Extended Framework for a General Systems Theory – Definitions & Propositions

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Idiom

The purpose of the ISSS is to develop systems theory and share its benefits across disciplines. In earlier decades, systems science made a major contribution to science, and much of its language was adopted elsewhere. Today, however, that flow has largely reversed: other disciplines have advanced and evolved their own terminologies, while systems science has tended to preserve its earlier ones.

The result is a growing idiomatic gap between systems science and the fields it seeks to inform. If we want systems science to regain its role as a foundational, integrative discipline, that gap needs to close.

This can be addressed by:
a) Using plain English as far as possible, so our ideas are immediately understandable across disciplines;
b) Borrowing established terms from other sciences when they convey meaning more precisely; and
c) Providing cross-mappings for legacy systems terms, so colleagues who prefer the traditional idiom can still orient easily.

This approach has been adopted as far as possible in this EFGST.

Key

- Definitions are numbered **Dx.x**
- Propositions are numbered **Py.y**
- Curly brackets **{term}** indicate systems legacy terms
- Curved brackets (05/07) refer to articles in Rational Understanding.com or other source.
- Square brackets [D3] refer to definitions or propositions in "Framework for a General Systems Theory".

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1. Philosophy

a. Two Compatible Philosophies

D1.1 Cognitive Physicalism — A philosophical position that assumes (1) everything is physical and exists in space-time, and (2) human perception and cognition are limited, necessitating simplification. (05/07)

D1.2 Critical Realism— A philosophical approach which holds that (1) reality exists independently of our thoughts or perceptions (realism), but (2) our understanding of it is always mediated by social, cultural, and linguistic factors (critical). It distinguishes between the real (what exists), the actual (what happens), and the empirical (what is observed). (New) [D16]

P1.1 Compatibility Proposition — Cognitive Physicalism and Critical Realism are compatible and jointly true philosophies; the former asserts that everything is physical, while the latter asserts that reality exists independently of our knowledge of it. (New)

b. Epistemology and Ontology

D1.3 Epistemology — The branch of philosophy that deals with knowledge: its nature, sources, limitations, and validity. (New)

P1.2 Epistemic Complementarity Proposition — Cognitive Physicalism and Critical Realism are epistemologically compatible: the former highlights cognitive limits of perception, while the latter emphasises social and conceptual constraints on knowledge. (New)

D1.4 Ontology — The branch of philosophy concerned with the nature of existence and what kinds of things exist. (New)

P1.3 Ontological Subset Proposition — The epistemic domain is a subset of the ontological domain; knowledge, thought, and perception are themselves physical processes occurring in space-time. When accurate, these processes function as internal models of other physical processes — that is, as physical systems that encode, within their own structure and dynamics, causal regularities present in the external world. (New)

Explanation: In this framework, there is no ontological divide between mind and matter: knowing is a physical act of modelling. True knowledge occurs when the informational structure of one physical system corresponds isomorphically to the causal structure of another.

D1.5 Epistemic Reflexivity — The property of a theoretical or cognitive system by which it recognises itself as part of the reality it describes. In EFGST, epistemic reflexivity denotes the understanding that knowing, modelling, and theory formation are themselves physical and systemic processes, subject to the same principles as all other systems. (New)

P1.4 Probabilistic Future Proposition — The future is probabilistic rather than predetermined: systemic trajectories unfold through branching possibilities, with actual outcomes shaped by contingent interactions and, in human systems, by agency. (New)

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2. Reality

a. Existence in Space-time

D2.1 Space-time — A single continuum comprising three dimensions of space and one of time. (05/06 Appendix A)

P2.1 Space-Time Existence Proposition — Everything that exists does so in a region or regions of space-time. (05/06 Appendix B)

D2.2 Physical — Anything that exists within, or constitutes, space-time, including matter, energy, and the fields and structures that occupy or define it. Even apparently empty regions of space-time are physical in this sense. (05/06 Appendix A)

D2.3 Metaphysical — Not existing in space-time, i.e., not physical. (05/06 Appendix A)

b. Entities and their Types

D2.4 Entity — Any concrete or abstract physical thing, including characteristics, relationships, and events. (05/06 Appendix A, 05/09)

D2.5 Collection — Any plural group of entities. (05/06 Appendix A)

D2.6 Set — Any group of entities treated as a singular entity. (05/06 Appendix A)

D2.7A Characteristic or Property — Any feature common to different entities that we use to draw them into collections. (05/06 Appendix A)

D2.7B Variable — as an adjective, variable means capable of taking different values, whether numerical (e.g., temperature, length), logical (e.g., present/absent), categorical, or abstract (pattern based) variability. As a noun it is the same as a variable characteristic. (New)

D2.8 Aggregation — The conversion of a collection into a set. (05/06 Appendix A)

D2.9 Disaggregation — The conversion of a set into a collection. (05/06 Appendix A)

D2.10 Set Duality — A set may be regarded either as a single aggregate entity or as the plurality of its constituent members. The choice of perspective determines whether relations are described at the level of the whole or of the parts. (05/09)

D2.11 Boundary — A demarcation that separates an entity from what is not the entity. (05/02)

D2.12 Concrete Entity — A physical entity whose components form a continuous region of space-time and can, in principle, be observed in its entirety. (New)

D2.13 Abstract Entity — A physical entity whose spatial–temporal extent cannot be fully apprehended at once. It may take either of two forms: (1) a distributed collection of concrete entities that together constitute a coherent pattern or relation; or (2) a continuous field whose boundary, though possibly contiguous, encompasses dispersed effects across regions of space-time. Examples include gravitational fields, ecosystems, or social constructs such as conflict, which manifest physically across multiple locations and interactions but cannot be contained within a single bounded object. (05/06 Appendix A, 05/07)

P2.2 Abstract Entity Proposition — Abstract entities (e.g., justice, conflict) are physical in existence but cognitively abstract because no single, all-encompassing iconic representation of them is possible. Their apparent abstraction arises from the limits of human perception and modelling, not from non-physical status. (05/07)

b. Relationships

D2.14 Relationship — A connection between entities that may involve transfers of matter, energy, or information (causal relationships) or static associations such as spatial proximity, membership, or constraint (structural relationships). A relationship persists for as long as the connection or constraint exists; causal relationships exist only during active transfer. (05/06 Appendix A, 05/07)

D2.15 Relative Disposition — The spatial and/or temporal positioning and orientation of two entities with respect to one another, without implying any relationship between them. (New)

P2.3 Relationship Ontology Proposition — Relationships are physical entities. (05/06 Appendix B)

P2.4 Relationship–Disposition Proposition — A relationship requires transfer; a relative disposition does not. The former implies causal interaction, the latter only spatial/temporal alignment. (New)

c. Networks and Structure

D2.16 Network — A group of relationships between entities in a collection. (05/06 Appendix A)

D2.17A Structure or Configuration (EFGST Idiom) — Structure is the spatio-temporal configuration of a system's components and relationships. Structural relationships specify relative position, orientation, connectivity, and temporal ordering. (05/06 Appendix A)

D2.17B Process (EFGST Idiom) — A pattern of causally connected components within a system through which inputs are transformed, structures maintained, or outputs produced. (05/09)

Explanation: Processes express what a system does in contrast to structure or configuration which express what it is. Each process arises from the causal interactions among components which may, for example, comprise feedback, flow, or cycling. A process is therefore the same entity as a system, understood in its causal rather than its configurational role. That is, a system viewed as an active network of transfers between components rather than as a static arrangement of components.

P2.5A. Process–Structure Reciprocity Proposition (EFGST Idiom) — Structural configurations can but are not necessarily generated by processes. Processes, in turn, are enabled or inhibited by structural configurations,. This recursive coupling of process and structure is a universal feature of systemic organisation. (New)

Explanatory Note: In EFGST, structure and process are complementary aspects of system organisation. Structure determines the potential pathways through which matter, energy, or information can flow and thereby establishes the system's potential causal dynamics. Processes, in turn, generate, modify, and sometimes dissolve structure. Thus, structure governs *what can happen*; process realises *what does happen*.

D2.18 Randomness — Interactions that are unconstrained or insufficiently recurrent to stabilise into coherent properties. Randomness represents the absence or breakdown of structure. (05/06 Appendix A)

P2.5B Structure-from-Randomness Proposition — Structured systems can emerge from random interactions when constraints, such as energy gradients or gravitational attraction, selectively stabilise certain configurations. Randomness provides variation; constraint provides order. (New)

Explanatory Note — Environmental Randomness and Structure Formation: Randomness in an environment is not merely the absence of order but a source of variation that enables the discovery of stable configurations. In molecular and larger systems, stochastic interactions among components expose many possible combinations; some become constrained by bonding energies or other stabilising forces, such as **gravitational attraction**, leading to the emergence of structure. Environmental randomness therefore provides the exploratory dynamics through which new stable forms can arise, linking entropy-driven variation to the assembly of complex systems and, ultimately, to the large-scale organisation of matter in the universe.

D2.19 Static Structure — A structure that persists from a human perspective. (05/06 Appendix A)

D2.20 Dynamic Structure — A structure in a state of non-random change, e.g., cyclical. (05/06 Appendix A)

P2.6 Dynamic Systems Proposition — All systems are dynamic, undergoing changes of state over time even when appearing static. (05/06 Appendix B)

D2.21 Information (EFGST Idiom) — A non-random recurring structure of entities in space-time, whether matter, energy, or both. This is the general ontological definition of information as patterned structure, independent of whether it is processed or interpreted. (05/05, 05/06 Appendix A)

P2.7 Information Replication Proposition — Information can be replicated without losing the original. (New)

d. States and Events

D2.22 State — The set of characteristics that apply to an entity or collection of entities. (05/06 Appendix A)

D2.23 Change of State — A change in the set of characteristics that apply to an entity or collection of entities. (05/06 Appendix A)

D2.24 Continuum Change of State — A gradual, often imperceptible change of state that culminates in an observable transformation (e.g., growth). (05/02)

D2.25 Event — A time-bounded instance of a relationship involving transfer, resulting in changes of state of the related entities. (05/06 Appendix A)

P2.8 Event Proposition — Every event is a relationship actualised in time, but not every relationship is confined to a single event. While each transfer is time-bounded, a relationship may persist as a continuing pattern or potential for repeated transfers across time. (New)

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3. Systems Core Definitions

D3.1 System— A set of components, each itself a system, interacting to form a coherent whole with emergent properties. A system comprises a boundary and internal processes, receives inputs, and delivers outputs. (05/12) [D3]

D3.2 Holon — A synonym for sub-system. In Koestler's original usage, a holon is a whole that is simultaneously a part of a larger whole. This aligns with the systems view that every system is composed of subsystems while itself being embedded within larger systems. The distinction is therefore one of emphasis: *system* stresses integrity and emergent wholeness, while *holon* stresses embeddedness within a hierarchy. For the purposes of this framework, the two terms are treated as equivalent. (05/06 Appendix A, 05/06 Appendix B, 05/07)

D3.3 Environment — All systems not contained within a system's boundary that can interact with it through transfer of matter, energy, or information. (New)

D3.4 Input — Matter, energy, or information entering a *system* from its environment. The term also applies locally to processes within a system, referring to the transfers they receive from other processes. (05/02, 05/06)

D3.5 Output — Matter, energy, or information delivered by a *system* to its environment. Within a system, processes likewise produce outputs that serve as inputs to other processes. (05/02, 05/06)

P3.1 Input Transformation Proposition — Inputs received by a system may be retained in their original form, disaggregated into component flows, aggregated into composite forms, or combinations of these, depending on the system's internal organisation and function. (New)

P3.2 Output Disposition Proposition — Outputs produced by a system may be transferred externally to the environment or retained internally to maintain or modify the system's own structure and processes. (New)

P3.3 Output–Property Proposition — All outputs of systems are system properties, but not all system properties are outputs. (New)

P3.4 Functional Equivalence Proposition — Systems of different composition or scale can exhibit outputs that are functionally equivalent, performing comparable roles or effects within their respective contexts. (New)

D3.6 System Network — A configuration of interconnected systems or components, where links represent relationships. (New)

D3.8 Function — The effects produced by one or more processes of a system, observed as changes within the system itself or in other systems. System functions arise from the combined operation of multiple process functions. (05/06 Appendix A, 05/07)

P3.5 Multiplicity of Processes Proposition — A system may comprise multiple interacting processes rather than a single one. These processes can perform different functions and combine in different ways to produce the system's overall functions. (New)

Explanation — Interacting Processes and System Function. Systems rarely operate through a single process. Their behaviour arises from multiple concurrent processes whose interactions determine the system's overall function or functions. Some processes may operate cooperatively, others competitively or conditionally, and their combined effects can yield emergent properties not present in any one process alone. The diversity and interaction of processes therefore underlie the flexibility, stability, and adaptability of complex systems.

P3.6 Process Function Proposition — Each process within a system performs a local function that contributes to self-maintenance, transformation, or interaction with the environment. The combined operation of these process functions gives rise to the system's overall functions. (Revised 05/09)

P3.7 Functionality Proposition — A system's process is functioning when it produces outputs that contribute to the system's self-maintenance, transformation, or interaction with its environment in accordance with its role or purpose. (New)

D3.9 Purpose (non-living sytems) — In non-living systems, *purpose* and *function* are indistinguishable. Processes occur according to physical laws and system structure, producing outputs that serve no internally represented goal. Any attribution of purpose is interpretive, describing what the system's functions achieve within a wider context. (05/06 Appendix A, 05/07)

D3.10 Purpose (living systems) — In living systems with agency, *purpose* represents a desired or internally represented function. Purpose arises from the system's capacity to model outcomes and to select or reconfigure processes to realise preferred states. In such systems, purpose may differ from actual function when intentions are unfulfilled or maladaptive. (05/06 Appendix A, 05/07)

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4. Systems Structure

D4.1 Scaffold — A temporary structural arrangement that supports the assembly, adaptation, or evolution of a system. Scaffolds facilitate the formation of higher-level structures or functions by providing provisional stability or guidance during transitional phases. Once these structures stabilise, the scaffold is typically removed, replaced, or absorbed into the new organisation. Examples include developmental tissues that shape organs, scaffolding proteins in molecular assembly, or provisional institutional arrangements that support social change. (05/12)

D4.2 Framework (c.f. Scaffold) — A permanent structural arrangement that supports and constrains the organisation and processes of a system. Frameworks provide enduring stability, preserve system identity, and channel the evolution of systemic processes within defined boundaries. Whereas scaffolds are temporary and transitional, frameworks persist as the stable architectures through which systems operate. Examples include the skeletal structure of organisms, the crystalline lattice of solids, and the institutional frameworks that organise societies. Physical frameworks provide enduring structural stability within systems, whereas conceptual frameworks provide epistemic stability within human understanding. The two are analogous but belong to different domains. (New)

D4.3 Subsystem— A subsystem is an organised arrangement of components that functions as a component within a more extensive system. It represents the *structural being* of systemic activity — the configuration through which processes are realised, constrained, or maintained. Viewed hierarchically, it is a subsystem; viewed causally, it is a process. Each possesses its own boundary and organisation, contains internal processes, and contributes outputs that support the operation or function of the larger system. (New)

Explanation: The term subsystem describes the same underlying structure viewed from different perspectives. The subsystem perspective emphasises hierarchical position within a larger whole; the process perspective emphasises causal operation and functional role. Both constitute the "what is" aspect of systems, in contrast to processes, which represent the "what it does."

D4.4 Supersystem {Suprasystem} — A system that has less extensive systems as components. (New)

P4.1 Subsystem–Process Duality and Independence Proposition — For the purposes of General Systems Theory, a *subsystem* and a *process* represent the same underlying reality viewed from different perspectives: the subsystem expresses what an organisation *is* (being), while the process expresses what it *does* (doing). In non-living systems, being and doing coincide passively through structural persistence. In living systems, independence arises when a subsystem's own processes maintain its organisation without continual reliance on a parent system; dependence arises when such maintenance requires external support. (New)

Explanatory Note — Subsystems, Processes, and Independence — Subsystems and processes are complementary perspectives on organised reality. The structural arrangement of components constitutes a subsystem when viewed in terms of *being*, and a process when viewed in terms of *doing* — the causal activities that sustain or transform structure. This distinction mirrors the Critical Realist differentiation between structure and process.
For non-living subsystems, persistence depends on external physical conditions rather than on internal self-maintenance. In living systems, however, *doing* becomes essential to *being*: existence depends on self-producing and self-regulating processes. A subsystem or process is therefore considered independent when it can sustain its organisation autonomously, and dependent when its continued operation requires a parent or supporting system. Artefacts may display partial or delegated independence when they emulate life's self-maintaining logic.

D4.5 Family Analogy — A conceptual schema for describing systemic relationships in terms of kinship. It captures hierarchical and lateral dependencies among systems by analogy with families, while remaining grounded in physical system interactions. (New)

D4.6 Parent System — A system that serves as the environment for one or more subsystems ("child systems"), providing enabling inputs and imposing constraints that shape their viability. (New)

D4.7 Child System — A subsystem embedded within a parent system, dependent on the parent for enabling inputs, protection from inhibiting inputs, and the conditions necessary for continued viability. (New)

D4.8 Sibling Systems — Subsystems within the same parent system that interact laterally, sometimes cooperating in assembly into larger structures and sometimes competing for shared enabling inputs. (New)

D4.9A Systems Hierarchy — A layered structure in which each system may function as a component within a larger system and may itself comprise multiple component systems. Such hierarchies express the recursive nested organisation of reality, where structural and processual relationships are repeated across scales. (05/02, 05/06 Appendix A)

Explanation: Systems hierarchies are both ontological and analytic: each level can be examined in terms of its constituent subsystems or regarded as a component within a broader whole. This bidirectional view enables the aggregation and disaggregation of systems for analysis or synthesis.

D4.9B System of Interest — The system against which family relationships, levels of assembly and levels of granularity are measured. The system of interest is a subsystem of its parent system and a supersystem of its child systems. It is the zero level of assembly and granularity, whilst its parent is the first level of assembly, its grandparent the second level, and so on. Its children are the first level of granularity, grandchildren the second level, and so on. (New)

P4.2 Recursion Limit Proposition — There may be a lower recursion limit in system hierarchies; current science recognises sub-atomic particles and four fundamental forces as that limit. (05/06 Appendix B)

D4.10 Module — A subsystem performing a specific function within a larger system. (05/12)

P4.3 Module Proposition — Modularity enhances adaptability by allowing subsystems to recombine in differing configurations. (05/12)

D4.11 Redundancy — The duplication of critical components or processes to improve reliability and resilience. (Second Order System Constraint) (05/04)

D4.12 Degeneracy — Multiple different components or pathways producing the same function. (05/12)

Explanation: The term degeneracy originates in molecular biology and genetics, where different DNA codons can specify the same amino acid, and in neuroscience, where different neural circuits can generate similar behaviours. It differs from redundancy, a term common in engineering and reliability theory, which refers to the duplication of identical components. Redundancy provides resilience by replication, while degeneracy provides resilience by diversity, allowing structurally different components or pathways to substitute for one another in producing the same function. Degeneracy therefore enhances robustness and adaptability by giving systems multiple, non-identical ways to maintain function in the face of disturbance or loss.

D4.13 Robustness — The ability of a system to maintain function despite perturbations or variations in components. (05/12)

Explanation: The term robustness has roots in engineering and control theory, where it refers to a system's ability to continue functioning under a range of operating conditions, and in ecology, where it describes the resilience of ecosystems to disturbance. In systems science, robustness captures the capacity of a system to maintain core functions despite internal fluctuations or external shocks. Robustness may be achieved through processes such as redundancy (identical backups), degeneracy (different pathways to the same function), modularity, or feedback regulation. It is thus a cross-disciplinary concept that highlights stability through diverse strategies of persistence.

