

# Tobler's First Law of Geography: A Big Idea for a Small World?

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As one of 13 geographers elected into the U.S. National Academy of Sciences after World War II, Waldo Tobler's contributions to geography are well known. The late Peter Gould (1979) even remarked that "an innocent ignorance of Tobler's work now constitutes a constraint on the geographic imagination. That is to say, if a graduate student is not aware of certain pieces of Tobler's research, [his]/her own research abilities are jeopardized because [he]/she cannot gain a new and crucial perspective" (p. 147). Gould made these remarks while discussing Tobler's contributions to cartography. Tobler's influence has obviously crossed the boundaries of cartography, as evidenced by his groundbreaking work in fields as diverse as spatial analysis, migration studies, spatial interaction modeling, and geographic information science (GIScience). The most ambitious of all, perhaps, was his attempt to define the first law of geography.

Based upon a paper, "A computer movie simulating urban growth in the Detroit region," presented in a 1969 meeting organized by the Commission on Quantitative Methods of the International Geographical Union (IGU) in Ann Arbor, Michigan, Tobler (1970) later published a paper with the same title in *Economic Geography*. In this paper, Tobler invoked the first law of geography for the first time: "everything is related to everything else, but near things are more related than distant things." This charming, deceptively simple statement later became known as Tobler's first law (TFL) of geography.

By calling it the first law of geography, Tobler apparently tried to capture something that is most fundamental to geography. And yet after its invocation, TFL remained buried in the literature without much notice throughout the 1970s and 1980s. The growth and development of geographic information systems (GISystems) and GIScience in the 1990s gradually brought new popularity to TFL both within and outside geography.<sup>1</sup> As of today, however, there is no scholarly literature that critically examines the different dimensions of TFL, al-

though large amounts of literature can be indirectly related to TFL (Fotheringham and O'Kelly 1989). So the motivation for this Forum is fairly straightforward: to conduct an exploratory assessment of TFL, and in doing so, to reflect on the nature of geographic inquiry and the essential aspect of the real world from a geographic perspective. If a statement like TFL can indeed be regarded as the first law of our discipline, an exercise like this forum is clearly long overdue. I hope this forum will serve as an invitation to readers of the *Annals* to continue the exploration of the twin themes embedded in TFL as well as the issues raised by our contributors.

This introduction consists of four sections. After a brief introduction, a synopsis of this forum is presented in the second section, followed by a general discussion on how TFL is related to the history of ideas in general and geographical thought in particular. The last section uses ongoing research on the small-world problem as an example illustrating how TFL is at work in the real world.

## Synopsis of This Forum

All the papers in this forum, but Phillips', were originally presented in the panel "On Tobler's First Law of Geography" during the 2003 AAG annual meeting in New Orleans. This forum consists of five commentaries on various facets of TFL plus Waldo Tobler's reply. Contributors were selected according to their substantive interests and philosophical outlook in order to better reflect the intellectual diversity of our discipline.

Drawing from science studies and the philosophy of science literature, Trevor Barnes discusses the basic elements of laws and attempts to restore the local and historical contexts that nurtured Tobler for his invocation of the first law. Echoing tones of mainstream poststructural arguments and the social construction of science, Barnes rejects the universality of laws. Instead, he believes all universal laws are necessarily local

