



## **W. Ross Ashby**

**United Kingdom, Psychiatry, Cybernetics and Systems Theory, 1903–1972**

William Ross Ashby was a British psychiatrist and one of the principal pioneers of cybernetics and systems theory. Trained in medicine at Cambridge and St Bartholomew's Hospital, London, he worked for much of his early career in psychiatry, where his interest in the brain, adaptation and stability led him towards a general theory of dynamic systems. During the 1940s he developed the Homeostat, an electromechanical device that demonstrated adaptive stabilisation by changing internal parameters after disturbance. His first major book, *Design for a Brain* (1952), developed these ideas into a theory of adaptive behaviour and ultrastability.

Ashby's *An Introduction to Cybernetics* (1956) deliberately sought principles that could be expressed independently of the material from which a system was made. It developed rigorous treatments of state, transformation, stability, constraint, variety, information and regulation. His Law of Requisite Variety became especially influential: effective regulation requires sufficient regulatory variety to counter the variety of disturbances that would otherwise affect essential variables.

After appointments at Barnwood House Hospital and the Burden Neurological Institute, Ashby moved to the University of Illinois in 1961, where he worked in the Biological Computer Laboratory. His work influenced cybernetics, systems theory, neuroscience, artificial intelligence, management and complexity studies. A distinctive feature of his approach was methodological: systems were defined operationally through selected variables and observable transformations rather than by assuming that a physical object constituted a system in itself.

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### 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. **Ashby 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

#### Ashby DG.1

**System** (*Explicit*): A system is defined by the variables selected for study rather than simply by pointing to a material object.

*Common idiom: A system is a selected set of variables used to represent some aspect of reality for a stated purpose.*

*Explanation: Ashby emphasises that any material object contains indefinitely many potentially relevant variables. The system therefore depends partly on the observer's selection of what is to be studied.*

#### Ashby DG.2

**State** (*Explicit*): The state of a system at a particular instant is specified by the values taken by its selected variables at that instant.

*Common idiom: A state is a particular combination of values of the variables used to represent a system.*

*Explanation: Because Ashby's system is defined through selected variables, its state is likewise relative to that representation. Different selections of variables may provide different state descriptions of the same underlying physical entity.*

#### Ashby DG.3

**Transformation** (*Explicit*): A transformation specifies how each possible state or operand is changed into a subsequent state or transform.

*Common idiom: A transformation is a rule or relation mapping system states to later states.*

*Explanation: This is Ashby's formal representation of change. It permits systems with very different physical substrates to be described in the same mathematical terms, but does not itself specify the physical causal mechanism producing the change.*



#### Ashby DG.4

**Variety (Explicit):** The variety of a set is the number of distinguishable elements or states it contains.

*Common idiom: Variety is the number of states or alternatives that can be distinguished for the purpose of the analysis.*

*Explanation: For Ashby, variety is not wholly intrinsic: what can be distinguished depends on the observer and the discrimination available.*

#### Propositions Relevant to General Systems Theory

#### Ashby PG.1

**Systems are observer-defined (Explicit):** A material object can support many different systems because different sets of variables may be selected according to the investigator's purpose.

*Common idiom: System boundaries and variables are epistemic selections from a richer physical reality; different valid system representations may therefore be constructed from the same entity or situation.*

*Explanation: This is a methodological proposition about representation, not a claim that the underlying physical reality is created by the observer.*

#### Ashby PG.2

**Constraint makes prediction possible (Explicit):** Prediction is possible only where the possible behaviour of a system is constrained.

*Common idiom: Reliable prediction depends on restrictions that exclude some otherwise possible state changes or trajectories.*

*Explanation: If every next state were equally possible, observation of the present state would provide no basis for predicting what follows.*

#### Ashby PG.3

**Coupled equilibrium (Explicit):** A whole composed of coupled parts is at equilibrium if and only if each part is at equilibrium under the conditions provided by the other part or parts.

*Common idiom: A stable configuration of an interacting assembly requires the states of its components to be mutually compatible under their reciprocal interactions.*

*Explanation: Ashby described each component as having a "power of veto" over equilibria of the whole.*

#### Ashby PG.4

**Information depends on alternatives (Explicit):** Communication requires a set of possible messages, and the information carried by a message depends on the set of alternatives from which it is selected.

