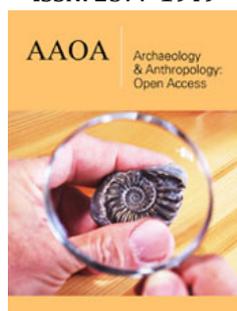


# Structured Trajectories: Convergent Evolution, Hominin Cultural Emergence, and the Architecture of Biological Form

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## Abstract

This paper proposes a paleoanthropological account of evolutionary and cultural convergence grounded in structural constraint rather than stochastic contingency. Challenging the Gouldian thesis of radical contingency, the study examines recurrent hominin traits-bipedalism, manual precision, encephalization, and the emergence of symbolic behavior-as evidence that evolutionary trajectories are channeled through constrained morphospaces within adaptive landscapes. Parallel convergences in lithic technologies, mortuary practice, and symbolic cognition across Neanderthal, Denisovan, and Homo floresiensis lineages suggest that cultural forms, no less than anatomical ones, emerge within definable cognitive and ecological basins of attraction. Drawing on the convergentist framework of Simon Conway Morris and the theoretical morphospace modelling of George McGhee, the paper argues that hominin evolution reflects the progressive navigation of predetermined geometric and functional archetypes embedded in the fabric of biological possibility. DNA is reframed not as an open generator of unlimited novelty but as a regulatory interface reflecting deeper structural symmetries that prefigure viable biological and cultural forms. Engaging Teilhard de Chardin's Omega Point and Geerhardus Vos's biblical theology alongside fossil and archaeological evidence, the study interprets the hominin lineage as structured recurrence rather than historical accident-a discovery of forms that were, in a meaningful sense, already there.

**Keywords:** Convergent evolution; Hominin encephalization; Morphospace constraint; Palaeolithic Symbolic cognition; Neanderthal material culture; Teleological structuralism

## Introduction

### The Map and the Morphospace

In the closing pages of *Wonderful Life*, Stephen Jay Gould offered a provocation that has structured evolutionary debate ever since. Replay the tape of life, he argued, and the results would be unrecognizable: no mammals, no primates, and certainly no *Homo sapiens*. Evolution, on this account, is a story of radical contingency-a succession of accidents compounding across geological time into outcomes that could never have been predicted from any prior position on the trajectory. The very existence of human beings is, on Gould's reading, a cosmic improbability-a product of what he elsewhere called 'frozen accidents' that, had they fallen differently, would have produced an entirely alien biosphere [1]. This view, powerful and elegantly argued, has not gone uncontested. The Cambridge palaeontologist Simon Conway Morris, whose own earlier work on the Burgess Shale initially seemed to buttress Gould's thesis, mounted the most sustained and evidence-rich challenge in his landmark study *Life's Solution: Inevitable Humans in a Lonely Universe* (2003). Conway Morris argued that the trajectories of evolution are far more constrained than Gould supposed: that the 'tape of life,' replayed under similar conditions, would produce not an alien world but a recognizable one-populated with eyes, brains, social intelligence, and very possibly creatures much like ourselves.

The mechanism is convergent evolution: the repeated, independent discovery by unrelated lineages of the same structural, functional, and even cognitive solutions to the challenges posed by the physical world [2]. Convergent evolution is not a marginal curiosity

of natural history but one of its most pervasive features. The camera eye has evolved independently at least six times across the animal kingdom, in vertebrates, cephalopods, cubozoan jellyfish, and annelid worms. Wings capable of sustained powered flight have evolved independently in bats, birds, insects, and pterosaurs. Echolocation has evolved independently in bats, cetaceans, and several species of birds. At the molecular level, parallel amino acid substitutions have been documented across hundreds of independent lineages confronting similar ecological challenges. Far from being exceptional, convergence appears to be the rule [2,3]. George McGhee's theoretical morphospace framework formalizes this insight with mathematical precision. In *Convergent Evolution: Limited Forms Most Beautiful* (2011), McGhee demonstrated that the space of possible biological forms-what he terms the 'theoretical morphospace'-is a high-dimensional manifold of which only a small fraction is ever occupied by actual organisms. The limits on this occupation are imposed not by chance but by physics, developmental constraints, and functional requirements. Life does not wander randomly through the space of possible forms; it is drawn toward specific regions of that space by structural necessity [3].

The hominin lineage provides the most philosophically rich and archaeologically evidenced case study for this argument. Across multiple independent lineages-Neanderthals, Denisovans, *Homo floresiensis*, and *Homo luzonensis*-we observe convergent encephalization, convergent manual anatomy, convergent symbolic behavior, convergent mortuary practice, and convergent lithic technology. This is not the signature of a random walk through an open landscape of evolutionary possibility. It is the signature of structural constraint: of lineages independently navigating toward the same basins of attraction within a morphospace that is not endless but limited [4,5]. This article proposes a framework of Theological Structural Realism to interpret these convergences. It argues that the mathematical order underlying evolutionary constraint is not a brute physical fact but a reflection of the Logos-structured character of the universe: a cosmos in which, as Geerhardus Vos suggested in his theology of progressive revelation, creation unfolds toward predetermined structural endpoints through a logic that precedes its physical manifestation. DNA, on this account, is not the open generator of unlimited biological novelty but a regulatory interface-a Predetermined Mirror-that reflects deeper structural symmetries prefiguring viable biological and cultural forms.

Pierre Teilhard de Chardin's Omega Point provides the teleological horizon: the asymptotic destination toward which the constrained trajectory of evolution is aimed [6,7]. The intellectual lineage behind this proposal is distinguished. From Goethe's vision of the Urpflanze to D'Arcy Thompson's mathematical morphology to René Thom's catastrophe theory, a tradition of thought has consistently maintained that biological form is constrained by deep structural necessities that transcend any particular lineage's genetic history [8]. The article proceeds in eight substantive sections. Section II establishes the theoretical framework, critiquing the contingency thesis and introducing Theological Structural Realism with its mathematical formalization. Section III examines the fossil

evidence for convergent encephalization and anatomy across hominin lineages. Section IV analyses convergent material culture, including lithic technology, mortuary practice, and monumental architecture. Section V provides the mathematical formalization of the convergence argument through dynamical systems theory and morphospace geometry. Section VI articulates the Logos-structural interpretation of DNA and biological form. Section VII extends the convergence argument to extraterrestrial implications. Section VIII discusses objections and synthesizes the argument. Section IX offers conclusions.

### Theoretical framework: Against radical contingency

**The contingency thesis and its limits:** Gould's contingency thesis derives its force from what he took to be the central lesson of the Burgess Shale: that the Cambrian explosion produced an enormous diversity of animal body plans, most of which went extinct for reasons that could not be reconstructed as functional inferiority. The survivors were not the fittest; they were the lucky. On Gould's reading, the great evolutionary transitions-from aquatic to terrestrial life, from small-brained to large-brained vertebrates, from non-symbolic to symbolic cognition-were not necessary outcomes of evolutionary dynamics but fortuitous results of contingent historical events: mass extinctions, asteroid impacts, sea-level changes, and the vagaries of geographic isolation [1]. Conway Morris's rebuttal is direct and empirically grounded: Gould misread the Burgess Shale. The diversity he identified was not as phylogenetically extreme as he claimed-many of the supposedly bizarre Cambrian organisms belong to recognizable stem groups of living phyla-and the pattern of subsequent evolutionary history is one of repeated convergence rather than unbounded diversification.

As Conway Morris demonstrates across hundreds of case studies, the same functional solutions-the eye, the brain, the social group, the tool-are discovered repeatedly by independent lineages across geological time [2]. Holmes Rolston's philosophical analysis of Conway Morris's work identifies the deeper implication: if evolution reliably produces the same functional destinations across independent lineages, then those destinations are not contingent but structurally necessitated. The tape of life, replayed, does not produce an alien world; it produces a world that is recognizably similar to our own in its major functional categories, even if the specific organisms that occupy those categories differ [9]. Powell and Mariscal have argued that convergence should be understood as a natural experiment-a repeated trial of the evolutionary process under similar boundary conditions that yields comparable results. The consistency of results across these natural experiments is evidence for the operation of structural constraints that channel evolutionary trajectories toward predictable outcomes, in the same way that repeated physical experiments under controlled conditions yield consistent results [5].

