

Chapter Two: A Genealogy of the Grid

Order is, at one and the same time, that which is given in things as their inner law, the hidden network that determines the way they confront one another, and also that which has no existence except in the grid created by a glance, an examination, a language; and it is only in the blank spaces of this grid that order manifests itself in depth as though already there, waiting in silence for the moment of its expression.¹

– Michel Foucault

The grid, a long-lived human construct, has initiated some of the greatest changes the species has undergone since first it wove a fabric or tilled a field. This orthogonal arrangement of thread or lines on earth, plan, map, canvas or in abstract space has, with each iteration, proven instrumental in helping humans (re)orient themselves in a world it has helped them to (re)configure. Found nowhere in nature, traces of its presence, as found in a series of novel technologies, can be taken as an indication of a group's or culture's incipient or shifting awareness of self, of its move toward seeing itself as other than that within which it is embedded. To dress in woven fabrics is to be other than animal. To live in a gridded city is to exist outside of nature. It is the quintessential, rationalist technology, paradigmatic of a modern impulse that runs throughout the whole of human history.

And yet this technology, especially with respect to its unique formal qualities, remains surprisingly under-theorized. This remains true in spite of the fact that the grid

has operated as an ordering device in both the discursive and material registers for thousands of years, its intuitively simple, orthogonal design continuously and iteratively shaping our (especially Western) mental and physical landscapes over that time. Not only has it structured the streets we walk, the spatiotemporal coordinates we follow, and, since the classical era, the classification systems we use to organize reality, but, in all its many guises, it is one of, if not the primary means by which subjectification has been effected since first the loom (likely the first example of a formal orthogonal technology) made its appearance in pre-historic times. In its optimization of material and discursive flows, it is the grid in the guise of the *table*, as Foucault convincingly argues in *The Order of Things*, which has served as the primary technology for the concentration of power and knowledge and the internalization of regulatory forces formerly imposed from the outside.²

Though little is known about the origins of this utterly human construct, it continuously channels flows of information and bodies according to a logic that sets it apart from, and marks the limit of, the natural world. As art critic and theorist Rosalind Krauss notes, the grid supersedes the real substituting for the latter's characteristic irregularities its own immaculate, originary aesthetic.

In the flatness that results from its coordinates, the grid is the means of crowding out the dimensions of the real and replacing them with the lateral result not of imitation, but of aesthetic decree. Insofar as its order is that of pure relationship, the grid is a way of abrogating the claims of natural objects to have an order particular to themselves; the relationships in the aesthetic field are shown by the grid to be in a world apart and, with respect to natural objects, to be both prior and final.³

In myriad ways then, the grid enacts a reality alien to the human. Its coordinate structure, having no referent in the natural world, can be said to refer to nothing other than itself. Timeless and static in its perfection, the latter evokes the existence of an ideal order underlying the chaos of the merely real, of an abstract plane holding in tension the latent forces of figure and ground, warp and weft, inside and outside. It represents and enacts, in other words, an all-encompassing, positively-given, logically-accessible reality, one invisibly supported by the cuts it makes and the differences it thereby establishes between formerly non-existent domains.⁴ And, as with any successful remediation, it folds back on itself effacing any trace of its origins effectively appearing to antecede that from which it emerged. Operating in the discursive or material register, at the social or individual scalar level (urban plan, map, table, coordinate space) it isolates the object of investigation (individual, region, species, curve) from its constitutive field of relations and instantiates, thereby, in a single gesture, both the concept of object and field and the dichotomous relationship as such. At the same time, it creates a framework by which a new set of reifying relations (citizenship, nation state, Homo sapiens, analytic geometry), relations which determine the boundary of the object, might be discovered/invented. To sum up, the grid simultaneously instantiates such dichotomies as inside/outside, observer/observed, nature/culture,⁵ creates a logic in which these newly minted categories legislate entirely novel relations between the proliferating object-entities to which the logic gives rise, and furthers its own evolution by so doing. And it manages to accomplish all this while

remaining invisible to itself so that its logics might be imagined to have preceded its arrival.⁶

But how did we come by this most versatile of tools? From whence does the force of its logic derive? And why only in certain times and places did its orthogonal relationships come to dominate a given cultural imaginary? These are some of the questions we will explore in this chapter though ultimately the focus will be on tracing the dynamic of this largely invisible, because ubiquitous, technology. It is my hope that by determining its mode of operation we might be able to anticipate its next evolutionary move, and perhaps learn to appropriate its successful survival strategies for use elsewhere, such as in the socio-political realm.

To understand more of how the grid's dynamic operates and how (especially Western) material-discursive processes have been colonized by its logics we will have to come to know something of its origins. These are murky at best but, as we shall see, still serve to illuminate what appears to be an underlying, topological dynamic.

Origin of the Grid

The organism and the environment are not actually separately determined. The environment is not a structure imposed on living beings from outside but is in fact a creation of those beings. The environment is not an autonomous process but a reflection of the biology [and culture] of the species. Just as there is no organism without an environment, so there is no environment without an organism.⁷

– Richard Lewontin

If the collection of right angles we call the square or rectangle is the frame we don't see when we see the world (and such appears to be the case when we consider

that almost all visual media – books, movies, paintings, photographs, television, computer screens, windows, plays – is presented in a rectilinear format) then the grid is the means by which we align, rank, order, juxtapose and otherwise organize the information contained therein. Which begs at least two questions: which came first, the largely invisible rectangular framing of space through vision⁸ or the organizational logics of the grid; and, does the ubiquitous rectilinear framing of reality reflect a physiological predisposition or is it a learned behavior based on exposure to grid technologies long-built into the material-discursive environment? There is a third option, of course, which is that these opposing pairs spontaneously arose together, resonating with and reinforcing each other as with Deleuze and Guattari's example of the co-determining structure of the orchid and wasp,⁹ another possibility we will consider.

The only reason either of these issues even present themselves as something of a puzzle, of course, is because there exist so few examples of rectilinear structures in the natural world to which we might point as the initial catalyst for breaking the quadrangle/grid, rectilinear/organic symmetries. All other primary geometric forms – circles, triangles, pentagons and hexagons – are represented repeatedly in nature's products. They have their own structural integrity derived from parsimoniously delineating or distributing forces (tensional, compressive, attractive) of the system in which they exist. They thus require no explanation because they are simply there, a facet of the natural world which humans often unthinkingly mimic and incorporate into the one they build or imagine for themselves. But the square or rectangle is different;

nature has found it to be neither structurally nor economically useful.¹⁰ This helps explain why its representation among natural phenomena is limited to a single instance, that of a small number of crystals from the cubic and tetragonal groups, such as pyrite, fluorite and halite.

And yet, from a formal perspective, it is probably the single most commonly used technology among sedentary, human populations. One need only look around one's environment to ascertain such is the case. By contrast, it would seem that examples of a rectilinear grid fail to appear *anywhere* in nature.¹¹ Odder still is the dearth of examples of the 90 degree angle in the natural register, it, too, being limited to an appearance in the latter group of crystals.¹² Little wonder then that the first evidence of any kind of rectilinear structure does not appear in the archaeological record until the late Upper Paleolithic period (c. 26,000 B.C.E.) when clay imprints of woven textiles indicate humans first to be in possession of loom technology.¹³

So, is the grid an invention or a discovery? Did humans discover the cube through encounters with, for example, salt crystals and then mimetically transfer its form to their technologies, or were they inspired to invent its unique relationships through an abstraction of the act of framing that sight engenders? Or were there other possible sources of inspiration for its relatively sudden eruption in the archaeological record? Is it possible, for example, that the construction of reality by the body itself might present one such alternative? As biologist Richard Lewontin stated earlier, and

Walter Benjamin articulates in another milieu, the search for origins is always a fraught and inconclusive exercise.

Origin, although a thoroughly historical category, nonetheless has nothing to do with beginnings [...]. The term origin does not mean the process of becoming of that which has emerged, but much more, that which emerges out of the process of becoming and disappearing. The origin stands in the flow of becoming as a whirlpool [...]; its rhythm is apparent only to a double insight.¹⁴

So though we might find the origin of the grid to be like a whirlpool, an object/process which forever eludes our grasp, Benjamin holds out hope that we might at least learn something of its rhythm. But to achieve even this we must effect a double insight, a trick best accomplished perhaps by making its rhythm our own, something which, as we shall see, should require very little effort on our part.

Despite these difficulties, three possible scenarios for the origin of the grid come to mind each offering at least a partially viable explanation without ruling out the influence of the others. Given that the wide variety of life forms on this planet express in their morphologies the field of forces in which they exist, one could argue that the novel arrival of the grid represents a remediation of these forces, one inspired perhaps by human's upright posture and perpendicular orientation with respect to the horizon. Abstracting from this one might arrive at the primitive unit (the right angle) which, in repetition, forms the grid. Another possible, closely related proposition is that human bipedalism and the improved ability to manipulate materials it provided inevitably led, through a process of trial and error, to the invention of the lattice, as in the weaving of mats or nets, and then to the grid.¹⁵ And finally, researchers have confirmed only in the

last year that the wiring of the human brain and indeed of all primates takes the form of a three-dimensional grid.¹⁶ This orthogonal arrangement of neurons is found, definitively, only in the deepest parts of the brain and is only visible using diffusion magnetic resonance imaging (fMRI). Nevertheless, the simplicity of the arrangement comes as something of a shock to neuroscientists who had always imagined the operational complexity of the brain to require an equally complex physical architecture. Because the neurons, arranged as orthogonally interlaced sheets, follow the contours of the brain's folds (especially as they move away from the deeper structures) they might not qualify within some classification schemes as "true" grids; however, the fMRI images suggest that, at the very least, they mark the only other known example of a naturally-occurring, right-angled phenomenon.

The idea that the origins of the loom, gridded urban plan, graticule (longitude and latitude), single point perspective, Cartesian space and parallel computing can all be traced to what has until now remained an invisible, three-dimensional, orthogonally-interleaved wiring system in the brain seems a somewhat strained concept. Function often does not follow form (electricity, for example, bears little resemblance to, and is little affected by, the way electrical wires are run in walls) especially when, in the context of human development, form is unavailable for visual inspection and mimesis. But what if all that was required to start a positive feedback loop of lattice-inspired design was an initial impetus from this system, a push from the inside to the outside

such that the grid might be made legible and thus available for translation into technological form?

This concept gains support from an unlikely source – the wall paintings in the caves at Lascaux (c. 17,000 B.C.E.). Interspersed among the hundreds of figurative elements for which the caves are famous are a number of enigmatic geometrical designs. Included among these is a vertically-oriented, three-by-three grid which seems to float above two mirror-image ibexes, and in a gallery nearby, a similarly oriented, simple rectangle, flanked by two incised, two-by-three, horizontal grids or “blazons” painted purple and blue. Theories abound as to the meaning or purpose of these and the other geometric forms found in the cave complex, but one particularly compelling and well-supported argument is that they represent entoptic phenomena, or images reflective of the physiology of the eye and/or brain. The latter include both “phosphenes”, images from inside the eye itself due, for example, to pressure on the eyeball, and “form constants,” or groups of patterns whose distinctive shapes are thought to reflect the architecture of the neural connections between the eye and visual cortex. “Evidence suggests that the form constants of phosphenes are directly related to spatial relationships between the ring-like structure of the retinal cells and the grid-like or columnar neural structures of the visual cortex.”¹⁷ Elements from one or more of the four known phosphenes groups: grids, spirals, cobwebs and tunnels, regularly appear to those experiencing sensory deprivation or psychoactive substance-induced

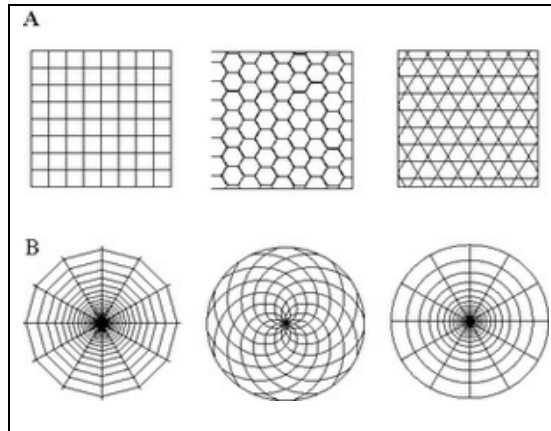


Figure 1. Phosphene groups: grids, spirals, cobwebs and tunnels.

hallucinations. The theory in connection with the geometric cave paintings of Lascaux then, as put forward by a number of neuroscientists and neuroaestheticians,¹⁸ is that the site was used for ritualistic practices perhaps involving the utilization of one or both of these trance-inducing methods, and that one or more participants transferred to the cave walls the images they “saw” while in an altered state. And what they saw would appear to be unrepresentative of the world outside but rather reflective of the structure of the brain itself (or, at least, the link between the eye and visual cortex). We might then judge the grid to be an example of a Kantian synthetic *a priori*, or that which is both empirically real and transcendentally ideal.

With respect to our own investigations into the origins of the grid, I think we can say that the entoptic theory looks very promising, though it is not without problems. As we learned earlier, evidence for loom technology dates to c. 26,000 B.C.E. pre-dating the Lascaux paintings by roughly ten-thousand years.¹⁹ This suggests that we cannot

immediately discount the likelihood of our other hypotheses. Perhaps it was an upright posture and horizon line that led, through the (intuited) rectangular frame of vision, to the grid after all. But then again, it is known that apes and monkeys and even dogs and cats are exposed to 'form constants' through spontaneous hallucination, so, even though the evidence is lacking, it would not be unreasonable to suggest that entoptic imagery experienced by Paleolithic humans prior to the invention of the loom was the initial inspiration for the grid. Supporting this further, of course, are the recent discoveries of the brain's orthogonal wiring plan and the "grid cells" in the visual pathways to the brain which integrate three-dimensional spatial information by following the contours of a self-organizing, triangular grid.²⁰ The brain and links between the eye and visual cortex, it would appear, are hard-wired for rectilinear perception and perhaps cognition, at least in part. So then why did the potential of the grid and rectilinearity, more generally, lie dormant for so long? And why once it appeared, did it take at least another 23,000 years to remediate itself as the urban plan?

