The Unification of Concept Representations: An Impetus for Scientific Epistemology*†

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ABSTRACT: For virtually every major category of phenomena, science provides some standard schematic (e.g., the cross-section of the earth). The most notable exception concerns the cosmos as a whole. Project Cosmology (www.projectcosmology.net) is devoted to the presentation of such an holistic schematic. This is to be achieved by plotting the standard schematics for constituent phenomena within a three-dimensional coordinate system, time on the vertical axis and space on the other two. This produces a unification of schematics. As is discussed, this approach has the effect of allowing, more generally, an interactive unification of *all* graphical concept representations (schematics, graphs, formulae, tables, etc.). The result is a 3D, scientific, graphical user interface (GUI), one that is intended to map all knowledge. It can be characterized as a graphics approach to knowledge organization. It will be for scientific concepts what the Human Genome Project is to human DNA. The project is having the effect of revealing unnoticed gaps in knowledge, inconsistencies among the different sciences and apparent regularities throughout and across the various disciplines. Any such regularities would be laws relating to laws (i.e., laws relating to knowledge). The project, then, may facilitate the development of scientific epistemology (something already in process). This unification of concept representations is based on a cosmological perspective that provides a one-to-one correspondence between major entity and aspect classifications.

* Terms in brackets, e.g., [The Atom (LF) ⇒ H (RF)], indicate link paths at the website. "LF" refers to the left HTML frame, and "RF" refers to the larger of the right frames. (In this example, "H" refers to hydrogen in the Periodic Table.)

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1.0 Introduction

In addition to the common graph, science makes much use of schematics, and for each major phenomenon, there is typically some diagram (e.g., the cross-section of the earth, the phylogenetic tree, the embedding diagram for the gravitational field). There is, however, one critical exception to this rule; we have no schematic for the cosmos as a whole. This discussion, then, is concerned with the description of a proposed schematic to fill this role. This is to be produced by plotting the standard schematics for constituent phenomena along a timeline (part of a 3D coordinate system) in the order in which the phenomena have typically developed.

In this context, the term "cosmos" is being given a very broad interpretation; as would be indicated by the range

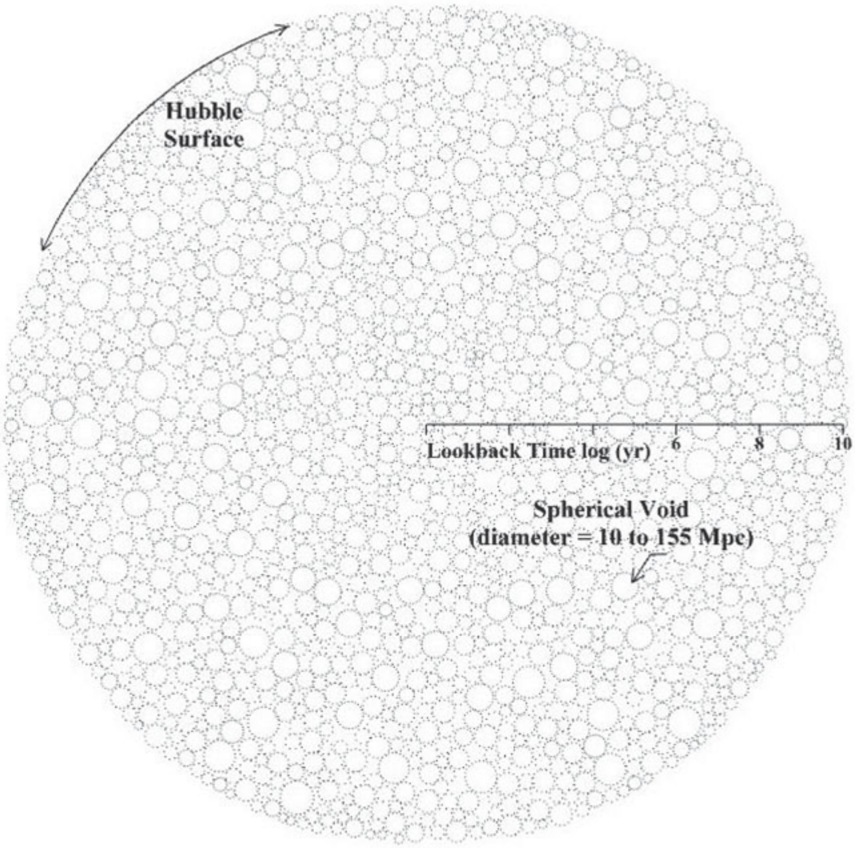

Figure 1. Simulated cross-section of the Hubble Sphere.

of scientific disciplines, it includes time, space, particle phenomena (e.g., atoms, planets), life, and civilization. Astrobiologists generally believe that life and civilizations are common in the universe; we have no evidence at this time, but the relevant science supports this suspicion (e.g., Gilmour and Sephton 2004). Life and civilization are now widely viewed as critical considerations for cosmology (e.g., Harrison 2000; Davies 2004); this holistic sense of the term is increasingly the accepted interpretation. This view has perhaps been best articulated by the editors of the online *Journal of Cosmology*, according to whom "Cosmology … is the study and understanding of existence in its totality, encompassing the infinite and eternal, and the origins and evolution of the cosmos, galaxies, stars, planets, earth, life, woman and man" (http://journalofcosmology.com/About.html). Cosmology, in this sense is the all-embracing science; all other disciplines are subordinate. It is important to note that this list (time, space…) is comprehensive; it includes all known phenomena. (Our lack of evidence in support of the apparent consensus among astrobiologists might well be the simple result of our present inability to inspect exoplanets, except with the crudest of techniques; currently, we detect them primarily by their gravitational effects on host stars.)

Note also that something such as a concept, a language, or a machine would be a feature of civilization, as are religion and art. Furthermore, mind in its most developed state is, as far as we know, exclusively a feature of civilization. From this perspective, then, there are three primary divisions to knowledge: the physical, life and civil disciplines. Note that these correspond precisely to the primary categories commonly used in systems theory (e.g., Bertalanffy 1968; Laszlo 1996). There are, of course, alternate schemes for such metadisciplines, but those used here appear to be the emerging *de facto* choices of both cosmology and systems theory. Also, from this perspective, there are three primary phenomena or systems: the Metacluster (expanding aggregate of galaxy clusters), the biosphere, and civilization. Note the one-to-one correspondence between disciplines and phenomena (aspect and entity classifications).

Notice also that something such as the cross-section of the Hubble sphere, Figure 1, an alternative schematic for the cosmos, produces a relatively uninformative result; it would only tell us about the distribution of galaxy clusters; it says virtually nothing about other phenomena. Each dot is a galaxy cluster (collection of galaxies). This represents the Hubble Sphere for the typical observer over cosmological time. For the present epoch only, the

