Biomanufacturing from the Ginkgo POV

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Synthetic biology can help solve your most challenging problems

Access economies of scale to drive down your cost of goods and services

Reshore and strengthen supply chains to increase domestic resiliency

Create products that petrochemicals or synthetic chemistry cannot

Unlock new properties and performance in materials

Synthetic biology impacts many industries

Unlock new properties and performance in materials

Identify and implement new climate and bioremediation solutions

Improve agricultural yields and detect and mitigate pathogens

Provide more sustainable food ingredients and more nutritious food products

Lower the cost and availability of pharmaceuticals

Reshore and strengthen supply chains to increase domestic resiliency

Successfully engineering biology is challenging

Image Credit: Studio ThinkingHand

COST CHALLENGES

- Extensive research & manual labor
- DNA design, synthesis & assembly
- Manual strain engineering & testing
- High volume of repetitive tasks
- Testing & scaling fermentation
- Navigating scale-up & industry

OPTIMIZATION CHALLENGES

- Billions of sequences to choose from
- Thousands of DNA designs to test
- Massive amounts of testing data
- Refining complex systems
- Optimization for desired product
- Maintaining quality when scaling

Founded in 2008

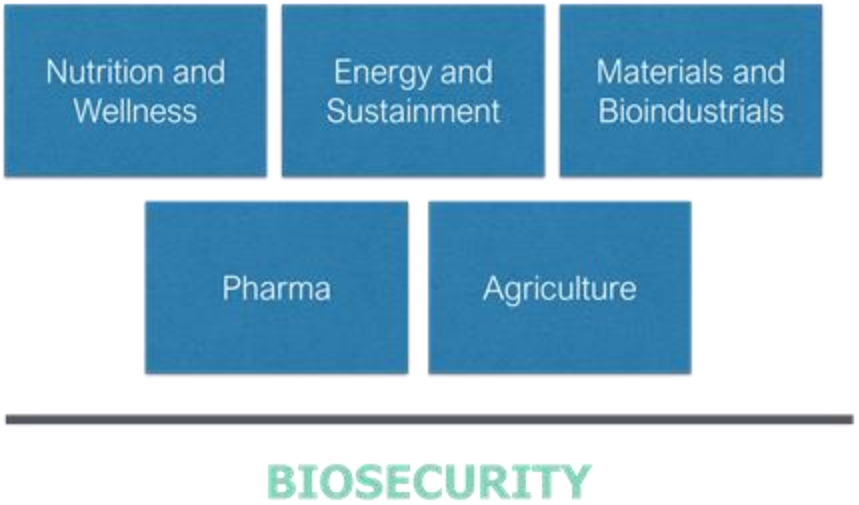
Headquartered in Boston with labs and offices in Emeryville, the Netherlands, Switzerland, France and Australia

In 2021, began trading publicly on the NYSE ($DNA) after raising $1.6 billion

Image Credit: Studio Thinking Hand

At Ginkgo, we're building the backend of the bioeconomy

Biology is everywhere. At Ginkgo, we see the potential for biology to transform all industries. Working with our partners and growing ecosystem, we design custom organisms that bring new products to life for countless applications.



Over 100 programs with partners across industries

We partner to address challenges from Discovery through Manufacturing

SELECTED WORK

PFAS detection

Designing and identifying biosensors to detect PFAS compounds

Biomining

Discovery of proteins that bind to hard-to-recycle metals from electronics

Therapeutics

Culturing and screening anaerobes from human microbiome samples for therapeutic applications

Water quality

Developing advanced biosensors capable of detecting harmful molecules and toxins in any water source