These questions can be more properly addressed by examining the grid's dynamic, the topic of our next section. But before moving on we can sum up what we have learned about the grid's origins so far. Though it will likely remain impossible to say whether one or some combination of the hypotheses given here will suffice to explain the appearance of the grid, it is reasonable to argue that, in all likelihood, it precipitated from an exchange between the internal and external environment of the human. Whether this movement was from outside to inside, inspired by crystal

structures, or inside to out, inspired by structures in the neural pathway, cannot be stated definitively, but the entoptic and neurological evidence seems to point towards an emergence from within, a sort of bodying forth of the visual/cognitive infrastructure. Either way, however, there would appear to be a reflexive dynamic at work, one which suggests the spontaneous appearance of the grid originated from an enfolding between the two seemingly autonomous domains of inside and outside, two concepts for which it might be largely responsible for instantiating.²¹ It is also a dynamic that feeds on itself, as we shall see, deriving energy for its unceasing, if punctuated proliferation from each subsequent instantiation of the grid in the material-discursive environment.

Grid Dynamics

As Krauss articulates in her earlier quote, the grid exists not so much as a 'thing' but as an "order of pure relationship." This allows it to retain its distinctive orthogonal character and attendant tensional force even as it manifests differentially in various substrates. Acting through its preferred medium, the human, it moves through the millennia like a wave impulse, serially heaving up out of a material-discursive matrix textiles, the gridiron, the graticule, single point perspective and Cartesian space. It actualizes these phenomena even as it reveals them to possess not "an order particular to themselves" but to exist as singular instances in a dynamic of differentiation. In this sense it resembles the computational revolution which revealed such formerly distinct platforms as photography, music, painting, writing, gaming and warfare to exist, in part, in a shared, purely informational virtual dimension. Philosopher Keith Ansell Pearson,

drawing on Deleuze, suggests we understand the process of evolution to be “not only one of change but of invention, since the forms do not exist in advance. The process involves not a realization of the possible but an actualization of the virtual, in which the virtual enjoys its own ‘consistency’ as a productive power of differentiation.”²² We might then think of the grid as an example of the virtual’s “consistency”²³ in that it creates (through imposing the “basic axioms of the calculus of indication”)²⁴ domains of proliferating differentiation wherever it manifests (most recently in the area of computation) even as it retains its own order of relationship. Interestingly, given the origins of the programmable computer (and by extension, digital media) in the Jacquard loom, we could say, accepting the entoptic hypothesis (the grid’s origins being traceable to phosphenes or ‘form constants’), that with the advent of parallel processing, the grid has come full circle; it has thoroughly remediated the material-discursive landscape such that the (modern) human exists inside of what formerly existed only inside of it.

The circuit, in other words, is complete; the modern human has turned itself inside out mapping its interior logics and perceptual constraints onto its external environment. But not for the first time are we witnessing such a dynamic. We have been here before, at least in part, as a brief genealogy of the grid will attest. Each iteration of the grid, as we shall see, represents or enacts a closure²⁵ and a self-reflexive reentry of what we might think of as the grid/human dyad (the one being so thoroughly implicated in the other as to be inseparable).

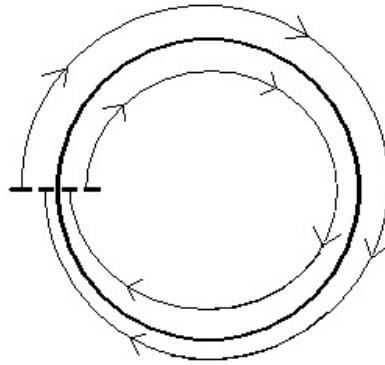


Figure 2. Reflexive closure and reentry: the dotted line represents the human, and the bold line the grid remediating the human with each completion of the circuit. Alternatively, the dotted line could represent the grid and the bold line the remediating human.

From the first moment the human began to cloth itself in (especially woven) fabrics of its own (and the grid's) making, for example, the human reflexively, if gradually, began to recognize itself as "other than," to exhibit an aesthetics and the recognition of the self this implies. From the obvious pride taken by weavers in their handiwork, as demonstrated by its detailed modeling in the earliest extant clay figurines,²⁶ to the association of Paleolithic textiles with important rites of passage, it is clear that grid technologies have played a critical role in the development of Homo sapiens sapiens. The form of self-recognition it initiates and heralds then attains closure in the manifestation of the gridded urban plan, the next in a series of grid technologies to trigger new forms of self-reflection and ultimately subjectification. The dynamic of this closure/reentry describes less the completion of a circle, however, than the enfolding of an involutory vortex. Insides and outsides not only implicate each other along a vertical axis, as with stirring tint into paint, but around a horizontal axis as well,

as interior and exterior circulate and implicate from top to bottom. At a finer level of analysis, however, scientists have discovered that these two, orthogonally-oriented movements have a torsional effect on each other such that they not only circle but spiral around their respective axes interpenetrating to form a stable, torsional core within a vortex ring. Given the central importance of this dynamic to the overall argument being made here I want to examine a graphic example of the latter's operation as found in the familiar object of the smoke ring.

The Vortex Ring

The morphogenesis of the grid/human as well as that of the smoke ring, then, combines three independent movements: propulsion, or forward progress; involution, or *creatio ex nihilo* (rolling or poloidal rotation); and ring rotation (orbital or toroidal rotation).

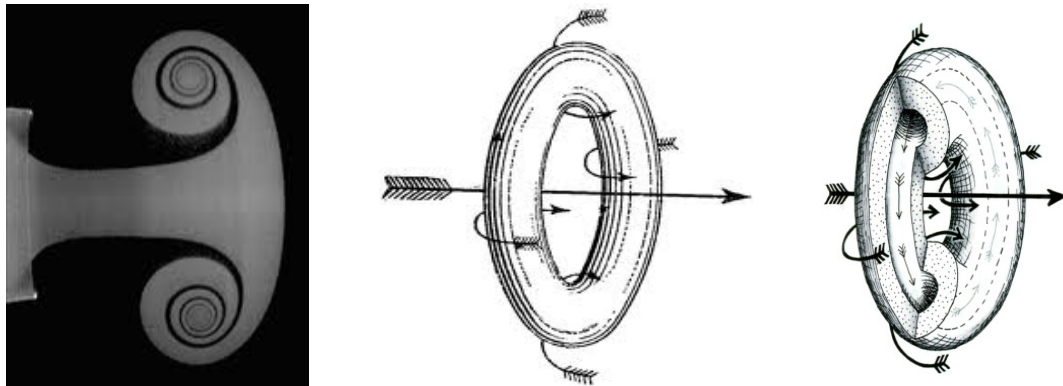


Figure 3. Three images of a vortex ring: 1. Cross-section of the initial phase of a smoke ring: impulse of air rolling up into a poloidal spiral and entraining surrounding material²⁷ 2. Ring translating forward while exhibiting poloidal rotation 3. Cut-away showing interior toroidal rotation at the ring's core.

The initial impulse of a smoke ring consists of a zone of high pressure, or pulse of air moving faster than the air around it. Meeting resistance the lead surface curves at the sides resulting in the formation of a ring of lower pressure around its edges. This ring then behaves like a vacuum causing both high and low pressure air to fold into each other and spiral under its leading edge, such that they resemble the shape of a mushroom in section. Trapped in the core of the resulting vortex ring is a low pressure zone much like that which forms behind the sail of a boat turned into the wind. And as with the boat attached to the sail, the ring is pulled forward by the surrounding atmosphere's attempts to fill this negative space. More precisely, each element of the vortex system is "propelled forward by the induced velocity fields of all the other elements of the ring vortex, [such that] the whole vortex is thus convected by itself."²⁸ By continuously turning its outside in, in other words, the ring, like a self-penetrating tornado turned on its side,²⁹ furthers its forward progress, a progress which, in turn, sustains its involutory movement. This sustained movement and identity appear to manifest out of nothing (continuing indefinitely in a frictionless environment)³⁰ lending the smoke ring the air of a magician's trick. Adding to this magical effect is the "toroidal" or rotational "vortex lines" of the ring which move orthogonally to the "poloidal" forming a robust, differentiated yet integrated, spiral flow at the ring's core.³¹ As the outside of the ring or "velocity field" spirals along "doing loop-the-loops in a progressive direction,"³² the circulating axial current helps prevent the particles entrained within the core from colliding with each other enhancing, thereby, the ring's

continuity and lifespan. As we shall now see, the evolution of the grid (and human) similarly advances by incorporating into its dynamic these propulsive, involutory and toroidal movements.

A Brief Genealogy of the Grid: From Textiles to Urban Plan

As with the origins of the grid itself, those of the orthogonal urban plan remain obscure and are likely multiple. Evidence for the existence of loom technology,³³ of course, long pre-dates that of even the earliest proto-gridiron settlements (Catal Huyuk c. 3,000 B.C.E.) though the cultural uptake and importance of the former seems to have varied widely by region. Crucially, for the argument being made here, however, it would appear that no non-weaving culture ever developed either a proto- or true gridiron settlement, which suggests there exists at least an affinity, if not a causal relationship, between these technologies. True-gridiron plans rarely delineate ancient (c. pre-700 B.C.E.) city streets, but when they do their epicenter is generally dominated by monumental architecture, evidence of strong monarchical, state or religious control.³⁴ This control does not necessarily mean that the inhabitants of ancient cities were oppressed. Participation in the construction of gridded streets and monumental architecture was, at least in some instances, part of a social dynamic based on reciprocity. In exchange for their labor, individuals gained a sense of participating in something larger than themselves, of connecting with their city and community and of being bound to their rulers with whom they identified.³⁵ Cities which featured orthogonal planning (either true or semi-orthogonal) arose in concert with, and

facilitated the transition to, agrarian settlements. Whereas some agrarian cities developed without benefit of an orthogonal plan, but no true, or even semi-orthogonal plan is believed to have predated agrarian-type settlements, it seems logical to suggest that the grid is in some way connected, not only with the earlier technology of the loom, but with the jump in scale (from an upper limit of 10,000 to that of as many as 1,000,000 inhabitants) that distinguishes these settlements from their ancient precursors.³⁶

Though the form of the grid might initially have precipitated out of humans' remediation of the "form constants" of their visual cortex pathways and often, it is speculated,³⁷ became of central importance to communities once translated into the technology of the loom, we can imagine that it became a technology of a different order, a sort of meta-technology (or what mediologist Lev Manovich might call a "meta-medium")³⁸ once people's everyday movements and social interactions were dictated by its form. Newly-minted subjects of the gridded, agrarian city would have become entrained by its spatiotemporal rhythms and logics reinforcing and amplifying those provided by the neural pathways of visual perception. The grid, in other words, as the epitome of ratiocination, enacts a radical break from all prior ordering structures (all of which resembled, more or less, their "organic" counterparts in nature). It represents a discontinuity, one well captured by mediologist Brian Rotman in his description of the changes wrought by the invention of writing.

...like any medium, [it] is a re-mediation; it engenders a clutch of interconnected discontinuities in the milieu of what preceded it: a disruption of the previous space-time consensus of its users and an altered relationship between agency and embodiment giving rise to new forms of action, communication and perception.³⁹

This description of how the introduction of writing affected humans' conception of the self transfers readily to the introduction of the urban grid (a phenomenon we should find perhaps not too surprising given that, as media archaeologist Friedrich Kittler notes,⁴⁰ writing itself takes the form of an abstracted grid). For there can be little doubt that the gridiron, among other things, represented/enacted a major disruption of the "spacetime consensus" of its users. The first uniformly gridded cities such as Babylon, Borsippa and Kahun (c. 1,800 B.C.E.)⁴¹ and even the semi-orthogonal cities such as Harappa and Mohenjo-daro (c. 2,500 B.C.E.) must have overwhelmed visitors and inhabitants alike with unfamiliar abstractions such as the endless repetition of the same (90 degree angles, uniform spacing of streets, buildings, lots and blocks) and internal viewsheds with, in some cases, seemingly infinite sightlines.⁴² With the way these conspired to order space and orient the populace it must have seemed to the latter as though they were inside and part of a larger, organizing entity or machine, one which, through the "soft control" of the grid, coordinated their movements, actions and thoughts. Such larger-scaled entities could only arise and sustain themselves through the creation of a division of labor. This would have manifested as an articulation of various essential functions (ingestor, distributor, converter, producer, extruder, motor, supporter)⁴³ whose performance, in turn, necessitated and fostered the rise of increasingly individuated subjects. Emerging out of this newly articulated leviathan

then, would have been not only an economy of scale capable of producing commodifiable goods, but a collection of individuated subjects which functioned as variables within an infinitely repeatable algorithm. Which is not to say that the more common and traditional, “organically” laid-out cities did not produce individuated subjects, but only that the efficiencies generated by gridded cities might arguably be expected to have amplified and expedited, for better and for worse, the rise of the rational subject.⁴⁴ For, as historian Robert Artigiani points out, there is a recursive and, to some degree, synchronous relationship between scalar levels of organization:

“More individualized humans sustain more complex societies. Thus, self-conscious humans emerge in concert with advanced social systems. Theirs is a complementary relationship, and neither can be imagined independently of the other. Nor can one be said to be more fundamental than or to dictate to the other.”⁴⁵

Returning to and continuing with Rotman’s earlier quote we find that writing:

... introduced a domain of virtual, seemingly ‘unreal’ objects, entities that are without context, endlessly repeatable, and free to be reproduced at any time, place, and cultural situation. For the medium of writing these virtual entities are texts. To engage with them writing posits, as does any medium, a virtual user, an abstract reading/writing agency who or which is as distinct from any particular, embodied, and situated user as an algebraic variable is for the individual numbers substitutable for it, an agency who/which accommodates all readers and writers of texts regardless of how and when in space and time they might have appeared.⁴⁶

Rotman brings out another useful point of comparison between writing and the grid which helpfully leads us back to our smoke ring model/metaphor. Where the “endlessly repeatable” and freely reproducible “virtual objects” of writing are “texts,” those of the urban grid are coordinates (which act not as signs but at the level of a Kantian synthetic a priori); and where the “virtual user” or “abstract agency” implied by these texts is a

reader/writer, that evoked by the gridiron (as becomes more apparent, as we shall see, with the Greek iteration of this scheme) is the subject/citizen. The latter implies the transmutation of the agent from an individual generated by local relations, to the function the agent performs in an economy of scale, the equivalent of an algebraic variable in the algorithm of the urban grid. The virtual agent, represented in this case by the subject/citizen, of course, changes with each iteration of the grid, the latter, I argue, occurring each time the grid re-encounters itself within the topological space of its preferred medium, the human. This re-entry of the grid into itself also results in the re-mediation of the human, the two leapfrogging their way through the historical record in much the same way as do two smoke rings issued from a single source in quick succession.

