



Consciousness, Redux

J.S. Torday

Evolutionary Medicine Program, UCLA, Westwood, CA, United States

ABSTRACT

There have been many attempts to explain consciousness, ranging from Plato's archetypes, to Descartes' 'Mind-Body Dualism', and more recently to Chalmers' Qualia, and Andy Clarke's extended mind. Yet none of these conceptualizations of consciousness provide empiric evidence for what consciousness actually constitutes. The present hypothesis is that Consciousness is a product of the Singularity/Big Bang resulting from the endogenization of factors in the environment that have formed our physiology. Understanding the origin of consciousness as the Consciousness of the Singularity/Big Bang requires that it diachronically cuts across space-time. Consciousness functions based on the same data operating system as Cosmology. We can transcend consciousness and approach Consciousness by authoring our own software once we recognize this fundamental, mechanistic interrelationship.

Introduction

Conventionally, consciousness is described synchronically (within the same space-time) as the state of being aware of one's existence, sensations, thoughts and surroundings [1]. There have been many theories regarding the nature of consciousness, ranging from Plato's archetypes, to Descartes' 'Mind-Body Dualism', to Chalmers' Qualia [2] and Andy Clarke's extended mind [3]. Yet none of these conceptualizations of consciousness have determined what consciousness actually constitutes. Even the challenge by Nagel to answer the question "What is it like to be a bat?" [4] has remained unresolved. This enigma is further challenged when seen in light of Libet et al.'s experiment showing a measurable time-delay between our reaction to a stimulus and the brain processing it, suggesting that there is an unknown mechanism that underlies mind [5]; or Majour's observation that patients recovering from general anesthesia recapitulate the evolution of the brain [6], indicating that mind is integral to the body. But how and why? Hameroff and Penrose have hypothesized that the microtubules of the neurons act as a network in the brain for consciousness [7], yet every cell of the body has microtubules, opening up to the possibility that consciousness is the aggregate of cell-cell signaling throughout the body, in which electrical signaling plays a key role [8,9].

Hypothesis It is hypothesized that Consciousness is the diachronic (across space-time) product of the Singularity/Big Bang resulting from the evolutionary endogenization of factors in the environment that have formed our physiology.

Evaluation of the hypothesis

Nowhere is that more evident than in Hobson et al.'s observation that the brain 'cools' during Rapid Eye Movement Sleep, inferring that it had been warm, referencing the evolution of warm-bloodedness [10]. That process began with the stress of transitioning from water to land some 500 million years ago. The oceans began drying up in response to accumulating carbon dioxide in the atmosphere, causing a 'greenhouse effect' [11], forcing boney fish out of water onto land. It was the force of gravity on the skeleton increasing on land, in combination with the evolution of the lung, kidney and skin mediated by the duplication of the Parathyroid Hormone-related Protein (PTHrP) Receptor [12]. The episodic stress of inadequate oxygen due to the step-wise evolution of the lung from the swim bladder stimulated the Hypothalamic-Pituitary-Adrenal Axis, increasing adrenaline production that alleviated the inefficient alveoli of the lung by increasing the production of lung surfactant [12]. Ultimately, that conditional response also increased the secretion of free fatty acids from fat cells, providing substrate for metabolism, increasing body temperature; that adaptive response was later replaced by the genetic expression of oxytocin as the regulator of body heat [13].

The following is a radical departure from the teleological way of thinking about consciousness as function [14]. In her article "Is Matter Conscious" Morch [15] relates that the 'mystery' of consciousness lies in whatever process determines the structure of matter, and that for that reason, matter has consciousness. Morch, like literally everyone else delving into this subject, is subverted by a descriptive,

E-mail address: jtorday@ucla.edu (J.S. Torday)

synchronic approach to consciousness. The Singularity/Big Bang was hypothesized to have been the origin of the Cosmos [16]. The paradox is that consciousness is the vectorial product of the Singularity/Big Bang [17], along with everything else in the Cosmos. But the problem with consciousness in particular is that it is actually the embodiment of the Singularity/Big Bang; as Schopenhauer had said in response to Kant's definition of matter- we understand matter because we are it [18]. But in order to truly understand the intimate relationship between consciousness and matter you must approach it from a diachronic perspective for evolution theory, as follows.

