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Cityspace, Cyberspace, and the Spatiology of Information

By Dr. Michael L. Benedikt, ACSA Distinguished Professor, Director, Center for American Architecture and Design,University of Texas at Austin

Abstract

Published in 1996 but not widely read, this article argues that space and information are so deeply related that the universe at every moment is exactly and only as large as it needs to be to "contain" the information it in fact is. Using three thought experiments—one about data visualization, one about cellular automata and consciousness, and one about the analysis of architectural space using isovists, each experiment blurring (or rather, uniting) the phenomena of psychological and physical space, the article argues that what we experience as "space" is that set of dimensions which provides the largest capacity for the world's other qualities, objects, and events to express their variety most fully. The natural universe is incompressible, expanding only as, and because, it becomes richer in information (i.e. cools and evolves). Imaginary and virtual worlds obey the same rule: they are "naturally" as big as they are rich in information. But the possibility exists in cyberspace—as it does not in nature—to choose which dimensions will serve as the spatial framework, and which will become/appear as properties of the things themselves. Data visualizers know this well. One wonders why virtual worlds to this day look so similar to ours, then, rather than to the one envisaged by William Gibson in 1984 and 1986 and which he called "cyberspace." A failure of architectural nerve? A constraint upon computation? Or has cyberspace proper yet to evolve?*

Keywords: cityspace, cyberspace, virtual worlds, architecture, information.

* With minor modification as "The Information in Space is the Space in Information," in Anders Michelson and Frederik Stjernfeld, Eds., *Billeder fra det Fjerne/Images from Afar*, (Oslo, Norway: Akademisk Volrag, 1996), 161--172.

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The concept of space has been critical to architectural theory for over seventy years now.[i] It remains, however, an elusive idea, on the one hand meaning and referring to everything, on the other hand meaning and referring to nothing.

Why? Is it because "space," like "time," is a category outside of which thinking itself seems to be impossible, just as Kant asserted? Is it simply one of those irreducible, universal *givens* without which the world as such would cease to *be* in any sense, let alone be *thought* of, or perceived by, sentient beings?

Certainly to suggest that space itself is an active, causative agent of some sort risks opening up that discussion to universalizing of the most extreme and vacuous kind. For if I am not to be a dualist, positing a separate, a-spatial and a-temporal realm for thought and feeling, then what in the real world, I can easily ask, occupies neither space nor time? What is it that cannot be reduced, be analyzed, or be spoken of finally in the language of position, duration, connection, inclusion, transformation, and so forth? Nothing.

If we wish to reach deeply into the "nature" of "space itself" then, I believe we must allow into it, as it were, a *substance* of some sort: not the æther of nineteenth-century science perhaps, but a registering, tracing, questioning, remembering substance, spread as thinly as we can imagine, but present nonetheless, and definitive of *here* versus *there* because of how it pools, how it vibrates, how it scatters difference, *différance*.

And what is this "substance?" Information.

And what does information require? It requires *us*. And it requires architecture.

With this proposition we are plunged very quickly into deep abstraction. I see no other way, however, to make progress with the question that ultimately confronts us—namely, of how space-*dissolving* technologies such as telecommunications on the one hand, and space-*making* technologies such as computer-graphical poeisis in cyberspace on the other, restructure and re-prioritize the ordinary space of the city—than to address the abstract foundations of the concept of space directly. For most occurrences of the word "space" in architectural and urban theory are either redundant or metaphorical, hardly more than figures of speech. These occurrences, finally and at best, allow us to refer to the symmetries, repetitions, enclosings, similarities and differences between entities that we experience as *existing* co-temporally. Moreover, we find that there is no space *per se*—architectural space or urban space—that is not really "space *for*..." or "space *of*...," "space *in*...." or "space *around*..." something tangible and/or perceptible. Indeed, without the concept of space we cannot have, think, or see plurality and identity, size and simultaneity, counting and grouping, position and disposition. And this observation is critical. For with "space" (and time) there is the room, so to speak, for the items of experience to array themselves maximally, without loss of uniqueness or variety...in short, without loss of *information*. In this sense, "space" and "information" are, if not identical, then reciprocal in

relation. All space is *space for*…the information of things to disport itself. Space both *is,* and is composed of, information.[ii] More of this argument soon.

One of the intentions of this paper is to inhabit the border zone, as it were, between the informal though useful employments of the concept of space in architecture and urbanism, and a stricter, information-theoretic rendition. It is from this ideational interzone, from this glimpse of a new discipline—a new study to which we ought to give the name *spatiology*—that I will try to address the radical continuity in one sense and discontinuity in another sense of *cityspace*, defined as the physical space of our streets and buildings and natural landscapes, and "*cyberspace*," defined as the electronic space of data and representations generated, organized, and presented consistently to all viewers connected to a set of globally-networked computers. The continuity of these two kinds of space, I will argue, is that they are both ultimately constituted by *information*, information spread through space and seeking, almost of itself, to maximize its own complexity and organization. The most basic discontinuity between cityspace and cyberspace exists because cityspace is bound up with the principle of least action, with energetics, with friction, gravity, occlusion, and mechanical contact. Cyberspace and what happens there is all but free of these constraints. Of particular interest to me, however, is this fact: because each space can—indeed must—be experienced at some level spatiotemporally, *cyberspace, like cityspace, can be inhabited, explored, and designed.* Indeed, I am going to argue that community, economy, art, design, commerce, recreation, and other urban amenities are possible in both worlds, in the real and the virtual, in cityspace *and* in cyberspace.

The reader may already be wondering why, with cyberspace, we need to go to such extremes—to the very edges of science fiction—to look for "urban amenity." Why not keep our attention focused on what architects and urbanists haven taken upon themselves to do historically, namely, to design and to manage the built environment, making real places for real people? God knows, our cities need all the attention they can get on this score, and the communication, entertainment, and computer industries seem to be taking care of themselves handsomely.

I offer two reasons.

First, because, the very phrase *New Urbanism* invites consideration of a braver future, one in which questions of space, information, meaning, work, value, and the "good life" have been re-thought from the ground up and quite agnostically with respect to whether these occur in cityspace or cyberspace or both. After all, it is not beautiful cities *per se* that people want, or nice houses and cars, but meaningful, interesting, sustainable, long, and pleasurable *lives*. Together. Who can prejudge the forms such lives might take in the future, or the venues in which "life, liberty, and the pursuit of happiness" might continue?

The second reason we ought to be open to cyberspace as urbanists is because cyberspace already exists, if in precursory form. We are in cyberspace every time we are "on the phone," every time we use a cash machine or log into a networked computer. We are there every time we drift through a magazine, go to a movie, listen to the radio, or watch television. Indeed, virtual worlds in the form of communities of interest and of the imaginal lives of institutions like corporations and religions have long captivated our attention as fully as has the real and "unmediated" world. *Not* to live simply and attuned, animal-like, to every forest sound and passing scent, but, rather, to be caught up in human intention, invention, and conversation is in

large part what it means to be civilized. To be civilized necessitates the having of memories and plans and dreams, unphysical things all three.