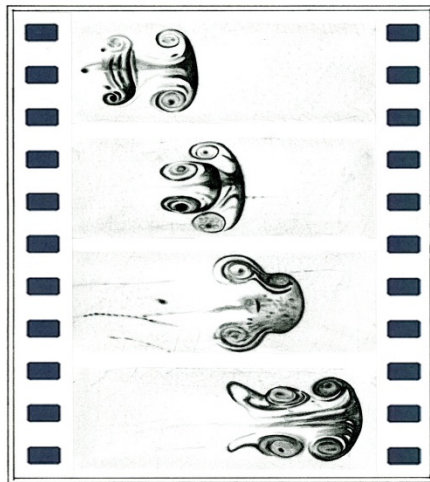


Figure 4. If two parallel vortex rings of equal size and equal moment move coaxially behind each other, they interact: The vortex elements of the one ring are influenced by the stream lines, generated by the other. The ring ahead therefore widens and slows down, the ring behind narrows , accelerates, catches up with and is drawn through the first ring. Then the process reverts: The ring which slipped through widens and slows down again, the one behind narrows until both are again equally large and their distance has become as before, etc..⁴⁷

Mapping the Grid/Human Dyad

Mapping this dynamic of the grid's multiple remediations onto the image of a self-propelling smoke ring should help us visualize this complex process. As we will remember, the wave impulse or smoke ring materializes at the intersection of three forces: propulsive/convective, involutory/poloidal and orbital/toroidal. In the argument being made here, the initial impulse for the grid comes from a vision, not of an external but of an internal reality. It thus constitutes not a representation but a propulsive, bodying forth of an enigmatic geometry, of what we might think of as a rectilinear force field seen through inverted eyes. Once made legible, humans were able to exploit the grid's algorithmic potential to transform themselves and their milieu. Through the simple iterative process it describes, a series of orthogonally-structured, self-reflexivity-inducing technologies⁴⁸ began to appear in relatively quick succession. The evolutionary process described here, of the grid moving, over millennia, from inside to outside and back again (from phosphene to net/loom to urban grid), remediating the human with every re-entry (through introspection, individuation, subjectification), can be mapped onto the involutory spiraling of the smoke ring. This involves the coiling together of outside and inside and a permanent circulation of low pressure (or that from which the faster-moving, high pressure exterior of the ring distinguishes itself) at the ring's core. It is this involuted, circulating distinction between high and low, fast and slow, which convects the ring forward facilitating its self-perpetuating cycle.⁴⁹

Though the grid demonstrates a complex dynamic, its operational strategy is, like that of the smoke ring, simple – by virtue of an initial, propulsive impulse, it makes a cut or distinction within a uniform milieu (entoptic phenomena distinguishing between inside and outside; textiles/loom distinguishing between human and “other;” urban plan distinguishing between culture and nature) harnessing the energy released thereby to further its ability to make additional cuts (cultural evolution) *ad infinitum* without ever having to acknowledge that it is inventing, not discovering, the dichotomies that its advancement furthers and requires. Though, of course, as with the smoke ring, coiled up within each of the grid’s products is the equivalent of a low pressure zone or that which invisibly works to distinguish the grid from its milieu and by so doing guarantees its continued existence/forward progress. So, for example, though the origin of the entoptic grid is said to be internal to the human, it should be noted that it emerges out of an interfacial, perceptual system (the neural pathways between eye and visual cortex) tasked with making precisely this distinction, that of an absolute difference between inside and out. In other words, to claim for the grid phosphene or formal constant an endogenous origin is to presume the prior existence of that which the visual system (from which it originates) is tasked with establishing, that of an operationally-closed, bounded, entity.⁵⁰ The tendency is to ignore that the entoptic grid image and formal constants in general, are part of the boundary-drawing operation the human pursues in its attempt to differentiate itself from its environment. But the possibility that the sought-after closure is never achieved is hidden from the system itself, buried

within its internal logics, creating in effect, a vacuum which ineluctably convects the system forward.⁵¹

Every entity at whatever scale might be said to maintain its corporeal or systemic integrity by wrapping itself around an originary distinction, incorporating within itself a map or sign of that-which-it-is-not as given by the slower-moving segment of the matrix through which it moves. In this sense, the map, sign or low pressure zone might be thought of a variable that reappears in different clothing whenever a system makes a distinction between that which is interior to it and that which is exterior. Flat ontologists such as Manuel Delanda and Niklas Luhmann, understand the social group to form such a system, an autonomous entity which differentiates between itself and that which is foreign to it – other groups, animals, machines, nature. The latter are some of the variables that help it to make a distinction between inside and outside forming, at once, both the Other by which it comes to know itself and the low pressure zone at its core, or the differential in speed which convects it forward. But it must also fold a sign of this exclusion into itself, a memory, map or sign of this exclusion, by which it might orient itself in the future, the equivalent of an inscriptive act of self-reference. “Through self-reference, a system creates its own teleology and, by so doing, reproduces itself indefinitely.”⁵² For Bruno Latour this teleology, motored by the vacuum or excluded Other at its core, takes the form of the mistaken notion, popularized during the modern era, that the human is separate from, rather than a part of, nature. Accepting that the natural and social are thoroughly entwined and even co-constitutive of each other

would presumably force humans to recognize and perhaps question the wisdom of their thralldom to a self-perpetuating logic of endless “progress.”

Of course this vacuum or originary distinction manifests too, at the level of the self-referencing individual (especially in grid-centric, self-reflexive cultures) leading each to seek, through elliptical means, the closure required of it by a cultural fixation on a positivist, instrumentalist rendering of reality. The variable or circulation of low pressure at the core of the individual manifests as the *affective register* (which we explore in later chapters) and it is this, as cultural theorist Sara Ahmed notes, which irremediably keeps the system open, denying individuals the closure they might seek.⁵³ But mapping the toroidal movement of the smoke ring onto our grid/human dyad reveals that, at least around the horizontal axis, a form of closure is achieved. Where the involutory (poloidal) spinning around the ring’s core never closes, that which takes place around its perimeter (toroidal) must in order for the ring to have an identity as such.⁵⁴ This is because where the poloidal movement emphasizes forward progress and the enfolding of inside and outside, the toroidal stabilizes the ring as a torus providing it a continuity which allows it to move through its environment as a unified entity. As noted, this latter motion works in conjunction with the former to preserve the ring’s shape. Together they mesh the torus’ elements into a single velocity field such that, as we read in an earlier quote, the movement of one affects that of all.

Mapping this toroidal movement onto our analysis of the grid, we recognize it as the circulation of elements which stabilizes any given instantiation of the latter. In the case of the first textiles, these might range from: the components of the earliest threads – such as milkweed, nettle or flax – and looms – such as weights, battens and shuttles; to the weavers themselves – accomplished, neophyte or indifferent; to the rituals demanding of special raiment – such as puberty, marriage or burial; to the need for markers of status in a given social hierarchy – such as plain-woven, twill and whip-stitched fabrics and garments. We could, of course, drill down even further into the molecular and atomic properties that give the products of the aforementioned plants tensile strength or that allow for wood to be carved into useful shapes, or include the skills and desires of the artisans who construct the looms. These and a multitude of other elements, at a myriad of scales, fold together to form and sustain the assemblage of the grid-as-loom a process repeated for every other manifestation of the grid as well. Each new instantiation assumes and maintains its orthogonal form as long as the requisite elements are available to circulate through it. And each builds on and amplifies the dimensions of those that came before until, as Kraus might say, those of “the real” are “crowded out” and replaced by “aesthetic decree.”

This, then, is the effect of the toroidal movement, a stabilization of form in space, even as the poloidal, moving from outside to in, stabilizes it in time; though, in truth, no stabilization is possible without the activity of both.⁵⁵ Spinning into each other these movements create a “floating entity” or grid/human vortex ring motored by a

“ghost effect,” a circulating vacuum, or originary distinction, which conveys the entity forward.⁵⁶ At the level of the group or individual, the impulse is to deny, ignore or expel this “uncanny” other and seal off one’s borders but to do so is to foreclose any further forward progress and thus the dynamic that sustains the whole. This dilemma is poignantly illustrated by Walter Benjamin in the ninth of his *Theses on the History of Philosophy*.

"Angelus Novus" shows an angel looking as though he is about to move away from something he is fixedly contemplating. His eyes are staring, his mouth is open, his wings are spread. This is how one pictures the angel of history. His face is turned toward the past. Where we perceive a chain of events, he sees one single catastrophe which keeps piling wreckage upon wreckage and hurls it in front of his feet. The Angel would like to stay, awaken the dead and make whole what has been smashed. But a storm is blowing from Paradise; it has got caught in his wings with such violence that the angel can no longer close them. The storm irresistibly propels into the future to which his back is turned, while the pile of debris before him grows skyward. This storm is what we call progress.⁵⁷

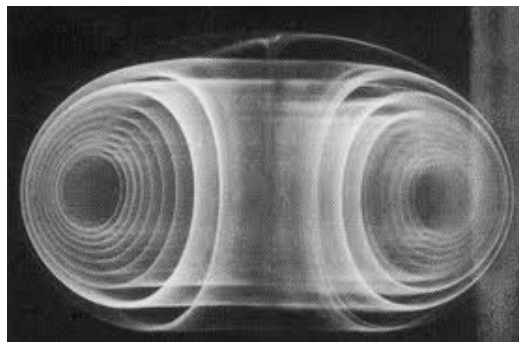


Figure 5. Cross-section of a smoke ring.
“The structure of a smoke ring is actually a tightly wound toroidal spiral.”⁵⁸

Storms, such as that blowing in from Benjamin’s Paradise, result from the meeting of faster and slower moving air. They have at their core a low pressure zone such as that

which, in miniature, powers the vortex ring. Coiling up around this core is the history of high and low pressure zones, Benjamin's ever-growing "pile of debris," or, in our model of the grid, the detritus of instantiations past. And Benjamin's angel, carried along by that which he is powerless to stop, forced to bear witness to the havoc and destruction it wreaks, stands in for all who find themselves convected by a progress they feel impotent to interrupt; for to impede "progress" is to arrest the vortex ring's forward motion, or that movement necessary to its survival and, arguably, to that of life itself. Yet, at the same time, it is precisely this movement which, as Benjamin understood, threatens both. What is to be done?

Benjamin seemed to believe that a richer understanding of the temporal dimension(s) would be necessary to any solution to this conundrum as we shall explore in the fourth chapter. But clearly, decoupling forward motion from our current understanding of "progress" is a move which he might favor, a possibility which Duchamp explores in the final chapter.

Abstraction of the Grid: From Gridiron to Cartesian Space

In the last section, three material examples from pre-history revealed how the "order of pure relationship" known as the grid circulates between the internal, topological and the external, Euclidian environments of the human. We saw how the grid becomes amplified and re-mediated each time it (re)encounters itself through the gaze and haptics of the human (phosphene, net/loom, gridiron) and how the human, in

turn, becomes re-mediated in its own right (introspection, individuation, subjectification) by this (re)encounter. We learned, too, how a dissipative system, or an inside with a co-constitutive, coiled up outside continuously circulating through it, is necessarily self-convecting and, in combination with its orbital or toroidal movement, self-sustaining. And we learned how the relationship between the grid and the human too, might be characterized as one of convection as each successively takes its turn as a vortex ring pulling the other forward.

In this section, we will be examining how the grid transitions from the material to the discursive register, or how its unique coordinate system shifts from the foreground in physical systems such as cave paintings, textiles and gridiron, to the background in the abstractions of first graticule, then single-point perspective and finally Cartesian space. The dynamic of these transitions remains consistent with that described in the last two sections. Thus the focus here will be less on the mechanics of remediation and more on how both grid and human are mutually affected by its co-constitutive dynamic. For, as we will remember, each serves as medium for the other with the grid, finding in the human, its sole means for evolution, and the human, discovering in the grid a sort of perpetual motion machine, a mechanism for cleaving the world together and apart in an ever-widening gyre of proliferating differentiation. Applying Artigiani's earlier quote to this dynamic, we could then say that "Theirs is a complementary relationship, and neither can be imagined independently of the other. Nor can one be said to be more fundamental than or to dictate to the other."

Additionally addressed in this section is the question of why, though some version of the grid is present in almost every culture, it becomes the animating feature of only a select few, at least initially, and then only at certain times in these cultures' histories.