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5. Systems Processes and Isomorphisms

a. Systems Processes

D5.1 Structure (SPT Idiom) — In Systems Process Theory, structure is understood as a stabilised configuration of interacting processes — effectively, slow process or process in equilibrium. It represents the persistence of particular process patterns over time. Because SPT treats every structure as resulting from prior processes and as constraining subsequent ones, it is included within the broader class of Universal Systems Processes (USPs), notably under the heading Structure-as-Process (Troncale SP #47).

Explanation — Relation to EFGST Idiom: While SPT subsumes structure under process, EFGST does not make this assumption and retains the distinction for analytical reasons such as the configuration spaces discussed later.

P5.1 Process–Structure Relationship Proposition (SPT Idiom) — In Systems Process Theory, structural stability represents the persistence of causal pathways over time, while process activity represents their realisation and transformation. (Troncale)

Cautionary Note: EFGST does not treat this as always necessarily being the case. Because causal relationships involve a transfer, this assumption would, in the case of gravitationally stable structures, for example, imply the existence of gravitons, for which there is no empirical evidence. This SPT assumption does not, however, undermine the value of the theory when describing known causal relationships.

D5.2 Universal Systems Process or Systems Process (SPT Idiom) — A Universal Systems Process (USP), also referred to as a Systems Process, is a recurring pattern of causal interaction that appears across many kinds of systems, regardless of scale or domain. Each Systems Process represents a generalised mode of activity. Examples include feedback, flow, cycling, emergence, and hierarchy. *(L. Troncale)*

Explanation: In Systems Process Theory (SPT), Systems Processes (SP) and Universal Systems Processes (USP) are conceptually equivalent; the qualifier *"universal"* indicates recurrence across domains and scales. In the EFGST framework, the term process specifies the causal processes, i.e., the transfers of matter, energy, or information, by which such systemic activities are realised.

D5.3 Linkage Proposition — In SPT, a Linkage Proposition is a generalised causal statement of dependency or co-occurrence that specifies how one Systems Process tends to give rise to, enable, constrain, or require another. Linkage Propositions identify the patterned relationships among Systems Processes (e.g., flows, cycling, feedback, hierarchy, emergence) and describe how such processes combine to produce coherent system behaviour across domains and levels of organisation. (L. Troncale)

Explanation: Each Linkage Proposition expresses a recurring dependency observed across many systems. Collectively, these propositions form a causal grammar describing how Systems Processes combine to yield stability, adaptation, and transformation. This network serves as a framework for predicting system behaviour. Note that linkage propositions do not themselves evolve but can generate evolution in systems.

D5.4 Nested Systems Processes — Both systems and processes are organised in nested hierarchies. Relationships between processes and systems within this nested hierarchy can be described using familial analogies. For example:

- Parent processes or systems can comprise and interact with several child processes or systems; and
- Child processes or systems can interact with several sibling systems or processes within the same parent; and so on.

These relationships express the recursive organisation of causality within systems and processes. (New)

Clarificatory Note: This familial terminology was not used by Troncale and has been introduced by EFGST as a descriptive aid for the relationships between components in a nested hierarchy. For example a relationship may be parent-child or sibling-sibling. They provide a natural grammar for describing causal organisation both within and among systems and processes.

D5.5 Lateral or Horizontal Relationships — These are alternative terms for sibling-sibling relationships. (New)

Clarificatory Note: These terms were not used by Troncale to classify linkage propositions but are commonly used in systems science.

b. Intra-system Relationships or Linkages

D5.6 Intra-System Relationships or Linkages — Relationships between processes within any given system of interest. (New)

Clarificatory Note: This term was not used by Troncale to classify linkage propositions but is commonly used in systems science.

P5.2 Intra-System Process Interconnection Proposition — Processes within a system never occur in isolation. Each performs functions that depend on, and contribute to, the operation of other processes through hierarchical (parent–child) and lateral (sibling) linkages. Higher-order ("parent") processes are realised through the coordinated activity of lower-order ("child") processes. Together these interdependent relationships form the organised network of activity that is the systems behaviour. (L. Troncale)

Explanation: In **Systems Process Theory (SPT)**, interconnection is definitional: all function arises from networks of interacting processes.

P5.3 Triadic Classification Proposition: Processes within a system can be grouped into three functional categories: input, self-maintenance and assembly, and output. These represent, respectively, the acquisition of matter, energy, or information from the environment; the internal transformation and organisation of those resources; and the delivery of outputs that affect the system's environment. (New)

Clarificatory Note: Troncale's Systems Process Theory enumerates many universal processes without subdividing them into these intra-systemic roles. The triadic categories are decriptive aids introduced in the EFGST framework to describe causal directionality within systems and to relate process linkages more clearly to system–environment exchange.

P5.4 Recurrence Proposition: The triadic structure of systems processes recurs at multiple levels of emergence, from physical systems to living organisms to social institutions, forming fractal-like patterns of organisation across scales. (New)

P5.5 Categorisation Proposition: Some, but not all, systems processes catalogued in Troncale's Systems Process Theory can be interpreted as variants within one or more members of the systems-process triad. (New)

D5.7 Input Processes: Input processes are systems processes that acquire, filter, and integrate matter, energy, or information from the environment into the system. They define the pathways through which environmental resources or influences enter the system and are made available for internal transformation. (New)

D5.8 Self-Maintenance and Assembly Processes: Self-maintenance and assembly processes are systems processes that preserve, repair, or reorganise a system's internal structure and functions, including the assembly of components into higher-order configurations. These processes sustain the system's integrity and adaptive capacity. (New)

D5.9 Output Processes: Output processes are systems processes that deliver matter, energy, or information from the system to its environment, producing effects on other systems or on the conditions of the environment itself. (New)

P5.6 Process Linkage Proposition: Processes within a system are interconnected through causal and configurational relationships. The activity of one process can generate, enable, constrain, or modify another, producing higher-order patterns of organisation. Linkages may operate sequentially, concurrently, or hierarchically, forming networks of interdependent processes that together determine system behaviour. *(New)*

Explanation: In Systems Process Theory (SPT), systems processes are linked in multiple ways, e.g., feedback, cycling, hierarchy, emergence, regulation, and others. In EFGST, these linkages are classified as being either causal (transfer of matter, energy, or information) or configurational (relative position and orientation in space-time). No other type of relationship is recognised.

P5.7 Functional Balance Proposition: For a system to remain viable, its input, self-maintenance/assembly, and output processes must be mutually supportive. (New)

Explanation: System viability depends on the dynamic reciprocity among a system's principal process types. Input processes supply the resources or stimuli required for self-maintenance; self-maintenance processes preserve the system's capacity to generate outputs; and outputs modify the environment in ways that sustain or regenerate inputs. The overall pattern of mutual support constitutes functional coherence.

P5.8 Process Interaction Proposition — Systems processes can interact nonlinearly, such that variations in input, self-maintenance/assembly, or output can produce disproportionate and sometimes unpredictable effects on other processes. These nonlinear interactions generate the complex dynamics characteristic of systemic behaviour. (New)

Explanation: In Systems Process Theory (SPT), systems processes are inherently interconnected and often exhibit nonlinear feedbacks that lead to emergent behaviour.

c. Inter-system Relationships or Linkages

D5.10 Inter-System (or Cross-System) Linkages — Inter-System (or Cross-System) Linkages describe patterned causal relationships between processes operating in different but coupled systems. These linkages capture how systems interact through exchanges of matter, energy, or information, such that the processes of one system can enable, constrain, or modulate the processes of another. Inter-System Linkages may take several relational forms, including:

- **Parent–child relationships**, where a process in a larger system generates or regulates a process in a smaller one (e.g., ecosystem → organism).
- **Sibling relationships**, where processes within systems at the same level interact laterally.
- **System–environment relationships**, where processes within the latter act as context for processes in the former. (L. Troncale)

Explanation: In Systems Process Theory (SPT), Linkage propositions apply to interactions between processes *among* systems as well as to those *within* them.

P5.9A Inter/Intra-system Linkage Proposition — An inter-system linkage can be regarded as an intra-system linkage and vice versa depending on the system of interest chosen. (New)

P5.9B Inter-System Dependency Proposition — Processes in one system can condition or give rise to processes in coupled systems, as expressed by cross-system linkages. (L.Troncale)

D5.11 Cross-temporal or Diachronic Linkages — A cross-temporal linkage proposition specifies a directional relationship between processes in which one tends to give rise to another over developmental, ecological, or evolutionary time. (L.Troncale)

P5.10 Evolutionary Tendency Proposition — Some processes are developmentally or evolutionarily generative of others, forming evolutionary linkages that, over time, drive the increasing complexity and diversity of systems. (L.Troncale)

D5.12 Linkage Network (or Causal Web) — The Linkage Network, also described as the Web of Systemic Co-Dependencies, is the totality of identified Linkage Propositions among Universal Systems Processes. It represents the interconnected causal architecture through which processes enable, constrain, or transform one another across systems and domains. Mapping this network reveals how systems maintain coherence, adapt, and evolve through recurrent patterns of mutual dependence. (L. Troncale)

P5.11 Linkage Network Proposition — Because Linkage Propositions express recurring causal tendencies, their systematic mapping into a Linkage Network enables both explanation and prediction. Explanation arises from identifying how particular system behaviours result from the configuration of interlinked processes; prediction arises from recognising which processes are likely to emerge, stabilise, or transform given the network of existing dependencies. (L. Troncale)

d. Isomorphisms

D5.13 Isomorphism (General) — An isomorphism is a recognition of equivalence in organisation — whether between processes, structures, or whole systems. Isomorphisms identify recurring patterns of systemic configuration and activity that share the same underlying pattern, regardless of scale or domain. In Systems Process Theory (SPT), isomorphisms refer primarily to equivalence among process patterns (Universal Systems Processes) that reappear across different systems. In EFGST, isomorphisms may also express equivalence among structural configurations. Together, structural and process isomorphisms reveal the deep regularities through which diverse systems manifest similar causal architectures. (05/07)

D5.14 Structural Isomorphism (EFGST only) — A Structural Isomorphism is a recognised correspondence between systems in which the internal configuration or spatial-temporal arrangement of components is the same, even when the components differ in substance, scale, or domain. Structural isomorphisms describe recurring configurational relationships—shared organisational forms through which similar processes can occur in otherwise distinct systems. (New)

Explanation: Structural isomorphisms are employed only within EFGST, where configurational relationships ("what a system is") are treated as distinct from causal processes ("what a system does"). In Systems Process Theory (SPT), such distinctions are unnecessary, because all organisation is expressed as interacting processes. The structural perspective is retained in EFGST because spatial-temporal configurations play an important causal-enabling and constraining role within physical and living systems.

D5.15 Process Isomorphism (SPT and EFGST) — A Process Isomorphism is a recognised correspondence between systems or domains in which patterns of causal organisation, such as feedback, recur. Process isomorphisms reveal the universality of systemic activity: different systems can instantiate the same causal relationships even when their materials or structures differ. (New)

Explanation: In SPT, all isomorphisms are fundamentally process isomorphisms because the theory describes reality entirely in processual terms. In EFGST, process isomorphisms complement structural isomorphisms by representing the "doing" aspect of systemic universality—recurring causal modes that operate across structures and scales.

P5.12 Structural Isomorphism Proposition (EFGST only) — Structural isomorphisms are recognised by identifying correspondences in the configurational arrangements of systems. (05/07)

P5.13 Process Isomorphism Proposition — Process isomorphisms are recognised by identifying equivalences in the causal dynamics of processes or systems. When distinct systems exhibit processes with the same causal dynamics or the same inter-process relationships, such as between feedback and stability or between flow and equilibrium, they instantiate a shared causal logic. These equivalences may also be documented empirically as cross-disciplinary linkage propositions, where the same causal pattern recurs in multiple scientific domains. (L. Troncale)

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6. Levels of Complexity, Assembly, and Emergence in Systems

a. Levels of Complexity and Assembly

D6.1 Complexity — The number of fundamental sub-atomic particles in an entity. (05/06 Appendix A, 05/07)

P6.1 Relationship Complexity Proposition — The complexity of a relationship equals the complexity of what is transferred between the related systems. (05/06 Appendix B)

D6.2 Hierarchy of Complexity — A structure of levels where entities at each level contain more fundamental particles than those below, and fewer than those above. (05/06 Appendix A)

D6.3 Level of Complexity — A point or span in the complexity hierarchy describing the number of fundamental particles in an entity or system. (New)

D6.4 Assembly Theory — Systems arise through stepwise, causally constrained assembly of components, many of which are themselves previously assembled subsystems (modules). Assembly is recursive and path-dependent: new wholes are built by combining, reusing, replacing, or reconfiguring pre-existing parts under structural and environmental constraints. Adaptation occurs when replacement/reconfiguration alters composition or arrangement while preserving (or improving) viability. (05/10)

Explanation: An assembly step joins available parts (which may be composites) into a more complex unit. Because parts can be pre-assembled, the history (provenance) of components matters, and assembly depth (minimal steps from primitives) can index complexity. Assembly differs from mere aggregation by producing new organisational relations and functions not present in the parts alone.

P6.2 Assembly Reciprocity Proposition — Assembly occurs when whole systems—realised outputs of prior organisation—interact reciprocally so that each functions as an input to the other. Through these exchanges, the participating systems become integrated into a new, higher-order system possessing its own boundary, organisation, and processes. (05/12) [P1]

Explanation: Entire systems may function as inputs or outputs to others. In biological contexts, predator–prey or symbiotic relationships exemplify this exchange: one system assimilates another in whole or in part, transforming both in the process. Such interactions illustrate that system-to-system transfers are not confined to energy or information flows but can involve complete organisational entities, providing a process for hierarchical assembly and transformation in nature.

P6.3 Logico–Mathematical Proposition — Levels are grounded in symbolic logic, with points and spans in a dimension mapping onto numbers. Note that mathematics is a specialisation of logic, and logic is more fundamental. This logical grounding connects quantitative models of complexity with the qualitative hierarchy of assembly and emergence. (New)

D6.5 Level of Assembly — A step in the assembly hierarchy defined by the degree of assembly; each higher level reflects the integration of lower-level components. (New)

P6.4 Assembly–Complexity Proposition — Hierarchies of system complexity arise from stepwise assembly, as each higher level emerges through the organised integration of simpler, previously assembled subsystems. Structured assembly thus generates the hierarchical pattern in which increasing complexity corresponds to increasing levels of organisation. (05/02, 05/10)

D6.6 Relative Levels — The comparative positioning of systems on dimensions such as complexity, assembly, or emergence, irrespective of any ultimate fundamental base. (New)

P6.5 Relative Levels Proposition — Levels of organisation are not absolute but relative, depending on the observer's framework and the granularity of analysis. Relative levels can be applied consistently even in the absence of a recognised fundamental base (e.g., in social or cultural systems). (New)

P6.6 Epistemic–Ontological Proposition — Levels can be understood both epistemically (as analytical constructs) and ontologically (as real structures in nature); both perspectives are valid and complementary. (New)

Explanatory Note — Epistemic systems (our theories and models) are themselves ontological systems, but epistemic levels of description should not be mistaken for ontological levels of reality. Both perspectives are complementary: epistemic levels allow us to model and compare systems across domains, while ontological levels identify the real strata of nature. Confusing the two may lead, for example, to treating disciplines (e.g. psychology, economics) as ontological layers rather than epistemic frameworks, or conversely, to denying the ontological reality of systems by calling them "just constructs.

D6.7 Granularity — Granularity is the conceptual inverse of assembly: it describes the degree to which a system can be resolved into component subsystems or processes. Whereas assembly emphasises the integration of components into higher-order organisation, granularity emphasises differentiation — the level of detail or resolution at which those components and their interactions are distinguished. Granularity thus defines the *scale of analysis* at which a system is described, linking physical subdivision with conceptual resolution. (05/06 Appendix A)

Explanation — Assembly and Granularity: Assembly and granularity are complementary perspectives on systemic hierarchy. Assembly traces the upward composition of systems from pre-assembled parts; granularity traces the downward decomposition of systems into constituent subsystems or processes. Together they define the bidirectional structure of system organisation, enabling movement between higher and lower levels of emergence.

D6.8 Level of Granularity — A level of granularity specifies a position within a hierarchy of resolution at which a system is analysed. The reference level (Level 0) is the system as a whole. Level 1 comprises the most complex subsystems that together constitute the system; Level 2 comprises the next level of component systems (sub-subsystems) that together constitute each Level 1 subsystem, and so on. Each successive level reveals finer structural and functional detail, enabling the system to be examined at progressively higher resolution. Levels of granularity therefore provide a formal framework for relating whole–part organisation to scale and complexity. (05/06 Appendix A)

Explanation — Granular Hierarchy: Levels of granularity are numbered downward from the whole (Level 0) toward progressively smaller and simpler subsystems. This convention complements assembly theory: as assembly moves upward to form higher-order systems, granularity moves downward to resolve those systems into their component structures. Together they describe the bidirectional hierarchy linking complexity, scale, and organisation.

P6.7 Granularity–Complexity Proposition — As granularity increases, the number of component systems increases and their complexity decreases. (05/06 Appendix B)

P6.8 Environmental Nesting Proposition — The environment of a system is scale-dependent and hierarchically nested. Each subsystem possesses its own environment appropriate to its scale and processes, which may overlap or interact with the environment of the larger system to which it belongs. (New)

Explanation: A system's environment is defined relative to its own size, complexity, and the causal reach of its processes. What counts as a system's environment depends on the level of organisation or granularity at which the system is defined. Only systems capable of meaningful interaction at that scale are included within the effective environment. However, a system's components are themselves systems, each interacting through an environment appropriate to its scale. These component environments may overlap or interface with that of the larger system. Cross-scale interactions — for example, molecular corrosion affecting the integrity of a ship — illustrate how environmental processes at one scale can propagate effects through higher levels of organisation.

b. Emergence

D6.9 Emergent Property— A novel causal property arising from internal organisation not evident in any component part. (05/12) [D2]

P6.9 Universality of Emergence Proposition — By definition all systems have emergent properties. (05/07)

D6.10 Holism — The emergence of new properties in a system that are not present in its components considered individually. (05/06 Appendix A, 05/07)

D6.11 Reductionism — A methodological approach assuming system behaviour can be fully explained by its parts independently. (New)

D6.12 Vanishing Property — A property of components that disappears in the system as a whole. (05/02)

P6.10 Vanishing Property Proposition — Integration of components into a higher-order system can suppress or transform some of their original properties. Once incorporated, a component's inputs and outputs are primarily exchanged with *sibling components* rather than with the external environment, and many of its previously expressed properties become latent or subordinated to the organisation of the whole. (05/02)

Explanation: A component's properties are not absolute but context-dependent. When integrated into a system, the component's boundary conditions and relational interfaces change: some causal powers that were active in isolation become inactive, while new emergent properties appear at the system level. The "vanishing" of component properties is therefore a shift in causal relevance, not elimination of potential.