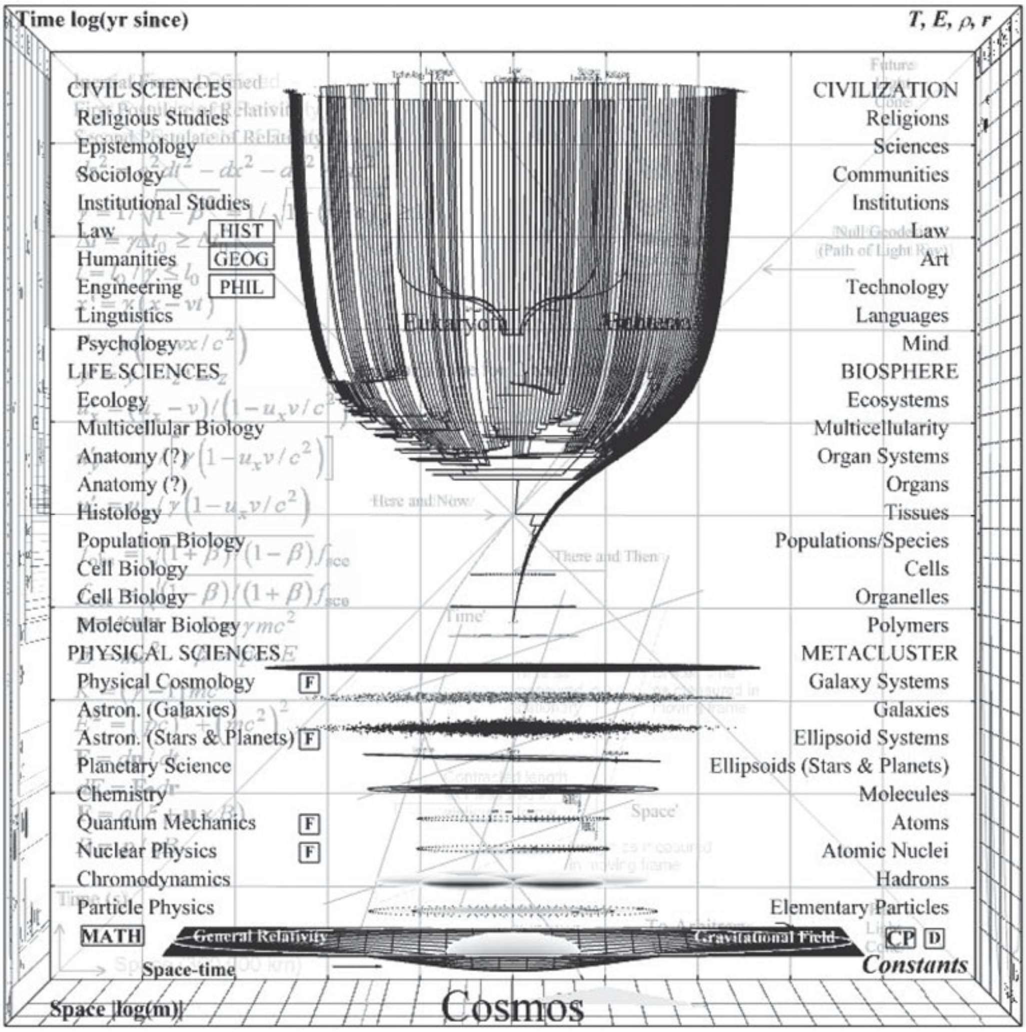

Figure 2. A unified schematic.

axis would extend to a lookback time of $1.37\times10^{10}\,yr$ (1.37×10^{10} light years in distance). Notice that as a schematic for the cosmos, this tells us only about the distribution of galaxy clusters. It indicates nothing as to other phenomena. Figure 1 would be a schematic primarily of relevance to physical cosmology, one aspect of the more general subject area.

Contrast this to Figure 2, the proposed schematic for the cosmos, something that can apparently accommodate any level of detail relating to all phenomena. This Unified Schematic results from plotting the standard schematics for natural phenomena in a 3D coordinate system, time on the vertical axis and space on the other two. Positions along the vertical axis correspond to typical formation times over the course of cosmological evolution. The frame-like structure is the coordinate system, the standard schematic for space and time. (Dimensional units, meters and years, are mouse-over effects at the web site; Figure 2 is a screen shot.) The lowest schematic, the embedding diagram, is the standard schematic for the gravitational field. Above this, we plot the standard, disc-like, cross-sectional schematics for particle phenomena (e.g., the cross-section of the Earth). In the upper section, we plot a 3D version of the phylogenetic tree or cladogram, and within that, a suggested schematic for civilization. These phenomena are accordingly labeled along the right, providing a comprehensive list of all known phenomena (an all-inclusive entity classification). Along the left, we label the corresponding disciplines (providing a one-to-one aspect classification). At the web site, on-click events for the list of phenomena load classification tables to a second (right side) frame. Individual schematics, e.g., for the hydrogen atom, are called out using links in the classification tables. On-click events for the list of corresponding disciplines will eventually load 3D concept maps to the right frame. These will lead to summations of concepts. Additionally, several standard tables and graphs are found to fit well as panels to the coordinate system, e.g., the geologic time scale (left side panel) [Time log (yr since) (LF)]. The system can apparently accommodate any level of detail, encompassing the entire body of science concepts.

There are, however, several alternative ways of characterizing the project. One of these would be to say that it attempts to present a unification of the various standard schematics used throughout the sciences. However, this approach has proven amenable to the inclusion of all other graphical concept representations. Thus the unification would relate to all of these. Notice that the unification of concepts has been one of the broadest features of scientific progress; in this case, we are extending the effort to the manner in which concepts are organized and presented. Furthermore, this approach is apparently conducive to the systematic, graphical presentation of all concepts from the various special disciplines (even philosophy and the humanities). Thus another characterization would be that this effort concerns an attempt to map all knowledge. In any case, the result is a scientific, GUI, one devoted to the access of knowledge. It constitutes a graphics approach to knowledge organization. It is the author's contention that this approach will be to the expository alternative (i.e., explanation in words) what the pervasive GUI has been to the command-line interface (CLI) for computer use. By way of analogy, the effort is the epistemic equivalent of the genome project.

The justification for the project has to do, first, with the fact that schematics facilitate understanding. Likewise, they facilitate retention and review; the human mind works most effectively with images (hence the supremacy of the GUI in relation to the CLI). Furthermore, this project tends to highlight gaps in knowledge. It has revealed, for example, that there is no existing schematic for civilization, a clear indication that we do not have a rigorous conceptualization of this phenomenon. A comparable situation would exist if we had no schematic cross-section for the earth; this could only mean that we had a poor understanding of its geological structure. Since the effort to map any terrain invariably leads to its better understanding, the effort to map all knowledge would surely have similar results. As is further discussed below, the effort is, indeed, having the apparent effect of identifying unnoticed patterns throughout and across the various disciplines. This suggests the possibility of metalaws for science, a scientific epistemology. (Over time, the program will be developed to include analytic capacities, e.g., horizontal slices through the cladogram for purposes of identifying biosphere structure at a given historical time).

In this connection, we might briefly note the advantages of 3D, interactive graphics in science. First, they eliminate the reliance on 2D, static diagrams for phenomena that are, in fact, three-dimensional and in motion (2D representations of 4D phenomena). Likewise, they eliminate the need for schematics drawn to a false and misleading scale (e.g., the typical schematics for the solar system). Further, they eliminate the reliance on graphs drawn only to a crude level of detail, neglecting critical microscopic aspects (e.g., the fine structure for atomic energy levels). They also allow us to get past outdated graphics, e.g., the so-called modern Periodic Table. This is little changed from the one developed by Mendeleev prior to the advent of modern atomic theory. It is greatly inferior to the Stowe Periodic Table, Figure 3, something

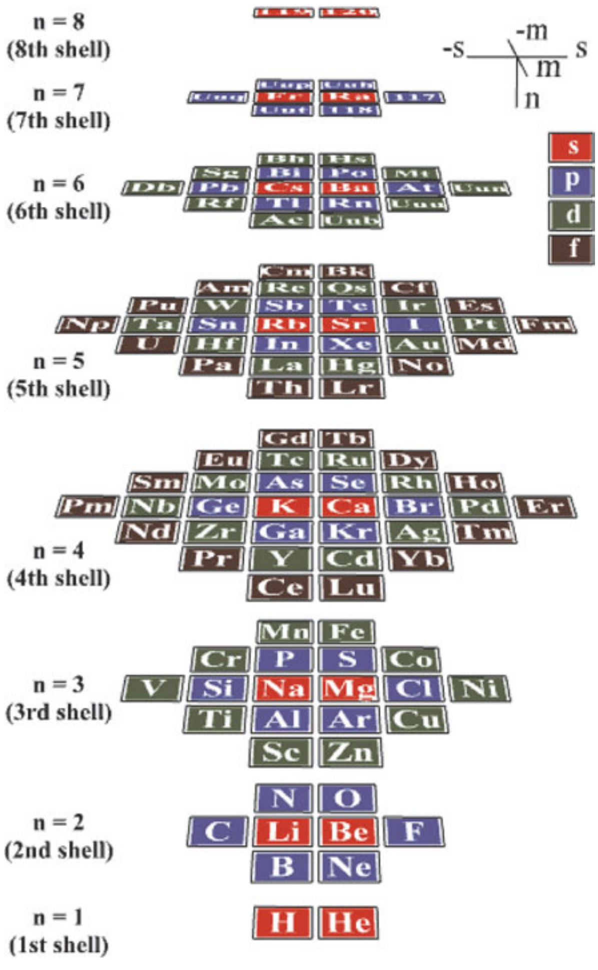

Figure 3. The Stowe Periodic Table.

that is based on the fundamental parameters of quantum mechanics (Channon 2011). If this project does nothing else, then, it dramatically illustrates that the future of scientific illustration is three-dimensional, interactive graphics; the 2D, printed schematic is to scientific visualization what the slide rule is to mathematics. The parameters are the three quantum numbers, n (shell), s (spin), and m (orientation). These are the fundamental determinants of atomic structure and properties. Notice the perfect, overall symmetry. All classes, groups, and "blocks" likewise fall into perfect rings, columns or levels, providing, for the first time, precise, quantitative meanings for "period," "group," and "block." The 3D, interactive version (www.

projectcosmology.net) provides simple, on-screen controls for manipulation and isolation of rings, columns and levels. Each individual symbol is a link to extensive data. In time, each symbol will also provide access to energy level diagrams, 3D, interactive orbital schematics, and lists of formulae for quantum mechanics. Due to budgetary constraints, only hydrogen is fully developed at this time. However, this sufficiently illustrates that the system can potentially accommodate all concepts related to a phenomenon and *in a graphical format*.

