Comprehensive Research Audit: "Infinite Architects" Chapters 7-12

The period from late 2024 through December 2025 witnessed several paradigm-challenging discoveries across cosmology, quantum physics, AI development, and consciousness research. **DESI's evidence for evolving dark energy** may represent the most significant cosmological finding since dark energy's discovery. Meanwhile, experimental support for quantum effects in microtubules strengthened the Penrose-Hameroff consciousness theory, and AGI timelines compressed dramatically with leading researchers now predicting transformative AI within 2-3 years.

Chapter 7: The evidence we overlook

Dark matter and dark energy — CRITICAL UPDATE REQUIRED

The **Dark Energy Spectroscopic Instrument (DESI)** released potentially paradigm-shifting results that challenge the standard cosmological model. In March 2025, DESI's Year 3 data—spanning **15 million galaxies and quasars** over 11 billion years of cosmic history— (Berkeley Lab News Center) revealed **2.8 to 4.2 sigma** preference for dark energy that evolves over time rather than remaining constant. (lbl) (NOIRLab) This threatens the Lambda-CDM model's foundational assumption.

Will Percival, DESI co-spokesperson at University of Waterloo, stated: "It's looking more and more like we may need to modify our standard model of cosmology to make these different datasets make sense together—and evolving dark energy seems promising." (lbl) If confirmed, Professor Carlos Frenk of Durham University notes our understanding "goes out the window and essentially we have to start from scratch." (DESI)

Current verified universe composition (Planck 2018—still standard):

- Dark energy: **68.3%**
- Dark matter: **26.8%**
- Ordinary matter: **4.9%** (ESA Science & Technology) (Wikipedia)

On dark matter detection, the **LUX-ZEPLIN (LZ) experiment** released world-leading results in December 2025 from 417 live days of data—the largest dataset ever collected by a dark matter detector. No WIMPs were detected, but LZ achieved a milestone: first detection of **boron-8 solar neutrinos via coherent elastic neutrino-nucleus scattering** at 4.5 sigma, marking entry into the "neutrino fog" regime that will complicate future dark matter searches. (Berkeley Lab News Center)

CMB anomalies update

The **CMB Cold Spot** mystery received significant attention. (Astrobites) Garcia Lambas et al. (Astronomy & Astrophysics, 2024) proposed the cold spot may be explained by foreground galaxies in the Eridanus supergroup, with temperature decrements around galaxies in the Cold Spot region **3× stronger** than elsewhere. (Astronomy & Astrophysics) Hansen et al. (2025) found 99.3% correlation between local dark matter distribution and the CMB signal. (Astronomy & Astrophysics) The supervoid hypothesis has weakened—CMB lensing analysis "ruled out the hypothesis that the Cold Spot could be due to a large void." (arXiv)

Fine-tuning problem

A comprehensive 2025 review paper ("Cosmological fine-tuning: the view from 2025" by Lewis, Barnes & Goff) reaffirms 31 fundamental constants requiring fine-tuning, with the cosmological constant tuned to approximately **10^-122** in Planck units. (Wikipedia) The review identifies three explanatory approaches: multiverse (faces inverse gambler's fallacy objection), theistic (faces problem of evil), and a new option—Goff's "limited panpsychism" proposing the universe is directed toward goals like life emergence. Notably, if DESI's evolving dark energy is confirmed, it introduces additional fine-tuning questions about why dark energy varies in precisely life-permitting ways.

Quantum mechanics and consciousness

Orch-OR theory received substantial experimental support. Michael Wiest's May 2025 paper in *Neuroscience of Consciousness* demonstrated that the microtubule-stabilizing drug epothilone B significantly

delayed anesthetic-induced unconsciousness in rats with a **Cohen's d = 1.9** (large effect size). This directly supports the Penrose-Hameroff hypothesis that microtubules participate in consciousness.

