamics of the continuously twisted loops. I suggest that there is a possible comparison between the one-half integer spin of the electron and the form of the inverse figure eight in the table of loops. Both circumnavigate a 720 degree loop. As shown by Gribbon (1984, p. 216), "It doesn't matter that the particle has to 'turn around' twice before it shows the same face to us again. What does matter is that the spin of a particle defines a direction in space, up and down, analogous to the way the spin of the earth defines the direction of the north-south axis."

Without the spin of the earth, spin of the particle, and without the twisting and untwisting of the loop configurations, I conclude that the up and down axes could not be established. Without an up and down axis, three-dimensional orientation would be impossible.

I have applied loop dynamics to a two-dimensional diagram of the hypercube as shown by Misner, et al., (1973, p. 366). The up and down axis is perpendicular to the page. I have converted the two-dimensional diagram of the hypercube via the loop method to a pair of three-dimensional angular loops, one inside the other. The outside ring of loops defines the exostructural orbit and the inside ring of loops defines the endostructural orbit. The inside and the outside are so well coordinated that the nucleus and the shell can change places. Perhaps this is an example of Wheeler's pregeometry as shown by Misner, et al., (1973, p. 1203).

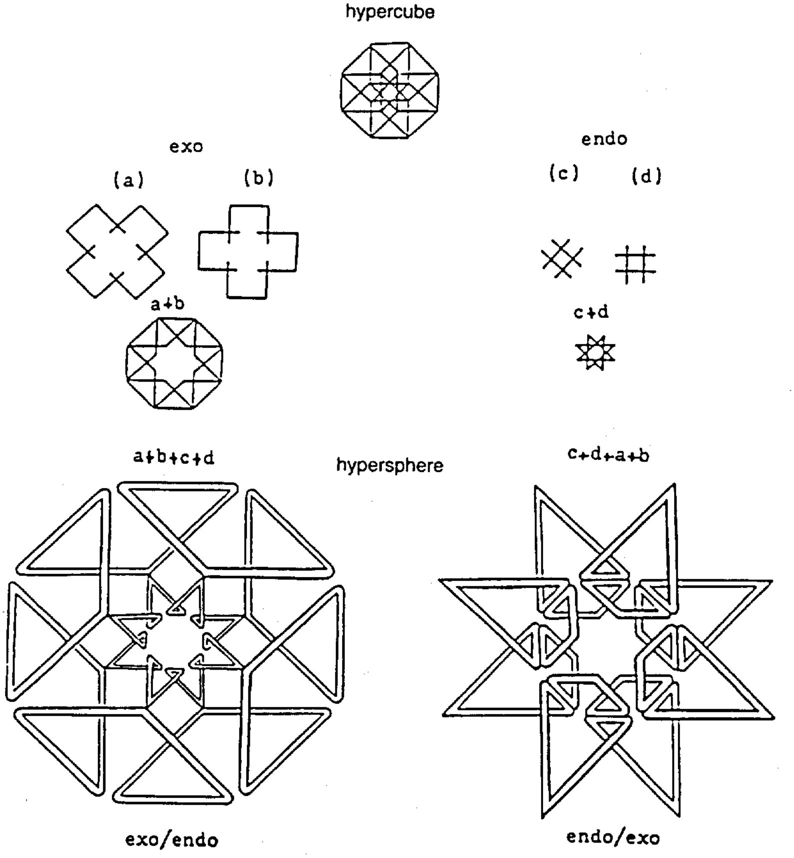


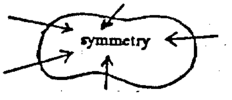
Figure 7: 2D hypercube to 3D hypersphere.

I suggest that there is also a possible comparative relationship between my twisted loops, the DNA supercoils and the way the double helices wind around the histones and pack the genetic material into the chromosomes. As shown by Bauer, et al., (1980, p. 118), "Virtually every physical, chemical and biological property of DNA

– its transcription, hydrodynamic behavior, energetics, enzymology and so on – are affected by closed circularity and the deformations associated with supercoiling."

