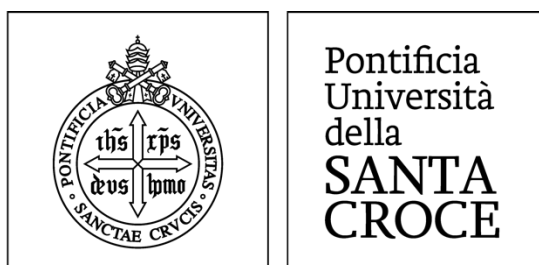


PONTIFICAL UNIVERSITY OF THE HOLY CROSS



Laboratorio di Ricerca

Research Seminar

Amazing Novelties

*Emergence and Creativity in Material, Biological, Sociocultural,
and Artificial Layers of Complexity*

January 26-28, 2026

Rome

PROGRAM & ABSTRACTS

Venue

Casa Bonus Pastor

Via Aurelia, 208

00165 – Rome, ITALY

Pontificia Università della Santa Croce

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INTRODUCTION

This Research Seminar is part of a project funded by the Pontifical University of the Holy Cross and titled “*De thesauro suo nova et vetera* (Mt 13,52). A cross-disciplinary inquiry into human creativity” (grant PRI-HCR) through an internal grant program (<https://www.pusc.it/research-project/creativity>). The project began in the A.Y. 2023-2024 with a planning grant, which facilitated the organization of a first seminar, in January 2024, titled *Creativity: Innovation, Transmission, and Motivation in Animals, Humans, and Societies*. This seminar featured five invited speakers who are experts in various disciplines: <https://www.pusc.it/article/creativity-innovation-transmission-and-motivation-centro-disf>.

Since then, other two Research Seminars have been organized within this project. One focused on creativity and innovation in religion (<https://en.pusc.it/article/expert-meeting-creativity-and-innovation-religion-2025>) and another one addressed creativity mainly from the viewpoint of aesthetics and philosophical anthropology (<https://en.pusc.it/article/research-seminar-creativity-and-emergence-between-aesthetics-and-anthropology>).

With the present Research Seminar we come back, in a sense, to the widely interdisciplinary scope of the first event, further expanding it so as to encompass also the “artificial layer of complexity”. The focus of the whole research project is on human creativity – has its title clarifies; however, a promising way to try to grasp the specifics of human creativity is to compare it with other forms of novelty emergence. This certainly includes animal and artificial systems. However, widening the scope so as to encompass also physical, nonliving and non-artificial systems will potentially unveil other aspects relevant to understand human creativity, both at the comparative level and at the level of the (pre-)conditions for creativity itself. Hence, the wide scope of the Research Seminar on “*Amazing Novelties: Emergence and Creativity in Material, Biological, Sociocultural, and Artificial Layers of Complexity*”.

SPEAKERS

- Giovanni E. **CORAZZA**
University of Bologna
- Niels Henrik **GREGERSEN**
University of Copenhagen
- Guy **THERAULAZ**
CNRS, Toulouse, France
- Andra **MENEGANZIN**
KU Leuven
- Ivan **COLAGÈ**
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Speakers’ **biosketches** at the end of this document