knowledge in disguise. The complexity and diversity of the real world render law-like statements impossible, especially in the social arena. Barnes further argues that TFL is not coming from nowhere, but actually coming from somewhere. Instead of calling it the first law of geography, Barnes concludes that TFL should better be regarded as local lore. Anchored in the domain of spatial analysis and modeling, Harvey Miller claims that TFL is central to the core of spatial analytical techniques as well as to geographic conceptions of space. He further argues that laws in science are compact descriptions of patterns and regularities. Miller contends that science often accepts the concept of empirical laws that do not have to be immutable truths; neither are scientific laws required to be causal. Miller accepts TFL as a reasonable regularity that generally holds true in the real world. With continuing progress in spatial analysis as well as advances in GISystems and GIScience, Miller is optimistic that new life will continue to breathe into TFL as we become better equipped to conduct detailed analyses of the “near” and “related.” To Jonathan Phillips, debating whether TFL should qualify as a law is not nearly as interesting as assessing the extent to which it helps us in understanding earth-surface systems. According to Phillips, most practicing scientists accept a much looser, more flexible, and more catholic definition of what constitutes a law. Phillips observes that TFL is often (though not always) true and relevant in helping physical geographers understand how the earth-surface system works. Reflecting his own research inspired by the perspective of nonlinear dynamics, Phillips contends that both general laws and local conditions should be considered in order to better understand the complexity of earth-surface systems. He also makes an interesting twist in the interpretation of TFL: accepting TFL simultaneously challenges a strictly law-based approach to science and to geography. Phillips' take-home message is that only by accepting this challenge, can we do justice to TFL. Based predominantly upon philosophical analysis, cultural geographer Jonathan Smith aims to make the case that TFL is neither true nor a law, despite the fact that it has been enshrined as a motto of our discipline. According to Smith, three requirements must be met if a statement is to be accepted as a law—it must be universal, synthetic, and necessary. Smith decomposes TFL into two propositions—the metaphysical and the geographical proposition—neither of which is strictly true according to his definition of law. Smith also expresses his unease about the verbal inflation of elevating not only nomological, but also accidental generalizations, analytic statements, and rules of thumb to the status of laws. By deploying a monetary analogy in

the debasement of coins that leads to inflation, Smith argues that the casual use of the word “law” has resulted in the verbal inflation that makes it difficult to differentiate between the spurious and the genuine in academic discourse.

Mike Goodchild, who served as the panel discussant in New Orleans, is concerned with the validity and usefulness of TFL in the specific context of GIScience. He first presents his perspective on the relationship between GIScience and geography, followed by a brief introduction to GIScience and the role of general principles in GIScience. Goodchild affirms the status and utility of TFL in geography in general and GIScience in particular and then speculates on the possibility of additional laws. The more general question to Goodchild is whether it is possible to build on Tobler's contribution to move forward. With the further development of GISystems and GIScience, Goodchild is hopeful that the timeless dilemma in geography—whether geographers should focus on the local or the global, whether geographic science should be idiographic or nomothetic—may be resolved. In his reply, Waldo Tobler addresses the two common themes that emerged from our five commentaries—what constitutes a law and whether TFL is valid. Tobler first makes it clear that his conceptualization of a law is influenced by physicist Richard Feynman, who argued that a law is nothing but an educated guess on how nature works, providing predictions that can then be compared with reality. Although Tobler concedes that the first part of TFL—“everything is related everything else”—may not be literally true, he nonetheless defends a law-based approach to geographic research. Not surprisingly, while endorsing the assessment made by Miller, Phillips, and Goodchild, he expresses reservations on Barnes's and Smith's stand. Broadening the context, Tobler further challenges us to think about the many other laws that have been proposed, including his own less-well-known second law of geography. The papers in the forum, although by no means comprehensive or exhaustive due to page limits, exhibit the intellectual diversity of contemporary geography. I hope this forum will become both a mirror reflecting crucial issues facing geography today and a window through which we can gain a glimpse over the vast terra incognita beyond the limits of our current knowledge.

### **TFL and the Big Idea: From the Great Chain of Being to the Cosmic Web**

Tobler is quite right (and modest) when he states unequivocally in his reply that the basic ideas in TFL are

