Eukaryogenesis and Human Macro-History: Crude Looks at Singular Transitions

Introduction

Some transitions in the history of the universe are so singular and creative that they resist full reconstruction. They are not reducible to gradualist models of selection, nor explicable solely through local adaptation. Instead, they demand what Murray Gell-Mann (1994) termed a *"crude look at the whole"*—a wide-angle perspective capable of capturing structural dynamics and emergent properties, even when empirical detail remains fragmentary.

Two such transitions, separated by billions of years but comparable in structure, are particularly instructive: the emergence of eukaryotic cells (eukaryogenesis) and the unfolding of human macro-history. Each represents the rise of a new level of organization in the universe. Each resists explanation within narrow selectionist frameworks. And each illustrates the need for integrative, developmental perspectives that can make sense of processes of emergence, integration, and teleodynamics.

This article develops the analogy between eukaryogenesis and human history. It argues that both processes are singular, unrepeatable, and insufficiently captured by evolutionary reductionism. Both are best understood through systems-dynamics approaches that emphasize integration, phase transitions, and emergent attractors.

Eukaryogenesis as a Singular Transition

Eukaryogenesis is widely recognized as one of the major transitions in the history of life (Maynard Smith & Szathmáry, 1995). It refers to the origin of eukaryotic cells, which occurred around 1.8–2 billion years ago when prokaryotic lineages fused through endosymbiosis. The dominant interpretation, pioneered and championed by Lynn Margulis (1970; 1981), emphasizes that mitochondria and chloroplasts are the remnants of free-living bacteria incorporated into host cells. Genomic and biochemical evidence now confirms this symbiotic origin (Martin & Müller, 1998; Archibald, 2015).

What makes eukaryogenesis singular is its creative integration. It was not the accumulation of small mutational steps filtered by selection, but a merger of entire organisms into a new systemic whole. This merger generated novel capabilities: complex cytoskeletons, linear chromosomes, regulated gene expression, and energy-rich metabolism. These, in turn, enabled the rise of multicellularity and eventually complex ecosystems.

The scientific controversy surrounding Margulis' theory highlights the conceptual stakes. For decades, the Modern Synthesis—focused on gradual genetic change and selection—dismissed symbiogenesis as marginal. Margulis' work was resisted precisely because it foregrounded systemic merger, cooperation, and developmental transformation over competition (Sapp, 2009). Only with molecular evidence did her view gain wide acceptance.

Eukaryogenesis illustrates a general lesson: certain major transitions are better understood through frameworks of emergence, cooperation, and developmental integration than through gradual selectionist explanations.

Human Macro-History as a Singular Transition

Human history, when viewed at the scale of millions of years, exhibits a comparable singularity. It is not a repetitive evolutionary cycle but a developmental trajectory: a movement from hominin foraging bands to a globally interconnected society.

This trajectory can be analyzed through four control parameters that interact dynamically:

1. **Division of labor** – the foundational driver of social and economic complexity, enabling cooperative specialization (Durkheim, 1893/1997).

2. **Tools and technology** – from stone tools to digital infrastructures, progressively amplifying human capacities.

3. **Consciousness and symbolic information** – the evolution of language, abstract thought, and cultural memory (Donald, 1991; Deacon, 1997).

4. **Population dynamics –** demographic growth enabling survival, cultural diffusion, and later, pressures for integration.

Together, these parameters create feedback loops. Division of labor fosters innovation; technologies reshape consciousness; population growth drives new forms of organization. The result is not linear progress but punctuated transformations: phase transitions such as the agricultural revolution, the rise of states, the industrial revolution, and the emergence of global communication networks.

This spatiotemporal trajectory resembles what Waddington (1957) described as *homeorhesis*: a stabilized developmental path, not predetermined but canalized by systemic constraints. Just as the fertilized egg unfolds into an organism through dynamic processes, human macro-history unfolds as a developmental system in which integration is an emergent tendency.

The Limits of Selectionist Explanations

Both eukaryogenesis and human macro-history illustrate the inadequacy of strictly selectionist models.

In biology, Margulis' theory of symbiogenesis disrupted the Modern Synthesis by emphasizing cooperation, merger, and systemic integration. Today, the evidence is overwhelming: endosymbiosis was a decisive driver of complexity (Archibald, 2015). Yet the initial resistance reflected the deep hold of selectionist orthodoxy.

In history, attempts to frame cultural change as "cultural evolution" have often replicated Darwinian analogues: variation, selection, and retention (Mesoudi, 2011). While useful at certain scales, such approaches risk reductionism. They obscure the systemic, teleodynamic character of historical change, treating cultures as if they were genetic replicators. As critics note, the assumptions of unidirectional causation and passivity that underpinned the Modern Synthesis are problematic even in biology (Oyama et al., 2001). To impose them on human history is doubly misleading.

The analogy with eukaryogenesis underscores this point. Just as symbiogenesis could not be adequately described in Darwinian terms, human macro-history cannot be reduced to cultural evolution. Both require conceptual frameworks that capture emergence, cooperation, and systemic thresholds.

