

Expressive Geometries of Curvature

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Abstract

Surfaces can be modulated with undulating curvatures to create dance abstractions of surprising naturalism. Apart from needing to convey a global impression of expressive movement, this resonance of naturalism seems to emerge from a subtly coherent interplay of lateral and longitudinal undulations.

Introduction

World sculpture from its origins in the Paleolithic has mostly represented the human figure, and to a lesser extent our close animal relatives. As a consequence sculpture by force of tradition has almost always had robust volume, a precedent which has naturally tended to be conserved in the non-representational sculpture of this and the last century. Indeed a significant percentage of my own sculpture has been volumetric. Nonetheless, for reasons of aesthetic preference more cogently felt than expressible in words, the larger percentage of my works have been surfaces in which a convex area on one side inverts to a concavity on the other. Rather than being the theoretic conceptions of zero thickness a mathematician might work with, my surfaces are real sculptures which obviously must have some thickness to physically exist. Sometimes that thickness is feathered to form the surface's blade-like edge (see Figs. 1 and 2). Alternatively it may end abruptly as a flat edge that has a continuous right angle relationship to the faces of the surface (see Fig. 3). Abstracting these blunt edges will reveal a torqued ribbon curving through space. While I've not tended to emphasize the distinction, surfaces should actually be regarded as a separate genre of sculpture in the light of the formatting challenges they uniquely pose. My striving to aesthetically optimize the surfaces I've created is to some extent communicable with reference to the paradigmatic logic they always have, but less so when it involves intuitive distillations of curvature which may approximate formal mathematical functions unknown to me.

All my works, whether surfaces or volumetric, have in common a characteristic continuity of constantly varying curvatures integrated into organic compositions. Seeking to resolve sculpture to the essentials of a paradigmatic logic in this way seems to have originally been less a conscious decision than an expression of aesthetic temperament. If the origins of this approach are somewhat mysterious, its fundamental nature is nonetheless clear. It has given me an aesthetic vision of economy related to the movement of Minimalism in the visual arts, as well as a perseverance immune to the attractions of other roads not taken. This vision ultimately put me in league with scientists and mathematicians, and led to sculptures reminiscent of the forms and dynamics found in nature.

Early Surfaces

In papers published in earlier Bridges' proceedings, and elsewhere, I have discussed the several motif cycles of locally minimal surfaces that followed my intuitive discovery of area-minimizing curvatures (see Figs. 1, 2, and 3 [1, 2, 3, and 4]). In the context of their different unifying paradigms, all the surfaces in these cycles approximate zero mean curvature, conforming in this respect to how a chemical film

would span their edge constraints. Apart from one exception this discussion will be confined to the early surfaces which preceded the minimal surface motifs. Most of these earlier surfaces were abstract evocations of the human figure. My aspiration for them was a sensuous expressiveness with a resonance of convincing naturalism. In particular, I wanted to refine pure geometry into the equation of disciplined beauty sought in classical dance. Interestingly, though I had lost interest in lyrically evoking the human figure by the time area-minimizing curvatures began to appear in my work, the restrictions inherent to the spare elegance of the latter actually precluded the possibility of figurative abstraction.

The earliest surface evocative of dance was created in 1978 and called "Prima" (see Figs. 4a and 4b). It can be visualized as being generated from a rectangular surface which has been helically warped to suggest an expressive torquing of a dancer's torso. At the same time it is corrugated making each side an inverse mirror of the convex crests and concave furrows of the other. These crests and furrows in turn fluctuate across its faces in a subtle maneuvering whose outcome is apparent if you contrast the bottom curvatures of either face with those at the top. It will be noticed that the sequence of curvatures at the bottom of the side seen in figure 5, which is usually perceived as the dancer's front, inverts en route to the top. The left to right sequence from convex to concave to convex at the bottom has transformed to a concave to convex to concave one at the top, and far from being arbitrary, this reversal is woven in as an integral part of the sculpture's organic wholism. The squared edges running lengthwise to the surface can be seen to twist 180 degrees as a consequence of the curvature transitions immediate to them: isolated from the sculpture and seen alone, they would appear as bands curving through space while torquing 180 degrees.

