REPORT

Human Cognition and the Anthropocene

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December 1, 2025

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Suggested citation:
Milkoreit, M., T. Lindahl, M.-L. Moore, M. Nyström, P. Olsson, C. Schill, *Human Cognition and the Anthropocene*, Stockholm Resilience Center (Stockholm University), Beijer Institute of Ecological Economics, Report prepared for the Anthropocene Paradigm Shift Symposium, December 1, 2025, Stockholm, Sweden.

Layout and graphics:
Jerker Lokrantz/Azote and Elsa Wikander/Azote.

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Abstract

Understanding the multiple reciprocal relationships between human cognition and the Anthropocene is emerging as a critical research frontier across the sciences and humanities. This report maps the rapidly expanding but conceptually disconnected landscape of research on how Anthropocene conditions shape the brain and mind—and how human cognition and social processes, in turn, drive and sustain global change. We sketch existing scholarship across four domains: material impacts on brain function and development; psychological consequences of Anthropocene stressors; socio-cultural effects that shape meaning making and behavior; and the mind's epistemic capacities for recognizing and interpreting planetary change. Building on this survey, we advance a broader conceptual framework that understands the human brain and mind as embedded in complex social-ecological systems across scales—linking neural processes to individual behavior, social networks, collective imaginaries, institutions, the biosphere, and ultimately the dynamics of the Earth system in a recursive loop. This framing provides a foundation that requires more integrative and collaborative research capable of tracing causal pathways across scales, from the biological impacts of heat and pollution to the cognitive roots of innovation, governance, and global coordination. Themes such as environmental change, novel entities, and technological mediation cut across this landscape. The report concludes by proposing three 'big' research questions aimed at guiding future areas of inquiry: (1) identifying the causal mechanisms through which cognition contributes to Anthropocene dynamics; (2) mapping the feedbacks that link environmental change and human cognitive processes; and (3) examining how cognitive processes operate across individual, collective, and institutional scales to shape Anthropocene dynamics. Taken together, these questions point towards a broader, coherent agenda for understanding the brain and mind as both shaped by and shaping the Anthropocene—and for mobilizing cognitive resources toward more sustainable and equitable futures.

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1. The Anthropocene – A Story of Mind and Matter

Twenty-five years after its first formulation, the Anthropocene (Crutzen and Stoermer 2000) has become one of the most influential concepts of our time. Even without formal geological ratification, it names a reality we can no longer ignore: humanity has become a *planet-altering force*. Though constituting a mere 0.01% of Earth's total biomass, human societies have ascended to a position of unparalleled influence – reshaping the planet's atmosphere, biosphere, hydrosphere, and lithosphere alike (Ellis 2011; Vitousek et al. 1997). By 2020, the cumulative weight of human-made matter had come to exceed the dry mass of all living organisms (Elhacham et al. 2020), a stark testament to our species' transformative reach. Yet, this transformation has not been driven equally by all, but largely by industrialized economies and global systems of power, production, and consumption (Rocha et al. 2015; Chancel 2022; Cappelli 2025). Humanity now functions as a hyper-keystone species (Worm and Paine 2016), a force whose influence, though unevenly distributed, rivals the slow, patient powers of geology in shaping the course of the Earth system (Steffen et al. 2018). Concurrently, an intricately interwoven world has emerged—propelled by global production systems, vast webs of trade and transport, entwined financial systems, and the ceaseless circulation of people, technologies, and information (Adger et al. 2009; Liu et al. 2015; Nyström et al. 2019). Humanity is thus driving a Great but uneven Acceleration of global change.

We live, increasingly, within what many call the polycrisis—a tangled web of overlapping disruptions in climate, ecology, economy, technology, justice, and politics (Morin and Kern 1999; Lawrence et al. 2024; Delannoy et al. 2025). Each crisis can amplify and cascade. Geopolitical change and financial shocks constrain efforts toward decarbonization (Babić and Mertens 2025); pandemics reshape social trust and inequalities (Devine et al. 2021). The problem is not simply that these crises coexist, but that their complexity may overwhelm our capacity to understand, navigate, or cope with them.

This complexity and the vast scale and speed of change, although propelled by human actions, challenge the human brain and mind. While the term Anthropocene references the current social-ecological conditions on Earth, it is also shaped by, and shaping, human cognitive conditions. The Anthropocene, then, is as much a story of mind and matter as it is of carbon and concrete. Grasping its complexity calls for attention to the human brain and the mind—not as metaphors, but as active components of the Earth system.

Brain and Mind: Two Ways of Knowing the Human

The distinction between the *brain* and the *mind* may appear merely philosophical, but we use the terms as part of our effort to build a bridge between research disciplines often operating in silos. The brain is a biological organ, evolved within and inseparable from the biosphere (Beattie 2019). Neurobiological research increasingly shows how rising temperatures, air pollutants, and chronic stress can alter neural development, cognition, and emotional regulation. The Anthropocene quite literally reaches *into our skulls*.

The mind, by contrast, often is treated as belonging to the subjective, social and symbolic world (Ryle 2009). It is the realm of meaning-making, imagination, memory, communication and culture. Minds are not only confined within individual heads—they are networked across languages, institutions, and digital systems. And of course they exist in natural environments. The mind interprets and projects; it invents futures and myths, economies and ideologies, it relates to people and nature. Hence, the brain and the mind anchor us to the biosphere and the sociosphere in distinct ways.

Separating the brain from the mind can seem artificial: neural, social and cultural processes coevolve in continuous feedback loops (Fischbach 1992). Yet maintaining the distinction can help highlight how material and symbolic processes interact and intertwine, sometimes reinforcing, sometimes contradicting one another. It lets us see how physical stress can shape collective meaning—how, for instance, ecological disruption gives rise to new narratives of loss or resilience. And it clarifies the converse: how our ideas, ideologies, and imaginaries drive planetary change.

Still, we must handle the distinction with care. Overemphasizing the mind risks forgetting that cognition is embodied and ecological; reducing everything to the brain erases culture and meaning. The challenge—and opportunity—is to think across the divide, to understand the Anthropocene as the product of cognition—both neural matter and symbolic imagination—and the well-studied growth in human activity on planet Earth.

