Proposed I.S.I.S. Institute for the Systems-Integrated Sciences

Len Troncale, President
General Systems Research, Development, & Consulting Co. (GSRDC),
Professor Emeritus, Dept. of Biology
Director Emeritus, Institute for Advanced Systems Studies (IAS),
California State Polytechnic University

USE OF NATURAL SCIENCES AS SOURCE AND TEST OF SSP

Logos for the Institute for Advanced Systems Studies (IAS), and California State Polytechnic University

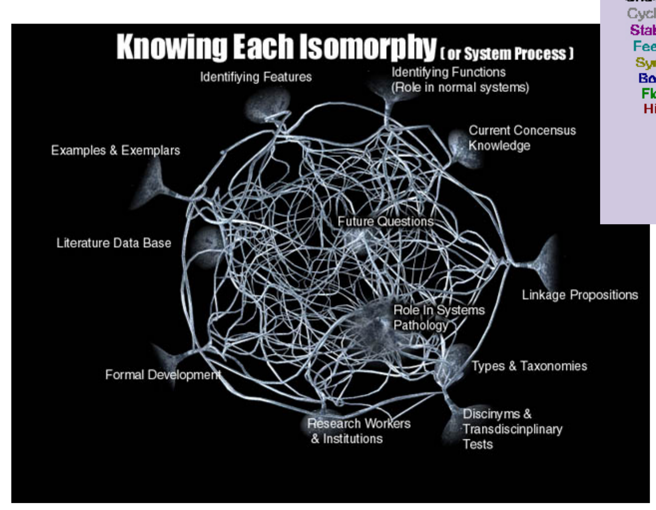
Purpose of This Work

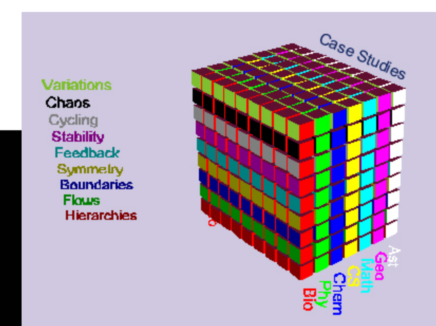
• This poster seeks to evaluate the utility of harvesting extensive, reductionist, empirical research from seven well-established sciences (i) to provide vital detail on isomorphic systems processes to develop systems science, (ii) to show that use of systems processes has a significant role in organizing & informing 100's of phenomena of the sciences, and (iii) to test the "extent" of universality or isomorphism of each systems process across the sciences or natural origins.
• The first chart below shows the number of peer-reviewed scientific articles in the SSP archives that demonstrate one or more isomorphic systems process in a scientific domain (xxx), while the second shows the total number of phenomena or case studies (282) that those experiments elucidate.

Database Articles by Systems Process

SSP-ISGE DATABASE ARTICLES BY SYSTEMS PROCESS & BY SCIENCE

	ASTRONOMY	PHYSICS	CHEMISTRY	GEOLOGY	BIOLOGY	MATH	COMP SCI	NATURAL SCIENCE PROCESS TOTALS	SOCIOLOGY	APPLIC'NS	LINK PROPS
HETEROPOIESIS - HIERARCHIES											
BOUNDARIES - LIMITS											
CHAOTIC PROCESS											
CYCLES, CYCLING - OSCILLATIONS											
DUALITY											
EMERGENCE											
FEEDBACKS											
FIELDS											
FLOWS											
INTERACTIONS											
NETWORKS											
ORIGINS											
PHASES - STATES											
STABILITY - EQUILIBRIUM											
SYMMETRY											
Total for Science =											