All of the above observations are also true of "Epiphanie," the evocation of dance depicted in figures 5a and 5b, though its helicoid dimension is less pronounced. Within the helicoid movement globally impressed on both sculptures, each has undulations which deploy across the surface in both longitudinal and lateral orientations. The orthogonal interplay of these curvatures confers a complexity which enhances, at least in intention, the simulation of naturalism needed to give these sculptures a convincing resonance as figurative abstractions. Ultimately all the geometric components of these sculptures should be grammatically integrated into aesthetically persuasive wholism which defines their existence as works of art. Both were originally modeled in wax which was the preferred medium, given its plastic flexibility, for the myriad trial and error modulations necessary to crystallize forms that were a cathartic revelation of what I was struggling to achieve, but couldn't imaginatively picture *a priori*.

The dance evocation in figures 6a and 6b is called "Firebird." It shares the geometric features of the previous two, while differing from them in having two inversions of curvature sequence, rather than one, from bottom to top. The first proceeds from the bottom of the sculpture to its midpoint and the second from midpoint to top. Left to right from bottom upwards, in the view seen in figure 8, which is usually perceived as the dancer's front, the reversals of curvature sequence are: a concave to convex sequence at the bottom which reverses into a convex to concave sequence at midpoint, and then back into a concave to convex one at the top. If you look at either of the edges immediate to these reversals, you will notice their consequent oscillation; first twisting 180 degrees in counterclockwise chirality from bottom to midpoint, and then 180 degrees in clockwise chirality from midpoint to top. This surface also has a consciously formulated convergence of its lateral and longitudinal undulations not present in the preceding surfaces. The minimum and maximum points of these undulations are now aligned. This means that lines passing through the lowest points of the surface's lengthwise furrows, or the highest points of its lengthwise crests, will be composite in concurrently tracing the pathways between the maximum and minimum points of correlated lateral and longitudinal undulations. This design feature makes this sculpture seem at once less lyrically lithe than the previous two, and in effect more taut in its vertical thrust, particularly when viewed from the back side perspective of figure 9, where it seems to almost rocket upwards.

The next dance evocations I will describe are chirally reversed twins. To convey their chiral twinhood they are shown complimentarily side by side in figure 7: “Oneiros 1” appearing on the left, and “Oneiros 2” on the right. “Oneiros 1” has a clockwise helicoid torque, while a ribbon abstracted from the edges of either side will twist 180 degrees clockwise from the bottom of the surface to its midpoint, and then 180 degrees counterclockwise from midpoint to top. In “Oneiros 2” all these geometric maneuvers are reversed which makes the surfaces chiral opposites, though not actually mirror inversions of each other. The “Oneiros” twins incorporate all the geometric features of “Firebird,” with the exception of having their lateral and longitudinal undulations in a repositioned alignment that represents the most significant design discovery to come out of this early work. This repositioning of alignment has the effect of embedding multiple linear helices in the surfaces. In “Firebird,” recall that the maximum and minimum points of its lateral and longitudinal undulations coincided. In the twins the maximum and minimum points of their lateral undulations coincide with the midpoints between the maximum and minimum of their longitudinal undulations, and vice versa. As a consequence of this the lines passing through the lowest points of their lengthwise furrows or the highest points of their lengthwise crests will follow a helical pathway winding around an imaginary cylinder. These embedded pathways aren’t, of course, visible, though they could be drawn on the surfaces lengthwise in their furrows or on their crests. These embedded helices are in effect the design algorithm for all the curvatures of these surfaces which emerge in conformance to them and share their sinuosity. Speaking from my experience as a sculptor, I don’t think a surface of richer or more pleasingly sensuous curvature is possible. Introducing further curvature overtones would only create decoherence, rather than the perceptual clarity of an aesthetic gestalt. Generating a surface of curvatures algorithmically from embedded helices is a geometry which to my knowledge has no precedent. I can’t imagine this surface occurring anywhere in nature or that it might be a useful way to visually model the dynamics of any natural system. Nor is any potential application for it in technology easily imaginable. Nor does its apparent geometric originality necessarily imply it has any larger significance as a mathematical artifact. It isn’t a minimal surface, since its curvatures systematically transition from positive to negative throughout. All of which leaves only its aesthetic significance, and the fertile resource its sensuous curvatures have been for my work, which brings me to the final much more recent surface of this kind.