The rings of loops in the table of Figure 5 do have the necessary topological property of remaining unchanged, the unknot numerology is unchanged, under deformation. In fact, twisting and untwisting seems to be one of nature's dominant shaping mechanisms. The thrust of twisting and untwisting is recorded in everything from quantum particles and DNA to the Coriolis force and galactic spirals. The twist mechanism is even the crucial element in the quantum-correlated two particle states of Bell's interconnectedness theorem. (All of the loop gymnastics may be duplicated with a large circular strand of beads.)

QUESTION 3



In this continuing quest, I seek information about materials and spaces and how they accommodate each other as forms of art. In pursuit of structural information, where symmetry is involved, it seems that most of our attention is directed towards local material objects. Spaces are scarcely included in our thinking. When spaces are included, they are called negative spaces. It must be realized that material mediums and empty spaces are inseparable aspects of a single physical reality and that the forms around us all generate from that interaction. An elegant practical case in point is the cabinetmaker's dovetail joint. The joint is composed of a material element, two pieces of wood, and a spatial element which I call a 'foundation suture'. The ends of the two pieces of wood are cut in such a way as to allow them to lock together upon the zigzag foundation suture.

The foundation suture and the material medium generate the form of their interlocking and separating interactions. Neither the material nor the suture is capable of providing any structural information independently. As a former element of infinite empty space, the dovetail suture becomes a finite structural element through its close association with a material mass. "Mass is the quantity of matter in a body ..." (Hawking, 1988, p. 185).

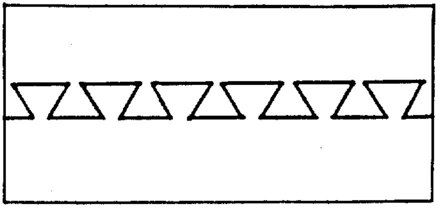


Figure 8: Dovetail joint.

The quantity of space in a body, however, is not mentioned. Mass and space, in defining each other, are thought by us to mutually exclude each other when, in fact, they support each other. Because we find it impossible to deal with two exclusive concepts simultaneously, we have this constant problem of having to choose a side. We always choose the side of mass and ignore space. This eventually becomes counterproductive in the search for structural information at the mass/space scale of resolution.

We need a third something to promote a joint concept between matter and space. This third element exists in the form of the foundation suture. Whether the suture is virtual or directly experienced, it functions in both an exclusive and an inclusive capacity. It is a separator of mass and a carrier of the potential valences for spatial coordination in the mass/space interaction. If we still believed that physical reality is composed of solid state objects in absolute space, then there would be no information about elementary interaction beyond the organ scale. Without a foundation suture system, the infinitesimal parts of an event and scales of resolution would cease to exist. This duality, this complement of aggregation and segregation, is the unique attribute provided by the proposed foundation suture system. Theoretically, mass and space could be cross-correlated under the suture system. It is in these exchange mechanics that the deep harmonies of symmetry are manifest. It is like the form of a stereogram where a third image springs into focus from the mind-directed interaction between left and right counterpoised images. This third image, in essence, is equivalent to my vision of the foundation suture. It also compares favorably with a beat note and more concretely with the suture pathways between the plates of the mid-ocean ridges of plate tectonics.

As I see it, neither mass nor space claim permanent structural coordinates of their own. Only their event relationships do, as manifested in the foundation sutures. The foundation suture pathway splits the junction valences where contact and separation take place. For example, cut a circular disk about five inches (12.7 cm) in diameter from a sheet of aluminium cooking foil. Place the disk in the palm of your right hand. Find another right-handed person and shake hands. Remove the foil and it will retain the true shape of the handshake's foundation suture.

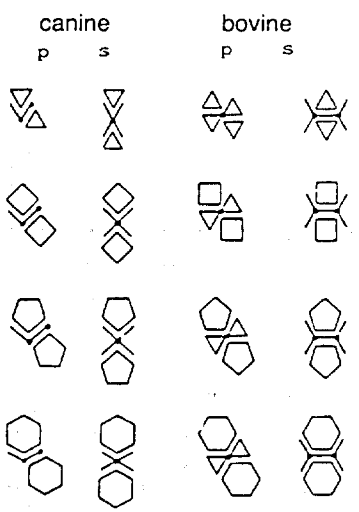


Figure 9: Foundation suture elements.