Case Studies (Phenoms) by Systems Process

SSP-ISGE CASE STUDIES (PHENOMENA) BY SYSTEMS PROCESS & BY SCIENCE

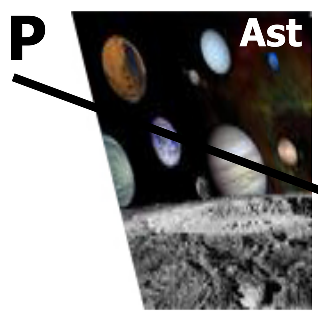
	ASTRONOMY	PHYSICS	CHEMISTRY	GEOLOGY	BIOLOGY	MATH	COMP SCI	NATURAL SCIE PROCESS TOTALS
HETEROPOIESIS - HIERARCHIES	4	3	5	3	7	5	7	34
BOUNDARIES - LIMITS - FIELDS	5	3	3	3	4	2	5	25
CHAOTIC PROCESS (see also origins)								0
CYCLES, CYCLING - OSCILLATIONS	5	5	5	6	6	3	6	36
DUALITY	2	5	4	6	5	5	5	32
EMERGENCE	4	3	5	3	7	5	7	34
FEEDBACKS	1	2	2	4	4		7	20
SYS VARIATION, DEV'T, EVOLUTION	1	4	1	2	5		3	16
FLOWS, NETWORKS, INTERACTIONS	3	6	5	8	9	2	6	39
INTERACTIONS								0
NETWORKS								0
ORIGINS	3	2	2	6	4	3	4	24
PHASES - STATES								0
STABILITY - EQUILIBRIUM	3	3	2	5	4		5	22
SYMMETRY								0
Total for Science =	31	36	34	46	55	25	55	282

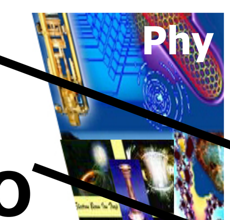
This chart has many uses. It shows how extensive are the independent discoveries of systems processes in the various sciences; it helps us locate where we need to focus attention to find more phenomena with systems processes active; it raises questions about the collapsing or grouping of processes; it provides proof of the various extents and ranges of isomorphy across the sciences

"I-Tests Using Established Natural Sciences

• **THE NATURAL SCIENCES:** The montages below are symbols of the phenomena that are studied by each of the seven natural sciences covered in SSP construction, namely, from left to right, astronomy, physics, chemistry, geology (the physical sciences); biology (the life sciences); mathematics and computer science (the symbolic sciences). We call them the natural sciences because the phenomena each studies would exist whether or not humans existed or not. They occur here in the order of their emergence in the unbroken sequence of origins shown at the bottom, but are listed simply alphabetically in the knowledge base of 282 case studies or phenomena shown at right. Here they represent the domains of nature that may or may not exhibit presence of a systems process.

P





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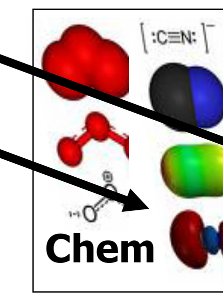

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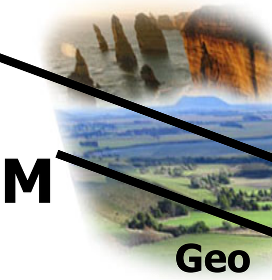

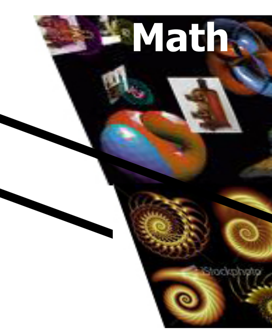

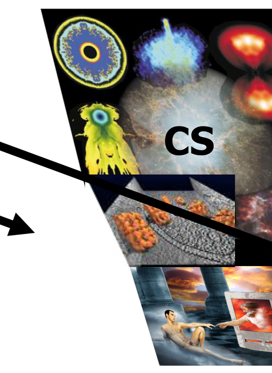

• **A WAY TO TEST EXTENT OF ISOMORPHY FOR EACH SYSTEMS PROCESS:** By searching the literature for experiments that show or do not show presence of one of the systems processes, we can learn more about the dynamics and function of each process while we show or measure (or we prefer to say "test") the extent of existence of each putative systems process. The arrows across the domains of the sciences above indicate how many disciplines each is found in leading to the concept of different types or classes of isomorphy. This is better shown with the higher resolution of the sequence of origins or table of nearly 300 phenomena and growing …….

