WHAT EMPIRICAL TESTING OF HIERARCHIES & SYSTEMS ALLOMETRY SAYS ABOUT GENERAL SYSTEMS MODELS OF EVOLUTION/EMERGENCE

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Abstract

This paper is about constraining theoretical speculation with empirical data. It applies lessons learned in attempts to verify the hierarchical levels of conventional disciplines to modelling systems evolution and systems emergence. Conversely it suggests that we use the empirical findings as powerful clues to promote theory formation. Finally, it speculates on how general systems theory can be placed on a firmer ground than before by relating and submitting general theories of systems evolution and systems emergence to the data of the conventional disciplines, but in a totally unique transdisciplinary way that is not available to the discipines of the natural sciences.

The Testing and Modeling Arena

Our Institute has sponsored a long-term program of research into the systems concepts of hierarchy theory, related duality theory, systems evolution, and systems emergence. We have confined our inquiry primarily to the natural systems of sub-atomic particle physics, chemistry, geology, biology, and astronomy. We have limited ourselves to these systems purposely for the following reasons: (1) these systems have a great deal of verified data associated with them; (2) they are less subjectively defined than all possible systems; (3) they are less effected by anthropomorphic influences (that is, they would exist whether or not humankind existed and, indeed, did for about 15 billion years before humankind appeared); (4) many technologies and resources important to humankind are derived from them, so that increased understanding of them may benefit humankind; (5) they are decidedly less complex to study than human or engineered systems.

While the research products for, and understanding of these natural systems is quite "mature" compared to social systems, the conventional disciplines have neglected several important aspects of phenomena on their range of scalar magnitudes. Each discipline has a convincing set of evidence describing the mechanisms at work **within** their discipline, but reductionist science has sort of ignored by agreement or convenience the difficult question of how nature arrived at new, more complicated levels. They are mute about mechanisms of emergence **between** levels. From our first paper in 1972 [], we have suggested that there is a "metahierarchy" of origins that operates across levels. We used as a working hypothesis the contention that the process by which any natural level gives rise to the next more complex level is a generic process. It might be described in terms of systems concepts that did not differ across all of the levels, and therefore, was an isomorphic process. Thus, our research arena was a comparative study of all natural systems in the universe in terms of their measurable attributes.

The Testing Database

We continue to work on the task of assembling a massive data base on all natural objects studied by science cataloguing measurements on them reported in the refereed literature. Figure 1 shows the 24 qualifiers and/or transformations we record for each raw datum collected. We record the 15 parameter types in *Paradox (C)*, a relational data base, which allows us to manipulate the raw data in numerous ways using the many qualifiers, for assembling various data packets for statistical analysis.

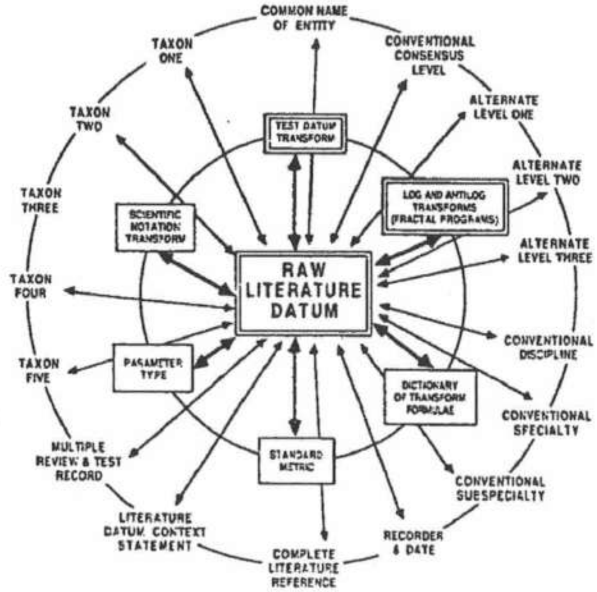

Figure 1. Twenty-four transformations and phenomenon-dependent adjectives which define "common fields" in relational databases kept for each one of the thousands of items of data on natural systems objects.

