

Original Research Article

Conceptual Evolution and Theorization of Bio-Aesthetics: Linking Human, Nature, and Meaning in Environmental Aesthetic Experience*

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Received: 28/10/2025

Accepted: 29/04/2026

Available online: 22/06/2026

Abstract | The rapid intensification of urbanization and the progressive detachment of human life from natural processes have eroded the depth of aesthetic experience and weakened the intertwined relationship between beauty, meaning, and liveability in contemporary built environments. Conventional aesthetic theories - rooted either in subjective judgment or in strictly formalist interpretations - are largely inadequate for explaining this multi-layered nexus. This conceptual limitation underscores the necessity of re-examining the philosophical, perceptual, and biological underpinnings of aesthetic experience. This study aims to trace and clarify the conceptual evolution of bio-aesthetics and to articulate a theoretical framework that elucidates the perceptual, cognitive, social, and biological mechanisms underpinning aesthetic experience within the triadic relationship of human beings, nature, and meaning. On this basis, the research seeks to formulate a comprehensive model for improving environmental quality. This study adopts conceptual analysis and theoretical inference as its core methodological strategy. The corpus comprises classical and contemporary scholarship in the philosophy of aesthetics, evolutionary biology, neuroaesthetics, environmental psychology, and architectural/urban design theory. The analytical process involved comparing and synthesizing key theoretical perspectives - from biophilia and biomimicry to ecological aesthetics and nature-based design - to distill a coherent explanatory framework for environmental aesthetic experience. The results of this study suggest that bio-aesthetics can be understood as a coherent theoretical system in which aesthetic experience arises from the concurrent interaction of perceptual, cognitive, social, and biological processes. The proposed framework operates across four interlinked analytical levels - biological, neural, functional, formal, value-oriented ecological, and perceptual-semantic - showing that environmental quality is shaped by the intrinsic interplay of mind, body, nature, and meaning. Within this perspective, beauty is reconceptualized as an expression of life, and nature as a primary carrier of meaning. In this sense, bio-aesthetic theory not only offers a comprehensive basis for improving the quality of residential and urban environments but also provides a conceptual platform for advancing a new integrative paradigm in architecture and environmental design.

Keywords | *Bio-aesthetics; Human-Nature-Meaning; Theorization; Aesthetic Experience; Environmental Quality.*

Introduction | Over the past few decades, the rapid expansion of urbanization and the industrialization of everyday living environments have progressively loosened the bond between aesthetic experience in the

built environment and the natural processes, rhythms, and senses of habitability that once underpinned it. The resulting disconnect between beauty and liveability is largely rooted in the mechanical and narrowly functionalist conception of the environment that shaped much of twentieth-century planning and design thought (Carlson, 2000, 14). In reaction to this trajectory, a series of interdisciplinary currents in architecture, philosophy, and the behavioral sciences have called for a renewed examination of the human-nature relationship through

* This article is extracted from "Parviz Aslani's" doctoral dissertation entitled "Explaining the Components of Bio-Aesthetics and Examining Its Manifestation in Improving the Quality of the Residential Environment," which has been done under the supervision of Dr. "Farah Habib" and advisement of Dr. "Azadeh Shahcheraghi" at the Faculty of Architecture, University of Science and Research, Tehran, Iran, in 2025.

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perceptual, biological, and cultural lenses (Kellert & Wilson, 1993; Salingaros, 2015; Browning et al., 2014).

Against this backdrop, the notion of bio-aesthetics has emerged as a contemporary framework for interpreting aesthetic experience as inherently intertwined with life processes. In the Biophilia Hypothesis, Kellert & Wilson (1993) contend that human affinity for nature is not a transient emotional preference, but an evolutionarily shaped disposition embedded in survival mechanisms. Ulrich's (1983) seminal research on affective responses to natural scenes, alongside Kaplan & Kaplan's (1989) Attention Restoration Theory, demonstrates that exposure to natural environments can alleviate stress and support cognitive recovery. From an evolutionary perspective, Dissanayake (1995) and Voland (2003) understand beauty as an outcome of adaptive behaviors and habitat selection, while Berlyne (1971), through his concepts of arousal and complexity, lays a psycho-aesthetic foundation for explaining how such experiences are formed.

Consequently, bioaesthetics, as an interdisciplinary paradigm, interlaces three core domains:

1. The philosophical and phenomenological foundations of beauty;
2. The biological and evolutionary mechanisms underlying perception;
3. The cognitive and perceptual processes through which spatial experience is formed.

Within this constellation of ideas, Carlson (1999) underscores the intrinsic relationship between aesthetic value and the vitality of the natural world, while Salingaros (2015) demonstrates that biophilic morphologies can trigger positive neural and emotional responses in users of architectural spaces. More recent work in environmental neuroaesthetics further strengthens the claim that the brain's reaction to natural patterns is closely linked to reward circuits and subjective experiences of calm and relaxation (Chatterjee & Vartanian, 2014; Pearce et al., 2016).