Today, and for better or for worse, Walkman-fitted heads float deep into this human-made æther. Just as they once did from the unconscious of medieval man, urgings and provocations, stories of dread and desire, fragments of music, news ideas, data, gossip, *pour* out of the dark of the electromagnetic spectrum—from screens and speakers, from every urban surface—and into streets and parks, homes and workplaces…penetrating our consciousness as perhaps never before. With recorded images duplicated and transmitted everywhere at the speed of light it is simply a fact that we hardly need head-mounted displays and gloves, the technology of "virtual reality," to experience the irrelevance of spatiotemporal distance, to understand what it means to dwell in a global sea of pure information and to come to believe implicitly, indeed pragmatically, that "I plug (or tune or log) in, therefore I am." Nature and old buildings stand silently by.

And if cyberspace is already with us in this contemporary form, then what might we say of the coming reality of cyberspace in its yet fuller, Gibsonian expression? What might we say, that is, of a time when super-fast computers, singly and together, generate and sustain totally absorbing virtual worlds, populated and teeming with avatars and scoundrels and gigantic, dizzying databases tilting like drunken electric pyramids…when, in the silicon banks of machines whirring in stuffy rooms there breathe whole alternative cities, the sites of a delirious new urbanism entire?

I would refer the reader to my book (Ed., 1991)[iii] for some descriptions, studies, and prognostications of cyberspace and its burgeoning reality.[iv] But I would also refer the reader to his or her daily newspaper, generally in the "Science" and "Business" pages, where the infrastructure of cyberspace can be watched being put into place satellite by satellite, optical cable by optical cable, computer chip by computer chip, interface innovation by interface innovation, software company by software company, and alliance by alliance of global telecommunications, entertainment, and computer corporations. Cyberspace is on its way as surely as a freight train heard two valleys away.

Having outlined the major themes and claims, I am now, finally, going to begin this article. After a brief review of the history of concepts of space, I launch into three thought experiments, each seeking to clarify the relationship of space to information at a fundamental level. Without this understanding we would be hard pressed to negotiate the complex cleavages and continuities between the information in cyberspace and the information in cityspace with any objectivity or confidence. I will then return to the question of telecommunications' impact on the form and condition of the city, first as propounded by Manuel Castells' notion of *the space of flows*, and then in terms of what cyberspace offers as the structural complement, and perhaps alternative to the space of flows, namely, the space *in* flows. I end with some specific advocations.

"Space" in Historical Perspective

Positive space, negative space, Baroque space, Modern space, urban space, domestic space, architectural space, pictorial space, abstract space, inner space and outer space, secular and sacred space, phase space, parameter space, color space, psychological space, auditory, tactile,

personal, and social space…what are the adjectives qualifying exactly? No one knows. Thinking about the problem has vexed philosophers since Plato. A quick review is instructive.

For Plato, space was the totality of geometric relations possible, i.e. the totality of numerical facts applicable to distances and directions, and vice versa; in short, *proportion*. The attention to proportion that characterizes classical architecture to this day, as well as the link that still exists between *ratio* as a comparison of two quantities and *ratio-* as the prefix to words denoting reasons itself, derive from this Platonic definition.

For Aristotle, space was nothing other than *place*, or the generalized sum and place of all places. If Plato's definition was geometrical, Aristotle's was more topological: (the) place (of something), he said, was the inner surface of the first stable, environing container. The place of a chair is the room it is in, the place of a river is the riverbed, the place of the moon is the next-outward celestial sphere.

The Medieval period saw these views commingled; but a new and spiritual element was added. Space was light, or Spirit, or God Himself. Whence, and why else, the apparent infinitude, insubstantiality, immanence, and permanence of space? (Henderson, 1983)

By the time Descartes put his mind to the problem, space *per se* had become an impossibly mystical notion. Descartes brought back to it a dynamic and mechanical aspect. In classifying space and everything physical as "extension" and by opposing this to "thought," Descartes reasoned that space was simply *that which permitted* mechanical motion. One atom impinged upon the other directly, like so many ball bearings but without any empty space between them. Vacuum, void, was impossible; space was full of atoms-in-contact. Rather than specify what space *is*, he specified what it *did*: space allowed motion.

Dissatisfied with only mechanical terms, Leibniz was to extend this kind of operational definition further. Space, he argued, was that which permitted not only atoms and motion but the very existence of *identity* and *simultaneity* as such. Without space, he argued, things could be neither unique nor countable. Everything would be collapsed to a single "point," to one thing, which is to say, to no-thing, since there would be no room for an-other thing to distinguish itself from the first. Moreover, in order to introduce change, such as motion, and in order for there to be *more* than one object in motion, not only simultaneity, but also an object-identity-that-survives-motion is required so that the motion can be said to have happened at all. With his principle of the "Identity of Indiscernibles"—as this doctrine is called, and which we will discuss presently—Leibniz probably came closest to what we could call an information-theoretical view of space.

Newtown, for his part, thought of space as pure vacuum, Absolute and unmoved, a plenum of nothing but positions—points—continuous and empty in every direction. This view remained largely intact for a hundred years. But by the twentieth century, space could no longer be thought of without *time*. After Einstein in particular, the project enlarged to understand space-time as the four-dimensional, fundamental "unified field" providing both the totality of all cosmic frames of reference in relative motion as well as the "substance" of reality itself as the ultimate weaving of light with gravity.

Now, the physicists' and philosophers' idea of space-time was to have enormous impact on artists and architects of the twentieth century, as we know. We also know that this impact had little to do with what Einstein was getting at with his theories of relativity. (Collins, 1965) Rather, space-time and "relativity" were taken as invitations to investigate the extremes of openness, "multiperspectivalism," dematerialization, and mobility as worthwhile aims for the design of buildings and cities. To this very day, ACSA surveys report that the text thought by architecture teachers to be the most important for students to read is Siegfried Gideon's 1941 *Space, Time, and Architecture*, surely one of academe's most mistaken explications of Einstein's ideas.