Developmental Systems and Teleodynamics

Developmental systems theory provides such a framework. Waddington's concept of *homeorhesis* emphasized that development is not the unfolding of a preformed plan but the stabilization of trajectories within a dynamic landscape. Esther Thelen and Linda B. Smith (1994) later applied similar thinking to cognitive development, showing how infant behavior emerges from the interaction of multiple constraints.

René Thom's catastrophe theory (1975) added mathematical tools for describing sudden transitions into new attractor states. Though controversial in its heyday, it remains valuable as a metaphorical and structural guide: complex systems can undergo bifurcations that reconfigure their dynamics.

Terrence Deacon's (2012) concept of *teleodynamics* deepens this insight. Teleodynamic systems are not externally goal-directed but generate their own ends through emergent constraints. Living systems, developmental processes, and—by extension—historical trajectories exhibit such properties. Human macro-history, understood in this way, is a teleodynamic process: not predetermined, but shaped by emergent attractors generated by its own dynamics.

From this perspective, the control parameters of history—division of labor, technology, consciousness, and population—function like developmental regulators. Their interaction channels the system toward integration, just as cellular processes channel embryogenesis.

Historical phase transitions resemble bifurcations, where small shifts in control parameters lead to new global patterns.

Crude Looks and the Problem of Missing Data

A striking commonality between eukaryogenesis and human history is the impossibility of complete reconstruction. Fossil evidence of early eukaryotes is sparse; the decisive steps of endosymbiosis remain hidden in deep time. Similarly, the lived details of human history—the countless unrecorded practices, ideas, and interactions—are lost.

Yet in both cases, we can understand the whole without knowing every part. Genomic evidence allows us to infer the symbiotic origins of eukaryotes. Archaeological, anthropological, and historical evidence allows us to trace the trajectory of human societies. What matters is not exhaustive data but the recognition of structural dynamics: why and how systems crossed thresholds into new organizational levels.

This is precisely what Gell-Mann (1994) meant by a “crude look at the whole.” To insist on micro-level completeness before forming macro-level understanding is to miss the larger picture. Some of the most important transitions in the universe are intelligible only at the scale of wholes.

Conclusion

Eukaryogenesis and human macro-history are both singular transitions in the unfolding of complexity. Each represents the emergence of a new level of organization. Each resists reduction to selectionist accounts. Each can never be fully reconstructed from empirical detail alone.

What unites them is their demand for integrative perspectives—developmental systems thinking, catastrophe theory, teleodynamics, and the willingness to take crude looks at the whole. Just as eukaryogenesis inaugurated a new biological attractor, human macro-history may be understood as movement toward an emergent global attractor: a conscious, integrated society.

The analogy is not metaphorical flourish. It points to a general truth about complexity: the universe’s most transformative processes cannot be understood through reduction alone. They require frameworks capable of grasping emergence, integration, and teleodynamics. By recognizing this, we may sharpen our understanding of both life’s deep past and humanity’s unfolding future.

References

- Archibald, J. M. (2015). *One Plus One Equals One: Symbiosis and the Evolution of Complex Life.* Oxford: Oxford University Press.
- Clemmensen, B. (in preparation). *Navigating Human History: A Systems Dynamics Approach to Our Global Future.*
- Deacon, T. (1997). *The Symbolic Species: The Co-Evolution of Language and the Brain.* New York: W.W. Norton.
- Deacon, T. (2012). *Incomplete Nature: How Mind Emerged from Matter.* New York: W.W. Norton.
- Donald, M. (1991). *Origins of the Modern Mind: Three Stages in the Evolution of Culture and Cognition.* Cambridge, MA: Harvard University Press.
- Durkheim, É. (1893/1997). *The Division of Labor in Society.* New York: Free Press.
- Gell-Mann, M. (1994). *The Quark and the Jaguar: Adventures in the Simple and the Complex.* New York: W.H. Freeman.
- Margulis, L. (1970). *Origin of Eukaryotic Cells.* New Haven: Yale University Press.
- Margulis, L. (1981). *Symbiosis in Cell Evolution.* San Francisco: W.H. Freeman.
- Martin, W., & Müller, M. (1998). The hydrogen hypothesis for the first eukaryote. *Nature*, 392(6671), 37–41.
- Maynard Smith, J., & Szathmáry, E. (1995). *The Major Transitions in Evolution.* Oxford: Oxford University Press.
- Mesoudi, A. (2011). *Cultural Evolution: How Darwinian Theory Can Explain Human Culture and Synthesize the Social Sciences.* Chicago: University of Chicago Press.
- Oyama, S., Griffiths, P. E., & Gray, R. D. (Eds.). (2001). *Cycles of Contingency: Developmental Systems and Evolution.* Cambridge, MA: MIT Press.
- Sapp, J. (2009). *The New Foundations of Evolution: On the Tree of Life.* Oxford: Oxford University Press.
- Thelen, E., & Smith, L. B. (1994). *A Dynamic Systems Approach to the Development of Cognition and Action.* Cambridge, MA: MIT Press.
- Thom, R. (1975). *Structural Stability and Morphogenesis.* Reading, MA: Benjamin.

- Waddington, C. H. (1957). *The Strategy of the Genes.* London: Allen & Unwin.