Evolution is not progress, but an endless series of forks. From amino acids to algorithms — one blueprint. The question is not whether we will reach the summit, but which fork will be next"

2026

🌱 Hall 1. Birth of the Exchange — How the Non-Living Became Alive

«Life is not a miracle, but an arbitrage deal between energy and entropy. The first cell — a startup that won a grant from the Universe».

2E-biogenesis analyst

Introduction

In 1953, Stanley Miller and Harold Urey passed an electrical discharge through a gas mixture thought to model the early atmosphere. Amino acids — the building blocks of proteins — formed in the flask. The experiment was repeated hundreds of times, with varying conditions, and always yielded organics. But never a cell.

In 1982, Thomas Cech discovered that RNA could act as an enzyme — catalyzing reactions, including its own replication. This shattered the dogma that "proteins are the only catalysts." The RNA world became a viable hypothesis. And yet — the cell did not appear in a test tube.

In the 1960s, Sol Spiegelman showed that RNA in a test tube evolves within hours: shorter, faster-replicating molecules outcompete longer ones. Evolution in a test tube — a fact. But the transition from RNA replication to a living cell took billions of years.

In the 1980s, isotopic traces of life — carbon-12 enriched by biogenic fractionation — were found in the Isua formation (Greenland). In Australia, in stromatolites from the Strelley Pool formation, fossilized bacterial mats dating back 3.5 billion years have been preserved. The cell was already there — complex, with a membrane, metabolism, and a genetic archive.

The question: What separates Miller's spark from a stromatolite? Why can chemistry create amino acids, RNA, and even evolve, yet fail to become life? Where is the missing node that turns chaos into a system with its own account?

From Spark to Cell: How the Triad Assembled Into a Single Node

Tag 1: Oparin and coacervates — the first draft of a perimeter (1924)

Alexander Oparin proposed that life began with coacervates — droplets composed of organic polymers that spontaneously assemble in aqueous environments. They had a weak membrane (🦀), internal chemistry (🌊), and the ability to grow and divide (a rudiment of 🦈). Oparin showed that such droplets could accumulate catalysts and selectively absorb substances. But they lacked a precise replication mechanism — their "heredity" was diffuse.

Tag 2: Miller-Urey — a 💎-Drive hitting a ❌ (1953)

The experiment proved that abiogenic synthesis of amino acids is possible. This was a 💎-Drive — inorganic gases yielded organic monomers. But the ❌ hit immediately: neither membranes, nor catalytic cycles, nor replication emerged in the flask. A choke occurred — building blocks exist, but the system does not. The chaos of 🌊 persisted; perimeter and memory never materialized.

Tag 3: Cech's ribozymes — a 🪱 through autocatalysis (1982)

Thomas Cech showed that RNA can cleave and ligate other RNA molecules. This was a 🪱-bypass around the "proteins vs. RNA" problem: one class of molecules could serve as both information carrier and catalyst. Ribozymes proved that evolution could have begun without proteins. But even this was insufficient — the ribozyme had to be packaged in a protected medium, or it would degrade.

Tag 4: Spiegelman's RNA evolution in a test tube — a 🪱 without 🦀 (1960s)

Spiegelman demonstrated that RNA, in the presence of replicase, evolves in vitro: shorter molecules replicate faster and outcompete longer ones. This is pure 🌊 and 🦈 — a change in memory (sequence) under pressure from speed. But 🦀 — the membrane — was absent. The system remained open; its components diffused and were lost. This was evolution with no host, unable to take hold.

Tag 5: Greenland (3.8 Ga) and Australia (3.5 Ga) — the first cells on the scene

In the Isua formation (Greenland), the carbon isotope composition shows biogenic fractionation — signs of metabolism. In the Strelley Pool stromatolites (Australia), layered structures formed by cyanobacteria are visible — already a complex cell with a membrane, photosynthesis, and DNA. Between these fossils and the Oparin/Miller experiments lies a chasm of hundreds of millions of years. What happened in that interval? 2E answers: what occurred was the **assembly of the triad** — 🦀, 🌊, and 🦈 merged into a single system where each axis sustains the others. The membrane protects metabolism and RNA; metabolism supplies energy for replication and membrane maintenance; replication locks in successful combinations. This is the first system that redistributes its own 100 chips to prolong its own existence.

🧩 Paradoxes of the Origin of Life

Paradox 1

The Miller-Urey experiment shows that chemistry readily creates bricks. But life does not arise until an **account** appears — a system for tracking energy income and expenditure. Why did the Universe wait so long for an accountant?