The Anthropocene as a Cognitive and Planetary Condition

Seen this way, the relationships between the brain, the mind, and the Anthropocene multiply. Some are material: the changing environment acting upon neural systems. Some are psychological and social-cultural: climate change shaping emotions and mental health, identity, and meaning. Others are epistemic: the difficulty of perceiving complex, non-linear global dynamics. Some of these dimensions have inspired a growing body of research—from environmental neuroscience and ecopsychology to the creative imaginary practices in the humanities and sustainability sciences focused on the Anthropocene. But critical connections between these fields remain thin. The neuroscience of stress rarely speaks to the cultural theory of crisis; studies of eco-anxiety often overlook the underlying biology of emotion regulation and the environmental embeddedness of the brain; environmental change studies seldom account for mental health effects. What's missing is a framework that treats mind, brain, and environment as entangled layers of social-ecological processes.

This perspective aligns with the lens of social-ecological (also complex-adaptive) systems theory, which emphasizes feedbacks, thresholds, multiple stability domains, embeddedness, cross-scale dynamics, and co-evolution between human and natural systems (Walker et al. 2004; Folke et al. 2005; Ostrom 2009). Applied to cognition, it reveals the Anthropocene as a multi-level system of thinking and feeling organisms within thinking and feeling societies within a thinking and feeling planet. Brains adapt to environmental change; minds generate cultural narratives that alter behavior; societies reshape ecosystems in turn. This recursive loop—from neuron to network to biosphere—is the cognitive architecture of the Anthropocene.

To frame the Anthropocene as an interdependent planetary-material and mental-conceptual condition is to grasp more of the complexity of the human condition today. The challenge is to understand both sides of the brain/mind-Anthropocene relationship—the destructive and the redemptive powers of the human mind and how they are shaping and being shaped by the Anthropocene context.

Aims and Structure of this Report

This report takes a first step toward such a systemic perspective on the relationship between the brain, the mind and the Anthropocene. Its aim is not to review every relevant study, but to sketch the contours of an emerging intellectual landscape and to point towards yet-underdeveloped domains of research that would strengthen our collective understanding and possibilities for navigation of the Anthropocene. Section 2 maps existing scholarship across four dimensions—the material and biological, the psychological, the social-cultural, and the epistemic. Section 3 proposes two new conceptual lenses that are currently underexplored in the scholarship: the mind as planetary agent and the mind as resource for addressing Anthropocene challenges. Section 4 outlines a set of "big questions" that could guide future interdisciplinary collaboration and expansion of research on the brain and mind in the Anthropocene. Section 5 concludes with reflections on how integrating mind and matter might reshape not only our research but our capacity to act.

This report has been developed as an independent contribution to the Anthropocene Paradigm Shift Symposium, Royal Swedish Academy of Sciences, December 1, 2025.

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2. Existing Scholarship – An Uneven Landscape

Within the rapidly expanding scholarship on the relationship between the Anthropocene and the human brain and mind, we here distinguish between four types of interactions. Three of these address impacts of the Anthropocene on the brain and mind—biophysical changes ('brain damage'), psychological effects (mental health and emotions) and socio-cultural implications (subjective life experience and collective meaning making). The fourth topic concerns the mind's ability to understand and recognize the Anthropocene (epistemic ability).

We selected three cross-cutting themes – environmental change, novel entities and technology – as core features of the Anthropocene that are woven throughout these research fields. Environmental change operates as a pervasive stressor, altering biophysical conditions (e.g., biodiversity, heat, air quality, extreme events), reshaping emotional landscapes, transforming cultural narratives, and complicating the cognitive work of grasping complex, non-linear planetary dynamics. Novel entities, ranging from chemical pollutants to synthetic materials and engineered biological agents, penetrate ecosystems and bodies, influencing neural development and functioning while also generating new cultural anxieties, political debates, and epistemic challenges about invisible or uncertain risks. Technology, meanwhile, mediates nearly every aspect of human–Anthropocene interaction: it amplifies environmental impacts through industrial and digital infrastructures, modulates psychological states through communication ecologies and attention architectures, and structures cultural meaning-making via algorithmic filtering, virtual experiences, and globally networked narratives. At the same time, technology expands human epistemic reach—through sensors, models, simulations, and AI—while also potentially reinforcing cognitive biases or fragmenting shared understanding. These cross-cutting themes thus not only connect disparate research fields but also underscore the need for an integrated, multi-level framework for understanding how the human mind is both shaped by and shaping the Anthropocene.

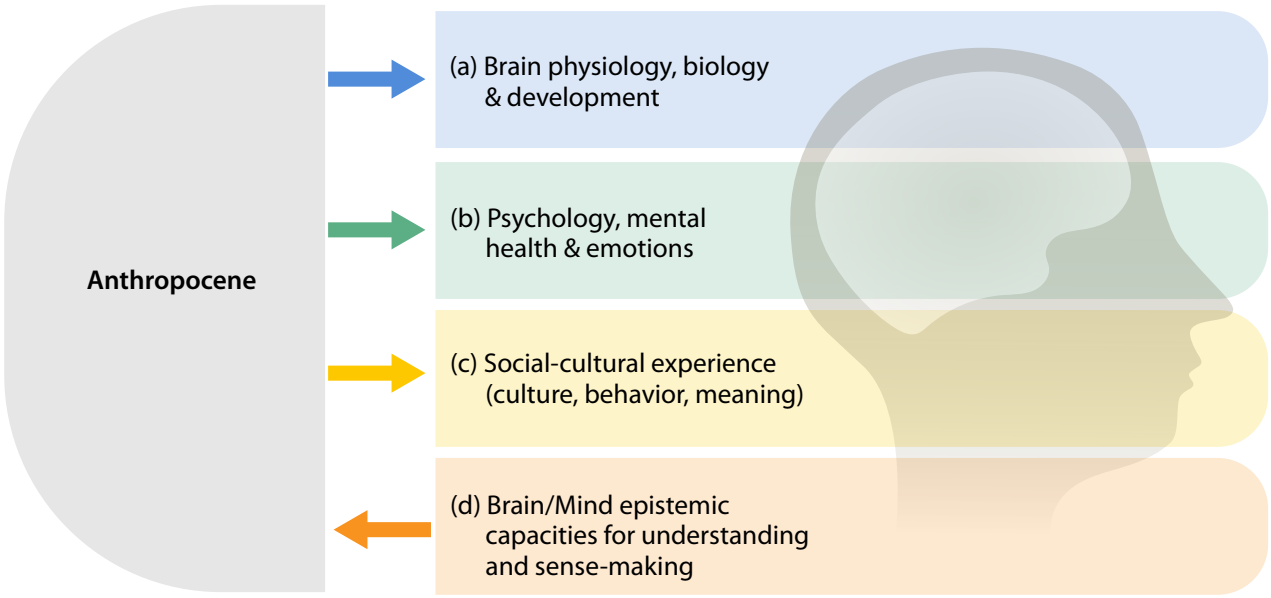

Figure 1: Four Relationships between the Brain/Mind and the Anthropocene

(a) Material Impacts on Brain Physiology, Biology & Development

The material Anthropocene has reached into the most intimate scales of human existence — including the molecular and neurological bases of thought. Mounting evidence suggests that environmental changes, novel entities, and technology directly influence the human brain's development, function, and evolution.