The untitled surface shown in figure 8 is formed by the intersection of two undulating wing-like sections at a right angle. Lines drawn over the tops of their crests and at the bottom of their furrows will follow helical paths. Likewise Escher’s ant walking astride the vertically angled intersection of the wing-like sections will follow a helical pathway. (While it would always be upright on the terra firma of the surface as it walked, were the surface to dematerialize save for a cord-like remnant of itself at the intersection of its two wings, the unfortunate creature would find itself walking on a helical tightrope in a pattern necessarily circumnavigating the tightrope’s circumference to consequently preserve the same upright orientation it had when walking on the surface before it dematerialized.) The surface’s multiply embedded helices generate a dynamic sense of ascension which suggests both the fluctuations of a flame and transcendence, at least in metaphorical intention, as a maquette for a monument in memory of those who were enslaved on this continent and are buried in millions of anonymous graves across it.

Volumetric Sculptures

Only two volumetric sculptures, one from a quarter of a century ago and the other very recent, will be discussed. The earlier one is an imaginary plant entitled, “Seedling”. A recent acrylic cast of it is shown in figure 9. My intention was to create a biomorphically plausible portrait of a life form which seemingly could have evolved. The sculpture is only of possible mathematical interest with respect to the intuitive resolution of its curvatures. A cross-section at any angle through the sculpture will have an outline of pleasingly smooth transitions between segments of arcs from circular or elliptical closed curves of widely varying diameters. The smoothness of these transitions resembles how arc segments curve more sharply

the nearer they are to the center of a logarithmic spiral as part of a continuous self-similar evenness of transition.

Actually all my volumetric sculptures, since I've always tried to optimize the evenness of their curvatures, might be viewed as having an aesthetic dimension of economy. This obviously has to do with how much their surface areas are minimized in relation to their enclosure of volume through the refinement of their curvatures. In nature soap bubbles enclose volume with an incomparably nearer approximation of perfect economy than any that might be achieved striving to resolve sculptural form to constant cross-sectional circularity. To do the latter necessitates a sustained effort to progressively project mental images as templates for the emerging forms, while simultaneously finely coordinating manual manipulation with visual and kinesthetic feedback. Actually all sculpture based on traditional modeling and subtractive techniques has necessitated this suite of skills since its emergence as an art form in the Paleolithic. We therefore know that our aptitudes for spatial visualization, complex manipulation, and creative expression had become features of our neuromuscular intelligence by the late Paleolithic. Given the critical role all such emergent potentials of our neuromuscular intelligence had for our collective survival and eventual hegemony among species, evolution has endowed our pursuit of challenges to them with *joie de vivre*. Meeting challenges to them is a form of thriving for our species. Biologically this is why as a cultural species we create art. Seeing our creativity in the light of its evolutionary origins lessens its mystery, and segues nicely to the last volumetric sculpture I will discuss (see Figs. 10a and 10b). This recent sculpture definitively concluded a motif cycle of six related works which were biomorphically expressive in their muscularity. All six similarly entailed the orchestral integration of a complex layering of geometries. As I describe this particular volumetric sculpture, the rationale of its title, "Gordian Knot," should become eminently clear. All of its commingling curvatures are correlated in belonging to one or the other of two columnar trefoils that interpenetrate each other, forming clefts around which they also spiral while simultaneously following identically curving paths over the surface of six invisible spheres overlapping in a deployment that reflects the logic of the sculpture's global geometry. Here I should note that sculpture whose geometric complexity can seem rather absurd when described in words may nonetheless have immediate perceptual eloquence for the eye. Complex music can have similarly immediate eloquence for aural perception in persons without musical training. The given in each instance is the incredible sophistication of our sensory perception in its original adaptation to the natural world. Perceiving the phenomena of the natural world in an aesthetically unifying gestalt probably brings us as close emotively as we can come to their essential nature, and can now be given the intellectual cast of the scientific world view. Such aesthetic perception is a phylogenetically ancient evolutionary endowment with obvious survival value in being among our incentives for living. As a cathartic release it no doubt boosts immune function. Artists will suffer through work of migrainous complexity for its moments of serene transparency. It informs the wonder we feel witnessing the thriving of other species in the exquisitely honed athleticism with which they respond to the challenges of their natural environments.