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PROGRAM

Mon. Jan. 26	
14:30	Welcome and opening remarks – Ivan Colagè
15:00	Short Introductory Thematic Talks by I. Colagè and G. Corazza
16:00	<i>Coffee Break</i>
16:30	TALK 1 <i>The Dynamic Universal Creative Process: Extended Evolutionary Perspectives</i> Giovanni CORAZZA
17:30	Discussion of Talk 1
18:00	End of session
19:30	<i>Dinner</i> (at the Meeting Venue)
Tue. Jan. 27	
9:30	TALK 2 <i>From self-organization to creative explorations of ecospace: Cultural Conflicts between the perspectives of “down to Earth” vs. “up”</i> Niels H. GREGERSEN
10:30	Discussion of Talk 2
11:00	<i>Coffee Break</i>
11:30	TALK 3 <i>How animal societies generate novelty through self-organization</i> Guy THERAULAZ
12:30	Discussion of Talk 3
13:00	<i>Lunch</i> (at the Meeting Venue)
TRANSFER TO THE HOLY CROSS UNIVERSITY	
15:30	Meeting with Academic Representatives
16:00	University Tour
16:45	TALK 4 <i>Innovating (in) the Middle Pleistocene: Reading and Rereading the Archaeological Record</i> Andra MENEGANZIN
17:45	Discussion of Talk 4
18:15	End of session and walk in the City Centre
19:30	<i>Dinner Out</i>
Wed. Jan. 28	
9:30	TALK 5 <i>Novel “problems”: how human cultural evolution proceeded via creative recombination and repurposing</i> Ivan COLAGÈ
10:30	Discussion of Talk 5
11:00	<i>Coffee Break</i>
11:30	General Discussion
13:15	<i>Lunch</i> (at the Meeting Venue) and end of the meeting

ABSTRACTS

(in order of presentation)

The Dynamic Universal Creative Process: Extended Evolutionary Perspectives

Giovanni E. CORAZZA

University of Bologna and Marconi Institute for Creativity

Abstract

This talk proposes a universal account of creativity based on the *dynamic definition of creativity* (Corazza, 2016), according to which creativity is best understood as *potential originality and effectiveness* (POE), estimated within specific contexts that themselves evolve. On this view, both creative *achievement* and creative *inconclusiveness* are recognized as key parts of the creative process, which is never a ride with guaranteed success. Originality alone is insufficient, as it must be matched by the capacity of an idea, artifact, or act to become effective under changing estimation conditions and time horizons. This framing foregrounds context, temporality, and the moving boundary between failure and success—clarifying why the same idea can be dismissed in one setting and transformative in another. The adoption of the dynamic definition of creativity leads to a Dynamic Creativity Framework (Corazza et al., 2022), with both theoretical and experimental implications.

Building on this foundation, the talk develops the Dynamic Universal Creativity Process (DUCP) (Corazza, 2019), defined as the active ensemble of all creativity episodes in the evolution of our cosmos. It is shown how this construct descends naturally through a shift in the leading perspective in creativity studies: from a focus on static creative achievements to the consideration of dynamic processes, which even transcend their agents. Four mechanisms for the dynamic extension in time and space of creativity episodes are presented: continued exploration, concatenation, estimation, and exaptation. The concepts of wide-sense and strict-sense creativity are introduced to allow the consideration of four layers of existence in the DUCP: material, biological, psycho-social, and artificial. Viewing creativity under the DUCP lens contributes to the mending of the cultural fracture between science and the arts. Among other concepts, complex systems, biological evolution, bipedalism, neoteny, individual and social mind-based behaviour, implications on education, as well as artificial intelligence, all find an integrated place in the framework of creativity studies, under the DUCP umbrella.

The third movement of the talk addresses how the rapid advance of artificial intelligence reconfigures this dynamic. AI dramatically changes the costs and speeds of variation and evaluation: search spaces expand; simulation becomes inexpensive; and platform-level metrics begin to act as de facto selectors. At the same time, AI can induce homogenization and cognitive offloading, implying a detriment in human creativity. To discuss these issues, I synthesize the emerging field of cyber-creativity and present a coordinated research agenda articulated as a *decalogue of challenges* (Corazza et al., 2025). The decalogue organizes open questions across ten interdependent domains: (1) theoretical framework (what uniquely defines cyber-creativity and how it integrates human and artificial forms); (2) sociocultural perspectives (how audience, norms, incentives, and digital affordances shape selection); (3) process (how to optimize human–AI co-creation pipelines, including defixation and evaluation loops); (4) agent (how capabilities and responsibilities are distributed across human creators and AI systems); (5) team (how to structure hybrid teams to leverage complementary strengths); (6) products (how to specify, detect, and measure value in digital artifacts and services); (7) domains (how different fields—science, art, policy, education, industry—stantiate cyber-creative dynamics); (8) education (how to teach context-sensing, evaluation, and ethical foresight for hybrid creativity); (9) ethics (identity, authorship, fairness, transparency, and governance in selection environments); and (10) the dark side (mitigating malevolent uses, deception, recursive content amplification, deepfakes, and broader misalignment risks). Together, these challenges

translate the DUCP perspective into a concrete, multi-stakeholder research program for the post-information era.