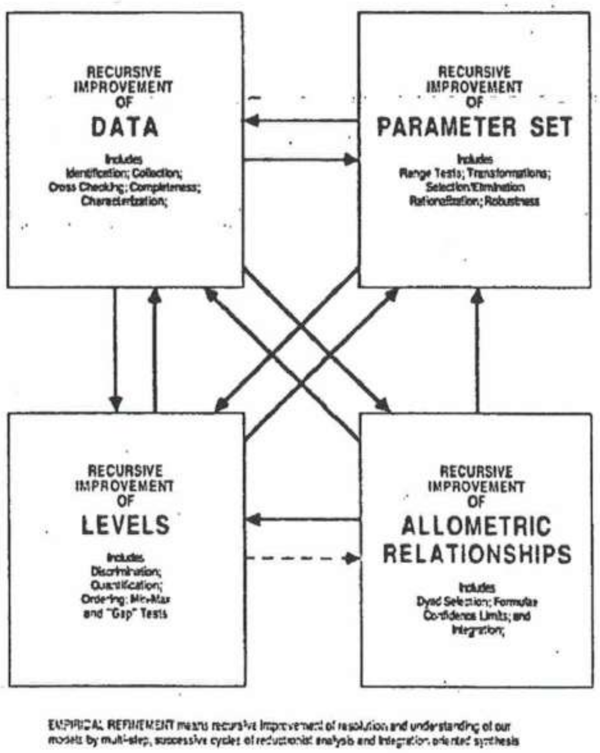

Figure 2: Tests for levels depend on data, data depends on parameters chosen and their availability, parameters are not common to all levels, data collected depends on the definition of hypothetical levels, which depend on the data, etc. All must be optimized in recursive cycles.

We use several standard multiparametric statistical packages to analyze and explore correlations in the data. At present we have thousands of data units recorded, but unfortunately on three different systems requiring an immense effort to unify the test database. Still we feel this project is merely at its beginning stages. Figure 2 shows the strategy we are using for simultaneous "empirical refinement" of the data and the hypotheses we are testing. Significantly unlike conventional science, this exercise in transdisciplinary research (or systems theory formation) requires real-time awareness of our use of the approximately objective data and our subjective modification and selection of it. We cannot hope to be totally independent of the data, or it of us, but we can require mutual consistencies leading to an improved, and more tightly coupled recursion between reductionist and synthetic tests on the data.

Survey of Some Results and Lessons Learned

Figures 3, 4, 5, and 6 show some of the tentative results of examining a wide range of natural systems in the universe for their relative magnitudes *vis a vis* **pairs** of the 15 parameters used to quantify each object. We treat all objects on a level of magnitude as mere variants of an "organizational" typology for that level. We have as an explicit operational assumption that the emergent mechanism which gives rise to any one "level type" is invariant for all of the possible manifestations (variant objects) for that "level type". The *korperplan* for each level of the universe is pre-established by constraint fields operable across the universe, but nature can spinoff many different particular objects within the canalization imposed by that constraint field or *korperplan*. Therefore, all biopolymers are regarded as a "level type", all planets as a "level type", all nucleons as a "level type." The data for each of these "level types" are converted to standard means for each of the parameters to represent that "level type". Thus, the plot shown in Figure 3 is the mean of all lifespan values for each of the various levels plotted on a log graph against the mean of all mass values for the whole sampled population of objects for each of the various levels. Beyond the discovery of simple, allometric formulae which are highly statistically signficant and invariant across all levels of the universe (leading to the new field of systems allometry)[], we would like to suggest that these same plots give some very useful clues as to the features of a truly systems-level mechanism of emergence.

Recommendation 1: Emergence Is Not Evolution

Many systems researchers make no distinction between the terms systems evolution and systems emergence. We prefer to make a very strong distinction between the two. We use systems evolution to refer to the slow, gradual, modification of objects (not level types) that occurs in replication dominant objects according to both the usual Darwinian and non-Darwinian mechanisms. Given these definitions, the plots of Figures 3-6 do not show anything about systems evolution. That process occurs completely within and between the objects on a level. This process is uneffected by the constraint field (and the allometries) of the universal field, except that whatever variants that occur can be stable enough to evolve only within the k*orperplan* of the level type. Systems evolution operates according to the reductionist mechanisms of its level type.

Systems emergence has opposite characteristics to these. It is sensitive to the constraints and allometries established by the universal field, and demonstrated by the existence of plots like Figures 3-6. The mechanisms of emergence does not utilize the reductionist mechanics of the predecessor levels, but, in fact; actually produces the new and unique mechanism of the subsequent level. As such it is discontinuous with the mechanics of the previous level. Still, whatever new mechanic originates *de novo*, must fit within the limits of the universal field evidence by these graphs.