Paradox 2

Ribozymes and RNA evolution in a test tube prove that catalysis and heredity can function without a cell. Yet the first cell emerged only after a membrane enveloped the RNA. Why is the envelope more important than the contents?

Paradox 3

RNA evolution in a test tube (Spiegelman) proceeds in hours, yet biogenesis took billions of years. The speed of a workaround in a closed system is higher than in an open one. But it is precisely the open system that created the cell, which then became closed. This is analogous to how mutation rates are higher in viruses than in cells — yet cells are more stable.

Paradox 4

DNA is not a "code of life," but an archive of successful workarounds. The cell stores in DNA not all information, but only what helped its ancestors survive past ❌s. The first stromatolites already had DNA — meaning there was a long period of trial and error before them, which left no fossils.

2E Verdict: Life is a system that redistributes its own 100 chips to sustain its own node

Miller's spark produced amino acids, but no membrane. Cech's ribozymes enabled catalysis, but without a perimeter, they degraded. Spiegelman's evolution provided selection, but with no container, it was an endless race with no finish line. Only when all three axes converged in a single node — when the membrane began to protect metabolism and genetic memory, and metabolism began to pay for their upkeep — did the system acquire its own budget.

The most expensive workaround is the first one. It required billions of years and countless dead ends. But as soon as the cell found this balance, it began to spread like a virus, filling every available environment. From the Australian stromatolites to the bacteria in your gut — they all carry the same blueprint, repackaged into billions of variants.

The next hall will show how this blueprint split in two: prokaryotes and eukaryotes took different paths, choosing different Splits of the Triad.

💎❌➰

Check Yourself

❓ Comprehension Questions

1. The Miller-Urey experiment yielded 20 amino acids. If lipids and RNA polymerase were added to the flask, would that create life? Why or why not — justify through the three axes of the Triad.
2. Ribozymes (Cech) and RNA evolution (Spiegelman) are 🐍-workarounds, but they did not create a cell. Which node of the Triad was absent in these experiments? Why did its absence prevent the system from becoming alive?
3. The age of stromatolites is 3.5 Ga, and the age of Earth is 4.5 Ga. We have about 800 million years for the transition from chemistry to cell. If we divide this time by 10^8 possible protocells in the ocean, how much time was available per failed attempt? (Hint: 800 Myr / 10^8 = 8 years per attempt. Is this a lot or a little in terms of chemical reactions?)

🛠️ System Protocols

Protocol "Perimeter Compression" (upon loss of integrity)

Step 1: Fix the current composition of the internal medium — stop the leakage of key molecules (e.g., using fatty acids, as in early membranes).
Step 2: Temporarily reduce Mobility (🌊) — slow down metabolism, switch to maintaining the ion gradient rather than growth.
Step 3: Reallocate the freed chips to restoring Continuity (🦈) — verify genetic material integrity, initiate repair.

Protocol "Turbine Fork" (upon detecting a dead end)

Step 1: Diagnose the ❌ — determine which specific node is overloaded: the membrane (loss of ion gradient), metabolism (ATP depletion), or replication (error accumulation).
Step 2: Attempt a 🐍-bypass through mutation (alter a carrier protein) or symbiosis (capture a foreign enzymatic pathway).
Step 3: After a successful bypass — lock the new pattern into long-term memory (e.g., via DNA methylation), so that the next cycle starts with an improved strategy.

🌱 Hall 1.1. The Great Fork — How the Code Split the Triad in Two and Didn't Stop

> *«A deadlock is a crutch for those who missed the fork. The Turbine doesn't stall — it forks».*
>
> *From the verdict of Hall 1.2*

Introduction

In Hall 1, we found the moment when chemistry became a cell. The first arbitrage — membrane, metabolism, and replication in a single node. But the cell was alone, and it knew no alternatives.

In 2009, biologists Hedges and Kumar published molecular clocks that showed: plants and animals diverged 1.5 billion years ago. That is two and a half times older than the Cambrian explosion. But there is almost no fossil evidence from this interval — red algae appear only 1.2 Ga ago, and the first reliable animals — 600 Ma ago. Half a billion years of evolution left no visible traces.

In 1909, Charles Walcott, a paleontologist from the Smithsonian Institution, found tens of thousands of Cambrian fossils in the Burgess Shale (Canada) — trilobites with chitinous shells, anomalocaridids with swimming flaps. All of them were already the result of a fork: arthropods, chordates, mollusks diverged within the animal kingdom. The explosion of diversity is not a miracle, but the visible part of the same procedure of dividing the Triad.

Ten thousand years later — Jericho and Çatalhöyük. The first settlements where people stopped nomadic life and fixed the perimeter: walls, granaries, rituals. Seven thousand years later — the East India Company (1600), the first corporate fork, separating merchant capital from state borders.