*Common idiom: Information conveyed by an event depends on the range of distinguishable alternatives that could have occurred, not on the event considered in isolation.*

*Explanation: This adopts the information-theoretic view associated with Shannon while expressing it through Ashby's concept of variety.*



### Definitions Relevant to Special Systems Theories

#### Ashby DS.1

**Regulator** (*Reconstructed*): A regulator is a mechanism interposed between disturbances and essential variables so that the effects of disturbance on those variables are restricted.

*Common idiom: A regulator is a system whose interactions constrain disturbance-induced changes so that selected target variables remain within acceptable states.*

*Explanation: Regulation presupposes a target or acceptable range and therefore applies to systems for which such a criterion is specified.*

#### Ashby DS.2

**Essential variables** (*Explicit*): Essential variables are variables whose values must remain within specified limits if an organism is to survive or another regulated system is to remain satisfactory.

*Common idiom: Essential variables are viability-critical or performance-critical variables that regulation must keep within an acceptable range.*

*Explanation: Ashby developed the concept principally in biological regulation but explicitly extended the formalism to engineered and other regulated systems.*

#### Ashby DS.3

**Ultrastable system** (*Explicit*): An ultrastable system has a primary feedback with its environment and a slower second feedback that changes parameters when essential variables pass outside given limits.

*Common idiom: An ultrastable system adapts by changing the configuration or parameters governing its ordinary behaviour when its viability-critical variables leave their acceptable range.*

*Explanation: Ultrastability is a particular architecture for adaptive regulation, not a property of systems in general.*

### Propositions Relevant to Special Systems Theories

#### Ashby PS.1

**Law of Requisite Variety** (*Explicit*): Successful regulation requires the regulator to possess sufficient variety to counter the variety of disturbances that would otherwise reach the essential variables.

*Common idiom: To constrain a range of possible disturbance effects, a regulator must be capable of a sufficiently differentiated range of responses.*

*Explanation: Ashby's compressed formulation is commonly expressed as "only variety can destroy variety". The proposition concerns regulation and therefore is classified here as Special Systems rather than universal GST.*



#### Ashby PS.2

**Regulation blocks disturbance variety (Explicit):** A successful regulator prevents or reduces the transmission of variety from disturbances to essential variables.

*Common idiom: Regulation protects target variables by constraining the causal pathways through which environmental disturbances could alter them.*

*Explanation: This connects Ashby's concepts of information, variety and survival.*

#### Ashby PS.3

**Error-controlled regulation requires stability (Explicit):** For an error-controlled regulator with a fixed target, the system must be stable for a given disturbance and the desired condition must be a state of equilibrium; feedback will therefore usually be negative.

*Common idiom: A feedback regulator can restore a target condition only if its feedback structure tends to reduce deviations from that target under the relevant conditions.*

*Explanation: The qualification "usually" is important: Ashby's statement concerns the class of error-controlled regulators he is analysing, not every feedback process.*

#### Ashby PS.4

**Adaptive parameter change (Reconstructed):** In an ultrastable system, departure of essential variables from acceptable limits activates slower processes that alter parameters until a stable acceptable configuration is found.

*Common idiom: Adaptive regulation can operate by changing the organisation governing ordinary system behaviour when existing organisation fails to maintain viability.*

*Explanation: This reconstructs the operational logic of Ashby's ultrastable system rather than presenting a sentence he states in exactly this form.*

#### Ashby PS.5

**Selection favours effective regulation (Explicit):** Other things being equal, natural selection favours organisms whose regulators better protect their essential variables from disturbance.

*Common idiom: Where persistence depends on maintaining viability-critical variables, configurations that regulate those variables more effectively are preferentially retained by selection.*

*Explanation: This is a proposition about biological/evolutionary systems and should not be generalised to systems lacking reproduction and selection.*

#### Ashby PS.6

**Good Regulator Theorem (Explicit):** Under the stated conditions, a regulator that is maximally successful and simple must be isomorphic with the system it regulates.

*Common idiom: Effective and economical regulation requires the regulator to embody a sufficiently accurate model of the relevant behaviour of the system being regulated.*

*Explanation: Developed with Roger C. Conant in 1970, the theorem concerns successful regulators under specified assumptions; it is therefore a Special Systems proposition rather than a universal property of all systems.*



### 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?