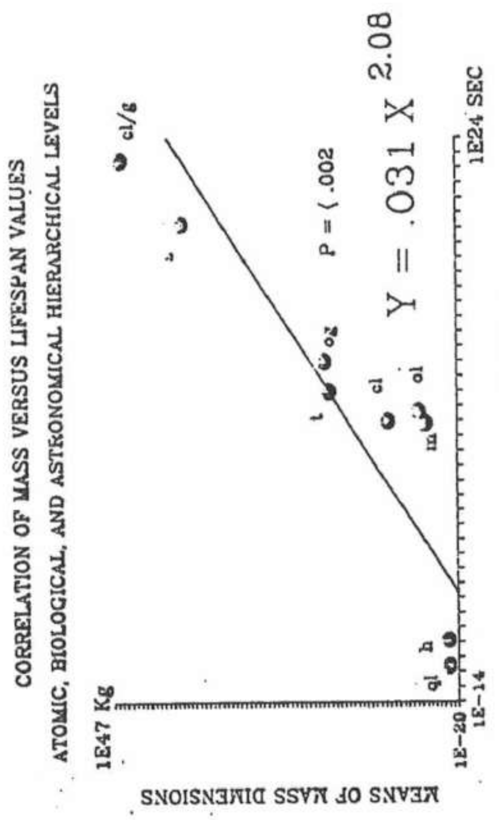

Figure Three

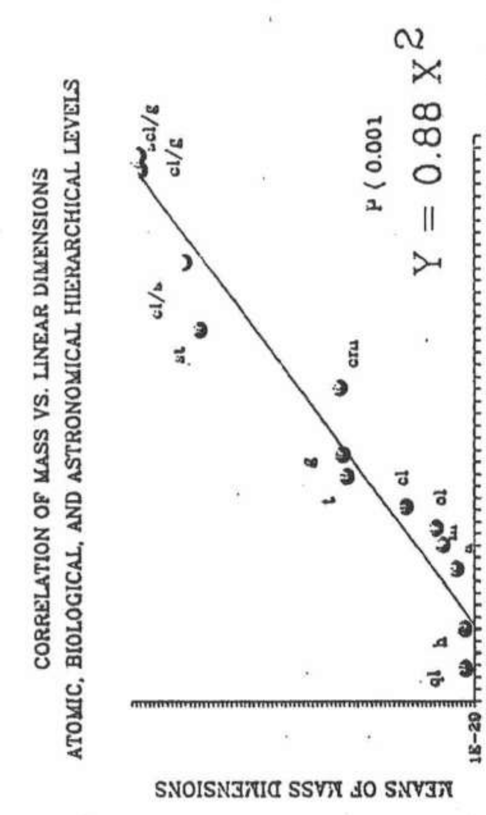

Figure Four

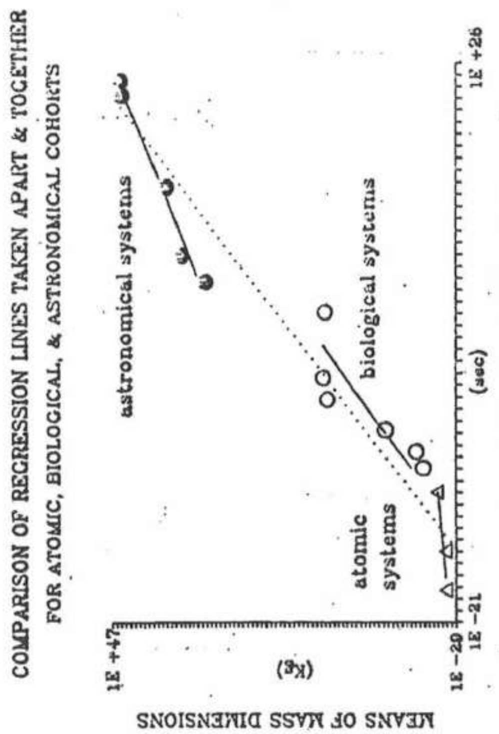

Figure Five

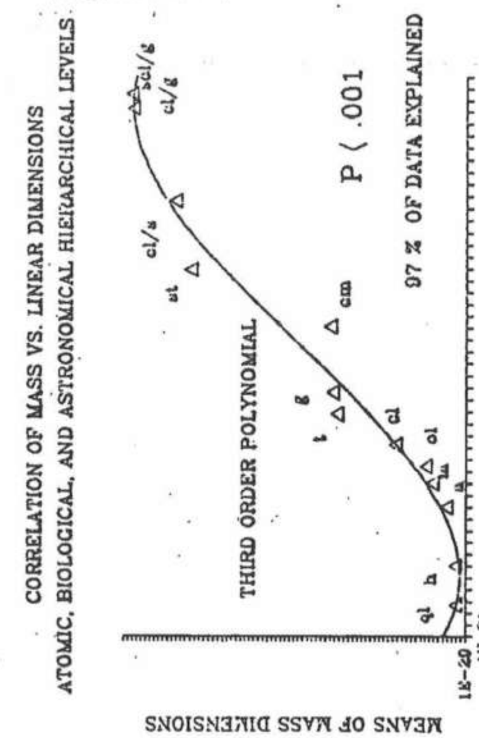

Figure Six

Previous work from our Institute indicated that there are major distinctions between "emergent" hierarchical levels and "subspecialization" hierarchical levels []. The former is the best candidate for discovering the details of the generic systems emergence process, in our opinion.