Novel Entities and Neurotoxicity

The proliferation of *novel entities* — new substances, modified materials, and synthetic compounds — constitutes one of the clearest material linkages between planetary change and neural health (Persson et al. 2022). Heavy metals, pesticides, micro- and nano plastics, and persistent organic pollutants such as PFAS have well-documented neurological and cognitive consequences (Costa and Cairrao 2024; Nannaware et al. 2024; Xie et al. 2024). Historical cases like mercury-induced Minamata disease or lead exposure in children reveal the brain's extreme vulnerability. Air-pollution studies show reductions in grey- and white-matter volumes and hippocampal size (Beckwith et al. 2020; Yuan et al. 2023) and effects on brain development (Peterson et al. 2022). Mechanisms include oxidative stress, neuroinflammation, and disruption of the blood–brain barrier (Iqubal et al. 2020). Such changes are associated with impaired memory, language, and emotion regulation, and with elevated risks of neurodegenerative and neurodevelopmental disorders (Costa and Cairrao 2024). Yet the combined and synergistic effects of multiple novel entities, and how these in turn might shape ideas, decisions, and imagination in the Anthropocene remains poorly understood, pointing to a broader research gap that spans neuroscience, environmental health, psychology and the social sciences.

Environmental Change Stressors and Neurophysiology

Rising global temperatures, extreme weather, and resource insecurity also affect the brain's material state and functioning. A growing body of evidence links both acute and chronic heat exposure to structural and functional brain changes and to a spectrum of psychological outcomes (Tan et al. 2024). Exposure to extreme or highly variable temperatures increases risks of cognitive decline (Ye et al. 2024) and correlates with surges in emergency visits for dementia, psychosis, and mood disorders (Christodoulou et al. 2024). Heat stress as well as exposure to extreme events such as wildfires impairs selective attention, working memory, and processing of interference from emotional distractions (Grennan et al. 2023) up to a year after the event (Nan et al. 2025). Additionally, combinations of biological heat load, sleep disruption, and co-stressors can create or aggravate existing neurological and psychiatric conditions (Bongioanni et al. 2021; Xu et al. 2025; Gulcebi et al. 2025). The neurological burdens of environmental change stressors thus link environmental physiology to mental health, forming a continuum from somatic change to psychological distress and illustrating how planetary instability becomes embodied within the human nervous system.

Land-System and Cognitive Change

Emerging evidence highlights a complex relationship between soil health, the human gut microbiome, and brain function—an integrated system increasingly described as the *soil–food–gut–brain axis*. Biodiverse soils shape the nutritional and biochemical quality of food, which in turn influences the diversity and resilience of the gut microbiota (Blum et al. 2019). This microbial community communicates with the brain through neural, immune, and metabolic pathways, including the vagus nerve and microbial metabolites (Forsythe et al. 2014; Wang et al. 2025). A balanced microbiome can support adaptive stress responses, emotional regulation, cognitive performance, and neuroprotection, while dysbiosis has been linked to depression, anxiety, autism spectrum disorders, and neurodegenerative conditions (Cooke et al. 2022).

Ecologically and evolutionarily, humans co-evolved with environmental microorganisms, forming a continuous microbial exchange that supported both physical and mental health. Modern lifestyles—urbanization, processed diets, reduced soil contact, antibiotic overuse, and increasingly sterile environments—have disrupted this long-standing symbiosis (Derrien and Veiga 2017). This microbial disconnection may contribute to rising immune and mental health disorders (Rook et al. 2017; Appleton 2018).

Technological Environments and Cognitive Evolution

Digital and communication technologies represent another layer of the Anthropocene's material-cognitive feedback. Continuous connectivity, algorithmic information exposure, and virtual environments shape neural plasticity, attention networks, and reward systems (Wilmer et al. 2017; 2019; Small et al. 2020). While such media can extend cognition and memory, they also contribute to "cognitive fragmentation," attentional overload,

altered social learning, and emotional fatigue (Shanmugasundaram and Tamilarasu 2023; Sheng et al. 2023; Fu et al. 2020). The resulting hybrid ecology of *brains in technological networks* may be driving new trajectories of cognitive evolution — accelerating symbolic capacities even as it erodes depth of focus and empathy. Understanding these technological–neurological entanglements will be essential for grasping how the Anthropocene reshapes not only the planet, but the very organ that perceives it.

Together, these findings suggest that the Anthropocene's material transformations are not merely environmental but neurobiological, progressively reshaping the substrates of perception, emotion, and cognition—a process Chen and Nakagawa (2018) describe as the emergence of *planetary distress within the human brain itself*, signaling that the future of human capacity is inseparable from the health of the planet.

(b) Mental Health and Emotional Dimensions of the Anthropocene

The Anthropocene is also transforming the emotional and psychological terrains of human life. A growing body of research demonstrates that climate- and environment-related distress arises through two primary pathways: the lived experience of environmental disruption and the anticipation of further, often uncontrollable, change. Both are distributed unequally across populations.

Experiencing Impacts of Environmental Change

Extreme events such as floods, fires, and storms, as well as slow-onset changes like drought and desertification, have profound mental health consequences. Direct exposure is associated with increased rates of depression, anxiety, suicidal ideation, and substance abuse (Burke et al. 2018; Belkin 2024). Survivors of disasters frequently experience post-traumatic stress, aggression (Seddighi et al. 2021; Daalen et al. 2022), and disruptions to social and familial bonds (Taylor 2013; Woods et al. 2014; Acosta et al. 2016). Longer-term consequences extend beyond immediate trauma: when landscapes are irrevocably altered, people report *solastalgia*—a deep distress rooted in the loss of place, identity, and traditional ecological knowledge (Cunsolo and Ellis 2018; Tschakert et al. 2019; Middleton et al. 2020).