Despite these advances, a critical reading of the literature reveals that, although notions such as biophilic design, ecological aesthetics, and nature-based design have gained considerable traction, a unified and comprehensive theoretical framework capable of explaining the multidimensional mechanisms of bio-aesthetics has not yet been fully formulated (Hosseini Nasab et al., 2022; Brady, 2003). Much of the existing research in biophilic design, environmental psychology, and neuroaesthetics tends to privilege a single dimension of aesthetic experience - biological, perceptual, or cognitive - rather than theorizing the human-nature-meaning nexus as an integrated system. A review of more recent studies likewise confirms the persistence of this conceptual gap. Contemporary studies on biophilic design (Tekin, 2025) and biophilic cities (Milliken, 2023), although they highlight the role of nature in human health

and environmental perception, still fall short of providing an integrated framework for explaining the multilayered mechanisms of aesthetic experience. As a result, the existing body of literature remains conceptually fragmented across philosophical, neuroaesthetic, and environmental design perspectives and lacks a model capable of reconstructing the conceptual evolution of bio-aesthetics through a structured linkage between perception, liveability, and meaning.

Against this backdrop, the present article seeks to elucidate the conceptual evolution and theorization of bio-aesthetics and to reconstruct the triadic relationship between human, nature, and meaning in environmental aesthetic experience. Employing conceptual analysis and theoretical inference, and drawing on a comparative review of the field's philosophical, biological, and perceptual foundations, this study aims to formulate a comprehensive theoretical system for understanding bio-aesthetic experience - one in which beauty is understood not merely as a subjective judgment or formal attribute, but as a living, perceptual, and meaning-oriented process (Soleimani & Mandegari, 2016; Ryan et al., 2014b; Joye & Dewitte, 2018; Zhang et al., 2019).

Literature Review

The concept of bio-aesthetics has evolved in close continuity with Wilson's (1984) Biophilia Hypothesis, which frames humans' innate affinity for nature as a primary source of aesthetic experience and psychological restoration. Ulrich's (1983) pioneering research, together with the work of Kaplan & Kaplan (1989), showed that exposure to natural landscapes can alleviate stress and replenish directed attention, thereby illuminating the neurobiological and perceptual underpinnings of environmental aesthetic experience.

During the 1990s, Benyus (1997) introduced the notion of biomimicry, interpreting beauty as an expression of structural coherence and the intrinsic logic of living systems in nature. Concurrently, Carlson (1999) and Brady (2003), through the lens of ecological aesthetics, emphasized the interdependence of beauty, environmental ethics, and ecological responsibility. In a parallel trajectory, phenomenologists such as Merleau-Ponty (1945/2012) and Seamon (2000b) reconceptualized aesthetic experience as an embodied and lived process, in which meaning emerges from the perceiver's situated engagement with place.

More recently, the works of Ryan et al. (2014a), Browning et al. (2014), and Salingaros (2015) have sought to bring these strands together within biophilic and nature-based design frameworks, showing that the integration of natural elements into the built environment can enhance perceptual quality, psychological well-being, and residents' sense of place attachment.

In Iran, a relatively limited but noteworthy body of scholarship has examined the biological, perceptual, and

neuro-aesthetic dimensions of environmental experience. Hosseini-Nasab et al. (2022), in a study on neuro-based aesthetics in residential façades in Tehran, demonstrated that sensory stimuli and perceptual patterns related to views, light, and spatial rhythm can activate neuro-aesthetic mechanisms and improve the quality of aesthetic perception. Likewise, Esmaili et al. (2024), in their investigation of the role of perceptual-aesthetic components of place in the mental health of residents in residential complexes in Gorgan, found that perceptual and aesthetic attributes - such as legibility, spatial coherence, and nature-oriented elements - significantly contribute to psychological well-being and to residents' lived experience of residential liveability.

Despite these advances, a review of the domestic literature indicates that a fully articulated, multi-level theoretical framework capable of explaining the interactive relationship between human, nature, and meaning within a single, coherent model has yet to be developed. In response to this gap, the present study aims to elucidate the conceptual evolution and theoretical architecture of bio-aesthetics in relation to environmental aesthetic experience. The proposed framework is constructed through the integration of biological-neural, cognitive-formal, social, and meaning-oriented layers and is intended to provide a new theoretical foundation for improving the quality of human living environments.

Theoretical Foundations and Conceptual Evolution of Bio-Aesthetics

Bio-aesthetics has its roots in a long intellectual lineage that binds together notions of beauty, nature, and life - a lineage that begins with classical philosophical reflections on order in nature and, by the twenty-first century, evolves into an interdisciplinary account of human aesthetic experience. In ancient philosophy, Plato and Aristotle regarded beauty as the manifestation of order and harmony in the natural cosmos, grounding it in the proportional correspondence between parts and the whole (Aristotle, 1998). During the Renaissance, figures such as Alberti and Leonardo da Vinci further advanced this view by examining the proportions of the human body, thereby underscoring the intimate relationship between living form and architectural or structural beauty (Wittkower, 1998). This trajectory was later reformulated by Kant in the "Critique of the Power of Judgment" (Kant, 1790/2000) through the concept of "purposiveness without purpose," according to which the experience of beauty in nature signals an inner vitality and inherent purposiveness within phenomena themselves (Guyer, 2005).

• Philosophical and phenomenological roots

In the twentieth century, phenomenological thinkers such as Merleau-Ponty reoriented the understanding of aesthetic experience from a matter of subjective judgment to one

of lived, embodied perception. From his standpoint, the body is not a neutral tool that merely receives stimuli, but the primary site through which the world is sensed and experienced (Merleau-Ponty, 1945/2012). In a similar direction, Seamon (2000a) contends that the experience of beauty in place arises from the dynamic interplay of body and mind as they move and dwell within the environment. This perspective - grounded in the notions of embodiment and the continuity between perception and nature - constitutes a crucial philosophical underpinning of bio-aesthetics, in which aesthetic experience is understood as emerging from the reciprocal relationship between body, space, and life.