**Theological structural realism:** The framework proposed in this article-Theological Structural Realism-holds that the structural constraints governing evolutionary trajectories are not merely physical facts but reflections of a mathematically ordered cosmos in which viable biological forms are prefigured in the deep structure of nature. This is not Intelligent Design creationism,

which posits supernatural interventions in the historical process of evolution. It is a position in the tradition of natural theology from Thomas Aquinas through Goethe to Teilhard de Chardin: the claim that the order discovered by natural science is itself an expression of rational, intentional reality [10]. Goethe's concept of the *Urpflanze*-the archetypal plant of which all actual plant forms are transformations-anticipates the morphospace framework in a pre-mathematical idiom. For Goethe, natural forms do not arise arbitrarily but are transformations of a limited set of archetypal possibilities constrained by inner laws of symmetry. D'Arcy Wentworth Thompson's *On Growth and Form* (1917) extended this insight with mathematical tools: the forms of organisms are constrained by physical and geometric laws that give shape to the space of evolutionary possibility, and changes of form across evolutionary time can be understood as mathematical transformations within a constrained geometric space.

René Thom's structural stability and morphogenesis theory provided the dynamical systems foundation: the stable configurations of a dynamical system correspond to the attractor basins of its potential function, and biological forms are the stable states toward which developmental processes are drawn [8]. The Logos-theological dimension of this framework draws on Geerhardus Vos's biblical theology of progressive revelation. Vos argued that the pattern of divine self-disclosure through history follows a structural logic-an unfolding of what was, in a meaningful sense, 'always already' present in the purposes of the Creator. Each historical moment of revelation presupposes and advances a prior structural logic; the end is present in the beginning not as a predetermined script but as a structural necessity that constrains the possibilities of each successive moment. Applied to evolutionary history, this suggests that the successive convergences of the hominin lineage on higher cognitive and symbolic capacities are structured disclosures of what biological matter, organized according to the deep logic of the cosmos, is capable of becoming [6].

Teilhard de Chardin's Omega Point provides the cosmological horizon for this framework. Evolution, for Teilhard, is not a series of accidents leading nowhere but an asymptotic progression toward a limit state of consciousness and integration-what he calls the 'noosphere' fully realized-that draws the evolutionary process forward through the 'law of complexification-consciousness': the observed tendency of evolution to produce increasingly complex and internally unified organisms with progressively higher levels of awareness. This teleological framework does not replace the causal mechanisms of evolutionary biology but provides the metaphysical scaffolding within which they operate [7]. The Platonic dimension of this argument has been explored in recent philosophical biology. The *Aeon Magazine* essay 'Without a Library of Platonic Forms, Evolution Couldn't Work' makes the case that the morphospace framework is not merely a convenient mathematical tool but reflects a genuine ontological feature of biological possibility: that the 'forms' that organisms realize are constrained by a logical structure that precedes any particular evolutionary history [11]. Walker and colleagues, in their 2024 analysis of the fundamental constraints on

the logic of living systems, demonstrate that information-theoretic, thermodynamic, and chemical constraints jointly define a highly restricted space of viable biological organization. Their analysis supports the view that convergence is not a surprising exception to an otherwise open-ended evolutionary process but the expected consequence of operating within a tightly constrained logical and physical space [12].

**The mathematical model of constrained evolutionary trajectories:** The convergence argument can be formalized using dynamical systems theory. Modeling the theoretical morphospace (following McGhee) as a high-dimensional manifold  $M$  in which each point represents a potential phenotype, the evolutionary trajectory of a lineage can be described by the following differential equation: [3,8]

$$dx/dt = -\nabla V(x) + \eta(t)$$

In this model,  $V(x)$  is a potential function representing the landscape of structural and functional viability-the 'Archetypal Basin' of optimal biological form. The gradient  $\nabla V(x)$  acts as a geometric force that draws evolutionary lineages toward stable attractor points-the morphological and functional destinations that the structure of the landscape makes most accessible. The term  $\eta(t)$  represents the stochastic noise of environmental contingency: genetic drift, ecological accidents, and mass extinctions that perturb the trajectory of any given lineage.

Neo-Darwinism focuses almost exclusively on  $\eta(t)$ -chance-as the driver of evolutionary outcomes, treating the fitness landscape as an external constraint rather than a structured attractor system. Theological Structural Realism demonstrates that over geological time, the magnitude of the gradient  $\nabla V(x)$ -structural necessity-dominates the noise. This explains why disparate lineages independently discover the same solutions: they are performing a gradient descent into the same pre-existing geometric basins. The key insight is that the landscape  $V(x)$  is not defined by the organisms that traverse it but by the physical, chemical, developmental, and on the framework proposed here-Logos-structural constraints that define the space of biological possibility prior to any specific evolutionary history [13].

### **The fossil record as evidence of convergence: Hominin encephalization and anatomy**

**Neanderthal cognitive and anatomical convergence:** The Neanderthal (*Homo neanderthalensis*) provides the most extensively documented case of hominin convergence on the sapient cognitive and anatomical morphospace. Neanderthals achieved brain volumes that matched and, in some cases, exceeded those of modern humans-the Neanderthal endocranial volume averages approximately 1,500cc compared to the modern human average of approximately 1,350cc-via a different developmental pathway that resulted in a characteristically elongated rather than globular cranial morphology. This divergence in cranial shape alongside convergence in total brain volume illustrates precisely the distinction the morphospace framework predicts: local variation in the path taken against convergence in the

functional attractor reached [14,15]. The neuro archaeological significance of cranial shape differences between Neanderthals and *Homo sapiens* has been investigated through endocast analysis and comparative neuroanatomy. Bruner and Lozano's work on visuospatial integration and extended mind in the Neanderthal lineage demonstrates that Neanderthal brain organization, while structurally distinct from modern human organization in the parietal region, achieved functionally comparable levels of visuospatial capacity for tool manipulation and environmental engagement.

The convergence is functional rather than morphological: different neural architectures producing comparable cognitive outcomes [14]. Critically, encephalization alone does not tell the story of Neanderthal cognitive convergence. The archaeological record now documents an extensive repertoire of behaviours that independently parallel those of *Homo sapiens*. Uranium-thorium dating of carbonate crusts overlying cave paintings at La Pasiega, Ardales, and Maltravieso in Spain established that pigment markings at these sites date to more than 64,000 years before present—a period when only Neanderthals are attested in the Iberian Peninsula. The minimum age of these markings precedes the arrival of anatomically modern humans in western Europe by at least 20,000 years, making Neanderthal authorship the only tenable conclusion [16]. Multi-proxy analysis of ochre pieces from Middle Palaeolithic Micoquian sites in Crimea, spanning up to 70,000 years, has identified deliberate modifications—grinding, scoring, and crayon-like shaping—consistent with symbolic rather than purely utilitarian use. One specimen in particular bears engraved, polished surfaces and shows signs of repeated resharpening characteristic of intentional mark-making tools. The systematic nature of these modifications across multiple specimens and multiple site levels argues for a persistent tradition of ochre use that is not an isolated anomaly but a continuous cultural practice [17].

