



Ilya Prigogine

Belgium, Physical Chemist and Non-equilibrium Thermodynamicist, 1917–2003

Ilya Prigogine was a Belgian physical chemist, born in Moscow in 1917. His family left Russia when he was a child and eventually settled in Belgium. He studied chemistry and physics at the Université Libre de Bruxelles, where much of his subsequent academic career was based. His research centred on thermodynamics, especially irreversible processes and systems maintained away from thermodynamic equilibrium. With collaborators he extended irreversible thermodynamics from near-equilibrium conditions towards nonlinear systems operating far from equilibrium. This work led to the concept of the dissipative structure: organised states that arise and persist through irreversible processes and continuing environmental flows. Prigogine received the 1977 Nobel Prize in Chemistry for contributions to non-equilibrium thermodynamics, particularly the theory of dissipative structures. His systems significance lies in showing that irreversible processes need not simply destroy organisation: under specified conditions, non-equilibrium processes can contribute to the maintenance and emergence of macroscopic organisation. His work is therefore highly relevant to systems science, but should not be treated as a complete General Systems Theory; many of its strongest results concern particular nonlinear, open, non-equilibrium physical systems.

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Nicolis, G., & Prigogine, I. (1977). Self-organization in nonequilibrium systems: From dissipative structures to order through fluctuations. Wiley.

Prigogine, I. (1977). Time, structure and fluctuations. Nobel Lecture, 8 December 1977.

Prigogine, I. (1980). From being to becoming: Time and complexity in the physical sciences. W. H. Freeman.

Prigogine, I., & Stengers, I. (1984). Order out of chaos: Man's new dialogue with nature. Bantam.

Notes

DG = General Systems Definition; **PG** = General Systems Proposition; **DS** = Special Systems Definition; **PS** = Special Systems Proposition. Each item is identified by the researcher's surname followed by its category and number (e.g. **Prigogine DG.1**). (*Explicit*) indicates that the definition or proposition is directly stated in the researcher's work. (*Reconstructed*) indicates that it has been reconstructed from the researcher's work but is not explicitly stated in that form.



Definitions Relevant to General Systems Theory

Prigogine DG.1

Open system (Reconstructed): A system across whose boundary matter and/or energy may be exchanged with its surroundings.

Common idiom: A system whose continuing state or organisation can depend upon flows across its boundary.

Explanation: The term is standard thermodynamic terminology rather than a distinctive Prigogine definition, but environmental exchange is fundamental to his treatment of non-equilibrium organisation.

Prigogine DG.2

Equilibrium (Reconstructed): The limiting thermodynamic condition in which there are no net macroscopic thermodynamic driving processes.

Common idiom: A state in which the relevant macroscopic thermodynamic gradients no longer drive net change.

Explanation: This is a thermodynamic definition and should not be confused with every use of 'equilibrium' in systems science.

Prigogine DG.3

Non-equilibrium (Explicit): A condition away from thermodynamic equilibrium, characterised by continuing irreversible processes and associated thermodynamic forces and flows.

Common idiom: A condition in which continuing physical gradients and flows sustain change rather than thermodynamic rest.

Explanation: Prigogine's work concerns how organisation can persist, and under special conditions emerge, in such regimes.

Prigogine DG.4

Irreversible process (Explicit): A process associated with positive entropy production and therefore with a macroscopic distinction between temporal directions.

Common idiom: A physical process whose thermodynamic history has a direction and cannot simply be reversed without other changes.

Explanation: This is specifically thermodynamic irreversibility, not merely practical difficulty in reversing a process.

Prigogine DG.5

Entropy production (Explicit): The production of entropy associated with irreversible processes occurring within a system.

Common idiom: Entropy generated by irreversible physical processes within an organised physical system.

Explanation: Entropy production is a central quantity in Prigogine's non-equilibrium thermodynamics.



Prigogine DG.6

Stationary state (*Explicit*): A non-equilibrium condition in which selected macroscopic variables remain constant with time although irreversible processes and environmental exchanges continue.