• Biological and evolutionary roots

In the nineteenth century, Charles Darwin, in "The Descent of Man", located the origins of the sense of beauty within the logic of natural selection, framing it as an adaptive mechanism that supports survival and reproduction. Following this line of reasoning, Dissanayake (1995), in "Homo Aestheticus", and Voland (2000) conceptualize beauty as a biologically grounded form of behavior that promotes social cohesion and the selection of favorable habitats.

Subsequent research in neuroaesthetics has strengthened this perspective. Zeki (1999) demonstrated that the experience of beauty is accompanied by activation in regions of the prefrontal and orbitofrontal cortex- areas closely associated with reward processing and pleasurable affect. Likewise, Chatterjee & Vartanian (2014) argue, based on neuroscientific evidence, that aesthetic perception relies on neural networks that substantially overlap with those involved in emotion and meaning-making. From this vantage point, bio-aesthetics forges a direct link between aesthetic pleasure, biological life, and the neural architectures that sustain both.

• Psychological and environmental roots

Over the twentieth century, environmental psychology added a robust empirical layer to this discussion. Wilson's (1984) Biophilia Hypothesis proposed that humans possess an innate tendency to affiliate with nature, a claim later elaborated by Kellert & Wilson (1993) within a broader bio-environmental framework. Ulrich's (1983) seminal work showed that exposure to natural scenes can lower stress levels and enhance cognitive performance, while Kaplan & Kaplan (1989), through Attention Restoration Theory, argued that natural environments relieve mental fatigue by offering gentle sensory engagement and sufficient perceptual variety. In a complementary vein, Nasar (1994), in his urban research, highlighted that an optimal balance between legibility and perceptual complexity is a decisive factor in shaping aesthetic experience within human environments.

In recent decades, these strands of evidence have converged in the emerging field of environmental neuroaesthetics, which investigates how the nervous system, emotional responses, and design interact. From this vantage point, bio-aesthetics is

understood as a multilayered system in which physiological reactions, cognitive operations, and symbolic meanings are co-activated in the experience of beauty.

• Historical evolution and theoretical convergence

A review of the intellectual genealogy of bio-aesthetics shows that it has not arisen from a single discipline, but from the gradual convergence of three major strands of thought:

1. Philosophical–phenomenological, which centers on the perceptual and lived dimensions of beauty (Kant, 1790/2000; Merleau-Ponty, 1945/2012);
2. Biological–evolutionary, which interprets aesthetic responses through natural selection and insights from neuroaesthetics (Darwin, 1981; Dissanayake, 1995; Zeki, 1999);
3. Psychological–environmental, which highlights the role of nature in mental health and environmental preference (Ulrich, 1983; Kaplan & Kaplan, 1989).

In the twenty-first century, these trajectories have increasingly overlapped, giving rise to an interdisciplinary paradigm in which beauty, life, and meaning are understood as inseparable dimensions of environmental perception (Kellert et al., 2008; Ryan et al., 2014b; Salinger, 2015). This paradigm underpins the emergence of bio-aesthetics as a distinct concept and informs a range of contemporary design approaches derived from it.

From this perspective, the development of bio-aesthetic thought can be seen as the outcome of an incremental synthesis across philosophy, biology, environmental psychology, and design theory. To clarify this trajectory, Fig. 1 maps the conceptual and theoretical evolution of bio-aesthetics from classical philosophical accounts to present-day interdisciplinary frameworks. The figure illustrates how understandings of “beauty” have progressively shifted -from an emphasis on natural order and formal proportion toward a bio-cognitive and meaning-oriented view- ultimately crystallizing into a coherent theoretical system within the interdisciplinary paradigm of bio-aesthetics.

To make the historical trajectory of this line of thought more explicit, Table 1 sets out an analytical overview of the principal stages in the development of bio-aesthetics. The table compares the defining theoretical features of each period, identifies key thinkers, and summarizes their specific contributions to the consolidation of bio-aesthetics as a theoretical field. Taken together, the entries in the table show that this trajectory begins with a classical–philosophical phase, gains a more explicit scientific grounding during the modern and evolutionary–biological period, and, in the twenty-first century, is ultimately reconfigured into a comprehensive paradigm through the integration of biological, perceptual, and design-oriented approaches.