neither very original nor necessarily true all the time. But he must be given credit for elevating a general statement to the status of the *first* law in geography for the first time. Among the five contributors to this Forum, Barnes argues that TFL should be regarded as a form of local knowledge, and he is obviously against the idea of a first law in geography. Smith does not even think TFL is a law, much less the first law in geography. Among the three contributors (Miller, Phillips, and Goodchild) who endorse TFL, all three have tried to flesh out deeper meanings of TFL. Miller and Phillips avoid addressing the issue of whether TFL should be the *first* law of geography although both extoll the value of TFL in our understanding of the human and physical world. Goodchild argues that TFL is essentially about spatial dependence, which is essentially a second-order effect, whereas spatial heterogeneity is a first-order effect. Thus Goodchild proposes that TFL (or spatial dependence, more specifically) be better treated as the second law of geography, whereas spatial heterogeneity be the *first* law of geography.<sup>2</sup> By elevating spatial heterogeneity as the first law, does that subtly imply that each region is different and unique, thus may be considered as a new form of exceptionalism? Obviously, whether TFL should be treated as the *first* law of geography will have profound implications at the ontological, epistemological, methodological, and even ethical levels. It is beyond the scope of this introduction to discuss such complex issues in detail. It will suffice here to draw a general sketch of the big idea to set up a broader context for discussing TFL. The big idea in TFL—"everything is related to everything else"—has been expressed in different ways over time and across the fields of human intellectual endeavor (Bateson 1979; Volk 1995). It must be considered a big idea because it is not only embedded in scientific theories and practices, but also manifested in religious faiths of all kinds (Ferngren, Larson, and Amundsen 2000; Brooke 2000).<sup>3</sup> It presents a cogent description not only of nature but also of human knowledge about nature. From ancient sages to contemporary scholars across disciplines, "everything is related to everything else"—by inference and implication the interconnectedness and the unity of all things in the universe—has been one of the most consistent themes (von Weizsacker 1980; Kuntz and Kuntz 1987; Marshall 2002). Humanity's explosive rise in intellectual mastery of the truths of our universe has its roots in the ancient Greek concept of an intrinsic orderliness that governs our cosmos and the human species. According to Lovejoy (1936), starting from the ancient Greeks through the Middle Ages and down to the late 18th century, most people in the West,<sup>4</sup> educated ones in

particular, accepted without question the conception of the universe as a "great chain of being." The vision of a great chain of being in an orderly cosmos found its apogee in the Age of Enlightenment, but then the hierarchical outlook eventually collapsed and gradually got lost in the increasing fragmentation and specialization of knowledge in the past two centuries (Holton. 1988).

Although the idea of great chains of being is no longer held as a dominant world view since the Enlightenment movement, the metaphysical motif behind this idea—everything is related/connected to everything else—continues to manifest itself in various forms in contemporary intellectual endeavor. The parallel nature and interconnectedness of human knowledge—unity among diversity—is one of the defining features of that knowledge (Capra 1975; Hofstadter 1979; Shlain 1991; Rothstein 1995; Deutsch 1997; Eglash 1999). Instead of being a hindrance, the specific, fragmented knowledge developed after the scientific revolution has provided the building blocks for a unified theory about nature. The Ionian enchantment—the search for a unifying world picture or a better understanding of how everything is related to everything else—has been the most enduring motivation for scientists and scholars alike. One of the paradoxes of the physical sciences is that, as our knowledge has progressed, more and more diverse physical phenomena can be explained in terms of fewer underlying laws, or principles. Tracing the history of physics, Taylor (2001) puts many of these findings into historical perspective and documents how progress is made when unexpected, hidden unities are uncovered between apparently unrelated physical phenomena, such as the unity of celestial and terrestrial dynamics (17th century), the unity of heat within the rest of dynamics (18th century), the unity of electricity, magnetism, and light (19th century), the unity of space and time and the unification of nuclear forces with electromagnetism (20th century).<sup>5</sup> Furthermore, it is interesting to note that despite the postmodern/post-structural tide in the late 20th century against general theories and meta-narratives,<sup>6</sup> scientists have not given up their dream of a final theory or a theory of everything (Barrow 1991; Weinberg 1992). The search for what Einstein called "the unified weltbild" (Holton 1995) is still the supreme task for scientists. Even the social sciences have been maneuvering for a return to the grand theory (Skinner 1985). E.O. Wilson (1998) attempted to revive the enlightenment ideal through a consilience approach aimed at the unity of knowledge. All these endeavors reflect humanity's quest to understand the unity of nature as well as the unity of human knowledge.<sup>7</sup>

Whether inspired by biological metaphors (e.g. organism, trees of life) or physical metaphors (e.g. clocks, steam engines), the theme of the unity of all things in the world has consistently been the most salient element underneath the intellectual history of humanity. Most recently, the growing use of the Web as a metaphor represents the latest human conceptualization of reality.<sup>8</sup> Using “the cosmic web” as the driving framework, Hayles (1984) found that the theme of interconnectedness has striking parallels in both scientific theories and dominant literary strategies. Capra (1996) argues that conceiving of the system of living things as “the web of life” is the most potent way to develop a new ethics for sustainable development. Historians are also discovering “the web” as a powerful metaphor to understand the complexity of human history and the evolution of human knowledge from antiquity to the present (Burke 1999; McNeill and McNeill 2003).