Common idiom: A persistent macroscopic state maintained despite continuing underlying processes and flows.

Explanation: Stationarity therefore does not imply thermodynamic equilibrium or absence of process.

Propositions Relevant to General Systems Theory

Prigogine PG.1

Irreversibility (*Explicit*): Irreversible physical processes introduce a macroscopic distinction between temporal directions.

Common idiom: Some physical processes possess a real thermodynamic direction in time rather than merely appearing irreversible because of limited observation.

Explanation: The proposition is physical and thermodynamic; its systems significance is that process history can matter.

Prigogine PG.2

Maintenance away from equilibrium (*Explicit*): Systems subject to continuing exchanges with their surroundings can be maintained away from thermodynamic equilibrium.

Common idiom: Environmental flows can sustain a system in a condition that would not persist in isolation.

Prigogine PG.3

Stationarity does not require equilibrium (*Explicit*): A system can maintain a macroscopically stationary condition while irreversible processes and environmental exchanges continue.

Common idiom: Persistent macroscopic organisation need not imply physical stasis; continuing flows can maintain it.

Definitions Relevant to Special Systems Theories

Prigogine DS.1

Fluctuation (*Explicit*): A local or temporary departure of variables from their prevailing macroscopic values; fluctuations become especially significant near instability.

Common idiom: A perturbation or deviation from the prevailing state of a dynamic system.

Explanation: Its consequences depend upon the stability and dynamics of the particular system.



Prigogine DS.2

Stability (Reconstructed): A state or regime is stable when sufficiently small perturbations remain limited or decay.

Common idiom: Persistence or recovery of a dynamic state following sufficiently small disturbances.

Explanation: This definition applies to dynamic regimes under specified conditions, not to systems universally.

Prigogine DS.3

Instability (Explicit): A condition in which perturbations no longer necessarily decay and may instead grow, allowing departure from an existing regime.

Common idiom: Loss of stability that allows disturbances to be amplified and the system to leave its previous regime.

Explanation: Instability is conditional upon system dynamics and prevailing control conditions.

Prigogine DS.4

Bifurcation (Explicit): A critical condition at which an existing solution or regime changes stability and alternative branches of behaviour become possible.

Common idiom: A threshold at which a dynamic system can enter alternative regimes.

Explanation: Bifurcation applies to systems with the relevant nonlinear dynamics and control parameters.

Prigogine DS.5

Dissipative structure (Explicit): A coherent organised structure that exists under non-equilibrium conditions and is maintained through irreversible processes involving continuing exchanges with its environment.

Common idiom: An organised physical system whose structure depends upon continuing throughput and dissipation.

Explanation: Dissipative structures are a special class of organised systems, not a synonym for systems generally.

Prigogine DS.6

Far-from-equilibrium (Explicit): A non-equilibrium regime sufficiently removed from thermodynamic equilibrium for qualitatively different nonlinear behaviour, including instability and new organised regimes, to become possible.

Common idiom: A strongly driven non-equilibrium condition in which nonlinear dynamics can permit new system behaviour.

Explanation: Distance from equilibrium alone does not guarantee self-organisation; appropriate dynamics are also required.



Prigogine DS.7

Self-organisation (Reconstructed): The development of organised macroscopic behaviour through the internal dynamics of a non-equilibrium system rather than through detailed external specification of the resulting organisation.

Common idiom: Emergence of macroscopic organisation through the system's own constrained dynamics under environmental flows.

Explanation: This is the Prigogine/Nicolis far-from-equilibrium usage and should not be assumed to cover every process called self-organisation.

Prigogine DS.8

Order through fluctuations (Explicit): A process in which fluctuations associated with instability are amplified and participate in the establishment of a new organised macroscopic regime.

Common idiom: Emergence of a new organised regime through amplification of perturbations near instability.

Explanation: This is a demonstrated mechanism for particular nonlinear systems, not a universal mechanism of emergence.

