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Article Summary: The long-held belief that space and time were independent entities has given way to a more realistic notion that the two are intertwined. The appearance and importance of any region tends to change over time. The spirit of an era both drives and reflects such changes in space.

Cataloging Information:

Names: Euclid, René Descartes, Isaac Newton, Arthur Schopenauer, Albert Einstein, Joseph Scaliger

Place Names: Greenwich, England

Keywords: Euclid, Isaac Newton, Arthur Schopenauer, Albert Einstein, Julian calendar, Gregorian Reform, Mean Solar Time, theories of relativity, atomic clock, laser clock, rhythmicity, curvature

Photographs / Images: (Fig 34) parallel lines in flat Space; (Fig 35) Cartesian coordinate system for three-dimensional flat Space; (Fig 36) two-dimensional flat Space representation of Nebraska, showing the Cartesian-like coordinates of the United States General Land Office township range system; (Fig 37) the timeline as dis-placed (de-spaced) linear abstraction; (Fig 38) spacetimes compared to linear Standard Time; (Fig 39) parallel lines in curved spacetime; (Fig 40) adjusting the flat Cartesian grid to the curved surface of the Earth; (Fig 41) schematic two-dimensional diagram comparing the annual geometries of static cyclical time, linear absolute time, and rhythmic time

SPACE & TIME & SPACETIME

By David Murphy

Space and Time are essential concepts in the description and analysis of the physical world. History, being a chronicle of change in this world, derives its major operations from the concept of Time. However, we tend to take both concepts for granted. This struck home some time ago following conversations with colleagues. The dialogues would turn on whether a spatial view of the past was as valid as a temporal one ("Place" was the term used, not "space;" but place, as it is typically used, is still really a spatial term; more about which later.) Invariably, it seemed, my colleagues would retain a preference for chronology.

I doubt that the hegemony of chronology would surprise many who work in history or enjoy its products. Some might even wonder why I should be surprised. I suppose my own connection with history should be described as a weak one, notwithstanding my work at this institution. My focus has always been spatial; not only have the objects of my study been spatial in character, but my conclusions have tended to be spatial as much as they have been temporal. Without fail, as near as I have been able to tell, events in time have specifically-related spatial dimensions. If this were more than just a personal idiosyncracy, it would seem legitimate to emphasize.

While I can dare to suggest this, the conversations convinced me that I did not really comprehend the underpinnings of either my own nor any of my colleagues' views on the matters of Space or Time. (In retrospect, neither concept was articulated as part of my education.) I hypothesized, rather simplistically, that I was just space-oriented and my colleagues were time-oriented. If there was any congruity between the two positions we simply hadn't communicated them well enough to achieve an understanding. But then, why need we? The fact is that, as an historical institution, chronological time has always been the operative paradigm. The intentional incorporation of historic sites into the equation via the historic preservation program—sites that are both essentially spatial and located in space—didn't necessarily imply that space, as such, had anything to do with history.

As I contemplated the situation, I wondered if it might be worth an attempt to understand these differences in order to see if there might be common ground. Henry Glassie's provocative study of houses in Middle Virginia came immediately to mind, since his final chapter added "A Little History" to his spatial analysis. That study, however, did not question time's hegemony in historical study. Was there, somewhere, an historical study to which the author had appended "a little space?" I then recalled Albert Einstein's formulation of "spacetime," and rather naïvely assumed that inquiry into that concept might provide the ground I was seeking. I say naïve because I had forgotten my former struggle with relativity physics in school, principally because the mathematics was beyond me. Fortunately, many words had been written about the concept since then.

A bit more disconcerting was the explosion of recent work on the concept of time, little of which dealt with the issue of spacetime. Only a smattering of writers have braved the translation of spacetime into the human terrestrial realm, as is my goal, and none so far as I've found have attempted the approach taken here. In asking the open question about spacetime, little did I know how unprepared I would be for what would emerge. Whether my attempt to convey an understanding of spacetime that makes sense in Earth opens a useful window for history or not will be left to the reader.

Originally, we might anticipate, there was "just" the world. Language allowed for the differentiation of things, so that say if a certain fruit came to be known as edible, an association of the fruit with a name would assist in spreading reliable knowledge of its edibility and whereabouts. As western culture developed and survival became less of an immediate concern, named things that seemed especially important became the subject of thought and study. The rise of modernity and the scientific method, in addition to finding and naming more things, raised some of them to very high levels of abstraction. Eventually this process of objective reduction led us to think of all things as separate and autonomous. The radical discoveries of this century, however, have brought about a renewed understanding of interconnectedness. Spacetime is but one of the important concepts that is helping us to reconceive the world again as a single, vital, whole.

For the sake of simplicity I use the

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term "things" broadly as any entity that can be apprehended or known to have existence in space or time, as distinguished from what is purely an object of thought. Things, then, will refer generally to phenomena that we ordinarily think of as part of physical reality, including living entities and events. Since I focus on the physical world and the way physicists and philosophers have come to describe it, "things" will also subsume terms such as "mass," "matter," "particles," "points," and "lines" without having to deal with their technical definitions. In distinguishing things from space or time, I merely need to insure that we include them as part of this essay, for two reasons. The first is that historical study is principally of things, and the concepts of space and time are fundamental to our understanding of them. Secondly, we need to be able to refer to them generally because it is only through things that we are able to perceive either space or time at all. The importance of this will become more clear when we discuss the spacetime continuum.

Space

It makes sense to begin with space. According to physicist Max Jammer, etymology indicates that time-consciousness followed that of space. Words qualifying time such as "short," "long," "before," and "thereafter" (instead of "thenafter") were all derived from spatial representation. We also refer to "spaces" and "intervals" of time, and "horizon" is a spatial term currently used primarily to refer to future time. Our present sense of space derives from geometry (literally, earth measure), a science we associate with Euclid. He coordinated piecemeal geometric discoveries into the logical system that bears his name, and published them as the *Elements* in Hellenistic Greece. Euclid's rules began an objectification of space by theoretically making it describable and measurable.

If we start by thinking of space as "extension," we perceive that things are extended (they have shape and size), and they appear to be separated from other things by extended nothingness ("non-thing-ness"), or space. Ordinarily, things take up a certain amount of space and they are separated from other things by "empty" space. Euclid's theorems for describing and measuring this space were derived from the description and measurement of ideal figures drawn within the space of a piece of paper. These governed the generation of other figures—two-dimensional (plane) or three-dimensional (solid) figures—within the space of the world. In other words, attributes of the space of the piece of paper, as derived from the generation of figures upon that paper, were projected to be attributes of the space of the world. While these ideal shapes—things, really, like points, lines, circles, squares, triangles, cylinders, cones, spheres, etc.—were not necessarily of great utility themselves in the world, the concepts and rules governing their generation came to be extremely useful for creating things in the world. Theorems governing such concepts as equality, the generation angles, perimeters, area, proportion, and parallel lines were useful in surveying and construction, at least in very small regions of Earth space during that period.