Industrial Enzymes

Fast and effective way to create enzymes for the food industry

Animal Feed & Nutrition

Strain engineering and improvement for bulk and specialty ingredients

Bio-agriculture

Engineered crop-colonizing microbes for sustainable agriculture

Chemicals

More sustainable bio-based chemicals for multiple industries

Systems bioengineering

Acceleration of product development in intermediate chemicals

Metabolic engineering

Engineered a strain to assimilate a low-cost substrate

Plastics remediation

Identifying proteins to adequately accelerate degradation

Process Improvement & Scale Up

Process optimization for production of key ingredient

Foundry

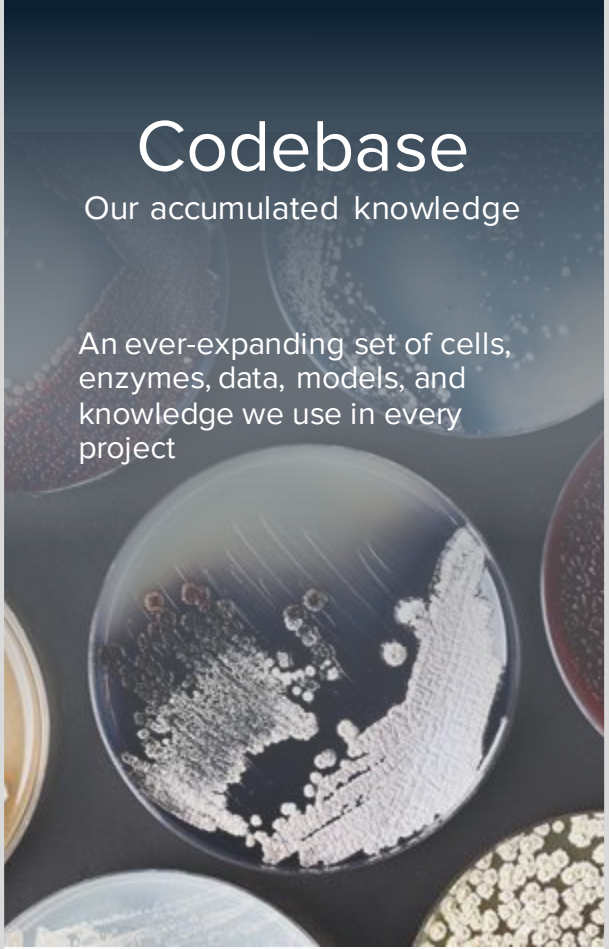
Our automated facility

Flexible, scalable lab unit operations connected by proprietary software that allows us to run high-throughput experiments

Codebase

Our accumulated knowledge

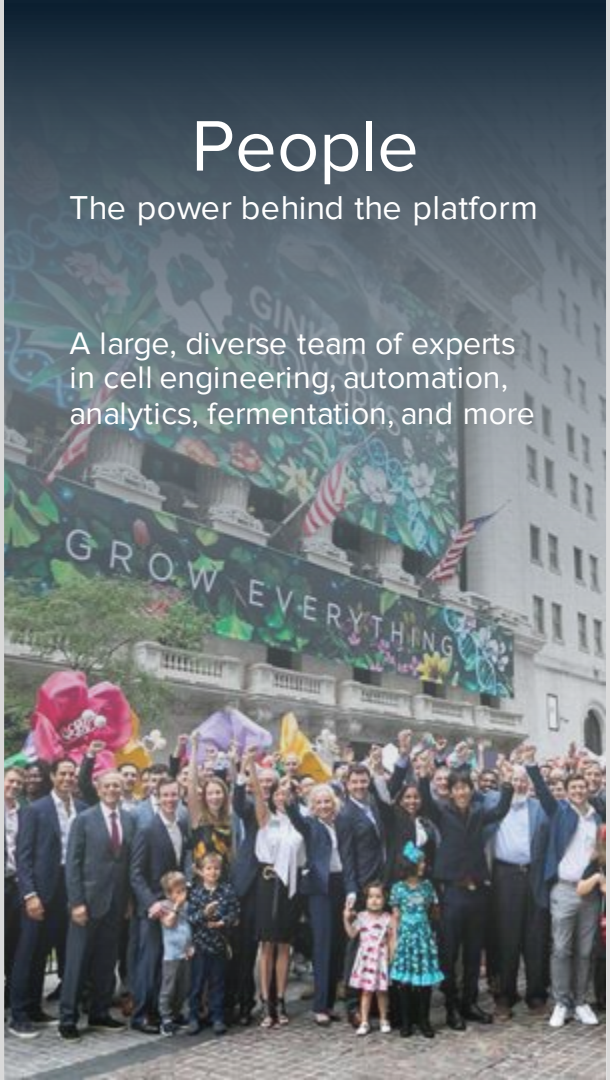
An ever-expanding set of cells, enzymes, data, models, and knowledge we use in every project