These experiences are unevenly distributed. Indigenous nations around the world, and many communities in the Global South face repeated and compounding exposures, often without adequate healthcare or institutional support (Fernández-Llamazares et al. 2020). Meanwhile, children and young people worldwide are more physiologically and psychologically vulnerable to chronic stress and loss, facing what could be described as a developmental burden of the Anthropocene (Léger-Goodes et al. 2022; Skopeliti and Gecsoyler 2023). Formative years in the Anthropocene are marked by a sense of instability that threatens future mental health trajectories.

Beyond climate change, several studies have shown the importance of access to green space for human mental health and cognition (see e.g., Bratman et al. 2019 for a review), especially during public crises (Patwary et al. 2024; Samuelsson et al. 2021). There is growing evidence that healthy, thriving ecosystems are deeply intertwined with human mental health and psychological and emotional resilience (Ives et al. 2017, Garrett et al., 2023). Beyond the role of underpinning urban ecosystem function, biodiversity plays an important role for a range of benefits for human, including mental, health (Aerts et al. 2018; Clark et al. 2014).

Anticipation, Anxiety, and Awareness

Even for those not yet directly affected, awareness of impending planetary crisis can generate its own form of psychological distress. *Climate anxiety*, *eco-anxiety*, and *anticipatory solastalgia* (Rafa et al. 2025) describe the emotional toll of imagining or expecting environmental breakdown (Clayton, 2020; Coffey et al., 2021; Pihkala, 2022; Uchendu, 2022; Stanley, 2023). Individuals report symptoms such as insomnia, stress, depression, and grief (Boluda-Verdú et al. 2022; Schwartz et al. 2023), as well as existential fears, a sense of helplessness, and reluctance to have children (Hickman et al. 2021; Patrick et al. 2023).

Debate continues over whether these responses should be seen as clinical pathologies or as rational, even *adaptive*, reactions to real planetary threats (Bednarek 2024; Galway and Field 2023; Crandon et al. 2022). Either way, anticipatory emotions reveal a crucial dimension of the Anthropocene condition: human minds are not only reacting to environmental change but *pre-living* it—absorbing future catastrophe into the present psychological landscape.

(c) Social-cultural Responses to the Anthropocene

In addition to biological and psychological effects of the Anthropocene on the human brain and mind, the Anthropocene shapes the lived, subjective experience

of humans, filtered through culture, narrative, language, institutions, and technology. Scholarship in this area explores how these mediating structures affect perception, meaning-making, and ultimately our responses to Anthropocene challenges – behaviors, decisions and policies.

Cultural frameworks determine not only how people *interpret* planetary change but also what they are capable of *imagining* in response. Narratives of progress, growth, and human exceptionalism—core elements of a dominant worldview —have shaped both the emergence of the Anthropocene and the ways it is understood (Girvan 2017; Biswas Mellamphy and Vangeest 2024; Malm and Hornborg 2014). Scholars of environmental humanities and cultural geography have shown how metaphors of mastery or loss, apocalypse or resilience, influence public attitudes and political will (Mangat and Dalby 2018; Swyngedouw 2010). Meanwhile, collective memory and identity are being reconfigured as communities experience environmental disruption and displacement, leading to new forms of belonging, collective grief and mourning (Árnason and Hafsteinsson 2020; Varutti 2024; Skrimshire 2025).

Language and media technologies mediate these experiences further. Digital networks amplify both awareness and polarization: the immediacy of online imagery can foster empathy and global solidarity (Fenton 2008) but also desensitization, disconnection, and anxiety (Kala Negi and Singh 2025). Institutions—from education systems to religious organizations and governments—frame moral interpretations of responsibility and care, while global inequalities shape whose stories are heard and whose suffering counts (Biermann et al. 2016). In this sense, the Anthropocene is lived not as a single shared reality but as *many Anthropocenes* (Amoureux and Reddy 2021; Yusoff 2018), differentiated by culture, class, race, and geography. Understanding these socio-cultural filters is crucial for any effort to translate knowledge of planetary crisis into meaningful collective action.

(d) Epistemic Challenges – Limits to Perceiving Planetary Change

The scholarship reviewed so far has focused on how the Anthropocene affects the human brain and mind. Equally crucial, however, are the limits of how the brain and mind make sense of the Anthropocene itself — the epistemic capacity to perceive and understand complex, planetary-scale changes.

Humans struggle to comprehend complexity because our cognitive systems evolved to address gradual and local risks, not global, nonlinear processes. Cognitive effort is metabolically costly, and the brain is wired to minimize energy expenditure by defaulting to effortless thinking (Kahneman 2011). This tendency toward cognitive ease, though adaptive for everyday decisions, undermines engagement with complex or temporally distant challenges (Tversky and Kahneman 1974; Spence et al. 2012; Pahl et al. 2014). As a result, people tend to underestimate feedbacks, inertia, and scale effects (Moxnes 1998; Sterman and Sweeney 2007; Hey et al. 2009).

Even as scientific and technological systems now monitor planetary processes with extraordinary precision (Edwards 2017), our collective responses remain inadequate. Among the reasons often cited is a failure of imagination. The current planetary crisis is, at least in part, a crisis of imagination (Wapner and Elver 2016; Norgaard 2017; Moore and Milkoreit 2020). Humans' ability to envision the future is constrained by lived experience and analogies from the past. Because planetary-scale transformations lack historical precedents, they remain cognitively and emotionally distant. Thus, despite abundant evidence, many perceive global change as occurring "elsewhere" or "later," too abstract to evoke visceral concern (Slovic 2004; McDonald 2016, Weber 2016). Confirmation bias and motivated reasoning further protect existing worldviews, preserving psychological comfort over cognitive dissonance (Druckman and McGrath 2019).

Moreover, attention and concern themselves are finite cognitive resources. According to the finite pool of worry and finite pool of attention (Sisco et al. 2023) hypotheses, individuals allocate limited emotional and cognitive capacity to a few salient risks at any one time. When personal or immediate challenges — health, livelihood, family — dominate, diffuse and temporally distant threats like climate change are deprioritized. Perceived inefficacy further dampens motivation: when people believe their actions cannot meaningfully affect global outcomes, they withdraw emotionally (Bandura 1977; Heald 2017).