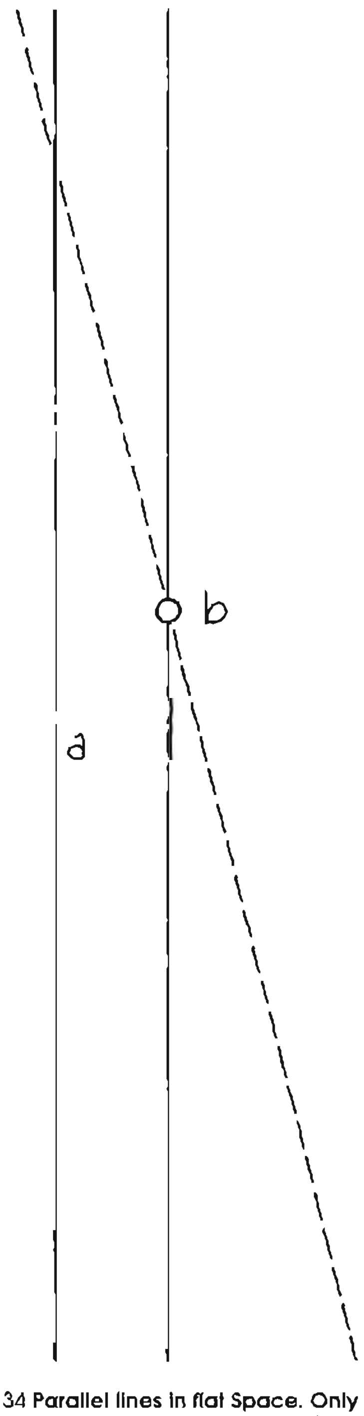

Fig. 34 **Parallel lines in flat Space. Only one line can be drawn parallel to line (a) through point (b), and these two lines will never converge; all other lines drawn through (b) will converge with (a).** All illustrations by author except where noted

Euclid's spaces were either two- or three-dimensional and flat. Extension essentially was determined along straight lines and upon flat planes; later mathematics was used to "straighten" the extensions of curved things. While he avoided the concepts of infinity and the infinitely small, his geometry implied them. The straight lines formed by his theorems were considered capable of indefinite extension, a property needed in order for the geometry to achieve perfection. A classic example, which we will refer to again later, are parallel lines. According to Euclid, through any given point external to a nearby straight line, only one other straight line can be drawn that is parallel to that line; and the two lines thus derived will extend in space without ever diverging from or converging upon each other (Fig. 34). The implication was that space extended indefinitely.

F. M. Cornford argues that Euclid's version of space was contrary to the common sense views of the era. In fact, it was several centuries after his work before philosophers began to fully adopt Euclid's abstractions as part of their own. According to Cornford, the common perception of space was spherical, unlimited and boundless, but not infinite. The "sphere" of Earth space illustrates this. It too is unlimited and boundless in the sense that you can circumnavigate it continuously without ever reaching a boundary, but while it is limitless in this regard, it is not infinite in that you would eventually find yourself "retracing your steps." While the Pythagoreans before Euclid viewed space as an emptiness or "void" between things that both kept them apart and allowed room for them to move about, they did not conceive that there was an "infinite" emptiness outside the spherical world. By comparison, the implied infinity of the Euclidian geometry seemed nonsensical.

The idea of a spherical universe, with the Earth at its center, was replaced over the course of the scientific revolution. Led by the Copernican discovery that the Sun did not revolve around the Earth, the seventeenth-century French philosopher René Descartes proceeded to redefine the world along a number of different lines. As the founder of analytic geometry, his contribution to the conception of space was its rather complete abstraction and objectification. He introduced the idea of the linear coordinate system, which intellectually allowed the reduction of things into mere points in space. This outgrowth of the Euclidian thought resulted in the flat three-dimensional x-y-z coordinate system that bears his name (Fig. 35).

Isaac Newton followed the Cartesian abstractions in transforming space even further. He defined it as an "absolute:" that is, as having standing apart from the world as a uniform, homogenous, and infinite extension in three dimensions. Schopenhauer's attributes of this absolute Space provide a concise summary: there is only one Space, and anything resembling different spaces are really all a part of it; Space is homogenous and a continuum, in that no part of it is different from the rest, nor separated by anything other than Space; it is infinitely divisible, composed of three dimensions, and infinite.

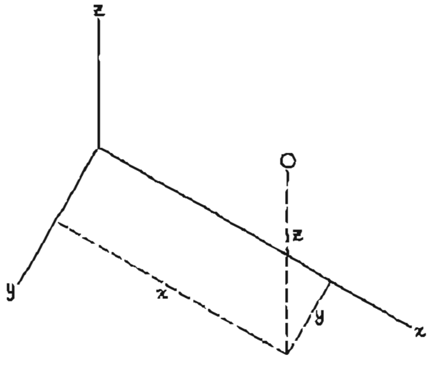

Fig. 35 **Cartesian coordinate system for three-dimensional flat Space, showing the x, y, and z axes.**

The purge of the old views of space following Newton took time, and to some extent common sense is still distrustful of the abstraction. On the other hand, its adoption by the élite insured that it was put into practice as a matter of policy, just as surely as it gained status as scientific fact. The adoption of the Cartesian system by the United States General Land Office surveys is indication enough of the vast impact this early modern view of space has had upon local places (Fig. 36).

Time

This brief outline of the evolution of the western concept of absolute Space allows us to more easily understand a related conception of absolute Time. Even more than the idea of change *per se*, a sense of time probably grew out of the movement of things in space; an idea captured by the term "duration." For our purpose I want to focus on just two awarenesses: one exemplified by the cycle of daylight and darkness, and the other by the birth, life, and death of living beings. These essential ways of perceiving duration can be characterized as the cyclical and the linear.

The cyclical is the older, having been derived from the cycles of the human "environing" world; the diurnal, the lunar, and the annual cycles. In terms of consciousness these cycles have a long history of awakening; beginning, perhaps, from the light and dark cycles and the mystery of whether or not the Sun would rise again, to the seasonal cycles and fears that the world might either freeze or burn. In western culture, the cyclical evolved from a sense that the Earth was at the center of the spherical cosmos, with all of the celestial bodies rotating around it, to a Renaissance awareness that the Sun was at the center of these cycles. Today we realize that our Sun is but one of countless stars that make up the Milky Way, which itself cycles and is just one of at least fifty billion other known cycling galaxies in a cycling universe.

