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Analytic Summary

Emergence. An Interdisciplinary View

Etxenike, Pedro M. (Donostia International Physics Center (DIPC). Manuel de Lardizabal, 4 20018 – Donostia-San Sebastián): **Emergence and Reduction: A Brief Overview** (Orig. en)

In: *Rev. int. estud. vascos*. 70, 2 (2025)

Abstract: This article explores the dialogue between reductionism and emergentism in science. While reductionism seeks ultimate laws and unification, emergentism emphasizes the novelty that arises at higher levels of complexity, irreducible to fundamental equations. Using examples from condensed matter physics and superconductivity, the text argues that both approaches are complementary: science progresses by unifying laws while embracing new phenomena that emerge beyond them.

Keywords: Reductionism. Emergence. Complexity. Condensed Matter Physics. Superconductivity. Symmetry Breaking. Philosophy of Science. Scientific Knowledge.

Vega, Luis (Fac. Ciencias y Tecnología. EHU/UPV. Barrio Sarriena, s/n. 48940 – Leioa); **Fanelli, Luca** (Ikerbasque. Plaza Euskadi, 5. 48009 – Bilbao): **Emerging Singularities: When Mathematics Unveils the Hidden** (Orig. en)

In: *Rev. int. estud. vascos*. 70, 2 (2025)

Abstract: We explore how rigorous mathematics transforms paradoxes into insight. Through examples, like string vibrations and Fourier series, shock formation in fluid dynamics, Weierstrass' nowhere-differentiable function, and Ramanujan's divergent sums, we show how smooth beginnings produce singularities. Mathematics thus reveals hidden structures, turning contradictions into coherent frameworks for understanding nature's complexity.

Keywords: Emerging singularities. Fourier series. Wave equation. Shock formation. Burgers equation. Weierstrass function. Divergent series. Ramanujan summation.

Uriagereka, Juan (Linguistics and School of Languages, Literatures & Cultures. University of Maryland. 1401 Marie Mount Hall (or 4225 Juan Ramón Jiménez Hall). College Park, MD, 20742); **Orús, Román** (Donostia International Physics Center. Manuel de Lardizabal, 4. 20018 – Donostia-San Sebastián): **Weak & Strong Emergence in Language & Mind** (Orig. en)

In: *Rev. int. estud. vascos*. 70, 2 (2025)

Abstract: Despite continuous sensory flows, animal behavior shows discrete actions. This discontinuity requires a *weak emergence*: spectral channels shaped by biophysical constants leading to categorical motor decisions. But the compositional, inferential, and counterfactual capacities of bilaterians demand a *stronger emergence*, as afforded in non-commutative representational spaces. This framework connects linear algebra and oscillatory binding for an evolutionary trajectory from sensation to thought.

Keywords: Language-of-Thought. Syntax. Non-commutativity. Uncertainty Principle. (Evolution of) Cognition. Perception-action Loop.

Barja, Sara (University of Basque Country (EHU). Department of Polymers and Advanced Materials. Paseo de Manuel Lardizabal 3. E-20018 Donostia-San Sebastián): **From Discovery to Design: Emergence at the Atomic Scale** (Orig. en)

In: *Rev. int. estud. vascos.* 70, 2 (2025)

Abstract: This perspective essay explores emergence at the atomic scale through three condensed-matter milestones: superconductivity, the quantum Hall effect, and moiré materials. While microscopic laws are complete in principle, explanation and engineering proceed through the effective degrees of freedom that control macroscopic behavior: order parameters, symmetries, and topological invariants. A layered format combines a main narrative with optional technical boxes, takeaways, and a glossary for interdisciplinary readers.

Keywords: Emergence. Condensed matter. Superconductivity. Quantum Hall effect. Moiré materials. Topology. Effective theories. Collective behavior.

Marcaide, Jon (Jakiunde, Zientzia, Arte eta Letren Akademia. Prim, 7. 20006 – Donostia-San Sebastián); **Salvador, Eduard** (Universitat de Barcelona. Physics Faculty. Martí I Franquès, 1. 08028 - Barcelona): **Emergence of the Structure of the Universe** (Orig. en)

In: *Rev. int. estud. vascos.* 70, 2 (2025)

Abstract: It is relatively recent that we have reached a comprehensive understanding, probably close to reality, of the structure of the Universe at both the large and subatomic scales. Remarkably, the understanding the large-scale structure (and its emergence) depends crucially on the subatomic scale. Emergence and reductionism go hand in hand in understanding our Universe.