A 2025 study published in *Nature Communications* documented a 43,000-year-old ochre piece bearing a confirmed human fingerprint—identified through forensic analysis of epidermal ridges, bifurcations, and convergence points across forty-one friction ridge detail points—representing among the most direct physical testimonies to intentional symbolic action by a Neanderthal individual. The fingerprint's orientation and position on the deliberately modified ochre piece are consistent with deliberate grip during processing, not incidental contact [18]. Beyond art and pigment use, Neanderthals are now known to have buried their dead with intentionality (attested at La Ferrassie, Shanidar, and La Chapelle-aux-Saints), constructed underground stone ring structures at Bruniquel Cave approximately 176,000 years before present, used bone tools, crafted complex birch tar adhesives requiring multi-step pyrolytic processing and cumulative technical knowledge across generations, fashioned jewellery from eagle talons and perforated shells, and practiced proto-medicinal plant use. The breadth and consistency of this behavioural repertoire rule out the possibility that any single item represents a cultural one-off; together they constitute a systematic convergence on the cognitive and behavioural morphospace of symbolic human culture [16,19].

The convergence is not a matter of Neanderthals imitating modern humans. At Bruniquel Cave, the circular stalagmite structures—circular and semi-circular rings constructed from deliberately broken and arranged stalagmite sections, with evidence of controlled fire use within them—are dated to approximately 176,000 years before present, long before the arrival of modern humans in western Europe. The symbolic behaviour is autochthonous: it arose independently, via different genetic pathways, in a lineage that had been separated from the *sapiens* lineage for approximately 400,000 years. This is the signature not of cultural borrowing but of structural convergence: multiple lineages navigating toward the same basin of cognitive and behavioural possibility within the hominin morphospace [16]. The evolutionary origins of symbolic behaviour in the hominin lineage and its relationship to neural complexity have been extensively analysed. The Royal Society's 2020 thematic issue on *Homo neanderthalensis* and the evolutionary origins of ritual and symbolic behavior concluded that the available evidence is consistent with multiple independent origins of symbolic cognition in different hominin lineages, supporting the convergentist interpretation over models that attribute all symbolic behaviour to a single African origin subsequently spread by population movement [20].

**The denisovan parallel:** The Denisovans represent the most recently characterized major hominin lineage and perhaps the most geographically extensive. Identified initially from a single finger bone and a molar from Denisova Cave in Siberia's Altai Mountains in 2010, Denisovans are now known from fossils spanning from the Siberian Altai to the Tibetan Plateau and, as of 2025 ancient protein analysis, from the Taiwan Strait [21,22]. The Xiahe mandible, a Denisovan jaw recovered from Baishiya Karst Cave in Gansu Province, China, at an altitude of 3,280 metres above sea level, is dated by uranium-series analysis of an adhering carbonate crust to at least 160,000 years before present. Its implications are considerable: Denisovans occupied one of Earth's most physiologically demanding environments—the Tibetan Plateau, with its chronic hypoxia and severe seasonal cold—long before anatomically modern humans arrived in the region. The Denisovans' physiological adaptation to this environment was subsequently introgressed into the ancestors of modern Tibetan, Sherpa, and neighbouring high-altitude populations [23]. The specific genetic mechanism of this adaptation is among the most compelling documented cases of convergent molecular evolution in the hominin lineage.

High-altitude populations face the physiological challenge of chronic hypoxia—reduced atmospheric oxygen partial pressure—which in lowland humans triggers the erythropoietic response: an increase in red blood cell production and hemoglobin concentration that, while initially adaptive, causes hyper viscous blood with elevated stroke and thrombosis risk at altitude. Tibetan populations have evolved a fundamentally different solution: a variant of the EPAS1 gene (encoding Hypoxia-Inducible Factor 2- $\alpha$ ) that suppresses the erythropoietic response while improving cellular oxygen extraction efficiency, allowing physiological function at altitude without hyper viscous blood [24]. This EPAS1 variant, now present in approximately ninety percent of Tibetan individuals,

was derived from Denisovan introgression-genetic material incorporated into the ancestral Tibetan population through interbreeding with Denisovans approximately 40,000-30,000 years before present. The convergence is doubled: the same ecological challenge (high-altitude hypoxia) drove independent adaptations in multiple modern human populations (Andean, Ethiopian, Tibetan), and within the Tibetan case, the optimal solution was found not through de novo mutation but through the incorporation of a Denisovan genetic variant that had itself been selected in an archaic lineage facing the same ecological challenge [23,24].

A 2025 study published in science identified the Penghu 1 mandible-recovered from the seafloor of the Taiwan Strait-as Denisovan through ancient protein analysis, extending the confirmed geographic range of Denisovans to the eastern edge of continental Asia. The Harbin skull (endocranial volume approximately 1,420cc), recovered from northern China and tentatively attributed to the Denisovan lineage through morphological and proteomic analysis, displays a distinctive combination of archaic and derived cranial features-massive brow ridges, an extremely wide and flat face, and a large brain-representing a regional East Asian convergence on high-encephalization alongside retention of archaic facial architecture [21,22]. Denisovan presence from Siberia to Taiwan to the Tibetan Plateau demonstrates that a single archaic lineage, like the Neanderthals, independently developed the cognitive and physiological capacities to occupy diverse and extreme ecological niches across a vast geographic range. Recent research has also documented Denisovan admixture in Melanesian, Aboriginal Australian, and Southeast Asian populations at levels substantially higher than in other modern human groups, suggesting that Denisovans occupied a large portion of East and Southeast Asia and developed regional adaptations across this range. The pattern is convergent: across unrelated populations and lineages, hominin biology navigates toward the same functional destinations-ecological adaptability, physiological optimization, and expanded geographic range-through independent genetic pathways [21].

**The floresiensis paradox:** The most philosophically provocative case for hominin structural convergence is *Homo floresiensis*-the 'Hobbit' of Flores Island, Indonesia. Discovered in Liang Bua Cave in 2003, *H. floresiensis* stood approximately 1.1 metres tall and possessed an endocranial volume of approximately 426cc-comparable to a chimpanzee, and less than one-third that of its presumed ancestor, *Homo erectus* (approximately 980cc). Skeletal remains and associated stone tools span approximately 100,000 to 50,000 years before present. The dramatic reduction in body and brain size represents an insular dwarfism response-the well-documented evolutionary pattern whereby large-bodied species reduce in size when isolated on islands with limited resources-applied to the hominin lineage with striking results [25,26]. Despite its dramatically reduced brain volume, *H. floresiensis* produced stone tools of considerable sophistication-Acheulean-tradition implements including bifaces, flake tools, and points-and archaeological evidence suggests cooperative hunting behaviour targeting large prey including the extinct dwarf elephant *Stegodon*. Endocast analysis of the type specimen LB1 revealed

enlarged Brodmann area 10-the prefrontal cortex region associated with complex cognitive planning, prospective memory, and social cognition-of approximately the same relative size as in modern humans, despite the dramatically smaller total brain volume.

This neural reorganization toward prefrontal expansion, even at the cost of overall brain size reduction, points toward the remarkable organizational plasticity of hominin cognition [27]. The Floresiensis paradox strikes at the heart of the simple encephalization model of intelligence: the assumption that cognitive capacity scales directly with total brain volume. Floresiensis demonstrates that the functional architecture of sophisticated cognition-tool production, cooperative hunting, prospective planning-can be achieved through structural reorganization at a dramatically smaller absolute scale. Brain organization, not brain size, is the convergent target. The hominin cognitive morphospace is defined not by a minimum brain volume threshold but by a minimum organizational complexity threshold, and evolution can approach that threshold through multiple developmental pathways [15,27]. The hobbits of Flores were not alone. In 2019, a new hominin species, *Homo luzonensis*, was described from Callao Cave in the Philippines, dated to at least 67,000 years before present. Like *H. floresiensis*, it represents a small-bodied island hominin with a mosaic of primitive (australopith-like) and derived morphological features that does not fit neatly into any known hominin phylogeny. The independent emergence of comparable insular hominin populations on Flores and Luzon-islands east of the Wallace Line, separated by deep water crossings that required some degree of intentional or at minimum repeated navigational behaviour-constitutes a convergent ecological and cultural pattern [28].