Our awareness of what we can now call our ethnocentric time evolved from observations of the celestial transits: the sunrises and sunsets; the waxing and the waning of the Moon, and its shifting position with respect to the Earth; the seasonal cycles of the Earth's rotational tilt as it circumnavigates the Sun; and the "rotation" of the stars in the night sky. These are all spatially marked: in the rise and set of the Sun, and high noon; the new, full, and quarter Moons; the equinoxes and solstices. The significance of these spatial markings seems indisputable, for we now know that the relative size, spacing, tilts, rotations, and orbits of these celestial bodies are rather precisely implicated in making the lifeworld on this planet possible. But whence these markings in our consciousness today?

Our modern view of time has little regard for these celestial transits. Though the counting of time is derived from them, the evolution of western time has been away from the cycle toward a birth-to-death-like vector. Whatever the

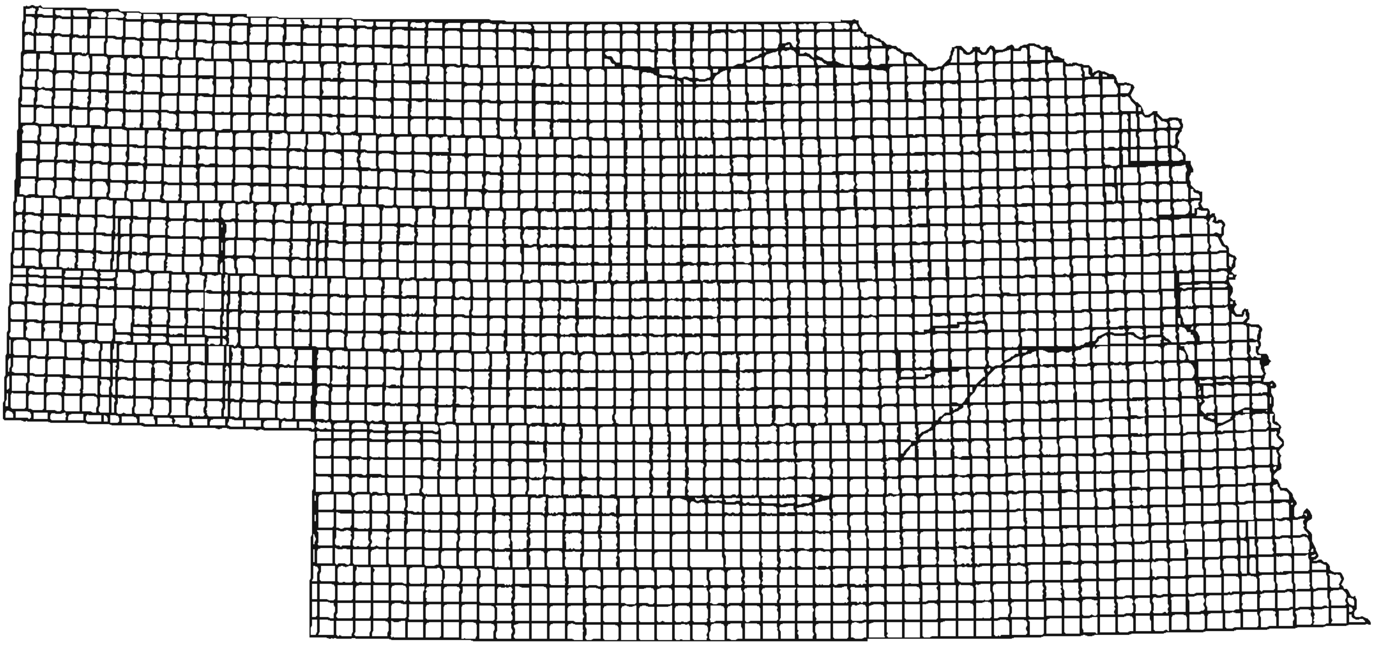

Fig. 36 **Two-dimensional flat Space representation of Nebraska, showing the Cartesian-like coordinates of the United States General Land Office township-range system.** University of Nebraska-Lincoln, Conservation & Survey Division

earlier awareness of the life cycle, the time of our era converted cyclical returns into Beginnings and Endings in linear sequence, or into a lifeline. The latest scientific iteration of this idea is the Big Bang and the Big Crunch.

The straightening of time was gradual and involved several processes. We can probably begin 2,043 years ago with the Julian calendar, which initiated shifts from a timing that was a reflection of the cosmos to one that was a reflection of Man. What was then perceived to be the solar and lunar transits around the Earth were well enough known that Julius Caesar could fix the idea of months without any basis in the lunar cycle. His successor, Caesar Augustus, advanced the beginning of the year from the vernal equinox to the calendar day of January first. These mark the invention of the human year.

One of the great impulses of the linear thrust was to allow inquiry into where one exists in this "journey" between the Beginning and the End. Once the year had been established, and its days numbered, it was only natural to want to count the years. But from whence do you count? The Julian calendar started from the founding of Rome, but this was not acceptable to the Church. Its scholars made numerous calculations to fix the date of Creation—the Beginning of Old Testament time—based upon Biblical genealogy. Inconsistent results led Pope St. John I to adopt a pragmatic solution about 1,473 years ago with the establishment of the AD/BC system. Calculated by Dionysius Exiguus, the system refers to "anno Domini"—the year of the Lord—and to "before Christ." This calculation, performed five centuries after the fact, is now both historically and numerically controversial.

The new system of counting was very slow to be adopted outside of the Church. The first secular use appears only about eleven hundred years ago during the reign of Charlemagne. Even by the sixteenth century of our era, when Pope Gregory XIII instituted his reform of the calendar, few outside the literate religious and political hierarchy were aware of the numbers that had been assigned to the years. The Gregorian reform was required to correct for slight miscalculations of the Earth's solar transit, which by then had resulted in a shift of ten days in the date of the vernal equinox. This affected the calculations for Easter.

The Easter question raises a more subtle nuance of both the linearization of time and its uncoupling from the cosmic cycles. The latter is evident in the Church's shifting of significant days from those that were spatially-marked—such as the substitution of Easter for the spring equinox, or Christmas for the winter solstice—to spatially-arbitrary days. Instead of celebrations of cyclical *returns*, the significant days were displaced and became commemorations of *past* events. These moves diminished or purged cyclically-significant days from the calendar, disconnected culturally-significant time from space, and consummated a historical linearization that was compatible with the assignment of numbers to the years.