Types, Classes, or Extent of Isomorphies

• A major tenet of the SSP is that the key 90 to 100 systems processes elucidated to date are isomorphies (used as a noun), not just isomorphic (used as an adverb to denote a two-way comparison). SSP uses isomorphies as multiple and not singular and as a *sine qua non* and *a priori* necessity as a interlinked group required for a natural system to achieve a "mature" status. But do all putative isomorphies apply to all natural phenomena studied by the natural sciences?
• Critics easily challenge general theories of systems because we use the term "isomorphic loosely relative to its original use in mathematics, and because all systems processes similar to a set of systems are uncritically presented as universals. It is very difficult to prove universality to reductionists who focus exclusively on their discipline or a limited set of phenomena.
• Here we suggest a solution. Add common prefixes to the term isomorphy to indicate the actually demonstrated "range" or "extent" of natural systems in which they have been studied by the most rigorous of empirical methods. This more precise use of terminology, when coupled by the clear evidence for existence of the isomorphy in specifiable domains might render systems theory more a science of systems. Exact specification of limits of use and range pf applicability is the goal.
• Oligo-Isomorphic: (as in "O" arrow above) "oligo-" is Greek for "few"; in common use e.g. oligopeptides; refers to empirical research that has identified existence of a candidate systems process in a few neighboring disciplines or emergent levels in the sequence of levels shown below.
• Multi-Isomorphic: (as in "M" arrow above) "multi-" is Latin for "many"; in common use e.g. multidisciplinary; refers to empirical research that has identified existence of a candidate systems process in a many, but not all neighboring disciplines or emergent levels in the sequence of levels shown below.
• Pan-Isomorphic: (as in "P" arrow above) "pan-" is Greek for "all"; in common use e.g. pantheism, panomics; refers to empirical research that has identified existence of a candidate systems process in a virtually all neighboring disciplines studied to date or all emergent levels in the sequence of levels shown below.
• Critical use of these terms rather than simply using isomorphy indicates the "limits" of isomorphy and tests of reliability An additional advantage of the above approach is that it relates the transdisciplinary study of isomorphic systems processes to their demonstration in reductionist sciences using the accepted methods, protocols, and even reports accepted by their individual disciplines. It thus unites the empirical reductionist approaches with the systems approach.

"I-Tests" Using Unbroken Sequence of Origins

• Self-Organization: Logo at right represents several independent, separate entities or subsystems integrating (combining) into one new entity as a unit of origin or emergence. This new integration ("I" events below) a new scalar size level of entity appears for the first time in the our space-time continuum.
Diversity to Complexity: Such emergent entities create a new scalar level of manifest ystem organization that in nature quickly diversifies (evolves) into vast numbers of ariants. The logo represents one new order diversifying into numerous slightly different ntities. Represented in the graphic below by "D" for diversification event.

• **SEQUENCE OF ORIGINS:** Below find what the SSP describes as the major emergent events (milestones) in the history of our universe. Each unit cycle represents the integration of the past variants into a new entity plan on a new level (scalar size) of the meta-hierarchy of nature and its subsequent radiation into many alternative manifestations. The entire series of individual I/D (integration or Diversification) cycles is shown as a continuous series because the scientific discipline for that level of phenomena often have discovered multiple scenario's that would explain how the subsequent level arose spontaneously from the previous level. Concatenation of these local theories results in an unbroken sequence resulting from a unified process of emergence. Just as we searched across several science disciplines to test for "presence" of any one systems process, we could search across these emergent levels for presence of one systems process. Many workers have noted that the various sciences tend to focus on one or more of these scalar levels because that is where their phenomena reside.