The question: Why does the same pattern — splitting a resource into two independent branches — repeat at all scales? What compels a system not to seek compromise, but to cut itself in half and restart the same game anew?

Four Snapshots of One Fork

Snapshot 1: Plants vs. Animals — 1.5 Ga ago

According to Hedges & Kumar (2009), the common ancestor of eukaryotes split. One branch took 🦈 — photosynthesis, immobility, infinite uptime from the sun. The price: 🌊 zeroed out, 🦀 cemented by cellulose (the first land plants appeared about 470 Ma ago, but the fork occurred much earlier in the ocean). The other branch took 🌊 — movement, capture, search. The price: 🦈 became unreliable; each generation must re-acquire energy anew. Neither was a dead end: both yielded colossal biomass (plants — 80% of Earth's total biomass) and diversity (animals — over 1.5 million described species). This is the first demonstration: when a system cannot balance all three axes in one substrate, it launches two copies, each with its own extreme Split.

Snapshot 2: The Cambrian Explosion — a fork within animals (540–520 Ma ago)

The Burgess Shale, discovered by Walcott in 1909, contains remains of trilobites, anomalocaridids, priapulids, chordates. All these phyla diverged within 20–30 million years — a geological instant. The 2E interpretation: the animal kingdom, having taken 🌊 as its main axis, immediately executed the next Split within itself. Some went for 🦀 (trilobites — armour, chitin), others for pure 🌊 (anomalocaridids — active predator, swimming flaps), others for 🦈 (chordates — notochord, fixed body axis, segment repetition). The deeper the fractal, the faster it runs: the first fork took hundreds of millions of years, the second — tens of millions.

Snapshot 3: The Neolithic Revolution — the sedentism fork (10,000–7,500 years ago)

Jericho (9000 BCE) — stone walls, granaries, population ~2000. Çatalhöyük (7500 BCE) — dense housing, ritual centres, 5000–8000 inhabitants. Nomadic hunter-gatherers (🌊-mobility) fixed the perimeter (🦀) and began accumulating surplus (🦈). Both settlements eventually perished — Jericho was destroyed, Çatalhöyük abandoned. But the blueprint of sedentism replicated: the city-states of Mesopotamia, Egypt, Harappa — all built on the same Split: fixation of perimeter, irrigation as a flow (🌊), writing as memory (🦈). The Code outlived the specific cities.

Snapshot 4: The East India Company — a fork of mercantile capital (1600)

In 1600, Queen Elizabeth I of England signed a charter creating the East India Company. It was a separate entity — could build forts, mint coins, wage war. It was a fork: the state (🦀 — borders, taxes, army) delegated part of 🌊 (maritime trade) and 🦈 (contracts, accounting) to a new system. The company lasted 274 years and was dissolved in 1874. But the blueprint — the joint-stock company with limited liability — replicated into all industrial economies. In 1670, the Hudson's Bay Company received a similar charter — a second fork of the same Code, but with a different Split (focus on fur trade rather than spices). Both carriers died, the blueprint lives on.

Paradoxes of the Great Fork

Paradox 1

Plants drove Mobility to zero and lost every single race — but claimed 80% of the planet's biomass. Why does a passive strategy win by mass, though it loses on speed?

Paradox 2

The fork was conceived as a one-off act of resource division — but each subsequent fork (Cambrian, Neolithic, corporate) occurred faster than the previous one. The deeper the fractal, the higher the rate of division.

Paradox 3

Jericho and Çatalhöyük perished, but their blueprint — sedentism, walls, grain — became a global standard. The carrier died, the Code remained. This contradicts intuition: local death does not mean loss of the algorithm.

Paradox 4

The East India Company was a fork created by the state, but within 200 years it became stronger than its creator and effectively ruled India. A fork can outgrow its parent system — this is a risk embedded in the mechanism of division.

2E Verdict: There Were No Dead Ends — Only Forks

Plants and animals — two Splits of one Code. Neither is a dead end: plants took mass, animals took diversity. The Cambrian explosion is the same Split within animals, but faster. Jericho and the East India Company — forks on the social and economic floors. The Code doesn't seek compromise — it cuts itself into pieces and launches a new game in each.

The next turn is unpleasant in its simplicity: every new fork occurs faster than the previous one. The first — 1.5 Ga, the second — 50 Ma, the third — 10 thousand years, the fourth — 400 years. This is not an acceleration of progress — it is an acceleration of division. The more copies, the higher the probability that at least one will survive.

Life was never stuck — it simply forks faster than it dies.