Conclusion

My sculptures are constructed from their foundations as either surfaces or objects with volume. Subsequently an integrated layering of elementarily coherent geometries defines the distinct grammars of the works in particular motif cycles. The eventual organic complexity that emerges in them is managed initially by orchestrating it one step at a time. Essential to ultimate success, however, phase transitions must occur at certain points, leading to a "peak" momentum of spontaneous creativity, where everything feels right and thinking is unhesitatingly translated into knowing action. This state of conscious and neuromuscular grace has been variously characterized as "flow," the "effortlessness at the height of effort," the "zone," and so forth. It is another phylogenetically ancient potential that evolution has given our species. Its rudiments are seen in all species that play, and in ours, with the appearance of culture, it finds expression in innumerable ways.

Parsing sculpture to its geometric grammar is analogous to viewing life at the reductive level of anatomy. Perceiving the expressive dynamics a sculpture may have as an aesthetic wholism is more like an appreciation of a living organism's emergent intelligence. Artistic expression can have no more inclusive value than contributing in its way to the emergent dynamics of life's complexity that have long enriched the world...the "enchanted loom" of the human brain and the synchronized firing of fireflies are actually much alike, both being phenomena emergent from species whose distinctive genomes have evolved from a common ancestor and continue sharing laddered helices of clockwise chirality with the same four letter chemical alphabet of rungs.

My human faith as an artist draws strength from the accomplishments of those who have gone before, some known and many more unknown, but all exemplifying the native visual intelligence of our species so movingly apparent in the high naturalism of anonymous Paleolithic cave art. How is it that we, in so many times and places, have created art of wonderful mathematical subtlety, as well as ethnomathematical systems, were we not preadapted to do by our phylogenetically ancient aptitude for logical perception coupled with a more recent one for symbolic representation, which appeared with the evolution of language? Imagine an early speechless hominid lacking the linguistic ability and perhaps the hubris to entitle his or her kind "sapiens." Picture it defensively wielding a stick or in concentration mentally mapping a landscape. Its lineage would have been one of many that branched over time, all having once had a possible evolutionary destiny to solve problems in dreams, to compress meaning in poetry, and to feel empathy for other sentient beings. Only one such lineage survived to have this destiny, and the looming choice to be more or less complicit in the tragedies of suffering and extinction.

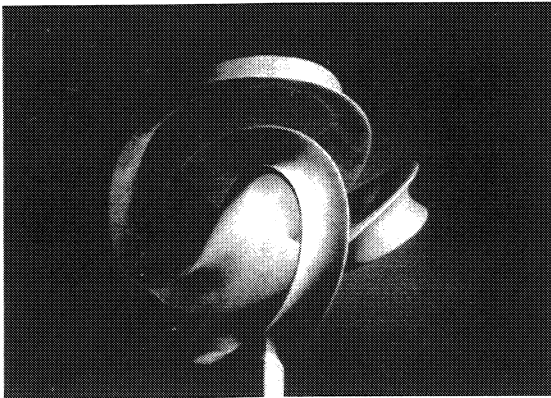


Figure 1: "Atomic Flower 1", wood, 20 x 20 x 20 inches, 1999. Photo : Phillip Geller.

Figure 2: "Sanctuary", epoxy, 24 x 24 x 20 inches, 2003. This trefoil has negative Gaussian curvature, and is deployed over a hemispheric space with its triplet of crossings at the apex. Photo : Phillip Geller.