The Graticule

The first part of our analysis then begins with tracing how the gridiron first becomes decoupled from a specific cultural, geographical context and then deployed as a machine or algorithm for the production of citizen/subjects. This requires an investigation into the origins of citizenship as such and why it was thought that the grid might further its spread.

The Greek philosopher and sage Solon is generally credited with being the first to codify rules of governance offering the demos some measure of control in their own affairs.⁵⁹ Internecine squabbling among the oligarchs in Athens in 632 B.C.E. resulted in the former requesting of Solon that he mediate their affairs so as to prevent them from bringing ruin upon themselves. He acceded to this request and arrived at a solution which required the oligarchs share political power with the hoi polloi. The former accepted his ruling because it maintained their exclusive right to govern, and the latter did the same because they were, for the first time, empowered to revoke this right by majority vote. His solution also stipulated that no Athenian could ever own another thus establishing the concept of a civil right. Thus began a political trend within Greece and its colonies towards the development of a citizen-based form of self-governance,

one which some one-hundred and forty years later, Hippodamus of Miletus (498 B.C.E. — 408 B.C.E.) was to articulate in material form through the then new art of urban planning.

While Aristotle credits Hippodamus with having invented this “new art” it is most likely not, as is traditionally reported, because he believed him to have invented the orthogonal urban plan. Classics scholar Alfred Burns argues persuasively that Aristotle would have known, for example, that Hippodamus’ plan for the rebuilding of his home city, Miletus (his first project in 473 B.C.E.) merely followed, to a large extent, its original, centuries-old, orthogonal layout.⁶⁰ He would also have known that a similar plan had been employed in laying out a number of Greek colonies in Sicily, including Syracuse and Megara Hyblaea, long before Hippodamus’ birth.⁶¹ No, Aristotle (begrudgingly) acknowledged Hippodamus’ talents not because he was the inventor of the gridiron but because he was “an [aspiring] adept in the knowledge of nature... and the first person not a statesman who made inquiries about the best form of government.”⁶² He was, in other words, what some might consider the first political philosopher and one who understood the need to articulate the necessary relationship between the discursive and the material. Though he did not invent the orthogonal plan, he recognized in its uniform relations of streets, *insulae* (or rectangular blocks), and lots, an opportunity to reinforce and disseminate the egalitarian ethos he championed. This idea is bolstered by the way he reiterated these relations at the macro level, dividing the city into what Aristotle describes as three equal areas:

one of artisans, one of husbandmen, and a third of armed defenders of the state. He also divided the land into three parts, one sacred, one public, the third private: the first was set apart to maintain the customary worship of the gods, the second was to support the warriors, the third was the property of the husbandmen. He also divided laws into three classes, and no more, for he maintained that there are three subjects of lawsuits - insult, injury, and homicide. He likewise instituted a single final court of appeal, to which all causes seeming to have been improperly decided might be referred; this court he formed of elders chosen for this purpose.... He also enacted that those who discovered anything for the good of the state should be honoured: and he provided that the children of citizens who died in battle should be maintained at the public expense... As to the magistrates, he would have them all elected by the people, that is, by the three classes already mentioned, and those who were elected were to watch over the interests of the public, of strangers, and of orphans.⁶³

In the manner of his contemporary and future patron, Pericles, then, Hippodamus made manifest physically the democratic ideals he articulated rhetorically, though his approach unlike that of the former, was based less on a love of the arts than on the rational logics of number and proportion for which Miletus, his place of birth, was known.

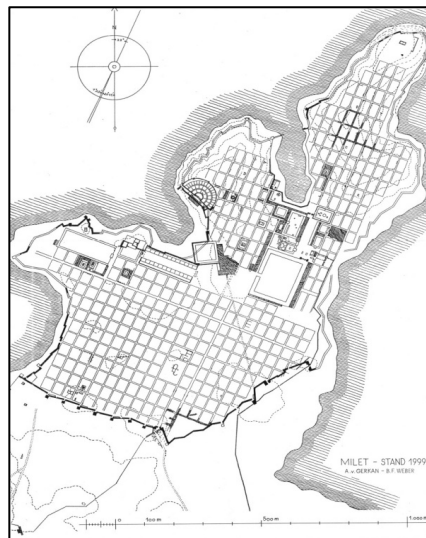


Figure 6. Hippodamian Plan: City of Miletus

For Miletus, a prosperous and powerful cultural center in Asia Minor (then a part of Greece), is considered to be the birthplace of both science and philosophy, home not only to Thales, deemed by Aristotle to be the first philosopher, but also of his fellow pre-Socratics Anaximenes and Anaximander, creator of the first world map. Together these three founded what came to be called the Milesian School of philosophy known for its attempt to explain the cosmos in terms of matter and its interactions rather than in those of the mysticism that was popular at the time. According to Boyer in *A History of Mathematics*, Thales was “the first man in history to whom specific mathematical discoveries have been attributed.”⁶⁴ He is also reported to have been the first to have measured the height of the pyramids by using the length of their shadows and the concept of self-similar triangles, an accomplishment which no doubt left an impression on his student, Pythagoras.⁶⁵

So, the city-state of Miletus is credited with having given birth to a surprising number of (Greek) firsts: urban planner, political philosopher, natural philosopher, mathematician, and to have fostered the career of the first geometer. What was it about this Ionian metropolis of fifty thousand that made it a crucible of modernity, or what cultural theorist Sanford Kwinter describes as “a reverse stream that is present *virtually* (but relatively rarely actualized) throughout history, emerging here or there as a kind of counterhistory or counterpractice...a transvaluation of all values?”⁶⁶ Clearly its wealth, cosmopolitanism, and location “as a gateway between Aegean and Anatolian worlds”⁶⁷ played a role, but there is also its history as a gridded city, the foundations of

which, as noted, are believed to have predated Hippodamus' plan by hundreds of years. If true, one then could argue that the rectilinear environment itself might have effected such a transvaluation of values among these philosophers, mathematicians and planners inspiring in them a vision of a type "of Being free of any transcendent unity and without reference to anything outside itself as its cause or ground."⁶⁸

This is the logic of the self-referencing, self-generating grid, a timeless algorithm that antecedes that which it produces and whose unvarying rhythm entrains all who enter its coordinate architecture. By lodging itself within the psyches-somas of its inhabitants, it makes cognizable/tangible the concept of an "order of pure relationship," of a floating variable detached from any particular material substrate, of a citizen-subject, city-state or cosmos capable of creating its own ground of being. And it is a concept which can be exported, not only in the form of a foundational urban plan enactive of an egalitarian ideal, but also in the guise of a purely rational, practical argument for parsimony and progress.⁶⁹ Mysticism, monarchs and the gods would each meet their match in this simplest of geometric configurations though millennia would pass before it gained the absolute advantage.⁷⁰

In the short term, between 600 – 300 B.C.E., however, it was perhaps Greece's most important export. Some three hundred colonies based on the Hippodamian model are thought to have been established during this period in the eastern Mediterranean, within modern day Turkey, Italy, Sicily, Syria, Lebanon, Egypt and Libya⁷¹ (a number the

Romans would more than double during their own pursuit of empire even as they converted the grid plan for use as a tool of totalitarian control).⁷² Three of these colonies are of importance to the genealogy of the grid: the Hellenistic city of Cyrene in modern Libya, original home of Eratosthenes (276 – 194 B.C.E), the inventor of a proto-longitude and latitude;⁷³ Ptolemais Hermiou, in upper Egypt, founded c. 300 B.C.E., the birthplace of Claudius Ptolemy (90 – 168 AD), the first to make use of a coordinate system of parallels and meridians to construct a world atlas; and Alexandria, established by Alexander the Great as his new Pharaonic capital c. 332 B.C.E., home for both of the aforementioned geographer/ mathematicians for most of their adult lives. All three cities operated under a Greek style of government with a constitution and some form of democratic self-rule, each thrived well-beyond the Hellenistic period when Greek power was at its zenith, and each is believed to have been built on an orthogonal plan.

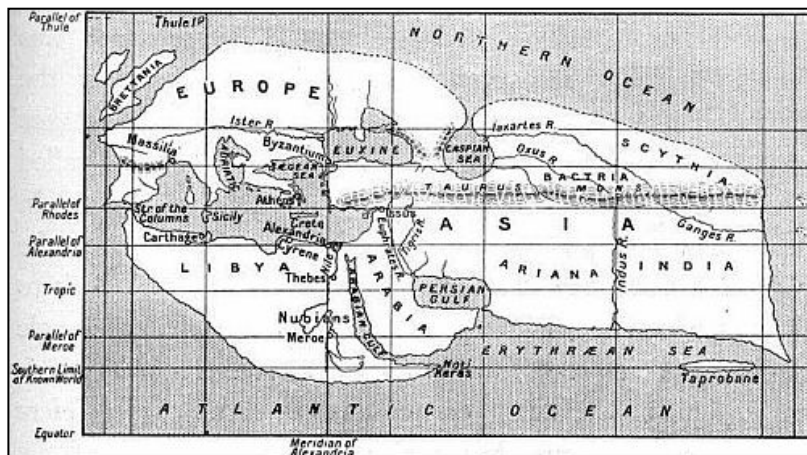


Figure 7. Eratosthenes' map of the world, circa 220 B.C. (reconstruction).

As with the gridiron and its effects on Milenesians, such as Thales and Hippodamus, it is impossible to attribute Eratosthenes' invention of the graticule solely to his having spent the bulk of his life in a gridded environment. Growing up in Egypt, the birthplace of surveying,⁷⁴ for example, might also be expected to have influenced his interest in mathematics and geodesy (literally, earth-dividing). And we might expect, too the pyramids and great temples, and his studies in the great library of Alexandria (of which he would later become head) to have piqued his interest in astronomy, providing us with ample explanations for what might have inspired him to conceive not only of a gridded planet, but also of how this idea might be used to draw the first map of the world and to measure the circumference of the earth (which he did to within an amazing two percent accuracy). But as before, the method here is not to argue for a strict relationship of cause and effect between exposure to, and remediation of, the grid but rather to suggest that feedback loops such as those which circulate between body and environment often have the effect of altering both as in Steigler's example of the stone ax and hominid brain.

The exterior does not precede the interior, any more than the interior precedes the exterior—at stake is an originary complex through which they compose..."Interiority" sounds like a potentiality of which exteriorisation would be the act (in Aristotelian terms)—the expectation or promise of, the tendency to, exteriorisation. But expectation already means projection and future—anticipation. Thus the problem is that the tool appears to be both the result and the condition of anticipation. The tool is like a mirror, a place of recording and inscription but also a surface of reflection, the reflection that time is, as if the human were reading and linking his future in the technical... And if this technical becoming is not simply directed by the "who," then does the "what" have a return effect on the "who", governing its differentiation? The "who" is differentiated by the non-living, by the "what."⁷⁵

Exposure to the grid on the part of humans, in other words, might be considered a necessary but not sufficient explanation for their involvement in its remediation.

Subject to the Graticule

While Eratosthenes' achievements are remarkable, our interest in them here stems more from what they have to tell us about the subjectification of the human than in how they advanced the cause of natural philosophy. For it is in its instantiation as (proto-) longitude and latitude, meridians and parallels that we see the grid take a dramatic leap from the material to the discursive, from that which is tangible, visible to the naked eye (warp and weft, cross streets and avenues) to that which, in this instance, must be inferred from occupying an imaginary spatiotemporal location. To draw or view a plan of a city or region is, of course, already to enjoy an elevated vantage point. To imagine the earth as a partitionable sphere, floating in space, however, is to become virtual, to detach oneself from one's physical being and to adopt a transcendent perspective. It is to engage in a form of abstraction, in other words, more readily accomplished by those who have become habituated to the "endlessly repeatable," virtual coordinate system of the Hippodamian plan, one such as Aristarchus, for example, who studied in Alexandria under the atheist philosopher Strato of Lampsacus, and who was the first to propose the concept of a heliocentric cosmos. Having lived its abstractions, he, as well as Eratosthenes and Ptolemy, is then a product of the algorithm of the grid, one primed to reproduce by opening up new areas of investigation, new territories, be they actual or virtual, for colonization. Each of these astronomer/

mathematicians is equally comfortable with representing the actual – tracing the (apparent) movement of the stars or the grid plan of their home city – as they are with presenting the virtual – the ratios between objects viewable or imaginable only from a transcendent perspective (a spherical earth in relation to sun and moon, regions of the globe in relation to each other).

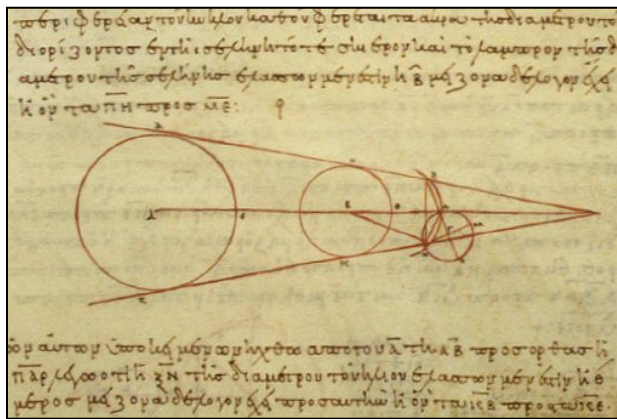


Figure 8. Aristarchus's 3rd century BCE diagram of the relative sizes of (from left) the Sun, Earth and Moon, from a 10th century AD Greek copy.

Each, in other words, is ready to adopt the disembodied perspective necessary to remediate the grid in the virtual realm opened up by the mathesis of the graticule.