In many interesting ways, the web metaphor is replacing the great chain of being in the information age as a dominant worldview for us to understand the interconnectedness of reality. One fundamental difference, though, is that the great chain of being implies linearity and hierarchy, whereas the cosmic web emphasizes multiplicity and complexity. Despite the differences, humanity has not escaped the one big idea that “everything is related to everything else.” The reason for this motif can go much deeper, as Goethe emphasized in arguing that the primary motivation for human intellectual endeavor is to bound or relate, when he wrote in a quasi-religious fervor: “When we do science, we are pantheists; when we do poetry, we are polytheists; when we moralize, we are monotheists.”<sup>9</sup>

Relating TFL to broader historical and interdisciplinary contexts is an interesting exercise in the spirit of TFL, but may be a little bit far-fetched for some readers. Perhaps a more meaningful and relevant question is: where and how does TFL fit in the history of geographical thought? Again, answering this question adequately requires more space than is warranted here. I can only delineate a general contour to stimulate further discussion.

The two propositions in TFL have appeared, although different in emphasis and substantive topics, in various forms in many geographers' work throughout history (Glacken 1967). Interconnectedness is a consistent theme among the four traditions of geography, as summarized by Pattison (1964): earth science, human-environmental interactions, area studies, and spatial analysis.<sup>10</sup> Articles in this forum by Miller, Phillips, and Goodchild provide a good testimony. Buttner (1993) presented a detailed analysis of how Pepper's (1942)

four root metaphysical metaphors—the world perceived as mosaic of forms, mechanical systems, organisms, and spontaneous events—have manifested themselves in geographical thought and practices. Underneath the voluminous geographical work following these four root metaphysical metaphors is the idea, implicitly or explicitly, that everything is related to everything else and that distance plays a role in these relationships.<sup>11</sup> In other words, the spirit of TFL, if not the substance, has been intimately interwoven in geographical thought. TFL contains overarching ideas that cut across the disciplinary boundaries of geography.

Furthermore, TFL also has important (although very subtle) implications about the nature of geographical inquiry. On the one hand, by invoking a law-like statement such as “everything is related to everything else,” TFL obviously affirms the belief that there exist general patterns and connections among the things geographers study. On the other hand, “near things are more related than distant things” implies that there exist local factors and circumstances that can potentially make one area significantly different from other areas. If the first statement in TFL denotes spatial dependence explicitly, the second statement of TFL connotes spatial heterogeneity implicitly. At a more philosophical level, TFL is advocating a nomothetic approach to geography, but at the same time it is also showing due respect for the idiographic traditions, as “near things are more related than distant things” necessitates the consideration of territoriality as defined by local factors and circumstances.<sup>12</sup>

The full meaning of geography, if one follows the implications of TFL, must include the study of both the structure of spaces and the texture of places, or sticky places in slippery spaces (Markusen 1996). Thus, embedded deeply in TFL, is a rather dialectical synthesis that nomothetic and idiographic approaches to geography must and should be artfully integrated and reconciled.<sup>13</sup> As Phillips so forcefully argues in this forum, accepting TFL simultaneously challenges a strictly law-based approach to geography. This near-Zen-like interpretation of TFL reminds me of physicist John Wheeler's (1983) idea of “law without law.”<sup>14</sup> I concur with Phillips that only by interpreting TFL at this level can we do real justice to it by transcending the dualities of local vs. global, part vs. whole, place vs. space, human vs. physical, and systematic vs. regional that have plagued geography for so long. Perhaps for this reason alone, TFL deserves to be the *first* law of geography?