The Gregorian Reform was made possible by the increasing accuracy of observations of the celestial transits. The solar cycle became so well known that a fixed calendar with numbered years could be calculated forward and backward indefinitely. The regularity of these cycles in part enabled Descartes to state that the universe ran like a machine. Though minute irregularities were eventually observed, due to refinements in clock-making, Descartes' mechanistic metaphor has held. Isaac Newton, his intellectual successor, elaborated this paradigm by setting forth the proposition that astronomers could "correct" celestial time by measuring duration using an even more "accurate" time. He called this more accurate time "absolute, true, and mathematical" Time, and distinguished it from "relative, apparent, and common" time. His new definitions greatly facilitated the oncoming scientific revolution.

Newton perceived absolute Time as that which flowed equably and unchangeably without relation to anything external. Since celestial movement does not "flow at a constant rate," "mean solar time" was invented. It is a peculiarity of anthropocentrism that human mechanical time is designated as more accurate than the solar; yet, it is mechanical time that is adjusted to the solar through the use of Mean Solar Time.

The idea of a constant rate of temporal flow—the linear vector—made it imperative to be able to record time in more detail. As a result, an increased interest in clocks developed that has had even greater impact on the linearization. While clocks originally were modeled on the cycle, and the counting repeats in cyclical fashion, modern time (the real time of machines such as computers) continued to be straightened into the linear mode made possible by counting. Not only were the years and days counted, but humanity began to count the hours and minutes, and eventually the seconds, until today we can count nanoseconds. Digital clocks with their numeral displays perfect the paradigm. The "equitable flow," infinitely divisible, is clearly seen in the display of a digital atomic clock (I should say, "clearly not seen," as the display changes so rapidly that the clock must be "stopped" in order to be read.)

The full realization of linear time, as we've seen, derived from the concept of absolute Time. Again Arthur Schopenhauer provides the most succinct summary of its attributes: There is only one Time, and anything appearing to be different times are parts of that one Time; this one Time is infinitely divisible; it is homogenous and a continuum, in that no parts are different from the rest, nor are separated from it; it is omnipresent, in that every part of Time is everywhere, all at once; it is by reason of Time that we count; and Time can be perceived *a priori* only in the form of a line. With the straightening complete, all that was left was for common sense to catch up with this new perception. The best way for this to happen was with practice, and especially from the time of the Industrial Revolution onward the regulation of people's lives by the hour and the minute was added to that of the days, the months, and the years.

One of the products of linearization, chronology, is a familiar historical idea. Once the concept of a single time had been rationalized, and once datability via the numbered calendar had been realized, the potential was opened for describing the history of the world, or, at the very least, of placing all the events of the world into a single chronological order. The advance of chronology was contemporary with Descartes' mechanistic paradigm and Newton's elaboration of absolute Time. Joseph Scaliger, a seventeenth-century scholar, essentially founded world chronology, and codified, according to historian Arno Borst, the ideas of progress and of historical time itself. Scaliger's work included calendrical computation for a variety of cultures at different times, and attempted to fix and collate the dates of important events from around the world—not just to the year, but to the day. Scaliger's counting was based upon a wide range of celestial motion, so he proposed the use of a "universal" measure of astronomical chronology known as the Julian Period, and set the "beginning" at January 1, 4713 BC. As this date substantially preceded Biblical calculations, Scaliger's opponents retained the AD/BC system of numbering. Julian Period dates, however, are still in use by modern astronomers.

From Scaliger's time onward especially, the idea of the timeline has taken hold and chronology has informed historical projects. Absolute, countable or datable Time can be assigned to any event, *anywhere*, then placed in order along a single, universal timeline. One of the underlying bases of all modern or scientific history follows from this abstraction (Fig. 37).

Spacetime

But what happened to absolute flat Space and linear Time after Einstein? A caveat is necessary: the special and the general theories of relativity—of 1905 and 1915 respectively—are most evident mathematically and are therefore generally inaccessible to most of us. It is also true that the full implications of the theories are manifest at the macro-scale of the universe, and with phenomena that are moving very rapidly with respect to each other. Terrestrially, we are told, our ordinary experiences are still describable by the absolute concepts of Time and Space.

There is, I suppose, a certain insurance in such a statement; we can cling to those old ideas if we want. On the other hand, the capabilities of atomic and laser clocks have made spacetime relativity measurable in Earth, and many philosophers and scientists have considered the everyday implications of the theory to be profound. Having set out to consider whether spacetime had implications for us in Earth, it became clear to me that the principles of relativity theory, especially as expressed philosophically, revealed significant truths about space-and-time in the biosphere.

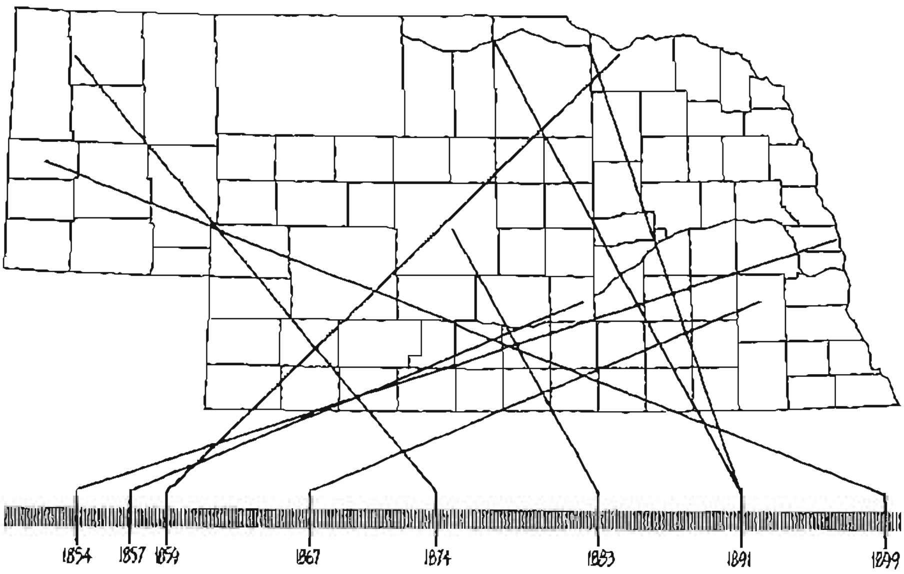

Fig. 37 **The timeline as dis-placed (de-spaced) linear abstraction.**

Not the least of these concerned the aspect of point-of-view, which is discussed immediately below. While all of the protagonists of the Space and Time stories were dwellers in the biosphere, their perspectives were elsewhere. Time and space must look quite differently depending upon your perspective