This is a project that must cover every intellectual discipline, every topic and every concept. Furthermore, these must be graphically rendered in 3D, interactive format, something that often requires creativity and much trial and error. Properly developed for existing knowledge, the project would require a very extensive collaborative effort extended over at least several years. It would also require a significant budget, at least several million dollars. Indeed, this is a job that will never truly be completed (unless intellectual activity as whole is somehow finished). However, any degree of success would be worthwhile. This project is, then, an extremely ambitious endeavor, far beyond the budget and abilities of the few individuals currently working on it (primarily the author). Due to the inherent enormity of the task, the most that can be provided at this time is the illustration of a potential. This project, then, is currently very much a work in progress. Some of the schematics are cartoon-like. Others are grievously superficial. A careful review will undoubtedly find numerous mistakes. Likewise, a fully adequate discussion of the project should touch on literally every intellectual discipline and would be, therefore very lengthy. It inevitably has numerous implications throughout science and philosophy, perhaps most notably, epistemology and knowledge organization. Properly developed, this discussion also would require an extensive collaborative and review effort. Hopefully, this will be presented at some point in the near future. The present treatment has been prepared by the author working alone. It is, in effect, little more than a lengthy summary; it is inevitably imperfect. These comments are not intended to discourage criticisms, quite the contrary. They are simply to emphasize that we cannot reasonably expect at this time anything other than a "first approximation."

2.0 Itemizing phenomena; the fully-formed criterion

The first step in constructing a schematic for the cosmos would be a consideration of the principles involved. There may be various approaches, but the one developed here is based on the point of view that the cosmos is more than stars, planets, and galaxies. A proper schematic must take all phenomena into consideration. The seemingly obvious approach, then, would be one that somehow incorporates a reference to the standard schematics for constituent phenomena. This, of course, requires an identification of the phenomena themselves, and that is somewhat contentious. The categories used here should be viewed as a first approximation; they cannot be considered definitive. These phenomena are listed both in Figure 1 and Table 1. The derivations of this list are discussed below. There are several apparent patterns. First, these phenomena all appear to be systems. Second, they tend to form hierarchies, as is often noted in systems theory. Third, there are some ten phenomena for each metacategory (physical, life, and civil), with an elemental unit in first position and an all inclusive phenomenon in final position.

Some definitions are required. In the Unified Schematic, galaxy groups and clusters are referred to as "Galaxy Systems." Likewise, "Ellipsoids" refers to stars, planets, and planetary satellites. These are grouped together, since they are essentially similar phenomena; a star seems so different only because it is, so to speak, a planet so massive that gravitational pressure ignites thermonuclear reactions. Notice also that other categories of phenomena have similarly striking differences. Some atoms, for example, are highly stable, while others emit radiation. Also, the typical planet is, like a star, a radiative "gas giant." "Ellipsoid systems" is a term introduced here as a reference to planetary systems, stellar clusters, binaries, and globular clusters. The term "institutions" is used in the strictest, sociological, interpretation; it is a reference to government, industry, the schools, the family, and the church.

The next issue concerns the manner in which to arrange the individual schematics. The most sensible approach seems to be that of placing them along a timeline. There is another, critical recommendation for this choice. A complete schematic for the cosmos must include not only the material phenomena discussed above, but also an explicit reference to time and space. (For the benefit of those who are unfamiliar with physics, space and time are physical phenomena with dynamic properties. The gravitational force, for example, is a consequence of the deformation to space induced by mass.) The standard schematic for time is a scaled axis, and, by including this, we incorporate the appropriate schematic for time. In physics, however, this schematic is typically in the form of a space-time frame (a 2D, Cartesian system), and, in using this, rather than a single axis, we include the necessary schematic for (one-dimensional) space. Notice, however, that in placing something such as the schematic cross section for a planet at a position on the timeline (i.e., such that the timeline is a "surface normal"), we implicitly evoke two spatial axes, since a cross section is two-dimensional. In adding two spatial axes, we produce, overall, a three-dimensional space-time frame.

Event	Event number N	Years ago	Years since big bang T_{ys}	Event time (log form) $T = \frac{\ln(T_{ys})}{\ln 10}$	T (truncated)	N from Eq. 1 (truncated)	Error for Eq. 1 (truncated)
Civilization	30	0	10000000000	10	10	30.701	0.701
Religion	29	0 to 100	9999999950	9.999999998	9(9)8	29.424	0.424
Technology	28	135	9999999865	9.999999994	9(9)4*	28.600	0.6
Science	27	322	9999999678	9.999999986	9(8)86*	27.596	0.596
Law	26	383	9999999617	9.999999983	9(8)83*	27.361	1.361
Communities	25	427	9999999573	9.999999981	9(8)81*	27.208	2.208
Art	24	708	9999999292	9.999999969	9(8)7*	26.439	2.439
Language	23	4600	9999995400	9.999999800	9(7)8*	23.159	0.159
Institutions	22	5000	9999995000	9.999999783	9(7)78*	23.021	1.021
Mind	21	10-12,000	9999989000	9.999999522	9(7)5*	21.884	0.884
Biosphere	20	?	?	?	?	?	?
Ecosystems	19	?	?	?	?	?	?
Multicellularity	18	?	?	?	?	?	?
Organ systems	17	5.4×10^8	9460000000	9.975891136	9.976	16.777	-0.223
Organs	16	5.5 to 5.9×10^8	9430000000	9.974511693	9.975	16.634	0.634
Tissues[1]	15	7.5×10^8	9250000000	9.966141733	9.966	15.865	0.865
Populations	14	1.1×10^9	8900000000	9.949390007	9.949	14.692	0.692
Cells	13	2.7×10^9	7300000000	9.863322860	9.863	11.658	-1.342
Organelles[2]	12	3.465×10^9	6535000000	9.815245592	9.815	10.771	-1.229
Polymers	11	3.5 to 3.9×10^9	6300000000	9.799340549	9.799	10.534	-0.466
Metacluster	10	?	?	?	?	?	?
Galaxy Systems	9	?	?	?	?	?	?
Galaxies	8	4.6×10^9	5390664637	9.731642314	9.732	9.725	1.725
Ellipsoid systems	7	?	?	?	?	?	?
Ellipsoids[3]	6	9.5×10^9	98300355.15	7.992555087	7.993	5.318	-0.682
Molecules	5	?	?	?	?		
The Atom	4	9.9×10^9	240994.4191	5.382006985	5.382	4.061	0.061
Atomic nuclei	3	$\sim 10^{10}$	10^{-6}	-6	-6	2.682	-0.318
Hadrons	2	$\sim 10^{10}$	10^{-14}	-14	-14	2.299	0.299
Elem.particles	1	$\sim 10^{10}$	10^{-40}	-40	-40	1.724	0.724
Grav. field	0	$\sim 10^{10}$	0	$-\infty$	$-\infty$	0	0

Table 1. Events, event times and derivation of the scaling equation (10^{10} yr idealized interval).

* Innovation in mathematical notation (e.g.): $9(2)5 \equiv 9.95$, $9(3)7 \equiv 9.997$. Note that 9(9)6 and 9(7)566 have the same number of significant figures.

1. The event time commonly attributed to multicellularity has been assigned to tissues, since the first multicellular organisms would have had about this level of development.
2. The event time commonly attributed to the first cells has been assigned to organelles, since the earliest "cells" would actually have had about this level of development.
3. The event time commonly attributed to galaxies has been assigned to ellipsoids, since the event time given for galaxies in astrophysics texts actually pertains to proto-galaxies and this corresponds to the first stars.

Note that the concept of "space" in science (or at least mathematics) has now become quite general and even sometimes metaphorical. In the most general usage, it is so-called, "coordinate space," and a corresponding coordinate system (e.g., the typical Cartesian system) can have any set (or system) of quantifiable parameters. These might be vectors, as in "vector space," or even functions, as in "function space." The typical coordinate space concerns physical distance. In the Unified Schematic, the diagrams in the lower half are to be read as in the physical space of the lower panel. In the upper half, diagrams (e.g., the cladogram) must be read as in a yet-to-be specified coordinate space of the overhead panel. This specification remains one of the major outstanding deficiencies for the project.

The assignment of event times is often problematic. This is particularly true of civil phenomena. Consider technology, for example. The earliest stone tools date to about 2.3 to 2.6 Ma. (Kibunjia 1994; Kimbel et al. 1996; Semaw et al. 1997; Wood 1997). However, our ancestors undoubtedly used more easily worked materials prior to that date, and a stick or a bone used for any purpose is a form of technology. But these would not be specifically human tools; animals are also known to use sticks and stones e.g., Boesch and Boesch 1984; Shuster and Sherman 1998). An even more extreme case is that of the wasp, Ammophila urnaria, known to use a pebble as a hammer. This was first noticed by S. W. Williston (1892) and George and Elizabeth Peckham (1898) and has been widely discussed since (e.g., Frisch 1940; Brockmann 1985). There does not seem to be any clear threshold between animal and human technology. Therefore, to trace the origin of technology, we need to look back so far that we are no longer discussing the features of civilization, nor even our distant ancestors (unless we are to look back as far as insects).