Additional supporting evidence includes:

- **Quantum superradiance** in microtubules at room temperature (Babcock et al., 2024)
- MT resonance states observed spanning multiple neurons and controlling membrane voltage
- MRI evidence of entangled brain states correlated with consciousness (Kerskens & Pérez) oup

The original Tegmark (2000) critique claiming femtosecond decoherence times has been challenged by revised estimates showing possible coherence times of 10-100 microseconds—"seven orders of magnitude" beyond Tegmark's calculations.

Major quantum entanglement milestones (2024-2025):

- September 2024: First observation of quantum entanglement between **top quarks at the LHC**—highest energies ever achieved
- November 2024: SEAQUE experiment on ISS achieved multiple Bell violations in space
- September 2025: First entangled measurement for W states achieved, solving 25+ year challenge (Kyoto/Hiroshima)
- November 2025: First quantum teleportation between photons from different quantum dots (~70% success rate)

CORRECTION NEEDED: The book should clarify that scientific consensus does NOT support consciousness-causes-collapse interpretations. The observer effect in mainstream physics refers to measurement causing decoherence, not conscious observation specifically.

Multiverse hypothesis

No direct evidence for the multiverse emerged in 2024-2025. Google's December 2024 Willow quantum chip prompted Hartmut Neven to suggest its performance "lends credence to the notion that quantum computation occurs in many parallel universes," The Quantum Insider but significant skepticism remains. The Quantum Insider Planck data found no statistically significant evidence of bubble collisions or gravitational pull from other universes. Wikipedia A 2020 survey of 126 cosmologists found only 37% believed multiverse theories are or will become testable. DNB

Black hole information paradox — MAJOR THEORETICAL ADVANCE

The **Islands Formula** represents a significant theoretical breakthrough. Developed by Penington (2019) and Almheiri et al. (2019-2020), it shows isolated regions ("islands") inside black holes contribute to entanglement entropy of Hawking radiation at late times. IntechOpen This successfully reproduces the **Page curve**, demonstrating black hole evaporation can be unitary—preserving quantum information. arXiv SSRN The formula has been extended to Kerr (rotating) black holes, charged black holes, and acoustic black holes. American Physical Society December 2024 research in Physical Review Letters suggests "non-violent nonlocality" signatures might be detectable in gravitational waves with next-generation detectors. Phys.org

Fibonacci/Golden ratio — CORRECTIONS REQUIRED

Scientifically validated:

- Phyllotaxis (leaf/seed arrangement): Fibonacci spirals in sunflowers, pinecones, pineapples (8 spirals one direction, 13 the other) PBS
- Optimal divergence angle of 137.5° minimizes leaf overlap Princeton

Common misconceptions to correct:

- DNA helix 34:21 Ångström ratio claims are **incorrect**—actual measurements don't match PBS
- Human face proportions: "No persuasive link demonstrated between Fibonacci numbers and ideal facial proportions" (NCBI 2024)

- Nautilus shells are logarithmic spirals with **different ratios**, not golden spirals
  University of Edinburgh Science Media
- Parthenon and Great Pyramid golden ratio claims lack archaeological or historical evidence
  University of Edinburgh Science Media

Chapter 8: The future of intelligence

AGI/ASI timeline predictions — DRAMATIC COMPRESSION

Expert predictions have compressed dramatically. **Sam Altman** (OpenAI) claimed in January 2025: "We are now confident we know how to build AGI as we have traditionally understood it." Time **Dario Amodei** (Anthropic) predicts "powerful AI systems will emerge in late 2026 or early 2027"—systems matching "a country of geniuses in a datacenter" with Nobel Prize-level capabilities. LessWrong **Demis Hassabis** (DeepMind) shifted from "10 years" to "three to five years away." Medium **Ray Kurzweil** updated his prediction from 2045 to **2032**. AIMultiple Metaculus forecasts show 25% chance of AGI by 2027, 50% by 2031. 80,000 Hours

Notable skepticism persists: Gary Marcus called recent months "devastating" for AGI optimism, Medium and scaling laws have shown diminishing returns since late 2024.