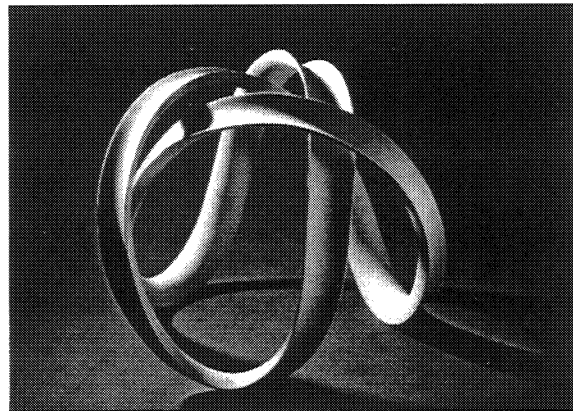
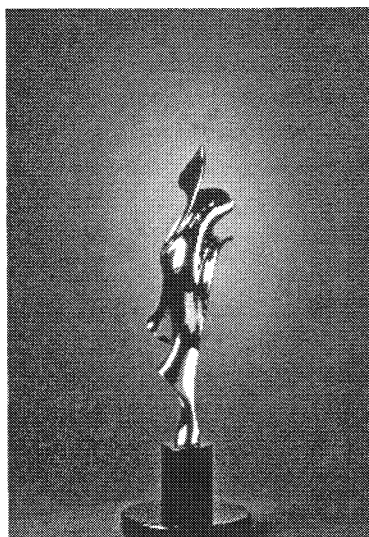
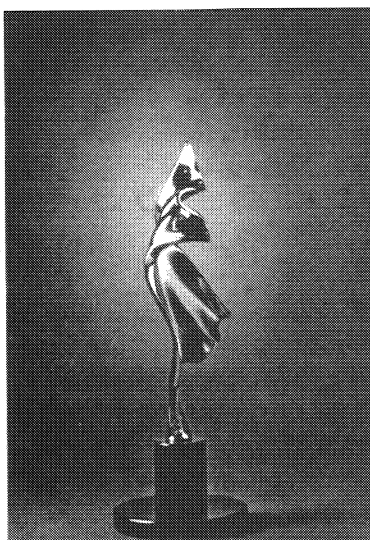
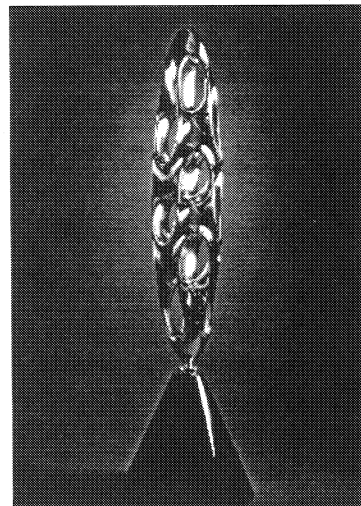
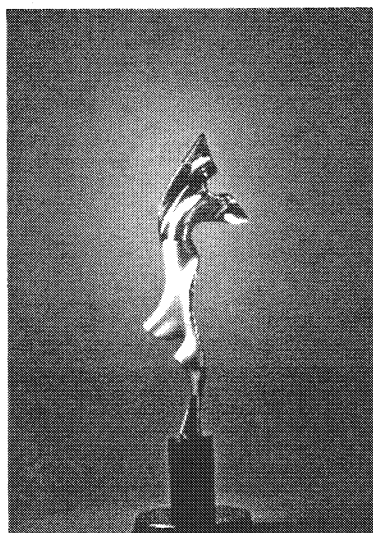
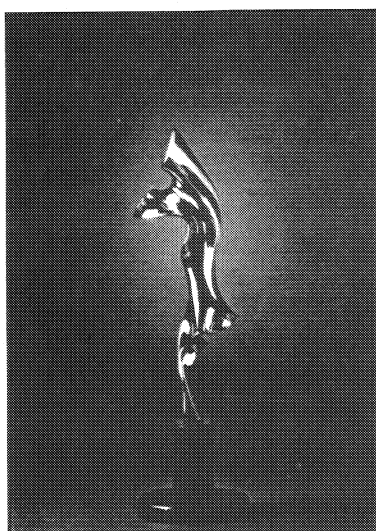


Figure 3: "Eikon", bronze, 22 x 7 x 7 inches, 2001. This bronze is the first from a limited edition now being cast from a wood master created in 1988. Its area minimizing curvatures span its edges across the otherwise hollow interior of its midsection. Though I cite it as an example of a minimal surface, its end caps are actually at variance in having positive curvature. Photo : Phillip Geller.



