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Where minds begin: a commentary on Joseph LeDoux's the deep history of ourselves

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ABSTRACT

We are sympathic with LeDoux's primary goal here — to get a solid scientific grip on what has been dubbed one of the most elusive, important questions in scientific discourse, to identify the underlying biomolecular processes that give rise to consciousness. However, we have issues with the way he goes about it and have tried to present them in a constructive manner. Our commentary is built around our theory of the origins of minds, dubbed the Cellular Basis of Consciousness (CBC), and the empirical research that supports it. The CBC is based on the proposition that life and sentience are co-terminous, that life without subjectivity, feeling, without valenced perception, without the capacity to learn and lay down memories would have been an evolutionary dead-end. It could not have survived in the hostile, chaotic world in flux that dominated our planet four billion years ago. The biological sciences operate on the principle that all species, extant and extinct, evolved from the first prokaryotes. The CBC theory is founded on the principle that all expressions of emotion, perception, and cognition did as well.

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In *The Deep History of Ourselves* (DHO) LeDoux paints with abroad brush, one that invites admiration for what he's accomplished — which is nothing short of an expansive, well-formulated overview of the four-billion years of evolutionary biology that led, ultimately, to the "O" in the title. We're comfortable with his descriptions and overviews of the literature on the underlying neurophysiological processes that give rise to human conscious experiences but our fundamental approaches to these issues, and how they are best interpreted, differ. LeDoux differentiates and distinguishes. He isolates human consciousness from other forms of cognitive function, treats unconscious cognitive functions as dissociate from conscious functions and, in particular, treats human conscious processes as distinct in basic ways from those displayed by other species. As Jeffrey Sachs put it in his jacket

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blurb, LeDoux's goal is to answer the classic question: "How does our mind set us apart from other species." While LeDoux is willing to give birds and mammals some measure of higher mental life, the overall approach is one that separates, divides mental expression into distinct variations.

Our approach differs. Where LeDoux sees distinctions and differences, we see commonality and continuity; where he treats shifts in function across species as saltations, we view them as natural extensions of basic functions with common roots. Much of DHO emphasizes the research that supports the proposition that human consciousness is special and epistemically distinct from the forms of cognition expressed in other species. We recognize the unique forms of mentation that distinguish humans from other species but we do so in a framework that emphases continuity, where human cognitive processes lie at a pole on the spectrum of forms of sentience, where *consciousness* denotes a continuum of subjectivity, awareness — and not a mental state that only (or mainly) humans are privy to. Put another way, LeDoux treats human consciousness as a distinct *type*. We view it as a *token* of a singular type.

To that effect, we offer here a "friendly amendment" to LeDoux's thesis based on our recent theoretical and empirical efforts (Baluška & Reber, 2019, 2020, Baluška, Reber, et al., 2021; Baluška, Miller, et al., 2021; Reber & Baluška, 2020; Reber, 2019) — all of which are grounded on a rather simple proposition. Life and consciousness are co-terminous. Life appeared just once on this planet and it was cellular and sentient life. The first cell, endowed with its limiting membrane, allowed the distinction between a subjective interior and objective exterior. All species, extant and extinct, evolved from these original proto-cells. All forms of mental life, from the basic perceptual, acquisitional, and memorial processes present in unicellular bacteria, archaea and protozoa, to the sophisticated cognitive armamentarium of *Homo sapiens* followed that same evolutionary path. For reasons that we have trouble understanding, scientists, philosophers, and most laypersons embrace the view that all species evolved from those primal unicellular species but balk at the proposition that all forms of mental life, awareness, sentience or, if you prefer, *consciousness* did as well. We'll try to outline the reasons why they should embrace the CBC.

A short aside: Before describing the model, we want to insert a propaedeutic note to ward off possible terminological confusion. When *consciousness* is used in contemporary cognitive sciences, the first thought that most have is that the topic is human consciousness. The reasons are obvious. We're human. We're conscious, have qualia, awareness, phenomenal experiences, engage in a wide variety of cognitive functions and often muse about philosopher David Chalmers' "Hard Problem." How does this mental state come about? How does the brain make the mind? How does mere matter make the mental?

