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Sysinformatics & Systems Mimicry: New Fields Emerging from a "Science" of Systems Processes Engineering

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Abstract

This paper gives an overview of the **S**ystems **P**rocesses-**P**atterns/Systems **P**athology (SP3) project of the INCOSE SSWG (Systems Science Working Group) because we see two new specialties arising from that research program. The project is based on research conducted over the last 300 years on natural systems in the seven natural sciences (astronomy, physics, chemistry, geology, biology, math and computers).[1] It seeks to unify that knowledge with systems thinking from human and social systems research. The resulting integrated knowledge base (KB) is overwhelming, even when abstracted to only those 50 principles and pathologies that tell us something experimentally about how natural systems work or don't work. The SP^3 project collects facts in 25 categories (each described in this paper) and hundreds of Linkage Propositions (LPs) that explain how 55 systems processes influence each other to maintain systems health. We suggest a new approach called sysinformatics modeled after the bioinformatics courses that today prepare workers for genetics and systems biology. We need corresponding courses in sysinformatics to prepare workers in systems science, systems engineering, computer-based modeling, and new fields such as sustainability studies. The need for bioinformatics resulted from a range of advances in new experimental tools and techniques that led to terabytes of data that required meaningful analysis to bring from the lab bench to the hospital bed. Similarly, sysinformatics would attempt to make more meaningful the mountains of data and relations resulting from a new science of systems. It will require active participation of the computer sciences, engineering specialties, and deep mathematics. Overall, it would help in understanding of how systems processes work and don't work. Sysinformatics would be a rigorously transdisciplinary field aimed at the discovery, storage, retrieval, organization, classification, and analysis of systems science data. It would stimulate discovery of new tools and algorithms for analysis of data, encourage invention of new ways to present and display data in ways more easily or intuitively meaningful to humans (like the Circos maps of genomics that interpret many

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different whole genome changes). Sysinformatics would add data mining, AI, simulation image processing, a range of algorithms, new companies and computerized tools to the toolboxes of practicing systems engineers. This paper describes initial similarities and differences between bioinformatics and sysinformatics. It also introduces "systems mimicry" as a potential new specialty and suggests similarities and differences between biomimicry and systems mimicry.

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1. Two Ongoing Projects of the INCOSE Systems Science Working Group

In 2010 the INCOSE SSWG officially adopted two projects at an INCOSE International Workshop. The objective of the first was to integrate numerous diverse and fragmented sources from systems thinking to systems science to develop a more usable KB representing a new evidence-based science of systems for SEs rooted in both the natural and human sciences. This unification would use previous work on candidate "systems processes" and "linkage propositions" as its framework.[2] The resulting KB would explain in unprecedented detail "how systems work." The objective of the second was to formulate a new systems pathology based on the process approach.[3] These "top-down" systems pathologies would show "how systems don't work." Results from both projects would require systems mimicry and sysinformatics.

1.1. Shared Productivity with the ISSS (International Society for the Systems Sciences)

An official agreement between INCOSE and the ISSS, was signed in 2011.[4] ISSS has long-standing SIG's (Special Integration Groups) on General Theories of Systems and Systems Pathology related to the 2 aforementioned INCOSE projects. Past work of ISSS was joined with present INCOSE efforts resulting in > a dozen systems scientists and systems engineers working on shared goals and products. At the time of this publication this has resulted in: 17 published research papers, 3 INCOSE Webinars, 9 Workshop sessions, 8 Reports, 2 Systems Radio Interviews, and 30 Powerpoint lectures for a total of ~70 products. There were also a number of electronic debates on these topics using email and Google during this period that are ongoing.