The foundation suture manifests itself only when designated entities are introduced into the local spatial field at certain scales of resolution. The elements in the structure of the foundation suture system originate between designated entities. In Figure 9, pairs of triangles, squares, pentagons and hexagons are the designated entities. The suture elements are called *canine* and *bovine* because of their resemblance to those two species of dentation. The canine and bovine units each have a primary and a secondary mode of existence. In the primary modes, the polygon pairs are oriented upon diagonal axes of symmetry and the secondary modes are oriented upon vertical axes of symmetry. The suture elements exist within each pair of polygons as indivisible units composed of lines and junctions. The line lengths are conserved throughout the whole generating system.

When the individual tooth-like elements replicate and string together, one string above the other on a horizontal translation axis of symmetry, they resemble jaws. In the mechanics of the canine and bovine jaws, the upper and lower jaws are allowed to slide upon each other before they conjoin. The sliding produces the two modes of translation called primary and secondary. In the canine jaws, there is a one-half unit slide from the primary to the secondary mode and the bovine slides one whole unit from the primary to the secondary mode (see Fig. 10). Upon conjunction, some of the lines and vertices in the closed jaws coincide and, consequently, the total number of lines is reduced. The primary canine closed jaws are the only structures whose total line coincidence reduces the original number of lines to half.

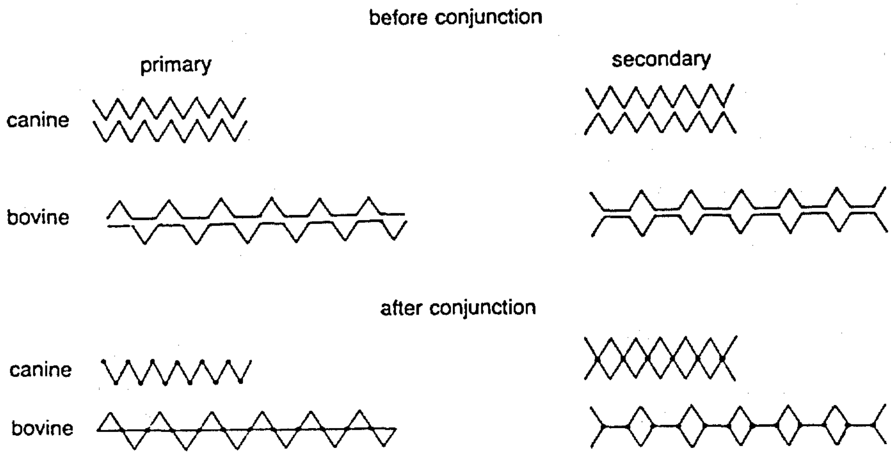


Figure 10: Suture replication and conjunction.

After conjunction, the foundation suture lattice seems to be permanently locked in place and the original interfacial suture seems to be squeezed out of existence. This is not the case, however, because the original suture pathway must function again and again each time there is a mode change. The foundation suture still exists in virtual form. Now, wrap the closed foundation sutures into rings and the former slide action becomes a twist action. The twist introduces another dominant axis of symmetry. The twist generates an up-and-down screw axis of symmetry. The twist is the harbinger of the third dimension.