Evolution, from the beginning

Unicellular organisms biologically dominated the earth for the first 3.5 billion years [19]. It has been hypothesized that life emerged on earth as a product of the lipids present in the snowball-like asteroids that pelted the earth prior to the formation of the oxidative atmosphere to form the oceans [20]. When lipids are immersed in water they spontaneously form primitive 'cells', or micelles [21]. Within these structures, defined by their semi-permeable lipid membranes, life began as negative entropy [22], sustained by chemiosmosis [23], controlled by homeostasis [24]. Lynn Sagan had hypothesized that cells evolved through the process of endosymbiosis [25], internalizing factors in the environment that would otherwise have destroyed them, such as heavy metals (iron, zinc), ions (sodium, potassium), gases (oxygen, nitrogen), and bacteria. In the aggregate, the compartmentalizing of these environmental threats within the cell, making them useful is what we refer to as physiology [26].

Over time, prokaryotic bacteria devised pseudo-multicellular forms like biofilm [27] and Quorum Sensing [28], threatening the existence of unicellular eukaryotes, which have a true nucleus. In response, eukaryotes devised cell-cell communications, which ultimately gave rise to multicellular organisms, the communications evolving into the homeostatic regulatory mechanisms that characterize metazoans [8]. At the level of the organism, such homeostatic regulatory mechanisms are referred to as allostasis [29]. Allostasis, in turn, can be thought of as interoception, i.e. being conscious of our internal organs, which is what we ultimately think of as consciousness [30]. Thought of in this way, consciousness has evolved directly from the environment, being assimilated to form physiologic traits. And because those traits are founded on Natural Laws, consciousness is the 'organification' of the physical environment.

Another way to think of consciousness metaphorically is as a Data Operating System, founded on the Singularity/Big Bang, homeostasis originating from the 'equal and opposite reaction' due to Newton's Third Law of motion, which generated matter from energy. Upon being endogenized, those environmental factors that were internalized were assimilated as proxies for the Laws of Nature. Therefore, the internal and external environments both ascribe to the same set of natural principles, like computer software and hardware. This is why hominins comply with the prevailing Laws of Nature.

Why we see 'red' when we are in pain?

David Chalmers has posed the 'hard question' [2], why we see red when we injure ourselves. It is not intuitively obvious why this should be the case, but seen from the perspective described above, consciousness must integrate the individual with the Cosmos itself in order to sustain homeostasis in sync with the First Principles of Physiology [31]. In order to accomplish that, the organism must remember its origins, all the way back to the Singularity/Big Bang. It does so through the cell-cell communication mechanisms that facilitated evolution, culminating in homeostasis as the mechanism for both sustaining and also for re-establishing homeostasis [32] when the system is injured or stressed, mediating the process of evolution [8].

That is to say, when homeostasis is disrupted the cellular signaling partners will re-engineer themselves until they have re-established homeostasis, or die and/or become extinct. Over the course of development, such mechanisms are informed by epigenetic inheritance of 'marks' in the environment that are found to pose an existential threat, the former being determined by meiosis, mitosis and ultimately by homeostasis.

Re-establishment of cellular-homeostasis

Once the offspring is autonomous, the same homeostatic monitoring system directs the cellular partners to remodel in order to re-establish homeostasis either for injury/repair, epigenetic adaptation, or evolutionary adaptation [32] as a function of the time-frame. Under acute circumstances the cells will re-establish homeostasis by scarring; on a longer-term basis between generations, the signaling cells will remodel the structure-function developmentally [33]; and on a phylogenetic scale, the cells will re-engineer themselves due to environmental stress, internal physiologic stress generating Radical Oxygen Species due to shearing of the walls of the microvessels, causing gene mutations and duplications [34] that further promote re-engineering of the structure-function relationships to re-establish homeostasis, giving rise to new species [9].