1.2. Systems Process Theory (SPT) – How Systems Work:

Why did these projects focus on systems processes (SPT) for unification of the currently fragmented systems areas (as a core for SE)? Here are some reasons: (1) Engineers are sensitive to the processes they use and processes they design into their products. (2) Processes are the ways that systems respond to their context to accomplish their function. (3) Processes are the ways that systems achieve change, adaptation, and sustainability. (4) Processes usually drill down to the most fundamental causes why any system came into being and maintains its becoming – so they are ontology, ontogeny[5] and identification all in one. (5) Processes can be studied in great detail and their steps are measurable and falsifiable. (6) Processes are what the natural sciences study in the phenomena of nature they identify (e.g. photosynthesis; mountain building; continental drift; galaxy formation; star stages; origins and adaptation of species, dozens of cell processes). (7) As a result, there is an immense repository of evidence-based (that is, experimentally verified) knowledge on the processes of natural systems. (8) But these processes are not seen as "systems" processes. (9) SPT compares across many domain level processes to see general system architectures, archetypes, or universals (isomorphies). (10) SPT provides evidence of the range of validity or proof of isomorphy for these systems processes. (11) SPT adds the significant new level of how the systems processes impact or influence each other to elucidate a detailed systems dynamics of systemness in general. Since these systems processes have been "tested" across billions of years, in many different particular instantiations, vast numbers of events, at vastly different scales (masses from 10^{-25} to 10^{52}), it would suggest that the resulting isomorphies, used over and over again are reliable architectures to use in many engineered systems, or that they should be considered in many attempts at modelling, or in diagnosis of systems dysfunctions. (12) Thus, translations of the works of soft systems approaches and hard systems approaches into these processes would be a useful knowledge base to learn, teach, and conduct research on.

1.3. Unifying Fragmented Systems Areas:

There are many different workers in the general area of systems. They range widely, many almost completely isolated from each other. We have libraries of lifework of multiple workers in each: soft systems methodologies, systems thinking; mathematical systems theory; single isomorphy sysmodels; sysmodels with a few systems isomorphies; systems engineering per se; single natural science isomorphy; natural science models with a few isomorphes; natural science models; general systems theory; systems biology; systems chemistry; earth systems science; systems neuroscience; systems management; systems philosophy, and more.

This is not an exhaustive list of systems thinking categories. At one recent workshop for the SP^3 projects a group of 25 participants identified 135 systems workers in 20 minutes.[6] The primary objectives of these two new fields is to bridge the chasms between these areas by abstracting from the particular instances using rigorous comparison across the entire set to find processes common to most. Translating the commonalities of all areas into a process-oriented framework unifies SS fragmentation to serve a process-based SE (with the advantages of 1.2).

1.4. Systems Pathologies – How Systems Don't Work:

Based on the systems processes, we have identified major classes of systems dysfunction[3] (e.g. cyberpathologies, rheopathologies, heteropathologies, nexopathologies, and more. Within each class, we have identified dozens of specific diseases based on dysfunctions of the normal systems processes. We anticipate being able to suggest the consequences of each particular dysfunction allowing improved diagnosis, prognosis, comparative treatment regimens, and predictions. This new top-down classification of many systems dysfunctions amplifies the data load on SS and SE further demanding development of a rigorous sysinformatics.

2. Initial Look at Information Quantities for Systems Processes and Pathologies

Bioinformatics enjoyed immediate success (recognition, funding, jobs, innovation) because it answered a pressing need. Biology from molecular to physiological to genetic to neuroscience domains erupted with vast quantities of data. Would the products of SP^3 lead to significantly increased data? Only a gross estimate can be provided at this early date. We start with over 115 candidate systems processes in our SP^3 study, each needing 26 categories of information. While some of these categories have only a dozen initial entries in them, others have thousands of items which amounts to > quarter million items to keep track of and apply for the systems processes alone. We anticipate that computerized repositories will also include hundreds of Linkage Propostions (LPs). Each LP will require many dozens of independent citations from the peer-reviewed natural science literature. Combined with the SP information load, the entity density then exceeds a billion items. This exceeds human brain capacity and shows the need to manage and curate a vast database. This emerging challenge is not new. It is part of the expected natural evolution of sciences that study complex systems. Astronomy, space science and physics faced it long ago with vast streams of data being produced by probes, telescopes, and sub-atomic particle accelerators. How do you make such immense data sets or knowledge bases manageable for humans? How do you find patterns within them? That is the goal of sysinformatics.