Seen through the arc from the dynamic definition (Corazza, 2016) to the dynamic universal creativity process (Corazza, 2019) and the cyber-creativity decalogue (Corazza et al., 2025), creativity emerges as the connective tissue of evolving systems—linking episodes to processes, individuals to institutions, and human intelligence to machine augmentation. The implication is both scientific and civic: if creativity is the mechanism by which possibility spaces are explored and stabilized, then designing our selection environments—in research, education, and policy—becomes the central lever for steering human imagination toward beneficial outcomes. This talk invites creativity researchers and educators to join forces on that design task, establishing a robust discipline of creativity fit for an AI-accelerated world.

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From self-organization to creative explorations of ecospace: Cultural Conflicts between the perspectives of “down to Earth” vs. “up”

Niels Henrik GREGERSEN

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Abstract

Conservation and creativity take place all over the universe in an interplay between energy flows and formative structures. In this paper, I will argue for the relevance of information not only for describing reality but for detecting relevant causes of creativity. “Information matters.” The relation between analogical and digital information is important for understanding cultural conflicts as well.

In the received view, the basic furniture of causality resides in mass-and-energy translations. More recently, however, physicists and biologists argue for adding information to the causal structure of the universe (Davies & Gregersen 2014). This proposal of an ontological triad of ‘mass, energy, and information’ can take weak and strong forms. In the weak form, informational structures are viewed as inevitable results of prior energy interactions, important as descriptive short-hands for complex physical chemical interactions, otherwise intractable. In the strong form, information is metaphysically irreducible, having causal effects of its own. Information is about making differences, leading to (1) “shaping information,” thus giving priority to morphological structures (emergence from below). In the stronger form, informational structures decide what to do: “Energy makes physical systems do things. Information tells them what to do” (Lloyd 2006, 40). In this view, formative features exert causal effects on their material constituents (strong emergence). Such features are visible in chemistry, as shown by Prigogine among others, pointing to principles of self-organization in nature. This view has a long pre-history in both philosophy and theology, as when Bonaventure stated the principle that “matter is full of forms,” seeing God as the ultimate principle of informational growth.

Biology has been termed an informational science by Maynard Smith, giving preference to (2) the “coding information” of DNA. Biosemiotics adds the important point that the interpretative agency resides in organisms, grading the possibilities and pressures of the environment with regard to the interest of living organisms (from bacteria to lions). Coding information becomes (3) “meaning information”, attentive to salient aspects of the environment and facilitating in learning processes (Baldwinian evolution). The informational unit is here the organism + the interpreted environment.

Human societies fully share the same need to find ever new inhabitations in shifting environments. Yet human imagination and language adds the sense of always undefined world-openness (Max Scheler, Helmut Plessner), going beyond presently available environments via imagination and language. In our ecological age, we see cultural conflicts between the wish to come “down to earth” (Latour 2027) and the urge to erect “intelligent civilizations” via digital information growth (Zimmer 2025). How is it possible to balance the conflicting moves of current culture, in which the future of humanity depends on the simultaneous formation of a creative ecological conservation and technological innovations?

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How animal societies generate novelty through self-organization

Guy THERAULAZ

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Abstract

Creativity in biological systems is often implicitly associated with individual cognition, innovation, or problem solving. In animal societies, however, some of the most spectacular forms of novelty and adaptive complexity emerge at the collective level, from interactions among individuals that possess limited cognitive capacities and no global knowledge of the structures or behaviors they collectively generate. In this talk, I will address creativity in animal societies through the lens of underlying mechanisms and processes, focusing on how novel forms, coordinated behaviors, and adaptive responses arise from collective dynamics. The emphasis will be placed on collective forms and behaviors, and on the biological and cognitive mechanisms that enable groups to generate solutions that exceed the capabilities of their individual members.