The gridiron, through the medium of Eratosthenes, remediates itself as the graticule, while some four hundred years later the graticule, through the medium of Ptolemy, re-mediates itself as the world atlas. But of course, the human, too is remediated in this cycle of closure and re-entry. In order to comprehend the concept of earth as reticulated globe the subject must adopt, as mentioned above, a transcendent

perspective, one which locates him not only above a given city or region but in the void of outer space. It is a position which can be occupied only virtually and in this it resembles the position the subject must assume when viewing a perspective painting.

What we are really observing, in this first geological age of perspective, the epoch of the vanishing point, is the transformation of subject into object: like the camera, the painting of perspective clears away the diffuse, non-localised nebula of imaginary definitions and substitutes a definition from the outside. In its final form...the only position for the viewing subject proposed and assumed by the image will be that of the Gaze, a transcendent point of vision that has discarded the body...and exists only as a disembodied *punctum*.⁷⁶

By being willing to substitute, however briefly, in place of its lived experience of the local the graticule's rationalized representation of the global, the individuated human begins a transition from subject to object. The citizen/subject becomes an incorporeal, dimensionless punctum though one rewarded with a god's eye view of an earth that is measurable, quantifiable and thus, in some ways, controllable. In helping the graticule to objectify (what now appears as) the planet in this way the cartographer-colonizers are themselves objectified as it is they who serve as the medium through which the grid remediates itself.

But, as noted, their environment has prepared them for this transition for, by occupying the coordinates of the grid, they have absorbed not only its rational logics but also its perspectival ratios. Casting their gaze down the streets of their home cities of Cyrene, Ptolemais Hermiou, or Alexandria they would have encountered the three-dimensional equivalent of the vanishing point first used to organize two-dimensional, pictorial space in Renaissance Italy. Though the vanishing point is always and everywhere present in the viewing plane, a feature, as we shall see in the next chapter,

of stereoscopic vision, its effects become exaggerated within the orthogonal framework shared by the gridded city and perspectival painting. This framework is constructed of a system of transversals and rays which, when organized by the vanishing point, reflect back to the viewer a location “infinitely far in the distance,” one “unoccupiable by a person or indeed any physical object.”⁷⁷ That the viewer occupies the mirror-image of this un-occupiable point and can only exist as a punctum within the logics it establishes would not have been obvious to our cartographer-colonizers and, indeed, would not become apparent until painters such as Velasquez and Vermeer gestured toward this effect of perspective in their self-referential paintings.⁷⁸ But one might expect the inhabitants of a gridded environment to have internalized its logics, including those of the vanishing point/punctum, and to reflect this in their ability to imagine objects or relationships which lie outside the realm of the phenomenological. Just as occupants of the gridded cities of Babylon and Borsippa, in other words, are believed to have been the first to use algorithms in computation (specifically for the calculation of square roots), so it should not surprise us to learn that it was citizens of the Hippodamian-planned city of Alexandria who were the first to envisage the earth as a measurable, free-floating sphere (and one which, in the case of Aristarchus, circled the sun).⁷⁹ While it is conceivable that any analytically-minded interlocutor might be able to entertain such a counter-intuitive idea, it would seem that those who have become entrained by the logics of the grid are already primed to adopt the non-occupiable position of the disembodied punctum entertaining such an idea requires.

Despite the great preponderance of Greek and Roman gridded settlements during this period (c. 300 BCE – 200 AD) it would appear that relatively few individuals were able to achieve this unique perspective. Aristarchus' heliocentric model was largely dismissed by his contemporaries as either impious (Cleanthes, head of the Stoics) or mathematically meaningless (Archimedes). Eratosthenes' concept of the graticule would fare better, influencing Crates, the creator of the first globe, and of course, Ptolemy, but it too, suffered from what might be described as an indifference on the part of other cartographers towards the mathematization of space, such as Posidonius (whose own world map dispensed with longitude and latitude and underestimated the circumference of the earth by almost thirty percent) and Dionysius Periegetes (a contemporary of Ptolemy's whose failure to employ a standard of measure in his mapping practice begins to show the move away from cartography and towards the sort of cosmography which is to dominate the medieval period). It is then left to Strabo, an Alexandrian scholar and compiler of all pre-Christian geographical knowledge; Marinus of Tyre, geographer/mathematician and proponent of the use of longitude and latitude in map-making; and, especially, Ptolemy, some 400 years later, to advance the mathesis of Eratosthenes.

Ptolemy is renowned for, among other things, having produced the first atlas, his *Geographia* which depicted the known world in a series of 27 maps – 26 regional and one *mappamundi*. Described as the first scientific geographer, he is credited with having solved the problem of transferring geographical information from a three-

dimensional globe onto a two-dimensional plan by inventing the conical and modified spherical projections.

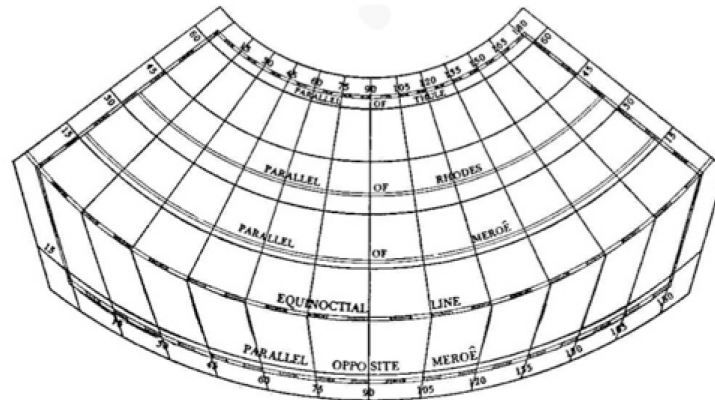


Figure 9. A reconstruction of Ptolemy's conic projection, suggested for the construction of a map of the habitable world.

We find in his atlas the first example of a true graticule⁸⁰ in that the ratios described by the parallels and meridians remain uniform throughout keeping distance and scalar distortions to a minimum. Such accuracy would have been a boon to Rome's expansionary aspirations. Unfortunately for both the latter and the graticule, within less than a hundred years of the atlas' introduction, the Empire was to begin to experience a series of shocks (assassination, plague, civil war, invasion) which would lead to its decline and ultimate collapse two centuries later. Much of the knowledge that had been gained during the prior two millennia would be lost in the one to follow including many of the technologies of the grid discussed here. Not only was there little need for accurate maps in a fragmented world turned insular and xenophobic, but even less for a

planned town or settlement which conformed to a grid allowing it to be navigated easily by invaders. Instead of a focus on expansion – of trade, rational knowledge, hegemony – the emphasis in the West during this era was on fortification, religiosity (specifically Christianity) and, in the High to Late Middle Ages, scholasticism. The overall dynamic is perhaps best described as involutory – inward-turning and self-enclosing – as reflected in the morphology of the medieval hill towns which began to populate areas left vulnerable by the receding tide of empire. Only the technology of the loom (and, of course, its distant cousin, writing) would remain to remind the knowledge-seeker of the logic of the grid and the practical value of its mathesis.

Linear Perspective

This would begin to change in the 11th and 12th centuries when the writings of Aristotle were “recovered” (which is to say translated from the largely dead, Greek language into Latin) and introduced into the increasing number of cathedral schools and universities that were being established during this period. His heretical, if well-reasoned arguments pertaining to the (non)existence of divine providence and the soul would send shock waves through these centers of learning sparking philosophical debates among their theologically-minded scholars. The on-going Crusades and dissemination of these and similar antiquarian texts increased interest in the knowledge of the ancients more generally leading to the translation in Sicily, then a thriving cosmopolitan center, of some the works of Euclid and Ptolemy. It was not until 1400, however, that a copy of the latter’s *Geographia* found its way to the West via

Constantinople and another ten before it was translated and its maps gradually made available to collectors. Its reintroduction to a Western audience newly interested in other peoples, lands and knowledges would prove momentous in the scope of history in that its gridded logics would soon come to dominate those that had been in place for a millennium. For these would be put to use in a colonizing effort that would come to dwarf any the world had yet known, wresting control both of physical space, as geometrized maps and charts allowed their possessors to move about the planet almost at will, and mental space, as the process of the objectification of the subject, begun in Hellenistic times (but cut short by the Roman Empire's disintegration) could begin anew, only this time, in the form of a powerful new transformational technology – linear perspective.

By the beginning of the 15th century, then, the grid had been reduced to a shadow of its former self, employed mostly by tapestry makers and local surveyors. But as with vortex rings which release a crown of miniature, self-similar copies upon collision with an opposing force, so too did the grid seed the future with miniatures of itself. One of these, in the form of Ptolemy's *Geographia*, found fertile soil in Florence where an elite group of artists and scholars had become newly fascinated by the philosophical and aesthetic systems of classical antiquity. Arguably among these were the architect and engineer Filippo Brunelleschi and humanist polymath Leon Batista Alberti, though whether either of these men drew their inspiration for their contributions to linear perspective directly from Ptolemy's atlas remains a matter of

debate. What is almost universally accepted, however, is that Brunelleschi was the first to demonstrate the mechanics of linear perspective (with his now famous experiment at the Florentine Baptistery wherein he showed how the use of the vanishing point enables the artist to transpose accurately the proportions in the visual field), and that, roughly ten years later, Alberti, his friend and fellow Florentine, was the first to mathematize its ratios in his famous treatise *De Pictura* (On Painting). Also beyond dispute is that the logic of the grid makes a radical resurgence in this same time and place and that this is due in no small measure to the interest these two, among others, took in (re)introducing to their contemporaries the aesthetic forms and values of classical antiquity.⁸¹ While evidence for the *Geographia's* direct involvement in the inventions of Brunelleschi and Alberti might be considered circumstantial by some and compelling to others, the outcome of the debate remains somewhat incidental to the argument being made here.

For what is of importance is that the grid resurfaces after a long hiatus and is almost immediately embraced and remediated by 15th century Florentines who know almost nothing of its logics. Being familiar with the dynamic of the grid, we should not be surprised by this for we are aware that, though they might know little of the grid, it cannot be said that it is foreign to them. This is because, as we will remember, all systems are conected by the circulation at their core of that from which they distinguish themselves. Every system has folded within itself a sign or map of the originary distinction it made establishing the boundary between what is interior and

exterior to it, which, in the case of medieval Europe, would be the digital logics of the grid. Thus it is that the medieval subject would have been familiar with the latter, or at least its ghost, because it is this which would have circulated through the coiled material-discursive armature of the era animating its persistently analog logics and haunting the medieval subject with its lost promise of progress and a secular paradise on earth. Thus whether the cascade of change which was to originate in 15th century Florence and sweep through the world in the centuries to follow was triggered by Alberti's and Brunelleschi's familiarity with Ptolemy's atlas, as the majority of scholars believe, or by other means, such as their interest in astronomy and contact with texts such as Ptolemy's *Almagest* (his treatise on the subject) and Euclid's *Optics*, as others suggest, is of little concern to us. These two were clearly haunted by the logics of the grid as were fellow 15th c. artists Masolino da Panicale, Masaccio, Mantegna, Fra Angelico and Leonardo, logics which were not to be denied. But at the same time, as art historian Samuel Edgerton points out, it also seems "...clear that there could have been no appreciation or application of linear perspective in pictures and no appreciation or application of Brunelleschi's modular system of architecture without the kind of space structuration Ptolemy's atlas now encouraged in the Renaissance mind."⁸²

At a minimum, it then would seem, the atlas contributed to the creation of a cultural environment which was favorable to the grid's (re)emergence and one which would further its eventual dominance of the material-discursive field. But before this could happen, it is almost as if all trace, save for isolated instances, of the grid's memory

– of the hopes it had raised and the havoc it had wreaked – had to be erased from the mind of the human.⁸³ Only in this way could the second impulse of the modern move frictionlessly into our own era. With the way cleared and the graticule’s resurgence ensuring “progress” in the material domain (improved mapping of geographical areas to be colonized), it was left to linear perspective, the latter’s remediated avatar, to further progress in the discursive. This it accomplished by endowing the artist with the ability to mimic nature exactly, capturing her truth through the use of the vanishing point, as demonstrated by Brunelleschi, and projective geometry as described by Alberti in his *De Pictura*. “I use a thin veil, finely woven, dyed whatever colour pleases you and with larger threads [marking out] as many parallels as you prefer. This veil I place between the eye and the thing seen, so the visual pyramid penetrates through the thinness of the veil.”⁸⁴ The punctum, or disembodied observer, towards which the gridiron had merely gestured subliminally in classical antiquity is here, in the ratios of perspective and the



Figure 10. Artist employing Alberti’s grid method for drawing in perspective. Albrecht Dürer: Woodcut from his *Treatise on Perspective*, 1527.

immobilization of the observer, formulated exactly. In art historian Norman Bryson's terms, "Alberti's conception of the subject is already Cartesian in its reduction of the space of painting to dimensionless punctuality."⁸⁵ The ratios of the grid and the structuration of space they engender, in other words, give rise to a tripartite subject/object/punctum (as we saw earlier) for whom the experience of mind/body contradictions, for better or for worse, might be expected. On the positive side of the ledger such contradictions might be said to have facilitated the adoption of the disembodied view necessary for discoveries such as Aristarchus theory of the heliocentric universe. On what some might consider the negative side, they can be seen to destabilize confidence in the reality of material existence such that one has only one's performance of doubt to affirm one's being.

Cartesian Grid

Such, of course, was the case with René Descartes, but happily, he then leveraged his anxiety over the distortional effects of corporeal perception, in particular vision,⁸⁶ to create the foundations of modern Western philosophy.