Recommendation 2: Evidence For A Generic Mechanism of Emergence: The Universe As One

The invariant nature of the allometric formulae (i.e. pairs of parameters) across incredibly different levels like subatomic particles, clusters of galaxies, multicellular organisms, and biopolymers indicates to us that every object in the universe (and so every level type admitted) is behaving according to our yet-undetected, but common limit field. Each of the level types, of course, originated at remarkably different and independent times in the history of the universe. While subatomic particles originated around 15 billion years ago, some stars originated 5 billion years ago, unicellular organisms about 3.5 billion years ago, and multicellular organisms only 2.5 billion years ago. Not only are their times of origin (emergence) separated, but so are their mechanisms. The mechanisms of operation of each of these levels as recognized by the separate conventional disciplines are incredibly different. Yet these graphs show that the results of each mechanism are so close in terms of parameter sets that their separate times and mechanisms of origin are responding to some common guidelines. Thus, the diverse objects of the universe are shown, empirically, by comparative systems science treatment of the reductionist-recognized data, parts of one unified whole. Note especially that while in Figure Five each of the major domains of level types (eg. astronomical vs. biological) there are somewhat distinct regression curves, the fitting of 97 % of the data with a third polynomial curve looks suspiciously like the normal S-shaped growth curve. Does this imply that the objects of the universe have grown across all potential level types to occupy the original "potential" of the universe at its point of origin? What an interesting idea, impossible to conceive of without this type of data treatment. This is direct evidence, in our opinion, that an emergence mechanism common to all of them exists.

Recommendation 3: Focus On Truly Emergent Levels

But of the plethora of levels suggested by reductionist workers, which are the truly emergent levels to focus on to derive clues from the data concerning the systems emergence mechanism? This same data base also has utility for testing which of the levels are distinctly different from the others using clustering analysis and multiparametric statistics. Former results of these tests have been reported [], and show that not all of the "levels" recognized by the conventional sciences are correct and emergent. Some are subjective "noise" which need to be eliminated to perceive the "signals" in the data regarding identity of the mechanism of systems emergence. For an excellent, comparative study of the debate between ecologists on which are and which are not the true levels in biological systems from the point of view of their cohort of disciplines see []. The lack of consensus in this supposedly more exact science than systems science indicates the need for distinguishing between "emergent" and "subspecialization" types of levels. The need becomes even more acute when, as proposed here, the entire metahierarchy of conventional hierarchies of the various disciplines is considered all at once for evidence of emergence. In this case, one not only has to deal with disagreement within a specialty, but with major disagreements between admissable types of data and methods between specialties. We hope to continue this work by extending into the realm of the social sciences this next year. Imagine the disagreements to be overcome between the natural and social systems concepts of levels!

Recommendation 4: The Need To Specify Predictions Tightly Coupled To The Mechanism Proposed and Recommendation 5: Unconstrained Theory Is Counterproductive

Perusal of the literature on systems evolution and emergence indicates that there is a lack of predictions from the various models now proposed. Without predictions there is no way to distinguish between the alternative theories. To state that nothing can be predicted is to state that nothing can ever be known about emergence and is an unacceptable position, in our opinion. If a theory appears with no predictions, we must immediately ask why its various components have been proposed. Further, if predictions advanced have no connection at all to measurables they cannot be confirmed or improved. There can be no evolution of the systems emergence theory proposed. Without predictions coupled to the data of the real systems, there can be no relation between the postulates of general systems science and the conventional disciplines, leaving systems science alone, and in the realm of vague generalizations; its undesirable present position. But by use of data sets such as those proposed here, which are derived from the conventional sciences own literature, there is a very tight coupling to the conventional sciences. This would allow them to directly criticise and improve our products, which is more desirable than their complete ignorance of our attempts. From these back-and-forth debates the conventional sciences could develop a relationship with and mutual respect for systems science. An empirically based systems science might then actually contribute to the conventional sciences, and even change our and their *Weltanschauung* (worldview) during the 21st Century.