In the first part of the talk, I will focus on social insects, such as ants and termites, which provide some of the clearest examples of collective creativity in the living world. These societies routinely construct large-scale, functional architectures (nests with chambers, galleries, ramps, and ventilation systems) without centralized control, blueprints, or supervisory individuals. I will show how such architectural complexity emerges from the coordination of countless local actions mediated by *stigmergic interactions*, in which individuals indirectly influence one another through modifications of their environment. Empirical studies combining behavioral experiments, high-resolution imaging and computational modeling reveal how simple positive feedback mechanisms, coupled with finite signal lifetimes and spatial constraints, generate ordered structures such as pillars, walls, floors, and interconnected networks.

Beyond stigmergy alone, I will highlight the role of template-based mechanisms, in which insects use physical cues (such as body size, gravity, or environmental gradients) as references to guide construction. These mechanisms allow colonies to translate local information into globally coherent structures. Crucially, I will show that the modulation of social interactions by environmental factors (including temperature, humidity, substrate properties, and airflow) can dramatically enhance the plasticity of collective responses. Changes in environmental conditions alter interaction strengths, activity levels, and feedback dynamics, enabling insect societies to collectively generate novel architectural solutions when confronted with new constraints or disturbances. In this sense, creativity in insect societies emerges from the dynamic coupling between behavior, material properties, and environmental context.

In the second part of the talk, I will turn to collective motion in vertebrates, focusing on fish schools as model systems for studying coordination, adaptability, and emergent collective intelligence. Fish schools display a wide range of collective states, such as polarized schooling, milling, and disordered swarming, which arise from simple attraction and alignment interactions among neighbors. Recent advances in automated tracking and data-driven modeling have made it possible to quantitatively reconstruct these interaction rules directly from experimental data. I will show how collective motion emerges from distributed information processing, where individuals attend to only a small number of neighbors, yet collectively achieve robust coordination.

A central theme of this second part will be the role of stress and perturbations in shaping collective behavior. Experimental studies reveal that stressors (such as sudden changes in light or environmental conditions) can drive fish schools toward highly ordered, responsive states in which the group behaves as a single super-organism. In these regimes, collective sensitivity and reactivity are maximized, allowing rapid and coherent responses to external threats. I will discuss how these dynamics can be understood within the framework of criticality, where animal groups self-organize near phase transitions to balance robustness and flexibility.

Taken together, these two case studies, social insects and schooling fish, illustrate how creativity in animal societies arises from emergent collective processes rather than from individual ingenuity. Across very different biological systems, similar principles recur: decentralized interactions, nonlinear feedback,

environmental modulation, and adaptive tuning of collective states. These mechanisms provide a general framework for understanding how novelty, flexibility, and innovation can emerge across material, biological, sociocultural, and even artificial layers of complexity.

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Innovating (in) the Middle Pleistocene: Reading and Rereading the Archaeological Record

Andra MENEGANZIN
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Abstract

The Middle Pleistocene sits at the crossroads of outstanding questions in human evolutionary research. These span from the origins of our species, *Homo sapiens*, and the biological and cultural interactions with other coeval hominin forms (*Homo neanderthalensis* in particular), to the emergence of behavioural and cognitive complexity. Questions of innovation crosscut many of these topical issues in critical ways and are at the centre of both empirical and philosophical discussion. How has innovation been tracked in the Middle Pleistocene archaeological record? How have material patterns evolved through time, shaping the state-of-the-art problem agenda? How is the propensity to innovate compared between extinct hominin lineages? These questions will constitute the focus of my presentation.