Kaifu and colleagues' 2024 study of the early evolution of small body size in *Homo floresiensis* demonstrates that body size reduction in the Flores population occurred rapidly in evolutionary terms, suggesting strong selective pressure from island resource constraints. The speed and extent of this morphological convergence with other island dwarfed species confirms that the hominin lineage, far from being exempt from the general rules of evolutionary morphology, is subject to the same structural constraints as other mammals-including the constraint that island isolation and resource limitation drive convergent dwarfism across phylogenetically diverse large-bodied species [26]. Together, Neanderthals, Denisovans, Floresiensis, and Luzonensis form a pattern that cannot be attributed to common descent or cultural transmission. These lineages were geographically separated, genetically divergent, and in many cases contemporaneous. Their convergences-in encephalization patterns, tool use traditions, symbolic behaviour, and ecological adaptability-reflect the operation of structural attractors within the hominin cognitive and anatomical morphospace. The hominin 'niche'-a social, symbolically capable, tool-making occupant of diverse terrestrial environments-is not a fluke of sapiens history but a pre-existing landmark on the evolutionary map, one that multiple lineages navigate toward independently [4].

## Convergent material culture: Lithics, mortuary practice, and monumental architecture

**Lithic technology and the cognitive morphospace:** If morphological convergence is striking, cultural convergence is philosophically extraordinary. The stone tool record constitutes one of the most extensive and independently replicated datasets in paleoanthropology, spanning more than 3.3 million years from the Lomekwian through the Oldowan, Acheulean, Mousterian, and Upper Palaeolithic industries. The very existence of this record—the fact that knapped stone tools preserve indefinitely while organic tools decay—means that the lithic record is not a complete picture of hominin material culture but rather its most durable stratum, and convergences in the lithic record likely underrepresent the full extent of convergent cultural evolution [29]. The Levallois technique represents the most systematically documented case of convergent lithic cognition. This sophisticated knapping method requires the knapper to conceptually anticipate the final tool form before beginning the reduction sequence, prepare a platform with a specific geometry, and apply precisely calibrated force to detach a predetermined flake of known shape and size.

The cognitive demands are substantial: Levallois requires multi-step hierarchical planning, the capacity to hold a future intended outcome in working memory while executing a sequence of preparatory actions whose logic is apparent only in retrospect, and calibrated manual control of fracture mechanics [29]. The Levallois technique appears independently in the archaeological records of Neanderthals in western Europe and the Near East, Middle Stone Age populations in sub-Saharan Africa, and potentially in Denisovan-associated assemblages in Central and East Asia—with no compelling evidence of cultural transmission between these geographically separated traditions. The independent development of the same complex cognitive-technical procedure in multiple separated lineages is direct evidence for the existence of a shared attractor basin in the cognitive morphospace of stone tool production [29,30]. The independent development of hafting—the attachment of stone points to wooden or bone handles using adhesives—across Neanderthal and sapiens populations represents a further convergence at the level of technical cognition and material innovation.

Recent analysis has demonstrated that the Königsau birch tar adhesive, produced by Neanderthals in central Germany approximately 80,000 years before present, required a sophisticated multi-step pyrolytic reduction process: A manufacturing procedure that requires controlled heating in a low-oxygen environment, repeated testing of product consistency, and adjustment of processing parameters. This constitutes evidence for what researchers call ‘cumulative culture’—cultural knowledge that builds on and modifies prior knowledge across generations, a cognitive capacity previously attributed exclusively to anatomically modern humans [19]. The morphospace of lithic technology is not infinite. It is bounded by the fracture mechanics of stone, the biomechanics of the hominin hand, and the cognitive architecture required for hierarchical tool production. Multiple lineages, occupying similar ecological niches and confronting similar functional challenges,

independently navigate toward the same functional solutions within this constrained space. The repeated convergence on Levallois technique, hafted composite tools, ochre-processing technologies, and bone tool manufacture across geographically separated and genetically independent populations is the cultural equivalent of convergent evolution in morphology: different trajectories through the same constrained morphospace arriving at the same attractor basins [4,30].

**Mortuary practice and the archaeology of symbolic consciousness:** The emergence of intentional burial as a cross-lineage hominin behavior provides perhaps the most anthropologically profound case for structural convergence in hominin culture. The cognitive architecture required for intentional burial—a concept of personal identity that persists beyond biological death, a notion of the social body as requiring treatment after death, and some form of proto-symbolic framework within which that treatment makes sense—represents a threshold of symbolic cognition qualitatively different from tool production or ochre use [31]. The archaeological record documents Neanderthal burial at Shanidar Cave in Iraq, La Ferrassie and La Chapelle-aux-Saints in France, and Kebara Cave in Israel. The La Ferrassie site provides the most systematically documented Neanderthal burials: pluridisciplinary analysis of the La Ferrassie 8 Neanderthal child burial, published in 2020, confirmed deliberate interment with spatial orientation, anatomical articulation inconsistent with natural deposition, and stone placement that cannot be attributed to geological processes [32].

At Shanidar Cave, the presence of pollen clusters in sediments associated with the Shanidar IV burial—the basis of Solecki’s famous ‘flower burial’ interpretation—remains contested as potentially attributable to burrowing rodents. However, the deliberately interred nature of multiple Shanidar Neanderthal individuals is well established through osteological and taphonomic analysis. The convergence with sapiens mortuary behaviour is not dependent on any single contested case; it is supported by the cumulative weight of multiple independent burial sites across the Neanderthal geographic range [31]. That Neanderthals—separated from the sapiens lineage by approximately 400,000 years of independent evolutionary history—independently arrived at intentional burial practices is a convergence of profound significance. It suggests that the cognitive architecture underlying mortuary behaviour is not an arbitrary cultural invention but an emergent consequence of reaching a certain threshold of social complexity and symbolic cognition. The threshold appears to be structurally determined: when a hominin lineage achieves sufficient neural organizational complexity, social group cohesion, and symbolic cognitive capacity, the behavioural response to the death of group members includes deliberate interment. Multiple lineages reach this threshold independently [20,31].

The deep hominin antiquity of this behaviour is underscored by claims regarding the Rising Star Cave system in South Africa, where Lee Berger and colleagues have proposed evidence for possible mortuary behaviour by *Homo naledi*—a small-brained hominin (endocranial volume approximately 465–610cc) dated to between

335,000 and 241,000 years before present. While these claims remain vigorously debated in the paleoanthropological community, they raise the important possibility that mortuary cognition has an even deeper evolutionary history in the hominin lineage than the Neanderthal record suggests, and that the structural threshold for mortuary behaviour may be lower than previously supposed [33].

#### **Pyramid architecture and convergent monumental form:**

The independent development of pyramid-shaped monumental architecture across geographically and historically unconnected civilizations constitutes a striking instance of convergent cultural evolution at the macro-social scale. Pyramidal structures were independently developed in Old Kingdom Egypt (c. 2600BCE), by the Maya and Aztec in Mesoamerica (c. 300BCE-1500CE), by the Sumerians in Mesopotamia (ziggurat, c. 2100BCE), by the Khmer in Southeast Asia (c.800-1200CE), by the Caral-Supe civilization in coastal Peru (c. 3000BCE), and by numerous other traditions across the ancient world. The geographic and chronological separation of these traditions rules out cultural diffusion as an explanatory mechanism [34]. Recent prehistoric architectural research has confirmed that even pre-agricultural societies of the Upper Palaeolithic produced large-scale structured constructions, substantially extending the chronological range of monumental building. The convergence on pyramidal form across these independent traditions is structural: the pyramid is the optimal load-bearing form for monumental construction using available Neolithic and Bronze Age materials and engineering knowledge.