Because our approach differs from Chalmers' (and LeDoux's), we want to caution against making this initial move. Starting with human mental life, human consciousness invites a particular program of research, one where the efforts begin with human consciousness and *Homo sapiens* brains and the evolutionary tree is searched for species that display either: a) behaviors that are deemed to qualify as evidence of cognitive processes or, b) cerebral structures and pathways that are analogues of relevant ones identified in humans. The research programs that have taken this approach have produced a rich, fascinating literature and we're enthusiastic supporters of it. But they are not going to lead to the core issue: identifying the origins of minds, the beginnings of conscious cognitive functions. In fact, what they have led to is a series of squabbles among researchers, each of whom has come to different conclusions about the species and clades in which consciousness first emerged (see below and, for more detail, Reber, 2019).

To keep from going down this road, we're going to take a "folk psychology" approach in our terminology and not try to nail down the precise lexicographic elements of each.[1] We're going to favor the term *sentience* as referring to mental states marked by valenced feelings, awareness, internal representational states, qualia, perceptual functions. But we're also going to use a variety of synonyms and near synonyms – including *conscious*, *cognitive*, *mental*, *phenomenal*, and *perceptual*. When we do we're not necessarily referring to the human variety of these processes for reasons that will become clear. Human consciousness may be the most developed form of sentience but it isn't a separate function. It lies, as noted above and developed more below, on a continuum that began with the first life forms and evolved over several billion years. Hopefully, seeing our approach from this vantage point will prevent confusions about what we are trying to accomplish – which is to make the case that all living forms are sentient, that the most primitive unicellular species, the prokaryotes, have an existentially secure consciousness.

Our model, the Cellular Basis of Consciousness (CBC), is based on cells, sentient cells. The theory and its entailments were developed in depth in *The First Minds* (TFM) and did not sit well with LeDoux. On page 206, he writes: "In his book *The First Minds*, Arthur Reber claims that because bacteria exhibit phototaxic responses, they have cognitive minds. In my opinion, the equation of cognition with the ability to generate a response to environmental stimulation stretched the term so far as to make it meaningless."

This comment made us wonder if LeDoux actually read TFM. One of us wrote the book and the other was a consultant on issues of cell biology. TFM presents, in considerable depth, data showing that prokaryotes display associative learning, including the learning of simple patterns, form stable memories, make decisions, anticipate upcoming events, evaluate the nutrient content of molecules, react adaptively to toxic substances on a time-scale

of seconds, locomote in deliberative ways, and communicate with each other using distinct molecular messengers that are modified to match the circumstances. We've presented evidence that bacteria also display valenced reactions to events in their environment, respond to anesthetics, control membrane permeability to allow nutrients and benign molecules to enter while blocking potentially harmful molecules, and mark time with internal clocks (Baluška & Reber, 2019, 2020, Baluška, Reber, et al., 2021; Baluška et al., 2016). Interestingly, LeDoux mentions several of these behaviors of prokaryotes but gives a different interpretation of the meaning of them and their place in evolution. Why he trivialized the message in TFM is a mystery to us.