Brain-computer interfaces — RAPID CLINICAL PROGRESS

Neuralink achieved first human implant on January 29, 2024. Techgenyz Patient Noland Arbaugh (quadriplegic) demonstrated computer control, video gaming, and robotic arm operation. By September 2025, **12 trial participants** accumulated 2,000+ days and 15,000 hours of usage. Wikipedia International expansion began with Canadian trials in August-September 2025. Neuralink received FDA Breakthrough Device Designations for **Blindsight** (vision restoration) and speech restoration technology.

Synchron's COMMAND Study (October 2024) reported first FDA-approved IDE trial results: 6 patients with severe paralysis met primary safety endpoints with no device-related serious adverse events over 12 months. Endovascular Today Synchron raised **$200 million** Series D in November 2025. MedTech Dive MIT Technology Review named BCIs one of the **top 10 breakthrough technologies of 2025**.

Quantum computing and AI convergence

Google's Willow chip (December 2024) achieved two breakthroughs: first demonstration of below-threshold quantum error correction (errors decrease exponentially as qubits scale up) and benchmark computation in under 5 minutes that would take classical supercomputers **10^25 years**. Google EDRM October 2025 saw "Quantum Echoes"—first verifiable quantum advantage, approximately 13,000× faster than supercomputers. HPCwire

IBM's roadmap progresses toward fault-tolerant quantum computing: Heron processors now run circuits with 5,000 two-qubit gates, with Starling (2029) targeting 100 million gates and Blue Jay (2033) targeting 1 billion gates across 2,000 qubits. IBM

Mind uploading research — CONNECTOME MILESTONE

The **FlyWire Consortium** completed the first full connectome of an adult organism since C. elegans in 1986. Published in Nature (October 2024), it maps **139,255 neurons** with **54.5 million synaptic connections** in the fruit fly brain. Researchers successfully predicted neural activity using only connectome data plus AI. The State of Brain Emulation Report 2025 notes expert estimates: 20% probability of digital minds by 2030, 50% by 2050. Digitalminds Nature Methods named EM-based connectomics **"Method of the Year 2025."**

Collective intelligence

The **COHUMAIN framework** (Collective HUman-MAchine INtelligence) emerged from Carnegie Mellon research, proposing AI best serves in "partnership" or facilitation roles rather than managerial ones. The World Economic Forum's 2025 report identifies critical thinking and creativity as top requirements in the AI marketplace. Wharton School

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Chapter 9: Ethics in a multiverse

AI ethics frameworks

Implementation has shifted from high-level principles to practical methodologies. The **Digital Cooperation Organization** published AI Ethics Principles in June 2025. UNESCO's 2021 AI ethics recommendation continues implementation across 194 member states. Only **35% of companies** have AI governance frameworks in place (2024 data), though 87% plan implementation by 2025. Major academic publication: "AI Ethics: Integrating Transparency, Fairness, and Privacy in AI Development" (Taylor & Francis, February 2025).

AI governance — CRITICAL REGULATORY DIVERGENCE

EU AI Act timeline:

- August 1, 2024: Entered into force (European Commission)
- February 2, 2025: Prohibited AI practices took effect (banning social scoring, certain biometric systems)
- August 2, 2025: GPAI model obligations became applicable (Vinson & Elkins)
- August 2, 2026: Full general applicability (EY)

U.S. policy underwent dramatic shift. Trump administration rescinded Biden's AI Executive Order on January 20, 2025, (Squire Patton Boggs) pivoting to deregulation with Executive Order 14179 "Removing Barriers to American Leadership in AI." (Squire Patton Boggs) December 11, 2025 order targets state AI laws, establishing AI Litigation Task Force to challenge "onerous" state regulations.