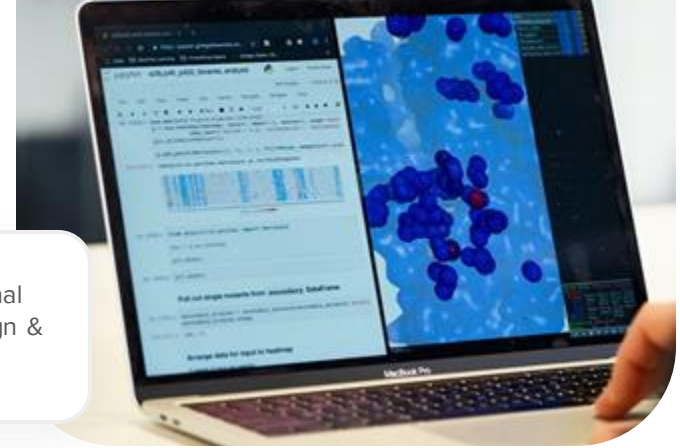


People

The power behind the platform

A large, diverse team of experts in cell engineering, automation, analytics, fermentation, and more

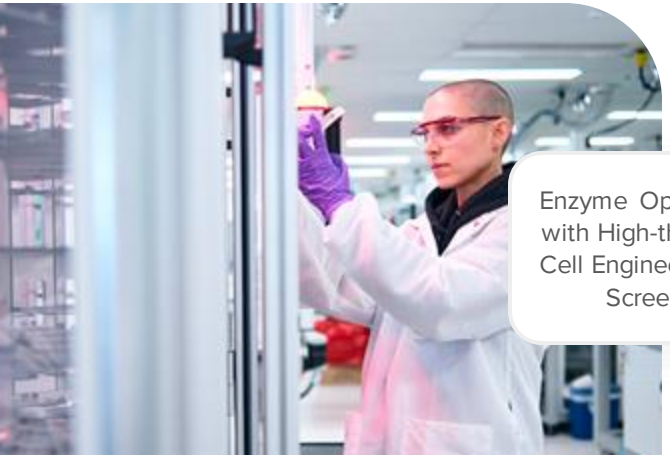




Computational Enzyme Design & Discovery

Strain Optimization & Manufacturing Process Design

End-to-end synthetic biology



Enzyme Optimization with High-throughput Cell Engineering and Screening

Downstream Processing & Manufacture Scale Up

The Design, Build, and Test cycle accelerates development while optimizing for scale-up

PHASE

Design

Computational design of 100,000s of DNA sequences & strains

Discover new enzymes or gene circuits

Protein engineering

Build

Synthesize and assemble custom DNA sequences

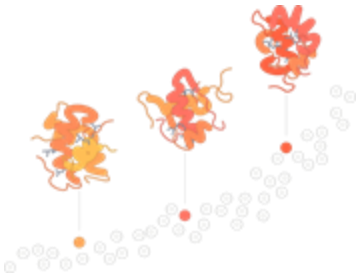
Construct thousands of potential strain candidates

Test

Screen to select highest-performing strain candidates

Characterize strains & molecules

Small-scale fermentation to predict strain performance



Grow

Process development & scale-up

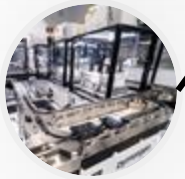
Fermentation optimization

Organism deployment & **technology transfer**

Quality assurance and control

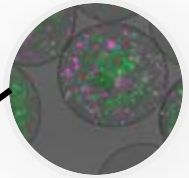
Bringing the best technologies together for you