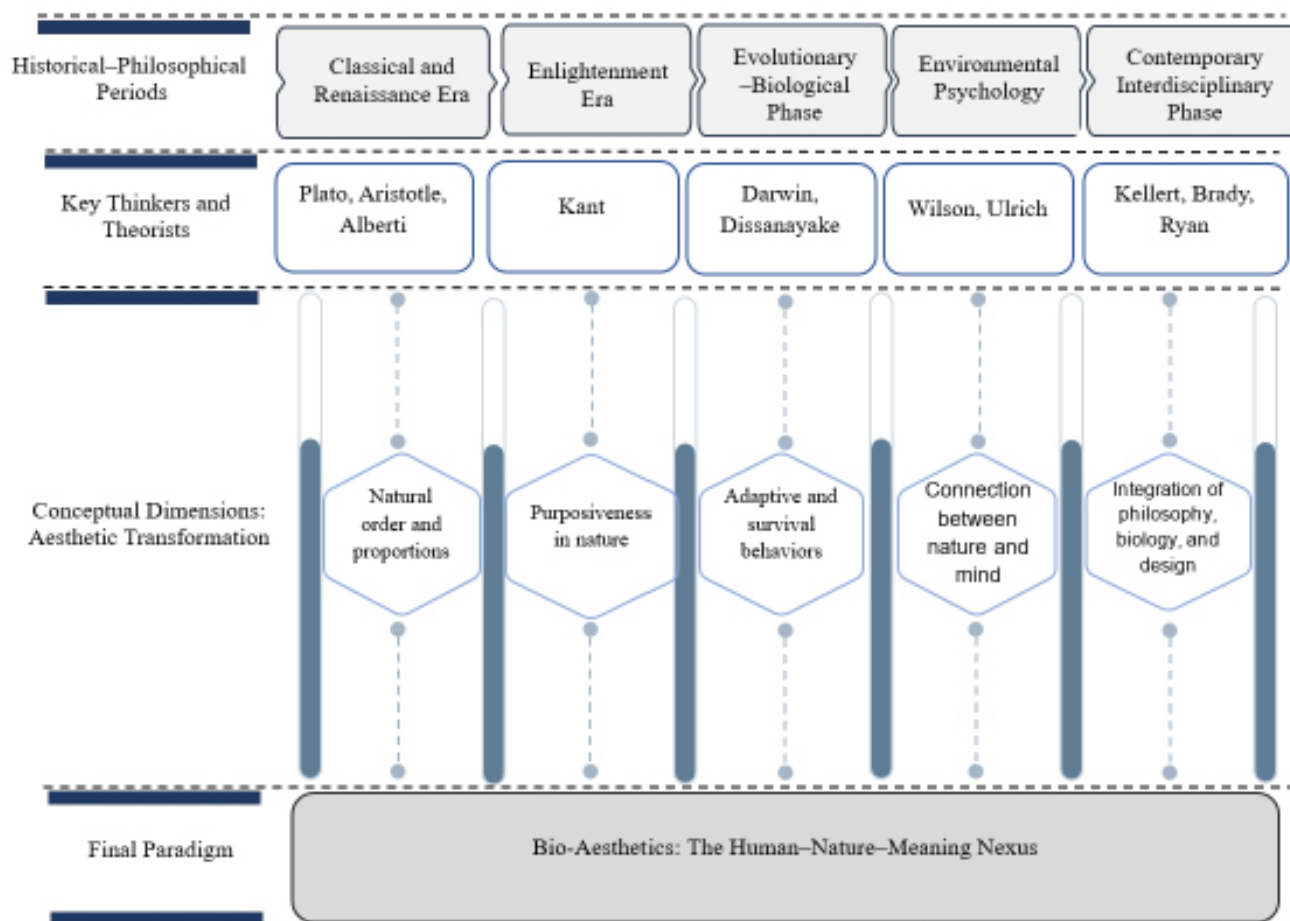


Fig. 1. Conceptual and historical evolution of bio-aesthetics from philosophy to an interdisciplinary theory. Source: Authors.

Overall, bio-aesthetics can be understood as the historical extension of aesthetic thought from a focus on natural order to an experience that is biologically and perceptually grounded. It is not merely a subfield of philosophical aesthetics, but a scientific and interdisciplinary framework for explaining how perception, meaning, and life are interconnected in human environments. From this standpoint, beauty is neither a purely subjective judgment nor a strictly visual attribute; rather, it is a living, evolutionary process that emerges from the networked interaction of body, mind, and nature. In this sense, bio-aesthetics provides a new theoretical foundation for enhancing the aesthetic quality of human living environments.

Approaches and Theories Shaping Bio-Aesthetics

Bio-aesthetics has taken shape through the convergence of a series of interdisciplinary approaches that seek to explain the perceptual, biological, and meaning-oriented mechanisms of aesthetic experience in human environments. Over the course of the twentieth and twenty-first centuries, advances in environmental philosophy, perceptual psychology, ecology, and architectural design have progressively shifted the understanding of beauty beyond the confines of classical and purely mentalist aesthetics toward a biologically grounded account of aesthetic experience and the lived quality of space. Within this intellectual landscape, four major theoretical currents have crystallized - the biophilic approach, the biomimetic approach, ecological aesthetics, and nature-based design - which, through their mutual interaction, provide the core theoretical scaffolding of the bio-aesthetic paradigm.

• The biophilic approach

The biophilic approach is rooted in Wilson’s (1984) seminal Biophilia Hypothesis, which argues that humans possess

an innate, emotionally and evolutionarily grounded affinity with the living world - a bond that underpins experiences of beauty, pleasure, and tranquility. Kellert & Wilson (1993) later elaborated this idea into an interdisciplinary framework, positioning biophilia as a foundational principle for health-oriented and aesthetically responsive design. Drawing on the empirical findings of Ulrich (1983) and Kaplan & Kaplan (1989), this approach maintains that visual and sensory exposure to natural landscapes can lower stress levels, modulate emotional states, and facilitate cognitive restoration. Consequently, biophilic design is understood not simply as an aesthetic option, but as a neurobiological strategy for supporting human health and psychological well-being (Kellert et al., 2008; Ryan et al., 2014b). Within this perspective, natural beauty acquires a distinctly restorative and therapeutic dimension, reactivating and strengthening the human connection with the rhythms and continuity of life.