These cognitive tendencies have become *institutionalized* in modern societies. Short-term thinking, rooted in neural reward systems, is mirrored in social and political structures that prioritize immediate gains over long-term wellbeing. Democracies organized around election cycles, economies driven by quarterly profits, and bureaucracies operating within narrow planning horizons all reinforce temporal myopia (Homer-Dixon

2001; Hulme 2020; Boston 2016). The result is a systemic incapacity to connect present actions with delayed planetary effects. Overcoming this bias may require not only what some scholars call "temporal institutions" — collective mechanisms capable of representing future generations and the deep-time consequences of present decisions – but first and foremost adaptations in collective temporal thinking.

At the same time, the Anthropocene's epistemic environment is deeply shaped by digital media. Despite growing scientific knowledge, many people still struggle to recognize and internalize the realities of planetary change in part because contemporary information systems actively distort how risks are perceived. The attention economy amplifies emotional heuristics and cognitive shortcuts: outrage and novelty dominate visibility, while complexity and nuance are marginalized (Pariser 2011; Sunstein 2018). Engagement-maximizing algorithms and recommender systems amplify emotionally charged or misleading content, creating fertile ground for climate misinformation and false beliefs to spread rapidly (Galaz et al. 2023; 2025). Algorithmic curation produces echo chambers that reinforce prior beliefs (Terren and Borge 2021), and the relentless flow of information fragments attention, discouraging reflective thought. These architectures exploit existing cognitive vulnerabilities—such as confirmation bias and emotional salience—thereby further eroding the public's capacity to make sense of complex planetary dynamics.

Yet digital media also hold transformative potential. Networked communication, visual storytelling, and immersive technologies can collapse psychological distance, bringing planetary change "closer to home" and fostering empathy (Milkoreit 2017; Hartley et al. 2020). The digital Anthropocene is thus ambivalent — simultaneously a machine of distraction, ecological degradation, and a medium of planetary awareness.

Taken together, these patterns — evolutionary, institutional, and technological — reveal that the limits of Anthropocene understanding are not merely intellectual but systemic. They are embedded in the ways human cognition, social organization, and media ecologies co-produce meaning. Addressing these limitations will require more than data or awareness; it demands the cultivation of new architectures of attention, imagination, and care that allow human minds to apprehend the planetary scale of their own agency.

The Gist

Existing scholarship illuminates multiple causal pathways by which Anthropocene processes affect the brain (heat, pollutants, infectious disease, acute disaster stressors), and these have measurable neurodevelopmental and neurodegenerative consequences. Climate and environmental change also drive psychological outcomes such as PTSD, depression, anxiety, climate distress via acute trauma, slow-onset loss, and social-ecological disruption. Importantly, cultural meaning-making, algorithms, and institutional patterns mediate and modulate these Anthropocene effects. How societies narrate, cope with, and politically respond to environmental change shapes subjective experience and policy responses (e.g., eco-anxiety may be political or depoliticizing depending on context). At the same time, the human capacity to understand and recognize the Anthropocene is limited by interacting cognitive, social and institutional mechanisms.

These bodies of work often remain siloed, leaving unexplored the integrative picture of the human mind and brain and the Anthropocene, including possible feedback loops between physiological stresses and the cognitive ability to make sense of the Anthropocene. For example, a missing dialogue between neuroscience and cultural theory could explore the effects of the Anthropocene's material brain impacts on cultural sense-making of large-scale environmental change. There are also big, unanswered questions at the interface of psychology and collective action: how do individual emotions such as eco-anxiety, denial, or hope translate (or not) into collective and institutional capacities for adaptive or transformative responses to Anthropocene challenges, including Earth system tipping points, or Anthropocene traps (Søgaard Jørgensen et al., 2024)? Or how do evolved cognitive biases (e.g., short-term focus, difficulty with abstract systems) shape public and expert understandings of Anthropocene processes?

These epistemic constraints point to the need for new conceptual tools—lenses that can expand the cognitive and cultural range through which humanity perceives and acts within the Anthropocene.

3. New Conceptual Lenses

Cognition in the Anthropocene cannot be understood solely at the level of the individual brain and mind. A growing body of scholarship conceptualizes the mind as embedded, systemic, and multi-scalar—shaped not only by neural processes, but by social networks, cultural meaning systems, institutions, and the broader biophysical environment (Markus and Kitayama 1991; Schill et al. 2019; Weber et al. 2023). At larger scales, collective cognitive processes emerge: groups develop shared beliefs, coordinate action, and generate narratives and norms that no individual alone could produce (Thagard 2010; Milkoreit 2017; Beckert 2016). These "group minds" influence political decisions, scientific paradigms, market dynamics, and technological trajectories, creating a cascade of cognitive activity that reverberates from neurons to nations. Decision-making, too, unfolds across multiple nested scales—from personal risk perception to community deliberation, institutional routines, national policy-making, and global governance—each level filtering, amplifying, or constraining the cognitive work occurring at the others.

This multi-layered cognitive architecture of the Anthropocene is profoundly shaped by inequality. Individuals, communities, and institutions do not enter this landscape with equal access to the cognitive conditions that enable understanding, reflection, or action—whether education, reliable information, time and attention, social support, or psychological safety. Socio-economic precarity, cultural marginalization, and institutional failures can suppress the capacity to imagine alternatives, restrict participation in collective sense-making, and narrow access to the knowledge required for informed decision-making. These asymmetries, in turn, reinforce whose worldviews dominate public discourse and whose interests define the boundaries of possible futures.

Recognizing these uneven cognitive ecologies is essential for designing interventions that genuinely expand human agency. By identifying where systemic bottlenecks constrain understanding and where latent capacities remain untapped, research can illuminate how to cultivate collective imagination, enable institutional learning, and support more equitable pathways for navigating—and transforming—the challenges of the Anthropocene.

This social-ecological, multi-scale, systemic perspective guides our proposal for new conceptual lenses on human cognition and the Anthropocene.