It is quite beyond the scope of this article to rehearse the concepts of space as propounded by architects and architectural scholars during this long history, except to note that it was not until the 1750s that the notion arose that space as such had anything to do with architecture, (Lefebvre, 1974/1991) and *primarily* did was "shape space." Consider these passages:

> …though we may overlook it, space affects us and can control our spirit; and a large part of the pleasure we obtain from architecture…springs from space. The architect models in space as a sculptor in clay. (Geoffrey Scott, 1915)
>
> Space and Time are reborn to us today. Space and Time are the only forms on which life is built and hence art must be constructed. (Antoine Pevsner, 1920).
>
> …the new reality that is space instead of matter. (Frank Lloyd Wright, 1943)
>
> To get a hold of space, to know how to see it, is the key to understanding buildings. (Bruno Zevi, 1957)
>
> (This) is easier for architects because they are used to dealing with the slippery impalpable stuff. (Sinclair Gauldie, 1969)
>
> (Walls) tightly stretched by the pressure of the continuously open spaces inside them… (T)he interior space, maternally rounded and swelling… (Vincent Scully, Jr., 1961)
>
> It only becomes possible to perceive and experience space when it is enclosed by architectural forms. (Miles Danby, 1963)

In the writing of architect-planners, from Camillo Sitte in the 1890s to Rob Krier in the 1970s, these same ideas abound. Streets and plazas are outdoor rooms; their shaping "control(s) our spirit." Far from exempt from the European discourse on space, the American highway and gridiron city, the skyscraper and strip, were seen as simply another *kind* of space. As early as 1908, Hendrik Berlage, scorning nostalgia for the picturesque space of the European street, square, and plaza, wrote: "Feeling for space: only those equipped with that feeling can understand the beauty of the American city." And most recently, under the impact of postmodern realities, theorists have pushed beyond the essentially aesthetic discourse that has preoccupied architects. "Space is political and ideological," proclaimed philosopher Henri Lefebvre, inspiration of many architect-planners today. "It is a product. It is a product filled with ideologies."[v]

Oh, what a load space must carry! Every responsibility devolves upon it: from supporting the innocent play of geometry to being answerable for our well being, from providing the ground of physical reality to accounting for political and economic evolution. Clearly there is more being asked of the concept of space than space alone could possibly supply. Indeed, as we look over this sample of what modern architects and urbanists have propounded about space, we are reminded strongly of the medieval identification of space with pure spirit, with *geist*, one might even say with "*raumgeist*," inextricably bound up with *zeitgeist*. And what is *geist* if not information? What is an ideology if not information?

As for the accounts offered by modern philosophers and scientists: for all their precision they offer us no real alternative. They prove also to rely upon acts of measurement, perception, feeling, counting, referring, and knowing…cognitions all, "spirit" all, *information* all. Even the infinite, absolute, empty night of Newtonian space presupposes a plenum of radiation and gravity with differences in their distribution enough to locate "points," in principle, anywhere (and to locate someone or something to *take note* of these points anywhere as well).

The question naturally begins to arise: *is information in space, or is space in information?* I submit that this is a pivotal question. In fact, we are ready to take the next step, which is to explore the more radical idea that *space and information are one and the same "thing."* Consider:

Thought Experiment I

We have a computer with which we wish to represent a body of numerical data to ourselves graphically. The data consists of a set of **N** strings of **n** numbers, with $\mathbf{N} \geq 3$, and $\mathbf{n} \geq 1$. We have no idea what these numbers represent. We intend to explore the best way to render apparent whatever patterns of organization lurk in data, and to ignore no data in the process. (The reader may recognize this sort of task as belonging to the field of endeavor called "scientific visualization.")

We set up a Cartesian coordinate system with the usual axes X, Y, and Z. The positions of **n** points (more precisely, of **n** *dots*) in the abstract space created can take care of representing three of the strings.[vi] But what if there are two or more data-points (i.e. number triplets) that are the same, and that therefore compete, as it were, for the same dot location? And what of the (**N** – 3) remaining strings? What do we do with them? Thinking about the second question helps with the first.

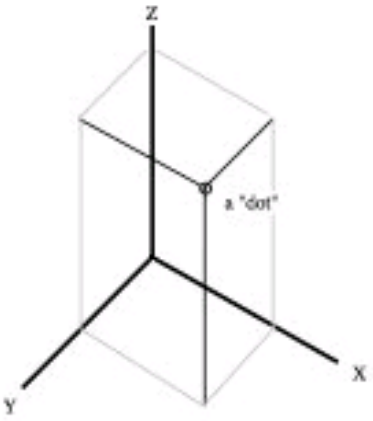

figure 1

One approach would be to generate **N**/3 coordinate systems, arranged like adjacent rooms, and join the dots in one to corresponding dots in the next, and the next, with **n** *multiple segmented lines*. The constituent slopes and lengths of each **N**/3-times-articulated line would then represent one **N**-dimensional "data-point" (or row of **N** numbers) in the original data.

Another approach would be to devise a way to encode some or all of the remaining (**N** – 3) strings of numbers as some perceptible quality intrinsic to the dot itself, such as, say, its color. Color could take care of three more strings in the form of three *intrinsic dimensions*, "redness," "greenness," and "blueness," which are independent in principle from each other and from the three *extrinsic* or positional dimensions X, Y, and Z. Informationally, a dot without intrinsic dimensions in **N**-dimensional space is equivalent to a dot with **M** intrinsic dimensions in an (**N** – **M**)-dimensional space. In addition to color, or instead, we might give each dot other intrinsic, essentially a-spatial qualities such as spin, or vibration frequency, or even sound.

Now both of these approaches can quite handily attack the problem of how to represent **n** **N**-dimensional data-points. Both can minimize the occurrence of competition for a position, but neither can guarantee that a certain number of identical data-points competing for a particular dot or line in the abstract space(s) will not remain. To obviate this last problem we would have to introduce time, or add yet another dimension, intrinsic or extrinsic, to our representation in order to reflect the actual *ordering* of the numbers in the strings.

Now in all this we can see a deep and important principle at work. It was a principle known to Leibniz, who gave it the name of the "Identity of Indiscernibles." If the differences between two points, dots, lines, atoms, cats, whatever…he reasoned, are indiscernible, then we do not have two but *one* point, dot, line, atom, or cat. Whatever things we see two or more of, therefore, are *ipso facto* different from each other *in some dimension*. There are really no two identical objects even when they seem "identical" in all but spatiotemporal location; nature produces no real twins. *Indeed, the three dimensions of* "space" *and the one of* "time" *are simply that handful of dimensions of our much-greater-than-four-dimensional reality that forms the most capacious coordinate system; the one, that provides the greatest number of opportunities for the identities of things with further inherent qualities to "express" themselves.* Space and time minimize the loss of uniqueness and variety that would otherwise occur amongst the myriad things that, in some sense, *want to be* in our universe. The inhabitants of some other

multidimensional universe would call whichever subset of *their* world-dimensions that serve this information-preserving purpose *their* "space" and "time," and they would probably regard the ineluctability and universality of these dimensions with the same mystified awe that we do ours.