Propositions Relevant to Special Systems Theories

Prigogine PS.1

Stability and fluctuation (Explicit): Around a stable state, sufficiently small fluctuations tend to remain limited or decay; when stability is lost, fluctuations may instead become amplified.

Common idiom: Whether a perturbation dies away or grows depends upon the stability of the current dynamic regime.

Prigogine PS.2

Instability and qualitative change (Explicit): Changes in controlling conditions can cause an existing regime to lose stability, permitting qualitatively different regimes of behaviour to appear.

Common idiom: Changing conditions can destabilise an existing system state and open alternative trajectories.

Prigogine PS.3

Bifurcation (Explicit): As relevant control parameters change, a system may reach critical conditions at which the existing regime loses stability and alternative macroscopic regimes become possible.

Common idiom: Threshold changes in conditions can create alternative possible dynamic regimes.

Prigogine PS.4

Nonlinearity (Explicit): Far from equilibrium, nonlinear relationships can permit multiple stationary states, oscillations and instabilities not represented by linear near-equilibrium thermodynamics.

Common idiom: Nonlinear interactions can create qualitatively different system behaviours under appropriate conditions.



Prigogine PS.5

Dissipative structures (*Explicit*): Under appropriate far-from-equilibrium conditions, irreversible processes can support the emergence and persistence of coherent organised structures.

Common idiom: Throughput and dissipation can maintain, and under suitable conditions help generate, organised structure.

Prigogine PS.6

Dependence upon environmental exchange (*Explicit*): Dissipative structures depend upon continuing exchanges with their surroundings.

Common idiom: The viability of a dissipative structure depends upon continuing environmental inputs and outputs; removal of the sustaining flows destroys the conditions for that organisation.

Prigogine PS.7

Instability can generate new organisation (*Explicit*): When an existing non-equilibrium regime loses stability, new forms of organised behaviour can become possible.

Common idiom: Destabilisation can create conditions in which a system reorganises into a qualitatively different regime.

Prigogine PS.8

Fluctuation amplification (*Explicit*): Fluctuations that remain limited under stable conditions can become amplified around instability and contribute to macroscopic organisation.

Common idiom: Perturbations can become system-level changes when the existing regime loses stability.

Prigogine PS.9

Order through fluctuations (*Explicit*): Under suitable far-from-equilibrium conditions, fluctuations can participate in the emergence and selection of a new organised macroscopic regime.

Common idiom: New organisation can emerge through amplified fluctuations when the system has the required nonlinear dynamics and environmental conditions.

Prigogine PS.10

Long-range order (*Explicit*): Far-from-equilibrium instabilities can produce coherent macroscopic organisation extending over spatial scales much greater than the local interactions from which it arises.

Common idiom: Local interactions can, under appropriate conditions, become coordinated into larger-scale organised patterns.

Prigogine PS.11

Function, structure and fluctuation are interdependent (*Explicit*): The processes occurring within a system, its resulting space-time structure and the fluctuations capable of destabilising that structure are interrelated in far-from-equilibrium organisation.

Common idiom: System processes, organisation and perturbations can recursively affect one another.



Prigogine PS.12

Global conditions affect organisation (*Explicit*): Whether dissipative structures can occur can depend upon global properties and boundary conditions of the system.

Common idiom: Emergent organisation can depend upon system-wide constraints as well as local interactions.

Explanation: Prigogine's reaction-diffusion examples show that even system dimensions can determine whether dissipative organisation is possible.

Student Exercise

1. **Understanding:** In your own words, describe one of this researcher's principal contributions to systems science.
2. **Generalisation:** Select one General Systems proposition. Give an example of it operating in a different kind of system from those studied by this researcher.
3. **GST or Special Systems Theory?** Select one item classified as a Special Systems Definition or Proposition. Explain why it should not necessarily be generalised to all systems.
4. **Critical evaluation:** Select one proposition and identify evidence or an example that would support it, challenge it, or indicate limits to its applicability.
5. **Translation:** Choose one of this researcher's original concepts and compare it with its common-idiom translation. What information, if any, is gained or lost in the translation?