D6.13 System Duality — Every system exhibits a dual aspect: it can be described as a coherent whole with emergent properties and as a configuration of interacting components whose relationships generate those properties. This duality underlies the complementary perspectives of holism, reductionism, assembly, and granularity. (New)

P6.11 Conditional Emergence Proposition — Emergent properties arise only when interactions among sufficient subsystems cross a threshold of organisation that enables new functions or behaviours. Below this threshold, component interactions remain subcritical and no new system-level properties appear. (05/06 Appendix B, 05/07, 05/10)

P6.12 Discrete Emergence Proposition — Emergence occurs in discrete steps rather than continuously. Each threshold crossed marks the formation of a new level of organisation with qualitatively distinct properties. These discrete transitions generate the hierarchical structure observed in complex systems. (05/10)

P6.13 Subcritical and Transitional States Proposition — Between thresholds of emergence, systems occupy transitional or unstable configurations in which interactions lack the coherence required for stable emergent properties. Such regions may exhibit apparent randomness — ontological when no higher order exists, epistemic when hidden structures remain subcritical. (05/06 Appendix B, 05/07)

P6.14 Interaction–Assembly Proposition — Systems at each level of emergence are assembled according to principles determined by the levels below, e.g., the ability of subsystems at the level below to interact, while also enabling new forms of interaction at the levels above. (05/12) [P7]

D6.14 Threshold of Emergence — The threshold of emergence is the point at which new systemic properties appear due to sufficient complexity or assembly, marking a step between levels. (05/07, 05/10)

D6.15 Recursive Emergence— The repetition of emergent processes across multiple levels, so that emergence at one level sets conditions for emergence at the next. (New) [D4]

P6.15 Complexity–Emergence Proposition — As complexity increases through successive levels of assembly, new properties and processes emerge that are characteristic of each level. While the specific forms of systems processes differ across domains—for example, metabolism in living organisms or institutions in societies—they preserve underlying organisational patterns such as triadic input–maintenance–output relations. Each level of emergence thus expresses new causal powers, evidenced by the appearance of novel system outputs—capabilities or effects not possible for the component systems in isolation. (05/06 Appendix B)

Explanation: In systems terms, *causal powers* refer to what a system can do because of its organisation. The emergence of new causal powers therefore manifests as new types of output or influence—for instance, a molecule's chemical reactivity, an organism's behaviour, or a society's institutions. These novel outputs signal that a qualitatively new level of causal capacity has formed.

P6.16 Threshold Flexibility Proposition — Complexity ceilings are thresholds that can be crossed due to the emergence of new system properties (energy access, information processing, modularity). (05/12)

Explanation: what looks like a hard ceiling is often just a threshold. With new enabling properties, systems can exceed previous limits.

D6.16 Levels of Emergence — Layers of organisation where qualitatively new properties arise. The hierarchical levels at which systems processes manifest, from physical to biological to social and symbolic domains. (New)

P6.17 Assembly–Emergence Correspondence Proposition — Levels of assembly and levels of emergence mirror one another. Each step in the structural assembly of simpler systems into higher-order organisation provides the conditions for a corresponding level of emergent properties. The hierarchy of assembled structures thus parallels the hierarchy of emergent properties, linking physical composition to functional complexity. (New)

Explanation: Assembly describes the organisation of components into systems; emergence describes the appearance of new properties at each organisational level. These two hierarchies are reciprocally related: each higher level of assembly enables a distinct level of emergence, while emergent properties at one level become the enabling capacities for further assembly at the next. The co-development of structural and emergent hierarchies underlies the cumulative evolution of complexity.

P6.18 Hierarchy Defined by Emergence Proposition — System hierarchies are defined jointly by assembly and emergence: each higher level of organisation is formed through the structured assembly of lower-level systems and distinguished by the appearance of new emergent properties and processes. The resulting hierarchy expresses both compositional order and qualitative novelty, defining the progressive architecture of complexity recognised in systems science. (05/02)

Explanation: The systems hierarchy is the foundational structure recognised across systems science: molecules assemble into cells, cells into organisms, organisms into societies, and so on. At each stage, assembly integrates prior systems while emergence introduces new properties and causal powers. The interplay of these two dynamics—structural composition and emergent differentiation—defines the multi-level organisation of reality.

P6.19 Conditional Range of Emergence Proposition — Emergence occurs only within viable ranges of complexity where component interactions can stabilise new organisation. Different system types—such as chemical, biological, or social systems—emerge at distinct complexity intervals, and component subsystems may reach their own emergent thresholds at slightly different stages. This staggered pattern produces nested and overlapping levels of organisation. (05/06 Appendix B)

P6.20 Level-Specific Operation and Cross-Level Coupling Proposition — Emergent properties exert causal influence primarily at the level where they arise and on systems at equivalent levels of organisation. However, cross-level interactions are possible when the outputs of one level are compatible with the inputs of another, allowing coupling between adjacent levels in the hierarchy. (05/06 Appendix B, 05/10)

P6.21 Divergent Developmental Pathways Proposition — Systems hierarchies can follow distinct developmental or evolutionary trajectories, producing different kinds of complex systems—such as astrophysical, chemical, or biological structures—according to the enabling conditions and constraints of their environments. (New)

P6.22 Finite/Infinite Universe Proposition — If the universe were finite, all paths of increasing complexity would merge at the level of the whole universe; in an infinite universe, emergence continues indefinitely. (05/06 Appendix B)

D6.17 ~~D6.6~~ Organising Principles (Speculative) — Underlying principles or constraints that may shape the emergence of new levels; while not always directly observable, they guide system development and structure. (New) [D22]

P6.23 Distinct Dimensions Proposition — Levels of complexity, assembly, and emergence are distinct but interrelated dimensions: complexity measures component quantity, assembly describes structural integration, and emergence captures the appearance of new properties. (New)

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7. Causality

a. The Nature of Causality

D7.1A Causality or Systems Causality — A relationship in which outputs from one collection of events, objects, or circumstances of a type (the cause) become inputs to another (the effect), provided instances of the former precede those of the latter and are directly or indirectly contiguous within the same causal field. (05/12) [D21]

D7.1B Contiguity — The condition of spatial, temporal, or energetic adjacency required for causal interaction. Systems are contiguous when their boundaries or fields overlap sufficiently to permit the exchange of matter, energy, or information. (New)

P7.1 Relationship Proposition — Relationships can be causal, involving active transfers between entities, or non-causal, representing structural, spatial, or logical associations without transfer. Both types contribute to system organisation. (05/06 Appendix B)

D7.2 Cause — A collection of events, objects, or circumstances whose outputs may produce effects. (05/01)

D7.3 Effect — A collection of events, objects, or circumstances whose inputs arise from a preceding cause. (05/01)

D7.4 Transfer or Causal Transfer — A system or collection transferred from cause to effect. (05/10)

P7.2 Transfer Proposition — A causal relationship involves a transfer of matter, energy, or information from cause to effect. In physical systems, causal transfers are further constrained by relativistic limits: no influence can propagate faster than the speed of light in vacuum. (05/02)

D7.5 Transfer Duality — A transfer can be seen either as a relationship or as a system in itself. (05/09)

D7.6 Causal or Structural Network — A model representing entities (nodes) and the relationships (edges) among them. Networks may be **structural**, depicting static patterns of adjacency, constraint, or potential interaction, or **causal**, depicting active transfers of matter, energy, or information between entities. Most real systems combine both forms, where structural connectivity constrains and enables causal flow. (New)

P7.3A Structure–Causality Coupling Proposition — Structural networks define the configuration of potential interactions within a system, while causal networks describe the realised flows within that configuration. The dynamic behaviour of systems arises from the interplay between structural potential and causal actualisation. (New)

P7.3 B Causal Information Proposition — Information is the structural expression of causality. Each causal interaction transmits not only energy but also organised difference, enabling the universe to preserve and transform structure without invoking metaphysical principles. (New)

P7.3C Energy–Information Coupling Proposition — Every causal transfer conveys both energy and information; energy provides the capacity for change, while information—the structured pattern within that energy—directs and constrains the change that occurs. (New)

P7.4 Disposition for Causality Proposition — Causal relationships between systems require relative disposition: spatial and temporal proximity, and compatible states or interfaces, sufficient to permit transfer of matter, energy, or information. (New)

P7.5 Originating Transfer Proposition — Every transfer in a causal relationship must previously have been contained within, or generated by, the originating system or event. (New)

P7.6 Complexity Limit Proposition — Causal transfers cannot exceed the complexity of the cause. (05/10)

P7.7 Assembly of Transfers Proposition — Transfers in causal relationships are assembled from previously assembled parts. (05/10)

P7.8 Emergent Transfer Proposition — A causal transfer may itself be an emergent property of the causal system. (New)

D7.7 Integration — Transformation and incorporation of transfers into the receiving system. (05/10)

P7.9 Receiving Options Proposition — A receiving system may reject, fully integrate, or partially disaggregate a transfer. (New)

P7.10 Integration Purpose Proposition — Integrated transfers may serve assembly, self-maintenance, output generation, or combinations of these. (New)

P7.11 State Change Proposition — Except where a continuous flow of matter, energy, or information is maintained, a causal relationship entails a change of state in both cause and effect. Each discrete transfer event alters the conditions of the systems involved, distinguishing event-based causation from steady-state flow. (05/09)

b. Types of Cause and Effect

D7.8 Direct Causality — A causal relationship where the effect follows immediately from the cause through a single identifiable transfer. (New)

D7.9 Indirect Causality — A causal relationship in which the connection between cause and effect operates through one or more intermediary systems or events, forming a chain or network of direct causal links. (05/07)

P7.12A Necessity–Sufficiency Proposition — Properties of necessity and sufficiency apply to system inputs. (New)

D7.10 Necessary Cause — A cause without which an effect cannot occur. (05/01)

D7.11 Sufficient Cause — A cause that, under specified conditions, always produces a stated effect. In systems terms, sufficiency requires (1) spatial proximity between cause and effect sufficient for transfer, (2) temporal precedence of the cause, and (3) the absence of inhibiting influences or counteracting conditions from the effect or its environment. (05/01)

D7.12 Enabler or Enabling Cause — A cause that allows a process in the effect to function. (05/01)

D7.13 Enabling Input — An enabling input is a transfer from a parent system, sibling system, or environment that provides the necessary conditions for a system's processes to function. It is the input analogue of an enabling cause. In the context of living systems, enabling inputs are often described as *satisfiers* of needs. (New)

D7.14 Probabilistic Enabler - A cause that increases the likelihood of a system's process functioning, but is neither necessary nor sufficient to guarantee the outcome. (New)

D7.15 Inhibitor or Inhibiting Cause — A cause that prevents a process in the effect from functioning. (05/01)

D7.16 Inhibiting Input — An inhibiting input is a transfer from a parent system, sibling system, or environment that disrupts, constrains, or prevents a system's processes from functioning. It is the input analogue of an inhibiting cause. In the context of living systems, inhibiting inputs are often described as *contra-satisfiers* of needs. (New)

D7.17 Probabilistic Inhibitor — A cause that increases the likelihood of a system's process functioning, but is neither necessary nor sufficient to guarantee the outcome. (New)

D7.18 Complex Causality — Complex causality occurs when several necessary causes combine to form a sufficient cause. This can apply to both enablers and inhibitors. (05/01)

P7.12B Assembly–Causality Proposition — Assembly is a form of causation in which the cause, in whole or in significant part, is transferred into and incorporated within the effect. The effect thus extends or recontextualises the cause, producing persistence through integration rather than transformation. (New)

c. TPT and PTP Causality

D7.19 PTP (Process–Transfer–Process) Causality — Each cause and effect comprises two processes connected by a transfer, forming an event. (05/10)

D7.20 TPT (Transfer–Process–Transfer) Causality — Each cause and effect comprises a process and two transfers, forming a system, its input and output. (05/10)

D7.21 Causal Duality — The two perspectives on causality, PTP and TPT. These are epistemic distinctions, not ontological. (05/09)

P7.13 Alternating Structure Proposition — Any chain in a causal network alternates between processes and transfers (P–T–P–T). (New)

P7.14 Minimal Structure Proposition — Minimal causal structures are PTP (events) and TPT (inputs, systems and outputs). (New)

P7.15 Interchangeability Proposition — Every cause is also an effect of prior causes, and every effect may become a cause. Thus, causes and effects must both have a common structure which can be either PTP or TPT. (New)

P7.16 Shared Feature Proposition — Causes and effects require a shared feature binding them in space-time. In PTP causality this is a process and in TPT causality it is a transfer. (New)

D7.22 Rothman's Causal Model — Ken Rothman's sufficient–component cause model represents a form of TPT causality in which different systems or configurations can produce equivalent outputs through distinct structures or pathways. It acknowledges that the underlying causal transfers may be unknown or unobservable, yet still sufficient to generate the stated effect. (New)

P7.17 Hypothesis Proposition — TPT causality can indicate potential causal links even with unknown transfers. (05/10)

P7.18A Systems–Process Causality Proposition — Every system can be understood as a configuration of causes and effects: its structure (what it is) embodies potential causal relations, while its processes (what it does) express those relations through transfers of matter, energy, or information. The system and its processes are therefore two perspectives on the same causal organisation — the former emphasising configuration (TPT), the latter flow and transformation (PTP) . (05/02)

Explanation — Systems, Processes, and Causal Duality: Systems represent the stable configurations through which causality is organised; processes represent the dynamic expression of that causality in action. The Transfer–Process–Transfer (TPT) perspective highlights structural continuity and potentiality ("being"), while the Process–Transfer–Process (PTP) perspective highlights functional activity and transformation ("doing"). Together, they describe how systemic organisation and causal operation are two inseparable aspects of the same reality.

P7.18B Structure–Causality Feedback Proposition — Structure constrains causal processes, while causal processes in turn reinforce or erode structural connections. The resulting feedback between form and function enables systems to learn, evolve, and self-organise over time. (New)

P7.18C Causal Duality Proposition — Causal relations can be interpreted from two complementary perspectives: **PTP** (Process–Transfer–Process), which highlights transformation and corresponds to processual reasoning, and **TPT** (Transfer–Process–Transfer), which highlights continuity and corresponds to structural reasoning. Together they express the dual nature of systems as both changing and continuous. (New)

d. Causal Structures

Explanation: Causal structures describe the patterned arrangements through which causes and effects are connected. They range from simple one-to-one relations (linear causality) to branching, converging, cyclic, or feedback forms. These patterns determine how influence propagates, stabilises, or amplifies within and between systems.

D7.23 Linear Causality — A causal structure in which a single sufficient cause produces a single effect. (05/06 Appendix A)

D7.24 Causal Tree Structure — A branching causal structure in which one cause gives rise to multiple distinct effects. (New)

D7.25 Causal Root Structure — A converging causal structure in which multiple causes combine to produce a single effect. (New)

D7.26 Domino Causality — A sequential chain of causes and effects, each effect becoming the cause of the next. (05/06 Appendix A)

D7.27 Cyclic Causality — A repeating chain of causes and effects that recur in a cycle of the same types. (05/06 Appendix A)

D7.28 Mutual Causality — A reciprocal causal relationship in which two entities each act as both cause and effect of the other. (05/06 Appendix A)

D7.29 Feedback Loop or Circular Causality — A causal structure in which outputs of a process, which may comprise several causes and effects, are reintroduced as inputs, forming a closed causal loop. (05/02, 05/03)

D7.30 Internal Feedback Loop — A feedback loop operating within a single system, where causes and effects are components of the same system. (05/04)

D7.31 External Feedback Loop — A feedback loop linking distinct systems, where causes and effects belong to different interacting systems. (05/02, 05/04)

D7.32 Positive Feedback Loop — A feedback loop in which increases in causes amplify their effects, reinforcing the original change. (05/06 Appendix A)

D7.33 Negative Feedback Loop — A feedback loop in which increases in causes dampen their effects, counteracting the original change. (05/06 Appendix A)

D7.34 Regulating Feedback Loop — A feedback loop in which increases or decreases in causes are matched by compensatory adjustments that promote stability. (05/06 Appendix A)

P7.19 Feedback Influence Proposition — Feedback loops influence a system's stability according to the nature of their causal interactions. (05/03)

P7.20 Energy Dependence Proposition — Positive feedback loops require external energy input to sustain amplification. (05/06 Appendix B)

P7.21 Energy Dissipation Proposition — Negative feedback loops reduce system activity by dissipating energy, driving the system toward equilibrium. (05/06 Appendix B)

D7.35 Cascading Causality — A directional chain of causes in which successive causes also act on a single target system, cumulatively amplifying or dampening a feature of its state. (05/06 Appendix A)

P7.22 Cascading Distinction Proposition — Cascading causality differs from feedback because it propagates outward through connected systems rather than returning to its source. (New)

D7.36 Relational Causality — A causal relationship based on relative states or differences between entities (e.g., temperature, pressure, potential) that serve as the basis of the effect. (05/06 Appendix A)

D7.37 Threshold-Based Causality — A causal relationship in which an effect occurs only when a variable characteristic of the cause crosses a critical threshold. (New)

e. Differential Coupling {Near-Decomposability}

D7.38 Delay Constraint — In all real-world systems, causal transfers involve a finite delay between input and output. No system can transmit matter, energy, or information instantaneously; every causal process requires measurable time for propagation and transformation. (New)

D7.39 Differential Coupling {Near-Decomposability} — Subsystems interact more strongly and rapidly within themselves than across their boundaries. This difference in coupling strength and timescale allows partial independence among subsystems, enabling hierarchical organisation, modular behaviour, and local stability. Because internal interactions are faster and denser, changes within a subsystem tend to equilibrate before their effects propagate outward, allowing complex systems to remain both integrated and analytically tractable (05/03)

P7.23 Differential Coupling {Near-Decomposability} Proposition — Differential coupling enables faster local and slower global causal interactions, allowing subsystems to stabilise internally before responding to slower system-wide dynamics. This temporal differentiation supports modular organisation, stability, and adaptability in complex systems. (05/03)

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8. Energy Landscapes

a. Core Definitions

P8.1 Energy Landscape Proposition — Systems and collections of systems can be represented within multidimensional spaces defined by configurational and qualitative variables. Within these spaces, regions of correlated stability form attractors whose depth and shape may correspond to energy and information gradients. Systems traverse these landscapes probabilistically, moving among attractors as energy and information flows modify their constraints. (New)

D8.1 Macrostate — The large-scale condition of a system defined by overall variables (e.g., energy, volume, pressure, temperature, or average properties), irrespective of the specific internal arrangement of its components. (05/12)

D8.2 Microstate— A specific, detailed arrangement of a system's components at the microscopic level, consistent with a given macrostate. (05/12)

Explanatory Note 1 (Macrostate–Microstate Relationship):
A macrostate represents the overall condition of a system in terms of large-scale variables, while a microstate represents one particular configuration of its underlying components. Many microstates can correspond to the same macrostate. The number of microstates compatible with a given macrostate determines its entropy: high entropy corresponds to many possible microstates, while low entropy corresponds to fewer. This distinction underpins statistical mechanics but generalises across systems theory, where macroscopic patterns emerge from microscopic arrangements.

Explanatory Note 2: The distinction between macrostate and microstate illustrates how the physical arrangement of components underpins the abstract qualities of systemness as represented in our models of system behaviour. Macrostates capture systemic characteristics at the level of systemness, while microstates describe the detailed physical arrangements that generate them.

D8.3 Entropy— A measure of disorder or randomness, reflecting the number of possible microstates corresponding to a macrostate. (05/12) [D6]

D8.4 Free Energy — Free energy is the portion of a system's internal energy that is available to do useful work. (New) [D7]

D8.5 Information at Source (EFGST Idiom) — Information conceived as an ontological property: the patterned structure of matter and energy in space-time itself. It represents the negentropic order of the system. (05/12) [D8]

Explanation — Relation to Process and Negentropy: When structure changes, information at source also changes. Processes an act upon structure, redistributing or dissipating its stored information (negentropy) and generating new structural configurations. Information at source therefore functions as the structural correlate of negentropy.

D8.6 Negentropy — Order or structure within a system that offsets entropy, representing information accumulated across all levels of granularity and through the system's history of energy and matter exchanges. Negentropy reflects the integrated organisation of subsystems and sub-subsystems — the enduring coherence built and maintained through processes of assembly, regulation, and adaptation. (05/12)

Explanation — Negentropy and Granularity:
Negentropy accumulates hierarchically as well as temporally. Each level of granularity — from component processes to subsystems to the system as a whole — contributes to the system's total organisation. The structural patterns that persist across these levels embody *information at source*: the physical record of past assembly and stabilising processes. Total negentropy therefore indexes the depth of coherent organisation sustained against entropy through both time and hierarchy.