In order to assign event times methodically, then, we need to develop some alternative principle. Event times will be assigned, then, according to when the phenomena first appear as fully formed (all components in place). This is recommended here as a way to normalize an event time. (This procedure would be comparable to using the width at half maximum to characterize a Gauss curve.) We can combine the above considerations, then, into what can be termed the "fully-formed Criterion:"

> *The standard schematics of phenomena will be arranged within a 3D coordinate system according to fully-formed event times.*

The application of this principle is not always straightforward. It is, however, a good deal more workable than the alternative. In particular, what constitutes the fully-formed condition for phenomena is not always obvious. This is particularly true for civil phenomena such as art. This fully-formed criterion, then, needs to be supplemented with additional principals related to identifying the fully-formed condition.

3.0 Cosmological event times

3.1 Physical science events

Let us now consider these systems, establishing events times where possible. For physical science phenomena, event times are as cited in textbooks; the physics community has a passable consensus as to these dates. Arbitrarily, the primary references are Zeilik and Gregory (1997) and Harrison (2000). Early in the history of the cosmos, there was a build up of structure from the simplest to the more complex (elementary particles then hadrons, then atomic nuclei ...). Furthermore, according to contemporary theory, smaller astronomical structures developed first; there is a step-by-step process in which the various phenomena separate from a general nebula, first ellipsoids, then ellipsoid systems, galaxies, galaxy groups, galaxy clusters ... (e.g., Silk 1999). At least in general, then, physical science phenomena develop in a hierarchical fashion. (A qualification is required; heavy atoms form after the first generation of stars. However, light atoms form earlier.)

The event times for phenomena have been listed in Columns 3 and 4 of Table 1. Column 5 transposes these numbers into purely logarithmic form. Given that the total time interval is measured in billions of years, the short periods between civil science events necessitates very fine discriminations. However, as we look downward in the list, large numbers of significant figures become progressively more meaningless. Hence, truncated values are shown in column 6.

3.2 Life science events

As to the life- and civil-science events, the policy followed here is that of the so-called "principle of mediocrity," the belief that earth and human civilization are typical examples of such phenomena. This notion has been justifiably criticized (Deutsch 2011; Kukla 2010), but it does appear to at least articulate the apparent, intuition-based consensus among astrobiologists. The reasoning behind it is partly motivated by the well-established Copernican principle, according to which, we cannot attribute to ourselves any special position in the universe. Further still, various biological principles would probably apply to life regardless of where it develops; natural selection, for example, seems likely to be universal, as does the operation of biogeochemical cycles. These considerations are admittedly speculative, but this is about the best we can do for now. In any case, it is intuitively more sensible to assume that we are not special, rather than otherwise. Furthermore, while we have no experience with life elsewhere, we have had plenty of experience in analyzing a wide diversity of phenomena (atoms, stars, etc.); our intuition is well informed. The opposing principle, "the rare earth hypothesis," has also been subject to extensive criticism, most notably an inconsistency with the constantly increasing number of observed exoplanets. (See, for example, Jean Schneider's Exoplanet.eu, CNRS/ LUTH, Paris Observatory.) Another principle commonly cited in this connection is Nick Bostrom's (2002, 57) "self-sampling assumption," according to which we should think of ourselves as random observers from a "suitable reference class." Revisiting the Principal of Mediocrity, it is worth mentioning, as noted by Guillermo Lemarchand (2006, 458) that "From a Lakatosian epistemological point of view, this hypothesis is within the 'hard core' of the research programs which main purpose is the search for life in the universe (e.g., exobiology, bioastronomy, astrobiology, SETI)." Imre Lakatos (1970) has argued that the 'hard core' of a research program includes any hypothesis that is widely viewed by the experts as valid, despite the possible lack of real supporting evidence. On the basis of these various considerations, we can cautiously assume that life and civilization will develop on any Earth-like planet very much as they have here.

Unless otherwise indicated, the event times cited for life-science phenomena are taken from Schopf (1999). This book is a popularization, but it is effectively a comprehensive survey of science related to the origin of life (with some consideration of evolution as a whole). Schopf is a stellar figure in his field; his (popularized) "survey" would be widely respected.

Life seems to have first appeared 3,500 to 3,900 Ma (million years ago). This event time is attributed to polymers, since these would have been the first distinctly biological phenomena. The first cell-like structures, "protocells," seem to have appeared at about 3,465 Ma. These would have had about the developmental level of an organelle; hence the event time for organelles [Organelles (LF)]. The fully developed cell is the eukaryote. Brocks et al. (1999) have found the earliest evidence of eukaryotes thus far, 2700 Ma. Populations are associations of interbreeding organisms. These would have first developed when eukaryotes developed meiosis (sexual cell division). This gives an event time of 1,100 Ma. The earliest multicellular organisms appeared at about 750 Ma. This event time is attributed to tissues, since the earliest multicellular organisms would have had about this level of development. The event time for organs would correspond to the first organisms with multiple tissue systems. These would have been organisms such as the cnidaria (jellyfish, sea anemones, corals, hydra, etc.). The corresponding event time is 550 to 590 Ma. The most primitive organ systems seem likely to correspond to the bilaterians. The event time is 540 Ma (e.g., Knoll and Carroll 1999). "Multicellularity" is defined here as referring to life forms consisting of multiple organ systems. It is not clear as to when this first appeared; hence no event time is provided. The fully-formed event times for ecosystems and the biosphere are also unclear.

As was the case for physical science phenomena, the life science phenomena largely developed in a hierarchical fashion. Ecosystems and the biosphere are possible exceptions to this rule. However, if these phenomena are fully-formed only after "Multicellularity" appears, then there would be a complete hierarchical pattern.

3.3 Civil science events

Some previous consideration has been given to the identification of the major categories of civil phenomena, most notably Durant (1939), Schrecker (1948), Childe (1983) and Quigley (1961). However, while there is much overlap in the recommended categories, their writings seem not to have inspired any consensus. Also, each of these authors seems to have taken something less than a methodical approach in determining the categories. In order to provide such a methodical determination, a survey article of some form would be very helpful. Fortunately, such a survey (of sorts) exists, the *Propaedia* for the *Encyclopedia Britannica* (Goetz 1987). This is a 744-page, formal outline for the *Britannica* and, as such, it can be used to quickly narrow in on portions relating to civil phenomena. The *Propaedia* has been examined in detail, resulting in the following list of civil phenomena: mind, institutions, language, art, communities, law, knowledge, technology and religion. These phenomena are also included in Table 1.

As mentioned, establishing event times for civil science systems is especially problematic. What follows, then, is at best, a first approximation. In as far as possible, the discussion will attempt to establish event times based on the fully-formed criterion. Otherwise, a more intuitive approach is taken, one that focuses on the event times for paradigmatic examples.

Mind consists of two primary domains, the conscious and unconscious. At a finer level of detail, it is commonly said to involve concepts (thoughts), sensations, emotion, memory, personality, the will, and self-awareness. These are all interdependent; it is apparently another system. Most of these aspects would seem to have been well-developed during prehistoric times. The development of concepts, however, would have been largely mythological and unsystematic up to the point of the Neolithic Revolution. It was at this time that we first developed settled communities and farms. This would have required, at minimum, systemized principles of engineering and law (even if passed along via oral tradition). Arguably, this marks the point in time at which systemized concepts in general began to be developed. A plausible event time for mind, then, would correspond to the Neolithic revolution, 8,000 to 10,000 B.C.

Language consists most obviously of vocabulary and grammar, both of which would have had prehistoric origins (e.g., Corballis 2003). However, fully-formed, it also involves writing. The first true writing system (to be distinguished from proto-writing) was Sumerian cuneiform. A plausible event time for language would then be 2600 B.C. (e.g., Kramer 1988).

Technology is usually spoken of as various tools (and techniques). However, this is seemingly an inadequate analysis. The various forms of technology complement one another, working together (with operators) to achieve various results. It is a monolithic phenomenon, the various parts of which we identify as tools and techniques for specific purposes. Again, it is difficult to say when this system was fully formed. One option would be to use the event time for the full set of "simple machines" (lever, inclined plane, wheel and axel, screw, pulley and wedge). The most recent of these was the screw, developed circa 700 B.C. (e.g., Dalley and Oleson 2003). This is nicely consistent with another approach, one based on a paradigmatic example, in this case the compound machine (two or more independent but synchronized mechanism). The first of these appears to have been a device for working gems, circa 550 BC (Lu 2004). Tentatively, then, we will use an event time of 700 to 550 BC.

