Progression without progress

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Progress in the use of artificial intelligence (AI) to advance scientific discovery has made it increasingly realistic to envision automated "end-to-end science" (ETES) systems: integrated pipelines that could generate hypotheses, run experiments (in silico or robotic), analyze results, and produce publishable outputs with minimal human intervention. The critical question is not whether AI can "do" science but whether science—as a social, evolutionary system that generates trustworthy knowledge—survives the way AI does it.

Although no single community is explicitly calling for fully autonomous science, ETES is the logical endpoint of current trajectories: increasing automation, integration across tasks, and competitive pressure for speed and scale. In this sense, it is less a proposal than a direction of travel. Fully autonomous pipelines may ultimately occupy only part of the scientific landscape. But they epitomize, in extreme form, the same forces already reshaping knowledge production.

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However, science is not simply a sequence of tasks that can be optimized. It advances through a process analogous to Darwinian evolution: variation across many independent efforts; selection through critique, replication, and competition; and retention of robust results. This distributed structure is what allows science to correct itself and to generate novelty. Independence is not incidental; it is the mechanism that produces both reliability and discovery.

Science has never fully lived up to this ideal, having been shaped by bias, incentives, error, and even fraud. Proponents of ETES may argue that automation could mitigate some of these limitations while accelerating discovery and expanding participation. Therefore, the relevant comparison is not between ETES and an idealized science but between ETES and the imperfect system we have. The question is whether ETES reduces those imperfections—or amplifies them at machine scale.

ETES risks altering the structure of science in a fundamental way. Even if individual AI systems generate internally diverse hypotheses, they are likely to be built on a small number of dominant platforms, trained on overlapping data, and optimized under similar objectives. As in other markets for digital technologies, concentration is a plausible outcome: a handful of systems shaping the majority of scientific output. This produces correlation, not independence. Simulated diversity within a system does not substitute for epistemic diversity across genuinely competing approaches.

The consequence is not merely institutional; it is epistemic. The scientific system thrives on inefficiency: redundant efforts, failed attempts, and divergent paths. These are not costs to be eliminated but sources of discovery. By contrast, optimization pressures drive convergence—faster iteration within a constrained search space. The result may be more output but less exploration of the unexpected.

This narrowing has implications for creativity. Much of AI's strength lies in combinatorial exploration, the rearranging of existing knowledge into new configurations. But many consequential advances in science are not combinations; they are breaks, conceptual shifts that violate assumptions of prior frameworks. Because such advances depart from patterns encoded in existing data, they are the ones least likely to emerge from systems trained on the past. An evolutionary system can generate such breaks because independent lineages explore fundamentally different directions. Independence is not only a safeguard for reliability; it is the condition for conceptual rupture.

The philosopher of science Karl Popper contrasted clocks, systems that can be decomposed and optimized piece by piece, with clouds, systems whose behavior emerges from complex interactions. The structure of scientific workflows can be treated like a clock. But science as a system of discovery is a cloud. Optimizing each component does not guarantee the integrity of the whole. Optimization may, in fact, undermine it.

The implication is not that ETES should be rejected but that it cannot be treated as a purely technical advance. Preserving core properties of an evolutionary scientific system becomes a design constraint. Scientific outputs must retain clear accountability—an identifiable chain of responsibility that cannot dissolve into opaque systems. Institutional and technical arrangements must ensure genuinely distinct approaches, not merely variations within a shared architecture. Processes such as replication, critical evaluation, and limits on throughput must be preserved, even at the cost of efficiency, because they are the mechanisms through which error is exposed and corrected.

These requirements are not inefficiencies to be engineered away. They are the accumulated solutions to the problem of making knowledge trustworthy. An ETES system may produce impressive results. But if it replaces an evolutionary process with an engineered one, it risks narrowing not only what we discover but what we are capable of discovering at all. □

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