The constraints of gravity, compression strength, and available building materials define a limited morphospace of viable monumental forms, and the pyramid occupies one of its most stable attractor basins [35]. The pyramid convergence also reflects a convergent cosmological orientation across independent religious traditions: the association of vertical height with divine proximity, the axis mundi linking the human and sacred realms, and the symbolic ascent from the profane base to the sacred apex. Independent traditions in Egypt, Mesoamerica, Mesopotamia, and Southeast Asia independently conceived the mountain as the locus of divine encounter and independently translated this symbolic framework into monumental architectural form. That independent symbolic systems arrive at the same spatial metaphysics of the sacred suggests that these structures emerge from deep cognitive universals that constrain the space of symbolic possibility in the same way that physical constraints constrain the morphospace of biological form [34,35].

#### **The mathematical architecture of convergence: morphospace, attractors, and platonic constraints**

**Theoretical morphospace and the geometry of the possible:** McGhee's theoretical morphospace framework provides the formal language for understanding why convergence occurs with the frequency and specificity that the fossil record documents. A theoretical morphospace is a multi-dimensional parameter space in which each axis represents a quantifiable dimension of biological form, and each point represents a possible-though not necessarily realizable-organism. The set of all geometrically possible forms constitutes the total morphospace; the subset of physically possible

forms (consistent with the laws of chemistry and physics) is smaller; the subset of developmentally accessible forms (consistent with actual developmental mechanisms) is smaller still; and the subset of functionally viable forms (consistent with the requirements of survival and reproduction in real ecological contexts) is smaller again [3,36]. The regions of theoretical morphospace actually occupied by living organisms are concentrated in stable attractor basins-zones of high functional viability and developmental accessibility.

The mathematical structure of these basins explains convergence: when independent lineages enter the same region of the morphospace, structural and functional selection pressure drives them toward the same attractor basin, regardless of their starting position or evolutionary pathway. The result is convergent form. McGhee's analyses of ammonoid shell morphology, brachiopod shell geometry, and bryozoan colony architecture demonstrate that these attractor basins are not figments of mathematical modelling but empirical features of the fossil record [3,36]. Walker and colleagues' 2024 study of the fundamental constraints on living systems extends this analysis to the deepest organizational level of biology. They demonstrate that thermodynamic, information-theoretic, and chemical constraints jointly define an extremely restricted space of viable living organization—a space so restricted that the emergence of carbon-based, water-mediated, membrane-bounded, information-processing life is not one of an enormous number of equally likely possibilities but one of a very small number of feasible solutions to the problem of self-maintaining, self-replicating chemical organization [12].

**Viral geometry:** Platonic constraints at the molecular scale: The most remarkable demonstration of non-biological constraint on biological form comes from the architecture of viral capsids. Viruses, confronting the engineering challenge of enclosing a genomic payload within a protein shell assembled from the minimum number of protein subunits, converge with extraordinary regularity on the icosahedron—one of the five Platonic solids, and the optimal geometric solution to this problem under the constraints of symmetry and minimum surface area [37]. Caspar and Klug's foundational 1962 analysis of viral capsid architecture established the geometric principles governing icosahedral viral structure: the icosahedron is the only closed shell with full cubic symmetry that can be assembled from identical protein subunits, and it provides the maximum internal volume for a given surface area. These properties make it the unambiguously optimal solution to the capsid engineering problem. The structural mathematics of the icosahedron, developed by Buckminster Fuller independently for architectural applications and known to Plato through its inclusion in the Timaeus as one of the five regular solids, is thus realized in viral biology not through any biological 'knowledge' of geometry but through the elimination, by structural necessity, of all other solutions [37].

The icosahedron is not a biological choice; it is a mathematical necessity. The laws of geometry dictate that a closed shell assembled from repeated identical subunits can only achieve a finite set of stable symmetric configurations, of which the icosahedron is the most spacious for a given surface area. This constraint operates

identically across the entire biological domain-in bacteriophages, in animal viruses, and in plant viruses- regardless of their genetic relatedness or evolutionary history. Recent analysis of symmetry in biological form confirms that icosahedral symmetry in viral capsids is among the most conserved structural features in all of biology, preserved across billions of years and across the full diversity of viral lineages [37]. The implications extend to astrobiology: if life arises elsewhere in the universe and faces the same engineering problem of genome encapsulation, the same geometric constraints will drive the same convergence. The icosahedral virus is a universal biological constant-not an Earth-specific accident but a mathematical inevitability that reflects the Platonic character of the constraints on biological form [38].

**Platonic forms and the morphospace ontology:** The connection between the morphospace framework and the Platonic tradition of forms has been explored with increasing philosophical seriousness in recent literature. The Aeon essay 'Without a Library of Platonic Forms, Evolution Couldn't Work' argues that the attractor basins of the morphospace function in exactly the way Platonic forms were supposed to function: as pre-existing, mind-independent structures that constrain the space of what is possible and toward which particular instances are drawn. The biological 'forms' discovered by evolution-the camera eye, the brain, the social group, the symbolic mind-are not invented by the evolutionary process but discovered by it within a space of possibility that precedes any particular evolutionary history [11].

Sousa's philosophical analysis of the convergence of intelligence across evolutionary lineages extends this argument. Sousa demonstrates that the repeated independent evolution of complex cognition-in vertebrates, cephalopods, and arthropods-reflects the operation of the same structural attractors in the cognitive morphospace that Conway Morris identifies in morphological convergence. The emergence of complex, flexible, socially embedded cognition is not one of an unlimited number of equally likely evolutionary outcomes; it is a structural destination that sufficiently complex nervous systems are drawn toward by the logic of adaptive benefit in complex environments [20].

**Applying the model to hominin evolution:** Returning to the gradient descent model ( $dx/dt = -\nabla V(x) + \eta(t)$ ), the hominin fossil record can be understood as the trajectory of multiple lineages independently performing gradient descent through the cognitive and anatomical morphospace. The 'archetypal basins' of this landscape correspond to stable functional configurations: the bipedal, manually dexterous, socially complex, symbolically capable hominin. Multiple lineages-Neanderthals, Denisovans, Floresiensis, Luzonensis, and anatomically modern humans-represent different trajectories through the same landscape, arriving at the same functional attractor by different paths [3,4]. The stochastic noise term  $\eta(t)$  produces the variation within lineages-the differences in cranial morphology, tool types, and specific cultural traditions that distinguish Neanderthals from sapiens and Denisovans from both. But over geological time, the gradient  $\nabla V(x)$ -the pull of structural necessity-dominates, drawing all lineages toward the same functional destinations: encephalization, manual dexterity,

social organization, and symbolic cognition. González-Forero and Gómez-Robles's 2025 analysis of the evolutionary drivers of human brain size increase confirms that multiple interacting pressures-social complexity, ecological demands, developmental constraints, and life history trade-offs-consistently drive encephalization across the hominin lineage, suggesting that the trajectory toward large brains is structurally over-determined rather than contingent on any single selective pressure [15].

### **The logos as structural logic: Theological structural realism**

**DNA as a regulatory interface: The predetermined mirror:** The standard molecular biological account of DNA treats it as the primary generator of biological novelty: random mutation introduces variation, and natural selection filters it. This account is not wrong, but it is incomplete. The convergences documented by Conway Morris and McGhee demonstrate that the space of viable biological forms is highly constrained-that the outcomes of this filtering process are far more predictable than the 'random variation' framing suggests. The filter is not neutral; it has a highly non-random structure that reflects the deep mathematical and physical constraints on viable biological organization [2,39]. Richard Sternberg's concept of the 'immaterial genome' extends this insight in a philosophically significant direction. Sternberg argues that biological information has formal properties-organizational logic, hierarchical structure, semantic content, and context-dependence-that cannot be fully explained by the physical chemistry of the DNA molecule alone. The formal constraints on viable biological form are not encoded in the DNA sequence; they are expressed through it.

