

Cognition-Based Evolution

Subjects: Evolutionary Biology

Contributor: William Miller, Jr.

Cognition-Based Evolution (CBE) asserts a comprehensive alternative approach to phenotypic variation and the generation of biological novelty. In CBE, evolutionary variation is the product of natural cellular engineering that permits purposive genetic adjustments as cellular problem-solving. CBE upholds that the cornerstone of biology is the intelligent measuring cell. Since all biological information that is available to cells is ambiguous, multicellularity arises from the cellular requirement to maximize the validity of available environmental information. This is best accomplished through collective measurement purposed towards maintaining and optimizing individual cellular states of homeorhesis as dynamic flux that sustains cellular equipoise. The collective action of the multicellular measurement and assessment of information and its collaborative communication is natural cellular engineering. Its yield is linked cellular ecologies and mutualized niche constructions that comprise biofilms and holobionts. In this context, biological variation is the product of collective differential assessment of ambiguous environmental cues by networking intelligent cells. Such concerted action is enabled by non-random natural genomic editing in response to epigenetic impacts and environmental stresses. Random genetic activity can be either constrained or deployed as a 'harnessing of stochasticity'. Therefore, genes are cellular tools. Selection filters cellular solutions to environmental stresses to assure continuous cellular-organismal-environmental complementarity. Since all multicellular eukaryotes are holobionts as vast assemblages of participants of each of the three cellular domains (Prokaryota, Archaea, Eukaryota) and the virome, multicellular variation is necessarily a product of co-engineering among them.

Keywords: self-reference ; natural genetic engineering ; natural cellular engineering ; cognition-based evolution ; senome ; niche construction ; holobiont

1. Introduction

Traditional Neo-Darwinian precepts have been richly modified over the last several decades but remain centered within several enduring pillars: (a) evolution is primarily due to random genetic variations; (b) such variations are subject to differential selection across a fitness landscape; (c) the resulting process of descent through modification is necessarily gradual; and (d) the target of selection is the visible macroorganic form ^{[1][2]}.

The essentials of Cognition-Based Evolution (CBE) as an alternative to Neo-Darwinism have been previously enumerated ^{[3][4][5][6][7][8][9][10][11]}. CBE upholds that cellular cognition underscores biology and its evolutionary development. Life is both defined and characterized by self-referential awareness as basal cognition ^{[3][4][12][13][14][15]}. Cellular intelligence is the uniformly exhibited property of self-referential assessment of information at its scale ^{[3][4][7][13][16][17][18][19][20][21]}. Accordingly, intelligent cells can receive, assess, communicate, and deploy information to sustain individual states of self-integrity. Importantly, this process of information assessment is characterized by inherent self-reference. It is argued that it is this 'knowing' quality, as instantiated within the cellular form billions of years ago, that separates living entities from automata or machines. This sense of 'self' is crucial to biology since the defense of 'self' defines biological development and its immunological context. Hence, when cells sense and deploy information, it represents cellular problem-solving as its bioactive means of maintaining self-directed homeorhesis as states of dynamic flux that support cellular equipoise ^{[3][4][7][9][10][22]}. This type of discriminating self-referential assessment requires cellular measurement of both an internal status and the outward environment. Furthermore, cells abundantly communicate this measured information to other cells. This is not at all theoretical. Recent research demonstrates that during morphogenesis, cells use filopodia (actin-based finger-like protuberances from cell membranes) to coordinate angiogenesis as an active form of basal perception, time-keeping, and adaptive problem-solving ^[23].

It is this coordinating cell-cell communication that propels the linked tissue ecologies that enable living forms. Although there is no universally agreed-upon definition of basal cognition, in the introduction to their thematic issue, 'Basal cognition: conceptual tools and the view from the single cell', Lyon et al. ^[24] quote the well-recognized definition of Shettleworth: "Cognition refers to the mechanisms by which animals acquire, process, store, and act on information from the environment. These include perception, learning, memory, and decision-making" ^[25] (p. 5). Importantly, Lyon et al. ^[24]

categorically assert that this definition encompasses all living organisms, including microbes and further contend that the information-processing dynamics of all forms of life are part of a 'continuum' with human cognition. With that background, it specifically argued that basal cognition is embodied in the cellular form. This level of cognition enables capable cellular sensorimotor functions that can be directed to cell-centered problem-solving through self-referential measurement and directed cell–cell communication. Consequently, coordinate multicellularity is the product of natural cellular engineering and cellular niche construction as cellular problem-solving.