With our modest thought experiment we found ourselves engaged in *increasing the amount of space (or time)* available in order *to lose no data* to limited intrinsic dimensions. To the extent that each **N**-dimensional data-point was unique—if only by one numerical value on one dimension—we sought to maximize the display of its uniqueness. If the conservation of information necessitates the conservation of space, then the *production of new information* in addition *necessitates the production of new space.*

How exciting it was, then, for physicists to discover this space-making law actually at work in nature, and this some 250 years after Leibniz intuited it. Wolfgang Pauli's "Exclusion Principle" of 1925 states that no two fermions (e.g. electrons) that have the same quantum state (spin, charge) can occupy the same orbital of a given atom at the same time. This single principle explains why the world we know is not condensed to a single, infinite-intrinsic-dimensioned point. Atoms build up shells and layers of electron orbitals "in space" quite literally because there is only "room" for one electron of a kind in a given orbit. The structure of the periodic table and the existence of matter as we know it—all matter—is the result of this kind of limitation, and *atomism* is nothing other than the name of the two thousand year-old project to explain all natural phenomena while at the same time reducing the number of nature's intrinsic dimensions necessary to their explanation to one binary-valued dimension: existence/non-existence. The idea of *room* and the *fact* of space, then, are entirely the outcome of nature attempting to resolve her own, evolving, particulate complexity to the utmost degree extrinsically. It is as though the Matrix—the Mother—wished to represent herself to herself—through us—entirely and without omission; as though Reality were a cosmic "scientific visualization" of itself, expanding only because it is growing more complex.[vii]

Need I point out to the reader the parallels here between the informational spatiologic of nature and that of cyberspace? Consider:

Thought Experiment II

Another area of scientific inquiry which can throw some light on the issues that concern us is a new subdiscipline situated at the intersection of biology and computer science. It goes by the name of Artificial Life (AL), or Cellular Automata (CA) theory, the latter term going back to John von Neuman's ground-breaking work in the 1950s. In both, life processes such as reproduction, group interaction patters, and evolution are simulated by allowing a computer to "play out" simple programs assigned to "cells" over time. Each cell's behavior always depends not only on its inner, given program, but on the condition or state of its neighboring cells. As the immediate environment of each cell changes, the cell responds by changing *its* state or behavior accordingly. It thereby constitutes part of the altered environment of the cells to which it is neighbor in turn.

En masse, results are often marvelous and unpredictable. When each cell is represented by a group of pixels, large-scale patterns can spontaneously develop on the computer screen. Whorls and waves, clusterings, migrations, and dispersals develop. Individual digital "creatures" evolve and die off, to be replaced—in certain systems—by smarter ones. There are predators and

parasites, eras of calm, eras of warfare…etc. etc. And all this, as I noted, can come about with rather elementary beginning programs – programs in the order of twenty to forty lines of code assigned to each cell. Complexity not apparent at the start develops over time by leaps and bounds, and all the more so if the initial cell programs are revisable by certain events in the cell's history.

Now, for many people it would be too far-fetched to draw parallels between cells in an AL/CA system and individuals in a society. There may be some analogy to termite behavior perhaps, they would say, but not to humans! The far-fetchedness of an analogy depends, however, on the specificity of its claims. In this case, I believe, something rather interesting and relevant can be said about *all* social organizations before the limits of plausibility are reached.

For example, consider some simple informational accounting:

Let B be the number of behaviors (or states) that a cell can display both to us, as observers, and to its neighbors in "screenworld." Let X be the number of cells in the effective neighborhood of any given cell. If the particular behavior of a given cell *depends* on the combined behavior of the ones around it—i.e. the ones in its effective neighborhood—then each cell must have, by virtue of its program, the capacity to perceive, remember, and process the B^x possible states of its effective neighborhood in order to decide what to do next. Now if $X > 1$ and $B > 1$, then clearly B^x is a quantity greater than B – easily much greater. From this we learn that no cell can behave in as many distinct ways as the ensemble of its similarly adept neighbors can. Each cell('s program) therefore must engage in some sort of decision-making, filtering, or blurring process that *reduces* B^x to B. Each cell must be able to register $X\log_2 B$ bits of information, manipulate it—condense it, add it up, average it, even discard parts of it—and then *produce* $\log_2 B$ bits of information for display.

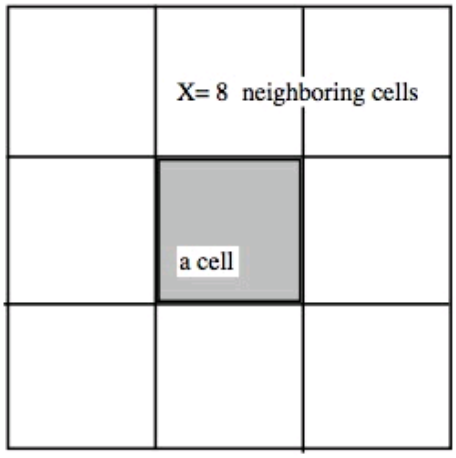

figure 2

What does this mean for *us*? Think of a cell as a human individual. The greater the number of behaviors she allows herself and others to engage in and display ("B"), and the greater the number of friends, neighbors, and objects she interacts with ("X"), then, quite precisely, the

possible complexity of the environment she must deal with is exponentially greater ("B^x"). And if "Thought Experiment I" holds any water, then greater too is the amount of *space* required for that information to exist.

Space? Just where *is* this space? *What* is this space?

It is not the space of "screenworld." Screenworld acts out another, global history (which is interesting enough). It is, rather, the space locked up, as it were, in the domain of each cell, in the imagination of each mind. Seen from above, from outside, the abstract motion of data-points within intrinsic dimensions is visible as "behavior" of $\log_2 B$ bits in complexity. But inside, the remaining $(X - 1)\log_2 B$ bits are at play.[viii]

I am in an open-air market in Rome. It is April. Heaps of fruit and vegetables—tomatoes, squash, red peppers, no two the same—shine in raw wooden boxes under yellow canvas awnings. Water glistens, black, between the cobblestones under me. The air is filled with the sounds of traffic and voices, each from a unique direction. The smell of fresh fish wafts in a wayward breeze, and then the smell of coffee. To my right is a fountain and sculpture in white marble: figures caught in ecstatic agony, struck in sunshine against a shady Baroque façade, and in the blue, blue sky I see the contrail of a jet headed west, away from the sun. Why do I see all this, this excess of detail that I can do nothing about? Precisely because I can do nothing about it! I am a dam, a delay; and this information is accumulated behind me and in me like a lake. A world is constituted in me because the world cannot flow through me unjudged, unreduced. I can respond with actions and thoughts to a vanishing fraction of the welter of information I can perceive, and I "perceive" only because I cannot respond fast enough. Think: were it not this way, were I to have a specific and instant response for every bit of data entering my system, then I would be nothing but a "throughput" device with a passive display; I would be like a billion-stringed puppet, a crazed switchboard, a rail-yard of lightning-quick trains, like a pile of mirrors or a glass chandelier in the sun…each quite beautiful perhaps, but quite dead, without consciousness. There would be no world in me, pooled in me, circulating, evaporating, being filtered. The street market that is in my head is a holding action. In other words, just as stomachs make it possible for creatures not to eat all the time, so consciousness makes it possible for us not to react all the time, to hold a world behind my eyes and posit it before my eyes…while I decide what to do next.

