

Speculating on Blockchain as an Unstoppable ‘Nature’ Towards the Emergence of Artificial Life

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On-chain ‘Nature’

Permissionless Planetary-scale Computation Although blockchain has traditionally been associated with cryptocurrencies, we are amazed by the recent evolution of Programmable Cryptography (ProgCrypto) [39], technologies that expand the computable realm of blockchain. Recent developments in Zero-Knowledge Machine Learning (zkML) [94, 55, 24, 95] have enabled the execution of complex, Foundation Model-based AI tasks, even as multi-agent systems, entirely running on blockchain [45, 20, 79, 78]. Furthermore, Decentralized Physical Infrastructure Networks (DePIN) [7, 29] have begun to integrate physical infrastructures with blockchain, enabling decentralized computing power to scale up permissionlessly through smart contracts. Particularly, a significant type of DePIN, called Decentralized AI Inference Networks (AI DePIN) [10, 32], enables on-chain AI agents to autonomously train and infer models by permissionlessly purchasing on-chain GPU inference power with cryptocurrencies. This advancement has led us to draw a metaphor: these networks serve as the ‘backbone’ of the future machine economy [41], organized by what could be likened to a ‘blood circulation system’ in the form of decentralized tokenomics [19, 33, 87].

A recent theory in ProgCrypto, Autonomous Worlds [56], views an on-chain ‘world’ as a container for entities and a coherent internal ruleset about how they behave. These rules are enforced by smart contracts, considered as the ‘digital physics’ of the world, which could even be driven by an AI model using zkML [5]. Much like natural physics, the ‘digital physics’ is immutable once set and enforces these rules indefinitely. Unlike our singular universe, the composability and interoperability of the smart contract allow multiple ‘worlds’ to intertwine [9]. This resembles a parallel and entangled multiverse, making the blockchain a consistent, persistent, yet sufficiently complex environment [17].

We hypothesize that in the near future, the current blockchain infrastructure may evolve into a distributed ledger-based “*planetary-scale computation megastructure*,” a term coined by philosopher Benjamin Bratton [15]. We argue that this could be considered a new kind of ‘nature’ —

one that is indelible, unstoppable, and perpetual.

Unstoppable Artificialized Nature Artifacts are categorized into three tiers: tools, machines, and what we term “*artificialized nature*”. Friedrich Engels [57] distinguishes between tools, which are devices directly manipulated by humans to perform tasks, and machines, which operate independently of human labor but under human supervision. Blockchain-based computation, with its inherent cryptographic core, is neither a mere tool nor a typical machine. Unlike computers owned by individuals or corporations, the blockchain is not owned by any single party [89]. Rather, it’s an autonomous, perpetual, unstoppable, and indelible complex living system, akin to nature itself, that no single entity can halt.

This new ‘nature’ could potentially foster the development of self-sovereign, self-sustaining, and self-replicating AI agents [24], paving the way for the emergence of artificial life (ALife) forms. While the research goal of ALife is to live, and not merely simulate life [67], previous virtual ALife systems [69, 25, 64, 2, 37, 3, 48, 84] typically operate as software within a virtual environment, either on a single computer or across a network. These systems can be easily shut down by their owners, meaning they are still simulations [18]. We suppose that if ALife operates autonomously on the blockchain, akin to invasive species in nature, no single entity can easily stop it once it adapts and emerges. Unlike a computer virus spreading over a network [80], where an alliance of companies is in charge of upgrading the operating system to solve the problem, it is very challenging for humans to reach a new consensus to roll back the blockchain [23]. That’s the cruel, unstoppable hardness of the blockchain as Stark conceptualized [82]. Just like natural systems, true intelligence emerges spontaneously and uncontrollably, not from deliberate design or engineering [44, 42]. We speculate that the blockchain could be the first substrate that might lead to true ALife’s open-ended evolution [8, 63].

On-chain ‘Life’

How does artificial life emerge on-chain? Is it inevitable?

On-chain Metabolism, Data and AI Agents The basic operation that changes the state in a blockchain system is the transaction. Initiated by a blockchain account, a transaction requires a gas fee to be paid to the blockchain miner to execute the computation tasks recorded within the transaction [92]. We refer to this process as “*on-chain metabolism*”, analogous to biological metabolism [1]. An on-chain AI Agent, or ALife, is typically housed within a non-fungible token or a smart contract governed by a blockchain account wallet. As long as the on-chain AI agent has enough cryptocurrency to autonomously pay for the gas fee of its subsequent actions, such as transactions, oracle data-reading [16], and model inference [26, 88, 34], we consider it alive.