The principal point-of-departure for relativity theory concerns the idea of frames-of-reference, or what we might call points-of-view. Think of these as observers of events positioned in different spaces, such as on different celestial bodies, then think of those bodies moving at different rates of speed. Each observer carries a clock accurately synchronized to a single time. According to Newton any observer of an event, no matter where they are positioned or what their speed, would agree with others on where and when the event took place. However, Einstein found that clocks run at different rates depending on the motion of the clock. Newton's assumption that true duration flowed equably without reference to anything external, that it was independent of motion, implied that somewhere there was an absolutely motionless place from which true absolute Time could be measured. We now know that a stationary place does not exist in the Universe (Cf., for example, any observer on Earth might perceive that the planet is stationary, while one positioned on the Sun would see it spinning and moving in excess of 600,000 miles per hour.) . The idea of a privileged objective position from which could be detected a single, true, universal, or absolute Time gave way; all views of time became valid from the perspective of their own space.

To put another spin on this, consider ordinary observers on different rotating planets, all moving at different speeds. Knowing that the same clock would run at different rates on each planet, we can see other ways that time in each planet's space would be distinct. Days would be defined by the duration of each planet's rotation, and years would be defined by the duration of their revolution about their sun. If each were to divide their days into hours and minutes, they would all be quantitatively different. Measurements of duration would be unique to each space. Contrast this with Newton's notion of absolute Time. It came to be measured geocentrically, or in Earth years, minutes, and seconds, and then those units were projected out into the rest of the Universe. The numbers that we think make sense here seem nonsensical elsewhere.

Related to the projection of absolute Time onto the Universe was a need to make it manifest *in* Earth in order to count it from here. If absolute Time was to be the same everywhere at any given instant, this Time somehow had to be made the same here also. Since time was the same in Earth only along any given meridian (half a great circle), those who might count this universal Time from one place would have different values from those counting from another. The solution was to establish a "prime" meridian as the standard. Greenwich, England, eventually became the "point" through which this line ran, and Greenwich Mean Time became the "universal" Time that was counted at the Prime Meridian. (This has been superceded by Universal Coordinated Time, which is controlled by a laser clock in Washington, D.C.)

There really wasn't an acceptable way to project absolute Time other than by concentrating its measurement onto a single meridian. The logical choice of making time everywhere the same in Earth would still require a prime meridian, since the measurement is in relation to the positions of other celestial bodies. On a spinning sphere the relative positions of these other bodies are constantly changing, and the timing is dependent upon where on the sphere the measurement is being taken. In order for everyone to count the same time, adjustments would have to be made for position. So while Time became focused along the Prime Meridian, ordinary time remained spaced and was measured by the movement of the midnight/noon meridian. (Nor would tradition have allowed the institution of the same time everywhere; solar noon, for example, somehow had to remain in the vicinity of 12:00 P.M. Curiously, the same apparently would not prevail with calendar time; the springtime month of May in the northern hemisphere is an autumnal month in the southern.)

The idea of local time remaining spaced itself exemplifies spacetiming. Like all meridians, the one at Greenwich is a "great circle" that divides the Earth in half; and the line itself is divided in half by the poles (or into quarters by the poles and the equator). Each of the divisions of this line, being in different spaces, marks different times. Solar noon is also a meridian "line", and is, in fact—like the sunrise and sunset geodesics—a single "time" that never changes but constantly changes space. Noon along one side of the meridian is midnight along the other, and a winter solstice along one half is summer along the other. Local time did not become de-spatialized until the onset of Standard Time in 1883, and then even more noticeably in 1942 with the advent of Daylight Savings Time (Fig. 38).

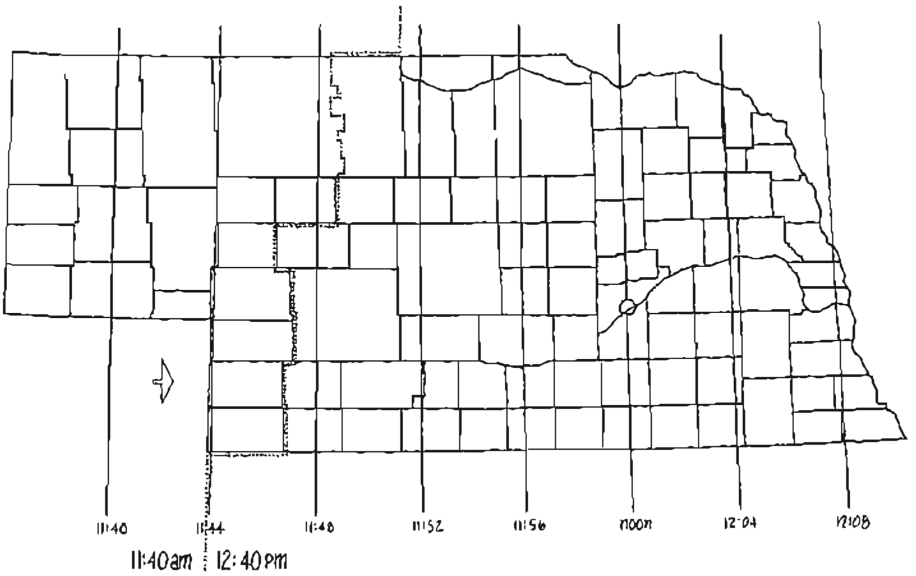

Fig. 38 **Spacetimes compared to linear Standard Time (cf. Table 2). The map shows local times at meridian intervals of one degree of longitude for solar noon at Central City; the dotted line indicates the corresponding Central/ Mountain Standard Time over the same area. The CST extends eastward to the Indiana border, and MST westward to the Nevada border. The arrow indicates the direction of planetary spin.**

At any rate, measurement of time from different points-of-view first revealed the spacetime continuum. Physicist Leo Sartori states that part of Einstein's genius was in his fundamental reassessment of Time; since Newton's formulation no one had considered that it might need rethinking. Following Einstein, the single, universal "clock" was replaced with multiple clocks, and time became absolutely *relative* to each observer.

To understand the spatial aspect of spacetime we need to first return to "things." Both of Newton's absolute determinations really followed from his definition of absolute motion, which was a restatement of Galileo's law of inertia. In essence this law asserted that every thing moves uniformly along a straight line provided nothing interferes with its movement. Since Einstein, however, we know that movement along a straight line is impossible, for he showed that bodies formerly thought to be merely *in* space could no longer be thought to be separate from space, and that moving bodies tend to bend space in their vicinity. As Sartori puts it, space cannot remain flat in the presence of matter, and geometry on a rotating body is not Euclidian.