• The biomimetic approach

The biomimetic approach understands beauty as arising from structural coherence and the intrinsic logic of natural systems. In “Biomimicry: Innovation Inspired by Nature”, Benyus (1997) portrays nature not as a passive object to be copied, but as a mentor and model - a repository of intelligent, efficient, and self-regulating systems from which designers can learn. Extending this line of thought, Pawlyn (2011), in “Biomimicry in Architecture”, shows how evolutionary processes in nature can inform architectural forms that are at once resource-efficient and aesthetically engaging.

By drawing on biological mechanisms and principles of adaptive engineering, the biomimetic approach introduces concepts such as self-organization, feedback-driven design, and material efficiency into the aesthetic domain. Within

Table 1. Historical and theoretical evolution of bio-aesthetics. Source: Authors.

Historical period	Theoretical contribution	Key concepts and keywords	Major theorists	Orientation/contribution to bio-aesthetics
Antiquity to Renaissance	Beauty is perceived as a natural order and harmony	Proportion, harmony, cosmic order	Plato, Aristotle, Alberti, Leonardo da Vinci	Philosophical foundation for the linkage between beauty and nature
18th–19th centuries (Enlightenment and early modern)	Beauty as an experience of the mind and the faculty of judgment	Teleology, disinterestedness, and perceptual understanding	Kant, Burke, Schiller	Transition from metaphysical beauty to perceptual/experiential beauty
19th–20th centuries (biological–evolutionary)	Beauty as an evolutionary mechanism and adaptation	Natural selection, habitat preference, artistic behavior	Darwin, Dissanayake, Voland	Scientific foundation of bio-aesthetic thought
20th century (environmental psychology)	Linking perception, nature, and mental health	Biophilia, attention restoration, stress reduction	Wilson, Kellert, Ulrich, Kaplan	Empirical and perceptual basis of bio-aesthetics
21st century (contemporary interdisciplinary)	Integration of perception, meaning, and livability	Biophilic, biomimetic, ecological, nature-based	Kellert, Salingaros, Ryan, Pawlyn	Application of theory in design and environmental quality; consolidation of the interdisciplinary bio-aesthetic paradigm in architecture and urbanism

this framework, beauty is conceived as the emergent result of the synergy between performance, efficiency, and the inherent order of living systems - effectively reinterpreting the modernist dictum “form follows function” through the lens of dynamic, life-based systems.

• **The ecological aesthetic approach**

The ecological aesthetic approach, grounded in environmental philosophy, was developed most prominently by Carlson (1999) and Brady (2003) as an ethical–perceptual account of beauty. From this standpoint, aesthetic experience is regarded as deficient if it is detached from an understanding of the ecological conditions in which phenomena are embedded, since beauty is inseparable from the moral and cognitive dimensions of human existence within the natural world.

In this view, beauty and sustainability are conceived as two inseparable aspects of a single process: an aesthetic experience is deemed genuine only when it is formed within a framework of respect for, and responsibility toward, ecosystems. Accordingly, the perception of beauty is not understood as a purely emotional response, but as an ethical and reflective act that locates the human subject within the network of life rather than positioning them outside or above it.

The Nature-Based Design Approach

The nature-based design approach is a hybrid construct

grounded in the phenomenology of space, environmental neuroaesthetics, and theories of environmental perception. Seamon (2000b), by foregrounding the notion of the lived body in the experience of place, and Zeki (1999), by identifying the activation of reward-related brain regions in response to beauty, provide key conceptual and empirical foundations for this perspective.

In this view, nature is incorporated into design not only through its physical presence but also via metaphorical, symbolic, and sensory dimensions. As Salingaros (2015) contends, natural forms and rhythms are unconsciously decoded by the human brain, activating cognitive and emotional networks associated with pleasure, meaning, and a heightened sense of presence. Through the careful orchestration of natural light, spatial rhythm, material transitions, and organic patterning, nature-based design generates a multisensory and participatory experience of beauty in which users are engaged as integral components of a living spatial system.

Comparative Analysis and Theoretical Synergy

As summarized in Table 2, the synthesis of these four approaches indicates that bio-aesthetics operates as a multi-layered system, ranging from biological–neural processes to perceptual–semantic experience:

- **Biological–neural level:** immediate physiological and

Table 2. Comparative analysis of approaches influencing bio-aesthetics. Source: Authors.

Theoretical approach	Conceptual and theoretical foundations	Primary aim and orientation	Mechanism of influence on aesthetic experience	Manifestation in environmental and architectural quality	Key references
Biophilic	Biophilia hypothesis (Kellert & Wilson, 1993); environmental psychology and environmental neuro-aesthetics (Ulrich, 1983; Kaplan & Kaplan, 1989)	Re-establishing the intrinsic human–nature bond in living environments; enhancing mental health, meaning, and place attachment	Activation of affective–biological responses through direct or indirect contact with nature	Presence of natural elements (light, water, vegetation), visual access to landscapes, use of natural materials, and a sense of biotic place	Kellert & Wilson (1993), Kellert et al. (2008), Ulrich (1983), Kaplan & Kaplan (1989), Ryan et al. (2014a)
Biomimetic	Comparative biology and nature-inspired engineering (Benyus, 1997); evolutionary and sustainable design (Pawlyn, 2011)	Emulating natural forms, functions, and systemic organization to achieve sustainability and ecological coherence	Learning from the organizational logic of nature and transferring it into architectural form and structure	Nature-inspired forms and structures, smart/ adaptive materials, self-regulating design systems	Benyus (1997), Pawlyn (2011)
Ecological Aesthetics	Environmental philosophy and ecological ethics (Carlson, 2000; Brady, 2003)	Integrating beauty and environmental ethics; explaining senses of belonging and coexistence with ecosystems.	Understanding beauty as a participatory and responsible mode of engagement with nature	Green architecture, sustainable landscapes, and spaces mediating human–nature interaction	Carlson (1999), Brady (2003)
Nature-Based Design	Phenomenology of place (Seamon, 2000a); environmental neuro-aesthetics (Zeki, 1999)	Integrating sensory and meaning-oriented experiences of nature into human spaces	Activating perceptual and emotional networks through metaphors, symbolic references, and natural patterns	Sensory–symbolic spatial configurations, use of light and material, immersive nature-oriented experiences	Seamon (2000b), Zeki (1999), Ryan et al. (2014b), Salingaros (2015)

