

Threshold Concepts in Biology

SciMaG – Work Package 2

Threshold concepts are conceptual gateways that can open a previously inaccessible way of thinking about a subject and enable further learning. They are commonly described as potentially transformative, irreversible, integrative, bounded, and troublesome. Not every difficult or important concept is necessarily a threshold concept; the key issue is whether understanding it changes the learner's way of seeing and using disciplinary knowledge.

Identified Threshold Concepts

Biomolecules as a Threshold Concept

Biomolecules provide a molecular basis for understanding structure, function, energy, and information in living systems.

Threshold characteristic	Explanation
Troublesome	Learners must coordinate molecular structure with biological function across several molecule classes.
Transformative	Biological processes become interpretable through molecular mechanisms.
Integrative	It connects chemistry, cell biology, metabolism, genetics, and biotechnology.
Bounded	The concept is bounded by major molecular classes and biological roles.
Irreversible	Molecular structure-function reasoning becomes a durable lens for later biology.

Related SciMaG learning activity: Amino acids – G11, S12

The Cell as a Threshold Concept

The cell is the basic structural and functional unit of living organisms.

Threshold characteristic	Explanation
Troublesome	Learners must connect microscopic structures with macroscopic functions and understand cells as dynamic systems.
Transformative	Learners shift from viewing organisms as wholes to understanding life through cellular processes.

Integrative	It connects molecular biology, physiology, anatomy, metabolism, and genetics.
Bounded	The cell defines a central level of biological organisation.
Irreversible	Cellular thinking becomes a stable framework for interpreting growth, function, disease, and reproduction.

Related SciMaG learning activity: Memory Challenge – G11, S9; Domino Challenge – G12, S10

Embryology as a Threshold Concept

Embryology explains how a single cell develops into a multicellular organism through regulated processes.

Threshold characteristic	Explanation
Troublesome	Learners must integrate cell division, differentiation, genetics, and developmental sequences that are difficult to observe directly.
Transformative	Development is understood as regulated change rather than simple growth.
Integrative	It links cytology, genetics, histology, physiology, and evolution.
Bounded	It is bounded by the processes and timescales of individual development.
Irreversible	Developmental reasoning becomes a durable basis for understanding growth and developmental disorders.

Genetics as a Threshold Concept

Genetics provides a framework for explaining inheritance, variation, gene expression, and biological information.

Threshold characteristic	Explanation
Troublesome	Learners may initially interpret inheritance as a simple direct transfer of visible traits.
Transformative	Traits and variation become interpretable through information flow, gene expression, recombination, and mutation.
Integrative	It integrates molecular biology, evolution, medicine, and biotechnology.

Bounded	The concept is bounded by genetic mechanisms and explanatory levels.
Irreversible	Genetic reasoning becomes a stable framework for interpreting heredity and variation.

Related SciMaG learning activity: Curious Kitty – G13, S8

Ecology as a Threshold Concept

Ecology explains relationships among organisms, populations, communities, ecosystems, and environments.

Threshold characteristic	Explanation
Troublesome	Learners often focus on organisms in isolation and underestimate system-level interdependence.
Transformative	Nature is reconceptualised as a network of interacting systems involving energy, matter, organisms, and environments.
Integrative	It integrates population dynamics, biodiversity, energy flow, nutrient cycles, and human impacts.
Bounded	Ecological explanations are bounded by interactions among organisms and their environments.
Irreversible	Systems thinking becomes a durable framework for interpreting environmental phenomena.

Related SciMaG learning activity: Curious Kitty – G13, S7

References

Meyer, J. H. F., & Land, R. (2005). Threshold concepts and troublesome knowledge (2): Epistemological considerations and a conceptual framework for teaching and learning. Higher Education, 49(3), 373–388. <https://doi.org/10.1007/s10734-004-6779-5>