Again we can readily see this principle in the curved space of Earth: two lines projected from points to run parallel to each other, in any direction, will eventually meet—such as we have configured our lines of longitude—and those lines, projected to be straight, are really bent by the gravity of the planet (Fig. 39; a level line on Earth is "level" only at the tangent point, or at the location that level was determined). In curved spacetime the so-called Euclidian straight lines turn out to be geodesics that describe great circles; in spacetime the shortest distance between two points is a geodesic, not a straight line. The Cartesian grid of the government survey lines are perfect only on a sheet of paper; or on a map that is drawn as a Mercator projection, which distorts real space dramatically the farther one is away from the equator. Placing this grid in the spherical space of the Earth's surface was quite difficult. East-west lines would tend toward the equator, so surveyors had to continually correct these lines to make them appear correct in flat space (notice, for example, the undulations of the northern and southern state boundary lines on any accurate map of Nebraska). North-south lines required a different sort of correction to keep them from converging as well, for they would tend to be meridians like the lines of longitude (thus the offset of north-south section lines at the "correction" lines along each standard parallel; see Fig. 40).

A comparison with flat space clarifies the situation. I recall being erroneously taught in primary school that before Columbus, people thought the world was flat; that if you sailed the oceans far enough you would reach the edge and fall off. If you imagine yourself sailing away from the land and were predisposed (by being taught) to see space as flat, you would probably "see" the features of the land diminish in apparent size and then disappear as though they simply had become too small to see any longer. As you looked out upon the ocean in any direction, you would likewise see neverending flatness.

What you should actually see is curved Einsteinian space. When the land disappears, it does so "over" the horizon, and when you look out upon the ocean in any direction, you do not

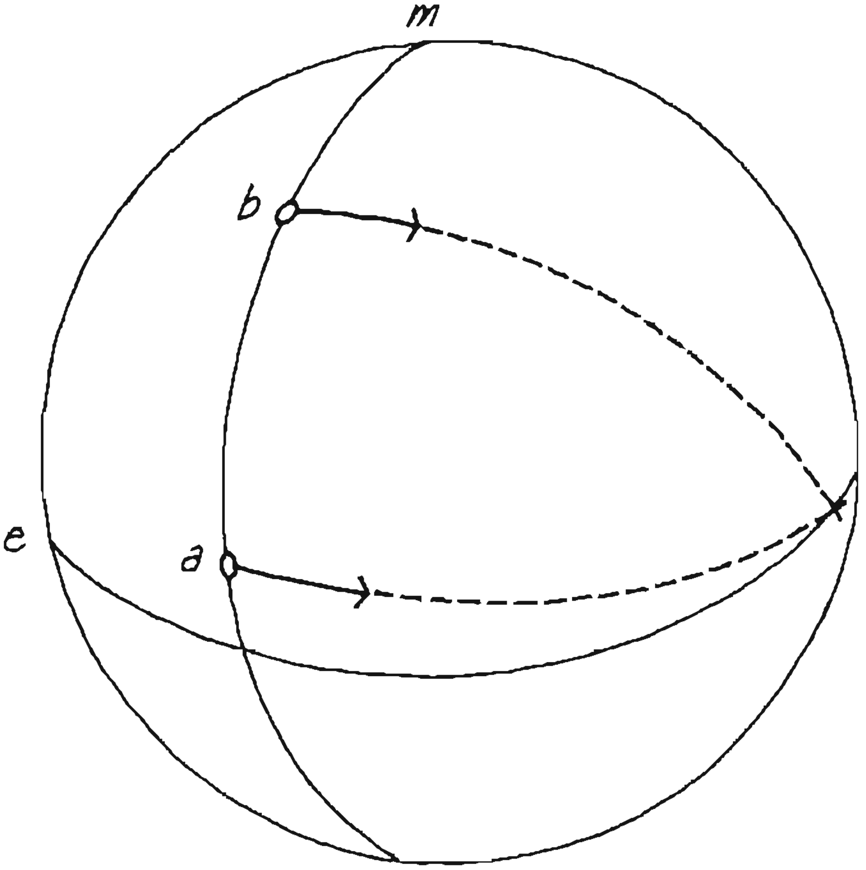

Fig. 39 **Parallel lines in curved spacetime. Two lines projected to run parallel and due east from points (a) and (b) along a common meridian (m) are bent by gravity and converge at the equator (e).** After Sartori, Fig. 8.15

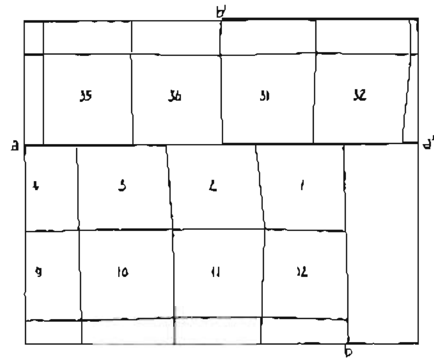

Fig. 40 **Adjusting the flat Cartesian grid to the curved surface of the Earth. The depiction is of survey lines along the 7th Standard Parallel "correction line" (a-a') in western Cherry County. The correction, or shift, in the township lines is indicated at (b-b'). Other odd adjustments to the grid (note the non-orthogonal lines and the missing lines) have been made for complex historical reasons; these are found throughout the Sand Hills region.** Adapted from USGS 15 Minute Series topographic map, Turpin Lake Quadrangle

see infinite flat space but instead a space contained by the *circular* horizon. Within this horizon, at which you are centered, the world itself appears as a *curved* surface, like the bulging segment of a sphere with your ship at the highest point. (The closer to the ground your point-of-view, the closer the horizon is to you. Sailors could see "farther" from their position in the crow's nest because it extended the horizon away from them.) In essence, this can also be seen from selected locations on the High Plains, though perhaps somewhat less clearly depending on local topography. Nevertheless, all around is the circular horizon, over which the world *recedes* from view, as opposed to disappearing by virtue of distance alone.

Returning to Newton's first law of motion, upon which was built the whole of early modern physics, we can begin to sense the impossibility of his "straight" lines. Neumann, even before Einstein, called the law completely unintelligible. His anticipation of the curvature of Space was summarized in the statement that every motion that appears to be rectilinear with respect to one celestial body will appear to be curvilinear with respect to another. While it is not motion *per se* we are discussing, motion and gravity play key roles in the curvature of spacetime.

