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The Organism Is the Product

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ABSTRACT: A new industry model is emerging where microbes are first developed by specialist organism engineering firms and then deployed by customers in specific application areas. It is now realistic for companies without prior fermentation experience to purchase and deploy an engineered organism to expand their business.

Advances in synthetic biology are enabling the engineering of organisms that behave as predicted. The time to deploy a new industrial microbe has steadily decreased and is now as short as three years.[1] Ginkgo BioWorks and other organism engineering firms are reducing this period to less than one year *via* highly automated organism fabrication facilities. This focus on high performance fabrication infrastructure mirrors the semiconductor industry. S. Shankar Sastry, UC Berkeley Dean of Engineering, recently spoke on this topic at the Synthetic Biology Institute:[2]

> *"There are a lot of parallels [to Synthetic Biology] with the semiconductor revolution. I think that we are where we are because we don't think about doing semiconductors for entertainment and defense and communications separately. ... [at Intel] Gordon Moore and Andy Grove and several others actually had the conviction that developing tools and developing methods which worked across the spectrum of applications was critical. And they did it at a time when a lot of industry — [Texas Instruments], IBM, Motorola — were pulling them in different directions."*

Ginkgo's organism fabrication facility is used to produce organisms for a range of applications. Like Intel we are not directly pursuing the applications enabled by our products; rather we work with customers in pharmaceuticals, energy, and chemicals to engineer organisms that will "drop-in" to their systems.

In addition to Ginkgo, companies such as Synthetic Genomics and Intrexon leverage a core organism fabrication infrastructure across many joint ventures or spinouts in different application areas. In the past two years, seven joint ventures have launched from organism engineering firms in applications ranging from pharmaceuticals to fuels. This trend represents a powerful industry model where organisms are first developed by specialist firms and then deployed by customers in their specific application areas.

It is now realistic for companies without prior fermentation experience to inexpensively deploy an engineered organism to expand their business. New customers of engineered microbes can begin producing products without a large upfront capital investment by contracting with toll manufacturers that provide pay-per-use bioreactors and fermentation expertise. Ginkgo licenses our organisms with low upfront costs to increase adoption; we capture value once our organisms expand our customers' businesses.

Organism engineering firms will play a critical role in the synthetic biology revolution, providing new organisms to companies poised to disrupt established industries. As an example, the rise of petrochemicals in the 1940s provides a template for the changes to expect in the chemical industry today. Crash programs during World War II to produce high-octane gasoline and synthetic rubber led to the invention of new polymer chemistry and the replacement of coal with petroleum as the primary feedstock for chemical production.[3] This new feedstock disrupted the existing chemical industry and oil companies emerged as the new primary suppliers of commodity chemicals.

Today's rising oil prices mean that agricultural companies such as ADM, Bunge, and Cargill are in a position to leverage their sugar feedstocks to disrupt the chemical industry. By working with organism engineering firms these companies can dramatically increase the value of their feedstock by deploying organisms that convert sugars to higher value chemicals. Eventually engineered organisms will also expand feedstock options *via* cellulose degradation or direct-from-CO_2 approaches such as photosynthetic algae or electrofuels.[4]

By focusing on the development of fabrication facilities, organism engineering firms such as Ginkgo BioWorks will continue to reduce the time and cost to deliver a scale-up-ready organism. Such improvements to organism engineering will disrupt existing industries and generate new markets. As in the beginning of the semiconductor revolution the most valuable future applications are difficult to imagine, but the capabilities of natural biology hint that engineered organisms will touch nearly every aspect of our lives.

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Notes

The authors declare the following competing financial interest(s):I am a founder of Ginkgo BioWorks, Inc.

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