affective responses to natural stimuli (Ulrich, 1983; Zeki, 1999).

- **Functional–formal level:** translation of nature’s organized logics into efficient and sustainable design strategies (Benyus, 1997; Pawlyn, 2011).

- **Value-driven–ecological level:** integration of beauty with environmental ethics and ecological responsibility (Carlson, 2000; Brady, 2003).

- **Perceptual–meaning-oriented level:** multisensory experience and the (re)construction of meaning through the symbolic and metaphorical presence of nature in space (Seamon, 2000a; Salingaros, 2015).

These four levels interact in a networked and mutually reinforcing manner, and together they form the theoretical nucleus of the bio-aesthetic paradigm -a paradigm that understands beauty, meaning, and life as three inseparable and co-constitutive dimensions of human experience in the environment.

The above comparative analysis suggests that each approach illuminates a distinct dimension of the broader and inherently complex system of aesthetic perception. The biophilic approach highlights the physiological and emotional bond between humans and nature; the biomimetic approach uncovers the structural and evolutionary logic of living

systems; ecological aesthetics brings to the fore the ethical and value-laden dimensions of beauty; and nature-based design articulates the perceptual–semantic layer of aesthetic experience.

The synergy among these four approaches lays the groundwork for an integrated human–nature–meaning model, which is developed in the following section as the core of the theoretical framework and the final conceptual model of bio-aesthetics. Within this model, aesthetic experience is not treated as a purely mental or abstract phenomenon, but as a bio-perceptual mechanism that is intrinsically intertwined with life and meaning.

Research Method

This study is conceptual, analytical, and explicitly interdisciplinary in orientation, with its central objective being to trace the conceptual evolution and theoretical development of bio-aesthetics. Consequently, the methodological framework is grounded in conceptual analysis and theoretical inference. Within this framework, the researcher engages with foundational sources in philosophy, psychology, biology, and environmental/architectural design, in order to systematically reconstruct

Table 3. Research methodology. Source: Authors.

Dimension of the research methodology	Description and specification of research characteristics
Type of research	The study is qualitative–theoretical in nature and, within the classification of research methods in architecture, falls under theoretical development research (Groat & Wang, 2013). Its aim is not empirical testing, but the construction of an integrative theoretical framework grounded in conceptual, historical, and interdisciplinary evidence
Methodological strategy	The primary strategy is a comparative and inferential analysis of theoretical sources.
Scope of sources and selection criteria	The sources used in this study include classical and contemporary works in the fields of philosophical aesthetics, evolutionary biology, neuroaesthetics, environmental psychology, and architectural design theory.
Process of theoretical data analysis	Theoretical data were collected through library and documentary research. Data analysis was conducted via conceptual coding and conceptual abstraction, whereby basic concepts were elevated to intermediate categories and subsequently to theoretical components. Finally, an inductive–deductive synthesis was employed to reconstruct the network of relations among human, nature, and meaning.
Theoretical validity and credibility Interdisciplinary validity	<p style="text-align: center;">Internal validity</p> <p style="text-align: center;">This research examines the logical coherence between theoretical components and philosophical and empirical background.</p> <p>The compatibility of the proposed framework with theories from related fields, including environmental psychology, biophilic design, and contemporary aesthetic philosophy, is assessed.</p>
Methodological output	The outcome of the present methodological design is the development of an integrative theoretical model—the Human–Nature–Meaning framework—which is presented in the subsequent section as the final theoretical product of the study. This model is derived from the synthesis of historical, biological, perceptual, and design-oriented findings and seeks to explain the multi-level mechanisms of human aesthetic experience in the environment.

key concepts, identify and formalize the relationships among them, and ultimately articulate a new, integrated theoretical structure.

A concise summary of the methodological characteristics of the study is provided in Table 3.

Discussion: Theorizing Bio-Aesthetics as a Human–Nature–Meaning Nexus

Bio-aesthetics may be conceptualized as an integrated theoretical framework that accounts for the multi-layered mechanisms of aesthetic experience in the environment through the intrinsic interconnection of human beings, nature, and meaning. This perspective is grounded in the assumption that beauty is neither a purely subjective judgment nor a solely formal–visual attribute; rather, it emerges from the systematic interplay of perceptual, cognitive, social, and biological processes. From this vantage point, understanding aesthetic experience in human living environments requires the identification of an underlying structure in which sensory perception, cognitive awareness, social interaction, and evolutionary memory are activated and interwoven at the same time.