I saw that while I could pretend that I had no body and that there was no world and no place for me to be in, I could not for all that pretend that I did not exist. I saw on the contrary that from the mere fact that I thought of doubting the truth of other things, it followed quite evidently and certainly that I existed; whereas if I had merely ceased thinking, even if everything else I had ever imagined had been true, I should have no reason to believe that I existed. From this I knew I was a substance whose whole essence or nature is simply to think, and which does not require any place, or depend on any material thing, in order to exist. Accordingly this "I" - that is, the soul by which I am what I am - is entirely distinct from the body, and indeed is easier to know than the body, and would not fail to be whatever it is, even if the body did not exist.⁸⁷

Here in his *Discourse on the Method*, Descartes outlines the radical rupture for which he is justly famous, separating mind from body, inside from outside, immanent from transcendent. Arguably no single philosophical gesture has led to a greater proliferation of material-discursive objects than has this simple attempt to ground thought in itself with the proliferation continuing apace today.⁸⁸ Though most scholars agree that he did indeed achieve the “transvaluation of all values” that, according to Kwinter, accompanies thinking “Being...without reference to anything outside itself,”⁸⁹ there is debate about what role the prior invention of perspective, and by association, the grid played in this transvaluation. In the above quote Descartes describes what sounds like the experience of the disembodied punctum we associate with the logics of linear perspective. And indeed, a number of philosophers and art historians have come to assume a causal relationship between the 15th century introduction of perspectival logics and Descartes’ construction, in the *cogito*, of the objective observer (mind imagining itself capable of thinking without the body).⁹⁰

But others find evidence for a retrograde origin of Descartes’s rational subject. Art historian Lyle Massey, for example, suggests that Descartes does not construct the relationship between this subject and the extended world perspectivally but instead, anchors his system in the performative act of doubting/thinking and in the “meta-perspectival” positionality of the rational observer. Drawing on the work of colleague, Karsten Harries, Massey notes that Descartes can ascertain the validity of his point-of-view only by acknowledging that there exist differences between individual viewpoints.

To acknowledge this is already to assume a “meta-view” or the position of what Harries terms the “angelic ‘I.’” Massey then recommends scholars replace the dimensionless punctum, of the subject/object/punctum triumvirate associated with linear perspective, with Harries’ meta-perspectival angelic ‘I.’⁹¹ Self-certainty is then only achieved through a process of “disorientation” and the subsequent anchoring of “self-knowledge to an impossibility (irrationality).”⁹² Massey views this arguably scholastic construction as capturing the essence of Descartes’s rational subject far better than theories which assign to the latter a spatial positionality little indicated in Descartes’s writings. “The spatiality of Descartes's "world view" is similarly ambiguous and in fact closer in spirit to the kind of decentered model presented by Nicolas of Cusa, in which subjectivity becomes a product of a kind of misperception, a dislocation rather than an emplacement.”⁹³

In some ways this discussion belongs more properly in the next chapter where issues of stereoscopic vision and perspective are more directly addressed but given the central importance of the *cogito* to the development and subsequent unfolding of the Cartesian grid in the modern era, we would be remiss not to examine its origins more closely. And what we find in so doing is that, just as mathematics can never be grounded in its own logics⁹⁴ but requires of its practitioners something of a “leap of faith,” so too does Descartes’s axiomatic system of rational argument have at its core an element of the irrational. Not only is this true epistemologically, with his ability to ‘think’ being the functional output of a double negative⁹⁵ (his inability to doubt that he

is doubting) but, according to art historians such as Massey and Harries, ontologically as well; only by relinquishing claim to a perspectival positionality and adopting instead that of the angelic 'I' (wherein each sees himself diffracted through the perspective of all others) can he gain access to the certainty of his own existence. That this kind of convoluted or topological dynamic should result in something as paradigmatically rational as an abstract coordinate grid on which algebraic equations can be translated into geometric forms, and vice versa, seems counter-intuitive. And yet, looking back we find each successive closure and re-entry of the grid following a similar pattern, where early would-be adoptees of a new iteration must decouple from an established subject position before transitioning into the one just forming. Some, of course, are unable to bridge the inevitable gap that separates, what retrospectively has become, the two worldviews, such as Cleanthes and Archimedes in the case of the heliocentric paradigm. And those who are first to initiate such a shift are most at risk of failing to realize fully their goal as there is as yet no stable formation for them to transition into.

Those who are successful in their attempts, however, are often aided by dreams or visions. Such was the case, as we saw, with the dreamers/painters of Lascaux, but so too was it with Descartes, himself. In what he called his "*Little Journal*," now lost but copied in part by his 17th century biographer Andre Baillet, Descartes recorded three dreams "which he imagined could have come only from on high."⁹⁶ Occurring in one night in quick succession, the sequence inspired in him first fear as he found himself being buffeted about by a malevolent phantom, and then exaltation as the contents of

the last dream convinced him that he had discovered the foundations of “a wonderful science.” Numerous scholars, including Sigmund Freud and Descartes, himself, have provided interpretations and some valuable insights into the possible meaning of these dreams but our interest in them here is limited to two fairly simple observations. First, as evidenced by the great many scholars who have tried to diminish or dismiss their importance, it is difficult to reconcile Descartes’s personal investment in these dreams with his otherwise thoroughly rationalist agenda. But for us, having already recognized irrationality to be at the core of this agenda, it is almost to be expected. And second, Descartes, himself must have recognized how his reporting on these dreams’ cathartic nature, not only in the lost notebook but also in the *Discourse*, would have been interpreted by some as undermining of the “foundation of [his] wonderful discovery.”⁹⁷ Dreams, after all, as he informs us in the *Method*, are no more reliable a source for establishing reality than are the senses. And yet, here he announces that one has revealed to him “the wish of the Spirit of Truth that the treasures of all the sciences be unlocked for him.”⁹⁸

Of all the iterations of the grid, past and future, Cartesian space perhaps best conveys the transformational potential of the grid’s formal properties; where before space was discontinuous and secondary to the Euclidian objects which defined its presence, suddenly, with Descartes, space emerges as “autonomous and preexisting... independent of solid bodies, preceding them and containing them.”⁹⁹ Sloughing off need of a material substrate, it reveals the crystalline logic of its coordinate structure

and how this puts into relation objects once thought to be purely autonomous. No extended substance can escape the unyielding logics of its orthogonality, and yet these remain obscure to it, the grid having no way to recognize the mechanism that has convected it through these last centuries. It remains blind to the diffractive, meta-perspectival, low pressure zone at its core because such doesn't exist for it within its *Umwelt*. Descartes had at least an intuition of this irrational convection zone, one which he would appear to have embraced in some ways. And though it is his creations – the cogito, coordinate space and analytical geometry – which are most associated in the minds of some with the so-called 'disenchantment of the world,' one can begin to see from the vantage point of the 21st century how the later iterations of these, especially parallel computing, are beginning to make the grid's recursive dynamic and irrational core legible to itself. Whether this simply signals the initiation of a whole new cycle of the vortex ring-driven, grid/human assemblage or whether one or both of these elements might be supplanted by others in the current post-human period is as of yet unknown but is a question that will be more fully explored in the final chapter.

And as to the question of whether or not Descartes had any suspicion that there were forces at work which eluded the logic of the grid, or that he might be introducing, buried within the mathesis of his coordinate space, a sort of hybrid rational/irrational technology, we might attempt to arrive at an answer by examining two suggestive images he left behind. The first is from his vortex theory of planetary motion as presented in 1633 in his book, *The World*. It illustrates the swirling vortices of matter

that Descartes believed explained the motion of all heavenly bodies including the circular orbits of planets around the sun.

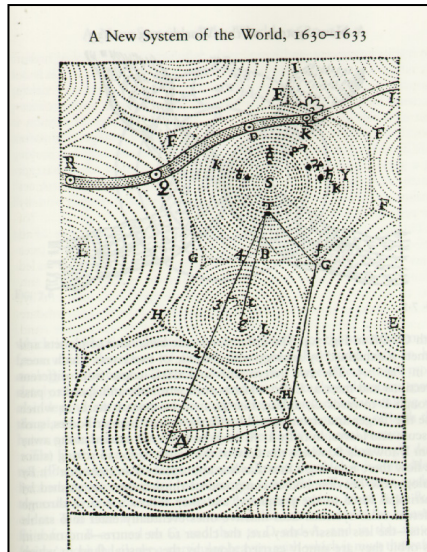


Figure 11. Descartes' vortex theory of matter.
"A New system of the World (1630-1633)."

And the second is a description of the "terrifying phantom" in the first of the three cathartic dreams that were to set him on his life's path. As paraphrased by Baillet, Descartes describes himself as experiencing a "great weakness on his right side"¹⁰⁰ forcing him to lean to the left and drag himself through the streets to escape from the ghost who had frightened him.

Because he was ashamed to walk in this way, he tried to straighten up, but he was buffeted by gusts that carried him off in a sort of whirlwind that spun him around three or four times on his left foot sideways to get to the place he wanted to go.¹⁰¹

Such images suggest that while he may have been fully committed to the rationalist project some part of his being had an intuition of the immense power of the non-linear, involutory dynamic that escaped its coordinates.

¹ Michel Foucault. 1994. *The Order of Things: An Archaeology of the Human Sciences*. Vintage Books Edition. Random House: New York. p. xx.

² *Ibid.*, p. 74. Foucault gives us the summary formula of the Classical episteme:

"an articulated system of a mathesis, a taxinomia, and a genetic analysis. The sciences always carry within themselves, however remote it may be, an exhaustive ordering of the world; they are always directed too, towards the discovery of simple elements and their progressive combination; and at their center they form a table on which knowledge is displayed in a system contemporary with itself."

³ Rosalind Krauss. 1985. *The Originality of the Avant-Garde and Other Modernist Myths*. MIT Press: Cambridge, MA.

⁴ "The marks left on the agencies of observation (the effect) are said to constitute a measurement of specific features of the object (the cause). In a scientific context, this process is known as measurement. (Indeed the notion of measurement is nothing more or less than a causal intra-action.) Whether it is thought of as measurement, or as part of the universe making itself intelligible to another part in its ongoing differentiating intelligibility and materialization, is a matter of preference. Either way, what is important about causal intra-actions is that "marks are left on bodies": bodies differentially materialize as particular patterns of the world as result of the specific cuts and reconfiguring that are enacted. Cause and effect emerge through intra-actions. Agential intra-actions are causal enactments." Karen Barad. 2007. *Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning*. Duke University Press: Durham. p. 176.

⁵ Indeed, one might even trace the roots of Boolean logic to its dichotomous, positive/negative structure.

⁶ This is where the theories of Brian Rotman and Bruno Latour coincide.

⁷ Richard Lewontin. 1985. "The Organism as the Subject and Object of Evolution." *Scientia* vol. 188. pp. 65-82.

⁸ Of course, this may be an anachronistic "framing" in that one could argue that we only come to model the picture plane as a rectangle after it has been thoroughly worked into our technologies.

⁹ Gilles Deleuze and Felix Guattari. 1987. *A Thousand Plateaus: Capitalism and Schizophrenia*. Trans. Brian Massumi. Minneapolis: Minnesota Press.

"The orchid deterritorializes by forming an image, a tracing of a wasp; but the wasp reterritorializes on that image. The wasp is nevertheless deterritorialized, becoming a piece in the orchid's reproductive apparatus. But it reterritorializes the orchid by transporting its pollen. Wasp and orchid, as heterogeneous elements, form a rhizome. It could be said that the orchid imitates the wasp, reproducing the image in a signifying fashion (mimesis, mimicry, lure, etc.). But this is true only on the level of the strata — a parallelism between two strata such that a plant organization on one imitates an animal organization on the other. At the same time, something else entirely is going on: not imitation at all but a capture of code, surplus value of code, an increase in valence, a veritable becoming, a becoming-wasp of the orchid and a becoming-orchid of the wasp." p. 10.

¹⁰ Triangles are inherently more stable than squares because their angles do not change under compression but shift load to the sides.

¹¹ While it is true that the eyes of the long-bodied decapods crustaceans (shrimp, prawns, crayfish, lobsters) are known for their grid-like structure (the inspiration for microwave telescopes), the eyes themselves are spherical such that they exhibit no true 90 degree angle. See Michael F. Land. 2000. "Eyes with mirror optics." *Journal of Optics: A Pure and Applied Optics*. Volume 2. Number 6. pp. 44-50.

¹² For an informed if contentious debate on this issue see <http://www.scienceforums.net/topic/36437-the-simplest-unit-of-spatial-thought-is-the-right-angle/>

¹³ James M. Adovasio, Bohuslav Klima and Olga Soffer. Sept. 1996. "Upper Paleolithic fibre technology: interlaced woven finds from Pavlo I, Czech Republic, c. 26,000 years ago." *Antiquity*. 70.269. p. 526.

¹⁴ Susan Buck-Morss. 1991. *The Dialectics of Seeing: Walter Benjamin and the Arcades Project*. MIT Press: Cambridge, MA. p. 8.

¹⁵ Birds weave nests and build bowers while great apes make quasi-sophisticated sleeping nests in trees requisite of a tacit understanding of physical forces and material tolerances. One can imagine that humans might have recognized efficiencies in making more durable and portable versions of such structures. Evidence of twisted fiber cordage dating back to the Paleolithic (30,000 B.C.E.) suggests its use in construction of nets for hunting small prey and in the weaving of mats and baskets. Interleaving rather than mounding-up found plant materials is likely to have begun even earlier than this and is accomplished more readily with the improved hapticity commensurate with an upright posture.

¹⁶ Van J. Wedeen, Douglas L. Rosene, Ruopeng Wang, Guangping Dai, Farzad Mortazavi, Patric Hagmann, Jon H. Kaas, Wen-Yih I. Tseng. 2012. "The Geometric Structure of the Brain Fiber Pathways." *Science*. Vol. 335. (6076). pp. 1628-1634.

¹⁷ James L. Kent. 2010. *Psychedelic Information Theory: Shamanism in the Age of Reason*. PIT Press: Seattle. Ch 09.