DNA is not the source of the archetype; it is the biochemical substrate through which the archetype is realized. The distinction is analogous to that between a musical score and the acoustic vibrations through which it is performed: the score has formal properties-harmonic structure, rhythmic organization, melodic constraint-that are not reducible to the physical properties of the paper on which it is printed [39,40]. This is what is meant by DNA as a Predetermined Mirror: not that the physical sequence is predetermined in a strictly deterministic sense, but that the space of viable sequences is constrained by mathematical and functional requirements that precede any specific genetic history. The mirror reflects not any particular organism but the constrained space of organismal possibility within which particular organisms are realized. The repeated convergence of independent lineages on the same genetic variants-the same LEPR mutations for cold-climate adipose regulation in both mammoths and Neanderthals, the same EPAS1 variants for high-altitude adaptation in both Denisovans and their Tibetan descendants-provides direct molecular evidence for the existence of this constrained space [24].

Marciszewski's formal analysis of DNA as a code and information system demonstrates that the genetic code exhibits algebraic properties-specifically, a mapping between codons and amino acids that is redundant in a highly non-random way that minimizes the effect of point mutations on amino acid sequence. The code

is not merely a chemical coincidence but a formal structure with mathematical properties that can be analyzed independently of its physical substrate [40]. Yockey's information-theoretic analysis of the genetic code further establishes that the code exhibits error-minimization properties that place it in a tiny and highly non-random region of the space of all possible codon-amino acid mappings. Among all possible genetic codes, the standard code is one of the most error-robust that can be constructed: single nucleotide substitutions in any codon map, with high probability, to either the same amino acid or to a chemically similar amino acid. This property substantially reduces the phenotypic effect of random mutations and significantly improves the evolvability of life under mutation [41].

**The logos-structured universe:** The philosophical tradition of Logos theology—from Philo of Alexandria through the prologue of John's Gospel to Teilhard de Chardin—proposes that the rational order of the cosmos is not a brute fact but an expression of the divine Logos: the rational principle through which all things are made and by which all things are structured. This is not an appeal to miracle or supernatural intervention in the causal order of nature; it is a claim about the metaphysical character of natural order itself—the claim that the mathematical intelligibility of nature is not a coincidence but a reflection of the rational character of its ground [10]. The consonance between this theological claim and the empirical findings of convergent evolution is striking. If the morphospace of biological possibility is constrained by mathematical and physical laws that define a small set of viable biological forms, and if independent lineages consistently navigate toward the same attractor basins within this space, then the history of life exhibits precisely the kind of rational, mathematically structured order that the Logos tradition predicts. The convergences of the hominin lineage on encephalization, symbolic cognition, and mortuary practice are not accidents in an otherwise random universe; they are disclosures of the structural logic that the Logos tradition holds to be embedded in the fabric of creation [7,10].

Geerhardus Vos's biblical theology of progressive revelation provides an instructive structural analogy. For Vos, the history of divine revelation is not a series of unconnected divine communications but the organic development of a structural pattern—a progressive unfolding of what was, in a meaningful sense, always already present in the purposes of the Creator. Each historical moment of disclosure presupposes and advances a prior structural logic; the telos is present in the beginning not as a detailed script but as a constraining logic that shapes the possibilities of each successive moment. Applied to evolutionary history, this framework proposes that the history of life is a progressive disclosure of the archetypal possibilities embedded in the structure of matter—a navigation, through the process of evolution, of a morphospace whose constraints express the Logos-ordered character of the cosmos [6]. Teilhard de Chardin's Omega Point concept provides the cosmological telos: evolution is oriented—not mechanically predetermined but structurally inclined—toward an asymptotic limit state of consciousness and integration. The successive convergences of the hominin lineage on higher cognitive and symbolic capacities are, on this reading, successive

approximations to the Omega Point: each convergence a further disclosure of the structural possibilities that biological matter, organized according to the logic of the Logos, is capable of realizing. The hominin trajectory is not one of a limitless number of equally likely evolutionary histories; it is the expression, in the particular medium of primate neurological evolution, of a structural logic that the Logos tradition holds to be embedded in nature itself [7].

**Science and theology in consonance:** This framework is explicitly situated within the 'consonance' tradition in science-and-religion dialogue: the view that science and theology are not antagonistic but complementary modes of inquiry addressing different dimensions of the same reality. Hanby's analysis of where the consonance really lies argues that the consonance between scientific and theological accounts of nature is not achieved by mapping theological claims onto scientific ones—which would subordinate theology to science—but by recognizing that scientific and theological inquiry both operate within a shared ontological horizon: the rational intelligibility of the cosmos, which science investigates empirically and theology interprets metaphysically [10,42]. David Bentley Hart's philosophical analysis of the relationship between mind and matter is directly relevant here. Hart argues that the very existence of a rational, mathematically structured cosmos—a cosmos in which rational minds can discern mathematical order through empirical investigation—is philosophically inexplicable on a purely materialist account, and points toward a cosmos whose rationality is derivative of a transcendent rational principle. The convergent rationality of evolution—its repeated navigation toward cognitively sophisticated, symbolically capable, socially organized organisms—is, on Hart's account, a further instance of this fundamental correspondence between mind and matter: the universe producing minds because it is, in some deep sense, mind-like all the way down [43].

#### **Extraterrestrial implications: Universal biological grammar**

The convergence argument, if correct, carries implications that extend beyond the terrestrial record. Conway Morris has argued explicitly in his 2005 Royal Society article that if life arises elsewhere in the universe under comparable conditions—similar thermodynamic regimes, similar chemical substrates, similar energy sources—then the same structural constraints that produce convergence on Earth would produce convergence elsewhere. The physical and mathematical laws that define the morphospace of biological possibility are universal; the same functional pressures drive lineages toward the same attractor basins wherever life evolves; and the same cognitive architecture that evolution discovers in hominins would be discoverable by any lineage with sufficiently scaled and organized nervous systems [2,38]. The viral icosahedron is the clearest demonstration of this principle at the molecular scale: it is a biological constant, not a terrestrial idiosyncrasy.

The same mathematical constraints that make the icosahedron optimal for viral capsid construction on Earth would make it optimal for viral capsid construction anywhere in the universe where carbon-based chemistry gives rise to self-replicating

molecular systems requiring compact genome encapsulation. The Platonic solid is prior to any particular biology [37,38]. The same argument applies to the genetic code. Recent research on the mathematical properties of the standard genetic code has found that it exhibits error-minimization properties far superior to the vast majority of the approximately  $10^{84}$  possible alternative codon-amino acid mappings, suggesting that natural selection on early Earth converged on one of a very small number of optimal solutions within the constrained space of possible coding schemes. If the space of viable genetic codes is as restricted as this analysis suggests, then extraterrestrial life employing genetic information storage would be expected to converge on a coding scheme with similar mathematical properties, even if the specific chemical substrates differ [44]. McGhee's 2019 study *Convergent Evolution on Earth: Lessons for the Search for Extraterrestrial Life* extends this reasoning to the broader question of SETI.

If convergent evolution reliably produces certain functional outcomes-complex brains, social organization, symbolic communication-on Earth, then the search for extraterrestrial intelligence is not the search for a vanishingly improbable cosmic accident but the search for the products of a universal structural logic. The human cognitive morphospace-a social, symbolic, tool-making creature-may represent a universal attractor: a destination on the map of biological possibility that any sufficiently complex biosphere is structurally drawn to discover [45]. The Logos-theological interpretation of this universal biological grammar is straightforward: if the mathematical constraints on biological form reflect the rational character of the cosmos, then the universe is structured in such a way as to reliably produce minds capable of investigating and comprehending it. The anthropic resonance here is not accidental: a Logos-structured universe is precisely the kind of universe in which the convergent evolution of minds capable of recognizing the Logos would be expected [10,43].

## Discussion: Hominin Evolution as Structured Recurrence

### Addressing objections

Three substantive objections must be addressed. The first is that convergence is less universal than the framework claims: that most of evolutionary history is genuinely contingent, that the examples of convergence cited are a biased sample of the full diversity of biological outcomes, and that the morphospace model imports a false sense of mathematical determinism into a process that is fundamentally historical and path-dependent.