3. Description of Twenty-Five Data Categories for Each Systems Process

What do we need to know about each systems process? Here are preliminary descriptions of the twenty-five categories of vital information that we are currently exploring. These give a sense of the depth and span of information that is coming out of systems science creating a pressure for sysinformatics and the potential for systems mimicry. SP^3 project workers are collecting information continuously for these categories. A Workbook for a core course (Intro to Systems Science for SEs) has placeholders for each. As teammates encounter information key to each, they can enter them into the reserved place. In this way, the categories provide for significant synergy among workers in the SP[3] projects for producing a unified product for SS and SE. At present there are many university programs for graduate degrees in Systems Engineering. By prior agreement, students can elect to do a part of their thesis specializing on just one SP[3] category and then apply it to their SE domain or task. All can then share harvest of the vast literature and information across the natural and systems sciences. Selection and specification of relevant categories at the outset will facilitate curation and maintenance of the shared knowledge base promoting much-needed integration of a previously fragmented systems science. Precise specification will also enable cloud sourcing. Can you think of any category we have left out?

(1) Discipline-, Domain-, Tool-, and Scale-Based Exemplars (DDTs): Clear examples serve to quickly introduce a new user to the meaning of each SP. Just as a picture is worth a thousand words, an exemplar effectively communicates the scope and meaning of the systems process. Exemplar implies utility beyond a mere example. Like an anecdote or parable, an exemplar captures the essence of, is an ideal example of, a paragon, the epitome of the SP. Because we are comparing across so many different disciplines to find processes common to most, it will be important in the intro to show exemplars from several different scales (size dimensions), domains, and disciplines. This would provide a sense of its isomorphic nature from the outset. An example of DDTs-independence for one SP would be HIERARCHIES present across: (i) astronomical objects; (ii) the periodic table for chemicals; (iii) in the lithostratigraphy and biogeography of geology; (iv) subsystems forming systems in the body from molecules to cells to tissues to organs to organ systems; (v) in social systems such as military, religion (from which the word originated), and government (social dominance). There are many more.[7]

(2) Identifying Features and Signifcance: Research leading to a new curriculum to attract students to STEM, Integrated Science General Education (ISGE)[8] indicated the effectiveness of giving students identifiers that would help them recognize a systems process on new scales, or from different science disciplines rather than just a word definition. The “word definition” made them more comfortable. That is how we usually learn new terms. But the cluster of identifiers gave them the ability to “discover” the common pattern when comparing many different systems. Identifying features capture the essential characteristics of a systems process. How it works; how it makes systemness work. Sometimes two SPs share one or two ID Features; but that overlap just indicates that all SPs interact and does not interfere with discriminating between them as each has several unique identifiers. That SPs are individual but highly interconnected mimics the neural net structure of the brains we use to understand systems. So the initial learning events for SPT entails becoming familiar with the ID Features for each SP. Some Identifying Features for the SP hierarchy-forming processes would be: (i) scales/levels; (ii) subunit to unit; (iii) clustering; (iv) emergence; (v) seven cross-level parameter trends; (vi) subsumption.

(3) Identifying Functions and Significance: Functions describe how & what any particular SP contributes to system stability and sustainability. Natural science rejects use of the word goal or purpose as anthropomorphic and damaging to the objective approach central to science. However, quite appropriately, SE, focuses a great deal on the “purpose” as do other human pursuits. We suggest the word function to serve both purposes (pun intended). Function can subsume goal or purpose and yet preserve the demand for objectivity espoused by scientists. The function of a system defines how it fits into and adapts to its environment while ensuring its own continued stability and sustainability. Examples of identifying functions for hierarchy-forming processes would include: (i) reduce total complexity by bounding in subsystems; (ii) increase stability of multi-level assemblies; (iii) employ benefits of modularity; (iv) enable increase of mix-n-match variation; (v) escape upper interaction limits; (vi) allow for redundancy; (vii) simplify top-down regulation; (viii) enable bottom-up control; and more.