¹⁸ J. D. Lewis-Williams, T. A. Dowson, Paul G. Bahn, H.-G. Bandi, Robert G. Bednarik, John Clegg, Mario Consens, Whitney Davis, Brigitte Delluc, Gilles Delluc, Paul Faulstich, John Halverson, Robert Layton, Colin Martindale, Vil Mirimanov, Christy G. Turner II, Joan M. Vastokas, Michael Winkelman and Alison Wylie. April 1988. "The Signs of All Times: Entoptic Phenomena in Upper Palaeolithic Art." *Current Anthropology*, Vol. 29, No. 2. pp. 201-245.

See also: James L. Kent. Ibid. And Surfdaddy Orca. April 13, 2010. "Art, Neurobiology, and Mescaline: The Neuroaesthetics of Semir Zeki." H+ magazine. Online, accessed May 14, 2012.

¹⁹ As I write, new dating techniques have assessed the cave paintings at El Castillo in Spain, including rectilinear imagery, to be far older than those at Lascaux. "The biggest surprise was the age of several large red disks, also made by blowing pigment, at El Castillo: at least 40,800 years ago. Dozens of such disks and 40 hand stencils are in the same panel, along with rectangles and ovals, suggesting that 40,800 is the minimum age of the entire composition." <http://www.reuters.com/article/2012/06/14/us-usa-neanderthal-idUSBRE85D1B120120614> - Accessed 6/23/12.

²⁰ Torkel Hafting, Marianne Fyhn, Sturla Molden, May-Britt Moser & Edvard I. Moser. Aug., 2005. "Microstructure of a spatial map in the entorhinal cortex." *Nature*. Vol. 436|11. pp. 801-806.

²¹ The quote from Richard Lewontin at the beginning of this section captures my unease with suggesting that a boundary enclosing the human has been successfully established. I don't want to presume that which we are, in some sense, trying to ascertain.

²² Keith Ansell Pearson. 1999. *Germinal Life: The difference and repetition of Deleuze*. Routledge: London. p. 27 (see Deleuze 1956:98).

²³ Delanda associates this consistency with the attractors of dynamical systems theory rather than anything as static as the grid, and rightly so. However, examining the dynamic of the grid over millennia we find that it demonstrates a periodic orbit in what is, in effect, a state space, which in cross-section, very much resembles a Poincaré section (see illustration on p. 14 of "closure and re-entry. The dotted line in this diagram is actually a Poincaré section)."

²⁴ Topologist Louis Kaufman discusses George Spencer Brown's logical system of distinction and indication. The first entry in Spencer-Brown's mathematical treatise:

"We take as given the idea of a distinction and the idea of an indication, and that it is not possible to make an indication without drawing a distinction. We take therefore the form of distinction for the form." Louis H. Kaufman. "Laws of Form - An Exploration in Mathematics and Foundations."

²⁵ "Closure thus defines a unity that is produced by the contained network of interactions producing themselves 'as a unity in the space in which the components exist by constituting and specifying the unity's boundaries as a cleavage from the background.'" André Reichel. 2011. "Snakes all the Way Down: Varela's Calculus for Self-Reference and the Praxis of Paradise Systems." *Research and Behavioral Science*,

Volume 28, issue 6. pp. 646-662. p. 648. Citing Francisco Varela. 1981. "Autonomy and autopoiesis." In: *Self-Organizing Systems. An Interdisciplinary Approach*. Eds. G. Roth and H. Schwegler. Campus Verlag: Frankfurt/ New York. pp. 14–23. p. 15.

²⁶ Olga Soffer, James Adovasio and David Hyland. Aug., 2000. The "Venus" Figurines. *Current Anthropology*. 41(4). pp. 511-537. See also: Natalie Angier. December 14, 1999. "Furs for Evening, but Cloth Was the Stone Age Standby." *New York Times*.

²⁷ <http://lyle.smu.edu/~pkruieger/vrentrainment.htm>

²⁸ Ascher H. Shapiro. "National Committee for Fluid Mechanics Films: Film Notes for Vorticity." MIT Press: Cambridge, MA. p. 8. <http://web.mit.edu/hml/ncfmf/09VOR.pdf>

²⁹ It is like a tornado in that it is a spiral with a low pressure, convecting core. It is unlike a tornado in that it does not have the characteristic funnel shape and it is horizontal. In this sense, it is more like a supercell: "Many tornadoes result from the tilting of rotation around a horizontal axis. This horizontal vorticity is due to vertical shear of the wind in the storm's environment. Most supercell storms form in a sheared environment, with poleward winds near the ground and strong westerly winds aloft. The horizontal vortex tubes then are tilted as the air turns to rise in the storm's updraft, creating a component of spin about a vertical axis... The wind shear responsible for the horizontal vorticity may be storm-induced, rather than environmental." B. Geerts and E. Linacre. June, 1998. "Tornado formation." http://www-das.uwyo.edu/~geerts/cwx/notes/chap07/tornado_form.html

³⁰ Lord Kelvin noted this when he proposed the vortex ring as the model for the then posited existence of the atom. For more on Kelvin's vortex theory of the atom see: Lord Kelvin (Sir William Thomson). "On Vortex Atoms." *Proceedings of the Royal Society of Edinburgh*, Vol. VI, 1867, pp. 94-105. Reprinted in *Phil. Mag.* Vol. XXXIV, 1867, pp. 15-24.

³¹ For a thorough analysis of the various axes of rotation and translation in the vortex ring see: T. Maxworthy. July 1977. "Some experimental studies of vortex rings." *Journal of Fluid Mechanics*. Volume 81. Issue 03. pp. 465 – 495.

³² Rodney Cole. 1991. *Introduction to Classical Fluids or Divergence, Curl, and Other Things that go Bump in the Night*. University of California at Davis. http://maxwell.ucdavis.edu/~cole/phy9b/notes/fluids_ch3.pdf p. 61. See also: J. M. V. Rayner. 1980. "Vorticity and Animal Flight." in *Society for Experimental Biology, Seminar Series: Volume 5, Aspects of Animal Movement*. H. Y. Elder, E. R. Trueman eds. Cambridge University Press: New York. pp. 177-199.

³³ James M. Adovasio . Ibid.

³⁴ There are exceptions of course, such as Stonehenge.

³⁵ Michael E. Smith. Feb., 2007. "Form and Meaning in the Earliest Cities: A New Approach to Ancient Urban Planning." *Journal of Planning History*. Vol. 6, No. 1. pp. 3-47.

³⁶ J. H. Bodley. 2003. *The Power of Scale: A Global History Approach*. Armonk, N.Y.: M.E. Sharpe.

³⁷ James M. Adovasio. Ibid. – See also: Olga Soffer. June 2004. "Recovering Perishable Technologies through Use Wear on Tools: Preliminary Evidence for Upper Paleolithic Weaving and Net Making." *Current Anthropology*. Volume 45, Number 3.

³⁸ Lev Manovich. 2001. *The Language of New Media*. MIT Press: Cambridge, MA. p. 6. Here Manovich uses the term "meta-medium" to refer to the digital computer.

³⁹ Brian Rotman. 2008. *Bringing Becoming Into Being: The Alphabet, Ghosts and Distributed Human Being*. Duke University Press: Durham. p. 6.

⁴⁰ As Kittler notes, "[t]he same cities that translated the anthropological schema of head, hand and torso in to the architectonic schema of palaces, streets and storehouses needed scripts for the processing, transmission and storage of their data. Friedrich Kittler. 1996. "The History of Communication Media." Eds. Arthur and Marilouise Kroker. Special Issues: ga114. Date Published: 7/30/1996. www.ctheory.net/articles.aspx?id=45

⁴¹ The long held notion that Babylon was a gridded city has been contested recently. Heather D Baker. 2007. "Urban form in the first millennium BC." Ed. G. Leick. Routledge: London. pp. 66-77.

⁴² Michael E. Smith. *Ibid.*

⁴³ "All nature is a continuum. The endless complexity of life is organized into patterns which repeat themselves—theme and variations—at each level of system. These similarities and differences are proper concerns for science. From the ceaseless streaming of protoplasm to the many-vectored activities of supranational systems, there are continuous flows through living systems as they maintain their highly organized steady states." James Grier Miller. 1978. *Living Systems*. McGraw Hill: New York. p. 5.

⁴⁴ Of course, another way to look at these developments is from the perspective of the newly emergent entity itself, that of the agrarian city. Just as the self-conscious, agentive human emerged from the orthogonal layering of white matter cells in the brain, so too, it would appear, does the city begin to emerge as an active participant in its own morphogenesis as the orthogonal grid begins to articulate and coordinate its parts (streets, lots, buildings, boundary) and processes (citizens/subjects). "We...see the idea of the city as an abstract, sometimes sacred, character assuming a personality and role in the administration of power and in the fate of rulers..." Simon Parker. 2008. *Cities, Politics, and Power*. Taylor and Francis: London. p. 26.

⁴⁵ Robert Artigiani. 1991. "Model of Societal Self-Organization." In *Time, Rhythms and Chaos in the New Dialogue with Nature*. Ed. George P. Scott. The Iowa State University State Press: Ames IO. p. 114.

⁴⁶ Brian Rotman. *Ibid.*, pp. 6-7.

⁴⁷ <http://mpec.sc.mahidol.ac.th/radok/phymath/physics/f3.htm#F3> accessed June 2, 2012

⁴⁸ With recent discoveries of their early and sophisticated nature, the importance attributed to woven fabrics in the development of the self-reflexive human has begun to grow. For more information see James M. Adovasio. *Ibid.* Also: <http://old.postgazette.com/healthscience/19990621venus2.asp>

⁴⁹ It is like a magician's trick, one which riveted the attention of Lord Kelvin causing the one significant error of his otherwise illustrious career, his theory of the vortex atom.

⁵⁰ Object oriented ontologists such as Graham Harman privilege this operationally closed, toroidal sense of the object or entity. Fractal ontologists, by contrast, recognize that the object/entity is at once closed, in the toroidal plane, yet open in the poloidal, as in a vortex ring.

⁵¹ In the terms topologist Louis H. Kauffman articulates:

At least one distinction is involved in the presence of self-reference. The self appears, and an indication of that self that can be seen as separate from the self. Any distinction involves the self-reference of "the one who distinguishes." Therefore, self-reference and the idea of distinction are inseparable (hence conceptually identical). We explore self-reference by examining what appear to us as distinctions. Through experiencing self-reference, we come to understand the possibility of distinguishing." L. H. Kaufmann. 1987. "Self-reference and recursive forms." *Journal of Social and Biological Structures* 10(1). pp. 53–72. p. 53.

⁵² A. Weber and Francisco Varela. 2002. "Life after Kant: natural purposes and autopoietic foundations of biological individuality." *Phenomenology and the Cognitive Sciences*. 1(2). pp. 97–125. p. 120.

⁵³ Sara Ahmed argues that humans exist not so much as "selves" but as "nodal points" within an "affective economy." This means that they exhibit a perpetual openness to the outside, one effected by emotions which "stick" to nodes differentially largely as a result of historical precedent:

Emotions do not positively reside in the subject – a lack of positive residence which suggests that 'we don't always know how we feel.' This does not mean that emotions do not involve subjects; emotions are felt and lived through the corporeal experiences of being-in-the-world. But the 'involvement' of emotions is precisely about how they open subjects to others and worlds, in ways that make any distinction between 'inside' and 'outside' impossible.

Sara Ahmed. May – June 2003. "The politics of fear in the making of worlds." *Qualitative Studies in Education*. Vol. 16, no. 3. pp. 377–398. p. 386.

⁵⁴ Luhmann cites this as the operational closure of Maturana and Varela:

...closure does not mean empirical isolation. Closure is a highly selective, improbable, artificial achievement – not in the sense of intentional design, but as an outcome of evolution. The

emergence of closed systems requires a specific form of relations between systems and environments; it presupposes such forms and is a condition of their possibility as well. The theory of "open systems" describes these forms with the categories of input and output. This model postulates a causal chain in which the system itself serves as the connecting part linking inputs and outputs. The theory of autopoietic systems replaces the input/output mode with the concept of structural coupling. It renounces the idea of an overarching causality (admitting it, of course, as a construct of an observer interested in causal attributions), but retains the idea of highly selective connections between systems and environments.

Niklas Luhmann. 1992. "Operational Closure and Structural Coupling: The Differentiation of the Legal System." *Cardozo Law Review*. Vol. 13. pp. 1419 – 1441. pp. 1431– 1432.

⁵⁵ "If the unmarked state is now inserted, the result is the marked state and so on. For every odd number of crosses or marks, there appears to be some-thing from no-thing (Robertson, 1999: 255); in fact, both are identical in the form of re-entry. George Spencer Brown's most out-standing contribution (Varela, 1979a: 138) was the realization that this behavior was in fact equivalent to that of imaginary numbers, that is, numbers that have an imaginary part *i of the form $i^2 = -1$* . Although in normal mathematics, these numbers were interpreted as being 'orthogonal' to the real numbers, Spencer Brown interpreted his re-entering expressions as oscillations *in time*. Whereas the calculus produces space by the injunction to draw a distinction, by re-entering the calculus into itself, it produces time. Although Spencer Brown finished his work there, Varela decided to start his journey right here. (Varela, 1979a: 138)

We have to pay attention to the fact that the double nature of self-reference, its blending of operand and operator, cannot be conceived of outside of time as a process in which two state alternate... Both aspects are evident in the idea of autopoiesis: the invariance of a unity and the indefinite recursion underlying the invariance. Therefore we find a peculiar equivalence of self-reference and time, insofar as self-reference cannot be conceived outside time, and time comes in whenever self-reference is allowed. Varela (1979a: 125)

This is exactly the conceptual foundation Varela needed for the question posed by Schrödinger. Life itself is autonomous; it arises out of itself and cannot be reduced to anything outside or inside its own creative, repetitive loop, where end products are fed back into the system as new points of departure (Marks-Tarlow *et al.*, 2002)."