I: ylem, cosmic origin | I: quark str | I: hadron str | I: first atomic nuclei | I: matter-energy joined | I: H & He formed | I: cluster & nebulae form | I: massive stars form 3rd & 2nd G | I: nuclear fusion | I: 1st G. stars & planets & asteroids | I: aggregation of inorganic geomorphs | I: organic monomers self-organize | I: aggregation into polymers | I: concentration of polymers in protobionts | I: short metabolic pathways | I: nucleic acid (RNA) & protein paths couple; genetics | I: RNA info integrated in DNA; genome | I: Integration metab & genes | *I: UC indiv → populations | *I: UC pops → communities | *I: UC comms → ecology nets | I: complex genomes → nuclei | I: aggreg --> organelles | I: cells into colonies | I: appearance of complex MC dev't plans | I: neural nets into brains | ETC.

D: big bang expansion | D: types of quarks | D: many types of hadrons | D: many variant nuclei | D: matter-nrg separate | D: simplest gasses separate | D: diversity of nebulae | D: nuclear fission in stars | D: diversity of heavy atoms form | D: many diff't star & solar systems form | D: diversity of geomorphs (atm/cont) | D: organic monomers diversify | D: diversity of polymers self-organize | D: diversity of protobionts | D: diversity of pathways | D: diversity of genetic codes | D: diversity of genomes | D: diversity of unicell UC types | D: diversity of UC populations | D: diversity of UC commun's | D: diversity of UC ecologies | D: diversity of nuclei cells | D: diversity of organelles | D: diversity of MC species | D: diversity of MC dev't plans | D: diversity of neural nets

Outline Listing of Phenomena by Systems Process

Hierarchies & Emergence: *Rules of Scale*
- **Astronomy**
  - Astronomical Hierarchy
  - Particle Physics Hierarchy
  - Theories of Motion Hierarchy
  - Atomic Force Hierarchy
- **Biology**
  - Muscle Types and Structure
  - Levels of Sensory System: The Human Eye
  - Levels of Digestive System
  - Chromosome Structure Hierarchy
  - Developmental Programs as Hierarchies
- **Chemistry**
  - Periodic table
  - Intro to life polymers
  - Structure of DNA
  - Structure of protein
  - Structure of atom
- **Computer Science**
  - Hardware Hierarchy
  - Software Hierarchy
  - Information Hierarchy
  - Numbering system
  - Database --Hierarchical model
  - Graphics Hierarchy
  - Concepts of Stepwise Refinement
- **Geology**
  - Geological Time Scale
  - Litho-stratigraphic hierarchies
  - Stream System (Hierarchical form)
- **Mathematics**
  - Set Theory: Terms & Functions
  - Classes of Numbers
  - Subunits of Algebra
  - Dimensions in Topology
  - A Taxonomic Chart of Math Specialties & Functions
- **Physics**
  - Structure of the atom
  - Nuclear structure and stability
  - Quark structure of elementary particles

Flows, Interactions, Networks: *Rules of Supply*
- **Astronomy**
  - Solar wind (and cometary tails?)
  - Gravity between stellar bodies
  - Convection currents in stars
- **Biology**
  - Cell Metabolism
  - Osmosis and Diffusion
  - Human Body Metabolism
  - Information Flows: RNA Synthesis
  - Information Flows: Protein Synthesis
  - Principles of Ecology
  - Human Circulatory System
  - Succession in Ecology
- **Chemistry**
  - Types of chemical bonds: Compounds
  - Intermolecular forces
  - Metabolism
  - Chemical Reactions
  - Batteries Everywhere: Chemical Cycles
- **Computer Science**
  - Computer networking
  - Logic and circuit
  - Software development cycle
  - Neural Network
  - Capacities and bandwidth
  - Robotics
- **Geology**
  - Convection Cells in the Upper Mantle (asthenosphere)
  - Stream system
  - Continental Drift & Volcano's
  - Basic Interactions Between Land, Sea, and Air
  - Earthquakes (Ring of Fire)
  - Convection Cells in Weather Fronts
  - Lakes & Oceans (convection overturn; upwelling; offshore winds)
  - Erosion (Particle Entrainment & Sedimentation)
- **Mathematics**
  - Rate of Change: Linear Mathematics
  - Graph Theory
- **Physics**
  - Gravitational force between two masses
  - Columbs law
  - Voltage, current, resistance, and Ohm's law
  - Conservation of mechanical energy
  - Lorentz force law, Biot-Savart Law
  - Bernouli's Principle