Ginkgo integrates all the leading tools for synthetic biology under one "roof"



Ginkgo Headquarters

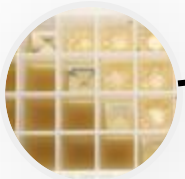
Boston
~800 Employees
Ginkgo Foundries



Ginkgo Switzerland

Basel, Switzerland
18 Employees
Formerly F-Gen

Incredibly high throughput multiplexed screening technology



Ginkgo Netherlands

Utrecht, Netherlands
26 Employees
Formerly Dutch DNA
Powerful fungal strains

Image Credit: Studio Thinking Hand

Current state of biomanufacturing?

It's happening!

Why are businesses pursuing biomanufacturing?

- **ESG** (Environmental, Social, and Governance) Factors–going green, improving climate, replacing petroleum products
- **Lower costs,** eventually
- **Supply Chain security**–on-demand, distributed manufacturing, equanimity
- **Improved performance**–new chemistries, functionalities

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Why they fail

COST
Right intentions, wrong economics

- *Significant up-front investment*
- *Unfavorable TEA/COGS (cost of goods sold)*

Assembly line approaches will drive down costs

But there is a lot of trial and error along the way and bespoke projects make it difficult to iterate.

Photo credits: Ford Media Center

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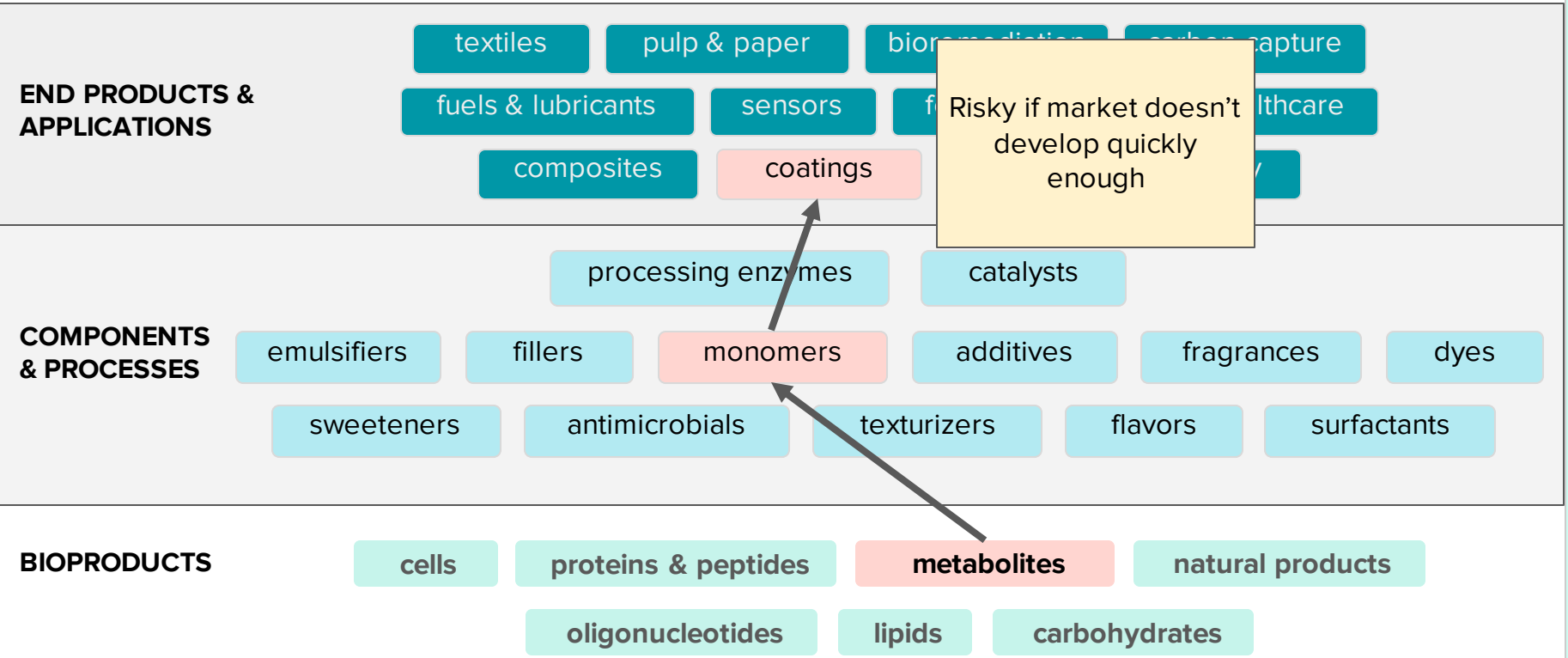
- *Unfavorable TEA/COGS (cost of goods sold)*