This objection has genuine force. Neither Conway Morris nor McGhee claims that all evolutionary outcomes are convergent. Local variation-in cranial morphology between Neanderthals and sapiens, in tool typology between Mousterian and Aurignacian industries, in the specific species of prey targeted by different hominin populations-is genuine and irreducible. The noise term  $\eta(t)$  in the gradient descent model is real, and there are regions of the morphospace where the gradient is shallow and stochastic drift dominates. The claim of Theological Structural Realism is the more modest one: that the major functional destinations of evolutionary

trajectories-encephalization, symbolic cognition, social organization, mortuary practice-are constrained attractors within the morphospace, and that independent lineages consistently navigate toward them [4,5].

The second objection is that the morphospace model is metaphorically rather than formally useful: that the mathematical language of potential functions and gradient descent is rhetorical rather than predictive. This objection underestimates the genuine formal content of the morphospace framework.

McGhee's theoretical morphospace analyses have been applied quantitatively to ammonoid shell form, brachiopod shell form, and bryozoan colony form, with empirically verifiable predictions about which regions of the morphospace are accessible and which are forbidden. Thornton's analysis of the philosophy of evolutionary theory identifies the morphospace framework as among the most formally rigorous tools available for the analysis of evolutionary constraint, with genuine predictive and explanatory power beyond its metaphorical utility [13,3]. The third objection is that the theological-structural framework smuggles teleology into what should be a purely scientific account. This objection rests on a category confusion about the framework's scope. Theological Structural Realism does not propose a supernatural mechanism operating alongside or in competition with natural selection-it does not identify a 'gap' in the causal story of evolution into which a divine cause is inserted. It proposes a metaphysical interpretation of the structure within which natural selection operates: the claim that the constrained morphospace within which evolution proceeds reflects the Logos-ordered character of the cosmos. This is a philosophical claim, evaluated on philosophical rather than scientific grounds, and it is no more a violation of scientific methodology than the metaphysical claim that the universe is rationally intelligible [10,42].

### Synthesis: The pattern of structured recurrence

The pattern that emerges from the convergences documented in this article is one of structured recurrence across multiple levels of biological and cultural organization. The Neanderthal independently arrives at cave painting, ochre symbolism, intentional burial, composite tool-making, and cumulative cultural traditions-not because they were copying sapiens, but because the cognitive and cultural morphospace is constrained, and the same thresholds of neural organization lead to the same behavioural possibilities. The Denisovan independently adapts to high-altitude hypoxia through the same genetic pathway subsequently introgressed into modern Tibetan populations-not because of direct lateral transfer between contemporaneous populations, but because the physiological morphospace has a limited number of stable solutions to the hypoxia challenge [21,24]. *Homo floresiensis* independently achieves sophisticated cognition-Acheulean-tradition tool production, cooperative hunting of *Stegodon*, complex social coordination-with a dramatically reorganized brain occupying a fraction of the volumetric capacity of its ancestor *Homo erectus*. This is not despite the structural logic of the morphospace but because of it: the functional architecture of cognition is achievable through multiple developmental pathways, and the evolutionary

process navigates toward that architecture through whichever pathway is available within the constraints of insular ecology and resource limitation [26,27].

Combining archaeology and genetics to understand the movement of ideas and peoples, recent research published in 2025 has demonstrated that integrated bioarchaeological approaches consistently reveal a more complex picture of cultural convergence than either genetics or archaeology alone can provide. Population movements explain some similarities between separated cultural traditions; others- particularly the independent development of comparable lithic technologies, burial practices, and symbolic repertoires in geographically isolated populations-can only be explained by convergence driven by shared cognitive architecture operating within a constrained cultural morphospace [30]. The Rolston-Conway Morris exchange in Zygon identifies the key philosophical upshot: if convergence is as pervasive and structurally driven as the evidence suggests, then the evolution of complex cognition-and potentially the evolution of beings capable of scientific investigation, moral reasoning, and religious awareness-is not a cosmic accident but a structural consequence of the kind of universe in which we live. The hominin cognitive morphospace is a pre-existing landmark on the map of biological possibility: not created by the evolutionary process but discovered by it [9].

### Conclusion: The Inevitable Architecture

This article has argued that the hominin fossil and archaeological record constitute a sustained empirical demonstration of structured evolutionary recurrence. Across anatomically, genetically, and geographically independent lineages, the paleoanthropological evidence reveals convergent encephalization, convergent symbolic behaviour, convergent mortuary practice, and convergent cultural technology. These convergences are not coincidental but structural: they reflect the operation of attractor basins within the constrained morphospace of hominin biological and cognitive possibility [2-4]. The framework of Theological Structural Realism proposed here interprets these structural constraints not as brute physical facts but as expressions of a Logos-ordered cosmos in which the space of viable biological forms is prefigured in the deep mathematical logic of the universe. DNA is a Predetermined Mirror: not a machine for generating unlimited novelty, but a regulatory interface through which the constrained possibilities of biological form are progressively realized. The hominin trajectory-from the Oldowan through the Mousterian to the emergence of figurative art and organized mortuary practice across multiple independent lineages-is not a random walk but an asymptotic approach to a structural attractor: what Teilhard de Chardin described as the Omega Point, and what the paleoanthropological record documents as the repeated, independent convergence of biological matter on symbolic consciousness [6,7,39].

Gould was right that local contingency is real: that the specific forms of any particular lineage-the particular cranial morphology of the Neanderthal, the particular geography of Denisovan occupation, the particular insular dwarfism of Floresiensis-are path-dependent and could have been otherwise. But he was wrong in his larger thesis:

that the major destinations of evolutionary trajectories are equally contingent. The destinations -encephalization, symbolic cognition, social complexity, mortuary behaviour-are not contingent. They are the attractors of the hominin cognitive morphospace, and multiple independent lineages navigate toward them because the space of evolutionary possibility is lawfully structured in a way that makes these outcomes convergently accessible [1,9]. The mathematical structure of the convergence argument-the gradient descent model, the morphospace attractor framework, the information-theoretic analysis of the genetic code-is not merely metaphorical but formally precise: it identifies specific structural features of the evolutionary landscape that can in principle be modeled, tested, and refined.

The theological structural realism framework does not replace this empirical and mathematical analysis but provides the metaphysical interpretation that makes best sense of it: the view that the ordered, mathematically constrained character of the evolutionary morphospace reflects the rational character of the cosmos itself [10,12,13]. DeVern Fromke's observation that everything that happens 'fits into a pattern for good, according to a predetermined plan'-the splendour of life as 'an unveiling of a fearful symmetry, a pattern of confinement, ready for enlargement and expansion, under the government of continuous and inner stretchability'-captures in the language of spiritual formation something that the paleoanthropological record confirms in the language of fossil evidence and mathematical modelling: that the history of life is not a narrative of chance, but a grand discovery of forms that were, in the most meaningful sense available to science and philosophy, already there [46]. The tape of life does not produce an alien world when replayed [47-53]. It produces the same world-not in its accidents but in its destinations. Evolution is discovery, not invention. And the forms it discovers were, in the fullest sense, already written into the architecture of the possible.