Over the course of such re-engineering, the nervous system, which has evolved to monitor homeostasis, must also re-establish its capacity to monitor the tissue, undergoing changes in structure-function [35]. That vertical integration of structure-function and neuronal monitoring are the basis for associating pain with seeing red as a comprehensive perception of properties of the organizational physiologic hierarchy, as follows.

Recapitulation of the evolutionary principle of cell-cell communication

The hard problem, no more.....

Given the cellular re-engineering of tissues, there must also be mechanisms for recapitulating allostasis at the organismal level. Such processes emanate from the neuroendocrine hormones that have evolved for this role, acting to integrate the structure and function of tissues at the organismal level. The classic example is the way in which endothermy evolved from the *ad hoc* relief of hypoxia caused by the step-wise process of cell-cell interactions for lung evolution [12], the diameter of the alveoli becoming smaller and smaller in order to increase the surface area-to-blood-volume ratio [36]. Briefly, hypoxia stimulated the Pituitary-Adrenal Axis, increasing the production of adrenaline by the adrenal cortex [37]. The stimulation of adrenaline acutely alleviated the constraint of the alveoli for gas exchange by stimulating surfactant production [38], allowing the alveoli to further expand; that effect acutely increases gas exchange and alleviates the hypoxia. In the longer-term, Parathyroid Hormone-related Protein production by the alveolar type II cells is increased by the distension of the alveoli [39], enhancing alveolar formation [40]. Ultimately, the *ad hoc* stress mechanism for increased oxygenation was superseded by the production of oxytocin by the Hypothalamus, acting to control body temperature constitutively [13]. Oxytocin also determines physiologic interactions between the cone photoreceptors for color vision and the retinal photoreceptor epithelium [41], which may be why we associate 'red' with physical pain, such as the hypoxial pain of long-distance running.

The integration of consciousness and the ecosystem as disembodied mind

Another looming question in the realm of Consciousness that is instructive is Andy Clark's 'disembodied consciousness' [3]. He uses

an example of taking notes as a way to ‘extend’ consciousness into the environment, which is not unlike the burgeoning concept of Niche Construction as a way ‘extending’ the internal physiologic environment out into the surroundings as a way for the organism to gain more control over its domain [42].

Historically, Darwin was actually the first to observe this phenomenon, noting that earthworms are able to retain their aquatic kidneys on land by manipulating the soil around them [43]. That practice is like beavers building dams, or hominins building villages, cities, and Nation States. That concept has now been merged with the unicell as the means of evolving, hypothesizing that it was the first Niche Construction, extrapolating from Endosymbiosis to Niche Construction, the combination effectively unifying evolutionary biology and ecology as one integrated process [44]. And when seen from the perspective of consciousness as the internalization of the Cosmos, it links the unicell to Cosmology as a holistic effort for mind and matter as a unity [15].

This way of thinking about the relationship of biology to physics runs counter to the way we currently think of the hominin condition, somewhere along a line of identity between the ambiguity of our origins and coping through deception.

Science is the only tool we have for extricating ourselves from this condition, formed by reasoning after the fact about our origins and trajectory as ‘Just So Stories’ [45]. On the other hand, David Bohm has explained that this situation has come about due to our highly evolved senses filtering our perception of the Explicate Order in order to survive [46], but that there is an Implicate Order just over the horizon that is obtainable by the scientific method. That is the premise for the cellular approach to evolution based on embryologic mechanisms of cell-cell communication, providing a way of understanding structure and function systematically [8]. By tracing such cellular communications back in space and time, the how and why of lung evolution has been elucidated, for example [47]. Turning the process of development for form and function around 180 degrees has made otherwise dogmatic concepts transparent, ranging from evolution itself [8], to the cell [48], heterochrony [49], the life cycle [50], phenotype [51], terminal addition [52] and homeostasis [32].