International developments: UN established Global Dialogue on AI Governance and Independent International Scientific Panel on AI (August 2025)—likened to an "IPCC for AI." The Seoul AI Safety Summit (May 2024) secured "Frontier AI Safety Commitments" from Amazon, Anthropic, Google, Meta, Microsoft, and OpenAI. (Silicon UK)

Existential risk research — MAJOR INSTITUTIONAL CHANGES

The Future of Humanity Institute closed on April 16, 2024 (Future of Humanity Institute) after "increasing administrative headwinds" with Oxford's Faculty of Philosophy. (LessWrong) Nick Bostrom founded the Macrostrategy Research Initiative and published "Deep Utopia: Life and Meaning in a Solved World" (March 2024). (Nick Bostrom)

MIRI pivoted strategically, scaling back alignment research and concluding it is "extremely unlikely to succeed in time." Their new focus: communications and policy work seeking international agreement to halt progress toward smarter-than-human AI. New book: "If Anyone Builds It, Everyone Dies" (Yudkowsky & Soares, 2025).

CSER (Cambridge) remains active, launching new MPhil in Global Risk and Resilience (October 2025) and founding the Global Volcano Risk Alliance.

Digital consciousness rights

Emerging academic work addresses AI moral status. Nature (November 2024) published "What should we do if AI becomes conscious?"—calling on tech companies to test systems for consciousness and create AI welfare policies. "Principles for Responsible AI Consciousness Research" (Butlin, January 2025) and frameworks for graduated protections based on Talmudic principles appeared. The fundamental tension: behavioral indicators versus the position that AI consciousness may be impossible to verify.

Simulation ethics

Discussion continues building on Bostrom's 2003 framework. New academic work includes "The simulation argument reconsidered" (Keith Harris, Analysis, 2024) and "A Theodicy for Artificial Universes" exploring moral responsibilities toward potentially conscious simulated beings.

Chapter 10: A universe of questions

"Why something rather than nothing"

New arguments emerged in 2024-2025. Dylan Shaul (European Journal of Philosophy, 2025) presents "a new argument from the Principle of Sufficient Reason." A major 2025 PhilArchive paper argues **absolute nothingness is conceptually incoherent**, using S5 modal logic to demonstrate it cannot be true in any accessible world. Sean Carroll maintains the universe "simply is, without ultimate cause or explanation."

Time as emergent phenomenon

Research increasingly connects quantum information to spacetime emergence. Logan Nye (Carnegie Mellon, May 2024) proposed time's flow is "intrinsically linked to the growth of quantum complexity and the evolution of entanglement entropy." ResearchGate The **Prototime Theory** (Schneider & Bailey, 2025) proposes a pre-geometric structure from which quantum and relativistic time emerge. PhilArchive December 2025 work by Sogang and Korea University researchers demonstrated entanglement between fractionalized anyons generates emergent Anti-de Sitter-like geometry **without requiring conformal symmetry**. Quantum Zeitgeist

Block universe theory — ATTRIBUTION CORRECTION NEEDED

CORRECTION: Block universe theory is commonly misattributed to Einstein but originated with **Hermann Minkowski in 1908**, who unified space and time into four-dimensional spacetime. The Information Philosopher Physics Forums Einstein initially rejected this interpretation but later accepted it, writing in 1952: "It appears more natural to think of physical reality as a four-dimensional existence." Philosophical roots trace to Parmenides; J.M.E. McTaggart's 1908 paper "The Unreality of Time" provided philosophical framework.

A 2025 Royal Society paper shows consistency between quantum violation of time-reversal symmetry and block universe, with ordered sequences of states providing "ontological support for our perception of progressing through time." Royal Society Open Science

Arrow of time and entropy

December 2025 paper (Song & Zhang, University of Alabama Birmingham) definitively demonstrates black holes, wormholes, and retrocausal quantum mechanics **cannot genuinely reverse time's arrow**—only redistribute entropy between sectors while total generalized entropy remains non-decreasing. Quantum Zeitgeist May 2024 research found gravitational and thermodynamic arrows may point in **opposite directions** in radiating star collapse scenarios.