P8.2A Second Law Proposition — Information at source does not violate the Second Law of Thermodynamics; it is sustained by external energy. (05/12)

P8.2B Entropy–Information Proposition— Entropy and information at source are complementary measures: entropy increases with disorder, information at source with order and pattern. (05/12)

P8.3 Reciprocal Breakdown Proposition — The entropy–information at source reciprocity breaks down when simplification considers only one granularity level. (05/12)

Explanation: reciprocity is scale-sensitive; we must align granularity with the system's organisation to preserve the entropy–information link.

D8.7 First-Order Phase Change — A sudden change of state involving latent heat, e.g., melting or boiling. (05/12)

D8.8 Second-Order Phase Change — A gradual change of state without latent heat, e.g., magnetisation, where rates of change (derivatives) shift discontinuously. (05/12)

P8.4 Contiguity Proposition — Interacting systems can be represented by an energy landscape when intermediate states are physically possible, as in second-order or otherwise continuous phase changes. (Revised 05/12)
Explanation: Energy landscapes only make sense for interactions that permit continuous or multi-step transitions between states; where only discrete state changes occur, the landscape representation loses meaning. (05/12)

P8.5 Continuous Transition Proposition — A second-order phase change represents a continuous transition in an energy landscape. (05/12)

D8.9 Configuration Space — A multidimensional space in which each point represents a possible arrangement of a system's components. Each dimension corresponds to a spatial degree of freedom—such as the position or orientation of a component relative to others—so that the configuration space captures all physically realisable arrangements of the system. (05/12)

Explanation — Configuration and Energy Landscapes: Configuration space provides the geometric foundation for an energy landscape. Each coordinate specifies a complete arrangement of the system's components; the energy landscape overlays this space with a scalar field representing the potential energy associated with each configuration. Local minima correspond to stable arrangements (attractors), while gradients represent the forces driving transitions between configurations. The dimensionality of configuration space thus reflects the system's structural degrees of freedom.

D8.10 Physical Field — A region of influence generated by a physical entity or configuration in which measurable quantities such as energy, potential, or force vary with distance. The strength of a physical field typically diminishes from its source according to an inverse-square or similar decay relation, implying the emission or propagation of influence through space. Physical fields mediate causal interaction between systems by transferring energy across distance. (New)

D8.11 Logical Field — A region of inclusion defined by a shared property, relation, or characteristic rather than by spatial extension. A logical field comprises all entities that instantiate the defining characteristic, independent of physical distance. It represents an informational or conceptual structure in which membership, rather than energy, determines coherence. Logical fields mediate abstract or semantic relationships, enabling generalisation, classification, and symbolic interaction among systems. (New)

Explanation If *b* is a collection of physical entities and if *A(b)* is their aggregate, i.e., the collection treated as a singular entity, then the corresponding field is A(~b) where *~b* comprises everything that is not a member of *b*. *~b* includes (1) anything external to the objects, (2) parts but not wholes of the objects, and (3) anything intersecting with the objects. (New)

P8.6 Physical Entity – Logical Field Complement Proposition— Every physical entity can be understood as existing within, and shaped by, a logical field; conversely, every logical field is manifested through physical entities. (New)

Explanation Physical entities are bounded wholes aggregated as *A(b)*, while logical fields are defined as *A(~b)*, comprising what is external to, intersects with, or is part of those wholes.

P8.7 Logical Field Interaction Proposition — Fields interact when their underlying systems exchange matter, energy, or information, producing new configurations of systemness. (New)

Explanation — Logical relationships between fields are the inverse of logical relationships between physical entities. For objects, interactions are described using AND, OR, subset, and superset relations. For fields, the corresponding relations are OR, AND, superset, and subset.

Example: If the aggregate entity A(a) transfers a component *c* to the aggregate entity A(b):

- **Objects:**
    - Donor after transfer:

$$A(a)' = A(a \text{ AND } \sim c)$$

    - Recipient after transfer:

$$A(b)' = A(b \text{ OR } c)$$

- **Fields:**
    - Field of donor after transfer:

$$A(\sim a)' = A(\sim a \text{ OR } c)$$

    - Field of recipient after transfer:

$$A(\sim b)' = A(\sim b \text{ AND } \sim c)$$

Thus, the logical field equivalent of a causal transfer of a component from aggregate entity A(a) to A(b) is the transfer of the corresponding field from A(~b) to A(~a).

D8.12 Energy Landscape— A representation of a system's internal energy plotted over its configuration space, where each point corresponds to a possible arrangement of components. The landscape shows the energy associated with each configuration: low-energy troughs correspond to stable or metastable states (attractors), while higher-energy peaks and ridges represent unstable or transitional configurations. (05/12) [D9]

P8.8 Energy Landscape Proposition — Every mutually contiguous collection of systems has its own energy landscape. (New) [P2]

D8.13 Attractor, Basin or Trough — A stable configuration in an energy landscape toward which a system tends. (05/12) [D10]

P8.9 Attractor Stability Proposition 1— The stability of a system is determined by the depth and shape of its attractor basin. (05/12)

P8.10 Attractor Stability Proposition 2 — Systems persist within attractors until shocks or gradual changes enable transitions. (05/12)

D8.14 Barrier — A peak in the energy landscape that must be overcome for a system to transition between basins. (05/12)

P8.11 Barrier Proposition — Barriers determine the likelihood and energy cost of transitions between attractors. (05/12)

P8.12 Stability Correspondence Proposition— In closed systems, stability corresponds to the minimisation of free energy — the attainment of thermodynamic equilibrium. In open systems, stability corresponds to high information at source and low total internal energy — structured order maintained through continuous energy throughput. (05/12) [P4]

D8.15 Closed System — A system exchanging neither matter nor energy with its environment. (05/12) [D5]

P8.13 Energy Conservation Proposition — In a closed system, total energy remains constant. (05/12)

P8.14 Entropy Increase Proposition — In a closed system, entropy always increases, leading to disorder. (05/12)

P8.15 Mass Conservation Proposition — In a closed system, total mass (or mass-energy) remains constant. (05/12)

P8.16 Information Decay Proposition — In a closed system, information decays over time due to entropy. (05/12)

P8.17 Peak–Trough Proposition (Closed Systems) — In closed systems, troughs correspond to states of minimum free energy and maximum entropy, while peaks correspond to states of higher free energy and lower entropy. The dominant dynamic in such systems is the tendency toward increasing entropy, with troughs representing local minima in free energy and higher entropy consistent with the Second Law of Thermodynamics. (New)

D8.16 Open System — A system exchanging matter, energy, or information with its environment. (05/12) [D12]

P8.18 Open Systems Proposition — All systems with inputs and outputs are open systems. (05/12)

P8.19 Peak–Trough Proposition (Open Systems and Energy) — In open systems exchanging energy with their environment, troughs in the energy landscape correspond to configurations of high information at source — states of structural order and low total internal energy sustained by continuous energy flow. Peaks correspond to less ordered configurations with higher total internal energy and lower information at source. (Revised)

Explanation: High information at source reflects energy that has been bound into stable structures — potential energy stored in form rather than flux. In an energy landscape, this corresponds to low points (troughs) where the system's internal energy is minimal and stability is maximal. The system remains far from thermodynamic equilibrium because maintaining these low-energy, high-order configurations requires ongoing energy throughput from the environment. Thus, total internal energy decreases as structural information increases, even though the system's free energy dynamics depend on continuous exchange.

P8.20 Mass Exchange Proposition (Open Systems to Energy and Mass) — In systems open to both energy and mass, the entry or departure of mass alters the energy landscape by reshaping basins and barriers: added mass can deepen or shift attractors, while lost mass can destabilise existing troughs or collapse them entirely. (New)

P8.21 Degrees of Freedom Proposition — When a new system enters an open configuration space, the total number of degrees of freedom increases, expanding the range of possible configurations. Unless the newcomer is immediately integrated through constraining relationships, this expansion increases entropy by introducing additional unconstrained variability. (05/12)

P8.22 Landscape Disruption Proposition — When a new system enters an open configuration space, the addition of new interactions alters the potential energy relationships among existing components. This can reshape the energy landscape of the composite system, destabilising previous attractors, inducing oscillations, or generating new attractor basins that reflect the system's reorganisation. (05/12)

D8.17 Fractal Structure or Pattern— Recursive patterns of organisation repeating across scales. (05/12) [D11]

P8.23 Fractality Proposition— In an open system, if free energy is held constant, the landscape of total energy for any given collection of components is fractal in nature. Fractal structures in energy landscapes arise from repeating arrangements generated by (1) the interchangeability of similar components, (2) geometric symmetries including rotations, translations, expansions/contractions, and reflections, (3) recursive assembly rules applied iteratively, and (4) the recurrence of similar structures and processes at different scales. (05/12) [P3]

P8.24 Nested Landscape Fractality Proposition — The fractal character of energy landscapes arises not only from self-similar dynamics but also from the nested hierarchy of systems, in which the stability of child attractors contributes to the depth and stability of parent attractors. (New)

b. Behaviour in Landscapes

D8.18 Energy Shock — An influx of energy that can dislodge a system from its current attractor or can push a system over a barrier into a new attractor. (05/12)

P8.25 Disruption Proposition — Energy shocks can cause systems to oscillate or drive them out of stability into new configurations. (05/12)

P8.26A Oscillation Proposition — Oscillation within an attractor corresponds to vibration around a stable configuration. Excessive oscillation raises the system's energy toward the barrier of the attractor basin; if the barrier is exceeded, the system departs from stability, crossing the landscape peak into a new or degraded configuration. (05/12)

Explanation — Vibration–Disruption Correspondence: Oscillation around an attractor corresponds physically to vibration within a stable configuration. As the amplitude of vibration increases, the system's energy rises relative to the local minimum. When this exceeds the energy barrier of the basin, the system can cross into a neighbouring region of configuration space — corresponding to structural failure, transition, or collapse.

P8.26B Feedback–Energy Coupling Proposition — In open systems, positive feedback increases energy throughput while negative feedback decreases it; sustainable stability requires that their combined effect remains within the system's energetic bounds. (New)

P8.26C Feedback–Energy Asymmetry Proposition — In open systems, positive feedback amplifies change by demanding increasing energy throughput until resource limits or structural failure intervene, whereas negative feedback dissipates the organised energy of the behaviour it dampens, restoring stability through energy loss.

P8.26D Structural Feedback Proposition — The reciprocal influence between structure and process follows the same energetic logic as feedback in open systems: positive coupling amplifies structural change, negative coupling reinforces existing organisation, and regulating coupling balances both to enable adaptive self-organisation. (New)

D8.19 Relaxation Time — The time for a system to return to stability after disturbance. (05/12)

P8.27 Relaxation Proposition — Relaxation times depend on landscape shape, energy input, and system complexity. (05/12)

D8.20 Dynamic Equilibrium (Homeorhesis) — A system maintains a stable rate of change, not a fixed state. (05/12)

P8.28 Homeorhesis Proposition 1 — Dynamic equilibrium corresponds to oscillation within an attractor basin. (05/12)

P8.29 Homeorhesis Proposition 2 — Long-period systemic oscillations may appear stable in the short term but can mask latent transitions toward instability, collapse, or transformation. (New)

D8.21 System Lifecycle — The progression of a system through subcritical structure, sub-optimal system, optimal system, super-optimal system and collapse. (05/12)

P8.30 Lifecycle Proposition— A system's lifecycle is a non-teleological process driven by ratcheting. That is it is not goal-directed or not explained by purpose or intention. (05/12) [P13]

D8.22 Ratcheting— A dynamic in which systems move into progressively deeper attractors, making reversal improbable. (05/12) [D13]

P8.31 Ratcheting Drivers Proposition — Ratcheting arises from energy shocks, accessible shallow barriers, and prevalence of low-magnitude shocks. (05/12)

P8.32 Ratcheting Proposition— In open systems, information at source accumulates over time via ratcheting. Ratcheting dynamics tend to drive systems into progressively deeper attractors. (05/12) [P8]

D8.23 Equifinality — Different initial conditions converge to the same end state. (05/12)

P8.33 Equifinality Proposition — Some variables return to stability after disturbance (equifinality) and reach the same state via different processes. (05/12)

D8.24 Multifinality — Similar initial conditions can lead to different stable end states. (05/12)

P8.34 Multifinality Proposition — Systems starting in the same configuration can shift into alternative attractors under disruption (multifinality). (05/12)

D8.25 Assembly Path — A sequence of states through which a system develops as components combine. (05/12)

D8.26 Landscape Guided Assembly — The process by which assembly paths are biased by energy landscapes, favouring some trajectories over others. (05/12)

P8.35 Guided Assembly Proposition — System assembly is guided by energy landscapes, biasing trajectories toward some configurations and away from others. (05/12)

D8.27 Subcritical Structure— A configuration of components insufficient to generate emergent properties but stable at a lower level. (05/12) [D1]

P8.36 Subcritical Persistence Proposition — Subcritical structures may persist without emergent properties, forming reservoirs of potential assembly. (05/12)

P8.37 Emergence Proposition— Systems form when components ratchet into lower attractors until new properties emerge. (05/12) [P5]

D8.28 Emergence Window — The span in assembly space where emergent properties are most likely to arise. (05/12)

D8.29 Critical Structure — A configuration at the threshold where emergent properties first appear. (05/12)

D8.30 System Genesis — The transition point at which a sub-critical structure becomes a critical structure or system with emergent properties. (New)

P8.38 System Genesis Proposition — A new system arises when a critical structure passes the threshold of organisation necessary for emergent properties. (New)

P8.39 Complexity Barrier Proposition— The likelihood of a group of systems ratcheting from randomly distributed to structured diminishes as the internal complexity of the constituent systems increases. (05/12) [P6]

D8.31 Supercritical Structure — A configuration beyond criticality, capable of maintaining emergent properties robustly. (05/12)

D8.32 Replacement Complexification — Replacement complexification occurs when a sub-system is replaced with a more complex variant, thereby increasing the complexity of the system as a whole. (05/12)

D8.33 Iterative Complexification — Iterative complexification is the process by which a system increases in structural or functional complexity over time through repeated cycles of maintenance, replacement, and adaptation of its sub-systems. (05/12)

P8.40 Complexification Proposition — Replacement and iterative complexification increase systemic complexity, driving long-term evolution. (05/12)

c. Optimality and Super-optimality

D8.34 Systemic Optimality — The balance point between energy used for maintenance and the energy used for functional output that maximises the latter. (05/12) [D14]

P8.41 Optimality Proposition— Systemic optimality balances structure with free energy for maximal output. (05/12) [P12]

D8.35 Super-Optimal System — A super-optimal system, also known as an overcomplex or rigid system, is one that has accumulated more internal structure than is needed for its function, consuming most of its energy in self-maintenance thereby losing productive capacity. (New) [D15]

D8.36 Renewal and Reintegration — Renewal and reintegration describes the process by which a super-optimal open system regains functional capacity by simplifying internal structure. (New) [D19]

P8.42 Renewal Proposition — Super-optimal systems are renewed only by adaptive parent systems. (05/12) [P14]

D8.37 Sub-optimisation — A condition where improving the performance of one component in a system can reduce the overall efficiency of the system. (05/03)

P8.43 Sub-optimisation Proposition — Sub-optimising one component can damage overall system performance; system-wide optimisation may require local inefficiencies. (05/03)

d. Seeds & Contra-Seeds

D8.38 Systemic Potential — A latent capacity within a system or its environment to initiate change in structure, function, or organisation when enabling or triggering conditions are met. Systemic potentials represent possibilities inherent in a system's configuration or context, awaiting activation through suitable inputs or interactions. (New)

D8.39 Seed — A seed is a minimal self-contained system or entity that contains the information and systemic potential necessary to generate a more complex system through internal processes and interaction with its environment. An initial stimulus or idea that activates or reinforces a stabilising process, guiding a system into an attractor basin. (New)

P8.44 Seed Activation Proposition — Seeds become active when environmental conditions provide sufficient enabling inputs, allowing latent systemic potential to be realised. (New)

P8.45 Seed Reinforcement Proposition — Seeds activate stabilising processes, reinforcing system viability and guiding systems into attractors. (New)

D8.40 Contra-Seed — A systemic potential or configuration that disrupts, blocks, or diverts the development of structure, order, or function within a system. When activated, a contra-seed destabilises ongoing processes and diverts the system away from its current attractor basin, reducing structural integrity or altering developmental direction. (New)

P8.46 Contra-Seed Activation Proposition — When triggered by environmental conditions, a contra-seed disrupts systemic development by destabilising stabilising processes, weakening system viability and diverting trajectories toward alternative attractors. (New)

P8.47 Contra-Seed Collapse Proposition — If destabilisation exceeds the system's adaptive capacity, contra-seed activation may push the system toward instability or collapse. (New)

D8.41 Facilitation — A process by which seeds aid the assembly and stabilisation of system components, aligning and reinforcing their trajectories to reduce variation and turbulence. Through facilitation, seeds strengthen integrative processes and steer trajectories toward existing attractor basins, promoting coherent and consistent system development. (New)

D8.42 Hindrance — A process by which contra-seeds inhibit the assembly or maintenance of coherent structures, increasing variation, turbulence, or unpredictability in systemic trajectories. Through hindrance, contra-seeds weaken integrative processes, steer trajectories toward shallower or alternative attractor basins, and increase the likelihood of transitions between attractors. (New)

Explanation — Facilitation and Hindrance Dynamics: Seeds and contra-seeds act as differential influences on assembly within a fixed energy landscape. Facilitation processes aid the integration of components and promote convergence toward stable attractors, while hindrance processes inhibit integration and promote divergence by amplifying variability. These influences modulate how systems assemble and move through configuration space without altering the landscape's underlying topology.

e. System Stress

D8.43 System Stress — A measure of the extent to which a system's processes operate below their potential capacity due to inadequate enabling inputs or the presence of inhibiting inputs. If the system's processes operate at full potential there is no system stress; if they fail to operate entirely, there is maximum system stress. (New)

P8.48 System Stress Proposition — System stress reflects the balance between enabling and inhibiting inputs. Low stress corresponds to abundant enabling inputs and remote inhibitors, while high stress corresponds to scarce enabling inputs or proximate inhibitors, potentially leading to systemic failure. (New)

P8.49 Enabling and Inhibiting Inputs Proposition (Landscape Context) —
The presence or absence of enabling and inhibiting inputs to system components determines the relative stability of system states and shapes the hills and troughs of an energy landscape. (New)

P8.50 Stability–Landscape Proposition — Troughs in energy landscapes correspond to states where enabling inputs are reliably available and inhibiting inputs are remote or suppressed, while peaks correspond to states where enabling inputs are absent or inhibiting inputs are present. (New)

f. Big History

D8.44 Big History — A unified account of increasing systemic complexity across cosmological, biological, and social timescales, from quantum fluctuations to civilisation. (05/12)

P8.51 Evolutionary Sequence Proposition — Historical emergence follows a sequence of increasing information at source: Particles → Atoms → Molecules → Life → Intelligence → Technology. (05/12)

P8.52 Heat Death Proposition — If the universe is closed, entropy must increase to thermodynamic equilibrium. (05/12)

P8.53 Infinite Universe Proposition — If the universe is infinite, entropy need not increase universally; local negentropy can persist indefinitely. (05/12)

P8.54 Earth's System Proposition — Earth approximates to a system that is closed to matter but open to energy. (05/12)

P8.55 Anthropogenic Phase Change Proposition (Speculative) — Earth is undergoing a second-order phase change toward dominance of processed information. (05/12)

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9. Systemness

D9.1 Systemness — The defining set of characteristics that constitute a system, expressed through organised relationships, processes, and interdependencies among components. Systemness represents the presence of patterned organisation that maintains coherence and enables function, whether instantiated physically or represented abstractly. Because these characteristics can be embodied in physical, informational, or logical fields, systemness is not purely epistemic but reflects real structural and dynamic organisation in the world. . (New, 05/10)

Explanation Let *s* be the collection of all concrete systems. Then systemness is the complement aggregate A(~s): the generalised property of "being a system," abstracted from all particular instances.