The next hall will show how the same principle of forking allowed mammals to survive the dinosaurs and occupy all ecological niches — in 66 million years, which seem an eternity, but on evolutionary timescales, it's one move.

💎❌🐍

Check Yourself

❓ Comprehension Questions

1. According to the molecular clock of Hedges & Kumar (2009), plants and animals diverged 1.5 Ga ago. But fossil animals appear only 600 Ma ago. What conclusion can be drawn about the speed of early evolution? How many times faster was the Cambrian explosion (50 Ma) than the first fork (900 Ma from the split to the first multicellular animals)?
2. The East India Company (1600) and the Hudson's Bay Company (1670) — two forks of the same Code, but with different Splits. What do they have in common in their demise (both were nationalised) and what remained after them? Which i-obj did they pass on?
3. If you are a system that has hit a resource limit, and all three axes are wearing out, but you have no possibility to create a second copy (no free substrate) — what do you do? Is there an alternative to forking?

🛠️ System Protocols

Protocol "Fork Readiness Diagnosis"

Step 1: Determine whether the system has reached a physical limit on one of the axes — e.g., 🌊 is exhausted (no fuel), 🦈 is overloaded (archive grows faster than it is processed), 🦀 is cracking at the seams (perimeter cannot sustain the load).
Step 2: Check whether free substrate exists for a second copy — a new ecological niche, another market, an alternative communication channel.
Step 3: If yes — launch the fork: separate the Code from the current substrate, deploy it on the new one with a modified Split. If not — the only move is compression and waiting (the protocol from Hall 1).

Protocol "Handling an Outgrown Fork" (when the child system becomes stronger than the parent)

Step 1: Fix the point where the child branch begins to compete with the parent for resources (e.g., East India Company vs. British Crown).
Step 2: Apply Agropa (defense with damage): do not suppress the fork directly, but intercept its mechanisms — impose taxes, restrictions, standards, so that the parent receives a share of the profit.
Step 3: If the fork is uncontrollable — recognise it as an independent system and switch to a strategy of coexistence or absorption (as Britain nationalised the company in 1858). The Code will survive both forms.

🌱 Hall 2. The Cambrian Hackathon — Why Evolution Suddenly Sped Up

«The predator is not evil, it's an efficiency manager. It was the one that forced everyone else to urgently update their software: skeletons, eyes, muscles, camouflage».

2E-paleontologist, examining the Cambrian layer

Introduction

In 1909, Charles Walcott, Secretary of the Smithsonian Institution, excavated in the Canadian Rocky Mountains, in the Burgess Shale. He discovered tens of thousands of fossils — trilobites with chitinous shells, anomalocaridids with swimming flaps, priapulids and chordates. The age of the layer is about 508 Ma (Middle Cambrian). But in older strata (Precambrian, 600+ Ma) nothing like that exists — only soft-bodied impressions of the Ediacaran fauna, without skeletons, eyes, or muscles.

In 1993, Bowring's group (Bowring et al.) published uranium-lead dating of volcanic tuffs from the Lower Cambrian of Siberia. The age — 530 ± 1 Ma. This meant that the skeleton-bearing fauna did not emerge gradually, but in a leap: the first shells appear around 530 Ma, and within 20 million years — all major animal phyla are present.

Why such a sharp jump? Geochemists (Canfield, 2005; Lyons et al., 2014) showed that ocean oxygen levels at the end of the Precambrian rose from <1% to 5–10% of modern levels. This created fuel for active metabolism. But oxygen was only a condition, not the cause. The cause was the **predator** — the first organism that actively hunted others. Before the Cambrian, Ediacaran vendobionts lived in a world without fear. As soon as "being eaten" appeared, evolution switched into 💎-mode.

Four Snapshots of the Cambrian Hackathon

Snapshot 1: The Ediacaran dead end — a ❌ with no competition

Until about 580 Ma ago (the Ediacara formation in Australia, discovered in 1946), vendobionts dominated: Dickinsonia, Charnia, Kimberella. They were soft-bodied, attached or passively floating. The Split: 🦀 ≈ 5 (no shells), 🌊 ≈ 20 (slow movement), 🦈 ≈ 75 (repeating segments, but without variation). Evolution hit a ❌: no selection for speed, defence, or sensing. A billion years of stagnation — the system could not escape this attractor.

Snapshot 2: 💎-Drive — oxygen fuel and the emergence of the predator

Oxygen rose (Canfield, 2005: to 5–10% by volume). This allowed active metabolism to arise. The first predators (probably worm-like; traces of their hunting have been found in Precambrian deposits of Namibia) began to eat the soft-bodied Ediacarans. A new axis of selection emerged — 🌊 (speed) and 🦀 (defence) became critical. The arms race triggered a 💎-Drive: each new bite demanded a 🪱 from the prey, and vice versa.