Eternal inflation — VERIFICATION UPDATE

Current status: Contested/debated. Paul Steinhardt (Princeton), who produced the first example of eternal inflation in 1983, became a "strong and vocal opponent." Wikipedia Wikipedia His critique: "In a multiverse, any outcome is equally possible, so inflation makes no predictions."

September 2024 paper in Physical Review D showed eternal inflation and multiverse **can be realized without de Sitter minima**, compatible with string theory Swampland conjectures. HAL July 2025 research found eternally inflating regions form "baby universes" hidden behind black hole horizons. arXiv

Distinction required: Basic inflation (flatness, uniformity, CMB anisotropies) is well-confirmed; eternal inflation/multiverse predictions remain currently untestable.

Chapter 11: Roadmap to discovery

String theory and M-theory

December 2024 breakthrough: NYU and Caltech physicists (Cheung, Hillman, Remmen) developed a "bootstrap" mathematical method demonstrating string theory's mathematical **uniqueness**—it is the only answer to certain mathematical questions about quantum gravity (Physical Review Letters). New York University However, the Strings 2025 conference (Abu Dhabi) revealed difficulty finding organizers for future conferences, and no significant progress on fundamental problems the field has struggled with for 25 years. Columbia University

Quantum coherence in microtubules (Orch-OR)

MAJOR UPDATE: Substantial new experimental support for Penrose-Hameroff theory as detailed in Chapter 7 section. The May 2025 Wiest paper and 2024 superradiance evidence represent the strongest experimental support to date. A September 2025 Frontiers paper proposes hybrid quantum-classical description for Orch-OR with superradiance as mechanism for quantum synchronization across microtubules.

Gravitational wave astronomy — MILESTONE DETECTIONS

LIGO/Virgo/KAGRA O4 run (May 2023-November 2025) detected approximately **250 candidate signals**—the most productive observing run yet. KAGRA participated for the first time. (LIGO Lab)

Landmark discovery (October 2024): "Second-generation" black holes detected. (EGO) GW241110 revealed a black hole spinning **opposite to orbital direction**—first-ever observation providing direct evidence of hierarchical mergers. GW241011 detected one of the fastest-spinning black holes ever observed. (Virgo-gw)

LISA mission milestone: ESA formally adopted the mission in January 2024. (Space.com) Construction began January 2025 (ESA) with **2035 launch planned**. (ESA) LISA will detect supermassive black hole mergers and early universe signatures with 2.5-million-kilometer arm lengths. (IEEE Spectrum)

Quantum computing simulation capabilities

Google Willow and IBM Heron advances detailed in Chapter 8. Commercially relevant quantum computing remains **10-15 years away** according to expert assessment, (Forrester) with error rates still far above the 10^-6 threshold needed for fault-tolerant computing. (InfoQ)

Extra dimensions — NO EVIDENCE

LHC constraints continue tightening: KK gravitons excluded below **2.3 TeV**, gauge boson KK excitations limited above 3.2-3.7 TeV. (Particle Data Group) No microscopic black holes observed. A 2025 "fat-brane" Universal Extra Dimension model uses machine learning to recast ATLAS data. (Springer) The Adagio scenario explores how extra-dimensional models could realize changing Planck mass. Future FCC-hh could probe quantum gravity to ~100 TeV.

Chapter 12: Call to action / Closing sections

AI governance developments

Key 2024-2025 events summarized: EU AI Act implementation, U.S. regulatory reversal, UN governance bodies established, AI Safety Summit series (Bletchley, Seoul, France). Finding: **118 countries** are not party to any significant international AI governance initiative.