In sum: the production of spatiotemporal consciousness of a "world" is a consequence—though no *mere* consequence—of surfeit, of the surplus of information that surrounds each one of us relative to our capability of answering to it: $B^x >> B$. Our second "Thought Experiment," then, is not about data representation alone, but about its accumulation and processing. Both of these require not just sufficient neurological/computational complexity—a question of hardware—but also, phenomenologically, sufficient *imaginal room* to take place.

Moreover, as time goes by in an *evolving* CA system, the whole system grows rapidly in complexity. If cells' programs are revisable, then the short-cuts, summaries, and decision routines that the first programs employed and which capitalized upon the redundancy in any given cell's environment, soon cease to be effective. No longer can they hold and conserve and distill all the information about the environment that they need to. Rather, if the cell is to survive and proliferate, these programs are obliged to become longer and more complex; in other words, "smarter." And they do. As screenworld—and, dare I say now, as *society*—complexifies in its

external, spatiotemporal dimensions, and as individual (cell) behaviors increase in number and complexity and range of perceptibility, then so too, and ever faster, must the internal world of each individual cell expand in order to embrace the new information.[ix] In all, this is a model of *space producing itself* as a correlate of the proclivity of complex, dynamical systems to generate more complexity, more information, in themselves. It is also, I think, a model of what Henri Lefebvre wants to call *social space*, i.e. the space that exists chiefly by virtue of minds in a nexus of information exchange with one another, and that exists chiefly *in* those minds rather than in the physical world. (This is not to say, of course, that figures in physical space cannot be inscribed by figures in social space, just as screenworld may display some patterns fractaly similar to patterns found within each cell's "imaginal realm," were we to display that intrinsic activity.)

Now, the reader may wonder why I have gone to such lengths and technicality to elaborate upon what amounts to the quite modest claim: that as environments become more complex, and as effective neighborhoods (as defined) become larger and/or more complex, individuals within them are apt to have, and to *need* to have, "more on their minds." Indeed. To this self-evident insight I am adding only the notion that "more on our minds" means more *in* our minds, and that this means *more space in the world* in a very important sense. For if we can say that "the world" either reduces to, or that it contains as part of itself, the set-theoretic union of all inner worlds, we need only now relax our strictures as to the legitimacy of sources of information to see that cyberspace, which Gibson once called "a consensual hallucination," is but a pattern woven into the same informational tapestry as the one that caused in me the experience of the marketplace in Rome.

Thought Experiment III

"Thought Experiment III" is less a thought experiment than a real one, for a good portion of what I will relate to the reader here has been tested empirically. Also, rather than dealing with abstract space, it deals directly with physical space—with cityspace and our perception of it. I bring it to the reader's attention because it involves a rather unique treatment of the topic, one that shows as fundamental the fact that *the "shape of a space" is itself* (a) *the information in that space*, and (b) the *space in that information*.

Space itself can have no shape of course; light scattering objects and surfaces can, and certainly this is what is really involved when architects and urban designers work so hard "to shape a space." Walls and ceilings, buildings and trees, are positioned in such a way as to modulate experience: not just the experience of those very walls and ceilings (and buildings and trees), but the experience of the people and signs, images and machines, and so on, that move about and populate the room or cityscape. In other words, the disposition of enclosures, screens, and plays of elevation and light, etc., do more than make architectural spaces, they *regulate the presentation* of the rest of the world's contents to its inhabitants, pacing it, segmenting it, ordering it in importance, controlling its density. Any "grammar of forms" that would hope to help designers do their job would have to be one that took into account both of these functionalities: space as form(ed) *qua* space, and space as a medium of information transmission, where that information is itself sedimented in space in a way that tells of its sources-where they are, what they are, and even why.

To this end, the "Theory of Isovists" was developed. (Benedikt, 1980 & 1979; Benedikt & Davis, 1979) Stated most simply, an *isovist at x*, denoted V_x, is the set of all points in an

environment of opaque surfaces that are visible to a given point, x. (The spherical limit of the isovist is an artificial one, as shown in Figure 1, functioning something like a horizon in the absence of any other intervening surfaces.)

Isovists have a shape and a size, and every point x in an environment generally has, belonging to it, a uniquely shaped isovist. Even in a perfectly convex room, where isovist shape and size do not change with observer position in the room, the position of x relative to the isovist boundary does, and this affects various informational "measures" we are interested in. What are some of these measures? (For simplicity's sake we will think of two-dimensional isovists, in plan, being horizontal sections through full, three-dimensional isovists.)

Five measures prove to be useful: A, the area of the isovist, which gives us a measure of size (in 3-D this is a volume); P, the perimeter of the isovist, which gives us a measure of the boundary length (in 3-D this is an area) excluding the horizon and excluding Q, which is a measure of the length (area) of the radial, component of the isovist boundary; M_2, which is a statistical measure of the variability of the boundary's distance from x; and M_3, which is a measure of the asymmetry of M_2. To fully understand these measures, their computation, and their meaning, the reader is referred to the references in Note 13. Here, necessarily, I shall be very brief.

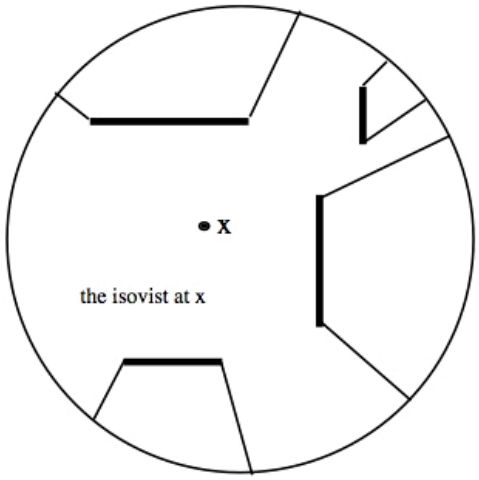

figure 3

It is clear, for example, that as we move around cityspace from street to square to lobby to elevator to office and so on, the size of our isovist changes. Conversely, one might say that an elevator interior is characterized by low values of A, and an urban plaza by high values of A. Similarly, a forest is characterized by high values of Q, and a ballroom, which may have a comparable value for A, will have a low value for Q even a Q of zero if there are no columns, corners, or obstructions. A tight enclosure, open only on one side like a cave, has very high M_3, while on top of a mountain or on an outside corner of a building M_3 is very low, even negative in value. Near the walls of a room, no matter what its shape, the values of M_2 and M_3 rise steeply, like a meniscus. And so on. In short, spaces, and locations within them, can be more and more closely characterized by (1) the absolute values of these five measures at that location, (2) by how these five values change with arbitrarily small motion of the observer in any direction, and (3) by how these values are distributed, field-like, throughout space. A, P, Q, M_2, and M_3 are intrinsic

dimensions of x, values within which happen to be indexed the disposition of surfaces in the (visual) environment around x (itself a point in space whose extrinsic dimensions are X, Y, Z, and T.)