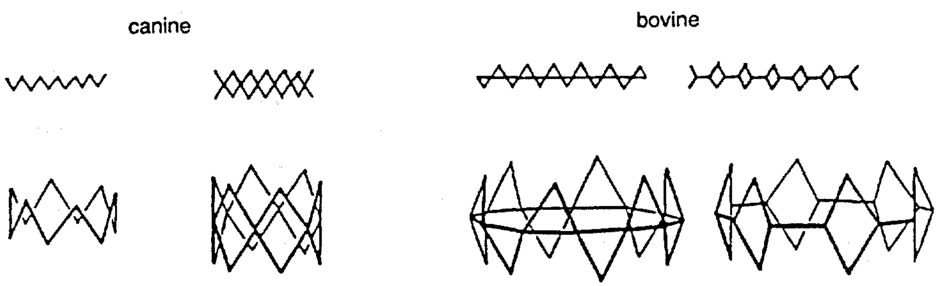
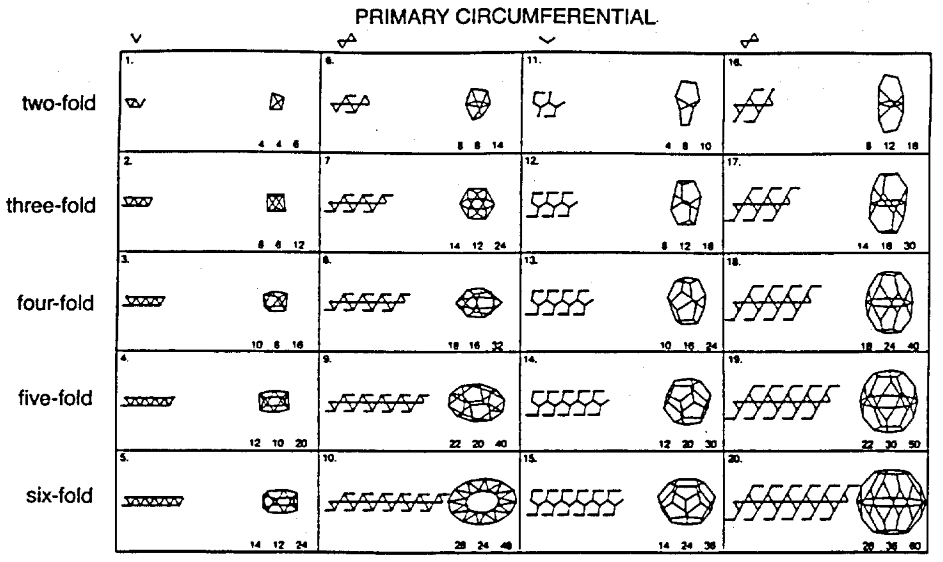
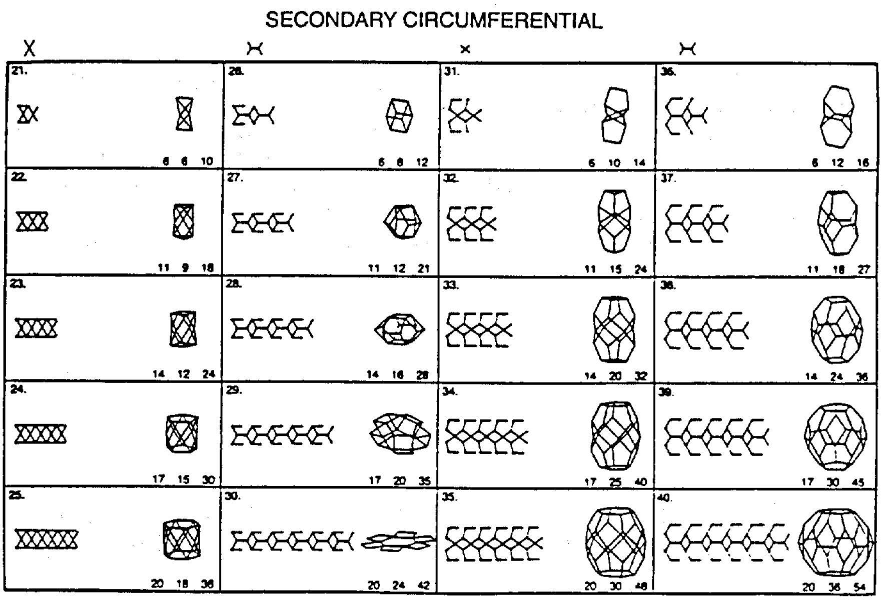


Figure 11: Foundation suture rings.