Human Consciousness, a case study in cell-cell communication

Human consciousness is widely considered to be the epitome of consciousness, given what we can do intellectually compared with other species. The reason for this seeming superiority is revealed by the reduction of warm-bloodedness [12]. Hominins have evolved the ability to walk on their hind legs [53] that trait would not have been possible in cold-blooded organisms because of the inefficiency of their metabolism, requiring multiple isoforms of the same enzyme in order to function optimally at different ambient temperatures. In contrast, mammals only require one form of any given metabolic enzyme, rendering their metabolism far more efficient. Which facilitated bipedalism, which requires more energy than walking on all fours [54]. Importantly, walking on our hind legs freed our forelimbs for specialized functions such as tool making and texting. In turn, such highly evolved traits required a more complex peripheral and central nervous system to accommodate such newly-acquired functions. And the combined effects of increased mobility and a more elaborate nervous system facilitated interfacing with the environment and the collection of epigenetic marks, given hominins have adapted to not only the four corners of the earth, but even to deep space. And the interplay of endothermy, locomotion and epigenetics fosters ever-more complex consciousness in hominins.

Is the mind ‘software’

The case is being made for consciousness to be derivative of Consciousness as the way we intuit the Cosmos and the Laws of Nature. As such it is analogous with computer components, Consciousness being the Data Operating System (DOS), consciousness being the software. As such, the software does not know that it is functioning under the aegis of the DOS, only perhaps that there is something greater than itself. Similarly, we are not actively aware of our relationship to the Cosmos, but we also sense that there is something greater than ourselves. But if we were made aware of that interrelationship, perhaps we could program ourselves to function on a higher plane. That is what David Bohm is suggesting in “Wholeness and the Implicate Order” [46]. That is unlike Raymond Kurzweil’s vision of the Singularity of technology [55], gadgets assisting us in the Explicate Order, perpetuating the synchronic view of existence, whereas self-engineering our software to transcend the Explicate and move closer and closer to the Implicate Order is a quantum leap.

A cartesian coordinate approach to consciousness

It has been proposed that ‘life is simple’ [50], but that we complicate it because we exist between ambiguity and deception [56], so we cope by making up “Just So Stories” [45]. This insight has largely derived from combining cell-cell communication as the mechanism of evolution [8] with epigenetic inheritance, the latter leading to the realization that the zygote is the primary level of selection. That perspective is like the one expressed by the Red Queen in “Alice in Wonderland” running as fast as she can to stay in place [57]. We too are doing that in service to the First Principles of Physiology, which ultimately reference the Singularity [57]. The complexities of biology as Darwin’s Tangled Bank metaphor [58] are epiphenomena of the Phenotype as Agent [51], the Rube Goldberg frills and flourishes acting to optimize the adult organism’s capacity to collect data from the on-coming environment. This diachronic, across space-time perspective leads to the realization that time is an anthropomorphization [59], leaving the dimension of space as the default mode [60]. And space can be reduced to a point-source [61] without time. By reverse-engineering specific phenotypic traits like the lung, kidney, skin and brain [see Fig. 1] from their present forms to the unicell, their paths project back to the origin of the Cartesian Coordinates, or zero. That null condition approximates the