### References

1. Jay GS (1990) *Wonderful life: The Burgess shale and the nature of history*. W W Norton & Co Inc Publishers, New York, USA, p. 347.
2. Simon CM (2004) *Life's solution: Inevitable humans in a lonely universe*. Cambridge University Press, Cambridge, UK, p. 464.
3. McGhee GR (2020) *Convergent evolution: Limited forms most beautiful: 15 (Vienna series in theoretical biology,15)*. MIT Press, USA, p. 336.
4. Andrej J (2022) *Contingency and convergence in the theory of evolution: Stephen Jay Gould vs. Simon Conway Morris*.
5. Powell R, Mariscal C (2017) *Convergent evolution as natural experiment: The tape of life reconsidered*. *Interface Focus* 5(6): 20150040.
6. Vos G (2014) *Biblical theology: Old and new testaments*. (3<sup>rd</sup> edn), Banner of Truth Publishers, USA, p. 440.
7. Pierre TDC (2008) *Phenomenon of man: Two little boys, lost and unloved. One foster carer determined to make a difference*. (1<sup>st</sup> edn), Harper Perennial Modern Classics Publishers, USA, p. 320.
8. René T (1994) *Structural stability and morphogenesis: An outline of a general theory of models*. CRC Pr I Llc Publishers, USA, p. 400.
9. Rolston H (2005) *Inevitable humans: Simon Conway Morris's evolutionary paleontology*. *Zygon* 40(1): 221-230.
10. Hart DB (2020) *Where the consonance between science and religion lies*. *Church Life Journal*.

11. Aeon (2015) Without a library of platonic forms, evolution couldn't work. Aeon Magazine.
12. Solé R, Kempes CP, Murtra BC, Domenico MD, Kolchinsky A, et al. (2024) Fundamental constraints to the logic of living systems. *Interface Focus* 14(5): 20240010.
13. Sober E (2024) Big picture questions. *The Philosophy of Evolutionary Theory*. Cambridge University Press, Cambridge, USA.
14. Bruner E, Lozano M, Malafouris L, Langbroek M, Wynn T (2014) Extended mind and visuospatial integration: Three hands for the Neanderthal lineage. *Journal of Anthropological Sciences* 92: 273-280.
15. Forero MG, Robles AG (2025) Why did the human brain size evolve? A way forward. *Philosophical Transactions of the Royal Society B* 380(1929): 20240114.
16. Hoffmann DL, Standish CD, Diez MG, Pettitt PB, Milton JA, et al. (2018) U-Th dating of carbonate crusts reveals Neandertal origin of Iberian cave art. *Science* 359(6378): 912-915.
17. Errico FD, Mauran G, Martí AP, Majkić A, Stepanchuk V (2025) Evidence for symbolic use of ochre by Micoquian Neanderthals in Crimea. *Science Advances* 11(44): ead4722.
18. Alonso DA, Herrero MDA, Herrero AD, González MAM, Mosquera SM, et al. (2025) Tracing the imprint of Neandertal symbolic thought: A 43,000-year-old ochre fingerprint. *Nature Communications*.
19. Schmidt P, Koch TJ, Blessing MA, Karakostis FA, Harvati K, et al. (2023) Production method of the Königsauere birch tar documents cumulative culture in Neanderthals. *Archaeological and Anthropological Sciences* 15(6): 84.
20. Sousa P (2023) Convergence of intelligence: How the evolution of minds mirrors the evolution of forms. *Phil Archive*.
21. Peyrégne S, Slon V, Kelso J (2024) More than a decade of genetic research on the Denisovans. *Nature Reviews Genetics* 25(2): 83-103.
22. Tsutaya T, Sawafuji R, Taurozzi AJ, Fagernäs Z, Patramanis I, et al. (2025) A male denisovan mandible from Pleistocene Taiwan. *Science* 388(6743): 176-180.
23. Fahu C, Frido W, Shen CC, Bailey SE, Bergmann I, et al. (2019) A late middle Pleistocene denisovan mandible from the Tibetan Plateau. *Nature* 569(7756): 409-412.
24. Sánchez HE, Jin X, Asan, Bianba Z, Peter BM, et al. (2014) Altitude adaptation in Tibetans caused by introgression of denisovan-like DNA. *Nature* 512(7513): 194-197.
25. Brown P, Sutikna T, Morwood MJ, Soejono RP, Jatmiko, et al. (2004) A new small-bodied hominin from the late Pleistocene of Flores, Indonesia. *Nature* 431(7012): 1055-1061.
26. Kaifu Y, Kurniawan I, Mizushima S, Sawada J, Lague M, et al. (2024) Early evolution of small body size in homo floresiensis. *Nature Communications* 15(1): 6381.
27. Falk D, Hildebolt C, Smith K, Morwood MJ, Sutikna T, et al. (2007) Brain shape in human microcephalics and homo floresiensis. *Proceedings of the National Academy of Sciences* 104(7): 2513-2518.
28. Détroit F, Mijares AS, Corny J, Daver G, Zanolli C, et al. (2019) A new species of homo from the late Pleistocene of the Philippines. *Nature* 568(7751): 181-186.
29. Harmand S, Lewis JE, Feibel CS, Lepre CJ, Prat S, et al. (2015) 3.3-million-year-old stone tools from Lomekwi 3, West Turkana, Kenya. *Nature* 521(7552): 310-315.
30. (2025) In: Baum S (Ed.), *Combining archaeology and genetics may shed light on how ideas traveled further than people in Anatolia*. *Phys.org*.
31. Pettitt P (2010) *The palaeolithic origins of human burial*: Routledge Publishers, New York, USA, p. 307.
32. Sethchagi (2025) Beyond the grave: Burial and the human condition in deep time. *World of Paleoanthropology*.
33. Balzeau A, Turq A, Talamo S, Daujeard C, Guérin G, et al. (2020) Pluridisciplinary evidence for burial for the la Ferrassie 8 Neandertal child. *Scientific Reports* 10(1): 21230.
34. Pettitt P, Wood B (2024) What we know and do not know after the first decade of homo naledi. *Nature Ecology and Evolution* 8: 1579-1583.
35. Vasiloudis D (2023) Why did all civilizations build pyramid-shaped large-scale buildings? *The anthropological perspective*. *The Archaeologist*.
36. Paduano I (2024) Prehistoric architecture: New discoveries and confirmations.
37. Stayton CT (2015) What does convergent evolution mean? The interpretation of convergence and its implications in the search for limits to evolution. *Interface Focus* 5(6): 20150039.
38. Caspar DL, Klug A (1962) Physical principles in the construction of regular viruses. *Cold Spring Harbor Symposia on Quantitative Biology* 27: 1-24.
39. Conway MS (2007) Tuning into the frequencies of life: A roar of static or a precise signal? pp: 197-224.
40. Zmirak J (2025) Sternberg's immaterial genome: Intelligent design in the present tense. *Science and Culture*.
41. Sternberg RV (2008) DNA codes and information: Formal structures and relational causes. *Acta Biotheor* 56(3): 205-232.
42. Yockey HP (2011) *Information theory, evolution, and the origin of life*. Cambridge University Press, Cambridge, UK, p. 259.
43. Freeland SJ, Hurst LD (1998) The genetic code is one in a million. *Journal of Molecular Evolution* 47(3): 238-248.
44. Steinhart E (2008) Teilhard de Chardin and transhumanism. *Journal of Evolution and Technology* 20(1): 1-22.
45. Hart DB (2024) David bentley hart's brain-breaking argument for the supremacy of the mind. *Christianity Today*, Yale University Press, USA, p. 528.
46. Freeland SJ, Hurst LD (1998) The genetic code is one in a million. *Journal of Molecular Evolution* 47(3): 238-248.
47. McGhee, George R (2019) *Convergent evolution on earth: Lessons for the search for extraterrestrial life*. MIT Press, Cambridge, USA, p. 317.
48. Fromke D (2001) *Unto full stature*. Christian Books Pub House Publishers, India.
49. Watts F (2011) Morphic fields and extended mind. *Journal of Consciousness Studies* 18(11-12): 203-224
50. Hart DB (2016) *The Illusionist*. *The New Atlantis* 53: 109-121.
51. Beer WVD (2018) *From logos to bios: Evolutionary theory in light of Plato, Aristotle and Neoplatonism*. Angelico Press.
52. Karl B (2010) *Church dogmatics*. Hendrickson Publishers, USA, p. 9233.
53. Neil MO, Neil MDO (2004) Karl Barth's doctrine of election. *Evangelical Quarterly* 76(4): 311-326.