Are we sensitive to any or all of our five measures of isovist shape and size walking about in the real world? Or are they all mere mathematical inventions? Between 1979 and 1982, with a grant from the National Science Foundation, perception psychologist Clarke Burnham and I tried to find out. The specific research question was this: can our judgment of *spaciousness* be affected, and hence predicted, by any or all of the isovists in an enclosed architectural space of arbitrary shape? The answer was, and is, most decidedly: yes. Our impression of spaciousness is evoked by high A, low P, low Q, and high M_3 (M_2 seemed to make little difference.) Cityspaces and parts of them that have these characteristic values—relative to the local norm—will be perceived as more spacious than those with any other combination. (Benedikt & Burnham, 1984, chap. 6)

Prior to our research, a number of preliminary studies had been carried out. Where would a solitary guard in a museum place his chair? Surely where A and /or P was highest and Q lowest. Indeed, calculations based upon drawings and a visit to the Michener Museum on my campus found the guard and his chair within feet of the predicted spot.

If you ask people to point to landmarks they cannot see (from where they are), their mispointing is predictable from an analysis of the radial distribution of Q.

If you wish to see but not be seen, choose high A and positive M_3, if you wish to see and be seen, choose high A and negative M_3.

What do we consider a "good view?" High A, M_3 and Q. Where is the best place to hide? Low A, low Q, high M_3. Which apartment can I safely break into? Low A, low P, high M_2 and M_3.

A classical "architectural space" is merely a region of the isovist information field where the *rate of change* of A, P, and Q is relatively low; a "threshold" is one where these rates of change are high. Modern architectural space, "restless" and "flowing," is characterized by sustained high levels of Q and M_2, while rates of change A and P are moderate. And so on.

It is easy to accept that football players must see "isovistically" quite directly as they negotiate the changing array of depths and proximities around them. So, as hunter and hunted judge their relationship to each other and the world, so do most animals, and indeed, so do we most of the time. The "painterly eye" and, with it our pictorial or cinematographic understanding of space, was a long time in evolving. Billennia, in fact. As J. J. Gibson argued, the world is seen first (i.e. most immediately) in terms of the dynamic and volumetric play of depths and distances from us; only secondarily, only derivatively, is it seen in terms of a static pictorial layout of surfaces across our vision. It is as though seeing were sonar or radar—extended touch—before it was seeing in the camera-image sense. Isovist information lies deeper and more salient to us than its pictorial transforms.

With the theory of isovists, we have a description of the world in its spatial aspects that permits us to study experience over time and with motion. More than this, however, isovists

provide us with a way of understanding space itself as neither logically prior nor subsequent to isovists and the information they contain. Isovist measures constitute a class of information about (visual) space. But it is equally true to say that (visual) *space is partially constituted by the structure of, and in, isovistic information*. Extrinsic and intrinsic dimensions turn out, in this case, to mirror one another. We can neither trust one more than the other, nor claim one to be more real than the other. Isovist information is embedded in/at every point in space, *as* "that point in space," *as* space.

Whether, then, we look at the positioning of architectural surfaces from outside, in a neutral Cartesian manner, as when we look at plans and sections and try to predict the experience of the space and its contents from within it, or whether we look at fields of isovist data not knowing or seeing the surfaces that "caused" them; whether we watch a movie of motion through that space or whether we experience that space in VR or in reality, the results can be the same. The results can be the same because the information is the same, and the information is the same because, ultimately, the space in information and the information in space are one.

Cyberspace and Telecommunications

What are "telecommunications?" Typically we associate the term with the transmission of information via electronic and electromagnetic means from one point on the surface of the earth to the other (although with space flight, the latter constraint is jettisonable). We mean telegraph, telephone, television, radio, and so forth, as well as their new recombinations, Of course, information traveled across large-scale geographical space by report, rumor, and letter, in minds, boxes, and satchels, long before telecommunications made it so fast and easy. To this day, human agents on foot, horseback, boat, plane, and truck deliver vast amounts of information in discrete (and usually discreet) *parcels* or packets whose inscription method resisted the information's natural tendency to entropic dissolution. Important to note is that unlike information that is "broadcast"—from the voice of a town crier and the peal of bells to the sight of a poster and commercial (pre-cable) television—much of the information physically transported in parcels *does not exist in the space between those parcels*. It cannot be picked up at any time and/or over a continuously extended region. Rather, one must be in direct receipt of the relevant parcel somewhere specific, for example, *at* one's "address" or "phone number." Moreover, unlike direct vision and direct sound and unlike, to a lesser extent, broadcast TV and shortwave radio, there is a very small penalty for distance from the source, even less for direction from the source, and little or no interference from geographic "blockages."[x]

This means that whatever imaginary spaces unfold from within the parcel, be it from a videotape, or book, or photograph, they remain both located in local geographic space and largely independent of it. One can read a novel (almost) anywhere: the story does not know where it is being read, or by whom. Over smaller regions ditto the radio. When one is "on the telephone" one is…where?

Real space—cityspace—neither affects nor is affected by such re- or dis-located information except by what I would call *cognitive occlusion*. For, as argued earlier, it is simply not the case that we live in this physical world only. With limited attention and with limited lifetimes, we live *in* information and, much as architects would have it be otherwise, only a small portion of this information is about, or comes from, the people, streets, and buildings present around us. A video camera set up in one place in the city and cabled to a monitor in a second

place in the city (or to another city, for that matter) can so channel our attention that consciousness of the second place is occluded by the first. We have already made mention of the Walkman. How much neglect of the physical environment has to do with our living less and less of our lives *in* it in the informational sense is something we shall want to discuss.

The ability of dis-located information to cognitively occlude one's surroundings is a function of only two factors: (1) the relative *salience* of the dis-located (and dis-locating) information, and (2) its sensory dominance. A lack in one factor can fairly substitute for a lack in the other.[xi] An intriguing postcard and a boring movie can, on balance, be equivalent in their environment-occluding effect.

With all this put on the table, it is time now to turn to those two latest developments in information technology, namely, the *networked computer*, and the technology that goes by the name of "virtual reality" or VR. The first excels at salience, the second at sensory dominance, and the two together could significantly displace reality as we know it.