D9.2 System Perspective Duality — Every system can be understood through two complementary perspectives: its concrete instantiation, referring to the specific material or informational organisation that exists in the world, and its abstract systemness, referring to the characteristic patterns of relationship and process that define it as a system. These perspectives are mutually informative; the abstract reveals the organising principles, while the concrete provides their embodiment. (New).

P9.1 System–Systemness Complementarity Proposition — Systems and systemness are complementary perspectives: the concrete system refers to entities and interactions, while systemness highlights their patterned organisation. (New)

Explanation — Concrete systems are represented by A(s), the aggregate of all instances. Systemness is represented by A(~s), the complement aggregate that captures the general properties abstracted from instances. The two are complementary perspectives: systems embody systemness, while systemness provides the abstraction that allows comparison across systems.

P9.2 Utility of Perspectives Proposition — Both perspectives, concrete systems and abstract systemness, are valid and complementary. The concrete perspective enables detailed causal analysis of specific entities, their interactions, and material constraints. The systemness perspective enables recognition of common organisational principles across domains, facilitates comparative and mathematical representation by mapping variable characteristics onto dimensions of state space, and through scaling, relates those dimensions to quantitative continua such as the number line. Switching between these perspectives enhances understanding by linking empirical detail with general systemic form. (New)

P9.3 Cognitive Alignment Proposition — The systemness perspective promotes cognitive alignment both within and across disciplines by providing a shared abstract language for describing organisation, relationship, and process. It also aligns with natural human reasoning, which tends to abstract from particulars to general properties and relations. By focusing on characteristics and their dimensional mapping, systemness resonates with intuitive modes of generalisation, thereby enhancing interdisciplinary understanding and conceptual coherence. (New)

D9.3 System Classification — *System classification* is the process of grouping systems by the presence, absence, or form of their characteristic or emergent properties, thereby defining subclasses of systemness. (New)

P9.4 Characterisation Proposition — Systems may be distinguished and classified by the variable characteristics that describe them, and by the combinations of values those variable characteristics assume. (New)

P9.5 Systemness–State Continuity Proposition — The characteristics that define *systemness* also define the dimensions of the system's *state space*; the variability of these characteristics provides the basis for both classification and dynamical description. (New)

P9.6 Emergent Classification Proposition — The presence or absence of particular *emergent properties* provides a natural set of additional characteristics for classifying systems into higher-order or more complex forms. (New)

P9.7 State Variability Proposition — Changes in a system's state correspond to movements through its state space, tracing trajectories that represent transitions among different combinations of variable characteristics. (New)

P9.8 Attractor Stability Proposition — Systems tend to move toward *attractors* within their state space — regions representing stable or recurrent configurations of variable characteristics. (New)

P9.9 Property Transition Proposition — As systems evolve through state space, some properties may emerge, vanish, or become latent, reflecting shifts in organizational pattern or energetic constraint. (New)

P9.10 Classification–Dynamics Bridge Proposition — The logic of system classification (based on the presence or absence of properties) and the dynamics of system evolution (movement in state space) are formally continuous: both depend on variable characteristics and their interdependencies. (New)

Explanatory Note: This definitional set establishes the ontological and formal bridge between Mobus's definition of systemness (as the possession of particular systemic characteristics) and state-space representations (as mappings of how those characteristics vary through time). In short: Systemness defines the axes; state space traces their evolution.

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10. State Space and Strange Attractors

Note: 'Attractors' as used in Energy Landscapes refer to general stabilising basins. Here, 'Strange Attractors' are defined in their technical sense from chaos theory.

Validation Note — Empirical and Theoretical Coherence:

The account that follows treats state space as a progressive enrichment of configuration space through two successive inclusions: first, of dynamic variables to yield phase space; and second, of emergent, informational, and environmental variables to yield state space.
This formulation is consistent with established treatments in physics, control theory, and systems science. Configuration and phase spaces are formally defined in classical mechanics, while the inclusion of higher-order and aggregate variables accords with approaches in thermodynamics, synergetics, and complex-systems modelling.

Empirical evidence supports each level of this hierarchy:

- configuration and phase spaces are experimentally validated in the study of mechanical, chemical, and thermodynamic systems;
- the emergence of higher-level variables is observed in biological, cognitive, and social domains, where aggregate or informational parameters govern collective behaviour;
- fractal and multifractal structures occur across all levels, from material assemblies to chaotic dynamics and organisational hierarchies.

No known empirical findings contradict this layered representation. It should therefore be regarded as a **scientifically coherent and observationally consistent hypothesis**—one that extends established formalisms rather than departing from them, and that provides a unified language for describing structure, dynamics, and emergence within the same conceptual framework.

Invitation to Further Verification and Development:

The theoretical synthesis presented here is intended as a foundation, not a conclusion. It brings into focus a coherent relationship between configuration, phase, and state spaces, suggesting that the geometry of systems evolves through successive enrichments—from structure, to dynamics, to organisation. Each step is consistent with known science and supported by existing empirical patterns, yet its full verification demands more detailed modelling and experimental inquiry than one author or project can achieve.

Readers, particularly those within the International Society for the Systems Sciences (ISSS), university research groups, and other interdisciplinary communities, are warmly invited to explore and test these relationships. Investigations might examine whether fractal or hierarchical patterns persist as new descriptive dimensions are added; how emergent variables alter the topology of state space; and how the formal mathematics connecting configuration, phase, and state spaces can be further refined.

Such collaborative work would not only confirm or elaborate the propositions set out here but would also advance the shared aim of systems science—to reveal the common structures that underlie complexity across all scales of nature and society. The author offers this framework as a seed for that collective endeavour.

a. Relationship between Spaces

Note: Configuration Space has already been defined in Section 8 as a multidimensional space in which each point represents a possible arrangement of a system's components. Each dimension corresponds to a spatial degree of freedom—such as the position or orientation of a component relative to others—so that the configuration space captures all physically realisable arrangements of the system.

D10.2 Phase Space — An extension of configuration space that also includes dynamic variables such as momenta, velocities, or rates of change. Each point in phase space specifies both the *arrangement* of components and their *motion* at a given instant, thereby defining a complete microstate of a deterministic system. (New)

D10.3 State Space — A state space is an abstract, multidimensional space representing all possible states a system may occupy. Each axis corresponds to a variable characteristic of the system, and each point within the space represents a complete state of the system at a given instant. In deterministic systems, trajectories through state space describe how these variables change over time, revealing the system's dynamic evolution and regions of stability. State space generalises phase space by including, in addition to structural and dynamic variables, those that represent emergent, informational, or environmental properties. It therefore encodes not only motion but also organisation, adaptation, and openness, capturing the full condition of the system at its level of description and providing a unified basis for analysing both its dynamics and its systemic coherence. (New)

P10. 1 Configuration Space–Phase Space Enrichment Proposition — Phase space is derived from configuration space by adding dynamic variables that describe the rates or directions of change of each structural coordinate. This enrichment transforms the static geometry of possible arrangements into a dynamic geometry of possible motions, allowing trajectories to represent the system's time evolution within its structural potential. (New)

P10. 2 Phase Space–State Space Enrichment Proposition — State space extends phase space by incorporating additional variables that represent emergent properties, internal organisation, and environmental couplings. These added dimensions capture collective regularities and informational constraints that arise from lower-level dynamics yet influence them in return. (New)

P10.3 Emergent Enrichment Proposition — The transition from phase space to state space constitutes the formal inclusion of **emergent properties** within the system's representational manifold. Each emergent variable corresponds to a collective constraint or order parameter that both arises from and regulates lower-level dynamics, creating new forms of causality and stability. (New)

P10.4 State Space Validity Proposition — A state space is a valid representation of a system only if the variables selected are independent, correspond to the physical or informational characteristics of the system under consideration, and together capture its essential dynamics — that is, the principal causal patterns governing how the system evolves over time. The adequacy of the representation depends on how well these variables express the system's degrees of freedom and constrain its possible trajectories.(New)

P10.5 Hierarchical Containment Proposition — Configuration space, phase space, and state space form a nested hierarchy: $Q \subset \Gamma \subset S$. Each successive space subsumes the coordinates of the previous and adds new dimensions that encode higher-order causal factors. Configuration space defines *structural potential*, phase space defines *dynamic realisation*, and state space defines *organisational coherence and adaptation*. (New)

P10.6 Projection–Lifting Proposition — Projection from state space to phase space removes emergent and contextual variables, yielding the underlying dynamic description; lifting from phase space to state space reintroduces those higher-level variables, restoring the system's open and adaptive character. These two operations formalise reduction and emergence as reciprocal transformations of the same descriptive structure These transitions occur within the model's representational space rather than in physical space-time itself. (New)

P10.7 Dimensional Continuity Proposition — Transitions from configuration space to phase space, and from phase space to state space, preserve all pre-existing dimensions while adding new ones that represent further degrees of freedom. Configuration space defines spatial or structural coordinates; phase space extends these with dynamic variables such as velocities or momenta; and state space adds higher-order variables representing emergent organisation, information, and environmental coupling. No dimensions are lost in these transitions—earlier coordinates remain contained within the later spaces. (New)

Explanation — Granularity and Apparent Loss of Dimension

Although no dimensions are eliminated, higher-level descriptions may *appear* lower-dimensional when fine-grained variables are aggregated or treated as parameters. Such coarse-graining represents a change in granularity rather than a true reduction of dimensionality. In principle, every higher-level state space subsumes the coordinate sets of its predecessors: $Q \subset \Gamma \subset S$, where added dimensions express new causal degrees of freedom—structural, dynamic, and organisational respectively. (New)

D10.4 Attractor Dependency — An attractor is a region or manifold within state space toward which system trajectories converge over time. Within this region, variables that were independent in the wider space become functionally dependent, their values constrained by the system's internal feedbacks and conservation relationships. The dimensionality of the attractor therefore represents the number of effective degrees of freedom that remain once these dependencies have stabilised. (New)

P10.8 Convergence–Dependency Proposition — As a system approaches an attractor in its state space, otherwise independent parameters become dynamically coupled through recurrent interaction. This coupling reduces the effective dimensionality of the system's behaviour and defines the structure of the attractor as a lower-dimensional manifold embedded within the higher-dimensional state space. The emergence of such dependency marks the transition from free dynamics to organised stability — the formation of a coherent system pattern within the landscape of possibilities. (New)

Explanation — Dimensional Reduction and Organisation: The convergence of trajectories onto an attractor does not remove dimensions from the model but reveals constraints among variables that reduce the system's independent variability. The apparent dimensional reduction is thus a signature of *organisation*, not simplification: the system continues to exist in the full state space, but its actual behaviour becomes confined to a structured subset defined by mutual dependency.

P10.9 Complementarity of Spaces Proposition — State space and configuration space are complementary abstractions. State space represents the dynamic conditions a system may occupy, defined by the values of its variable characteristics over time. Configuration space represents the structural arrangements of the system's components and the potential organisations those arrangements allow. Each provides a complete but distinct perspective on system behaviour — the one emphasising dynamical evolution, the other structural possibility. (New)

P10.10 Relational Inversion Proposition — Within any configuration or state representation, the variables that describe relationships among entities are not themselves entities but derived characteristics of the relational field formed by those entities. Each relational variable (such as distance, angle, or coupling strength) can be interpreted as the logical complement of the entities it connects — an abstraction representing *everything but* those entities taken separately. Through this inversion, relational properties become measurable variables that can be mapped onto numerical dimensions, allowing the structure of relations to be treated analytically alongside the entities themselves. (New)

Explanation — Inversion as Representation, Not Ontology

This inversion does not imply that configuration and state spaces are logical opposites; rather, it reflects how relational attributes emerge from the aggregation of entities within a common field. The logic of measurement thus converts relational existence into variable form, enabling the construction of configuration and state spaces as coordinate systems grounded in relational structure.

P10.11 Integration Proposition — Mapping between configuration space and state space may allow structural potentials to be linked with dynamic trajectories, revealing how the organisation of components constrains or enables patterns of system behaviour. Such mappings help relate the system's possible configurations to its realised states, providing a bridge between structural possibility and dynamic evolution. (New)

P10.12 Landscape Formation Proposition — Landscapes arise when underlying constraints shape the topology of a system's state or configuration space, determining which states are accessible and which tend to stabilise. These constraints may originate from energy, information, or other systemic regularities, depending on the nature of the system. (New)

P10.13 Energy Landscape Proposition — An energy landscape is a representation of a system's state space in which each possible state is assigned a potential energy value. The landscape's topology — its valleys, ridges, and barriers — determines how the system can change, with dynamics tending toward energy minima. The energy landscape perspective therefore applies only to systems whose behaviour is primarily governed by energetic constraints. (New)

P10.14 Information Landscape Proposition — In many complex or open systems, the structure of the state space is influenced not only by energy but also by information. Information constrains which configurations are meaningful or functional and can stabilise patterns within attractors even when energetic differences are small. Energy and information are thus distinct structuring principles that may coincide in some domains but operate independently in others. (New)

Note: Taken together, configuration and state spaces provide complementary views of the same system. Configuration space clarifies the structural possibilities and constraints that shape stability; state space reveals the dynamic trajectories and attractor patterns through which those possibilities are realised. Used in combination, they link explanation to prediction—showing both *why* systemic behaviour takes the forms it does and *how* it is likely to evolve within the boundaries of its structure.

P10.15 Ontological Summary Proposition — The evolution from configuration space through phase space to state space mirrors the evolution of systems themselves: from structure, through dynamics, to organisation. Each expansion introduces new variables that embody emergent properties and new causal pathways, expressing how higher-order systems integrate and govern the behaviours of their components. (New)

P10.16 Mapping Proposition — Configuration space and state space may be mapped onto one another when system variables can be consistently translated between structural arrangements and system states. Where such translation is possible, structural potentials can be related to dynamic trajectories; where it is not, the two spaces remain distinct but complementary perspectives on the same system. (New)

b. Fracticality

Note on Fractality: Fractal structure, fractal pattern and fractality were defined in section 8, Energy Landscapes, as recursive patterns of organisation repeating across scales. Here the term fracticality is used in a more general sense as the property of a system or space whereby patterns of structure, process, or organisation exhibit self-similarity across multiple scales, such that parts reflect the form or logic of the whole.

D10.5 Fractality in Configuration Space — Structural fractality arises when the possible arrangements of components follow recursive assembly rules, yielding self-similar geometries in configuration space. (New)

D10.6 Fractality in Phase Space — Dynamic fractality arises when the system's trajectories through phase space display self-similar attractor structures, reflecting iterative or chaotic behaviour that recurs across temporal scales. (New)

D10.7 Fractality in State Space — Organisational fractality arises when emergent variables form nested hierarchies of regulation or information flow, such that higher-order organisational forms mirror the patterns of lower-level interactions. (New)

P10.17 Fractal Transfer Proposition — Fractality established at the structural level of configuration space tends to propagate through the higher representations of phase space and state space. Structural self-similarity generates dynamic recurrence, and dynamic recurrence generates organisational recursion. (New)

P10.18 Fractal Transformation Proposition — The form of fractality transforms with each enrichment:

- in configuration space, it is **geometric**,
- in phase space, **temporal-dynamic**,
- in state space, **organisational-informational**.
  Yet in each case the recursive principle of self-similar constraint remains conserved. (New)

D10.8 Multifractal — A multifractal is a system or distribution that exhibits multiple interwoven scaling behaviours, rather than a single, uniform fractal dimension. In a multifractal structure, different parts of the system scale according to distinct exponents, reflecting a heterogeneous hierarchy of local densities, intensities, or fluctuations. The system's geometry or dynamics therefore cannot be characterised by one fractal dimension but instead by a spectrum of dimensions that together describe the diversity of its scaling properties.

Explanation — From Fractality to Multifractality: A simple fractal repeats a self-similar pattern at different magnifications with the same scaling ratio, producing a single fractal dimension (for example, the Koch curve or Sierpiński triangle). Real complex systems, however, seldom show such uniformity. Their structure or behaviour often varies in *degree* of self-similarity across regions or time scales: some parts are smooth and regular, others rough or highly variable. Multifractality captures this heterogeneity. Instead of one global scaling exponent, it uses a spectrum of local exponents that describe how scaling behaviour changes throughout the system. This approach originated in turbulence studies—where energy dissipation occurs unevenly across scales—and is now applied in ecology, physiology, finance, and network theory to quantify hierarchical variability and nested irregularity. In systems terms,

a multifractal represents a landscape in which different subregions or processes occupy distinct scaling regimes, yet remain coupled through the overall system organisation.
It is therefore a geometric expression of *differentiated coherence*: many local rules, one global pattern.

P10.19 Multifractal Integration Proposition — As new dimensions are added to describe emergent properties, the system's overall fractal geometry becomes multifractal, combining multiple scaling logics across structure, dynamics, and organisation. The coherence of these scaling relationships reflects the degree of systemic integration across levels of emergence. (New)

P10.20 Fractal Ontology Proposition — Fractality is not merely a property of system description but a reflection of how causality is recursively structured in reality.
Each emergent level inherits and reinterprets the recursive patterns of the levels beneath it, creating a hierarchy of self-similar causation spanning configuration, phase, and state spaces. (New)

c. Attractors in State Space

D10.9 Strange Attractor — A bounded region of a chaotic system's state space toward which trajectories converge and within which they remain confined without exact repetition. Strange attractors exhibit complex, often fractal geometry, reflecting deterministic but unpredictable dynamics. (New)

D10.10 Fixed-Point Attractor — A state in state space toward which trajectories converge and remain at a single equilibrium point. (New)

D10.11 Limit Cycle Attractor — A closed trajectory in state space that represents periodic or oscillatory behaviour. (New)

P10.21 Attractor Types Proposition — Attractors may take the form of fixed points, limit cycles, or strange attractors, depending on the dynamics of the system. (New)

P10.22 Strange Attractor Proposition — If a system's state begins within the basin of a strange attractor, its trajectory will be drawn into that attractor and remain confined there. The path taken within the attractor is deterministic yet unpredictable, reflecting sensitive dependence on initial conditions. Despite this unpredictability, the attractor defines the system's long-term behavioural pattern, constraining trajectories to a characteristic region of state space. (New)

P10.23 Unstable Centre Proposition — Strange attractors in state space often contain unstable fixed points or cycles that act as organising centres. Trajectories circulate around these centres but never settle on them, instead wandering chaotically within a bounded, often fractal region. These unstable centres shape the attractor's geometry and influence the system's long-term dynamics without providing equilibrium. (New)

P10.24 Fractal Dynamics Proposition — Strange attractors display fractal geometry, with self-similar patterns at multiple scales. (New)

Explanation: Strange attractors are not just unusual shapes in state space; they are fractals. This means they have structure that repeats at many scales, without ever simplifying to a smooth curve or surface. Three features characterise this fractal nature:

1. **Self-Similarity —** If you zoom in on any part of a strange attractor, you find smaller copies of the overall pattern. The "wings" of the Lorenz attractor, for example, break down into finer spirals, and those spirals split again at smaller scales.

2. **Non-Integer Dimension —** Strange attractors occupy more space than a one-dimensional line but less than a two-dimensional surface. This is described as a *fractal dimension*. For instance, the Lorenz attractor has a dimension of about 2.06, meaning it is "just over" two-dimensional.