In particular, drawing from recent contributions within the philosophy of paleoanthropology and archaeology, my talk will showcase how the Middle Pleistocene archaeological record has been read and reread, and how this has redrawn the questions we ask and the answers we look for. This interplay between the evolution of pressing *explananda* and adequate *explanatory* frameworks will be showcased by tackling debates centred on the concept and research on ‘behavioral modernity’—how hominins became ‘human’ in relevant behavioral and cultural respects—the contributions of the Neanderthal lineage to the innovation record, and emerging questions on shared and distinctive features in the innovative propensity between our species and the Neanderthals, including their aesthetic repertoires. This talk will ultimately demonstrate how this interplay between the material signature and its interpretation is an unfolding process, with still unscrutinized issues in business-as-usual archaeological research that bear concrete potential to reinvent the way we think about Middle Pleistocene innovation.

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Novel “problems”: how human cultural evolution proceeded via creative recombination and repurposing

Ivan COLAGÈ

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Abstract

The main idea I would like to convey with my talk is that human creativity’s main payoffs are not original and interesting *solutions* to some “externally-generated”, pre-existing problem but the generation of novel “problems” – i.e., new perspectives, contexts, enterprises that are not, in principle, triggered by pre-existing or incipient problems or challenges (this, of course, does *not* amount to claim that such new perspectives are fully unrelated to previous developments).

To do that, I will first present a conceptual framework to identify different kinds or levels of creativity based on the relationships between problems and solutions. The framework¹ (see Fig. 1) distinguishes “problem driven” creativity processes (where creativity is employed to solve given problems) and “solution driven” creativity processes (where creativity works in opening new perspectives – or in “posing new problems”, so to speak).

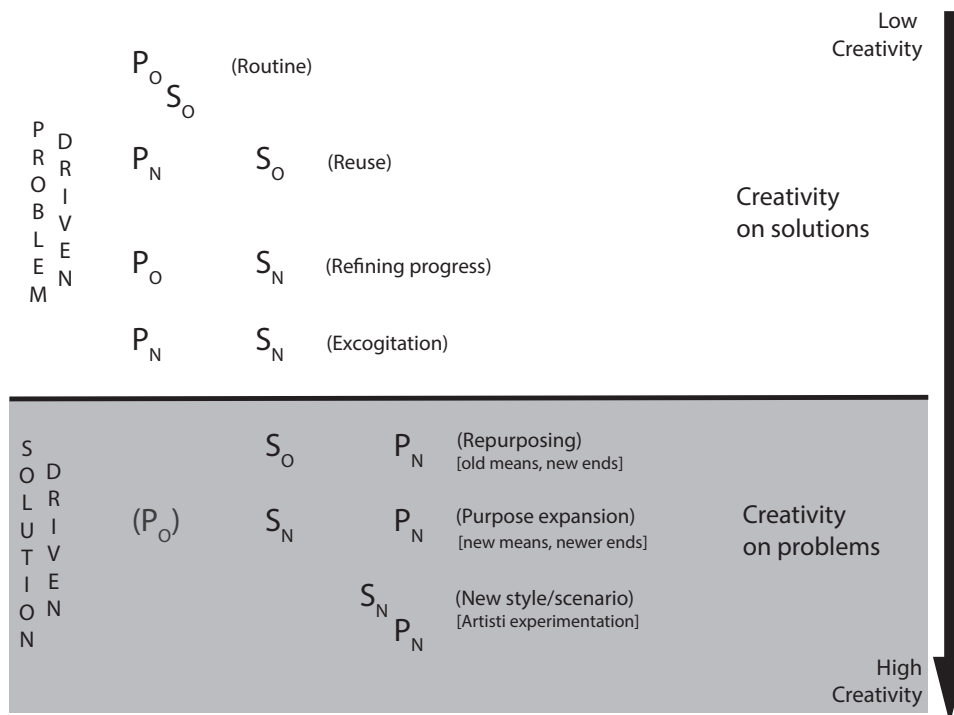


Fig. 1. Kinds of creativity processes according to the relationships between problems and solutions. P = “problem”; S = “solution”. Subscript O = “old”; Subscript N = “new”.