Keywords: Cosmology, elementary particles, primordial nucleosynthesis, galaxy formation, black holes, stellar populations, evolution of the Universe

Zubiaga, Ana; Rodríguez, José Antonio; Fullaondo, Asier; Iglesias Ara, Ainhoa (University of the Basque Country (UPV/EHU). Faculty of Science and Technology. Department of Genetics, Physical Anthropology and Animal Physiology. Sarriena auzoa, z/g E-48940 Leioa): **Emergence of New Genes and Gene Products: Mechanisms, Evolution and Functional Implications** (Orig. en)

In: *Rev. int. estud. vascos*. 70, 2 (2025)

Abstract: Genomes across the tree of life contain highly variable gene numbers, reflecting differences in biological complexity. The emergence of new genes is a major driver of evolutionary innovation, enabling the acquisition of novel traits. Gene duplication, first proposed nearly a century ago, is the primary mechanism underlying new gene formation. This review outlines the molecular mechanisms of gene duplication, the possible evolutionary fates of duplicated genes, and their functional consequences, highlighting their roles in organismal evolution, brain complexity, and human disease.

Keywords: Gene duplication. New gene emergence. Molecular evolution. Gene families. Segmental duplications. Retroposition. Functional diversification.

Pérez Iglesias, Juan Ignacio (Jakiunde, Zientzia, Arte eta Letren Akademia. Prim, 7; 20006 Donostia): **Reductionism, Emergence, the Unity of Selection, and the Origin of Altruism** (Orig. en)

In: *Rev. int. estud. vascos*. 70, 2 (2025)

Abstract: The article analyzes the tension between reductionism and emergentism in the life sciences and its impact on evolutionary theory, especially the unit of selection debate. It distinguishes forms of reductionism and emergence, examines biological organization and altruism, and argues that strong emergence and downward causation challenge strictly reductionist explanations, revealing deeper philosophical commitments about explanation and causality.

Keywords: Reductionism. Emergence. Multilevel selection. Altruism. Philosophy of biology. Evolutionary theory.

Jiménez, Sixto (Jakiunde, Zientzia, Arte eta Letren Akademia. Prim, 7; 20006 Donostia): **Emergence and Organizations** (Orig. en)

In: *Rev. int. estud. vascos*. 70, 2 (2025)

Abstract: This paper examines the phenomenon of organizational emergence, its creation, and its effectiveness in efficiently achieving goals that are unattainable individually. The human factor, acting individually and in groups, is also studied, along with its biases, as it is the key to the emergence, viability, and durability of organizations. Leadership, informal culture, and image, which are difficult to perceive due to their intangibility, are analyzed. The relevance of technology and the emergence of organizations and networks for the future of humanity conclude the study.

Keywords: Emergence. Organization. Culture. Future. Complexity. Enterprise. Image. Leadership.

Mancisidor, Mikel (Jakiunde, Zientzia, Arte eta Letren Akademia. Prim, 7; 20006 Donostia); **Ureta, Ivan** (Geneva Centre for Security Policy (GCSP). Maison de la paix. Chemin Eugene-Rigot 2D, 1211 Geneva): **Reframing Emergence in International Politics: Complexity, Agency and the Evolution of Global Order in Times of Polycrisis** (Orig. en)

In: *Rev. int. estud. vascos*. 70, 2 (2025)

Abstract: The article reframes how new political patterns form in global affairs within a context of polycrisis. Using systems theory and a realist-constructivist lens. The article shows how narratives and structures shape outcomes across weakening multilateralism, populist leadership, disinformation as well as shifting development debates. It argues for ethical leadership and narrative responsibility to guide diplomacy and governance amid today's interconnected instabilities.

Keywords: Polycrisis. Complexity. Multilateralism. Global Governance. Ethics

Innerarity, Daniel (Jakiunde, Zientzia, Arte eta Letren Akademia. Prim, 7; 2006 Donostia): **Democracy and Complexity** (Orig. en)

In: *Rev. int. estud. vascos*. 70, 2 (2025)

Abstract: The article contends that contemporary democracies cannot be understood through linear or reductionist models. In highly differentiated and uncertain societies, traditional control fails. Critiquing market and evolutionary self-regulation, it proposes a theory of complex democracy grounded in complexity science, emphasizing emergence, non-linearity, distributed intelligence, and learning-oriented governance to manage uncertainty while preserving legitimacy and accountability.

Keywords: Democracy. Complexity. Governance. Uncertainty. Collective intelligence. Political theory.

Barandiaran, Xabier E. (IAS-Research Center for Life, Mind, and Society. UPV/EHU. Departamento de Filosofía, Facultad de Educación, Filosofía y Antropología): **Emergence and Autonomous Agency** (Orig. en)

In: *Rev. int. estud. vascos*. 70, 2 (2025)

Abstract: Emergentism seeks to reconcile material reality with the complexity of biological and psychological phenomena, rejecting both dualism and strict reductionism while preserving scientific unity across levels. Focusing on agency as organized autonomy, it argues that goal-directed systems—from protocells to humans—require concepts such as norms, intentions, and reasons, highlighting organizational emergence and a distinctive, non-reductionist form of causality.

Keywords: Agency. Emergence. Agent-causation. Organization. Basic Autonomy. Sensorimotor Autonomy. Origins of Life. Intentional Action.