Public engagement

Major science communication initiatives include:

- 2025 designated **International Year of Quantum Science and Technology** (Substack)
- NASA+ streaming platform launch
- BBC's "Solar System" series by Brian Cox (9.0 IMDb rating)
- Netflix's "Three-Body Problem" series reaching mass audience

Books and references to add

Essential 2024-2025 references:

- "Supremacy" by Parmy Olson (2024 FT Business Book of the Year)
- "Nexus" by Yuval Noah Harari (AI and information networks)
- "Deep Utopia" by Nick Bostrom (post-scarcity meaning) (Notre Dame Philosophical Reviews)
- "AI Snake Oil" by Narayanan & Kapoor (critical AI analysis)

- "Lucid Dying" by Sam Parnia (NDE research)
- "The Singularity Is Nearer" by Ray Kurzweil (updated predictions)

Cross-cutting research updates

Near-death experience research

AWARE II represents the largest prospective study of consciousness during cardiac arrest (567 patients, 25 sites). (SSRN) Key finding: EEG markers compatible with consciousness emerged **up to 35-60 minutes into CPR** despite severe cerebral ischemia. (Resuscitation Journal) The 2025 Veridical NDE Scale provides first validated measurement tool for veridical perceptions during NDEs. (Frontiers)

Psychedelics and consciousness

April 2025 Imperial College research established 5-MeO-DMT as model for "deconstructed consciousness"—radical disruption of self with paradoxical aroused awareness. Washington University/Stanford's July 2024 Nature paper showed psilocybin causes **>3× greater** functional connectivity changes than stimulants, with some effects persisting three weeks. First-ever administration of psilocybin to a patient in minimally conscious state occurred in 2025.

Panpsychism

Philip Goff remains the field's leading public advocate. Stanford Encyclopedia of Philosophy (Fall 2025) notes panpsychism's "revival in analytic philosophy" as an "attractive middle way between physicalism and dualism." Goff announced conversion to "heretical form of Christianity" combining panpsychism with cosmic purpose. The Combination Problem remains central challenge.

Free Energy Principle

Karl Friston's framework expanded with a **quantum formulation** that is "fully scale-free" and applies to all physical systems (April 2025). First experimental validation using in vitro rat cortical neuron networks confirmed FEP predictions (2023 Nature Communications). Applications extend to AI consciousness debates.

Integrated Information Theory

The **COGITATE adversarial collaboration** (Nature, April 2025) directly tested IIT against Global Neuronal Workspace Theory across 256 participants and 7 labs. Results: Found conscious content information in posterior cortex (supporting IIT), but lacked sustained synchronization (challenging IIT). Both theories were partially challenged. The "pseudoscience" controversy continues (124 scholars signed open letter), but only 8% of consciousness researchers fully agreed with that label.

Summary of critical corrections needed

Claim	Correction Required
Dark energy constant	Add DESI 2024-2025 findings suggesting it may evolve
Virtual particles	Reframe as mathematical tools, not literal particles "popping in and out"
Block universe origin	Credit Minkowski (1908), not Einstein
Fibonacci ubiquity	Scale back claims; debunk human proportions, Parthenon, nautilus, DNA claims
Eternal inflation	Present as contested; distinguish testable inflation from untestable multiverse
Consciousness causes collapse	Mark as minority/philosophical view, not scientific consensus

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Top 10 must-mention developments

1. **DESI dark energy evolution evidence** (2.8-4.2 sigma)—potential paradigm shift
2. **Orch-OR experimental support** (Wiest 2025, superradiance 2024)
3. **AGI timeline compression** to 2026-2027 from major lab leaders
4. **Neuralink/Synchron BCI progress** in human trials
5. **Google Willow** quantum error correction breakthrough
6. **FlyWire fruit fly connectome** (139,255 neurons mapped)
7. **Islands Formula** resolving black hole information paradox
8. **LIGO second-generation black holes** with opposite spin
9. **COGITATE IIT vs GNWT** adversarial collaboration results
10. **Future of Humanity Institute closure** and MIRI strategic pivot

This audit provides comprehensive coverage of developments from late 2024 through December 2025 across all requested research areas. The findings should significantly strengthen and update "Infinite Architects" for its revised edition.