3. **Stretching and Folding Dynamics —** The system's equations continually stretch trajectories apart, then fold them back into the same region of state space. This process repeats endlessly, layering trajectories into an infinitely thin but richly structured set. A useful metaphor is kneading dough: stretching it out, folding it over, and repeating — creating layers that never fully merge.

These properties explain why trajectories in strange attractors are bounded but never repeating. The attractor confines the system's behaviour, yet the system never cycles through exactly the same path. The result is a persistent but unpredictable pattern — a hallmark of chaotic dynamics.

P10.25 State-Space Strange Attractor Proposition — Strange attractors show that a system can follow deterministic rules yet behave unpredictably. In such cases, the system's motion stays within a bounded region of state space but never repeats exactly. This happens when ongoing interactions among the system's variables create complex, correlated patterns that give rise to a structured but irregular form of order. (New)

d. Trajectories in State Space

D10.12 Basin of Attraction — The set of initial conditions in state space that lead trajectories toward a particular attractor. (New)

P10.26 Basin Proposition — Systems with multiple attractors divide their state space into basins of attraction, with system behaviour determined by initial conditions and perturbations. (New)

P10.27 Stability of Attractors Proposition (New) — An attractor is stable if small perturbations keep trajectories within its basin; it is unstable if perturbations readily shift trajectories to a different basin. (New)

D10.13 Bifurcation — A bifurcation is a qualitative change in a system's pattern of stability or behaviour that occurs when a control parameter crosses a critical threshold. The term originates from the simplest case, where one stable state splits into two ("bi-furcation"), but it now refers more generally to any reorganisation of attractors or their basins — such as the creation, destruction, or transformation of stable states — resulting in a new regime of system dynamics. (New)

P10.28 Bifurcation Proposition— The emergence of new attractors or the vanishing of existing ones occurs through bifurcations, as systems reorganise under parameter changes. (New)

P10.29 Emergence–Vanishing Proposition — Within state space, as a system traverses regions of its landscape and crosses thresholds that alter its pattern of organisation, attractors may be encountered and left behind. This marks shifts in how the system's variables interact and coordinate. The process reflects the continual renewal of systemic order as new patterns of stability arise and former ones dissolve. (New)

e. Explanation and Prediction in State Spaces

D10.14 Predictability Horizon — The time span within which the future state of a chaotic system can be predicted with useful accuracy, beyond which sensitivity to initial conditions makes prediction unreliable. (New)

P10.30 Predictability Proposition — In chaotic systems, predictive reliability declines rapidly beyond the predictability horizon, as small uncertainties in initial conditions amplify through sensitive dependence. Yet explanatory value remains: the system's underlying rules, attractor structures, and statistical regularities still reveal how and why its behaviour unfolds as it does. Chaos therefore limits foresight without negating understanding. (New)

f. Energy Landscape Mapping Aids

D10.15 Probability Measure — A probability measure quantifies the relative likelihood of a system's trajectories through configuration or state space as shaped by its energy landscape. Each region of the landscape corresponds to a set of possible states whose probabilities reflect their energetic accessibility, stability, and the system's current constraints. The probability measure thus translates structural potential into expected dynamic behaviour. (New)

Clarificatory Note — Relation to Energy Landscapes and Trajectories: Energy landscapes specify how potential energy varies across configurations; the probability measure expresses how frequently those configurations are realised. In closed systems this measure approximates the Boltzmann distribution; in open or informational systems it generalises to likelihood fields influenced by both energetic and informational gradients. Probability measures therefore provide the statistical basis for mapping attractors, barriers, and probable pathways within complex systems.

D10.16 Cliodynamics — A quantitative, historical science that models long-term social dynamics using system-level variables and attractor-like trajectories. (New)

D10.17 Agent-Based Modelling (ABM) — A simulation method in which many simple agents (systems or subsystems) follow local rules of interaction, with aggregate behaviours revealing systemic trajectories across energy landscapes. Useful for exploring emergent patterns when analytic solutions are intractable. (New)

D10.18 Network Mapping — An approach that represents possible system states or assemblies as nodes in a graph, with transitions as edges. Probabilities assigned to edges reveal likely routes across the energy landscape and highlight hubs, bottlenecks, or dead ends. (New)

D10.19 Information-Theoretic Analysis — The use of measures such as entropy, mutual information, or algorithmic complexity to quantify order, correlation, and predictability within system trajectories. Provides a way to evaluate the stability or fragility of paths across an energy landscape. (New)

D10.20 Cross-Domain Mapping — A comparative method for identifying isomorphic patterns across domains (e.g., physical, biological, cultural). It treats landscapes as structurally homologous, enabling insights from one domain to inform understanding in another. (New)

D10.21 Path-Dependency Analysis — A method for examining how past choices or configurations constrain present and future systemic trajectories, often through ratcheting into attractors that resist reversal. Clarifies why some evolutionary branches persist while others are pruned. (New)

P10.31 Mapping Aids Proposition — The mapping of energy landscapes to reveal attractors, barriers, and transitional regions can be aided by recognising underlying fractal structure. Fractality exposes self-similar patterns of stability and transition across scales, enabling more accurate identification of systemic potentials and constraints. (New)

P10.32 Trajectory Aids Proposition — System trajectories within an energy landscape are probabilistic. Estimating their likelihood can be aided by:
(1) cliodynamic modelling of historical trajectories,
(2) simulation approaches such as agent-based models,
(3) network or statistical methods representing configuration spaces, and
(4) causal networks derived from Troncale's linkage propositions.
These aids help reveal probable system trajectories and emergent pathways. (New)

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11. Universal Evolution

P11.1 Stability–Novelty Proposition — The balance between persistence and transformation defines a system's adaptive capacity and evolutionary trajectory. (New)

D11.1 Universal Evolution — The reciprocal process by which systems modify their environments through their inputs and outputs, while those environments, in turn, determine which systems persist and propagate through the availability of enabling and inhibiting inputs. Universal evolution thus describes the continual co-adaptation of systems and environments across all scales. (New)

Explanation Universal evolution is reciprocal causation. Systems act on their environments by consuming resources, releasing outputs, and altering conditions. Those altered environments then affect — through energy flows, constraints, and feedbacks — which systems can continue to exist, replicate, or recombine.

- **In physics,** matter structures energy fields that, in turn, determine which structures are stable.
- **In biology,** organisms change their environments (soil, atmosphere, ecosystems), which then shape the course of further evolution.
- **In social systems,** human institutions and technologies transform the global environment that will determine humanity's own future possibilities.

Universal evolution, in this view, is the perpetual dance between systems and the landscapes they create — a dynamic of mutual shaping that drives complexity forward.

D11.2 Shared-Environment Feedback — Feedback in which the environmental component of the causal loop is shared by multiple systems. Each system's outputs modify common environmental variables that, in turn, influence all participating systems. Shared-environment feedback therefore links many local loops through a pooled medium of interaction, coupling systems within a common field of causation. (New)

D11.3 Nested Shared-Environment Feedbacks — The shared-environment feedbacks that shape universal evolution form a nested hierarchy corresponding to parent, child, and sibling relationships among systems. Following recomposition, the direct shared-environment feedback of child systems with the wider environment of the parent may be wholly or partly replaced by participation in the parent's own shared-environment feedback. A child's effective environment may therefore consist primarily of its siblings and the parent's internal exchanges with its broader context. (New)

Explanation In universal evolution, systems exist within systems — a hierarchy of shared environments through which feedback operates. When smaller systems (children) become parts of a larger whole (the parent), their participation in the external environment is reduced or mediated. They continue to exchange inputs and outputs, but mainly through the parent's internal processes or via interactions with sibling subsystems. The parent system, in turn, participates in a wider shared-environment feedback with its own environment. Thus, nestedness in evolution is not simply spatial or structural; it is functional — recomposition determines which shared-environment field each subsystem primarily belongs to and how feedback is channelled across levels of organisation.

Examples

- **Biological:** Cells within an organism interact chiefly through the organism's internal milieu; their link to the external environment is mediated by the organism's physiology.
- **Social:** Individuals in a tightly structured organisation operate mainly within its institutional processes; the organisation as a whole engages in shared-environment feedback with society.
- **Ecological:** Species within an ecosystem influence and are influenced by the shared environmental variables (nutrient cycles, climate, habitat structure) that connect them all.

D11.4 Niche — A niche is a bounded subregion of a shared-environment field within which a subsystem maintains distinct feedback relationships. Niches arise when spatial, energetic, informational, or functional barriers limit direct coupling between nested environments, constraining the variables through which feedback operates. Each niche therefore represents a partial, locally coherent subset of the parent's shared environment, supporting differentiated but interdependent patterns of adaptation and evolution. (New)

Explanation: When two or more subsystems share a common parent environment but are separated by barriers or distance, their interaction with the parent's wider field becomes indirect. The accessible portion of that field—mediated through local exchanges and sibling interactions—forms a niche. Niches thus embody selective openness: they preserve participation in the broader system while enabling local specialisation. Over evolutionary time, niche differentiation drives the diversification of subsystems and the emergence of new levels of organisation.

D11.5 Divergent Shared Environments — Divergent shared environments arise when two or more shared-environment fields become partially or wholly separated by spatial, energetic, informational, or functional barriers. Each environment then maintains its own feedback loops and selective pressures, guiding the evolution of its constituent systems along distinct trajectories. Divergence at the level of environments thus creates multiple arenas of evolution, each capable of generating unique emergent properties. (New)

P11.2 Niche–Environment Divergence Proposition — When shared environments become separated or only weakly coupled, their internal feedbacks evolve independently. This independence allows evolution to take different pathways and produce distinct forms of organisation, even when originating from similar precursors. The emergence of divergent environments therefore underlies the multiplicity of evolutionary outcomes—the differentiation of life, cognition, and social systems into forms adapted to their own locally coherent feedback contexts. (New)

Explanation — Divergence as Generator of Novelty: Just as niches allow diversity within a single shared environment, the divergence of entire shared environments allows diversity among worlds of interaction. Each semi-independent environment becomes a self-consistent evolutionary domain, exploring its own segment of the universal possibility space. The separation of shared environments is thus the macro-scale analogue of niche differentiation and a major driver of evolutionary innovation.

D11.6 Enabling Shared-Environment Feedback — Reciprocal interactions through a shared environment that amplify a system's ongoing processes or reinforce its coherence within its energy landscape. Enabling shared feedback strengthens stability, deepens effective occupancy of attractor basins, and supports the persistence of emergent properties across the collective field linking multiple systems.
Enabling feedback is positive when:

1. enabling inputs from the environment are more than sufficient,
2. inhibiting inputs are few, and
3. assembly components required for system maintenance or reproduction are plentiful. (New)

D11.7 Inhibiting Shared-Environment Feedback — Reciprocal interactions through a shared environment that counteract or suppress a system's ongoing processes, reducing coherence or stability within its energy landscape. Inhibiting shared feedback weakens occupancy of attractor basins and may drive the system toward barriers, transitions, or collapse within the broader field shared with other systems.
Inhibiting feedback is **negative** when:

1. enabling inputs from the environment are insufficient,
2. inhibiting inputs are excessive, or
3. assembly components are scarce. (New)

Explanation — Relation to Conventional Feedback and Circular Causation: In this framework, enabling and inhibiting shared-environment feedback generalise the traditional notion of feedback. Classical feedback loops describe self-reinforcing or self-damping processes within an individual system; shared-environment feedback recognises that most systems operate through environments they share with others. Such feedbacks determine whether system types persist and propagate or decline and expire, depending on the balance of enabling inputs, inhibiting influences, and the availability of assembly components. This formulation retains the dynamic sense of feedback while acknowledging that causation in open systems is collective rather than self-contained.

Explanation: Systems rarely evolve in isolation. They share environments — physical, chemical, informational, or social — that transmit the effects of their actions to others.
Some of these effects help maintain or strengthen a system's stability (enabling feedback), while others hinder or destabilise it (inhibiting feedback).
Because the same environment serves many systems, these feedbacks are inherently shared: one system's stabilising output may become another's disruptive input.

Examples:

- **Ecological:** vegetation cools local climate (enabling feedback for the forest) but may limit sunlight for understorey plants (inhibiting feedback for them).
- **Social:** cooperation and trust reinforce communal stability; misinformation or resource competition erode it.

P11.3 Shared-Environment Viability Proposition — The long-term persistence of a system type within a shared environment depends on the balance between enabling and inhibiting feedbacks. When enabling feedback predominates and assembly components are sufficient, the system type tends to stabilise and propagate; when inhibiting feedback dominates or critical components are lacking, the system tends toward decline or extinction. (New)

P11.4 Shared-Environment Feedback Proposition — In universal evolution, patterns of shared-environment feedback between systems and their common environment determine each system's position and stability within its energy landscape. Enabling (positive) feedbacks reinforce occupancy of attractor basins, while inhibiting (negative) feedbacks drive systems away from them, toward barriers or collapse. (New)

Explanation Systems don't evolve in isolation. They act within environments that are shaped by the collective behaviour of many systems. Each system contributes outputs that modify shared conditions — atmosphere, energy flow, information, or culture — which then feed back to affect all participants. This shared-environment feedback is the engine of co-evolution: it binds systems together through the environments they co-create.

P11.5 Multi-Level Selection Coupling Proposition — The operation of selection across hierarchical levels depends on the degree to which subsystems remain coupled to the parent's environment.

- When child systems are **partly committed**, maintaining some direct feedback with the external environment, both the parent–environment and child–environment interactions influence their viability, producing multi-level selection effects.
- When child systems are **fully committed**, their viability depends entirely on the parent's feedback with its environment, and selection operates only at the parent level.
- When child systems are **uncommitted**, existing outside the parent's feedback domain, selection acts independently at their own level.

The continuum of commitment thus determines how selection pressures are distributed and transmitted across nested systems. Multi-level selection is therefore a transitional phenomenon characteristic of social or cooperative systems that maintain partial autonomy—

typified by humans and other social animals—but absent in fully integrated super-organisms such as eusocial insects. (New)

Explanaton — Commitment and Evolutionary Integration: "Commitment" describes the extent to which a subsystem's exchanges with its environment are mediated by the parent system. Partial commitment corresponds to evolutionary transition zones, where competition and cooperation across levels coexist. Full commitment corresponds to integration, where lower-level autonomy is subsumed by the higher system's coherence.

This formulation reconciles the long-standing debate within evolutionary theory by distinguishing between *structural integration* and *functional coupling*. Multi-level selection is not a separate evolutionary process but the outcome of nested feedbacks operating across semi-coupled systems. It disappears when integration is complete and reappears whenever new degrees of autonomy evolve within larger structures.

P11. 6 System Complexity/ Stability Proposition — Except for systems assembled under the influence of gravity, the more complex a system, the less likely it is to form randomly and the less stable it will be,. (New)

P11. 7 Natural Selection in Non-living Systems — Natural selection can be generalised beyond biological systems: among non-living systems, those that persist are the ones whose properties enhance stability and persistence within their environments. This principle expresses a universal evolutionary tendency for configurations that maintain coherence under prevailing conditions to outlast those that do not. (New)

P11. 8 Mutation and Speciation in Non-living Systems — In non-living systems, novel configurations arise through random assemblies constrained by physical laws, the availability of components, and organising forces such as gravity or electromagnetic attraction. These processes are analogous to biological mutation and speciation, producing variation upon which selection acts. (New)

D11.8 Systems Ecology (Analogy) — An analogy in which universal evolution is viewed as a network of coupled systems across scales, comparable to the ecological relationships among living organisms. Systems not only adapt to conditions within their shared environments but also modify those environments, thereby influencing the evolutionary trajectories of other systems. (New)

P11.9 Parent–Child Viability Proposition — When a system's environment functions as its parent system, the parent must provide sufficient enabling inputs and protection from inhibiting inputs for its child systems to remain viable. If these conditions are not met, the dependent subsystems decline or become extinct. The persistence of child systems therefore depends directly on the quality of support and shielding provided by their parent environment. (New)

P11.10 Sibling Interaction Proposition — Sibling systems within the same parent environment influence one another's viability through their interactions. When siblings predominantly exchange enabling inputs (co-operation), they reinforce both their own persistence and the stability of the parent system. When they primarily exchange inhibiting inputs (competition or interference), they constrain one another's persistence and may undermine the viability of the parent system itself. (New)

D11.9 Survivor Bias — The interpretive bias arising because only systems that persisted are observed, while failed or extinct systems leave little trace. Survivor bias makes the evolutionary process appear linear or progressive when it is, in fact, branching and contingent. (New)

P11.11 Apparent Ladder Proposition — The apparent historical "ladder" of increasing complexity across physical, chemical, biological, and social domains is an artefact of survivor bias. What appears as continuous advancement is the visible remnant of a branching process in which most lineages have vanished. (New)

P11.12 Probabilistic Evolution Proposition — Universal evolution proceeds through probabilistic pathways shaped by both systemic properties and chance events. Systems emerge, persist, or collapse according to the local structure of their energy landscapes and their capacity to maintain coherence within them. The overall process is contingent rather than predetermined. (New)

P11.13 Tree of Possibilities Proposition — Systemic evolution resembles a branching tree of potential trajectories shaped by energy landscapes. Environmental constraints, competition, and stochastic events act as pruning forces that eliminate non-viable branches while stabilising those occupying deeper or more resilient attractor basins. The apparent direction of evolution arises from the continued survival of systems able to persist within shifting landscapes. (New)

P11.14 Evolutionary Pattern Proposition — The historical record of systems reflects a continual branching and pruning of possibilities within evolving energy landscapes. Complexity increases locally where enabling conditions persist, but the broader pattern is one of adaptive persistence rather than predetermined ascent. (New)

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12. Recomposition

Introduction to Recomposition

Recomposition is often introduced in physics as a peculiarly quantum phenomenon — the moment when a superposition of possibilities resolves into a single outcome. But recomposition is better understood as a universal systems process: when independent possibilities are constrained by interaction, and a coherent state emerges.

At the quantum level, recomposition ties directly to entanglement: particles lose their local independence, yet the entangled whole acquires new properties such as nonlocal correlation. At higher levels of organisation, the same pattern recurs. Atoms recompose into molecules by committing electron freedom to chemical bonds. Cells recompose into multicellular organisms by committing processes to signalling and coordination. People recompose into societies by committing behaviour to shared norms and institutions.

The general principle is this: as parts commit their outputs inward, their external independence is constrained, but the whole gains new emergent properties. This trade-off between part-level freedom and whole-level coherence is the process through which emergence operates, from the quantum scale up to the social scale.

As systems become more complex, this balance shifts. Subsystems often retain more autonomy, and emergent properties become looser, probabilistic, and dependent on coordination processes such as nervous systems, governance, or communication networks.

Beyond certain thresholds, emergence may even plateau unless new processes are invented to restore inward commitment.

Thus, recomposition is not just the quantum transition from wave to particle; it is the engine of emergence in universal evolution.

D12.1 Recomposition — Recomposition is the process by which the independent degrees of freedom of subsystems are lost or constrained through interaction with one another, and replaced by new degrees of freedom expressed in the emergent properties of the parent system. (New)

Explanation

When separate parts interact strongly, they stop behaving independently. Their freedoms don't disappear — they're reorganised. The system "recomposes" into a new, higher-level whole with new freedoms (new variables, functions, or behaviours) that belong to the parent, not the parts.

- **Quantum:** Two entangled particles lose separate probabilistic freedom; the entangled pair gains new joint states.
- **Chemical:** Atoms lose individual electron configurations; the molecule gains new vibrational and bonding modes.
- **Biological:** Cells lose autonomy; the organism gains coordinated functions.
- **Social:** Individuals give up independent actions; the institution gains collective decision-making capacity.