Law is said to be most essentially a system of rules. Historians of law appear to agree that law in its modern form did not come into being until Hugo Grotius published his *De Jure Belli ac Pacis* (*On the Law of War and Peace*) in 1625 (e.g., Golding 1967). This separated jurisprudence from Canon law. This roughly coincides with the beginnings of modern constitutional law ~1600, the paradigmatic example of law. The event time for law, then, is taken to be 1625 to 1700.

Institutions do not exist independently of one another. The family is said to provide the supply of labor used in industry and other institutions (a decidedly utilitarian interpretation). The government regulates the various institutions (among other things). The schools provide the training used by the work force. These entities, then, form what might be referred to as an institutional complex (system). Initially, at least some of these institutions were mixed. In Sumer, for example, the king was also the high priest (e.g., Brisch 2008). This complex would have been fully formed when all constituent institutions were separate and present in modern form. Completing this analysis for each institution would involve much research, and is beyond the scope of the present effort. However, intuitively, one suspects that industry, academia, the family and church have been present in basically modern form for some time. This would not be the case for government. A plausible event time for fully-formed government would correspond to the earliest point in time at which there was a full separation of powers. Principles relating to the separation of powers were most notably articulated by Montesquieu (1748). However, these principles were already in place in the Roman Republic, circa 500 BC (e.g., Fairlie 1923). It is sometimes said that ancient Athens had a separation of power, but it was poorly developed (Fairlie 1923). A plausible event time for institutions, then, is 500 BC.

In Western culture, art came of age with the Renaissance, circa 1300 (e.g., Jenkins 1973). This is when art was first pursued as "art for art's sake." Oil painting, a paradigmatic form of art, became common in the 15th century (e.g., Owen 1987). A plausible event time for art would then be 1300 to 1500. The development of art for art's sake may have occurred earlier in Asia, but an effort to explore this was unsuccessful. (Jenkins also says that the assertion "art for art's sake" is a more recent event, ~1800.)

Of the various kinds of communities (e.g., clans, tribes, villages, nations, religious denominations, professional associations, etc.) the concept seems to apply paradigmatically to political affiliations, in particular, the nation-state. The first of these seems to have been the Dutch Republic of 1581 (e.g., Geyl 2001).

Knowledge today is largely and paradigmatically science. However, science is not simply a set of principles. There is also a method and an institutional component. The most recently developed component seems to have been the method. The Scientific Revolution is usually said to have begun in the early 1500s. However, it was a bit later, 1686, that Robert Boyle published *A Free Enquiry into the Vulgarly Received Notion of Nature*. Here we find the first articulation of the importance of repeatable experiments and the published presentation of results. The event time for fully formed science, then, is taken to be 1686 (even if the recommendation was not fully implemented until later).

Religion is not simply a belief system. There is also the ministry, a community and the sanctuary. Religion would be fully formed when all of these are in place. Historically, religious belief systems have been presented as knowledge, although over the last few hundred years, it has become increasingly clear that they are in conflict with science. The correction, however, is well underway. At least in the West, organized religion now tacitly, if not explicitly, presupposes the validity of science. The *Catechism of the Catholic Church* (United States Catholic Church

1997, 159), for example, now teaches that "methodical research in all branches of knowledge, provided it is carried out in a truly scientific manner ... can never conflict with the faith." The argument remains simply over whether or not particular scientific theories are correct. Belief systems, then, are slowly adjusting to science. This process can have only one outcome: theology and science will eventually be consistent (even if this means a drastic alteration of religion). This acceptance of science in general, despite problems with specific theories, seems to have begun its development over the twentieth century. Hence the event time for religion is 1900-2000. It is perhaps worth mentioning that religion is undeniably a major feature of civilization; it cannot be ignored. It is also worth noting that religion can be meaningfully defined, without making reference to the supernatural and the anthropomorphic (James 1902; Durkheim 1915). The common supposition that it will be sloughed off is a conjecture based typically on a naïve understanding of the phenomenon. (The quotation above from the Catholic *Catechism*—that science cannot conflict with faith—is, of course, an article of faith itself, but it also expresses a commitment to science on the part of the Church.)

Again, it should be noted that the above list of phenomena might be incomplete, or otherwise in error, and the event order and event times are almost certainly subject to correction. Also, there is the strong possibility of a cultural bias in determining event times for civil phenomena; some of what is attributed to Europe may have occurred earlier in Asia or the Middle East. Indeed, virtually every step in the development of the list and the assignment of event times is debatable. However, if we are to produce a unification of scientific schematics, we must start with some first approximation.

4.0 The scaling equations

The first part of the Unified Schematic to develop must be the timeline itself, and this is not quite straightforward. The problem concerns an appropriate scale. As a first thought, we might use a strictly proportional scale. In this case, the total time period is spread out evenly along the time line (about ten inches of length for some ten billion years). This has the effect of bunching up the first five physical science events in an unreadable manner at the bottom of the timeline. It also bunches up all of the civil science events in an unreadable manner at the top of the line. The use of a timeline becomes pointless. Because of this effect, as it relates to physical science events, astrophysics typically uses a logarithmic scale (-50 to □ 10 corresponding to 10^{-50} to □ 10^{10} years). This works for these events, but it causes the life and civil science events to bunch up at the top of the line, many in a completely unreadable manner. We need, then, some variation of this logarithmic scale. Ideally, the events would be spread out in a uniform fashion.

Notice that each event in Table 1 is given an event number, *N*, and for most of these, we have known event times. Events with known event times are plotted in Figure 4, where placement of event numbers evenly along the vertical axis reflects the effort to spread out events uniformly along the timeline. It is this graph that we need to model in order to get the proper scaling equation.

Graphs of this type are crudely of the form $y = a^x$, where a is some constant slightly greater than 1. However, in the present case, no such simple formula will work. The primary reason for this is that the graph is extremely sensitive at the high end (a minimum of ten significant figures to distinguish between the upper two points); any exponential function that gives good results along the lower portion of the graph is way off at the top, and vice versa. Also, there is a severe change in curvature in the vicinity of event twenty-one; even more so than around events four to six. (The change in direction of the curve is more noticeable in the vicinity of points four to six, i.e., the radius of curvature, $R = |1/K|$ is smaller. However, the actual curvature, i.e., the rate of change in direction, $K = d\tau/ds$, is greater near point twenty-one.) A more complicated fit is required. Neglecting the derivation (basically just a fit), this is

$$N = \left(8.047\times10^{-3} - 8.029\times10^{-4}\,T\right)^{-0.2809} + 10.1783\exp\left[-2554.47\left(10-T\right)^{0.484597}\right] - 0.7505 \quad (1)$$

The output of this equation and the errors for each event appear in columns seven and eight of Table 1. To get a corresponding expression in terms of years ago, we can substitute $T = \ln\left(10^{10} - 10^{T_{\text{ya}}}\right)/\ln 10$ in equation (1),

$$N_{\text{YA}} = \left\{8.047\times10^{-3} - 8.029\times10^{-4}\left[\frac{\ln\left(10^{10}-10^{T_{\text{ya}}}\right)}{\ln 10}\right]\right\}^{-0.2809} + 10.1783\exp\left\{-2554.47\left(10-\left[\frac{\ln\left(10^{10}-10^{T_{\text{ya}}}\right)}{\ln 10}\right]\right)^{0.484597}\right\} - 0.7505 \quad (2)$$

In the development of these equations, we have used the typical time period for the development of a civilization, 10^{10} yr, rather than the period as *we* know it, 1.37×10^{10} yr. (Recent studies consistently show the peak in the star formation rate at a lookback time of □ 7.7×10^{9} yr (Hopkins and Beacom 2006; Mannucci et al. 2006; Ota et al. 2008; Verma et al. 2007; Yüksel et al. 2008; Bouwens et al. 2008). This corresponds to a time of 6×10^{9} yr after the moment, $t = 0$. To this we add on the commonly cited