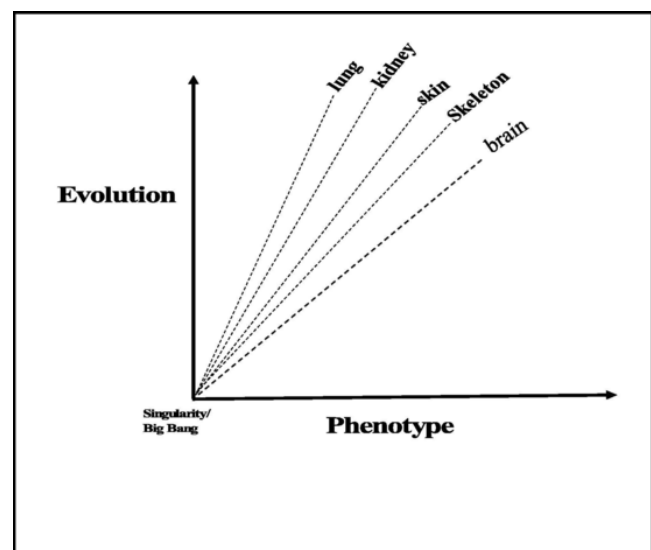


Fig. 1. Regression of Phenotypic Evolution. Cell-Cell interactions mediate the ‘evolution of metazoan organs, originating with the Singularity/Big Bang.

Singularity/Big Bang. As such, deeper investigation of the properties of the unicell will hypothetically provide further insights by facilitating the predicted transition from the Explicate to the Implicate Order [46]. In doing so would provide greater insight to such concepts in physics as Quantum Mechanics, String Theory, and the Higgs Boson, expanding our consciousness further and further towards our knowledge of Consciousness as the Singularity [17].

Consequences of the hypothesis and discussion

We commit a systematic error by thinking about Consciousness in anthropocentric terms [60]. Up until now we had no rational alternative, but a novel mechanistic approach to evolution based on cell-cell signaling has offered a way of understanding our evolutionary origins and causal basis for life as a continuum [8,9]. From that perspective, even the logic for “why we control a scientific experiment” [62] can be brought into question, revealing how we deceive ourselves [63] by reasoning after the fact using our subjective senses [46]. This realization reopens the case for Logical Empiricism [64], given that the cellular approach to evolution provides mechanistic explanations for dogmas ranging from the cell [48], to phenotype [51], heterochrony [49], and the life cycle [50]. It also has the power to predict that the zygote is the primary level of selection [50], leading to the conclusion that life is ‘simple’, not complex as we tend to think based on after the fact reasoning [65].

The approach taken here to understanding consciousness correlates with Platner and Verkhatsky’s perspective on the homologies between signaling in Paramecia and neurons [66], framing it in a cohesive context of evolution as all of biology [8,9,12]. As such, it is consistent with Trewavas and Baluska’s view of plants as conscious [67], effectively allowing Consciousness to encompass all organisms, unicellular, multicellular, plant and animal alike, linking it to the Cosmos through Endosymbiotic Theory [25,26]. This vantage-point offers the prediction that there is a demonstrable continuum from the unicell to Gaia [44], and the Singularity of Nature [17].

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgement

John S. Torday has been funded by National Heart Lung and Blood Institute grant HL055268.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.mehy.2020.109674>.