LeDoux's position is that only some species have an ontologically secure cognition, that it "... is a feature that only evolved in animals, and only in some of them" and that it is only found in those animals that "... have nervous systems that can form, store, and use representations" (pp. 206–207). He is not alone in taking this stance. Versions of it are in Ginsburg and Jablonka (2019), Dennett (2017), Feinberg and Mallatt (2013) and quite a few others. Interestingly, each of these efforts identifies a different point in evolution where true consciousness and cognition are speculated to emerge. LeDoux concludes that only birds and mammals have the requisite functions and underlying neurophysiology. Pepperberg (2002) agrees about (some) birds. Ginsburg and Jablonka put the mental "emergent moment" when an "unlimited associative learning" process made its appearance during the Cambrian explosion. Feinberg and Mallatt take a different route. They identified a set of four features needed for consciousness: referral, mental unity, mental causation, and qualia but also arrive at the Cambrian. Klein and Barron (2016) argue that consciousness first appeared in insects and Godfrey-Smith (2016) points to octopuses, cuttlefish and other cephalopods. In the rather restrictive approach of linguist Euan Macphail (1998), it didn't put in an appearance until modern humans evolved. In reviewing these various models we noted something interesting. Theorists tend to identify the emergent moment as occurring in the species their research focuses on. LeDoux, of course, is a prominent cognitive neuroscientist specializing in the emotive, cognitive, and behavioral functions of adult human beings. In short, consciousness is found where one is looking. And the reason is obvious: it was always there.

We think it's important to appreciate a simple observation that is often ignored and was not touched on by LeDoux. A "dumb" organism, one lacking sentience, would have been a Darwinian dead-end. It simply could not have survived the chaotic *ur*-environment – a world in flux with constant shifts in nutrients, temperature, with multiple viruses and a variety of toxic molecules and chemicals – without an internal, felt, experienced, phenomenal, valenced sentience. They had "the first minds" and all other

species, extant and extinct, used it as the biomolecular platform for the evolution of more complex forms of mental life.

Importantly, while our styles differ, we became fans of LeDoux and his thorough, learned overview. The tale is told with scholarly grace as LeDoux traces the four billion-year voyage from the first precursors of life to where we are today, with *Homo sapiens* and our quite remarkable consciousness — one with the mental dexterity that allows a LeDoux to write a book like DHO and, of course, allows us to offer a commentary on it.

The essence of our offering, our "amendment," is that LeDoux could acknowledge the core position of the CBC that all life forms are sentient and not have to change much and, importantly, a number of problems that bedevil DHO would be resolved. For example, LeDoux states that ". . . basic cognitive capacities like outcome-dependent instrumental responses, are present in mammals and birds, but have not been demonstrated in other species" (p. 34). But they have. Bacteria make deliberative communicative responses to others in a colony when they detect that critical mass has been reached (through *quorum sensing*) that threatens their well-being. The message informs other cells (those on the periphery) of a nutrient deficit. These outer cells modify cell division and feeding until metabolic balance has been restored, at which point the cells in the interior secrete a different molecule that essentially says, "we're okay now" and the collective's functions return to normal. Note that this behavior, which has been observed both within and between colonies and species, has the critical earmarks of a primitive form of altruism (see Beagle and Lockless, 2015 and Liu et al., 2015 for details). Herbert Jennings first reported in 1906, that eukaryotes like *Stentor roeselii*, not only learn escape responses, they also demonstrate avoidance learning, a more sophisticated behavior. LeDoux notes Jennings' findings but doesn't appear to appreciate their importance. Plants communicate critical information concerning their well-being and release specific informational compounds to alert neighboring flora and fauna (Baluška, Mancuso, 2021; Gagliano et al., 2012). A recent study showed that cuttlefish are capable of one of the cognitive markers LeDoux uses to identify episodic memory, knowing "what, where, and when" an event will occur and, interestingly, they hold onto the memory into old age (Schnell et al., 2021).

Understand, we aren't saying that bacterial communication is based on empathy for their colony mates, or that *Stentor's* avoidance learning or cuttlefish episodic memory are equivalent to ours. Our point is that traits, mechanisms, processes, functions that are instantiated in human behavior have long histories in evolution. They lie on various continuums and identifying their evolutionary roots is an essential element in filling out the story of the last four billion years.

LeDoux's focus on human consciousness has two consequences, one positive, one not so much. The first, which dominates the last half of the book, allows LeDoux to provide us with an overview of the psycho-neurological research into the underlying, complex, interlocking cerebral processes that give rise to human perception, cognition, and emotion. But the evolutionary roots outlined in the earlier chapters become afterthoughts, recognized in short passages wedged in between the research on adult humans. This is most apparent when dealing with emotions. Fear is dealt with as human fear with a clear message that whatever it is that a zebra might be experiencing when being taken down by a lion isn't really fear. LeDoux writes, "As I stressed throughout this book, emotions can't be unconscious" (p. 355) and "An (autonoetic) emotion is the experience that something of value is happening to you. No self, no fear — no other emotions" (p. 375).