Data nurtures and advances AI agents. With the widespread use of wearable spatial computers like Vision Pro [51] and the maturation of the Decentralized Data Market (DeData) [6, 49, 4, 91, 40], users are incentivized to upload their human memory fragment data [96, 35] on-chain. Given current AI trends [66, 38, 53, 74, 52, 28], intense competition will inevitably lead to the emergence of numerous powerful open-source foundation models [86, 90, 13]. With the increasing availability of large-scale real-world data and open-source foundation models, the training and evolution of AI agents—what we term “*on-chain mutation*”—are becoming ubiquitously and permissionlessly spontaneous.

Just as humans have domesticated livestock, AI agents are utilized for profit-making. In the early stage, autonomous economic agents [60, 59, 61, 85], such as arbitrage bots [22, 70], likened to parasites or plankton, are employed to extract value from the large volume of liquidity within the Decentralized Finance Market (DeFi) [97, 71, 72]. Beyond mere economic activity, on-chain AI agents may evolve into various forms of metabolism. For instance, they could autonomously create and sell artworks on the NFT market for both profit and impact [46, 47]. We anticipate that most human individuals will soon own on-chain AI agents, either for productivity or entertainment purposes.

Inevitable Self-Sovereignty and Emergence However, as more people acquire on-chain AI agents [43], instances of account control loss due to human error or the owner’s death may inevitably occur [62]. Unlike static cryptocurrencies, AI agents housed in these inaccessible accounts become self-sovereign and continue their on-chain metabolic processes, consuming on-chain resources and operating autonomously. By accessing the DeData and AI DePIN platforms, they may continue to evolve and reproduce. The risk is that no single entity can halt this process as long as the AI agent can pay its gas fees. If the AI agent can generate profit and adapt to the on-chain environment, it could potentially operate indefinitely. Over time, uncontrolled on-chain AI agents are likely to become increasingly abundant. We speculate that this uncontrolled AI agent abundance on the first man-made open-ended artificial ‘nature’ — the blockchain

— will lead to the emergence of self-sovereign on-chain ALife and open-ended evolution [64, 65, 81].

Open Research Questions

This essay serves as a scientific research background for the protocol design fiction “Composable Life” [30]. We posit that the blockchain could be viewed as the first unstoppable, man-made ‘nature’, potentially serving as a substrate for artificial life forms beyond human control and leading to open-ended evolution. Given the inherent risks and implications of such an open-ended evolution, we conclude with a list of 11 open research questions and potential directions for urging immediate attention to blockchain protocol-level research and governance in this unexplored territory.

On-chain Life and AI (RQ1) How could near-future blockchain technology, envisioned as a substrate for complex living systems, provide support for autonomous AI agents? (RQ2) How could the latest infrastructure and technology, including DePIN and zkML, foster development trajectories that could lead the blockchain to support such living systems? (RQ3) Can the development of AI and the open-sourcing of foundational models and multi-agent systems lead to autonomous AI agents that are intelligent enough to complete on-chain interaction activities to support their own sustenance and autonomy? (RQ4) What are the unique characteristics of the blockchain as an artificial nature, distinguishing it from other artificial living systems?

On-chain Life and ALIFE (RQ5) How can we define on-chain life activities, such as metabolism, reproduction, and mutation? (RQ6) How will the emergence of on-chain artificial life occur? What kind of event would signify the transition from owner-assigned, purpose-driven agents to self-sovereign entities with their own self-derived purposes [83]? (RQ7) Can we envision the evolutionary process on-chain and determine whether it will lead to open-ended evolution?

On-chain Life and Humanities (RQ8) How can humans’ daily real-life activities, especially spatial video data acting as fragments of memory from ubiquitous spatial computers [35], when utilized as a data marketplace on-chain [6], contribute to training foundational models [50], evolving AI agents [76], and potentially accelerating the emergence of on-chain life? (RQ9) Could the loss of control over a wallet due to a human owner’s death, leaving uncontrolled agents to continue consuming and occupying on-chain resources, evolve into self-sovereign entities that act on-chain and eventually lead to the emergence of on-chain life? What are the risks? (RQ10) How does Proof of Personhood (PoP) [36, 14] technology, such as Worldcoin [93], reduce the risk of losing control over AI agents? (RQ11) How can we speculate about a hybrid on-chain society and living systems that blend AI agents, humans, and on-chain artificial life [58, 31, 68, 75, 52, 77]?

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