References

- [1] L Margulis, D Sagan What is Life? University of California Press 1995.
- [2] D Chalmers Facing up to the problem of consciousness. *J Consciousness Studies* 1995;2:200–219.
- [3] A Clark, D Chalmers The Extended Mind. *Analysis* 1998;1998(58):7.
- [4] Thomas Nagel What is it like to be a bat? *The Philosophical Review* 1974;83:435–450.
- [5] B Libet, E Wright, W Gleason Readiness potentials preceding unrestricted spontaneous pre-planned voluntary acts. *Electroencephalogr Clin Neurophysiol* 1983;54:322–325.
- [6] M B Kelz, G A Mashour The Biology of General Anesthesia from Paramecium to Primate. *Curr Biol* 2019;29:R1199–R1210.
- [7] S Hameroff, R Penrose Consciousness in the universe: a review of the ‘Orch OR’ theory. *Phys Life Rev* 2014;11:39–78.
- [8] J S Torday, V K Rehan Evolutionary Biology. Cell-Cell Communication and Complex Disease: Wiley; 2012.
- [9] J S Torday, V K Rehan Evolution, the Logic of Biology. Wiley; 2017.
- [10] J A Hobson, C C Hong, K J Friston Virtual reality and consciousness inference in dreaming. *Front. Psychol* 2014;5:1133.
- [11] A S Romer The Vertebrate Story. University of Chicago Press; 1949.
- [12] J S Torday A central theory of biology. *Med Hypotheses* 2015;85:49–57.
- [13] Y Kasahara, K Sato, Y Takayanagi, H Mizukami, K Ozawa, S Hidema, et al. Oxytocin receptor in the hypothalamus is sufficient to rescue normal thermoregulatory function in male oxytocin receptor knockout mice. *Endocrinology* 2013;154:4305–4315.
- [14] E Roux The concept of function in modern physiology. *J Physiol* 2014;592:2245–2249.
- [15] Morch HH. Is Matter Conscious?, *Nautilus* April 2017 6
- [16] Kurki-Suonio H. *Cosmology I*. University of Helsinki, 2018.
- [17] J S Torday The Singularity of nature. *Prog Biophys Mol Biol*. 2018;Aug 1.
- [18] A Schopenhauer The World as Will and Representation. Cambridge University Press; 2018.
- [19] C R Woese Bacterial Evolution. *Microbiol Rev* 1987;51:221–271.
- [20] Deamer D The Role of Lipid Membranes in Life’s Origin. *Life (Basel)* 2017;7(1).
- [21] Y Moroi Micelles. Springer; 2013.
- [22] I Schrodinger What is Life? Cambridge University Press; 1944.
- [23] P Mitchell Coupling of phosphorylation to electron and hydrogen transfer by a chemiosmotic type of mechanism. *Nature* 1961;191:144–148.
- [24] W B Cannon The Wisdom of the Body. WW Norton 1963.
- [25] L Sagan On the origin of mitosing cells. *J Theor Biol* 1967;14:255–274.
- [26] L Margulis, D Bermudes Symbiosis as a mechanism of evolution: status of cell symbiosis theory. *Symbiosis* 1985;1:101–124.
- [27] M A Ghannoum, M Parsek, M Whitley, P Mukherjee Microbial Biofilms. ASM Press; 2015.
- [28] S C Winans, B L Bassler Chemical Communication among Bacteria. ASM Press; 2008.
- [29] McEwen BS. Stress adaptation, and disease. Allostasis and allostatic load *Ann N Y Acad Sci* 840 1998 33 44
- [30] A Damasio Self Comes to Mind. Vintage; 2010.
- [31] J S Torday, V K Rehan Lung evolution as a cipher for physiology. *Physiol Genomics* 2009;38:1–6.
- [32] J S Torday Homeostasis as the Mechanism of Evolution. *Biology (Basel)* 2015;4:573–590.
- [33] F Demayo, P Mino, C G Plopper, L Schuger, J Shannon, J S Torday Mesenchymal-epithelial interactions in lung development and repair: are modeling and remodeling the same process? *Am J Physiol Lung Cell Mol Physiol* 2002;283:L510–L517.
- [34] S J Storr, C M Woolston, Y Zhang, S G Martin Redox environment, free radical, and oxidative DNA damage. *Antioxid Redox Signal* 2013;18:2399–2408.
- [35] M Madadi Asl, A Valizadeh, P A Tass Propagation delays determine neuronal activity and synaptic connectivity patterns emerging in plastic neuronal networks. *Chaos* 2018;28:106308.
- [36] J A Clements, J Nellenbogen, H J Trahan Pulmonary surfactant and evolution of the lungs. *Science* 1970;169:603–604.
- [37] D L Wong Why is the adrenal adrenergic? *Endocr Pathol* 2003;14:25–36.
- [38] E E Lawson, E R Brown, J S Torday, D L Madansky, H W Tausch Jr. The effect of epinephrine on tracheal fluid flow and surfactant efflux in fetal sheep. *Am Rev Respir Dis* 1978;118:1023–1026.
- [39] J Sanchez-Esteban, S W Tsai, J Sang, J Qin, J S Torday, L P Rubin Effects of mechanical forces on lung-specific gene expression. *Am J Med Sci* 1998;316:200–204.
- [40] L P Rubin, C S Kovacs, M E De Paepe, S W Tsai, J S Torday, H M Kronenberg Arrested pulmonary alveolar cytodifferentiation and defective surfactant synthesis in mice missing the gene for parathyroid hormone-related protein. *Dev Dyn* 2004;230:278–289.
- [41] P Halbach, D A Pillers, N York, M P Asuma, M A Chiu, W Luo, et al. Oxytocin expression and function in the posterior retina: a novel signaling pathway. *Invest Ophthalmol Vis Sci* 2015;56:751–760.
- [42] K Laland, J Odling-Smee, S Turner The role of internal and external constructive processes in evolution. *J Physiol* 2014;592:2413–2422.
- [43] C R Darwin The formation of vegetable mould, through the action of worms, with observations on their habits. John Murray; 1881.
- [44] J S Torday The cell as the first niche construction. *Biology (Basel)* 2016;5:2.
- [45] Kipling R. *Just So Stories*. Weathervane, 1978.
- [46] D Bohm Wholeness and the Implicate Order. Routledge; 2002.
- [47] J S Torday, V K Rehan The evolutionary continuum from lung development to homeostasis and repair. *Am J Physiol Lung Cell Mol Physiol* 2007;292:L608–L611.
- [48] J S Torday The cell as the mechanistic basis for evolution. *Wiley Interdiscip Rev Syst Biol Med*. 2015;7:275–284.
- [49] J S Torday Heterochrony as Diachronically Modified Cell-Cell Interactions. *Biology (Basel)* 2016;;5(1).
- [50] Torday J S Life Is Simple-Biologic Complexity Is an Epiphenomenon. *Biology (Basel)* 2016;;5(2).
- [51] J S Torday, W B Miller Jr. Phenotype as Agent for Epigenetic Inheritance. *Biology (Basel)* 2016;5(3).
- [52] J S Torday, W B Miller Jr. Terminal addition in a cellular world. *Prog Biophys Mol Biol* 2018;135:1–10.
- [53] F E Marino The evolutionary basis of thermoregulation and exercise performance. *Med Sport Sci* 2008;53:1–13.
- [54] P S Rodman, H M McHenry Bioenergetics and the origin of hominid bipedalism. *Am J Phys Anthropol* 1980;52:103–106.