(4) Proof of Isomorphy: This is a crucial element missing in many past general theories of systems. Comparisons are too often left at the level of assumption and description without systematic testing. Using our concepts of identifying all of the hierarchical scale levels from the origins of the universe to the origin of societies, and coupling this with a recognition of the classification of traditional disciplines, we are charting where a particular pattern is present and where not. So we test isomorphy. Universal isomorphy may be rare, so it would be very useful to record where each has been experimentally observed and where not. The result will be “ranges of validity” for each candidate process, pattern, and pathology. We have presented, for example, a comparative analysis of cycles as an SP showing consistency of ID Features and Functions across 52 case studies from all science disciplines and many social science domains to exemplify “proof of isomorphy.”[9] We intend to do this for all candidate isomorphies.

(5) Linkage Propositions (LPs): The SPT goes beyond proving isomorphy to the meta-level of describing in detail how these SPs influence each other. The mutual impacts are captured in unit statements of how one SP affects another called "Linkage Propositions".[10] They "link" SPs together into one system. We call them "propositions" because they are proven by experiment in some systems, but not all. We stress that they must be continually evaluated and subjected to falsification. The many LPs across the many SPs produce a "system of systems processes" as a general theory. The action of the LPs on the SPs vastly increases the understanding of the dynamics of systems in general –the most important & significant value-added of the SPT.

(6) Prerequisites and Dependency Relations: One SPT tenet is that ALL SPs are equal. This combats the prevailing tendency of many systems workers to focus on a favorite isomorphy (e.g. feedbacks for Forrester; or synergy for Corning, Haken, Fuller) thereby ignoring many other SPs or making them subject to the one. This working hypothesis of axiomatic status for all SPs, though useful for balancing this tendency, has given way to our increasing recognition that some SPs are clearly prerequisite to others. For example, flows need to be present before other SPs like feedbacks or cycles can operate. It is important to recognize, develop information on, and catalogue these dependencies.

(7) Discinyms and Key Discriminations (Translation Tables): Comparing use of terms across disciplines reveals that some disciplines have discovered a process in their domain particulars that is also found in other disciplines and named it. The result is different names for the same abstracted, isomorphic process. We coined the term "**discinyms**" (**disci**plinary-based syno**nyms**) to increase awareness of this obstacle to communication across stovepipe disciplines and the accompanying failure to agree on isomorphic status. SPT provides tables of discinyms to raise awareness in specialists of the universality of certain processes.[11] An opposite obstacle is conflation of terms that are actually different. For example, conflating terms such as evolution & emergence, or development & evolution. A consensus general theory of systems like SPT may help discriminate between use of these currently promiscuous terms.

(8) Types and Taxonomies: Recognition of presence or absence of certain SPs, such as open vs. closed systems, has played a role in the past in identifying different types of systems. SPT cites as many as 30 different types of systems to date with many overlapping taxonomies. No one taxonomic strategy dominates because workers use different individual or clusters of SPs to establish their favorite taxonomy. SPT favors a multi-perspective view to allow and encourage different frameworks for different uses. SPT recognizes alternating, attracting, limit, adaptive, work, self-sustaining cycles, hypercycles, and marginally oscillatory cycles as types.

(9) Modelling Symbols & Logos to Use in Computer Graphics/Models: Inventing simple graphic representations for each systems process and using them often and consistently significantly helps learning in students new to the SPT. We call these logos. Diagramming the numerous SPs and LPs in simple concept maps helps ease understanding of the complex system of system processes produced by the LPs.[10] Widely available tools like CMap lets students construct these relationships piece by piece as they learn subsets increasing their understanding. We also see a need for CGI/GUI's that allow user-controlled fly-thrus of graphics of the SPT net and point invocation of any one of these 25 categories of information by the user. Future SPT versions will have regular symbol systems like those used by Odum, Forrester or Miller. The SP^3 modeling subproject of Schindel, Marzolf, & Smith are developing UML-based mappings.[12]