- *Displacing current products or manufacturing schemes takes time and tech push*
- *Specifications, standards, regulatory policies are not inclusive of bioproducts*

Some companies try to do the whole pipeline themselves



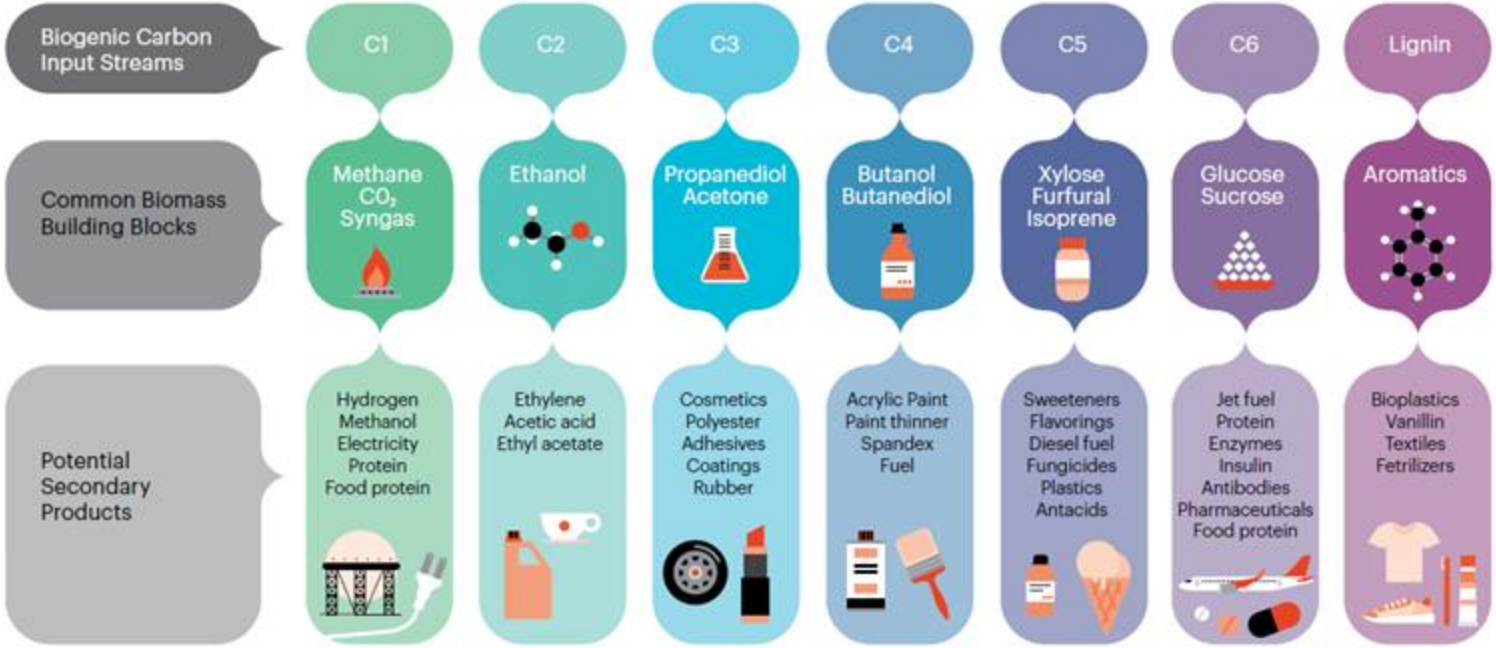
Biomanufacturing

Where are we headed?