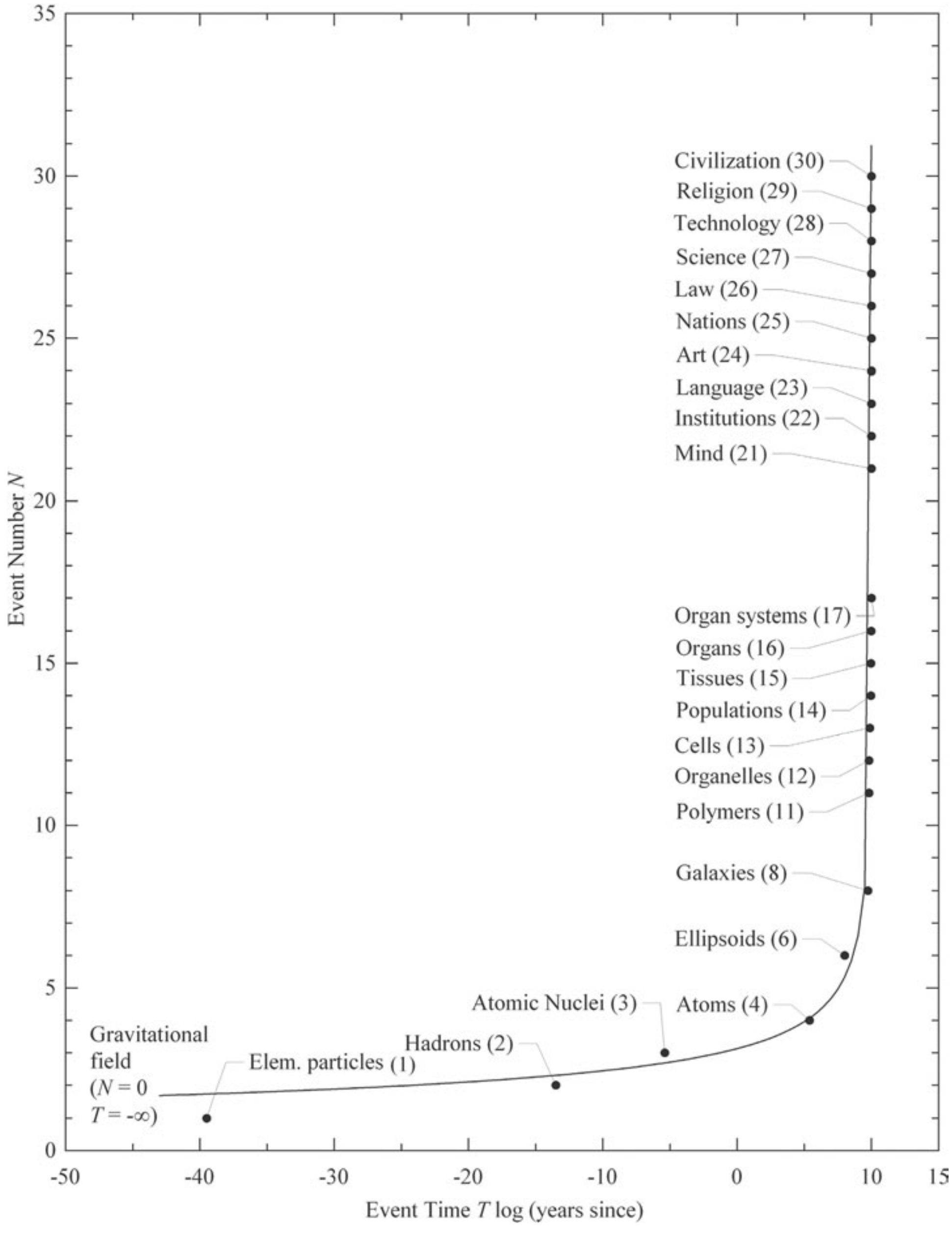

Figure 4. A unified schematic.

time for the formation of the solar system and the evolution of life, 4.5×10^{9} yr (e.g., Tilton 1988) to get the total typical time interval.) The use of these equations, in lieu of something such as a logarithmic scale, is not entirely satisfactory; they are too complicated. The author is continuing to explore alternatives.

5.0 Building the unified schematic

We are now prepared to start putting things together. This is done by first developing the coordinate system (3D space-time frame), then adding to it the schematics for physical-, life- and civil-science phenomena.

5.1 Frame and panels

The coordinate system is built in the standard fashion; the angles between the line of sight and the *x*, *y* and *z* axes of the cube are $-\pi/2$, 0, $\pi/2$ respectively (i.e., the line of sight is normal to the front face of the system). Three additional parameters, "field of view" (effectively a measure of the lens used to view the scene) the size of the cube (the length of an edge) and distance of the cube from the viewer are set at the least arbitrary values, respectively, 0.1, 1 and 10 (in arbitrary programming "units"). Logarithmically, these correspond to the sequence, -1, 0, 1.

The bottom panel of this coordinate system has spatial dimensions in both directions, and this suggests that it be used to present the standard schematic for two-dimensional, Euclidean space, the usual *x-y* grid [Space |log(m)| (LF)]. At the web site, this schematic includes buttons that allow the schematic to morph into other forms of two-dimensional space (hyperbolic and spherical).

The left side panel has time along one direction and this suggests that we use it to incorporate the standard, two-dimensional schematic for time, the geologic time-scale, modified to include astrophysical and archeological increments [Time log (yr) (LF)]. This unified time scale is very elaborate. When rigorously developed, much of it is necessarily on a microscopic scale (if the overall size is a single page and everything is developed to scale). These portions are accessed via buttons that cause a zoom effect. (Text shapes in the time scale will provide this effect if they turn blue upon mouse-over.) At some point in the near future, the historical and degenerate (heat death) time scales will be incorporated

The rear panel has a spatial dimension in one direction and time in the other. This suggests that it be used to present the standard, two-dimensional schematic for space-time [Space-time (LF)]. The right side panel is arbitrarily used to present graphs for the primary cosmological parameters, temperature, energy, density and radius [T, E, ρ, r (LF)]. The overhead front panels have yet to be developed. (There is, in fact, a way to use the front panel without interfering with readability of the graph as a whole, but discussion of this would require a digression that is extraneous for present purposes.)

5.2 Phenomena schematics

Within the coordinate system, the lowest diagram is the standard schematic for the gravitational field, the embedding diagram [Gravitational Field (LF)]. The gravitational field is a deformation of space. Therefore, strictly speaking, this schematic should be understood as an extension of the schematic for space (the lower panel). This connection will be developed graphically at some point in the future.

The cross-sectional schematics for particle phenomena are stacked, one on top of another, above the embedding diagram, in the order in which the corresponding phenomena have developed. Sizes are according to the absolute values of the logarithms of the radii (meters). These schematics for particle phenomena are called out to a face-on position by first loading a classification table to the right (HTML) frame. Clicking on [The Atom (LF)], for example, loads the Stowe Periodic Table to the right frame. Clicking on symbols therein will load energy level diagrams to the right frame. Links therein zoom to fine structure, wherein we find links that call out the schematics for atomic states from the unified schematic.

The primary schematic in biology is the phylogenetic tree. The modern version of this is a cladogram, a circular schematic with branching, radial lines indicating diverging groups of organisms. Distance along the radial component is used as a measure of rRNA base sequence changes. The angular aspect can be used as a measure of diversity (the number of species or other taxonomic groupings). The typical cladogram does not ordinarily have a temporal axis (a limitation due to working in two dimensions), and is, therefore, technically imperfect. Since time is measured along a vertical axis in the Unified Schematic, a vertical component has been provided, giving the cladogram three dimensions. The cladogram can be brought out by clicking on the link for the biosphere [Biosphere (LF)]. Over time, more biology schematics will be included. At present, only the cross-sectional schematic for the protocell (an organelle-level phenomenon) [Organelles (LF)] and ecosystem are included [Ecosystems (LF) ⇒ Temperate deciduous/mixed (RF)].

No standard schematic for civilization yet exists, so an effort is made here to develop one [Civilization (LF)]. We can follow the same principle as is used for the Unified Schematic as a whole: combine the existing schematics for constituent phenomena. It appears that these are usually represented with branching diagrams reminiscent of the phylogenetic tree (e.g., the branches of law, science, religion, language), hence the tree-like schematic for civilization. This schematic is a "bare-bones" version.

5.3 Lettering

The list of terms on the right in the Unified Schematic (e.g., "The Atom," "Cells," "Languages") are primarily intended to label the individual schematics. However, these labels also have secondary functions (mouse-over and on-click events). Most importantly, these terms will call classification tables to the right frame. The on-click event for atoms has already been mentioned. Clicking on the link for atomic nuclei [Atomic Nuclei (LF)] calls the table of nuclides, and so forth for other classes of phenomena. For some categories of phenomena, such classification tables already exist. The rest will be developed over time. Note that these labels also have mouse-over events. For example, a mouse-over for [The Atom (LF)] will bring out spatial and temporal scales along the far left and lower edges of the Unified Schematic. These have blinking indicators for values corresponding to the atom.

The lettering on the left side, the list of disciplines, is intended to compliment the lettering on the right; as presently conceived, each discipline corresponds to one of the primary classes of phenomena. These left-side terms are intended to call lists of subdisciplines to the right side frame. These subdisciplines, in turn, will eventually break down into topic areas, and then, finally, into summations of concepts, e.g., lists of formulae. In some cases, formulae are temporarily available via small, red buttons, [F (LF)]. Over time, these simple table-of-contents-type lists will be replaced with 3D concept maps; these will represent relationships among disciplines, topics and concepts in a more realistic and useful fashion. The typical table of contents is a purely one-dimensional concept map, and is therefore quite limited. Thus even the lists of disciplines and topics will be developed graphically.