D12.2 Entanglement — The condition in which two or more subsystems share a joint state such that their outcomes are intrinsically correlated, and the ensemble behaves as a single system until interaction with the environment extends that entanglement. (New)

D12.3 Sibling Freedom — The practical freedom of a subsystem to interact directly with the environment that lies beyond any parent system of which it may be a part. (New)

D12.4 Sibling Commitment — The proportion of a subsystem's outputs that are directed inward, to interaction with sibling subsystems within a parent, rather than outward to the environment. (New)

D12.5 Sibling Dependence — The proportion of a subsystem's inputs that are derived from interaction with sibling subsystems within a parent, rather than from the external environment beyond the parent system. (New)

P12.1 Entanglement–Recomposition Proposition — In an entangled system, the subsystems no longer possess independent states but form a single causal structure. When one subsystem interacts with the environment, the entire entangled set is simultaneously reorganised, producing correlated outcomes across all subsystems. (New)

Explanation: When two particles are entangled, they effectively share one state. They don't decide their outcomes separately; their possibilities are linked. If one particle interacts with the environment, the pair as a whole reorganises instantly — the other particle's outcome is fixed in correspondence. The same logic applies more broadly: whenever subsystems become tightly coupled (sharing states or processes), any recomposition of one affects all, because they behave as one system.

P12.2 Constraint–Emergence Proposition — Emergent properties arise when the freedom of sibling subsystems is constrained within a larger system, allowing the parent system to exhibit new behaviours or characteristics not available to the parts alone. (New)

P12.3 Vanishing Property Proposition — During recomposition, some properties of the component subsystems may cease to be expressed because the interactions that maintained them are replaced or suppressed within the new systemic organisation. These vanishing properties represent degrees of freedom that have been absorbed into, or rendered irrelevant by, the emergent structure of the parent system. (New)

Explanation: When parts combine to form a whole, not every property they once had survives in the new system.

- Some are **absorbed** — their effects are integrated into new collective behaviours.
- Some are **suppressed** — they can no longer operate under the constraints of the new organisation.
- Some are simply **rendered invisible** at the higher level of description because the new whole acts as a single unit.

Examples:

- **Physics:** isolated electron spin directions become paired and cancel in a molecule.
- **Biology:** individual cell mobility vanishes when cells form stable tissues.
- **Social:** personal autonomy in decision-making disappears within highly regulated institutions.

These properties don't necessarily cease to exist; rather, their freedom of expression is lost because their causal potential has been reorganised into the dynamics of the higher-level whole.

P12.4 Emergent Boundary Proposition — When sibling subsystems integrate into a parent system, the boundary of the parent supersedes those of its parts, becoming the primary locus of interaction with the external environment and the site at which emergent properties are expressed. (New)

Explanation: When parts form a larger whole, they stop interacting directly with the outside world. The whole develops its own boundary, and it is through this new boundary that the system now exchanges energy, matter, or information with its surroundings. The emergent properties of the parent are what appear at that boundary.

P12.5 Commitment–Constraint Proposition — The degree to which a subsystem's processes are directed toward interaction with sibling subsystems determines the extent to which it is constrained in interacting with the environment beyond the parent system. Greater inward commitment strengthens the emergent properties of the parent but reduces the subsystem's external independence. (New)

Explanation: The extent to which a subsystem's processes are committed to sibling interaction determines its constraint in interacting with the external environment of the parent.

- **High commitment**: Subsystems devote most outputs inward; they lose external independence but enable strong emergent properties of the parent.
- **Low commitment**: Subsystems devote fewer outputs inward; they retain more external independence, but the parent exhibits weaker or looser emergent properties.

When smaller parts join to make a bigger whole, they have to decide (so to speak) how much of their activity is spent working with each other versus acting independently.

- If they put most of their effort into cooperating inside the larger system, they give up freedom to interact directly with the outside world. In return, the larger system gains strong new abilities.
- If they put only a little effort into cooperating, they stay freer to act on their own, but the larger system is weaker and less coherent.

Examples

- **Atoms in a molecule**: Their electrons are mostly tied up in chemical bonds (high commitment), so atoms lose freedom but the molecule has strong new properties.
- **Cells in multicellular organisms**: A neuron puts nearly all its output into signalling other neurons; it no longer deals with the environment directly, but the organism gains cognition.
- **Human societies**: A civil servant commits most of their actions to their institution; their personal freedom narrows, but the state gains emergent order and governance.

P12.6 Quantum Commitment–Constraint Corollary — In entangled quantum systems, each particle's possible outcomes are fully determined by its correlations with its partners. This loss of local independence binds the particles into a single joint system whose shared interaction with the environment produces a simultaneous, correlated recomposition. (New)

Explanation: Entangled particles no longer behave separately. What happens to one is inseparable from what happens to the other. When they interact with the environment, they recompose together — not as two events, but as one correlated event belonging to the joint system.

P12.7 Complexity–Commitment Proposition — As systems increase in complexity, their subsystems tend to reduce their commitment to sibling interactions, retaining greater autonomy for external engagement. Emergent properties of the parent system continue to exist, but they become more diffuse and dependent on processes of coordination and regulation rather than on direct coupling between parts. (New)

Explanation: As systems increase in complexity, their parts can't stay as tightly bound to each other as in simpler systems. Each part keeps some independence. The whole still has emergent properties, but those properties depend on coordination — like communication, feedback, or shared control systems — rather than on parts being physically or causally locked together. In simple systems like entangled particles or molecules, the parts are "all in" — fully committed to each other, and unable to act independently. That's why the emergent property is so strong and reliable. In complex systems like organisms or societies, parts need some freedom to survive, adapt, or respond to their own environments. So they are not fully committed inward. They keep some autonomy, and the emergent properties of the whole (like cognition or culture) depend on coordinating semi-independent parts. This explains why complex systems can be both powerful and fragile: their emergent properties rely on balancing autonomy with coordination, not on tight binding.

D12.6 Spatial Freedom — The degree to which a subsystem retains freedom of movement or positional variability within its environment, allowing it to change spatial relations with other subsystems independently of the parent system's structure. (New)

Explanation: Spatial freedom measures how freely a component can move around relative to its siblings and the larger system that contains it. When parts have high spatial freedom, their interactions are fleeting and local; when they have low spatial freedom, they stay in stable contact and can integrate more easily.

Examples:

- **Physical:** atoms in a crystal lattice have minimal spatial freedom — they're locked into fixed positions; gas molecules, by contrast, have high spatial freedom.
- **Biological:** cells in a tissue are spatially constrained; animals in an ecosystem move freely and interact intermittently.
- **Social:** individuals in a mobile, networked society have immense spatial and informational freedom compared to members of a close-knit community.

P12.8 Spatial Freedom Proposition — The difficulty of recomposition increases with the spatial freedom of the component systems. As subsystems become more complex and mobile, their potential for sustained interaction declines, reducing the likelihood of forming tightly integrated parent systems unless new processes arise to constrain or coordinate spatial relationships. (New)

Explanation: Recomposition depends on parts staying in contact long enough to exchange energy, matter, or information effectively. When those parts can move freely through space — as independent organisms, human beings, or nations — their interactions become transient.
For higher-order recomposition to occur, new processes must appear to link spatially separated agents: networks, communication systems, shared symbolic structures, or fields of influence that transcend direct physical contact.

Examples:

- **Biological:** multicellularity succeeded because membranes and extracellular matrices constrained cells spatially.
- **Ecological:** species remain loosely coupled because they occupy separate niches; ecosystems recombine only through extended feedback cycles.
- **Social:** human recomposition into coherent global systems requires informational rather than physical coupling — a new kind of spatial constraint provided by communication and shared meaning.

Integration:

- Extends **P12.7 (Complexity–Commitment)** by identifying *spatial autonomy* as a key reason why commitment weakens with complexity.

- Complements **P12.10 (Emergence Saturation)**: recomposition saturates partly because spatial freedom dilutes the density of interactions needed for integration.
- Links naturally to **P12.9 (Recomposition–Assembly)**: assembly requires physical proximity or effective field coupling; spatial freedom adds energetic and informational cost to each assembly step.

D12.7 Assembly Complexity — The measure of a system's structural and historical depth, defined by the number of distinct recompositional steps required to produce its present configuration from simpler precursors. Each step represents a reorganisation of degrees of freedom that integrates prior components into a new, higher-order whole. (New)

Explanation: Assembly complexity captures how many stages of recomposition a system has undergone to reach its current form. Each stage in that history represents a moment when parts combined, lost some independence, and gained new collective capacities. The more recompositional steps in a system's lineage, the greater its assembly complexity — whether we're speaking of molecules, organisms, or civilisations.

Examples:

- **Chemical:** A simple molecule has low assembly complexity; a protein, built through many recompositions of smaller units, has high complexity.
- **Biological:** Multicellular organisms represent a higher assembly complexity than single cells because more recompositional layers are embedded in their structure.
- **Cultural:** Written language and technology have enormous assembly complexity — centuries of recomposition of prior forms and ideas.

P12.9 Recomposition–Assembly Proposition — Recomposition provides the process that underlies assembly in complex systems. Each recompositional event constrains the independent freedoms of existing components, integrating them into new configurations that become the building blocks for further assembly. Assembly theory describes the historical accumulation of these recompositional steps, while recomposition explains the causal process by which they occur. (New)

Explanation: Assembly theory tells us how complex objects record their history: each new structure embodies the steps that built it. Recomposition describes the *living process* behind that record — how parts join, lose some independence, and generate new capacities as wholes. In this view, every step in an assembly tree corresponds to a recompositional transition — a moment when freedoms are reorganised, new boundaries emerge, and new levels of causation appear. This closes a long-standing gap between *Assembly Theory* (which tracks the accumulation of structure) and *Systems Theory* (which explains the dynamics of emergence). Recomposition gives Assembly Theory its causal engine — the process through which assembly steps are realised in time.

Examples:

- **Chemical evolution:** molecules form by recomposition of atoms, which then act as new assembly units for polymers.
- **Biological evolution:** cells recombine into multicellular organisms, which become new agents of selection.

- **Cultural evolution:** ideas and technologies combine to form conceptual "molecules" that enable further invention.

P12.10 Emergence Saturation Proposition — At high levels of complexity, the emergence of new higher-level properties may plateau or cease if subsystem commitment to sibling interaction falls below the threshold required for coherent parent-level behaviour. Further emergence becomes possible only through the evolution of new processes of coordination and regulation (e.g., genetic control systems, nervous systems, governance structures, or information networks). (New)

Examples:

- **Atoms → molecules:** High commitment, strong new emergent properties.
- **Molecules → cells:** Moderate complexity, but new coordination (membranes, enzymes) allowed further emergence.
- **Cells → multicellular organisms:** Needed new coordination processes (signalling, genes).
- **Organisms → societies:** Needed language, norms, institutions.
- **Global society today:** Extremely complex. Without new coordination processes, emergence may saturate — we get fragility instead of new higher-level coherence.

P12.11 Recomposition–Landscape Proposition — Recomposition can be understood as the movement of a system into a trough of its energy landscape. Superposed or unstable possibilities are recomposed into a stable configuration (an attractor basin) under the influence of interaction or constraint. (New)

Explanation: Recomposition is what happens when a system "falls into a trough" in its landscape. Many paths were possible, but interaction forces one of them to be realised.

Example: A quantum particle localises; a molecule forms when atoms settle into a bond-energy trough.

P12.12 Recomposition–Attractor Proposition — In state space, recomposition corresponds to convergence onto an attractor, such as a fixed point, cycle, or strange attractor. The superposed or unstable trajectories of parts are replaced by a coherent trajectory of the whole. (New)

Explanation: Recomposition is when the system stops wandering and locks into a repeating or organised pattern.

Example: A pendulum damped into its lowest-energy position; neural firing patterns converging onto a stable rhythm.

P12.13 Recomposition–Feedback Proposition — Once a system has undergone recomposition, its stability and persistence depend on feedback loops between the system and its environment. These feedbacks filter fluctuations, amplify coherent patterns, and sustain the emergent configuration against disruption. (New)

Explanation: Recomposition doesn't just happen once; it has to be maintained. The system and its environment keep "talking" to each other through feedback loops that hold the new pattern together.

Example: A thermostat maintains temperature balance; ecosystems or economies keep stable cycles through feedback between participants and their environment.

P12.14 Universal Evolution Recomposition Proposition — Across universal evolution, recomposition links the inputs and outputs of subsystems to those of their parent systems. As entities integrate, their individual exchanges with the environment are progressively replaced or mediated by the inputs and outputs of the emergent parent system. This transfer of environmental interface enables coherence at the higher level and the appearance of new emergent properties. (New)

Explanation: At every scale, recomposition shifts who "speaks" to the environment. Parts that once acted directly now act through the whole. Their inputs and outputs are replaced by those of the parent system, which becomes the new participant in the larger environment. This is the fundamental pattern of universal evolution: the upward transfer of environmental exchange and the continual creation of higher-level coherence.

Examples:

- **Physics:** Recomposition converts independent quantum probabilities into shared outcomes; the entangled system interacts with the environment as one.
- **Chemistry:** Recomposition binds atoms into molecules, replacing atomic interactions with molecular energy exchanges.
- **Biology:** Recomposition commits cellular processes inward; the organism becomes the unit that exchanges energy and information with the environment.
- **Social systems:** Recomposition channels individual actions into collective institutions; societies become the interface with broader ecological and informational environments.

P12.15 Recomposition–Integration Proposition — Recomposition is the universal process by which systems achieve coherence and, in doing so, transform both themselves and their environments. It operates:

- in energy landscapes, as movement into troughs that reshape the surrounding landscape;
- in state space, as convergence onto attractors that redefine the accessible configurations of related systems;
- in system–environment dynamics, as feedback processes that replace the direct interactions of subsystems with collective interactions of the parent system, thereby altering the environment that future systems will encounter.

Through this reciprocal process, recomposition not only enables coherence and new emergent properties at higher levels of organisation, but also changes the evolutionary context itself — the very network of systems and environments through which further recomposition unfolds. (New)

Explanation: When parts combine to form a new system, the new whole doesn't just adapt to its surroundings — it also changes those surroundings.

- A newly recomposed system interacts differently with its environment than its parts did.
- This, in turn, reshapes the environment's structure and the systems within it.
- Over time, these mutual changes lift the whole process of evolution to a new level: systems and environments co-evolve, each redefining the other.

Examples:

- **Physics:** atomic recomposition produced radiation fields that changed the energy landscape for later matter.
- **Biology:** the emergence of photosynthesis altered Earth's atmosphere and thereby the evolutionary opportunities for all life.
- **Society:** industrial recomposition of economies changed the planetary environment, driving the next stage of social and ecological adaptation.

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20. Human Theories

The final section turns the systemic lens upon itself. Having explored the organisation and evolution of systems in nature, we now consider the human act of theorising as a systemic process. Human knowledge arises through definitions, propositions, and explanations — cognitive constructs that mirror the structures and feedbacks of the systems they describe. Theories, disciplines, and idioms are therefore not external to the systemic world but emergent within it, subject to the same principles of organisation, evolution, and adaptation.

This Extended Framework for a General Systems Theory is itself the outcome of productive co-ordination — a merging of multiple perspectives that together form a more coherent understanding than any one could achieve alone.
The process drew upon and integrated insights from several complementary standpoints, including:

- **Physicalist and Causal Perspectives** – grounding systemic behaviour in energy, information, and constraint (drawing on physics, chemistry, and thermodynamics).
- **Biological and Evolutionary Perspectives** – interpreting persistence and adaptation as outcomes of environmental feedback and selection processes.
- **Cognitive and Epistemic Perspectives** – recognising that systems are also mental constructs shaped by human observation, language, and conceptual framing.
- **Social and Communicative Perspectives** – viewing human systems, including science itself, as networks of interacting agents engaged in information exchange and coordination.
- **Philosophical and Methodological Perspectives** – providing logical structure, ontological clarity, and transdisciplinary bridges across domains.

Through iterative dialogue and synthesis, these views were coordinated rather than reduced, revealing deep isomorphisms that justify a unified systems framework spanning the physical to the human.
The Extended Framework thus stands as both a product and demonstration of the principle of poly-perspectivism: knowledge evolving through interaction among diverse yet compatible ways of seeing.

a. Foundations of Theoretical Construction

Purpose: Establish the building blocks of human knowledge as systems of meaning.

Comment: This subsection reads as a self-contained ontology of how humans construct theoretical systems.

D20.1 Definition — A statement of the meaning of a term, establishing its scope and use. (05/12)

D20.2 Axiom — A self-evident statement that does not require proof, serving as a foundation for reasoning and from which further propositions may be logically derived. (05/07)

D20.3 Proposition — A statement expressing a relationship between concepts, which may be true or false, and can be tested against observation. (05/12) [P15]

D20.4 Compound or Composite Proposition — A proposition that integrates two or more simpler propositions into a single statement through logical, causal, or hierarchical relationships. Such combinations may involve conjunction, disjunction, implication, or subset relations. (New)

P20.1 Definition–Proposition Equivalence Proposition — Every definition implicitly functions as a proposition. Structural definitions express states of being ("what it is"), while functional definitions express causal tendencies ("what it does"). Both serve as premises from which further propositions can be derived through logical or systemic inference. (New)

D20.5 Idiom — A specialised system of representation through which a theory, discipline, or community articulates and communicates its concepts. An idiom may be symbolic (using language, mathematics, or logic), iconic (using visual or spatial imagery), or enactive (using embodied or performative expression), following Bruner's typology of representational modes. In the case of fomal and natural languages and idiom is a set of definitions used to express a theory. Idioms give structured form to conceptual frameworks, enabling shared understanding within but not necessarily across domains. (New; cf. Bruner, 1966)

Explanation — Role of the Idiom: The idiom of a theory is its conceptual language: the set of defined terms and relationships that make reasoning coherent and reproducible. Clear idiom definition prevents semantic drift, enables comparison between theories, and provides the translation bridge needed for interdisciplinary synthesis. Within systems science, establishing the idiom through definitions is therefore a foundational act — the creation of the theoretical space in which propositions can operate meaningfully.

P20.2 Idiom Establishment Proposition — Definitions establish the idiom of a theory: the shared system of meanings, distinctions, and relations through which all subsequent propositions are expressed. Although each definition functions as a proposition, it must be identified and treated separately to ensure internal consistency, cross-domain comparability, and clarity of inference within the theoretical framework. (New)

D20.6 Discinyms — Different terms used in different disciplines to describe the same or closely related systems process. (Troncale)

P20.3 Discinyms Proposition — Identifying discinyms can reveal cross-disciplinary isomorphisms, demonstrating that systems processes are universal even when expressed in domain-specific language. Recognising these correspondences supports the integration of knowledge across disciplines and the development of a shared systems idiom. (Troncale)

D20.7 Conceptual Framework — A structured set of interrelated concepts and definitions that organises and guides theoretical work. It provides a foundation for developing or comparing theories, without necessarily achieving the full coherence or explanatory power of a complete theory. (05/07)

P20.4 Framework Dependence Proposition — The development and communication of any theory depend on a shared conceptual framework that defines its terms, boundaries, and underlying logic. The broader and deeper the framework—that is, the more fundamental the relationships it recognises—the more general and integrative the theory that can be built upon it. Frameworks therefore function as the scaffolding *for* theoretical thought, determining both the scope and communicability of human understanding. (New)

Clarificatory Note — Depth and Generality: A framework's depth refers to how far its concepts extend toward universal principles. As depth increases, it encompasses a wider range of domains, enabling theories of greater generality but also requiring more abstract idioms for their expression. Shallow frameworks permit rapid practical application within limited domains; deep frameworks enable unification across them.