(10) Comparative SP Use in Systems Sources: By analyzing and comparing the text index section for SPs, one can get a useful overview of which are covered at what depth in sources. Indices have much more detail than section headings. At CSER we will show a chart that has an initial comparison of seven key systems texts for an "at-a-glance" charting of SP coverage. This is another product for integrating the many sources using the SP^3 framework. None of these texts have anything like the Linkage Propositions of the SPT although Miller's Living Systems has "cross-level hypotheses" which are quite different from LPs.[13] In our INCOSE-SSWG project for unifying a fragmented systems science, we chart pure natural science books in addition to classic systems texts. Some on pure physics have much to tell us about certain SPs. For example, Auyung,[14] Barrow,[15] Randall,[16] Greene[17] all include details on symmetry & other SPs. Future SPT at-a-glance tables will include the total number of pages covering each SP and exactly what pages -- a very useful product for SS and SE students and researchers.

(11) Natural Science Case Studies: We identified 274 phenomena in seven sciences that experimentally showed presence of SPs in the aforementioned ISGE research funded by the NSF.[8] At CSER we will show a chart that summarizes the distribution of these case studies. This was only a proof-of-concept study, not an exhaustive study so more are expected. We have now exceeded 300 case studies. Why is this important to the SP3 project? Because each of these case studies can teach us much about the systems process involved even if they are not part of the systems science literature *per se*. Each of them is a proven example of application of a systems process to solve a problem in sustainability for a real system.

(12) Measurables: Another hallmark of the sciences and experimentation are quantities. Identification of components and their characterization in numbers is essential to science and one of its major products. Engineers need and use these measurables in their praxis. As SP^3 workers go through the voluminous source literature they will capture both for SPs & LPs.

(13) Equations and Formalizations: While engineers use equations and mathematical formulations daily, some systems scientists and even natural scientists do not. Many experiments in geology and biology do not routinely require or result in equations, although statistics is often required for their adequate interpretation. On the other hand, some systems processes (e.g. regulatory control through feedback) have a long history and knowledge base of using math. Work of Klir or Rosen is mostly mathematical.[18] It is important that the SP3 project collect and curate all formalizations found for each SP and LP.

(14) Associated Tools and Techniques: Some focus on one, some on several systems processes. They would be included in the workbook under that systems process. For example, systems dynamics tools are focused on feedback loops. There are other techniques, for example statistical packages that will do hierarchical clustering so would be included under hierarchy.

(15) Applications Exemplars: A critical category for SEs would be exemplars of successful implementations of the SPT theoretical knowledge base to solving practical engineering problems. It is also the most difficult to fulfill as the theoretical knowledge is just now becoming available in the detail needed to try significant application. Perhaps the best opportunity to collect exemplars on application would come from SE students using SPT in their thesis research. We could use the example of feedback as an initial example. It has a widespread, proven history of use in engineering across virtually every one of its domains. Another is the modularity characteristic of hierarchical structures. We argue that the 300 case studies cited above are also cases of SPs & LPs used by nature to solve critical systems problems.

(16) Brief History: Some of the SPs have been recognized for a long time. Feedback probably has the most obvious history beginning with its recognition as perhaps the first isomorph.[19] But each of the SPs will have an interesting set of stories about its discovery and elaboration. For example, whole books have been written on the history of symmetry,[20] chaos,[21] and fractals.[22] These poignant human stories capture the interest of the public and students.

(17) Workers: It is always a sign of someone adept at a certain knowledge domain if they can cite a large number of researchers who are active in the area. It is important that they not only be able to cite individuals, but also teams in this age of large sets of collaborators, or that they can cite the specific work coming out of a particular lab. It is through contact with these established experts that students and those who apply their knowledge develop their own careers and expertise in the area. This shows the utility of such a comprehensive survey.

(18) Institutions: The argument here is the same as the last section. Who working in systems is not knowledgeable of the professional societies involved (INCOSE, ISSS, IFSR, IEEE, etc.), or special Institutes and Centers like the Sante Fe Institute or NECSI. But there are many others. Google retrieves 2,400 for "complex systems institutes" and 4,630 for "centers complex systems." Likely there is redundancy in such searches, but they still indicate the size of the field.