In summary, I think that TFL has touched the bedrock of both human intellectual concerns in general and geographical thought in particular. As a major geographic canon, TFL permeates the boundaries of

geographic subdisciplines and other branches of the natural sciences, social sciences, and humanities. Whitehead (1933) once remarked that the entirety of Western philosophy is a footnote to Plato. If TFL is indeed the *first* law of geography, I'd like to challenge readers of the *Annals* to contemplate whether or to what extent we can say that geographical studies are essentially a footnote to TFL?

### TFL and the Small World: Six Degrees of Separation, Erdős Number, and Beyond

The vitality of a discipline hinges, to a large extent, on its concepts, theories, and laws that can move our inquiries beyond empirical facts. In his 1790 *Critique of Judgment*, Immanuel Kant (1959) remarked that "we have complete insight only into what we can make and accomplish according to our conceptions" (p. 139). Without an adequate and inspiring conception, we are not likely to go very far in our intellectual journey. Perceptive laws or theories often serve as searchlights or beacons that provide the means of illuminating certain types of objects and events as being significant (Popper 1959). TFL obviously has played, implicitly or explicitly, consciously or unconsciously, the role of a searchlight in geographers' explorations.

One promising and exciting development lately is that scholars have marched into "the small world" with the big idea—as also noted by Miller and Tobler in this forum. As an example showing how a general idea/law can be translated into rigorous research, and also as an illustration of TFL at work in the real world, I'd like to bring the ongoing research on the small-world problem to the readers' attention.

At approximately the same time Tobler invoked his first law of geography, social psychologist Stanley Milgram (1967) formulated the so-called small-world problem, which formalizes the anecdotal notion that a person has only six degrees of separation from anybody else on the planet (Kochen 1989). From a geographical perspective, Milgram essentially devised the first experimental method to empirically explore TFL in the context of social networks with the goal of understanding how everybody is related to everybody else. Milgram and his colleague tackled the problem (confined to the United States) by sending a series of traceable letters from originating points in Kansas and Nebraska to one of two destinations in Boston (Travers and Milgram 1969). The letters could be sent only to someone whom the current holder knew by first name and who was presumably more likely than the holder to

know the person to whom the letter was ultimately addressed. By requiring each intermediary to report their receipt of the letter, Milgram kept track of the letters and the demographic characteristics of their handlers. His results indicated a median chain length of about six, thus supporting the notion of "six degrees of separation," after which both a play and its movie adaptation have since been named.

The past few years have seen an explosion of interest in the small-world problem (Kleinberg 2000; Batty 2001; Watts, Dodds, and Newman 2002). Whether we call it the science of networks (Buchanan 2002) or the science for an interconnected age (Watts 1999, 2003), a burgeoning field of research inspired by the conceptualization of the small-world problem is catching attention both within the academy and among the public (Blakeslee 1998; Collins and Chow 1998; Peterson 1998). How everything is related to everything else and what it means are two dominant themes of this growing literature (Barabasi 2002; Johnson 2002; Strogatz 2003). One discovery to which we should pay particular attention is Watts's and Strogatz's (1998) groundbreaking work, in which regular networks were "rewired" to introduce increasing amounts of disorder. The procedure they followed was to shift gradually from a regular network to a random network by increasing the probability of making random connections from 0 to 1. They then measured the characteristic path length and the amount of clustering of the network as a function of the amount of randomness in the network. They found that these systems can be highly clustered, like regular lattices, yet have small characteristic path lengths, like random graphs. They call them "small-world" networks. The implication is that it only takes a few shortcuts between cliques to turn a large world into a small world—what Gladwell (2000) called "the law of the few."<sup>15</sup> The small-world research further reveals that minor changes in the arrangement of links between members of a network can dramatically alter the rate at which information, computer viruses, or infectious diseases spread throughout the system. The interesting and surprising thing is that it is impossible to determine whether or not one lives in a small world or a large world from local information alone. The average person (node) is not directly associated with the key people (the clique-linkers). It is interesting to notice that although the small-world problem is really a geographical problem at heart,<sup>16</sup> it was first formulated as a scholarly pursuit by a social psychologist (Milgram 1967). It then inspired sociologists to study the strength of weak ties in social networks (Granovetter 1973). Formal quantitative methods to study the small-world networks were not developed until two Cornell