After that, I will advocate the “solution driven” part on the basis of innovations emerged during the pre-history of humanity. Some of the innovations attested in the archaeological record cannot, I will argue, be fully explained in terms of solutions excogitated to solve problems or challenges that the environment had already posed to our ancestors. Understanding the emergence of such novelties implies, I suggest, the consideration of a deeper level of motivations, desires, aspirations.

The notion of recombination of existing elements to come out with novel cultural traits will be presented as the basic mechanism beneath human cumulative cultural evolution. The notion of *repurposing* (i.e., the

¹ This framework is being developed by myself, Stefano Oliva and Claudio Tagliapietra.

attitude to attribute new functions, goals or aims to existing items, or to a novel combination of old items) will be understood as the core mechanism by which new perspectives are disclosed in cultural evolution. The solution driven dimension of creativity will be understood as a process, not as an instantaneous “spark”, and will be interpolated with three key points: niche construction, collective intelligence and social learning.

The relationships of the human being with the environment is extremely complex and is part and parcel of the cultural-evolutionary process. It is essentially transformative, both ways: the human being transforms the environment and the environment transforms the human being in a reciprocal and complementary way. In the human case, niche construction often acquires epistemic features; this is the so-called *epistemic* niche construction through which information left in the environment affects cognitive and cultural processes even beyond direct contact among the actors of the process (this has links with the notion of stigmergy). Epistemic niche construction is linked to collective intelligence, whereby outputs are produced thanks to shared processes within collectives of actors. It is worth noting that cumulative cultural evolution is defined precisely as a process giving rise to products that *no single individual could have achieved alone*. Both niche construction and collective intelligence bear interesting relationships with social learning, as the ability to acquire skills and practices by others is essential to sustain the whole cultural-evolutionary process. Interestingly, social learning strategies, up to teaching (defined as the modification of the behaviour of an expert individual aimed at facilitating others’ learning), can be shown to have evolved along the human lineage, and also in this case, this cultural-evolutionary process cannot be explained entirely in terms of the need to find solutions to existing problems. Rather, fine teaching strategies appear to have been elaborated as a way to invest in new practices considered interesting and valuable also independently of their (initial) immediate utilitarian consequences, and exactly in view of a new perspective to be opened.

In sum, I will present a view of human creativity coming from insights from human cumulative cultural evolution interpreted in the light of the notions of (epistemic) niche construction, collective intelligence and social learning (and teaching). All that constitutes the “big picture” of creativity I will put forward for discussion, but the core of this view is the *repurposing* attitude the human being displays in several cultural evolutionary steps. And this is the point which the idea that human creativity clearly is a “solution driven” process hinges on.

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SPEAKERS' BIOSKETCHES

(in order of presentation)

Giovanni Emanuele Corazza is a Full Professor at the Alma Mater Studiorum University of Bologna, founder of the Marconi Institute for Creativity (MIC), Member of the Board of the International Society for the Study of Creativity and Innovation (ISSCI), Core Faculty Member of the Bologna Business School (BBS). He holds a PhD in Telecommunications and Microelectronics from the University of Rome Tor Vergata, and a PhD in Psychology from the Université Paris Cité. His research interests are focused on creativity studies, foresight, anticipation, next generation telecommunications.

He was President of the Fondazione Guglielmo Marconi in the years 2019-2023, President of the CINECA consortium for supercomputing in the years 2017-2019, Head of the Department of Electronics, Computer Science and Systems (DEIS) in the years 2009-2012, Member of the Partnership Board of the 5G Infrastructure Association in the years 2013-2018, Member of the Board of Directors of the University of Bologna in the years 2012-2018, Chairman of the School for Telecommunications in the years 2000-2003, Chairman of the Advanced Satellite Mobile Systems Task Force (ASMS TF), Founder and Chairman of the Integral Satcom Initiative (ISI), a European Technology Platform devoted to Satellite Communications.