(19) Funding Agencies: Engineers know who funds their organization. Much of the work in such a corporation is concerned with building capability and experience that attracts funding or with writing bids and applications for funding. Even university researchers spend a considerable amount of time trying to attract support for their projects. A comprehensive list of past, proven funding agencies of all types (federal, state, private & public foundations, corporate, philanthropic) would be beneficial to SSs & SEs.

(20) Literature and Bibliographies: A list of books and reviews on any particular SP would be very useful for students and researchers. For some SPs there are many text-length books, e.g. hierarchy.[23] But even for unusual SPs like symmetry (unusual to the average systems thinker), there are several books entirely focused on symmetry[20] while others have significant sections on symmetry.[14-17] Often these have not been harvested for SS because they are out of the traditional systems thinking categories. Journal research articles on SPs are far more numerous than fulllength books. We have 632 reprints in our personal collection on the Origins SP alone. SPT will collect many student searches in Endnote for sharing.

(21) FAQ's (Frequently Asked Questions): One often encounters this feature in many websites today. Such questions serve a very useful purpose as many humans stumble upon the very same confusions or need for inquiry when encountering new material. Collection of the FAQ's over time reveals explanations that need fine-tuning, measures categories of special interest, and provides quick intro's.

(22) Current Consensus Findings (stand alone facts): While there are many facts emerging from experiments in the hard systems sciences and mathematics, there are also insights and arrangements from other approaches with systems implications that must be seized and exploited. This is probably the category that will be most used to capture the insights of the workers in systems approaches like management, philosophy, systems thinking to join with the findings of the natural sciences.

(23) Future Questions and Hypotheses: A good theory is recognizable by the answerable questions it enables in the minds of its proponents and critics. Opposite the natural human tendency for finality and completion, science as it grows is instead characterized, like an inflating balloon, by an ever-increasing number of new questions (the balloon surface). There are also unresolved islands of bafflement in theories that should attract future work. Sometimes exploration of these leads to entirely new insights and paradigms. We would want any participant in the SP^3 project to continuously be hyper aware of (and record for others) new questions that arise in studying systems processes and pathologies. Like the time-honored success in mathematics of famous conjectures, there should be a similar tradition in SP^3.

(24) Comparative Word Definitions: There is utility, comfort and conciseness in word definitions. For many of the SPs there are many definitions by different authors in the literature. By assembling large numbers of these definitions and comparing them one can see repeated use of the same phrases. This side-by-side juxtaposition is instructive in itself. By collecting all such phrases one can assemble an uber-definition. The two-volume Encyclopedia of Systems Science attempts to do this.[24] So will SPT.

(25) Proof Candidate Systems Processes are Processes: Some challenge whether certain entries in our initial list of ~50 SPs are actually processes. This is especially true for the universal structures we insist are built by processes. So to answer those challenges, one of our categories is explaining the "steps" for each candidate SP. This also helps identify specific dysfunctions.

4. Elements of Bioinformatics and Initial Image of Sysinformatics

New techniques will be needed to make sense of and use the vast data gained populating the above categories. We suggest sysinformatics, mimicking bioinformatics, will be necessary.

The term bioinformatics was coined in 1970 but did not become widespread until the nineties. Modern sequencers can now decode an individual human genome (3.2 billion bp's) in one day for about $2000 resulting in an even greater flood of data. The main services of bioinformatics, & so sysinformatics, are to store, curate, classify, retrieve, and analyze the vast amounts of data being produced. They will accomplish this mostly by writing new computer software. Only computers can handle such gigabytes of data. Specific tools have appeared written in program languages such as Java, C++, and SQL and special algorithms in mathematics like control and information theory. Other services they may provide will be pattern recognition, taxonomy building, data mining, and improving visualization of data so humans can understand it. Both modern biology and systems science share focus on systems complexity problems. So we could use the experiences of bioinformatics to guide development of sysinformatics. There are differences. For example, the form the data takes in genomics (linear sequences of nucleotides or amino acids) is much more uniform in bioinformatics than the diverse categories for sysinformatics. Yet even in biology massive brain data is quite different from linear sequences, so perhaps they could inform each other. Recognizing features that we expect to see in Sysinformatics that are also in Bioinformatics would be a way to give Sysinformatics a head start in its development. Some common features might be: (i) both are highly interdisciplinary (sysinformatics even more than bioinformatics); (ii) both look for patterns in huge collections of raw data; (iii) both need to analyze complexity; (iv) both need to "mine" for specifiable information in a huge literature; (v) both need to analyze regulation and regulatory circuits; (vi) both need to detect circuits, subgraphs and motifs in representations of networks; (vii) both need algorithms for hierarchical clustering; (viii) both need algorithms for self-organized mapping; (ix) both do extensive modelling of networks; (x) both need tools to make the overall knowledge base more manageable and usable.