Image Credit: Studio Thinking Hand

2-5 years: the small molecule, drop-in replacement roadmap will fill out

If recession doesn't affect the industry *and* investment continues, we'll get good enough at making core molecules to drive costs down throughout the bioeconomy



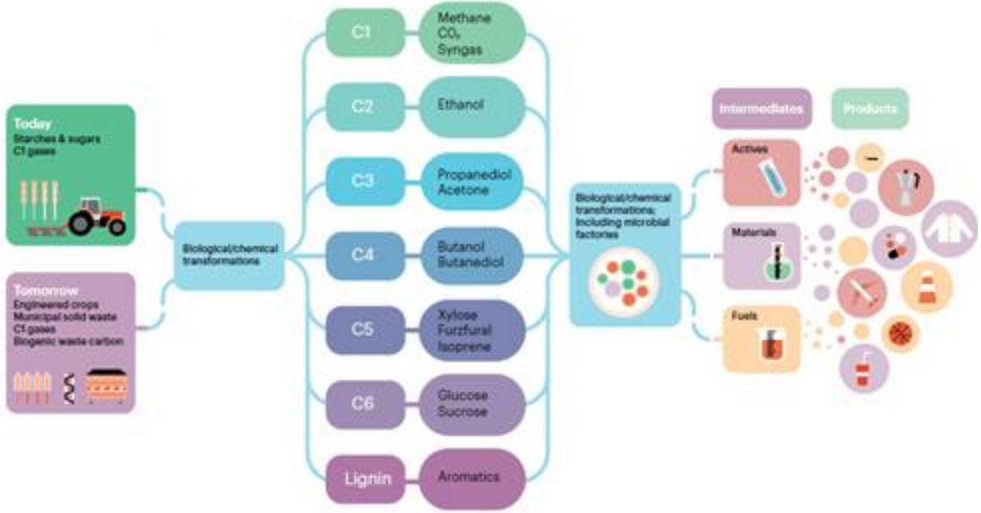
Schmidt Futures Report, 2022. The US Bioeconomy: Charting a course for a resilient and competitive future

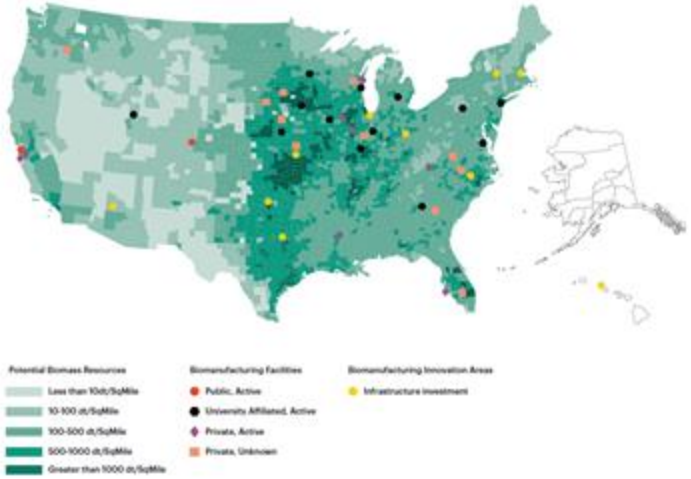
Future Technology: 5-10 years out

Strengthened supply chains, strategic national stockpiles

Distributed manufacturing:

- Fermentation infrastructure
- Tailoring to local feedstocks, water, infrastructure





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Future Biotechnology: 5-10 years out?