Since this discussion is out on the "edges" for the moment, we might just as well visit an interesting observation for the perspective it provides concerning the nature of spacetime. Minkowski's early description of the spacetime manifold suggested that the spatial and temporal dimensions were interchangeable, or isotropic. Einstein later clarified that though the dimensions are indeed fused into a single continuum, they are not isotropic in that the spatial and the temporal remain distinct. This preserved both space-like and time-like aspects as part of spacetime. You cannot go back in time, but you can turn around in space.

While we remain cognizant of the distinction between extension and duration, it may not be so clear wherein the actual flux of the Universe is evident. Physicists Clifford and Robertson, one before and one after Einstein, had commented upon the possibilities that the curvature of space was variable over time, and that it even varied in different "parts" of space. This raised some rather interesting philosophical possibilities. Čapek, in one of his articles, concluded that the relativistic union of space and time might be expressed more appropriately as a "dynamization of space" than a spatialization of time. With his view, the favored position of the temporal as record of the dynamism of the Universe is exchanged for the spatial; rather than viewing time as flowing, it may be more appropriate to view space as unfolding.

It seems difficult to exaggerate the extent to which the old concepts have been disposed: so much so I think we can say that as "truths" they have been reduced to historical artifacts. The long-held belief in a situation wherein Space and Time were considered to be absolute and independent entities has given way to a more realistic notion that the two are relative and intertwined. It now seems appropriate to discard those concepts in favor of a single spacetime continuum, a situation which in essence is neither rectilinear nor flat.

Spacetime In Earth

Is it possible to envision unified space-and-time in a more ordinary sense, and to what ends? The notions expressed here thus far have been *so* contrary to our previous ideas of absolute Space and Time that it seems futile to attempt an explanation in terms of those old abstractions. Maybe a brief restatement of the principles in different terms, focusing on earthly experience, will better capture the essence.

Three notions from the spacetime theory emerged in this discussion that seem to make sense in Earth. The unity of spacetime I take literally to mean space-time simultaneity, a principle that can be expressed by the terms place and embodiment; the curvature I take to be expressed by rhythmicity and horizon; and the relativity I take to mean points-of-view. This latter notion can be further expressed in terms of multi-rhythmicity and multispatiality, truths rather than Truth, and the demise of both ethnocentrism and anthropocentrism.

In terms of unity, forget Space, and Time: these absolute abstractions have no place in Earth. Rethink them as relative aspects of the world, both given together as revealed by the multiple "things;" or consider that both are dispersed together with whatever becomes organized in the Universe; or that each thing generates, in a way, its own spacetime. Just as gravity was essential to the formulation of the spacetime theory, so too can this concept of embodiment in "things" assist our understanding of how space-and-time are unified in the biosphere. Nobody has ever experienced a time that did not also involve an experience in space. In fact, every thing that can be said to have ever existed in time also—and this is crucial—*simultaneously* existed in space. The old Newtonian conception of there existing a simultaneity of all instants everywhere in absolute Time, gives way, as Robb put it, to instants that do not extend beyond their own *there*: times simultaneously in spaces, or spacetimes

A synthetic way to envision this unity is through the concept of "place." Though this term is used in many ways, I mean it here in a nonanthropocentric sense as the assemblage or community of things, in *their* particular spacetimes, that coexist within the horizon of one's own spacetime This horizonal embodiment in place shows spacetiming to be heterogeneous, as distinct from the homogeneity of absolute Space. Further awareness of this sense of place might be accessed through more particular expressions of space-and-time unity, such as present-and-present, or present-presence, and here-and-now (or there-and-then).

Place incorporates "horizon," an aspect of the curvature of spacetime. This concept readily demonstrates how infinite absolute Space lacks meaning in the biosphere, for place is physically bounded by horizon. Earlier I showed how horizon on the High Plains visually establishes a circular ground for place there. This horizon may be visually contracted or expanded in a variety of non-linear ways—such as by the deep spacetiming of place expressed in local geology and topography, or in the copresence of native biota—as well as by the flat and linear artifacts of western cultural expression. Curvature is continually manifest through the celestial animation of place that occurs as the horizon spins, wobbles, and revolves within the galaxy.

The temporal curvature of spacetime can be discerned in rhythmicity, a synthesis of the truths of both the cyclical and the linear perceptions. I take the genius of Newton's linear awareness to be in his radical break from old cyclical stasis, rather than in the assertion of absolute Time as Truth. Over the course of the scientific revolution that was fostered by linearity, awareness developed concerning the flux, not just of the cultural world, but of the *whole* world. Among the ramifications of this awareness, the retrospective historical and evolutionary visions have to be considered as revolutionary as any. (I perceive a fundamental distinction between "rational linear progress" [an historical abstraction] on the one hand, and "spontaneous rhythmic creativity" [an evolutionary phenomenon] on the other.)

Newton's abandonment of the cycle in favor of the line may have been a necessity of his era, but it didn't cause the Earth to quit spinning. Only westernized humans have fallen into line with Newton's Time. In contrast, the perception of the temporal dimension of spacetime developed here is that the linear is only one aspect of the cyclical, and that a synthesis of the two is required. "Rhythm" seems to fill this need (Fig. 41). (Flatten any biospheric rhythm onto a two-dimensional plane so that you can see it as a "line" and it will appear wave-like.) There is nothing straight or flat about the biosphere outside of culture. In terms of curvature, rhythmicity varies from place to place, horizon to horizon, as local response to the rhythms set by cyclic biospheric spin.

The notion of multirhythmicity (and thereby multispatiality) is derived from relativity's insight into the non-existence of any absolute frame-of-reference. Certainly there are multiple points-of-view for entities in the biosphere, and multiple truths, for the complex evolution of planetary spacetime resulted in an extraordinarily multirhythmic biosphere. No single Truth has priority over another in this context. Ethnocentric and anthropocentric positions falter; truths established by one cultural entity are not necessary truth in another, and truths established by cultural entities are not necessary truth for the other-than-human world.

At the risk of belaboring points made better by others, reconsider a familiar historical abstraction: the epic of Manifest Destiny. Taken from a Euro-American point-of-view, the settlement of this continent from east-to-west was the epitome of progress and success. Turning around in space reveals a different story. While I do not pretend to speak a Native view with any authority, I cannot but think that this event, looking from west-to-east, was anything but the epitome of chaos and decline. White western perceptions of the Plains as "emptiness" and "waste" are countered by Native perceptions of fullness and life. Taking the story out of Space and Time and setting it into place sharpens the image. Native peoples living in abundant place are invaded and subjected to all manner of abuse. Voice given to all others in place, nonanthropocentrically, turns Manifest Destiny into biogenocide. Looked at linearly, it may be that the ascent of any line of progress implies a decline along another. This is a matter of effect, or the other side of the story. In place it would seem impossible to ignore the other side, since I have defined place, in part, by the presence of Other.