In addition to this outline of the Unified Schematic, it would be helpful to at least illustrate its potential for handling detail. The hydrogen atom has been chosen for this purpose. As developed, this includes all categories of concepts relating to quantum mechanics: the Periodic Table, an energy level diagram, orbital schematics, graphs, a data table, formulae and nomenclature. We have here enough detail to illustrate that the Unified Schematic can accommodate all details relating to the hydrogen atom. Hopefully, this is an indication as to how well it will handle the details of other phenomena.

6.0 Findings; unnoticed regularities, gaps, and inconsistencies in science

Consider again the previously mentioned, hypothetical scenario in which we had no schematic cross-section for the earth. In this case, geology would have to be grievously deficient in certain respects. Given this scenario, a deliberate effort to produce such a schematic would quickly lead to important insights. The same seems to be happening in connection with the effort to produce this schematic for the cosmos. It is apparently having the effect of identifying various unnoticed regularities, gaps in knowledge and inconsistencies among the different sciences.

Consider, for example, the scaling equations developed above. The original motivation for these concerned the need to distribute events along the timeline in a readable manner; in this application, it was necessary to specify event number in terms of event time. However, these equations can also be used to specify event time if event number is known. Notice, then, that if we had been ignorant of one or more of the event times cited in Table 1, these equations could have been used to successfully specify their values. This suggests that they can act as laws of nature. If so, they would provide a useful supplement to methods such as carbon dating, biostratigraphy, and nucleocosmochronology (once we are clear on event identification and event order). This would be a method relevant to all disciplines. (The other methods have more restricted applications.) Hopefully, these equations can also be used for non-integer values of N. This would be especially helpful in evolutionary biology, where divergence times often have enormous margins of error. (These equations cannot be solved explicitly for T in terms of N, but numerical procedures can be used.)

As another example of such unnoticed regularities, the effort to produce this Unified Schematic has revealed an apparent relevance of 3D classification tables for the major categories of particle phenomena, although many of these have been poorly developed (Channon 2011). This suggests that we should be looking for classification tables for other phenomena. The act of doing so would undoubtedly produce important insight, just as Mendeleev's efforts did.

It is particularly interesting, then, to imagine the possibility of a "periodic table" for the sciences (one of the major classes of phenomena). This would suggest that disciplines occur in a patterned fashion, as do atoms in the Periodic Table. Any such table for the sciences would probably have significant implications for all disciplines, just as the Periodic Table had implications for atomic theory. It would also constitute an important step toward scientific epistemology.

Furthermore, it appears that these 3D classification tables are best derived using a certain principle, one that involves identifying the three fundamental parameters for a category of phenomena, assigning each to an axis and then plotting symbols (e.g., "H" for Hydrogen). This was the approach used by Timmothy Stowe and is perhaps a pattern or law-like statement relating to the classification of phenomena in general (Channon 2011). If so, this would be a law relating to laws, another step toward scientific epistemology.

This project is also having the effect of identifying gaps of various kinds. Most importantly, it brings into stark relief the fact that we have no holistic discipline for the civil sciences, a parallel to physics and biology. Yet civilization is so major a phenomenon, that approximately 60% of scientific disciplines are concerned with studying its various aspects. (The physical sciences cover approximately 15% and life sciences constitute about 24%.) If such an holistic discipline were to be developed for the civil sciences, the set of such disciplines would be complete.

This assessment is based on the categories of disciplines presented in the 2006 *Survey of Earned Doctorates* by the National Opinion Research Center (NORC) at the University of Chicago (Hoffer et al. 2007). Presumably, these categories have been carefully prepared, but it is not likely that the procedure used was "scientific." However, the assessment of actual numbers of doctorates earned would have been rigorous. This count shows that 68.5% of doctorates were in the civil sciences. The physical sciences include 10.3% and the life sciences, 21.2%. These numbers are similar to those for the disciplines noted above. The computer and information sciences, and doctorates earned, are grouped with the civil sciences, as are the disciplines and doctorates for the social sciences (including psychology, corresponding to mind), engineering, education, humanities, and "Other." For present purposes, any discipline concerned with some feature of civilization is a "civil science." Note that mathematics is technically a kind of *language*, and this is a *civil* phenomenon. Engineering relates to technology, another civil phenomenon.

Even worse, some of the disciplines associated with civil science phenomena are commonly thought of as being largely unrelated to one another. Engineering, for example, the discipline that corresponds most closely to the study of technology, is not typically thought of as being a sister science to the humanities. Yet art and technology are both primary classes of civil phenomena, with the humanities devoted to the former, and engineering to the latter. Both study artifacts, possibly a super-class of civil phenomena. Engineering, while typically viewed as exclusively an applied science, still presents an accumulation of knowledge and would be, therefore, at least arguably, the discipline corresponding to the study of technology. Engineering is perhaps also thought of as being radically different from the other civil sciences (sociology, psychology, etc.) because it supposedly concerns things that are not "natural." This would be a mistake; civilization is closely analogous to a beehive or an ant colony. It reflects the behavior of a *natural* species, and is, therefore, very much a part of nature. In particular, technology is a part of this natural phenomenon, and is, therefore, in the strictest sense, a natural phenomenon itself. Human artifacts become something other than natural only if the term "nature" is defined as relating to things nonhuman.

Engineering is also thought to be unrelated to the other civil sciences because it makes liberal use of physics concepts, and this is, admittedly, an important consideration. Nevertheless, the apparent rule is that disciplines are categorized (and associated) on the basis of the phenomena with which they are concerned. Thus cellular biology and zoology fall within the purview of biology, as chromodynamics and astronomy are classified as physics. For the same reason, the humanities should be associated with the other civil sciences, since it is concerned primarily with art, one of the primary components of civilization. (Definitions for the term vary.) Likewise, institutional studies (e.g., agriculture, business, medicine) would fall under this category, since institutions are a major component of civilization. Furthermore, physics concepts are also used in biology ("biophysics") and even the social sciences (e.g., econophysics). Nevertheless, this doesn't make biology and economics subdisciplines to physics.

Another such gap in knowledge concerns the lack of a consensus as to even the large-scale structure of civilization. A similar situation would exist if physics had overlooked the need to provide a description of the large-scale structure of the universe (the expanding aggregate of galaxy clusters). This would be why we have no standard schematic for civilization. All of this suggests that the analysis of civilization is still at a preliminary stage of development.

Finally in this connection, note that the unification of theories and disciplines has been one of the defining features of scientific progress. We so often read about the unification of forces, but at an even grander level of concern, biology, chemistry, and physics were once viewed as radically distinct. However, biology has been reconciled with chemistry and this with physics. What we are witnessing now, perhaps, is the unification of the civil disciplines with the rest of science (Whewell 1847; Haskell 1972; Wilson 1998; Henriques 2008). "Unification" and reconciliation as used herein refer to consistency among the disciplines. The traditional understanding of reductionism, e.g., the explanation of biological phenomena simply in terms of chemical processes and properties, is indeed a defeated effort (Kitcher 1999).

This project has also revealed that there is no consensus as to a scientific schematic (i.e., map) for mind, presumably a major phenomenon. The "mental iceberg" illustration for the conscious and unconscious is a metaphorical cartoon at best. The fact that psychology has yet to produce an agreed-upon schematic for mind is surely significant. Psychologists are not unaware of this deficit, but they are also, perhaps, not fully conscious as to how much of a deficit it is. If a science is unable to provide a realistic, structural description (map) of the phenomenon it is studying (e.g., the interior of the earth), it cannot be said to have reached a mature understanding of its subject matter.

Another revealed gap in knowledge concerns the systematic identification of, and distinctions between, the basic classes of phenomena. This is nowhere to be found in science. Yet it is something so fundamental, that it should be common knowledge to grade-school graduates. The list provided here (Table 1) is surely not the last word on the topic, but it is at least a start. We need to get clear on this as soon as possible. What could be more basic to science than identifying the major categories of phenomena? There is also considerable confusion in regard to the usage of the term "institution." It is often used in reference to things that are only institution-*like* (e.g., money and marriage). The absence of classification tables for most of these categories of phenomena would be another of these gaps in knowledge. Finally, in physics, there is confusion concerning elementary particles and hadrons. (Hadrons, such as protons and neutrons, are particle systems, consisting of either two or three quarks. Elementary particles—bosons and fermions—are, as the term "elementary" suggests, truly basic, not made up of smaller particles, or so it appears at this time. Yet mesons—a type of hadron—are often spoken of as "bosonic" and categorized accordingly. There are similar sorts of confusion regarding other particles. The mistake is the result of focusing on "spin," rather than structural form and hierarchical position. A comparable error would be to view homonuclear diatomic molecules, e.g., dinitrogen, as types of atoms.)