- **materials**: *self-healing, hierarchically designed materials, camouflage*
- **sensors:** *biofilms as sense-and-respond or communication systems*
- **biodegradation:** *self-destructing systems, hard-to-degrade chemicals*
- **circular biosystems:** *waste recycling and materiel synthesis*

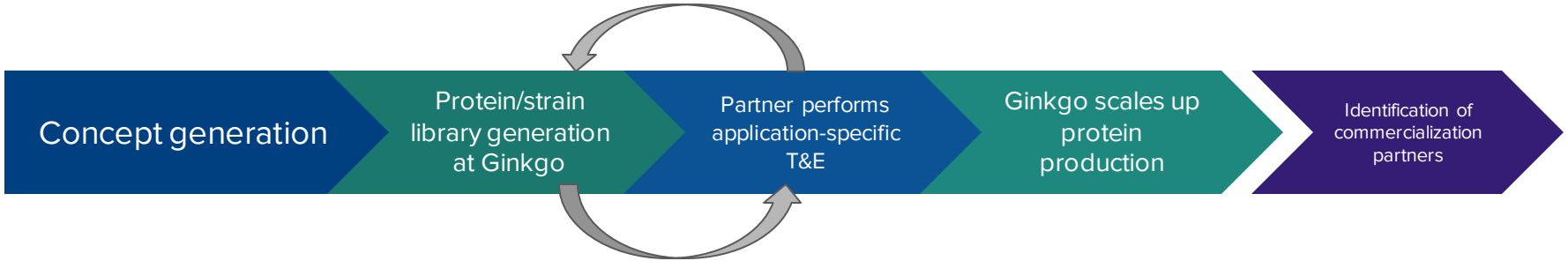
Image Credit: Studio Thinking Hand

What else limits biomanufacturing, technically?

- Limited number of natural sequences and strain resources… **we need more code!**
- Genetic tools for strains with unique capabilities
- The “right” assays and models that are predictive of real-world performance, be it in-field T&E or fermentation
- Lack of downstream processing for new molecule types
- Distributed manufacturing–reproducibility, utilization of different feedstocks


Thanks for your attention!
GINKGO
BIOWORKS

Collaboration framework



Initial solution identified

Some modeling may have occurred

Protein proof-of-concepts may/may not already be developed

Ginkgo onboards ideas, brings its SME to solutioning

Ginkgo's cell engineering team generates 500-10,000 member protein variant libraries and tech transfers to AFRL

Ginkgo strains are commercial-scale ready from outset

AFRL/RX uses protein library in materials development, evaluates protein variants