Perhaps another sense of the unity, multirhythmicity, and curvature can be gained from this broad summarization. the spacetime of the Universe, as a whole, is further expressed in the *various* spacetimes of galaxies; the spacetime of the Milky Way is further expressed in the various spacetimes of solar systems; the spacetime of our solar system is further expressed in the various spacetimes of planets; and the spacetime of Earth is further expressed in the various spacetimes of the diurnal and seasonal biosphere. The dispersion of spacetiming into smaller regions tends toward greater multiplicity and diversity. There are many ways to describe this dispersion for the biosphere, including species, cultures, bioregions, ecosystems, places, and ultimately, all the living things. Any of these, considered alone, is spatially and temporally distinct from the others. They all are also embedded, the smaller within the larger, and have been manifest only through very deep cycles

Our sense of the truth of spacetiming is enhanced by new stories: those that expanded history beyond its formerly exclusive expression of culture. Among the stories being told in our era, just by way of example, are those of the universe as a whole (cosmology), the planet as a whole (geology), and those of or in the biosphere (e.g. biogenesis and biological evolution). These, it seems to me, cannot but profoundly alter the context of our spatio-temporal thinking. Though told in historically linear ways, they clearly are stories of phenomena that unfolded non-linearly. They also only make sense when spaces are taken together with times, or the "things" are taken together within their own spacetimes. The story of biogenesis in Earth makes the point. This was no mere abstract event set somewhere in mechanistic Time or infinite Space Rather, it was *here*, in Earth/Solar/Milky Way spacetiming, that a planet evolved a biosphere.

Returning to my original point-of-departure, whether or not we are spatially-

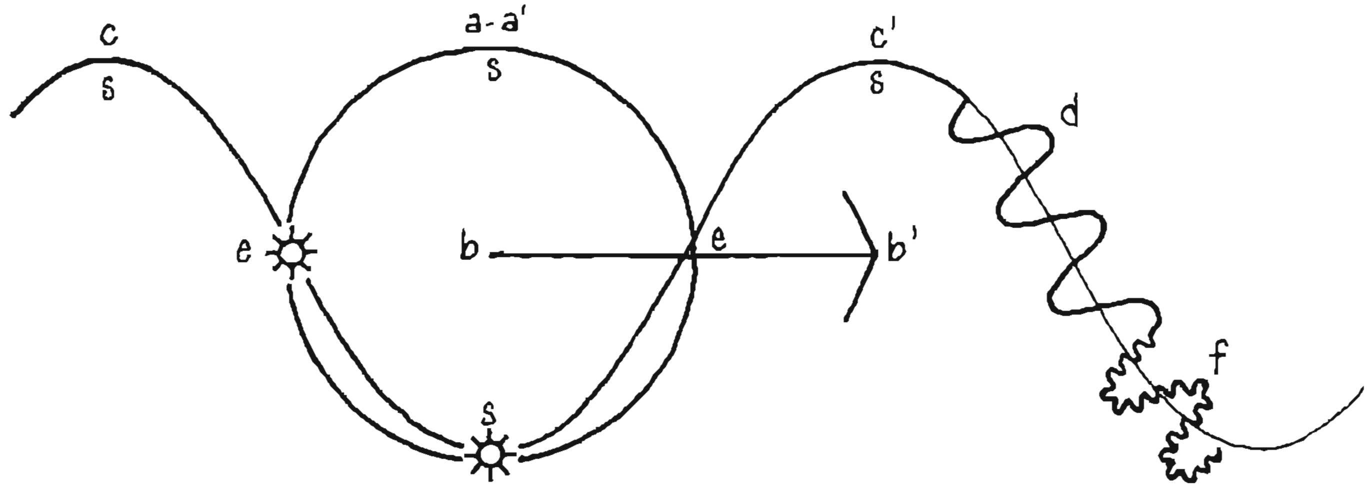

Fig. 41 Schematic two-dimensional diagram comparing the annual geometries of static cyclical time (a-a'), linear absolute Time (b-b'), and rhythmic time (c-c'); the embedded rhythms of the diurnal cycle (d) and an individual entity's rhythm (f) are also indicated. Equinox (e) and solstice (s) locations are shown for cyclical and rhythmic times.

or temporally-oriented, we usually do not think *about* time or space as such. Those concepts are just taken for granted and reside in the background of the histories we write. Henry Glassie's study may not have provided a polemic on the issue of time versus space, but he did provide one that critiqued the priority of text (in the context of this discussion, text often displaced, or even written out-of-place) as the principal source for history. His arguments on behalf of things in space as primary sources resonates with some implications of the spacetime theory.

The assertion that it no longer makes sense to temporalize phenomena without also spatializing them in historical analysis suggests that we are now required to reconsider our background assumptions. This does not mean that the stories need be *about* space-in-time any more than they need be about time-in-space; it merely means that stories set *in* time will make more sense if thoroughly set in spaces. More to the point for this discussion are the difficult tasks of avoiding the abstractions and setting histories in multirhythmic, simultaneous "there-then" place. Considering effects, accounting for others, and acknowledging embodiment as well as thought, might be included as strategies for accomplishing these tasks.

Just when will the old perceptions of Space and Time "fade away into mere shadows, and only a kind of union of the two. . .preserve an independent reality," as Minkowski stated so long ago? One difficulty in anticipating such a shift is that the linear paradigm has proven to be such a powerful abstraction. Its acceptance is indicated by the control it exerts over our behavior. Not only does it guide retrospective endeavors such as research programs, but it propels prospective development as well.

The manifestation of linear abstractions through our thinking, economy, and our various technologies is literally remaking—or replacing—the biospheric world with one that is linear and flat. We do this by chopping horizonal place into discreet flat spaces with rectilinear boundaries, then controlling what happens in those spaces according to goals, the progress of which is charted by ticks on clocks. Rhythmic place is displaced, converted into linearity, or eliminated.

But life is no mere abstraction. The imposition of flat linearity on the whole planet appears, from here-now, to be overwhelming the biosphere. Since the onset of history the linear vector has been accelerating, and we can now see the consequent loss of cosmogenetic biological and cultural diversity on the horizon. Maybe a shift into a spacetime perspective on biospheric place will help us to regain an appreciation of the lifeworld, for its own sake; the world that, while we are alive, is most important. In the lifeworld spaces are in times, and times are in spaces. They are everywhere always coincidental in place.

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