Niels Henrik Gregersen (born in 1956) obtained his PhD in theology from the University of Copenhagen, Denmark (1987). Since 2004, he has been Professor of Systematic Theology at the University of Copenhagen. He was a researcher in Ethics and Philosophy of Religion (1986-1989), Associate Professor of Systematic Theology (1989-2000), and Research Professor in Theology and Science (2000-2004) at Aarhus University. Gregersen has been a Fellow at the Center of Theological Inquiry in Princeton since 1996 and a J.K. John Russell Fellow at the Center for Theology and the Natural Sciences (CTNS) in Berkeley in October 2004 and 2013. He has received several international research awards, including from the John Templeton Foundation. He lectures extensively in Europe and the US and has been invited as a keynote speaker at major conferences in South Africa, China, Japan, South Korea, and Australia. He writes in Danish, English, and German and has been translated into Swedish, French, Dutch, Russian, Romanian, Korean, Japanese, and Chinese. He is the first and foremost proponent of the doctrine of Deep Incarnation.

Guy Theraulaz is a senior research fellow at the French National Centre for Scientific Research (CNRS) and a leading expert in the study of collective animal behavior. His work lies at the interface of biology, physics, and computer science, with a particular focus on swarm intelligence. While his primary empirical models are social insects, his research also extends to distributed algorithms and bio-inspired approaches to collective robotics. His research aims to understand a wide range of collective phenomena in animal societies by quantitatively characterizing individual behaviors and interactions and integrating them into mechanistic models. This approach has helped elucidate how simple local interactions give rise to complex, emergent properties at the group level. He has published extensively on nest construction in ant and wasp colonies, collective decision-making in ants and cockroaches, collective motion in fish schools and human crowds, and collective estimation in human groups. He has co-authored five books, including *Swarm Intelligence: From Natural to Artificial Systems* (Oxford University Press, 1999) and *Self-Organization in Biological Systems* (Princeton University Press, 2001), both of which are widely regarded as reference textbooks in the field. In 2019, he was appointed Visiting Chair Professor in Collective Behavior at the Indian Institute of Science in Bangalore by the Infosys Foundation.

Andra Meneganzin is a philosopher of biology and theoretical (paleo)anthropologist, currently an FWO senior postdoctoral fellow at the Institute of Philosophy, KU Leuven (Belgium). She earned her PhD in 2022 from the Department of Biology at the University of Padova (Italy), with a thesis on evolutionary and epistemic issues in *Homo sapiens* origins and interactions with Neanderthals. Her research focuses on the philosophy of paleoanthropology and archaeology, examining the evidential, theoretical, and methodological foundations and constraints of knowledge production in human evolutionary studies. Recent work addresses character identification in human evolution, species delimitation and speciation models, the transition to behavioral and cultural complexity, explanations of Neanderthal extinction and inferences in comparative cognitive archaeology.

Ivan Colagè is Director of the DISF Research Centre and Professor of Logic, Philosophy of Science and of Mind at the Pontifical University of the Holy Cross, Rome. He also has a visiting professorship (1 month a year) at the PACEA UMR 5199, CNRS, Bordeaux, France. He took his PhD in Philosophy, Specialization in Science and Philosophy, from the Pontifical Gregorian University of Rome in 2010. His research focuses on philosophy of biology, human biological and cultural evolution, the interactions between brain substrates and cultural practices and in embodied language. He has been PI of a John Templeton Foundation grant on Human Uniqueness from 2013 to 2016 and member of a research project by the European Space Agency on the regeneration of planarians in microgravity conditions, from 2008 to 2019. Currently he is member of the International Society for the Study of Science and Religion and PI of the research project “A cross-disciplinary inquiry on human creativity” funded by the Pontifical University of the Holy Cross, Rome. He is author or editor of 5 book, and author or co-author of more than 50 journal articles and 25 book chapters.