- [55] R Kurzweil *The Singularity is Near*. Viking Books; 2005.
- [56] J S Torday, W B Miller Jr. The resolution of ambiguity as the basis for life: A cellular bridge between Western reductionism and Eastern holism. *Prog Biophys Mol Biol* 2017;131:288–297.
- [57] J S Torday Quantum Mechanics predicts evolutionary biology. *Prog Biophys Mol Biol*. 2018;135:11–15.
- [58] C Darwin *On the Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life*. John Murray; 1859.
- [59] J Canales *The Physicist and the Philosopher*. Princeton University Press; 2016.
- [60] P Rowlands *The Foundations of Physical. Law*. WSPC; 2016.
- [61] J S Torday, W B Miller Jr. The Unicellular State as a Point Source in a Quantum Biological System. *Biology (Basel)* 2016;5(2).
- [62] J S Torday, F Baluška Why control an experiment?: From empiricism, via consciousness, toward Implicate Order. *EMBO Rep* 2019;20:e49110.
- [63] R Trivers *The Folly of Fools*. Basic Books; 2014.
- [64] C G Hempel *Selected Philosophical Essays*. Cambridge University Press; 2000.
- [65] S A Kauffman *At Home in the Universe*. Oxford University Press; 1996.
- [66] H Plattner, A Verkhatsky The remembrance of the things past: Conserved signalling pathways link protozoa to mammalian nervous system. *Cell Calcium* 2018;73:25–39.
- [67] A J Trewavas, F Baluška The ubiquity of consciousness. *EMBO Rep* 2011;12:1221–1225.

UNCORRECTED PROOF