Boundaries, Limits, & Fields: *Rules of Identity*
- **Astronomy**
  - Schwartzchild Limit
  - Event Horizon in Black Holes
  - Speed of Light
  - Size of the universe
  - Escape velocity
- **Biology**
  - The Human Skin System
  - Cell Membranes & Walls
  - The Nucleus
  - Why do Cells Exist?
- **Chemistry**
  - Reactants and Products
  - Conservation of Mass (introduction to formulas and balancing equations)
  - Laws of thermodynamics
- **Computer Science**
  - Attractors in chaotic system
  - Boundary of variable/constant
  - System security
  - Numerical Methods
  - Robotics
- **Geology**
  - Stratification in Earth & Sky (dynamic boundary conditions)
  - Stratification of the Ocean
  - Stratification of the Mantle (Continents)
- **Mathematics**
  - Derivatives
  - Limits
- **Physics**
  - Time dilation, velocity addition
  - Speed of light is limit of relative velocity
  - Heisenburg Uncertainty Principle

Symmetry & Duality: *Rules of Form*
- **Astronomy**
  - Pulsars
  - Matter, AntiMatter Galaxies
- **Biology**
  - DNA Structure
  - DNA Replication
  - Viral Structure
- **Chemistry**
  - Three dimensional structures of molecules
  - Crystal structures
  - Endergonic -- exergonic reactions (coupled)
  - Protein complementary
- **Computer Science**
  - Binary number system
  - Color system
  - Graphics algorithm (Animation)
  - Tessellation process
  - Data vs procedure
- **Geology**
  - Complementary Weather Pattern: No. vs. So. Hemisphere
  - Complementary Oceanic and Atmospheric Circulation
  - Paleomagneticism (paleomagnets are dipoles)
  - Twinning in Crystals (mirror images - enantiomorphs)
  - Crystal Classification
  - El Nino & La Nina Cycles
- **Mathematics**
  - "Rules of Form" by
  - Algebraic Topology
  - Super String Theory Math Dualities
  - Super String Theory Math Symmetries
  - Super String Theory Extra Dimensionality
- **Physics**
  - Newtons 3rd law: identify action/reaction pairs
  - Conservation of momentum
  - Double slit interference of light and wave/particle duality
  - Equivalence of inertial reference frames in Special Relativity
  - Particles and anti-particles

Feedback & Regulation: *Rules of Adjustment*
- **Astronomy**
  - Planetary Rotations
- **Biology**
  - Human Homeostasis
  - Gene Control
  - Predator-Prey in Ecology
- **Chemistry**
  - Extend of feedback in chemistry
  - End product inhibition
- **Computer Science**
  - Human-Computer Interaction
  - Control system
  - Logic and circuit
  - Information System
  - Robotics
  - Neural Network
  - Artificial Intelligence
- **Geology**
  - Geomorphic Cycles (Feedbacks in)
  - Origins of Hurricanes, Tornados
  - Global Warming (greenhouse effect)
  - Nutrient Cycle Feedback (upwelling; productivity)
- **Mathematics**
- **Physics**
  - Electromagnetic induction; Faraday's law
  - Electromagnetic radiation; electromagnetic spectrum

Stability, & Equilibrium: *Rules of Constancy*
- **Astronomy**
  - Motion of dual (or greater) star systems (connect to Physics)
  - Planetary Ring formation
  - Layers of Atmosphere (Jupiter is a good example)
- **Biology**
  - Species
  - Populations
  - Human Homeostasis
  - Succession in Ecology
- **Chemistry**
  - Energy equilibrium connections
  - Chemical thermodynamics II
- **Computer Science**
  - Simulation model for stable system
  - Control system
  - Numerical Methods
  - Storage degradation
  - Robotics
- **Geology**
  - Seawater Buffering (connect to Chemistry)
  - Lakes & Oceans
  - Radioactive Decay
  - Phase Shifts in Petrology; Regional Stabilities (connect to Chemistry)
  - Diamonds and Dust
- **Mathematics**
- **Physics**
  - Newton's first law: static equilibrium
  - Rotational inertial; torque; angular acceleration; condition for rotational equilibrium
  - Thermodynamic equilibrium