Mind as Planetary Agent | Mind as Anthropocene Maker

If the Anthropocene marks the moment when humanity became a planetary force, it also reflects the power of the human mind to imagine, design and transform the world. The deep history of the Anthropocene is, in part, a history of cognition — the evolutionary unfolding of neural and cultural capacities that allowed a primate brain to remake the Earth. Scholars of human evolution have traced how social learning, symbolic communication, and cumulative culture transformed cognition into a form of environmental engineering (Sterelny 2012; Henrich 2015). The control of fire, agriculture, and toolmaking were not just technological advances but neurocognitive revolutions: each restructured sensory experience, social organization, and energy flows. The planetary consequences of these feedbacks are the material imprint of cognition as it is enacted through social and technological systems.

This recognition highlights the distributed nature of human cognition and its entanglement with material and institutional systems. The Anthropocene cannot be understood simply as the aggregate result of billions of individual choices, but as emerging from *collective cognitive and cultural architectures* — language, abstraction, and foresight — that enable coordination across time and space. This is a world in which humans and nonhumans interact and are intertwined through networks of cognition and materiality that dissolve traditional boundaries between nature and thought.

The Anthropocene, then, can be understood as the culmination of a long co-evolution between neural complexity and material transformation. The same cognitive capacities that enabled collective imagination and problem-solving, such as abstraction, anticipation, and innovation, have also contributed to new forms of planetary feedback. Cognitive flexibility, once adaptive in small-scale environments, has scaled into a form of *geocognition* (Malafouris 2013; Clark 2015): the mind operating as a geological force through culture and technology.

Recognizing the mind as a planetary agent offers both insight and possibility. It highlights that the drivers of planetary disruption are not merely economic or technological but also cognitive and cultural. At the same time, the cognitive capacities that contributed to the Anthropocene, like reflection, imagination and foresight, could – if exercised collectively – support new modes of planetary stewardship. As Donna Haraway (2016) and Sheila Jasanoff (2015) suggest, the challenge is to cultivate collective intelligence that thinks with, rather than over, the Earth. In this sense, the ongoing task is for human minds to imagine — and help realize — ways of living within, navigating and altering harmful trajectories of the Anthropocene.

Mind as Resource | Developing and Implementing Solutions

The mind possesses a remarkable range of resources to confront the challenges of the Anthropocene in both adaptive and proactive ways.

Hope as Cognitive Practice

One of these vital resources is the emotion and cognitive capacity of hope (Frumkin 2022). Unlike optimism, hope does not assume that circumstances will inevitably change or improve, and it can coexist with uncertainty, grief, anxiety and even despair (Sangervo et al. 2022; Ojala 2023). Hope has been shown to enable solutions-oriented thinking and can motivate collective environmental action (Snyder 2002; Ojala 2023; Weber et al. 2023; Homer-Dixon 2020). Hopelessness, on the other hand, can stop people from constructive engagement with e.g. climate change (Hmielowski et al. 2019). Cultivating hope can equip us to respond affirmatively to ecological crises, to experiment within the present, and to contribute meaningfully to change.

Creativity and innovation as adaptive intelligence

Creativity — the production of novel and useful ideas — is often associated with a human trait (Runco and Jaeger 2012) but also exists in the non-human (Kaufman et al. 2011; Henriksen et al. 2022). Psychologists and neuroscientists have shown that creative cognition involves the interplay of divergent and convergent thinking, flexibility, and the integration of disparate knowledge domains (Beaty et al. 2016). These same cognitive mechanisms underpin scientific discovery, technological innovation, and cultural evolution — processes central to both the making and unmaking of the Anthropocene. However, as scholars such as Geoffrey West (2017) and Elinor Ostrom (2010) remind us, innovation without social and ecological grounding can accelerate unsustainability. The challenge is to redirect creativity toward regenerative systems design, social-ecological innovations, and collective intelligence — forms of creativity that expand rather than deplete future possibility space.

> The mind possesses a remarkable range of resources to confront the challenges of the Anthropocene in both adaptive and proactive ways.

Imagination as Anticipatory Capacity

Closely related to creativity, imagination is the mental capacity to construct, simulate, and emotionally inhabit futures that do not yet exist. Scholars in futures studies and cognitive science argue that imagination is essential for complex problem-solving, moral reasoning, and even transformative change (Suddendorf and Corballis 2007; Moore and Milkoreit 2020; Lehoux et al. 2020). In the Anthropocene, imagination enables both diagnosis and transformation: it allows societies to recognize the limits of past and current trajectories and explore alternative worlds. Yet imagination is unequally distributed or recognized— constrained by material insecurity, cultural narratives, structural power, and institutional inertia (Moore and Milkoreit 2020). Building what Ruth Levitas (2013) calls the *utopian method* requires using imagination not as escapism but as a heuristic for social-ecological experimentation.

Cognitive Resilience

Another crucial mental resource is the potential for post-traumatic growth (Tedeschi and Calhoun 1996). The positive psychological change that can arise from struggling with highly challenging experiences. Such growth may manifest as greater resilience, a redefined sense of purpose, or renewed appreciation of everyday joys. It neither erases pain or fear (like hope) but it

reveals the mind's capacity to channel fear, grief and anxiety into constructive engagement. Critiques caution, however, that emphasizing personal transformation in the face of adversity can obscure ongoing suffering and shift attention away from systemic responsibilities in global crises (Cooper et al. 2023).

Many of the mind's resources are inextricably linked to the social or collective contexts in which people are embedded. Humans are profoundly social beings; social pain is processed in ways similar to physical pain (Lieberman 2013; Eisenberger 2012), and some of the mind's most vital capacities, such as a sense of belonging, empathy, or compassion, are inherently relational. These capacities are supported and shaped by interactions with others, cultural norms, shared narratives and institutional structures. For example, empathy develops through a combination of biological, cognitive and social processes, including repeated engagement with diverse perspectives (Decety 2010), while a sense of belonging can be developed through participation in social groups or communities (McMillan and Chavis 1986). By providing emotional, cognitive and practical support, these social resources allow individuals to navigate stress, uncertainty, and loss (Brown et al. 2019; Manzo et al. 2023).

Together, these interdependent capacities form a vital source for navigating the Anthropocene.