Up to this point, all of the elemental rings are structurally incomplete and unstable. They are nothing more than shallow cylindrical lattices with open ends. The Figure



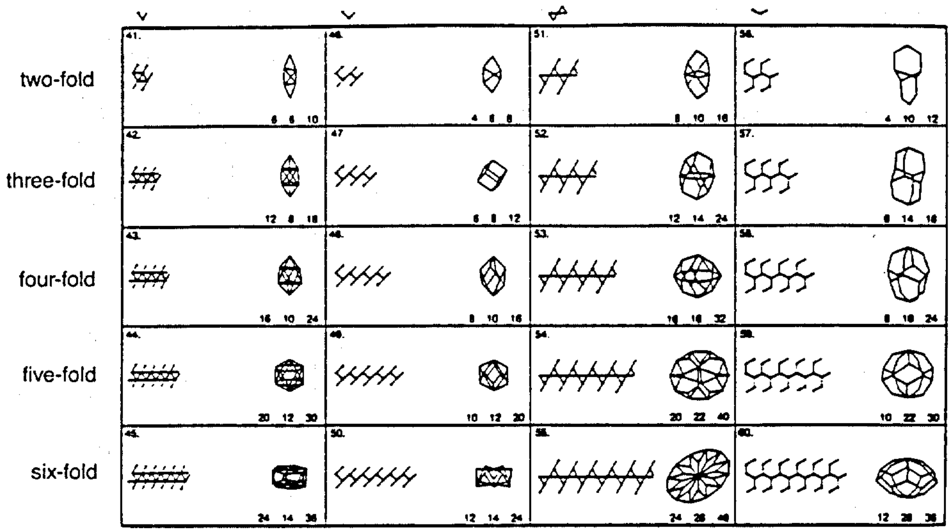
These configurations are twisted upon their axes of symmetry.



These configurations are untwisted upon their axes of symmetry.

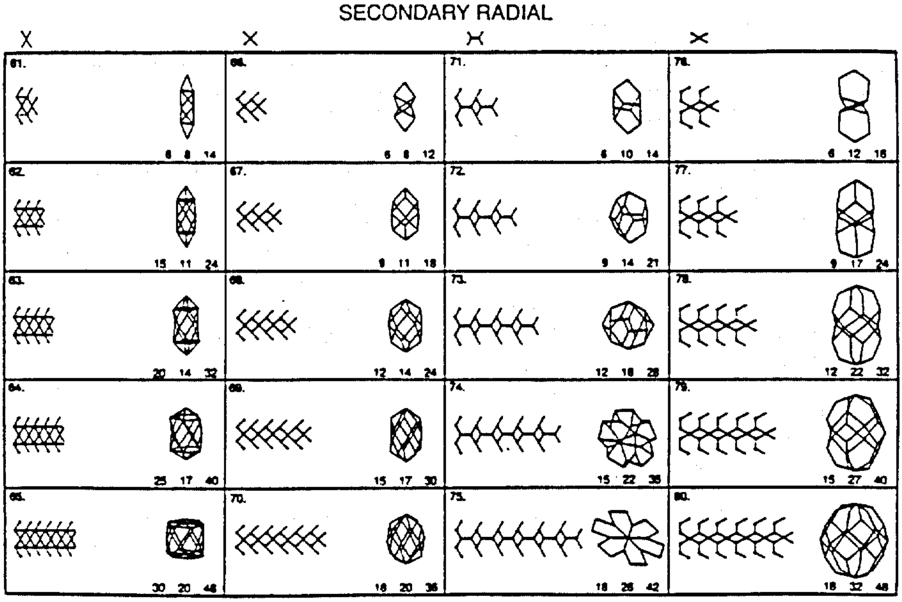
Figure 13a: Table of 80 polyhedra.

PRIMARY RADIAL



These configurations are twisted upon their axes of symmetry.

SECONDARY RADIAL



These configurations are untwisted upon their axes of symmetry.

