

Reflections

May 2022



Imagine if medicines could sense and respond to health conditions directly in your gut, thereby unlocking the next generation of therapeutics. Consider the potential for reinventing food production if we could develop meat, dairy, and plant-based proteins by fermentation, not animal agriculture. Let's push the thinking even further – imagine a single method for making just about any product in the world faster, cheaper, and more sustainably than conventional manufacturing. Sounds like science fiction, right?

In 2016, we met Jason Kelly, founder of Ginkgo Bioworks, a synthetic biology company. His central objective was to become the Intel of biology. Intel develops microprocessors which proved essential for computing breakthroughs; Ginkgo 'programs' cells in hopes of similarly transforming biology. Kelly maintains that what computers did for information; synthetic biology will do for the physical world. Ginkgo already helps make everything from fragrances, biosecurity, pharmaceuticals, and fossil-free fertilisers to vegan 'meat'.

The skill is in the engineering, as manufacturing living cells is hard – evolution has a four-billion-year head start on perfecting cell processes. Nature offers tantalising examples of the magical properties of biology – such as self-assembly, self-repair and self-replication – which Ginkgo sets out to harness for manufacturing at scale.

Jason Kelly and three MIT classmates – Reshma Shetty, Barry Canton and Austin Che – alongside their professor, Tom Knight, founded Ginkgo 14 years ago to do just that, to create tools to exploit the power of biology.

We find Ginkgo at the juncture of converging advances in computing power and DNA engineering. Biology has now become programmable, not in the 1s and 0s of the digital world, but in the A, C, G and Ts of the physical. The reprogramming of cells presents an almost unbounded set of potential applications.

Beyond possible applications, Ginkgo is also seeking to improve manufacturing processes. For those which have been historically resource-intensive and pollutive, Ginkgo is making them sustainable, renewable, and resource-light. For example, the company has partnered with Bayer Crop Science to change fertiliser production. Currently, farmers apply large amounts of synthetic fertiliser to grow cereal crops. These fertilisers are energy-intensive to manufacture and can run off into water supplies causing environmental damage. Ginkgo and Bayer have instead engineered microbes that live on the roots of crops providing nitrogen without the need for synthetic fertilisers, eliminating environmental harm.

However, Ginkgo is not limiting itself to reimagining old processes, but also inventing entirely novel ones. The 'cell apps' developed by Ginkgo create limitless opportunities for innovation, with examples ranging from developing enzymes used in vaccine production to renewable flavour and fragrance ingredients for food production. No industry is out of reach.

Crucially, while the applications may be very different, the underlying principles are similar. By combining best-in-class tools with an ever-expanding cell library, automation, and data science, Ginkgo is creating an industry-agnostic cell engineering platform that is an order of magnitude cheaper and faster than traditional in-house research and development. This flywheel provides huge cost and efficiency gains.

The company generates revenue by charging customers to redesign cells and takes a royalty on the resulting product once commercialised. This royalty revenue model scales as an increasing proportion of Ginkgo's programs bear fruit with successful products.

Currently, Ginkgo has 64 active programmes in place and aspires to 700 by 2026. If only a few of these prove successful, it's plausible that Ginkgo could be generating \$4bn in profits from foundry and royalties by then. This estimate seems conservative, as the end markets for Ginkgo's products are huge – McKinsey estimates that 60 per cent of all physical inputs in the global economy could be produced biologically equating to roughly \$4tn a year across the domains of agriculture, food, consumer products, materials, energy and health. These are the markets we can currently identify. If we consider new applications yet to emerge, the market could be much larger.

In the future, Ginkgo may come to understand biology so deeply and its codebase library may become so rich, that any new customer project may be solved by assembling the 'bio bricks' of genetic code. Biology could become predictable: products that don't exist in nature could be made in an almost off-the-shelf approach, making it the best manufacturing technology there is. In short, this could be the beginning of a new industrial revolution.

As Covid-19 has shown, a microscopic bit of RNA code can upend our entire world, while another bit of code re-engineered can tame a global pandemic.



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