The theoretical analysis developed in the preceding sections indicates that bio-aesthetics rests on four mutually reinforcing components:

- **Perceptual:** capturing the sensory and affective dimension of spatial experience, with particular emphasis on legibility, associative cues, and the felt sense of meaning (Nasar, 1994; Zeki, 1999).
- **Cognitive:** encompassing processes of awareness, learning, and sustainability that deepen and expand human capacity to understand beauty and relate to nature (Kaplan & Kaplan, 1989; Kellert, 1993).
- **Social:** rooted in place attachment, shared relations, and environmental identity, through which aesthetic experience is transformed into an intersubjective phenomenon (Seamon, 2000b; Norberg-Schulz, 1980).
- **Biological:** expressing the evolutionary and biological underpinnings of aesthetic perception and the innate human tendency to prefer ordered, life-supporting patterns in nature (Darwin, 1981; Wilson, 1984).

The synergistic interaction among these components generates a coherent bio-aesthetic system in which reciprocal relationships are formed between perception and meaning, awareness and sustainability, community and identity, and life and evolution. This integrated framework not only clarifies how aesthetic experience is constituted but also offers a robust conceptual basis for enhancing the quality of human living environments.

At the heart of this theory lies the human–nature–meaning triad, which underpins both ecological sustainability and the continuity of meaning in inhabited spaces. In this perspective, the human being is understood as an

integral part of nature's perceptual apparatus, while nature is, in turn, interpreted as a reflection of human inner life (Merleau-Ponty, 1945/2012). Within this reciprocal relationship, inner nature - encompassing biological and emotional dispositions - and outer nature - including physical, ecological, and perceptual environments - are interwoven through a continuous feedback process in which meaning arises from the ongoing interaction of body, mind, and environment (Ulrich, 1983; Kaplan & Kaplan, 1989).

Building on these foundations, the conceptual model of bio-aesthetic theory can be understood as an interactive system that operates across four interrelated analytical levels:

1. **Biological–neural level:** encompasses the physiological responses and positive affective reactions that arise from direct or indirect contact with natural elements.
2. **Functional–formal level:** refers to the structural logic, spatial organization, and morphological patterns in design that are derived from, or inspired by, natural systems.
3. **Value-oriented ecological level:** captures the alignment of beauty with bioethical commitments and ecological responsibility toward ecosystems.
4. **Perceptual–meaning-oriented level:** involves the (re) production of meaning through multi-sensory, symbolic, and metaphorical engagement with nature in space.

These four levels are linked through a network of reciprocal relationships and, taken together, form the theoretical core of the bio-aesthetic model. Within this framework, human beings, through perceptual and cognitive processes, extract meaning from nature, while nature itself is articulated in living environments through sensory, formal, and symbolic patterns. The outcome is a multi-layered aesthetic experience that is at once biological, cognitive, social, and semantic.

This conceptual model is represented schematically in Fig. 2. The diagram illustrates the reciprocal relations among human, nature, and meaning along four principal axes: the human–nature axis, which denotes the biological linkage; the nature–meaning axis, which captures the symbolic and metaphorical reflection of nature; the human–meaning axis, which expresses the sense of belonging and environmental identity; and the systemic integration axis, which represents the multi-level interplay of perception, form, and life.

This diagram makes the internal structure of the theory explicit, demonstrating that beauty, life, and meaning form three interwoven axes of human perceptual experience of the environment. In this light, bio-aesthetic theory operates as both an analytical lens and a design-oriented framework through which the quality of livable spaces can be elevated across biological, sensory, cultural, and semantic dimensions. Building on this model, bio-aesthetics, as a coherent theoretical system, establishes a shared ground for the convergence of biological, cognitive, and design sciences. In doing so, it opens the way for a new paradigm in architecture and environmental design - one in which beauty

is reconceptualized as a living, multisensory, and meaning-oriented experience, rather than as a merely formal attribute or a purely subjective judgment.

Conclusion

Over its trajectory of development, bio-aesthetics has moved beyond a loosely interdisciplinary notion to assume the form of a coherent theoretical and analytical system - one that seeks to explain the perceptual, cognitive, social, and biological foundations of aesthetic experience in human environments within a unified framework. The analyses presented in this study indicate that the three core concepts of beauty, life, and meaning are inseparable within this paradigm and operate in a simultaneous, networked fashion in the realm of environmental perception.

Through a comparative review of key theories and approaches - from biophilia and biomimicry to ecological aesthetics and nature-based design - this article has proposed an analytical structure for understanding how nature is present and operative in human aesthetic experience. Within this structure, the internal relationship between mind, body, and environment is redefined, offering a more integrated account of how aesthetic experience emerges and how it can inform the qualitative enhancement of human living environments.

The theoretical findings of this study suggest that bio-aesthetics should be understood not simply as a design strategy, but as a theoretical lens for gaining a deeper insight into human life in space. Within this lens, environmental quality is elevated through three principal pathways:

1. The activation of neural and sensory systems through the direct or metaphorical presence of natural elements;
2. The strengthening of cognitive and symbolic

understandings of nature by means of education, awareness-raising, and culturally embedded metaphors;

3. The shaping of collective and social experiences of beauty through interaction, attachment, and coexistence within the environment.

On this basis, aesthetic experience may be conceived as a perceptual-biological phenomenon that acquires meaning at both individual and collective scales. Understanding bio-aesthetic processes, therefore, requires concurrent attention to neuro-aesthetic, cognitive, cultural, and ecological dimensions. In this regard, the theory advanced in this article represents an effort to construct a conceptual bridge between sensory perception, symbolic thought, and the dynamics of natural life.