mathematicians jumped on board (Watts and Strogatz 1998). Major breakthroughs on scale-free networks were made by physicists (Barabási and Albert 1999). Novelist Guare's (1990) play *Six Degrees of Separation* and the Kevin Bacon game<sup>17</sup> further popularized the idea of the small world and interconnectedness among members of the public. Such serendipitous discoveries in small-world research have found surprising applications in understanding the neural network of the worm *Caenorhabditis Elegans*, the power grid of the western United States, collaboration among film actors, mapping the Internet, improving networks of cell phones, understanding diffusion of infectious diseases, modeling urban spatial structure, and even cracking terrorist networks; see Strogatz (2001, 2003) for comprehensive reviews. Intuitively, ongoing studies of small-world networks are themselves a lively demonstration of TFL. But are there any formal ways in which we can measure and test the influence of TFL, and how TFL is related to other thoughts and ideas both within and outside geography? Intellectual genealogies or academic collaborations are a special case of small-world networks. Erdős numbers have been a part of the folklore of mathematicians throughout the world for many years. There is an ongoing project that involves assessing one's Erdős number, which measures the number of links needed to connect one to the prolific mathematician Paul Erdős through jointly authored papers (Grossman 2000). For example, individuals have an Erdős number of 1 if they co-authored a paper with Erdős. If one of their coauthors wrote a paper with Erdős, then they have an Erdős number of 2, and so forth. Based on the data collected so far, most of mathematicians' Erdős numbers are surprisingly small. In geography, it would be interesting and fun to calculate the Tobler number, not only as an empirical way to test TFL, but also, to better evaluate the true influence of TFL in geographical practice.

Waldo Tobler comments in his reply that he did not expect such a forum when he wrote the paper in 1970. He was just having fun doing an animation in order to bring time into geography more explicitly. However, once put in print, words tend to develop a life of their own. What happens next often follows the law of unexpected/unintended consequences—another charming idea both applicable to and a testimony to TFL itself. Indeed, as Feynman (1965) so eloquently expressed “nature uses only the longest threads to weave her patterns so that each small piece of her fabric reveals the organization of the entire tapestry” (p. 34). It is fascinating for me to learn through this forum that Tobler was influenced by Feynman, who once confessed (Feynman 1998) that he was inspired by a poet who once said, “the universe is in

a glass of wine.” Geographers should appreciate this line if we believe in TFL. Or perhaps even better, let's have fun in whatever topics we are pursuing and keep in mind that the universe may just be contained in a glass of wine.

## Acknowledgments

This Forum on TFL was originally conceived during my sabbatical stay at UCSB in 2001. Informal conversations with Waldo Tobler and Mike Goodchild sustained my interest in TFL. I would like to thank all the contributors for their enthusiastic participation in this forum. In particular, I'd like to thank Professor Waldo Tobler who met all the deadlines while enjoying his retirement. Thanks are also due to five anonymous reviewers whose perceptive comments have enriched this forum.

## Notes

1. TFL has been discussed in an introductory GIS textbook by Longley et al. (2001). As of June 2003, if one tried to search for “Tobler's First Law of Geography” in Google on the Web, there would be at least 150 returns. Most of these links are related to GIS and GIScience, in general, and spatial interpolation methods, in particular.
2. The idea of putting spatial heterogeneity as the *first* law of geography is conceptually consistent with the worldview of a Darwinian evolutionary theory as championed by Gould (1996)—directionless change without necessary betterment, haphazardly tuned mechanisms, multiple ties between process and result, and catastrophic change. Vale (2002) documented that the development of physical geography is mixed with these four theses and antitheses.
3. This idea is undeniably one of the primitive religious doctrines. In fact, the root of the word “religion” can be traced to the Latin *religare* (*re*: back, and *ligare*: to bind), so the term is associated with “being bound.” To be religious literally means to be bound with/connected to other things.
4. In the East, the unity of man with nature/cosmos is also a dominant worldview (Needham 1954). Recent cognitive studies further reveal that Asians tend to think more holistically than Westerners (Nisbett 2003).
5. The development of quantum physics spawned the undivided universe interpretation on the one hand (Bohm 1980, 1993), and the development of many-worlds/parallel universes interpretation on the other (DeWitt and Graham 1973). Is this a reflection of the nomothetic versus the ideographic dichotomy at the cosmic level?
6. The skepticism as embodied in the core argument of post-modern/post-structural arguments is not new. Historically, human intellectual pursuits have been oscillating between order and skepticism (Szymanski and Agnew 1981), which is a reflection of the dualistic mode of human thinking at a deeper level. The dominance of one mode inevitably leads to its opposite (Maybury-Lewis and Almagor 1989). Such a seemingly paradoxical process has been captured vividly by Blaise Pascal when he wrote, “We have an incapacity for