2. Details about Cognition-Based Evolution

All the essentials of multicellular life have emerged from unicellular particulars. Every aspect of present life has extended forward across billions of years from a distinguishable congruent point of initiation. Every cell has individual self-referential awareness that permits the assessment, deployment, and communication of information for contingent problem-solving. From within that base, Cognition-Based Evolution represents a consonant evolutionary alternative to the conventional contention that evolution is governed by random genetic variations. Instead, evolutionary development is energized by intelligent cells upholding their own fates through the measuring assessment of information and its deliberate communication. Consequently, cellular actions are based within measurement. It defaults that this represents cellular prediction. Therefore, it cannot be random. To enhance the validity of their measurements and improve their predictions, cells enter into multicellular collaborative associations. This enacts the multicellular ecologies that yield biofilms or holobionts. All of these are the product of the measured assessment of biological information among their varied participants. Collectively, this productive use of cellular information energizes as natural cellular engineering and mutualizing niche constructions. As these latter conjoin, phenotype emerges within biofilms or holobionts to cope with environmental stresses through the exploration of the outward environment and the acquisition of epigenetic information. As all such outcomes are dependent on the assessment of information, natural cellular engineering represents the bioactive expression of the cellular information management system. Through this means, collaborative cells integrate environmental cues to regulate life-cycle biological development and provide the propulsive thrust of evolutionary variation.

It has been previously asserted that every novel function derives from a pre-existing one ^[26]. However, how genetic variations actually become biological creativity had remained a mystery. It is maintained that the origins of biological variation in holobionts should be explored through the dimension of intelligent measuring cells. Through this means, varying patterns of environmentally responsive linked cellular ecologies are deployed to effect the continuous internalization of the outward environment in the constant defense of cellular self-integrity. Among their many threats, the cellular defense against intruding pathogens is paramount. In such circumstances, genes are tools of cells in engineering robust immunity directed towards cellular self-integrity. That intricate process and its ensuing variations are the result of predominately non-random natural genomic editing and engineering. Certainly though, random genetic variations do supervene. These may be silenced or deployed as cell-centered 'harnessing of stochasticity' to provide further engineering solutions to stress. Consequently, selection can now be assessed as an over-arching post-facto filter of antecedent natural cellular engineering solutions to cellular problems. Selection imposes continuous cellular-organismal-environmental complementarity in confrontation with environmental stresses and assures that consensual cellular measurements meet current environmental stresses with sufficient flexibility. All living forms attest to that success.

From these rudimentary beginnings, all life on the planet spills forward in its myriad variations. No matter the means by which genetic variations arise, their entire panoply is actively commissioned toward self-directed cellular problem-solving, perpetually maintaining the tenuous balance of symbiotic and competitive relationships across the cellular domains and the virome.

Within Cognition-Based Evolution, all adaptations culminate from the cellular measurement of information. Thus, biological development and evolution become sciences that interrogate cellular measurements in all its varied circumstances. Biology is the study of the implications of cellular self-referential cognition in all of its manifestations. This newly refocused biology yields to a rewarding congruity. Science is measurement and biology is the science of biological measurement. Consequently, biology can now be re-energized as the science of why, what, and with whom cells measure. Biology is the fullest exploration of how cells can perpetually internalize the planetary environment in the defense of individual self-identity.

Life began as the cognitive attachment to information space. Ambiguous information is its context. Biological measurement is its privilege. Communication is its means. Evolution is its yield.