D20.8 Theory — A coherent system of definitions, axioms, and propositions that together explain or predict phenomena. A theory organises knowledge conceptually, integrating observed regularities into a structured explanatory framework from which new propositions may be derived. (05/07) [P17]

D20.8a Model — A model is a simplified or formal representation of a system or theory, constructed to explore, test, or communicate its behaviour, structure, or causal relationships. Models abstract from the full complexity of reality by selecting relevant variables, parameters, and interactions, thereby enabling prediction, explanation, or demonstration of systemic principles within a defined scope. A model may take linguistic, mathematical, computational, diagrammatic, or physical form, depending on its purpose and the idiom of representation. (New)

Explanation — Role of Models in Theoretical Construction: A theory specifies how elements of a system are related in principle; a model **instantiates** those relationships in a usable or testable form. Models therefore act as *interfaces* between theory and observation: they translate conceptual frameworks into empirical or computational practice. While frameworks define what can be theorised, and theories define what can be modelled, models provide the operational bridge through which theoretical understanding engages with measurable reality.

P20.4a Model–Theory Interaction Proposition — Models mediate between theoretical reasoning and empirical observation. By instantiating the relationships proposed within a theory, they translate abstract principles into operational representations that can be explored, tested, or simulated. The fidelity of a model depends on how well its simplifying assumptions preserve the essential causal relationships of the theory and how effectively it maps those relationships onto measurable or observable variables. Modelling thus serves as the practical process through which theories are evaluated, refined, and applied within specific domains. (New)

Explanation — Iteration Between Theory and Model: The relationship between theory and model is iterative. Theories guide model construction by specifying which relationships are significant; models, in turn, provide results that inform the revision or extension of theory. Through this feedback loop, human understanding advances from conceptual speculation toward empirically grounded explanation without confusing the abstract logic of theory with the contingent behaviour of particular models.

b. Theories as Systems: Structure, Causality, and Evolution

In this context, the word system refers to the internal organisation of propositions within a theory—a conceptual, not a physical, system.

Methods such as agent-based modelling, cliodynamics, and network mapping (see Section 10, Landscape Mapping Aids) provide practical means of exploring probabilistic trajectories within human systems, where analytic solutions are rarely tractable.

Purpose: Treat theories themselves as systems that behave and evolve.

Comment: These form a clear causal chain from internal logic → external effect → evolution.

D20.9 Physical Law — A generalisation describing consistent causal relationships among observable entities, established through repeated observation and testing. Variations in one quantity reliably correspond to variations in another, allowing — though not requiring — mathematical expression. Such laws are regarded as universally valid within their empirical domain. (05/06 Appendix A)

P20.5 Physical Laws Proposition — Physical laws are a subset of all relationships, and the same principles apply to them. (05/06 Appendix B)

D20.10 System (Cognitive Definition) — A cognitive or symbolic model representing entities, relationships, and processes, distinct from physical systems but used to understand, simulate, or reason about them. (05/06)

P20.6 Theory Proposition — A theory is a system of interacting propositions whose organisation produces emergent explanatory and predictive capacity not present in the individual propositions. (05/12)

P20.7 Causal Interaction of Propositions Proposition — Propositions within a theory interact causally. Some propositions enable, constrain, or condition the meaning or applicability of others. (05/12) [P18A]

P20.8 Causal Effect of Theories Proposition — Theories Interact Causally with the Physical World (05/12) [P18B]

P20.9 Evolution of Theories Proposition— Theories evolve via the recombination and assembly of propositions, much like biological systems evolve through variation and selection. (05/12) [P19]

c. Explanation, Prediction, and the Evolution of Reasoning

Purpose: Explain what theories *do*: explain, predict, and optimise.

Comment: Excellent internal logic. Optional addition: one sentence linking *Theoretical Optimality* to cognitive efficiency (ties to Section 6 Needs).

D20.11 Explanation — The clarification of observed phenomena through propositions that identify underlying causes, processes, or systemic structures. Explanations typically refer to past or present events, revealing how observed outcomes arise from their generative conditions. (New)

D20.12 Prediction — The projection of future states or behaviours of systems through propositions derived from present knowledge, models, or theories. Predictions express anticipated outcomes of systemic processes under specified conditions. (New)

P20.10 Dual Analysis Proposition — Causal structures enable both explanation (backward-looking) and prediction (forward-looking), providing dual analytical utility. (05/09)

P20.11 Predictive–Explanatory Decline Proposition — The reliability of causal reasoning decreases with temporal distance from the present. Predictive reliability declines further into the future as uncertainty accumulates through branching possibilities, while explanatory reliability declines further into the past as information is lost and multiple potential causes converge on the same outcome. (05/02)

D20.13 Theoretical Optimality — The condition in which a theory, as an informational system, achieves the best balance between simplicity, explanatory power, and generality. Theoretical optimality reflects the efficiency with which cognitive effort is transformed into structured, action-relevant understanding. (05/12) [D23]

P20.12 Epistemological Proposition — The evolution of human understanding reflects a gradual shift from pattern-recognition reasoning (TPT form), which perceives relationships through experience and analogy, toward mechanistic-explanatory reasoning (PTP form), which models internal processes and causal structures. This epistemic transition parallels the broader evolution of cognition from intuitive to analytical modes and underlies the development of modern scientific thought. (05/09)

d. Differentiation and Linguistic Divergence in Knowledge Systems

Purpose: Show how human theorising differentiates into fields and idioms.

Comment: Strong narrative on how specialisation fragments shared understanding.

D20.14 Discipline — A structured field of knowledge organised around a coherent set of theories, methods, and boundary assumptions that define its scope and focus of inquiry. (05/06 Appendix A)

P20.13 Emergent Physical Laws Proposition — Emergent properties can be new physical laws. This is because physical laws are causal relationships between systems. These causal relationships are determined by what is transferred from one system to the other. As the complexity of the source entity increases what is transferred can also increase in complexity. This is because it was a part of the source entity. (05/06 Appendix B, 05/10)

P20.14 Emergence of Disciplines Proposition — The emergence of new causal relationships represents the emergence of new laws and disciplines. (New)

P20.15 Hierarchical Emergence Proposition — The physical laws that emerge for a discipline cannot apply to disciplines at lower levels of complexity. (05/06 Appendix B)

P20.16 Tree of Disciplines Proposition — Disciplines emerge on different pathways of increasing complexity. (05/06 Appendix B)

P20.17 Language Distortion Proposition — Differences in experience and labelling (idioms) across domains distort understanding of shared systems and obscure isomorphisms. (05/07)

P20.18 Ambiguity Proposition — Natural language introduces ambiguity through ellipsis, anaphora, polysemy, syntax, and implicature. Understanding this is crucial for mapping natural language to formal logic. (05/09)

e. Epistemic Boundaries of Human Understanding

Purpose: Present epistemic constraints.

Comment: Excellent internal coherence;

D20.15 Black Box / White Box / Grey Box — Epistemic strategies for modelling and understanding systems: treating them as opaque (black box), fully transparent (white box), or partially known (grey box). These distinctions describe the observer's degree of knowledge about a system's internal structure and processes, not inherent system properties. (05/03)

D20.16 Darkness — The principle that no system can fully know itself or any other system. All representations are necessarily partial, because the observer is embedded within the processes being observed. Internal components cannot fully apprehend the complexity of the whole, making darkness a fundamental epistemic limit in systems understanding. (05/03)

P20.19 Modified Principle of Darkness Proposition — A modified principle of darkness would state that no system can be known completely by anything insufficiently complex to hold its information in a condensed form. Failing that, the information must be simplified and will, therefore, contain errors. (05/06 Appendix B)

P20.20 Modelling Proposition — No model of a complex system can capture all its behaviour; full understanding would require reproducing the system's complexity. (05/03)

P20.21Perception of Information Proposition— Due to limitations on human perception and cognition, cognitive information about a system normally comprises only the information at its level of emergence. (New) [P16]

P20.22 Invisible Emergence Proposition — A system or property may exist but remain undetected if its emergent effects fall below the resolution or sensitivity of available observational tools. (New)

P20.23 Invisible Transfers Proposition — The human ability to consciously trace cause and effect relies on the identification of distinct transfers between discrete processes. (New)

D20.17 Simplification — The process of reducing complexity in descriptions or models to bring phenomena within the limits of human comprehension and predictive capacity. Simplification typically involves grouping entities into broader categories, reducing the number of distinguishing characteristics, or representing variable ranges numerically. These reductions increase tractability but may obscure important system dynamics. (05/06 Appendix A)

P20.24 Valid Simplification Proposition — Simplification can only be carried out without introducing error by using fewer higher level systems in which new properties have emerged. (05/06 Appendix B)

f. Reflexivity and Integration in Human Knowledge Systems

Purpose: Present how partial perspectives are coordinated into unified understanding.

Comment: This is a powerful synthesis: how theories *about systems* become self-aware *systems of knowledge*.

D20.18 Transdisciplinarity — A principle and approach asserting that systemic inquiry requires the integration of concepts, methods, and perspectives across disciplinary boundaries to address complex, interdependent problems. Transdisciplinarity seeks coherence among diverse idioms and frameworks while respecting the integrity of each domain. (J. Wilby)

D20.19 Systemic Methodology — A methodology of inquiry grounded in systems principles, designed to engage with complexity, interdependence, feedback, and emergence. It emphasises holism, multiple worldviews, and reflexive awareness of the observer's role within the system of inquiry. (J. Wilby)

D20.20 Poly-Perspectivism — An epistemic framework recognising that no single perspective can capture the full complexity of reality. Understanding arises through the disciplined coordination of multiple partial perspectives, each reflecting distinct cognitive, cultural, or disciplinary standpoints. Poly-perspectivism values both convergence, through shared conceptual structures, and divergence, through the preservation of unique viewpoints within a coherent systemic whole. (04/16)

P20.25 Poly-Perspectival Utility Proposition — Poly-perspectivism enhances collective intelligence by distributing cognitive load across individuals, disciplines, and methods. It enables complex problems to be addressed adaptively through the interaction among diverse *cognitive frameworks and models*, reducing dependence on any single dominant paradigm and increasing the resilience of shared understanding. The integration of multiple perspectives thus functions as a systemic strategy for maintaining flexibility and innovation within human knowledge. (04/16)

Clarificatory Note — Distributed Cognition and Systemic Resilience: In a poly-perspectival network, each participant or discipline contributes a partial model of the system under study. The synthesis of these partial models forms a meta-system of cognition in which strengths and blind spots balance across participants. Such distributed cognition mirrors the dynamics of biological ecosystems: diversity stabilises function by preventing catastrophic failure of any one pathway of reasoning.

P20.26 Complementarity of Perspectives Proposition — Different perspectives may reveal complementary aspects of the same reality. When integrated appropriately, their interactions produce emergent insight that transcends the limits of any single viewpoint, analogous to coupled systems whose mutual constraints generate new properties not present in isolation. (04/16)

P20.27 Scope and Compatibility Proposition — Perspectives can be merged when they share scope and compatible assumptions; when their scopes differ, they should be maintained in parallel within a higher-order meta-framework. Compatibility is determined by the alignment of variables, boundaries, and levels of emergence, allowing perspectives to couple coherently without loss of contextual integrity. (04/16)

D20.21 Productive Co-ordination — The process by which differing perspectives or theories interact constructively to generate higher-order understanding. Productive co-ordination balances convergence (integration where possible) with respectful divergence (co-existence where necessary), avoiding both epistemic reductionism and relativism. It often involves translating theories into a common idiom and comparing their propositions to reveal shared structure and complementary insight. (04/16)

P20.28 Dialogical Engagement Proposition — Effective synthesis among perspectives depends on dialogical engagement conducted with intellectual humility, disciplined reasoning, and reflexive awareness. Through structured dialogue — such as Socratic questioning or steel-manning — participants can surface assumptions, test conceptual boundaries, and co-create broader, more coherent understanding. (04/16)

D20.22 Perspective Evaluation Framework — A structured set of criteria for assessing the quality and scope of perspectives. Core criteria include empirical grounding, internal consistency, coherence, parsimony, practical utility, reflexivity, and ethical soundness. The validity of a perspective arises from its fit to the level of emergence and context it seeks to describe, ensuring that evaluation remains appropriate to the system under consideration. (04/16)

D20.23 Reflexive Practice — A systemic practice in which the agent explicitly reflects on their own assumptions, methods, and position within the system being studied or transformed. Reflexive practice enhances awareness of feedback between the observer and the observed, improving methodological integrity. *(J. Wilby)*

D20.24 Principle–Structure Interaction — The relationship in which abstract systemic principles (e.g., holism, reflexivity) guide the structuring of systems, and system structures in turn influence the application and evolution of principles. This mutual shaping ensures that theory and structure co-evolve. (J.Wilby)

P20.29 Complexity–Emergence Proposition — Systemic complexity and emergent behaviour can be traced through symbolic compositions and relational mappings. Symbols and the relationships among them reflect the organisation of real systems: by analysing how symbolic structures combine and interrelate, we can identify where complexity accumulates and new properties emerge that are not present in the parts alone. (05/06)

Explanation: A symbolic composition combines simpler symbols to represent larger structures (e.g., words forming sentences, atoms forming molecules). A relational mapping represents how those symbols interact (e.g., grammar linking words, equations linking variables). Tracking these patterns reveals the parallel between the evolution of symbolic systems and the emergence of complexity in the physical world.

Examples

1. **Natural Language (everyday words and grammar)**
    - Symbols: words (e.g., "tree," "grow," "together").
    - Symbolic composition: words combine into phrases and sentences.

- Relational mapping: grammar specifies how words interact (subject–verb–object).
- Emergence: new meanings arise (e.g., irony, metaphor, narrative coherence) that cannot be reduced to the dictionary definitions of the individual words.

2. **Symbolic Logic (formal reasoning system)**
   - Symbols: variables (p, q, r), operators (¬, ∧, ∨, →).
   - Symbolic composition: propositions are built (e.g., p → q).
   - Relational mapping: logical rules define how propositions relate (e.g., transitivity, contradiction).
   - Emergence: complex theorems and proofs appear, which could not be anticipated by looking at isolated symbols alone.

3. **Chemistry (scientific symbolism)**
   - Symbols: atomic symbols (H, O, C).
   - Symbolic composition: molecules (H_2O, $C_6H_{12}O_6$).
   - Relational mapping: chemical bonds show how atoms interact.
   - Emergence: new properties (wetness, sweetness, metabolism) arise that are absent in the individual atoms.

P20.30 Reflexive Epistemology Proposition— The human act of theorising is itself a systemic process subject to the same constraints and feedbacks that govern other systems. Theories evolve through variation, selection, and integration of perspectives within the shared cultural and communicative environment of knowledge. (04/16)

g. Universal Integration and Systemic Isomorphism

Purpose: Conclude with the unification goal.

Comment: A fitting closing section —naming it "Universal Integration and Systemic Isomorphism" emphasises that human theorising mirrors the unifying dynamics found throughout your framework.

P20.31 Meta-Systemic Reflection Proposition — Human knowledge constitutes a meta-systemic reflection of the world it studies. By coordinating multiple perspectives within shared discourse, humanity participates consciously in the evolutionary process of systemic understanding. The development of knowledge is therefore both a product and an agent of universal evolution—an emergent feedback through which the universe comes to know itself. (04/16)

Explanation — Reflexivity in Universal Evolution: This proposition recognises that epistemology and ontology converge: the same systemic principles that govern natural evolution also shape the growth of human understanding. When knowledge becomes self-aware—reflecting not only on the world but on its own processes—it closes the loop of emergence, transforming cognition into a participant in universal self-organisation.

D20.25 General System Theory — General system theory is probably best defined by a quote from one of its founders, the Austrian biologist Ludwig von Bertalanffy: "...there exist models, principles, and laws that apply to generalized systems or their subclasses, irrespective of their particular kind, the nature of their component elements, and the relations or "forces" between them. It seems legitimate to ask for a theory, not of systems of a more or less special kind, but of universal principles applying to systems in general." (von Bertalanffy, 1968). (05/06 Appendix A)

P20.32 Isomorphisms Proposition — Isomorphisms between disciplines are based on properties that have emerged at a lower, common level of complexity. (05/06 Appendix B)

P20.33 Cross-Disciplinary Isomorphisms — Representing systems using Symbolic Reasoning can highlight isomorphisms and recurring patterns across disciplines. (New)

P20.34 Duality Proposition — The dualities identified here, i.e., "transfer, causal, set/collection, concrete/abstract" reflect fundamental structures of reasoning and may correspond to deeper ontological principles. (05/09)

P20.35 Complexity Mapping Proposition — Even if systems theories are productively co-ordinated into a unified General Systems Theory with a common idiom, the challenge of systemic complexity remains. To address this, energy landscapes must be mapped in ways that reveal the probabilities of alternative system trajectories. Potential ways forward include:
(a) examining the fractal structure of landscapes to expose repeating patterns across scales;
(b) applying cliodynamic models to capture historical regularities and probabilistic branching;
(c) analysing interactions between the landscapes of parent, child, and sibling systems to understand hierarchical and lateral constraints; and
(d) cross-mapping between configuration space, strange attractors, and energy landscapes to link structural, dynamical, and energetic perspectives.

Other potential ways forward include agent-based modelling, network mapping, information-theoretic analysis, cross-domain mapping, and path-dependency analysis. (New)

h. Formal Processes and Symbolic Reasoning

The drive toward unification within human knowledge culminates in the search for a common formal idiom. Across the universal disciplines—systems, causality, language, logic, and mathematics—shared structures of reasoning reappear. The following definitions and propositions outline how these disciplines converge in symbolic reasoning, providing a formal process for representing and combining propositions across domains.

D20.26 Universal Disciplines— Universal disciplines are those whose laws apply at all levels of emergence. They include not only systems theory but also natural language, mathematics, logic, and causality. Other disciplines are domain specific and limited to a range of organisation between levels of emergence. (New) [D20]

P20.36 Universal Disciplines Proposition: Fundamental systems theory, causality, natural language, and logic are distinct manifestations of a common cognitive structure that governs how humans perceive and reason about reality. (05/09)

P20.37A Unified Framework Proposition — Systems operate through causal processes, which can be described using natural language and analysed logically. These four domains (systems theory, causality, language, logic) form a coherent explanatory framework. (05/09)

P20.37B Symbolic Reasoning Proposistion [P20] — Symbolic Reasoning can unify the universal disciplines of systems, causality, logic, and natural language into a manipulable symbolic structure.

P20.38 Natural Language as Structural Reflection — Natural language inherently reflects the structures debated in systems theory, though its efficiency-driven usage often obscures this. (New)

P20.39 Attractor Toward Formalisation — There is a developmental attractor within systems science leading toward formal representation in symbolic logic, which institutions such as the ISSS could help advance. (New)

D20.27 Symbolic Reasoning — Symbolic Reasoning is a form of symbolic logic developed by the author (Challoner, 2023). It unifies the various branches of conventional logic by providing a common, intuitive symbolism and common axioms compatible with systems theory. Consistent symbols are used to represent system components and their interrelations, allowing logical inference across domains. Thus it acts as a potential common formal idiom. (05/06, 05/12) [D24]

P20.40 Symbolic Reasoning Proposition — Symbolic Reasoning is a single symbolic language that can unify the universal disciplines of systems, causality, logic, and natural language into a manipulable symbolic structure. It is a generalised form of set theory capable of representing causal relationships, logical inference, and linguistic structure provides a unifying formalism across disciplines allowing for unified modelling across levels of reality, from particle physics to societies. Translation into the idiom of symbolic reasoning would enable the fundamentals of systems theory to be formally represented and manipulated, providing a precise means of combining and extending propositions. (05/06, 05/12, 05/09)

P20.41 Relational Structure — Symbolic Reasoning can represent and manipulate propositions or relationships between systems. (New)

P20.42 Higher-Order Relational Structure — Symbolic Reasoning can represent and manipulate relationships between relationships, i.e., higher-order relationships. (New)

Reflexive closure: The Extended Framework itself exemplifies the systemic principles it describes: a living theory evolving through dialogue, recomposition, and poly-perspectival synthesis.