Begin with the Internet. It consists of roughly 2,600 U.S. and 600 foreign complete networks of computers linked to each other worldwide, each with several "gateways" to all the others. The traffic is already staggering: some 5 to 10 million people worldwide are personally connected through the Internet, sending e-mail, messages, data, pictures, and sounds about God-knows-what to each other. Traffic on the Internet alone is growing at a rate of 20% per month. One of these nets, a fairly fast one NSFNet, is now being expanded to carry commercial traffic. A non-profit called Advanced Network is completing a network that will transfer data at 45 million bits a second, 30 times as fast as NSFNet. By next year, this rate will be 622 million bits/sec. However, this is still slower than the future terabit network now being developed with federal support. This will transfer data at a *billion* bits/sec, and more. The Federal Communications Commission recently licensed regional telephone companies to transmit commercial television and video information services for the first time via optical fiber. More deregulation awaits us. This will mean the end of cable company monopolies and the beginning of a new era of computer integrated interactive entertainment, consumerism, and education. Hardly a week goes by without a major alliance formed between communication, computer, and entertainment companies.

What we are witnessing is not just the connecting of real places, cityspaces, together—as with plumbing or wiring—but the creation of a new medium entirely where real geographical place is irrelevant. More than just sensorially connecting distant real places, that is--with pictures and sound, and various telepresence VR systems, therefore making these places adjacent to each other, or even interchangeable—information in the quantities we will be dealing with, enables the creation of fictional, consistent, wholly electrical "third" spaces, places that exist nowhere and everywhere, whose light shines only in eyes and not on trees or streets. Rather than what Manuel Castells, following Henri Lefebvre, calls "the space of flows," referring to the flow of money and information through telecommunications, this is the space *in flows* sensorially reconstituted as space: urban space, architectural space, cityspace, and abstract space all together…reconstituted, namely as cyberspace. There may well be hundreds of cyberspace domains someday with unique cultures and purposes, like countries.

And of what do these "flows" consist? Of information, to be sure, but effectively—phenomenologically—of power, money, symbols, news, the presence of other people, decisions,

proposals, reports, linkages, references, affirmations, measurements, laws, entertainments, conferences, classes, stories, real and imaginary images…where shall I stop? As I have tried to demonstrate with my three thought experiments, information is intrinsically spatio-temporal, and cyberspace is merely the name given to information spatiotemporalized in a specific way.

Add to this now head-tracking 3-D video monitors, position-sensing large scale and head-mounted displays, "data gloves," "data suits" and all the other paraphernalia of VR that allow electronically generated worlds to take sensory dominance over the local architectural environment.

In The *Informational City* (1989), Castells makes note of the enormous expenditure on telecommunication equipment by U.S. business creating geographically nondescript landscapes of anonymous office buildings. "This is the best example," he writes, "of the direct relationship with location in a given place as a means (only) of access to the *placeless communications network.*"[xii] He is right of course, except that with cyberspace that "communications network" is no longer placeless, or rather need not be. Shoshana Zuboff, in her book *In the Age of the Smart Machine* (1988), makes a similar point: computerization cuts people off from each other, from place, physical intuition, and sensory reality. Once again, this is only true until cyberspace and VR technology can reconstitute and recover the space hidden, as it were, in the dimensions of pure information.

As an architect, I am interested in my profession and its future, and I think one can safely say this: cyberspaces will require constant planning and management. The structures proliferating within it will require design, and the people who design these structures will be called cyberspace architects. Schooled along with their brethren "real-space" architects and urban designers, cyberspace architects will design electronic edifices that are as fully complex, functional, unique, involving, and beautiful as their physical counterparts, if not more so, and the ways that these are disposed in the electronic landscape. Theirs will be the task of visualizing the intrinsically non-physical and giving inhabitable form to society's most intricate abstractions, processes, and organs of information. And all the while they will be re-realizing in a virtual world, in cyberspace, many vital aspects of the physical world, in particular those orderings and pleasures which have always belonged to architecture and the artifactual landscape.

No architect has ever yet designed a bank, or a university, for that matter. They have designed only the physical shell that houses them. Banks and universities have an informational structure and content more marvelous by far than any architect can depict or has yet needed to.

From the viewpoint of the discipline and art of architecture itself, cyberspace can be seen as extending an inexorable process that began a long, long time ago and which gained new impetus earlier this century, namely, the *dematerialization* of buildings. Indeed, architecture's most progressive practitioners and theorists of the day are already approaching the limit, the last steps, of the conversion of architecture's proper constructional and material discourse into its purely intellectual, graphical, and logical content. It is with the development of virtual reality technology and high speed computer networks that these "last steps" of architecture, rather than regrettable can be welcomed, not as last steps at all, but as the first unwitting steps into a new, parallel, and alternative architecture, into a new, parallel, and alternative realm for Being called cyberspace.

In Conclusion: Notes on Urban Growth

As the planner Richard L. Meier analyzed in 1962, much of the *raison-d'etre* of cities historically was the cultural and economic profitability of the increased density of communications that they could support. (Meier, 1962) At a time when information, like material goods, traveled slowly over land and sea and what did not was transmitted face-to-face or face-to-document, ever-denser urbanization was the only avenue to economic development. Through specialization and the sheer multiplicity of connection, complexity provided endless employment and business opportunities. Complexity was almost its own virtue. Through education and competition, it created ever more sophisticated products. Increasing complexity also required increasing organization, ever more subtle and more considerable regulatory structures in the form of bureaucracies. And not insignificantly, as victors celebrated and victims sought solace in this burgeoning system, so did intoxication, crime, and entertainment become major businesses.

The story of urban growth is not without its ups and downs, its tensions and resolutions. With the advent of telecommunications, however, the physical pattern of this development process, with its recognizably urban outcomes, began to change…change to the point that today we can seriously contemplate cityspace and cyberspace as complements, if not alternatives, in providing the medium of communication between people, the site of co-presence, and the repository space for the bulk of our cultural and economic data.

This trend has not been lost on popular commentators. Certainly, to assess the future impact of mass media and modern telecommunications upon everyday life by comparing it to the transportation-based explosion of urban and suburban development at the beginning of this century, as is fairly often done, is already to have discerned the parallels between cityspace and cyberspace, parallels which this paper has tried to investigate more deeply.[xiii] So let us look into the comparison as given, and see whether we are in a position to take it further.[xiv]

Henry Ford sold his first Model T in 1908. By 1916 he had sold 15 million units and the price had halved. The city, with its industrial stenches, noises, and social pathologies, was something to be escaped; the middle class would follow the rich into the countryside. Realtors, car dealers, tire makers, gasoline refiners, road builders, and homebuilders organized to lobby loudly for new roads. By 1921, government spending on the highway system reached $1 billion per year. No longer would it take a train and two trolleys to visit Aunt Maude, no longer would Harry and his family have to live near the plant. The automobile seemed to be the Constitution's promise of freedom made real. With new sewers, power grids, bridges, tunnels, airports, and freeways, America's infrastructural growth bent itself to the task of suburbanization, a task in the conveyance of material and energy to ever larger and more thinly populated areas, a task which is not yet complete. Mail service aside, the transmission of information—all but weightless—was left to private enterprise.