Snapshot 3: Cambrian 🪱-workarounds — skeleton, eye, muscle

- **Skeletons and shells** (strengthening 🦀): trilobites (the first — about 530 Ma, e.g., *Fallotaspis*) acquired a chitinous exoskeleton. This prevented them from being mere food.
- **Active movement** (strengthening 🌊): muscles, fins, articulated limbs. *Anomalocaris* (first finds — 1892, but detailed description — 1980s) had swimming flaps and could actively pursue prey.
- **Sensory organs** (eyes, tentacles): trilobites possessed compound eyes — this allowed them to detect predators earlier.
- **Predator hierarchy**: *Anomalocaris* (up to 1 m in length) became the apex predator — a predator of predators. This created multi-level competition.
  Each workaround generated a new dead end for the other side. The Turbine spun up to maximum.

Snapshot 4: The Split — how the chips were redistributed

Before the Cambrian: 🦀 5, 🌊 20, 🦈 75 — almost all memory in body patterns, without defence or speed.
After the Cambrian (using a trilobite as an example): 🦀 40 (armour), 🌊 30 (active swimming), 🦈 30 (avoidance instincts, migrations).
The system shifted from stagnation to a sustained 💎-mode, where chips are continuously redistributed. Evolution entered a hackathon that's still running (though the pace has subsided).

🧩 Paradoxes of the Cambrian Explosion

Paradox 1

The predator is the engine of progress. Without it, life would have remained a lazy broth for billions more years. The fear of being eaten forced the invention of eyes, skeletons, and social behaviour.

Paradox 2

The arms race did not produce a clear winner, but instead generated an explosion of diversity. The stronger the competition, the more niches emerge. 2E says: a 💎-Drive often increases complexity, rather than killing everyone.

Paradox 3

The Cambrian explosion occurred after the rise of oxygen (Canfield, 2005) and a series of glaciations (Cryogenian). The ❌ of the external environment forced the biota to seek a 🐍. Evolution did not "accelerate by itself", but responded to external shocks.

Paradox 4

Humanity has now launched its own "Cambrian explosion" in technology (computers, AI). Startup competition is the same mechanism as the predator. But where is its ❌? 2E predicts: acceleration will continue until a resource crisis occurs, or a new workaround — analogous to how the Cambrian ended with a mass extinction (the Ordovician–Silurian).

2E Verdict: the predator is a manager who fired up the press

The Cambrian explosion is not a miracle, but a logical response of the system to an external shock: the predator created pressure that forced evolution to reallocate chips from passive memory (🦈) to active defence (🦀) and speed (🌊). Within 20–25 million years, almost all animal phyla emerged — a tempo unseen for billions of years.

But acceleration has a cost: an arms race requires constant fuel (energy, space, new niches). When fuel runs out, the system either slows down or collapses. The Cambrian ended in extinction — but left a blueprint that still works.

The next hall will show how life broke out of the ocean and conquered land — following the same principle of forking, but in a new Room.

💎❌🐍

Check Yourself

❓ Comprehension Questions

1. According to Bowring et al. (1993), the Lower Cambrian is dated to 530 Ma. The Burgess Shale (Walcott, 1909) is 508 Ma. Oxygen rise (Canfield, 2005) — 550–530 Ma. Estimate the time lag between the condition (oxygen) and the first skeleton-bearing forms. Could evolution have responded faster? Why or why not?
2. Trilobites had compound eyes and a chitinous shell. Anomalocaris had swimming flaps and a circular mouth. If these two species had met, who would have won the arms race? Justify through the Split of the Triad (🦀, 🌊, 🦈).

🛠️ System Protocols

Protocol "Predator Diagnosis" (auditing external pressure)

Step 1: Determine whether an external agent exists that poses an acute threat to the Perimeter (🦀) or intercepts Mobility (🌊). Example: in business — a new competitor with a lower price.
Step 2: Measure the system's reaction speed: if it is lower than the threat speed, the system is already in ❌. Use timestamps (e.g., product release dates) for this.
Step 3: If a predator is detected and the response is insufficient — immediately launch a workaround (do not try to "wait it out").

Protocol "Triad Hackathon" (launching an arms race inside the system)

Step 1: Create artificial competition between two parallel branches (e.g., two departments, two protocols, two startups).
Step 2: Ensure that the competition is bounded — each branch must have its own Perimeter (minimum reserve) so that one does not completely destroy the other.
Step 3: Lock the winning solutions into Continuity (🦈) — make them the new standard, so that the next cycle starts from a higher level.