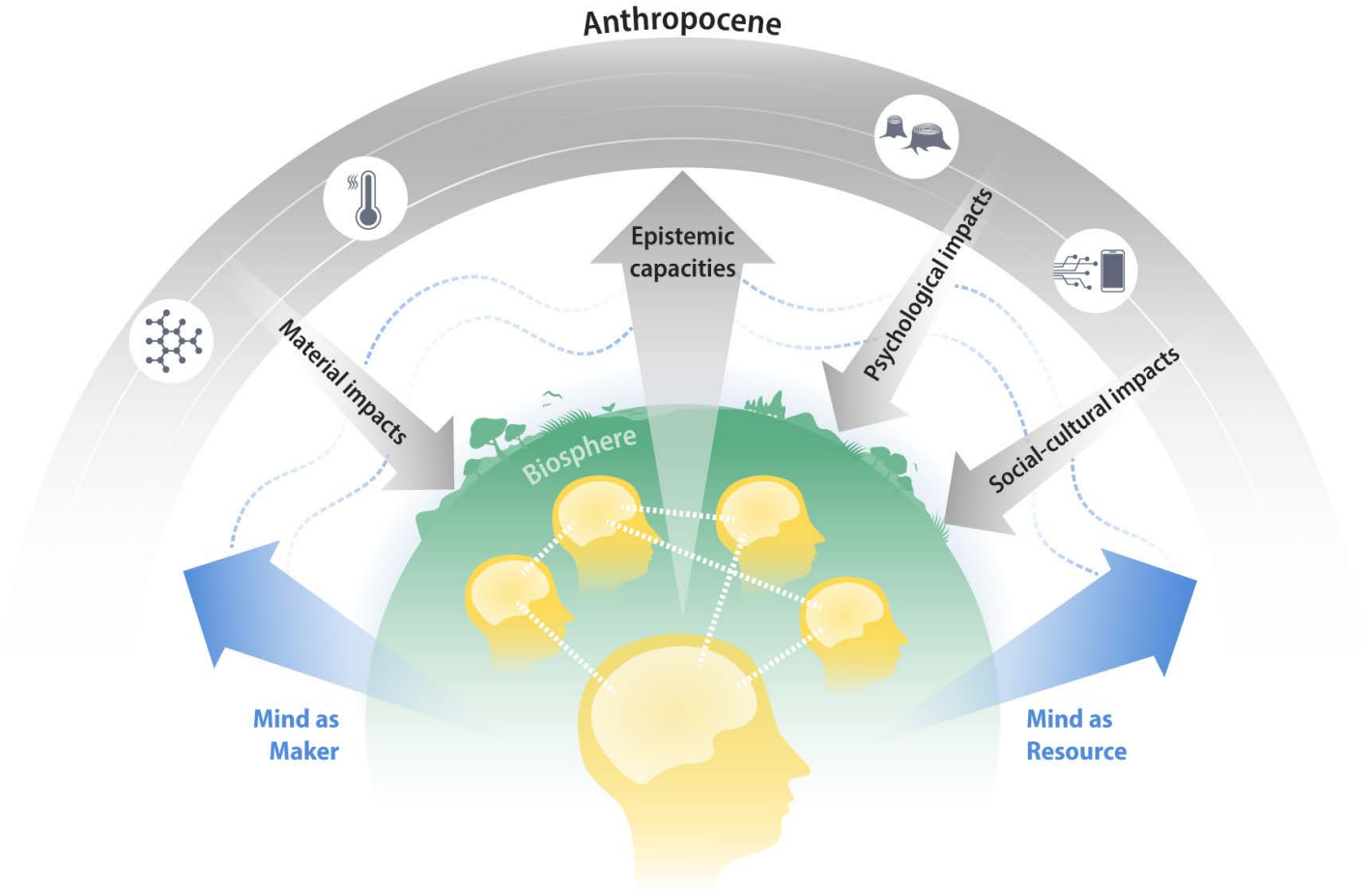

Figure 2: The Embedded Brain and Mind. Multi-scalar embedding of the human brain and mind within social and biophysical systems and the Anthropocene. Some characteristics of the Anthropocene include global (environmental change, technology, and the emergence and spread of novel entities. Grey arrows depict documented Anthropocene–brain/mind interactions (see Fig. 1), e.g., heat stress due to global climate change affecting brain function. Blue arrows highlight proposed conceptual lenses. There are multiple feedbacks between scales and processes often studied in isolation.

4. Future Research Directions: Three Integrative Questions

Taking the intertwined nature of the brain, mind, and the Anthropocene seriously inevitably leads to new questions. Questions that will require radically open collaborations to bridge studies of the brain, mind, culture, ecology, and more, across multiple ways of knowing. One of the challenges is methodological – finding ways to link for instance, neural-level insights with ecology and cultural analyses and more plural imaginaries. New disciplinary combinations are emerging, such as neuro-anthropology, environmental neurosciences, digital humanities, but these remain out of the mainstream and need additional support to ensure more relational, intertwined, and cross-scalar analyses are possible.

Grounded in a multiscale, social-ecological systems perspective, we propose three broad research areas oriented around three key questions to illustrate how such research efforts on human cognition and the Anthropocene could be approached.

1. **What cognitive capacities enable humans to generate—and potentially redirect—planetary-scale change? Through which causal mechanisms do individual minds influence Anthropocene dynamics?**

Human cognition is a key driver of Anthropocene transformation: our abilities to symbolize, imagine alternatives, innovate, coordinate, and construct institutions have produced agriculture, industrialization, globalized markets, and digitally networked societies. While many disciplines study human behavior, innovation, or institutions separately, we lack a unified framework that traces *multi-scalar causal pathways* from cognition to Earth-system change. Research is particularly needed on how psychological processes (e.g., risk perception, imagination, emotion regulation, social learning) become amplified through collective beliefs, institutional logics, technological infrastructures, and economic systems to produce planetary effects.

Future research should map such mind-to-planet causal pathways: how threat appraisal shapes energy and mobility decisions; how memory, identity, and narratives form consumption choices at collective scales; how cumulative culture and scientific reasoning yield technologies that restructure Earth systems; and how institutionalized cognition—shared norms, bureaucratic routines, political ideologies, scientific paradigms—amplifies or dampens Anthropocene forces. Equally important is identifying the capacities that could redirect trajectories, such as enhanced imagination, empathy, deliberation, long-term planning, multi-generational and multi-species ethics, and innovation-oriented cognition, and recognizing the various ways in which the Anthropocene itself is increasingly undermining these capacities. Advancing this agenda requires integrating cognitive science, neuroscience, cultural evolution, philosophy, anthropology, behavioral economics, political science, sustainability transitions research, futures studies, institutional theory, and more to build a complexity-based account of planetary agency rooted in the human mind.