- proving anything which no amount of dogmatism can overcome. We have an idea of truth which no amount of skepticism can overcome" [quoted in Boorstin (1998, p. 23)].
7. Skepticism about unified theory of nature or theories of everything has been voiced not only by postmodernists, but also leading scientists such as Nobel Laureate Phillip Anderson (1972). See also Horgan (1996) for a more extensive interdisciplinary review.
  8. To what extent is the growing use of the Web as a model and metaphor related to the technological advances in the World Wide Web (Weinberger 2002)? This question needs further investigation. Siegfried (2000) made a persuasive argument that the dominant worldview is always related to the dominating technology of an age.
  9. See <http://people.cornell.edu/pages/hd11/Pelikan-Faust.html>.
  10. Examples are abundant. According to Lukermann (1963), Bernhardus Varenius expressed in 1650 the idea of interconnected world, although heavily tinted in astrological terms, in his *Geographia Generalis*. Von Humboldt (1848, vol. 1, p. 2) declared early in his classic *Cosmos*, "Nature, considered rationally, that is to say submitted to the process of thought, is a unity in diversity of phenomena, a harmony blending together all created things, however dissimilar in form and attributes, one great whole animated by the breath of life." Even Hartshorne (1939), whose work has often been misconstrued as advocating an ideographic approach to geography, stated explicitly that "the separation of things natural from things human is possible only in theory, in reality they are interwoven" (p. 368).
  11. By making this statement, I am not denying the fundamental differences among these four metaphors. The point I am making is that behind the four metaphors is the fundamental idea that everything is related to everything else. Of course, "how" everything is related to everything else depends on the metaphor we choose. Harvey (1997) argued that modern geographic thoughts have evolved from Humboldt's holism to Hartshorne's integrative view on areal differentiation as a result of the mechanization of reasoning. GIS-based overlay analysis is conceptually consistent with an integrative view of reality.
  12. Harvard economist Hausmann (2001) captured this theme by calling people in poverty-ridden regions "prisoners of geography." *The Economist* (2003) also presented new evidence on "the revenge of geography": geography and distance have been more, not less, important in the information age. In both cases, evidences were presented to support TFL.
  13. Despite some geographers' recent emphasis on the geography of differences (Harvey 1996; Fincher and Jacobs 1998; Porter and Sheppard 1998), the architectonic impulses (Curry 1992) to develop overarching frameworks and metanarratives are still very strong in geography. These efforts reflect a very diverse philosophical outlook, as manifested in Tuan's (1996) *Cosmos and Hearth* thesis, Sack's (1997) relational framework, Whatmore's (2002) hybrid geographies—just to name a few.
  14. Wheeler's "law without law" states that physical laws would not appear in a truly fundamental description of nature. It is interesting to note that this seemingly paradoxical idea by a scientist has a religious precursor by Marcel Proust who once said, "The highest praise of God consists in the denial of Him by the atheist, who finds creation so perfect that

he can dispense with a creator" [quoted on <http://www.herbalquotes.org/viewherbs.php?herbcat=God>].

15. Similar ideas are also expressed in the so-called Butterfly economics (Omerod 2001) or the wave principle (Prechter 2002).
16. Geographers have expressed the same idea with different terminologies such as the world is shrinking, space-time compression, global village, etc.
17. The Kevin Bacon game involves connections among movie actors; one can play this game online at <http://www.cs.virginia.edu/~bct7m/bacon.html>. See also "Kevin Bacon, the small-world, and why it all matters," at <http://www.santafe.edu/sfi/publications/Bulletins/bulletinFall99/workInProgress/smallWorld.html>.

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