The final theoretical model developed in this study is structured around the human-nature-meaning triad and is sustained by the reciprocal interaction of four analytical levels:

1. **Bio-neural level:** physiological and emotional responses to natural stimuli;
 2. **Functional-formal level:** structural and spatial patterns derived from the intrinsic logic of living systems;
 3. **Value-driven ecological level:** the coupling of beauty with ethical commitments and environmental responsibility;
 4. **Perceptual-semantic level:** the (re)production of meaning through symbolic and experiential relationships with nature.
- This model implies that aesthetic experience acts as a mediating loop between human beings and nature, a loop through which meaning and life can be deliberately reinscribed into inhabited environments by means of reflective, well-informed design. In this sense, the proposed system is aligned, on the one hand, with theories in environmental psychology, neuroaesthetics, and cognitive science, and,

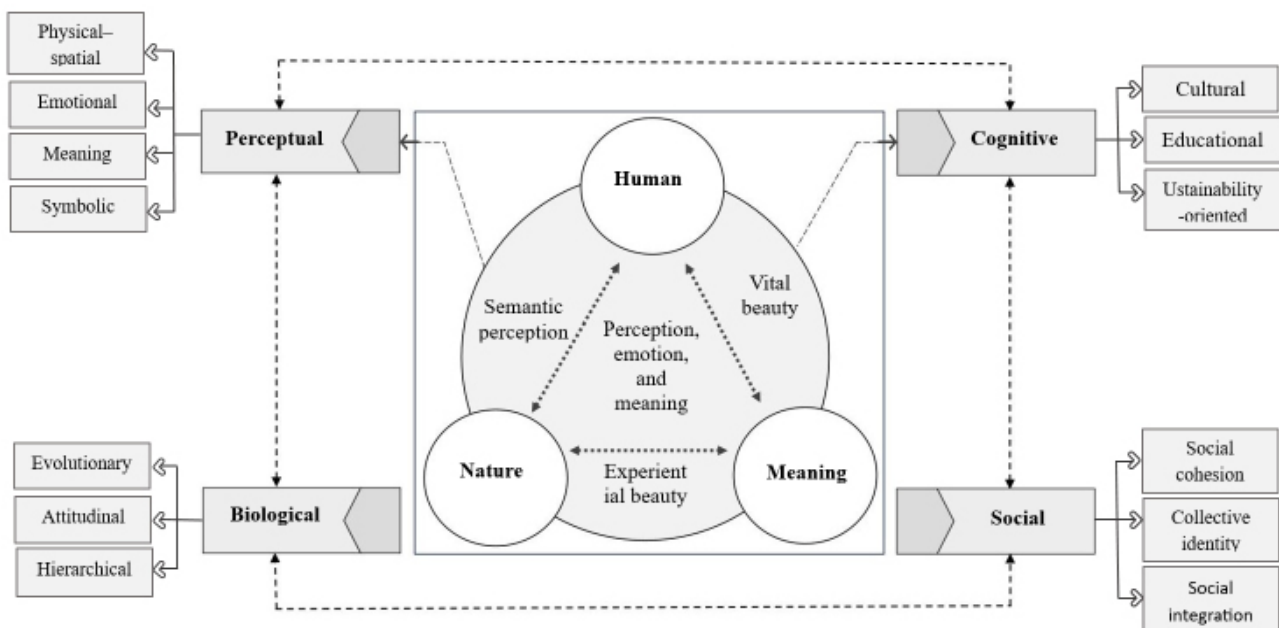


Fig. 2. Conceptual Model of Bio-Aesthetic Theory (Linking Human, Nature, and Meaning). Source: Authors.

on the other hand, rooted in the philosophical traditions of phenomenology and biophilic thought. It can therefore be regarded as an integrative framework that interlaces scientific, philosophical, and design-oriented dimensions within a single coherent analytical network.

From an applied perspective, bio-aesthetic theory can provide a robust foundation for formulating design indicators and evaluative criteria for the quality of residential and urban environments - so that environmental quality is not only improved at functional and performative levels, but also enriched in perceptual, emotional, and semantic terms. In this regard, future living environments ought to be conceived as places where nature is re-inscribed as meaning and beauty is re-enacted as life: spaces capable of eliciting positive emotional responses, a heightened sense of presence, and a renewed bond between human beings and the broader ecological system.

Ultimately, bio-aesthetic theory may be regarded as a

step toward the emergence of a new integrative paradigm in architecture and environmental design - one in which beauty is no longer set in opposition to function and science, but is instead understood as continuous with them. In this sense, bio-aesthetics offers a stable conceptual bridge between biology, cognition, meaning, and sensory experience, opening up new avenues for conceiving and creating living environments that are more livable, meaning-oriented, and life-centered in the contemporary era.

Data Access

The dataset used or analyzed during this research is available upon reasonable request from the corresponding author.

Declaration of No Conflict of Interest

The authors declare that they have no conflict of interest in conducting this research.

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HOW TO CITE THIS ARTICLE

Aslani, P., Habib, F., & Shahcheraghi, A. (2026). Conceptual Evolution and Theorization of Bio-Aesthetics: Linking Human, Nature, and Meaning in Environmental Aesthetic Experience. *MANZAR, The Scientific Journal of Landscape, 18*(75), 38-49.

DOI: [10.22034/manzar.2026.560670.2387](https://doi.org/10.22034/manzar.2026.560670.2387)

URL: https://www.manzar-sj.com/article_242196.html?lang=en