5. Initial Image of Systems Mimicry Modeled after Biomimicry

While theory is still not fully accepted in biology, and SS theory may not be accepted by SEs, the new field of biomimicry provides evidence of the great utility of natural science to engineering at a more minimal level of abstraction. There appear to be many ways that engineers ca have already used the solutions that bioevolution and adaptation have achieved across 3.8 billion years of trial and error, selection and elimination. It is hard for humans to appreciate the incredible numbers of events and entities used up to achieve these solutions. Why not take advantage of what nature has tested for us already in terms of biosolutions and general systems solutions? Systems mimicry would enable copying from a much wider set of systems from 14 billion years of testing. One place to observe the impressive number and wide range of potential uses of biosolutions in engineering is by visiting ….. http://www.asknature.org ….. There you will find 1,600 adaptations of biosystems organized into an engineering-oriented taxonomy to make them easier to explore and exploit. The taxonomy is organized into 8 "function" groups (each with from 90 to 1,096 cases), 30 subgroups and 162 classes of "function." The adaptations are termed "strategies" and defined as "ways that organisms overcome or meet a particular challenge." In our context, they could be defined as how species solved a particular problem, satisfied a need, or found a new function. Sometimes it was in response to a challenge from the environment, sometimes an exploitation of a new potential, and sometimes an exaptation from a previous solution -- modification to serve a completely new purpose. Some of these "strategies" have been copied to engineer useful products for human use. Think of Velcro. But many of the strategies have yet to be mimicked by engineers. To help us extend biomimicry to systems mimicry, here are some distinctions. Similarities include, that designs in both: (i) solve a problem; (ii) fulfil a need; (iii) exploit a potential; (iv) use components in a unique way. Differences include: (i) biomimicry = from particulars to particulars vs. systems mimicry = from high abstractions to particulars; (ii) biomimicry = only living systems vs. systems mimicry = all systems. Can you think of more? To extend the general concept of biomimicry to systems mimicry we need to: (i) recognize that not only biosystems' respond to their environment – all systems do. Every system, from galaxies to a species, must fit within the offerings and demands of its environment, at its scale, in order to achieve sustainability; (ii) understand that systems have had 14 billion instead of just 4 billion years to come up with solutions; (iii) organize papers, workshops, and institutions to spread awareness of potential; (iii) change focus from particulars to more abstract architectural solutions; (iv) overcome belief that different scales are completely separate and distinct (please see[1]).

6. Conclusion: Significance of Conscious Use of SysInformatics & Systems Mimicry

Rigorous comparison of many entities (through sysinformatics) can reveal evidence-based similarities of process to imitate (systems mimicry) for a process-based engineering. The key step is willingness to leave the level of particulars. But particulars are the exact level most selected for in our natural evolution as humans. We learn particulars. We sense particulars. We survive by adapting to particulars. So it is understandably difficult for us to focus on abstractions from particulars or to regard them as important. Yet they must be very significant in ways we do not understand else why would they reappear again and again at all scales of reality, in most all real systems. Although abstractions to us, they must be even more important than any cohort of particulars because they span them all. Once these isomorphic processes are widely enough recognized and tested, then they can be used to guide the design, development, testing, evolution, and repair of new and old systems just like biomimicry solutions help us imagine new engineering products.

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