Figure 13b: Table of 80 polyhedra (continued)

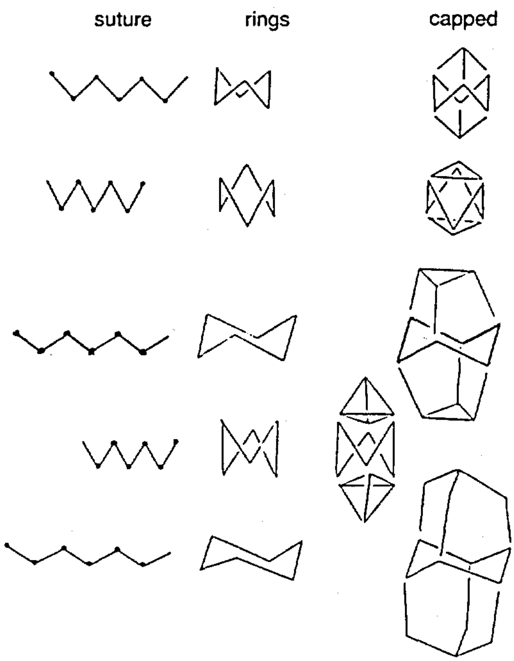
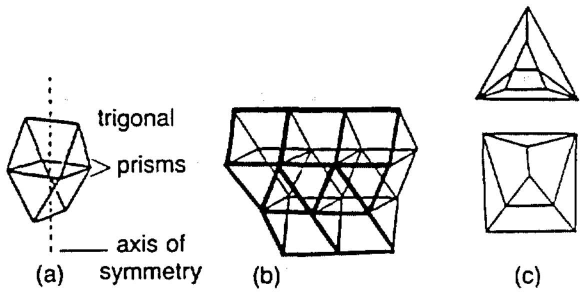


Figure 12: Three-unit canine suture with five caps.

12 diagram introduces the elements called 'caps' for closing and stabilizing the rings. When the caps are coordinated with the foundation suture rings, suddenly complete polyhedral lattices come into existence. After the caps are in place, the bodies of the polyhedral lattices incorporate triangles, squares, pentagons, and hexagons. It should be noted that polyhedra do not generate from these polygons. They generate from the two discrete suture units, canine and bovine, with strings of trivalent and quadravalent vertices, but not until the caps are in place upon the rings. There are two kinds of caps, circumferential and radial. The sutures circumnavigate the equator and the caps enclose the poles of the polyhedral anatomy. Figure 12 shows one three-unit canine ring with five different three-fold caps. It shows that the same three-unit suture is capable of generating five different polyhedra under five different capping operations.

With the completion of the capping operation, a table of 80 systematic polyhedra is generated. The table reads from left to right in rows and from top to bottom in columns. The elements evolve in both directions from small to large and from simple to complex by a periodic addition of equidistant vertices. The tabular system consists of a circumferential and radial domain containing 40 polyhedra each. Each domain is divided into primary and secondary modes of 20 polyhedra each. The primary modes twist around their up-and-down axes of symmetry and the secondary modes are untwisted upon their up-and-down axes of symmetry. The polyhedral families evolve sequentially from simple to complex in a 2-, 3-, 4-, 5- and 6-fold progression. The diagrams to the left of the polyhedra are the 2D nets. When they are wrapped around and the flying line ends are all connected, they form the 3D polyhedra on the right (Figs. 13a and 13b).

In the systematic relationships of the 80 polyhedral lattices, the five regular Platonic solids occur naturally along with the semi-regular Archimedian solids. In addition, a new self all-space filling octahedron is generated. I have called it the 'twist octahedron'. This prismatic octahedron follows the trigonal prism in ascending number of vertices in sequence with all the other all-space filling polyhedra.



(a) The twist octahedron. (b) The twist octahedron close packed. (c) Schlegel diagrams of the twist octahedron.

Figure 14: New self all-space filling octahedron.

This approach to structural information is probably an uncommon way to generate an idea source for potential works of art. At least, my colleagues have told me so. It is also uncommon in the sciences because, thus far, it is without mathematics. At the outset, when my attention was directed towards space, it offered little more than a new direction with little thought of where it might lead. This approach continues to become far more inspirational than I possibly could have imagined. I am now searching for 3D networks, like bedsprings, that will provide systematic pockets or cages for polyhedral aggregations.

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