André Reichel. *Ibid.* p. 8.

⁵⁶ Rotman's quote on writing concludes with: "This floating entity makes ideas of disembodied agency, action at a distance, and thought transference plausible. As a result all communicational media have about them an aura of the uncanny and the supernatural, a ghost effect which clings to them."

Brian Rotman. *Ibid.* p. 7.

⁵⁷ Walter Benjamin. 1968. *Illuminations: Essays and Reflections*. Ed. Hannah Arendt. Schocken Books: New York. pp. 257-258.

⁵⁸ T. T. Lim and T. B. Nickels. *Fluid Vortices*. 1995. Ed. Sheldon I. Green. Kluwer Academic Publishers: Dordrecht, Netherlands. Chapter IV. p. 96.

⁵⁹ "No meaningful, consistent concept of Athenian "citizenship" existed before the time of Solon."

"A general theme in all of Solon's reforms was the creation of boundaries -- spatial, legal and even psychological." Solon established individual rights of property and, in allowing individuals to choose their own heirs, had, so Plutarch tells us raised "philia" over "suggeneia"... . Solon more sharply distinguished the privileges of the insider and the disabilities of the outsider, thus enhanced the growing "Athenian consciousness." Philip Brook Manville. 1990. *The Origins of Citizenship in Ancient Athens*. Princeton University Press: Princeton. pp. xiv + 265.

⁶⁰ Alfred Burns. 1976. "Hippodamus and the Planned City." *Historia: Zeitschrift für Alte Geschichte*, Bd. 25, H. 4 (4th Qtr.) pp. 414-428. Franz Steiner Verlag: Stuttgart.

⁶¹ Matthew Fitzjohn. 2007. "Equality in the colonies: concepts of equality in Sicily during the eighth to six centuries BC." *World Archaeology* Vol. 39(2): 215–228.

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- ⁶² Alfred Burns. Ibid. quoting Aristotle. 1943. *Politics*. Trans. B. Jowett. Modern Library: New York.
- ⁶³ Ibid., p. 416. Quoting Aristotle. pp. 1267b22-1268a4.
- ⁶⁴ Carl Benjamin Boyer and Uta C. Merz. 1991. *A History of Mathematics*. John Wiley & Sons, Inc.: Hoboken. Thales' five theorems: 1/ A circle is bisected by any diameter. 2/ The base angles of an isosceles triangle are equal. 3/ The angles between two intersecting straight lines are equal. 4/ Two triangles are congruent if they have two angles and one side equal. 5/ An angle in a semi-circle is a right angle.
- ⁶⁵ John F. Brock. 2004. History of Surveying and Measurement. WSHS2 – History of Surveying and Measurement. "Pyramids to Pythagoras: Surveying from Egypt to Greece – 3000 B.C. to 100 A.D." FIG Working Week. Athens, Greece, May 22-27.
- ⁶⁶ Sanford Kwinter. 2001. *Architectures of Time: Towards a Theory of the Event in Modernist Culture*. MIT Press: Cambridge, MA. p. 35.
- ⁶⁷ Alan M. Greaves. 2002. *Miletos: A History*. Routledge: London. p. 45.
- ⁶⁸ Sanford Kwinter. Ibid., p. 35.
- ⁶⁹ "Plato and Aristotle who, concerned with civic strife caused by economic, social and political inequalities, suggested that urban planning could provide a correspondence between physical organization and social structure, possibly acting as a mechanism for achieving equality, unity and order." Matthew Fitzjohn. Ibid. p. 217.
- ⁷⁰ This is not to say that the logic of the grid has not also lent itself to the furtherance of totalitarian regimes (see endnote 52) but only that, as with rationality in general, it has the potential to act as a counterweight to transcendence-based regimes of power.
- ⁷¹ Lewis Mumford. 2012 (1922). *The Story of Utopias*. Kessinger Publishing: Whitefish, MT. p. 26.
- ⁷² "From the first century BC to the fourth century AD, the Romans built and expanded cities according to a rigid codex. Based on the model of the military camp and reflecting its discipline, the Roman colonial town shows a square or rectangular grid derived from two central axes often orientated to the cardinal directions...Subjugated peoples in the colonies were often moved into the towns, both for control and for assimilation. Walls surrounded the towns where defense was required. While wealth and resources were funneled to Rome and regional capitals, the colonial towns helped to disseminate Roman culture and integrate distant lands into the empire. The grid plan, rigorously executed from Africa to Britain, made the global authority of Rome physically manifest." Jill Grant. 2001. "The Dark Side of the Grid: Power and Urban Design." *Planning Perspectives*, 16. pp. 219–241. p. 231.
- ⁷³ Based on the map made by Dicæarchus of Messana more than a hundred years earlier, and which included an axis running from east to west through the Straits of Gibraltar, Sicily and the Taurus mountains, and another running from north to south through Rhodes.
- ⁷⁴ Brock. Ibid. Around 450 B.C. the first historian, Herodotus (c. 484-430/420 B.C.) of Halicarnassus (now Bodram, Turkey) gave us the first memorable record of what the early Greeks had obtained from Egypt: "Sesostris...made a division of the soil of Egypt among the inhabitants...If the river carried away any portion of a man's lot... the King sent persons to examine and determine by measurement the exact extent of the loss...From this practice I think geometry first came to be known in Egypt, whence it passed into Greece."
- ⁷⁵ Bernard Stiegler. 1998. *Technics and Time, 1: The Fault of Epimetheus*. Stanford University Press: Stanford. pp. 152 – 154.
- ⁷⁶ N. Bryson. 1983. *Vision and Painting: The Logic of the Gaze*. Macmillan: London. p. 107. as quoted in Brian Rotman. 1987. *Signifying Nothing: The Semiotics of Zero*. St. Martin's Press: New York. p. 32.
- ⁷⁷ Rotman. Ibid., p. 19.
- ⁷⁸ Ibid., pp. 32-46.
- ⁷⁹ Anaximander of Miletus was the first to start this tradition proposing a cosmology which had as its center a cylindrical earth supported by nothing other than itself, a model which the Pythagoreans would later adopt (modifying the earth's form to that of a sphere) and Aristotle later prove.
- ⁸⁰ His work in this area was heavily influenced by Marinus of Tyre, by his own admission.

⁸¹ Together Alberti and Brunelleschi traveled to Rome to tour the old ruins which would serve as inspiration for the latter's first commissioned structure, Ospedale degli Innocenti (1419–ca.1445,) and the former's comprehensive text on the architecture and planning of the ancient Romans, his *De re aedificatoria* (On the art of building in ten books).

⁸² Samuel Y. Edgerton Jr. Dec. 1974. "Florentine Interest in Ptolemaic Cartography as Background for Renaissance Painting, Architecture and the Discovery of America." *Journal of the Society of Architectural Historians*. Vol. 33. No. 4. pp. 275-292. p. 287

⁸³ In this sense the modernist impulse of the grid is laid bare, as described by Ruskin. "Modernity exists in the form of a desire to wipe out whatever came earlier, in the hope of reaching a point that could be called a true present, a point of origin that marks a new departure. This combined interplay of deliberate forgetting with an action that is also a new origin reaches the full power of the idea of modernity...The human figures that epitomize modernity are defined by experiences such as childhood or convalescence, a freshness of perception that results from a slate wiped clear, from the absence of a past that has not yet had time to tarnish the immediacy of perception (although what is thus freshly discovered prefigures the end of this very freshness)." John Ruskin. 2012 (1904). *The Works of John Ruskin*, vol. 15. General Books: Memphis, TN. p. 27.

⁸⁴ Leon Battista Alberti. 1956. *On Painting*. Trans. and ed. by John E. Spencer. Yale University Press: New Haven. p. 68.

⁸⁵ Norman Bryson. 1983. *Vision and Painting: The Logic of the Gaze*. New Haven and London. p. 103. As quoted in Lyle Massey. 2007. *Picturing Space, Displacing Bodies: Anamorphosis in Early Modern Theories of Perspective*. Penn State Press: University Park, PA. pp. 23-24.

⁸⁶ "...the sense of sight gives no less assurance of the reality of its objects than do the senses of smell and hearing, while neither our imagination nor our senses could ever assure us of anything without the intervention of our intellect." René Descartes. *Discourse*. 1985. *The Philosophical Writings of Descartes*. Trans. and ed. John Cottingham, Robert Stoothoff, and Donald Murdoch. 2 vols. Cambridge and New York. "I had many experiences which gradually undermined all the faith I had in the senses. Sometimes towers which had looked round from a distance appeared square from close up; and enormous statues standing on their pediments did not seem large when observed from the ground."(37) *Second Meditation*. 2:53.

⁸⁷ *Ibid.*, Descartes. 1985. 1:127.

⁸⁸ "the modern Constitution allows the expanded proliferation of the hybrids whose existence, whose very possibility, it denies." Bruno Latour. 1993. *We Have Never Been Modern*. Harvard University Press: Cambridge, MA. p. 34.

⁸⁹ Though, of course, in this he did not succeed entirely as he was forced to ground his intuition of perfection in a transcendent third substance, God.

⁹⁰ See Erwin Panofsky, *Perspective as Symbolic Form*. Trans. Christopher Wood. New York, 1991 [1927]. See also: Norman Bryson. 1983. *Ibid.*; and Samuel Y. Edgerton. 1976. *The Renaissance Rediscovery of Linear Perspective*. New York; and: James Elkins. 1996. *The Poetics of Perspective*. Cornell University Press: Ithaca and London.

⁹¹ He makes this move more intelligible by comparing it with the effect Nicholas of Cusa hoped to achieve with his gift of a painted icon to the brethren of a monastery.

The portrait de Cusa gave the monks was of an omnivoyant God painted in such a way that the eyes followed the observer wherever he went. In an accompanying note, de Cusa encouraged the monks to notice how the eyes followed "in like manner with one going in a contrary direction to himself." Lyle Massey. 1994. "Anamorphosis through Descartes or Perspective Gone Awry." *Renaissance Quarterly*, Vol. 50, No. 4, Winter. pp. 1148-1189. p. 1161.

Owing to the revelation made by the witness (*revelatio relatoris*), he succeeds in realizing that the face abandons none of the walkers, even when their movements are contrary If he observes that the gaze leaves none of the persons present, he will see that this gaze is concerned with each one with as much care as if it were the only one to have the experience of being

followed, to the extent that the one who is being looked at cannot conceive that another might be the object of the same attention. He will see that this gaze watches with extreme care over the smallest creature (minima) as over the largest (maxima) and over the totality of the universe. [Ibid., p. 28.]

Rotman, commenting on this same passage in his book, *Signifying Nothing*, uses it as an example of the dominant “code of pre-perspectival visual images...whereby like is signified by like [and] where material of an iconic sign, its signifier, is supposed to image or resemble what it signifies....” [Rotman. Ibid., 1987. p. 22.] De Cusa’s attempt to inspire the monks to experience for themselves God’s meta-perspectival, non-spatial locatedness through the use of a ‘natural’ icon (for us a banal painter’s trick), then illustrates for Rotman the “pre-perspectival” semiotic system which will be supplanted during the Renaissance by one dominated by a human-conceived and “imposed system of perspective.” [Ibid.]

Michel de Certeau offers yet another view of this passage, however, one more in line with Massey’s which focuses less on situating de Cusa’s icon and advisements within an analysis of the progressive unfolding of an imagistic semiotic than on grasping what significance his concept of a non-spatial, meta-perspectival viewer might have in its own right. For to actually enact what de Cusa exhorts the monks to do, that is, an occupation of the omnivoyant perspective of the icon, is to experience a radical loss of self that can only be reestablished through seeing through the eyes of all others. It requires that one “believe of the multitude what he does not see, in order to get out of his own uncertainty and to comprehend that the coincidence of all and each in ‘one’ (a gaze or faith) is ‘possible’.” [Michel de Certeau. Fall, 1987. “The Gaze of Nicholas of Cusa.” *Diacritics* 17. pp. 2 – 38. p. 34. As quoted in Lyle Massey. 1994. Ibid. p. 1161. (This is in many ways the same move that Niklas Luhmann makes with respect to the subject who requires the perspective of others in order to ascertain closure).

⁹² Lyle Massey. Ibid., p. 1162.

⁹³ Ibid.

⁹⁴ I am referring here to Kurt Godel’s ‘incompleteness theorems’ which are explained in more depth in the third chapter, ‘Artifacts of Vision.’

⁹⁵ The ‘double negative’ is also the source of the ‘irrationality’ that characterizes the Mandelbrot set in that it is the square root of -1 (also known as the imaginary number ‘i’) in its algorithm which prevents the set from achieving closure.

⁹⁶ Michael Allen Gillespie. 2008. *The Theological Origins of Modernity*. University of Chicago Press: Chicago. p. 178. Leibniz also copied parts of the “Little Notebook” but failed to make any mention of Descartes’s dreams as recorded in the section entitled “Olympica” (probably a reference to Olympus and “the Hermetic spirits that point us in the direction of the truth”).

⁹⁷ Alan Gabbey and Robert E. Hall. 1998. “The Melon and the Dictionary: Reflections on Descartes’s Dreams.” *Journal of the History of Ideas*, Vol. 59, No. 4. Oct., pp. 651-668. p. 653.

⁹⁸ Ibid., p. 654.

⁹⁹ Ibid., Kwinter. p. 58.

¹⁰⁰ John R. Cole. 1992. *The Olympian Dreams and Youthful Rebellion of René Descartes*. University of Illinois Press: Urbana and Chicago. pp. 32-40.

¹⁰¹ Ibid., p. 35.