Cycles and Cycling: *Rules of Tempo*
- **Astronomy**
  - Star life Cycle
  - Sunspot Cycle
  - Planetary Rotations
  - Malankovitch Cycles (connect to Ice Ages)
  - Pulsars
- **Biology**
  - The Cell Cycle
  - The Species Life Cycle
  - Krebs Cycle in Cell Respiration
  - The Carbon Cycle
  - Organism Life Cycles
  - The Human Life Cycle
- **Chemistry**
  - Biogeochemical cycles: The Oxygen Cycle
  - Dyes and Pigments: Cyclic Compounds
  - Recycling Aluminum
  - Oscillating reactions
  - Hypercycles (Eigen)
- **Computer Science**
  - Software Iteration and recursion
  - Software development cycle
  - Logic and circuit
  - Software Testing
  - Computer networking
  - Computer virus
- **Geology**
  - Seismic Waves
  - El Nino & La Nina Cycles
  - Biogeochemical Cycles (Water cycle)
  - Crustal Cycling & Continental Drift (Wilson Cycles)
  - Ice Ages (Melankovich Cycles) (connect to Astronomy)
  - Geomorphic Cycles
- **Mathematics**
  - Modular Arithematic
  - Fibonacci Sequence
  - Anything that Cycles Has Regularities: so Sine and Cosine
- **Physics**
  - Oscillating mass on a spring; swinging pendulum
  - Resonance phenomena, wave velocity, frequency and wavelength
  - Sound; production of sound; speed of sound in a medium
  - Single and double slit interference patterns
  - Thin film interference

Chaos & Origins Processes: *Rules of Beginning*
- **Astronomy**
  - Planet Formation & Turbulence
  - Origin of the Solar System
  - Origins of the Universe
- **Biology**
  - Fractal Structure in Plants
  - Origins & the Meaning of Chemical Information
  - Origins of Cells
  - Origins of Humans
- **Chemistry**
  - Oscillating reactions
  - Origins of Biopolymers
- **Computer Science**
  - Fractal Geometry and its visualization
  - Role of computer in discovering the chaos patterns
  - Pattern of errors found in a program
  - Fractal compression of data
- **Geology**
  - Turbulence in Geology (streams, atmospherics)
  - Mountain Formation and Island Boundaries
  - Stream Systems (Fractal structure of,)
  - Origin of Oceans
  - Origin of Solar System
  - Storm Development
- **Mathematics**
  - Interface between Computers & Math
  - Fractal Mathematics
  - Fundamentals of Chaos Theory
- **Physics**
  - Statistical mechanics
  - Radiometric Dating (connect to geology)

Sys Variation, Dev't, & Evolution: *Rules of Change*
- **Astronomy**
  - Physical Systems Evolution?
- **Biology**
  - The Process of Evolution
  - Evidence for Evolution
  - Neural Networks
  - Taxonomic Diversity
  - Ecological Functions
- **Chemistry**
  - Non-equilibrium thermodynamics
- **Computer Science**
  - Artificial life
  - Pedigree of programming languages
  - Tracing the development of operating systems
- **Geology**
  - The Geological TimeTable
  - Plate Tectonics
- **Mathematics**
- **Physics**
  - Velocity, acceleration
  - Newton's 1st and 2nd laws
  - Entropy
  - Angular acceleration, angular momentum

An Empirical Knowledge Base for SySSci

• This focused and concentrated effort to find, assemble, and study an extensive science-based literature on phenomena in nature that exhibit systems processes results in a very detailed curriculum for systems science practitioners. The listing above was used to attract two National Science Foundation grants to design a new curriculum for teaching general education science in any university or college. So for both applications, at opposite ends of the spectrum, SSP could contribute to an improved holistic systems science and to insights for the practice of research and problem solving in the reductionist sciences. A much needed additional result is a record of the extent of isomorphy for each process.