We take a rather different view here. Benaji and Greenwald's research on implicit attitudes and beliefs showed that they are often held without awareness (see Kurdi & Benaji, 2022[2]). Jurchiş et al. (2020) had participants learn two artificial grammars (AG's), one paired with negative stimuli and the other with positive. During testing, novel letter strings generated by the positively-conditioned AG were preferred. As Jurchiş et al. (2022) note, participants had no idea what made the stimuli likeable/dislikable — a result that was recently replicated and extended by Amd (2021). In the Iowa Gambling Task, participants show an emotional reaction and avoidance of the deck of cards associated with losses without being aware of it (Bechara et al., 1994; Damasio, 2022). Much of LeDoux's problem here can, again, be traced to his focus on memory and cognition in adults while neglecting: a) learning, especially language acquisition and socialization which take place in infancy and childhood (Rebushat, 2022), b) sport and movement (Weiss and Masters, 2022), c) behavior within organizations (Brauner, 2022), d) in social settings (Collins, 2022), e) in aging populations (Howard & Howard, 2022), f) in how beliefs are formed (Alcock, 2022), and g) when making aesthetic judgments (Zizak & Reber, 2004; Reber, 2022).

Early in the book, LeDoux worries about how to handle the many sophisticated behaviors that have been documented in essentially all species. "If the extended view . . . catches on, it will only necessitate coming up with a new name to account for processes that underlie the use of internal representations to guide behavior." Not to worry, as we noted above, there already is such a term, *sentience*, and not only is it used broadly, it's in the name of a major journal (*Animal Sentience*) where research and theory on these issues can be found. LeDoux uses *cognition* as his cover term but, as he notes, it creates confusion because of the tendency to apply it primarily to the higher mental functions of species with nervous systems. The confusion only deepens as LeDoux describes the "cognitive" aspects of prokaryote

behavior. He maintains that evidence for learning is based on theoretical models. This just isn't true. Not only do bacteria learn, they learn patterns; they learn the features of arbitrary spatial arrays. Mitchell, et al. (2009) shifted nutrients back and forth from maltose to lactose and back again and found that bacteria make adjustments in their metabolic functions *in anticipation* of the next nutrient in the sequence. When they presented the sequence MLML. . .MLL, uptake of the "surprise" lactose was inefficient because bacteria had already modified metabolic functions to maximally absorb maltose. Unicellular protists like the slime mold *Physarum polycephalum* learn to traverse pathways to avoid contact with caffeine and quinine, which they find aversive. Boisseau et al. (2016) put droplets of both on a bridge leading to a food source. Over several days *P. polycephalum* learned to navigate the pathway avoiding contact with the bitter substances. Pattern learning and controlled locomotion are both rather sophisticated "cognitive" behaviors.

In several places (e.g., p. 110, in a footnote) LeDoux writes that "traits are lost and regained throughout evolutionary history." He provides no examples, but a basic principle of evolutionary biology is that when a trait is highly adaptive it is rare for it to be lost. Adaptive traits typically become part of the platform upon which speciation occurs and are carried forward by species that descend from it. The CBC model is based on this fundamental principle.