Figures 4 a and b: "Prima", bronze, 19 x 5 x 1/4 inches, cast in 1998 from a wax master modeled in 1978. Photos : Phillip Geller.



Figures 5 a and b: "Epiphanie", bronze, 23 x 5 1/2 x 1/4 inches, cast in 2000 from a wax master modeled in 1978. Photos : Phillip Geller.

Figures 6 a and b:
"Firebird", bronze,
26 x 6 x 1/4 inches,
cast in 1998 from a
wax master
modeled in 1979.

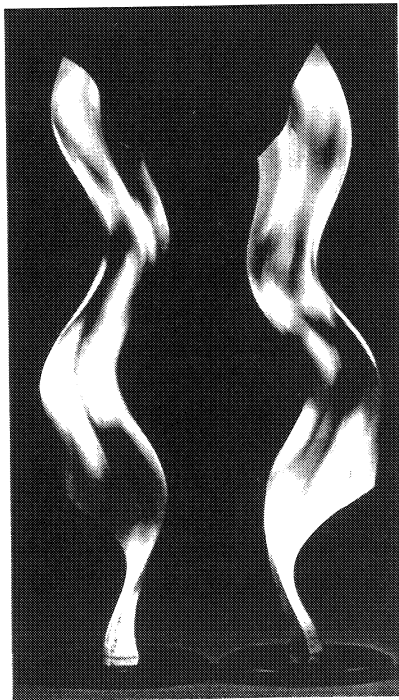
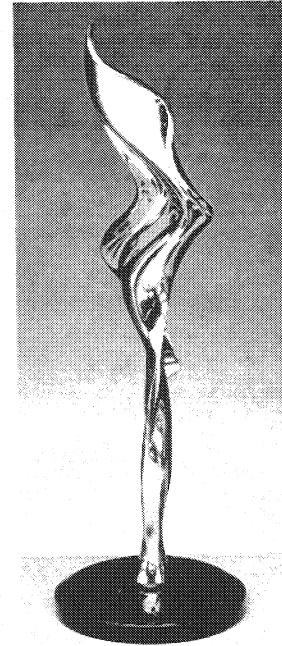
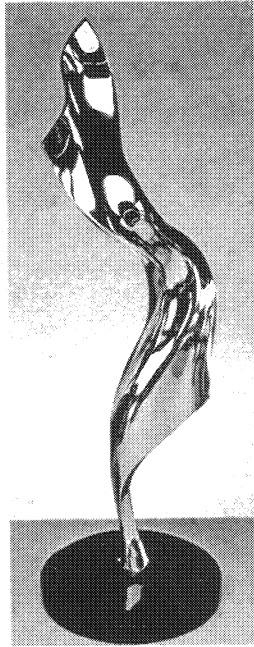


Figure 7: "Oneiros 1 and 2", bronze, 32 x 6 1/2 x 1/4 inches, cast in 1997 from wood patterns created in 1996 which were copies of wax patterns modeled in 1980.

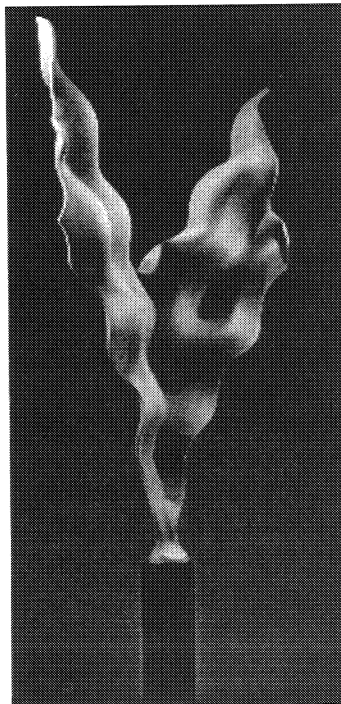


Figure 8: Untitled, Epoxy, 33 x 29 x 1/2 inches, 2003. This maquette is a metaphorical evocation of a flame for a memorial monument. Photo : Phillip Geller.