In this context, from this metaphor, Vice President Gore's "National Information Superhighway" is no empty concept. Members of the Clinton Administration are convinced that the future of our economy lies in the production efficiencies brought about by electronic connectivity, and in our global mastery of communications technology itself. They may be right. The price of computing power is dropping faster than did the price of Model T's. Already, with little or no Federal help, message traffic on computer networks such as the Internet is exploding.

Thousands of miles of better cable—wider roads—are being laid monthly. Giant electronics, entertainment, telephone, cable TV, and software companies are falling over themselves to establish strategic partnerships. At stake is future hegemony over the form and contents of the new media landscape and, eventually, of cyberspace proper.

However, there is a key difference between the infrastructure constituted by highways and power grids, and the infrastructure constituted by copper wire, microwaves beams, and optical fiber. The old highways went somewhere: to Aunt Maude's house, to the Grand Canyon, to California. America was waiting, populated, structured in space and time, and rich in natural resources from iron ore to beautiful vistas and with many cities already configured. Not so cyberspace. Cyberspace must be made: it cannot simply be discovered or gotten to. Cyberspace is a geography constructed of information, a new planet with an atmosphere no less breathable for being imaginary. Its topography is undeveloped, as yet still locked into the intrinsic dimensions of its nodal points. It lies compressed and unrealized in or vaults of tapes and discs of data, in our books and dreams, in the very way we appear to each other on screens, pages, and telephone lines. To unfurl and organize all this, to bring it to light in cyberspace, spatiology must complement archeology, and immersion must complement observation.

To be sure, left to itself, the new entertainment/communication/computation nexus will bring us five hundred channels of interactive television some day, as promised. But five hundred channels to choose from do not make cyberspace unless the places they depict and the things they do are coordinated and arranged in a pattern that no one person can change at will. Similarly, forty million simultaneous phone calls, with or without video, do not make cyberspace unless the people making the calls can hear or not hear each other, see or not see each other "isovistically," as a function of position and orientation in a virtual space given by the system itself. Design is required. Architecture is required; and not just to cope with the impact of cyberspace on the surface of the earth, but to give shape to the spaces flowing *out* of the information flowing *between* real places and real people.

Ultimately, then, I have a double advocacy:

First, I advocate an aggressive return by architects to the material reality of their buildings, to the questions of tectonics, ecology, and economy, to the art of construction, and to the romance of inhabitation in cityspace. Here alone lie the nuances of water and wind, of sun and stone, and roof and sail, the taste of food and the touch of a lover. These are things whose value only increases as they are threatened, and it is up to us to both celebrate and profit from this fact.

Second, and simultaneously, I advocate a bold advance by some architects into the realm of the unreal, into cyberspace, to reclaim the space and the community now lost, squandered, latent, in flows of information through wires, cables, and fibers world over. Architecture has always managed the information in space; now it must manage the space in information.

Finally, this is what cyberspace is about. It is, in a way, the revenge of the architects, urbanists, and environmentalists upon the media moguls, computerists, and developers. Even as the world we know becomes placeless under their ministrations, and even as we fight to preserve and enrich it, so we must construct another one which we have not yet fully seen, a world in

another image and from a material that is actually the universe's oldest and only material: *information itself*.

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[i] I take as a significant beginning, at least in the English-speaking world, Sir Geoffrey Scott's perennial *The Architecture of Humanism* (1914/1974).

[ii] And so, while one must concede that describing information as that "…*substance*: not aether, but thought-substance, a registering, tracing, questioning, remembering substance, spread as thinly as we can imagine…," does tend to dissolve the phenomenal world's luscious specificity and palpable solidity into a single, magical gruel, we might remember that magical indeed is that gruel. The entire set of specifications for building a human child, for example, is given in a single molecule consisting of (roughly) three billion pairings of the molecules adenine (A), guanine (G), cytosine (C), and thymine (T), A to T and G to C only, in sequence. The score for Beethoven's Fifth Symphony runs 50 pages, and its every performed nuance can be imprinted on a small and circular plastic disc called a CD. The sequence of ink marks that are these words, slithering by under your eyes and filling you with that mild dread of things-about-to-get-more-difficult…is information. It is nothing but information, and a hair's breadth away from a thousand ones and zeros.

[iii] See also Rheingold, 1991; Woolley, 1992; Heim, 1992; Gelernter, 1991. The reference to Gibson is to William Gibson's triology *Neuromancer* (1984), *Count Zero* (1986), and *Mona Lisa Overdrive* (1987).

[iv] One cannot help thinking here of Louis Kahn's sentiments about Form.

[v] Interestingly, as we shall see, the size of the space need only be n^3.

[vi] For a complementary perspective on this principle see Barbour (1989).

[vii] $(X-1)\log_2 B$ is a very conservative number of course, something of a minimum, since it excludes the contents of memory as well as the process of self-perception.

[viii] It is, of course, a hopeless quest: B^x is always greater than B, and we do not have the space here (!) to go into the various strategies that people actually use subjectively to balance the equation; nonetheless, this in order to live without the feeling of being overwhelmed or incompetent.

[ix] Once again, my aim is to demonstrate ways in which the everyday world can profitably be thought of as *information* as well as "the world" as it appears to us so compellingly. There is a certain strangeness in adoptng this perspective, of course. The theory of information is a great leveler. Like space, everything turns out to be information…if we define information broadly enough.

This universality, this danger of indifference to specific content, felling, form ("hey, it's *all* information to *me*") is, however, more apparent than real. As general as it is, the concept of information is a considerable few rungs "higher" than that of space or time alone. The very definition of "information" presupposes a sentient observer who is able to assess likelihoods and to have expectations, someone or some creature that is sensorially and temporally connected to, and part of, the world he or she (or it) is perceiving. The concept of information leads very naturally to concrete ideas about order, organizaiton, complexity, knowledge, and even *value*, for example. Space and time themselves cannot.

[x] Interestingly, cellular telephone, which due to its operating frequencies is particularly susceptible to real geographic constraints, overcomes them precisely by creating a network of multitudinous receiver/transmitters, as little as a few hundred feet apart in cities, and connected

via microwave links to geostationary satellites in order phenomenologically to simulate a noiseless and lossless broadcast medium impervious to geographical distance and circumstance.

[xi] Though neither can go to zero without having the information vanish from consciousness entirely.

[xii] My parenthesis and emphasis.

[xiii] There is another historical parallel to cyberspace to be made, which I do not take up here; namely, the "opening" of the West to railroad access a hundred years or so earlier than the establishment of the national highway system. For a most eloquent and insightful analysis of the comparison, see Lapham (1994, p. 7-11).

[xiv] Some of the material in the next three paragraphs appears in similar form in my article "Unreal Estates" (1993, p. 56).

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