2. **What feedback dynamics shape the co-evolution of human cognition and the Anthropocene? How do interactions across biophysical, psychological, social, and technological domains amplify or suppress future trajectories?**

Cognition both produces and is reshaped by Anthropocene conditions, yet the feedbacks linking these processes remain insufficiently understood. Extreme heat impairs attention and decision-making, reducing productivity, learning, and risk comprehension; environmental toxins alter neural development; ecological disruptions heighten anxiety and erode cognitive bandwidth. These changes, in turn, influence societal capacity to recognize, interpret, and respond to environmental risks. Socio-cultural and technological systems, including digital communication systems, also condition Anthropocene understanding. For example, Galaz et al. (2023) show, misinformation is no longer only the product of coordinated manipulation but also the emergent outcome of algorithmic curation, social reinforcement, and

emotionally compelling content. These dynamics can generate self-amplifying loops: distorted beliefs weaken public support for climate action, delayed action intensifies climate impacts, and escalating stressors further impair cognitive clarity—thereby reinforcing the very misperceptions that hinder effective collective responses.

Scholarship remains siloed but the social-ecological and complex adaptive systems perspective we draw on here could help with connecting these pieces, tracing cross-domain loops such as: climate stress ➞ gut health ➞ cognitive strain & mental health decline ➞ impaired problem-solving ➞ delayed mitigation ➞ intensified climate stress; or digital media ➞ identity-based reasoning ➞ political fragmentation ➞ weakened collective action ➞ escalating Anthropocene risks. Understanding these feedbacks could reveal opportunities where interventions—technological, psychological, institutional, or educational—can break maladaptive cycles and strengthen beneficial ones.

Anthropocene traps emerge when innovations or interventions that initially appear adaptive create unintended long-term harms, locking societies into unsustainable trajectories through powerful self-reinforcing feedbacks (Søgaard Jørgensen et al. 2023). These feedbacks—where attempts to solve problems generate new dependencies, escalate resource use, or amplify risks—help explain how humanity became a planetary force and why shifting course remains so difficult, even as global scientific assessments make the consequences increasingly clear. Because cognitive capacities such as learning, foresight, and problem-solving are themselves shaped by social and ecological contexts, understanding how they co-create trapping feedback effects is essential for identifying pathways out of traps. Escaping them requires transformative change, yet such transitions often bring emotional and psychological strains (Bogner et al. 2024), can trigger backlash (Olsson and Moore 2024) or derailment (Laybourn et al. 2023), and are further complicated by historical and geopolitical inequalities. Illuminating how cognitive, relational, and institutional capacities can interrupt harmful feedbacks—and activate stabilizing or regenerative ones—is therefore critical for enabling societies to navigate and ultimately break free from Anthropocene traps.

3. **How do cognitive processes operate across individual, collective, and institutional scales? How do interactions across these levels shape the emergent patterns that define the Anthropocene?**

Cognition is a dynamic, multi-scale phenomenon: individuals perceive and decide; groups form norms and shared narratives; institutions encode routines, laws, and long-term strategies; societies accumulate knowledge across generations; which in turn affect individual cognition. Yet the transitions and feedbacks between scales remain poorly understood. How do micro-level processes (attention, emotion, heuristics, identity, imagination) aggregate into meso-level phenomena like public opinion, polarization, cultural worldviews, and social norms and then give rise to biophysical changes at planetary scales? And how in turn do planetary changes affect meso- and micro-level phenomena? Moreover, how do organizations, bureaucracies, scientific communities, and states transform distributed cognition into large-scale action—including both the current carbon-intensive development and sustainable alternatives? Conversely, how do institutional designs, information environments, political economies, and cultural histories feed back into individual cognition, shaping what is thinkable, knowable, or imaginable? Research that links cognitive psychology, social psychology, organizational studies, cultural evolution, political science, network science, and complexity theory could help understand these scale interactions and the emergent dynamics they produce. The goal is to not only focus on why individual intentions often fail to scale into collective action, but also how institutional innovations, shared imaginaries, or redesigned knowledge systems could generate emergent dynamics that shift planetary trajectories.

5. Conclusion

The Anthropocene is not just a geological epoch; it is one co-created by human cognition. To understand it, we must study not only the sediments and systems we have altered, but also the cognitive dynamics and architectures that helped make such alteration possible, and that might yet enable a different—just and sustainable—future on a habitable planet.

Sketching the contours of the emerging scholarship on the relationship between the brain, the mind, and the Anthropocene, we have made the case for a multi-scale social–ecological systems perspective that emphasizes continuously generated feedbacks between cognition and the broader Earth system. Recognizing this embeddedness can open new avenues of interdisciplinary research, enabling a more complete understanding of the Anthropocene.

Across the three broad research questions we have proposed, a central theme emerges: the need to understand cognition not merely as an individual attribute but as a relational, distributed, and dynamic process. This includes examining how environmental degradation affects neural functioning and mental health; how emotions, meaning-making, and cultural frames shape responses to global change; how collective cognition and institutional structures amplify or constrain pathways for action; and how epistemic capacities enable (or limit) our ability to recognize complexity, anticipate risks, and imagine alternative futures. Such an integrated perspective allows us to trace the feedbacks—reinforcing or balancing—that link cognitive processes to social-ecological trajectories. It also highlights why societies may become trapped in unsustainable patterns of behavior, and what forms of cognitive, emotional, and collective capacity might be required to break free.

Looking forward, we outline possible research areas studying the brain and mind in the Anthropocene that move beyond disciplinary silos toward a more systemic, transdisciplinary agenda. This includes empirical work on how cognitive processes are conditioned by ecological contexts; theoretical advances that bridge neuroscience, psychology, sustainability science, and cultural evolution; and applied efforts that strengthen the capacities needed for equitable and sustainable transformations. Understanding the mind as a key site of both vulnerability and potential in the Anthropocene can help identify opportunities for fostering resilience, creativity, and care. Situating cognition within the living systems that sustain it opens new possibilities for navigating an increasingly uncertain planetary future.

> Situating cognition within the living systems that sustain it opens new possibilities for navigating an increasingly uncertain planetary future.

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