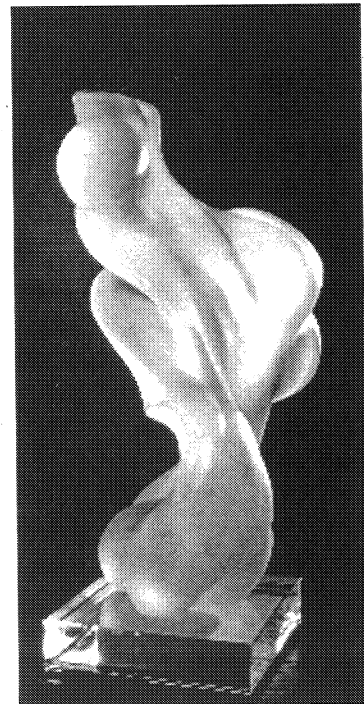
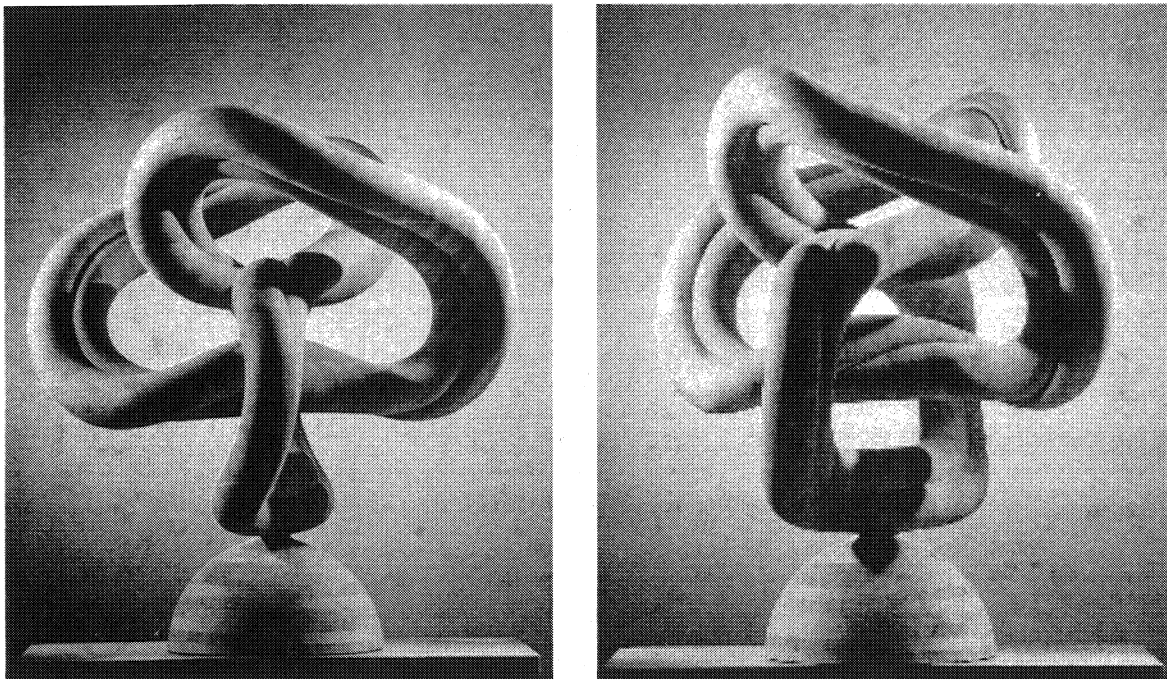


Figure 9: "Seedling", acrylic, 20 x 14 x 14 inches, cast in 2001 from a limestone pattern created in 1978. Photo : Phillip Geller.



Figures 10 a and b: “*Gordian Knot*”, wood, 48 x 48 x 39 inches, 2001. In this sculpture two columnar trefoils intersect in a continuous spiral embrace. Were it possible to pull the two trefoils apart along their entire length of intersection, they would remain linked like two units in a chain. Photos: Phillip Geller.

References

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