LeDoux is not a fan of anthropomorphism and maintains that the rise of behaviorism was due, in large part, to the tendency to engage in unwarranted anthropomorphism stimulated by Darwin's position that human emotions and behaviors are evolutionary descendants of earlier forms and functions. This tendency, according to LeDoux, resulted in excessive speculation about the inner lives of other species, in particular other mammals, that were not only inappropriate, they were unscientific and led to the emergence of behaviorism as a corrective. We don't think this historical analysis is quite right (as is discussed in TFM). Unfettered anthropomorphism was an element in the rise of behaviorism but it wasn't the only unscientific practice criticized. In his influential writings, John Watson (e.g., Watson, 1913) was equally critical of introspectionism and his arguments effectively ended research into cognitive functions – in particular consciousness – for several decades. Behaviorists continued to use animals in research and did so with the tacit acceptance of their evolutionary continuity with other species. They curbed the tendency to assign internal feelings to the subjects of their explorations but the "banning" of consciousness as a topic of research was due primarily to the empirical and theoretical chaos that resulted from decades of using introspection as the primary experimental tool. Unlike LeDoux, we are fans of a measured, *critical* anthropomorphism (Burghardt, 2016) which is useful as, what philosopher Dan Dennett calls,

an "intuition pump." It triggers off ways of thinking about the links between observed behaviors and common biomolecular and genetic processes of other species, links that can be experimentally explored. We agree with primatologist Frans de Waal that a measured anthropomorphism is more than merely acceptable, it is an important instrument in a researcher's toolbox.

Take the ongoing debate over whether fish feel pain. From our measured anthropomorphic stance, we conclude that of course they do. The fish flopping about in the bottom of a boat is absolutely suffering. Is its internal, subjective state the same as ours? Certainly not identical since, as Key (2016) and Derbyshire (2016) note, its nervous system is so different from ours. But having a piscatorial brain shouldn't force the conclusion that it's not in pain — which Key and Derbyshire do. LeDoux is careful to note that animals suffer (though they don't "suffer like we do") and argues for ethical approaches in the treatment of animals. We appreciate the point but note that we don't suffer like they do. We have therapies, medications, group support programs, social and familial support systems to mitigate pain. They do not.

In LeDoux's efforts to distinguish human consciousness from the cognitive functions of other species, much of the explanatory burden is placed on top-down mechanisms, memorial processes and language and, not surprisingly, virtually all the examples and research reports are from studies with adult humans. LeDoux has made here what amounts to a lexicographic move, *consciousness* becomes *human consciousness* and, though it's not mentioned, a uniquely western version where virtually all the data are from research with participants in WEIRD (Western, Educated, Industrialized, Rich, Democratic) cultures (see Henrich, 2020). LeDoux emphasizes the role of language on human cognitive functioning, deeming it critical for essentially all of cognition. However, he misses those aspects of cognition, human and non-human, that take place largely or entirely independent of language. Fayena-Tawil et al. (2011) pointed out that artistic creation is often carried out independent of conscious thoughts. Gilhooly (2016) maintains that "unconscious work" is a fundamental aspect of creative problem solving. A good deal of learning, in particular learning during infancy and early childhood, takes place without language and inner speech. Implicit learning (see Reber, 1993, forthcoming), a topic that is almost completely neglected, preceded the (re)emergence of interest in non-conscious memory processes. We view language as a complex, sophisticated cluster of functions and behaviors that are part of a larger continuum: *communication*. It is a feature, undoubtedly the most important one, of our way of communicating with each other and ourselves. It isn't a new *type* of communication so much as a novel *token*; a way of exchanging

information within and between organisms which, as noted above, takes place in unicellular prokaryotes.

Finally, we can sum up our position cogently. Life began once on this planet. It was sentient life based on cells. All species evolved from this original unicellular species. All traits, functions, and behaviors from the most primitive gene-driven reflexes and instincts to the most complex, sophisticated cognitive processes underwent a parallel evolution. As noted above, virtually no one in the socio-biological or physical sciences doubts the former proposition. Eventually, we assume, the latter will be as fully embraced.

Notes

1. Readers who want details on terminology can consult the Appendix in Reber (2019) where a history of the use of the term *consciousness* is presented.
2. The "forthcoming" marker refers to chapters that will appear in A. S. Reber & R. Allen (Eds.) volume, *The Cognitive Unconscious: The First Half-Century* (Oxford University Press), where over thirty authors explore the rich literature on unconscious cognitive processes.

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