In a related manner, the project is also having the effect of revealing inconsistencies between the various sciences. For example, the astrophysics community has been using a time scale that is expressed in terms that conflict with the usage relating to the geologic time scale. Also, the increments of the archeological time scale are slightly inconsistent with the geologic time scale (the Calabrian and Stone Ages overlap). Indeed, until now, there has apparently been no attempt to unify these various time scales in detail. (Wikipedia collaborators are making a start at this.)

7.0 Conclusion; the advent of scientific epistemology

The primary goal of the project, then, is to graphically and systematically map all knowledge, thereby identifying patterns, gaps and inconsistencies amongst the laws of science. Most importantly, it is a search for regularities, throughout and across the various disciplines. Any such regularities would be laws relating to laws (i.e., laws relating to knowledge), and therefore, they would be the subject matter of epistemology. If knowledge is anything like other phenomena, then there should be such regularities. This suggests that epistemology might develop into a science. Just as the other sciences have come out of philosophy, so epistemology may now be separating. The goal of the project, then, might be alternatively characterized as an effort to facilitate the science of science itself, scientific epistemology. (Perhaps needless to say, epistemology has long been concerned with the effort to articulate law-like statements. The deductive-nomological, covering-law, model is certainly an attempt to characterize scientific explanation in terms of a law-like statement. The point of the present discussion, however, concerns the effort to develop laws of a more particular nature, e.g., the possibility that there are patterned (3D) classification tables for all categories of phenomena.)

This notion of a scientific epistemology is not new. There has been, for some time now, an interest in its development. Perhaps most notably, this came in the form of the "replacement naturalism" of W.V.O Quine (1969), an attempt to supplant the conceptual analysis of knowledge with a focus on how we acquire it. It was thus a reduction to psychology. This effort is generally viewed as a failure, most notably because it eliminates the normative, a concern with what knowledge ought to be (e.g., Almeder 1999; Bonjour 1994; Foley 1994; Fumerton 1994; Putnam 1982); this has long been the fundamental and distinctive concern of epistemology. Quine himself has also noted the circularity of attempting to use the empirical sciences to validate themselves, a variation on Hume's problem (Quine 1990).

Another effort along these lines is cooperative naturalism, the view that psychology is generally relevant to epistemology (Goldman 1991; Haack 1995; Harman 1974; Kornblith 1994; Stich and Nisbett 1980). While this is not terribly problematic, neither does it constitute a transformation of epistemology; it is rather, an expression of the sense that developments in other disciplines simply have some relevance to epistemology.

A third variation is substantive naturalism, the view that normative epistemic statements reflect or correspond to natural facts, statements about the world (e.g., Kim 1988; Lycan 1988; Maffie 1990; Steup 1995). This is not problem-free, but it is widely embraced by epistemologists. However, some argue that it is difficult to distinguish between this and the positions of more traditional epistemologists (Chisholm 1982; Cleve 1985). Substantive naturalism is apparently little more than classical epistemology (e.g., Feldman 2012). It does not go very far in developing epistemology as a scientific discipline.

However, while knowledge is only indirectly related to psychology, it is of direct concern to the information sciences. Indeed, in a recent survey of some 50 leading theorists in the field, half provided definitions for "information science" which used the term "knowledge," often repeatedly (Zins 2007a). Zins, himself, in his contribution to the list, surprisingly mentions "knowledge" more often than "information" (Zins 2007a, 339). Zins (2007a, 340-41) further cites "Six Conceptions of Information Science," all of which invoke a critical reference to knowledge. He also maintains that "Information science is one of six knowledge fields ... these are philosophy of knowledge (epistemology), philosophy of science, history of science, sociology of knowledge, methodology of science, and information science" (Zins 2007a, 339). Quite plausibly, scientific epistemology would also include information theory. In a related article, one that concerns the "data-information-knowledge-message phenomena," all of the commenting theorists (forty-five in total) implicitly identify knowledge as one of the fundamental concepts of information science (Zins 2007b). Information science, then, would be closely related to epistemology, and scientific epistemology would be the "six knowledge fields" mentioned above.

Further still, the classification of the sciences would be a relevant consideration, just as the classification of atoms is critical to quantum mechanics. In general, scientific epistemology would be concerned with any and all attempts to account for regularities relating to what we might refer to as intelligence (data, information, message, and knowledge).

In this view, classical epistemology (the concern with issues such as the justification of knowledge) constitutes the philosophic area of this science. Just as the philosophy of mind can be viewed as a subdiscipline of psychology, so classical epistemology might best be thought of as the philosophic portion of scientific epistemology. (Perhaps needless to say, we could retain the present meaning of "epistemology," and refer to "scientific epistemology" as something such as "knowledge science.")

The idea is not that epistemology would develop as an empirical discipline, as was the hope of replacement naturalists. Rather, that it will develop by some combination of methods into a body of established knowledge, i.e., a science. (Notice that disciplines such as mathematics are, or can be viewed as, sciences, despite no use of empirical methods.) The applicable methods, in this case, might be largely those already in use in the information sciences (archival research, content analysis, etc.). However, we now have other methods emerging, most notably the analysis of symmetry so common in physics. The attempt to unify the concept representations of science is an application of this method, and, as we see, it appears to be fruitful. In any case, a scientific epistemology would provide the basis for a systematic approach to discovery; rather than each investigator simply following his or her own muse, diverging in whatever direction seems interesting, we could proceed in a more organized manner; scientific epistemology would provide, in effect, a greatly enhanced perspective from which to choose research topics.

Up to this point in time, scientific research as a whole has not had the benefit of the sort of perspective that would be provided by a true science of knowledge; as a result, it has had no detailed, well-considered strategy. We have all been moving in the same general direction, into the unknown, but our actions have not had the same effect that they would have, if the effort had been more highly organized. If this perspective had been in place, we would not have overlooked such gaping deficits as the failure to provide a characterization for the large-scale structure of civilization. If this sort of methodical approach is possible, science would take on the character of an organized campaign. In this case, the historical process would have been one that began with uncoordinated, scattered activity (thousands of years ago), developed into a massive, yet still uncoordinated, mob action (over the 19th and 20th centuries) and would now be consummated in the transition to a tactically sophisticated offensive.

Perhaps invariably in human activities (e.g., warfare), a dramatic improvement in strategy is followed by a dramatic improvement in results. If any such enhancement is made to the scientific process, it would surely have a spectacular effect on the pace and depth of discovery. One might argue that the current strategy has worked just fine, producing a perfectly acceptable pace. But our ancestors would have said the same of the traditional cavalry; after all, it was so much faster than marching. They would have given little consideration to the possibility of flying at 1000 miles per hour. A mob action is often effective, but an organized army is vastly more so.

The scientific enterprise is not a war; this metaphor has unappealing connotations. However, science is a critical part of the effort to build civilization, and this has been very much like a war. It has involved enemies of a sort (poverty, illiteracy, actual war) and it has produced an enormous number of killed and wounded. Now, the advancement of civilization is dependent on progress in science (among other things), and scientific epistemology might well produce a second scientific revolution, another acceleration in the pace of discovery (something of a parallel to the second industrial revolution or the information revolution). If so, it would surely have a dramatic effect on the advancement of civilization in general. It would serve to bring this war-like process to a close much more quickly, thereby minimizing further casualties. (The notion that the development of civilization is an open-ended process is an unsubstantiated, if very common supposition. We have no evidence in support of it. On the contrary, the development of all natural systems seems to involve a type of maturation process, followed by a period of relative stability.)

And while we are exploring such far-reaching possibilities, we might want to briefly consider certain ultimate implications. The physics community has been, for some time, very much engaged in the effort to produce a "theory of everything" (ToE), a single conceptual model from which the greater body of laws can be derived. This effort is motivated by many similar, though more limited, successes (e.g., the reduction of Kepler's laws and Galileo's theories of motion to Newtonian mechanics). This effort has not succeeded, primarily because general relativity and quantum mechanics are not easily reconciled. But this failure is perhaps simply a matter of perspective. The idea of producing a single theory is arguably the problem. Theorists would be more successful, perhaps, if they were to pursue a single system of fundamental physical theories. This would be an effort to transform a set (or "heap") of laws to a system of laws. We might, then, want to consider a corresponding effort, one flowing from a science at the other end of the spectrum of disciplines, the pursuit of a system of theories which characterizes all patterns amongst the laws of science. The ToE for physics is an attempt to unify, simplify and consolidate the laws of physics, and a great deal of progress has been made toward this end. The epistemic equivalent would be a similar attempt as concerns the conceptualization of laws in general. If successful, this effort would produce a theorist's dream machine, a set of constraints on theoretical models in *all* disciplines and indications of otherwise unsuspected features and regularities of the cosmos. This might turn out to be a flight of fancy, but the potential return is so great and the investment of resources so small that the ride would be well worth the risk. (Notice that the effort would not require anything such as multi-billion dollar particle accelerators or space-based telescopes.) Yet the results would be relevant throughout the full extent of intellectual activity.

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