References

1. Futuyma, D.J. Evolutionary Biology Today and the Call for an Extended Synthesis. *Interface Focus* 2017, 7, 20160145.
2. Koonin, E.V. *The Logic of Chance: The Nature and Origin of Biological Evolution*; Pearson Education: Upper Saddle River, NJ, USA, 2012; ISBN 978-0-13-254249-4.
3. Miller, W.B. Cognition, Information Fields and Hologenomic Entanglement: Evolution in Light and Shadow. *Biology* 2016, 5, 21.
4. Miller, W.B. Biological Information Systems: Evolution as Cognition-Based Information Management. *Prog. Biophys. Mol. Biol.* 2018, 134, 1–26.
5. Miller, W.B.; Torday, J.S. A Systematic Approach to Cancer: Evolution beyond Selection. *Clin. Transl. Med.* 2017, 6.
6. Miller, W.B.; Torday, J.S. Four Domains: The Fundamental Unicell and Post-Darwinian Cognition-Based Evolution. *Prog. Biophys. Mol. Biol.* 2018, 140, 49–73.
7. Miller, W.B., Jr.; Torday, J.S.; Baluška, F. Biological Evolution as Defense of “Self”. *Prog. Biophys. Mol. Biol.* 2019, 142, 54–74.
8. Miller, W.; Torday, J.; Baluška, F. The N-Space Episenome Unifies Cellular Information Space-Time within Cognition-Based Evolution. *Prog. Biophys. Mol. Biol.* 2020, 150.
9. Miller, W.B.; Baluška, F.; Torday, J.S. Cellular Senomic Measurements in Cognition-Based Evolution. *Prog. Biophys. Mol. Biol.* 2020, 156, 20–33.
10. Torday, J.; Miller, W., Jr. *Cellular-Molecular Mechanisms in Epigenetic Evolutionary Biology*; Springer Nature: Cham, Switzerland, 2020.
11. Leitão, A.L.; Costa, M.C.; Gabriel, A.F.; Enguita, F.J. Interspecies Communication in Holobionts by Non-Coding RNA Exchange. *Int. J. Mol. Med. Sci.* 2020, 21, 2333.
12. Shapiro, J.A. *Evolution: A View from the 21st Century*; FT Press Science: Saddle River, NJ, USA, 2011; ISBN 978-0-13-278093-3.
13. Baluška, F.; Levin, M. On Having No Head: Cognition throughout Biological Systems. *Front. Psychol.* 2016, 7.
14. Reber, A.S. *The First Minds: Caterpillars, Karyotes, and Consciousness*; Oxford University Press: Oxford, UK, 2018; ISBN 978-0-1-085415-7.
15. Slijepcevic, P. Natural Intelligence and Anthropic Reasoning. *Biosemiotics* 2020, 13, 285–307.
16. Ford, B.J. Are Cells Ingenious? *Microscope* 2004, 52, 135–144.
17. Ford, B.J. On Intelligence in Cells: The Case for Whole Cell Biology. *Interdiscip. Sci. Rev.* 2009, 34, 350–365.
18. Ford, B.J. Cellular Intelligence: Microphenomenology and the Realities of Being. *Prog. Biophys. Mol. Biol.* 2017, 131, 273–287.
19. Dodig-Crnkovic, G. Modeling Life as Cognitive Info-Computation. In *CiE 2014: Language, Life, Limits*; Beckmann, A., Csuhaaj-Varjú, E., Meer, K., Eds.; Springer International Publishing: Cham, Switzerland, 2014; pp. 153–162.
20. Lyon, P. The Cognitive Cell: Bacterial Behavior Reconsidered. *Front. Microbiol.* 2015, 6, 264.
21. Baluška, F.; Reber, A. Sentience and Consciousness in Single Cells: How the First Minds Emerged in Unicellular Species. *Bioessays* 2019, 41, 1800229.
22. De Loof, A. From Darwin's On the Origin of Species by Means of Natural Selection...to the Evolution of Life with Communication Activity as its Very Essence and Driving Force (=Mega-Evolution). *Life Excit. Biol.* 2015, 3, 153–187.
23. Zakirov, B.; Charalambous, G.; Aspalter, I.M.; van-Vuuren, K.; Mead, T.; Harrington, K.; Thuret, R.; Regan, E.R.; Herbert, S.P.; Bentley, K. Active Perception during Angiogenesis: Filopodia Speed Up Notch Selection of Tip Cells in Silico and in Vivo. *bioRxiv* 2020.
24. Lyon, P.; Keijzer, F.; Arendt, D.; Levin, M. Reframing Cognition: Getting Down to Biological Basics. *Phil. Trans. R. Soc. B.* 2021, 376.
25. Shettleworth, S.J. *Cognition, Evolution, and Behavior*; Oxford University Press: Oxford, UK, 1998; ISBN 978-0-19-988638.
26. Kassen, R. Experimental Evolution of Innovation and Novelty. *Trends Ecol. Evol.* 2019, 34, 712–722.