AFRL/RX downselects variants, requests scale up or new variants

Ginkgo conducts mid-scale fermentation and downstream processing

Ginkgo assists with tech transfer to a CMO

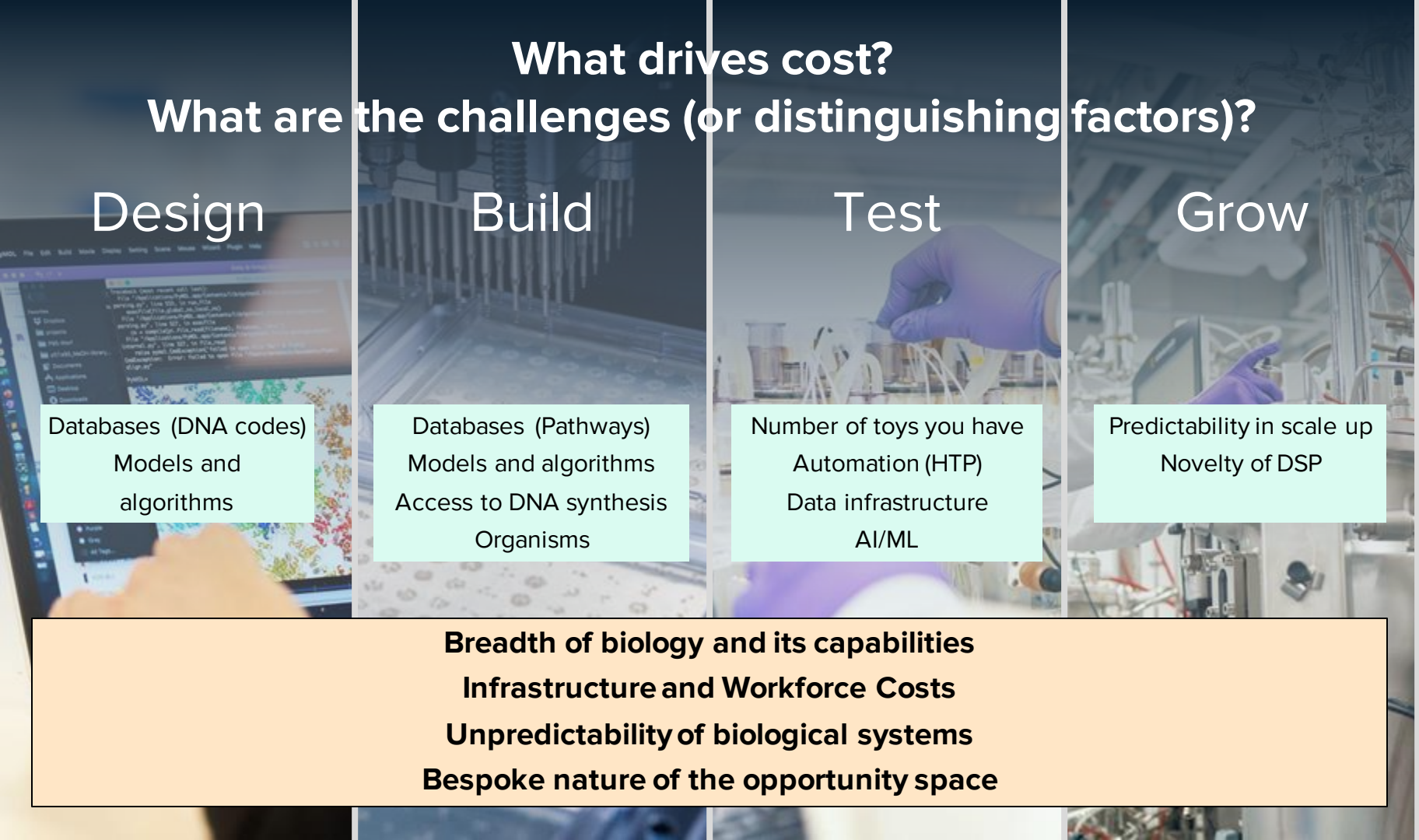
Depending upon application, Ginkgo could help in identification of transition partners for materials or manufacturing commercialization

Leveraging these capabilities, we have demonstrated best-in-class performance

PHASE	Design	Build	Test	Grow
	Computational design of 100,000s of DNA sequences & strains **Discover** new enzymes or gene circuits **Protein** engineering	**Synthesize and assemble** custom DNA sequences **Construct** thousands of potential strain candidates	**Screen** to select highest-performing strain candidates **Characterize** strains & molecules **Small-scale fermentation** to predict strain performance	**Process** development & scale-up **Fermentation** optimization **Organism** deployment & **technology transfer** **Quality** assurance and control
PERFORMANCE				
	Database of **3.8B+ unique gene sequences**	**50+ proprietary chassis**	**30 million+** strains evaluated (pooled multiplexed)	**8 commercialized products**
	Advanced computational tools to discover and optimize proteins, pathways, and cells	Ginkgo is the **biggest single user of synthetic DNA in the world** (100k+ constructs/yr)	**244** Ambr250 systems, running **8,000+** small scale fermentations annually	Up to **50,000L fermentation capacity** (with partners)
		100 million+ multiplexed genomes edited per year	**>10 robotic workcells** for high-throughput screening & advanced analytics	**200k+ sq ft** of Foundry space, **300 robots**

As of January 2022

What drives cost?
What are the challenges (or distinguishing factors)?



Design

Databases (DNA codes)
Models and algorithms

Build

Databases (Pathways)
Models and algorithms
Access to DNA synthesis
Organisms

Test

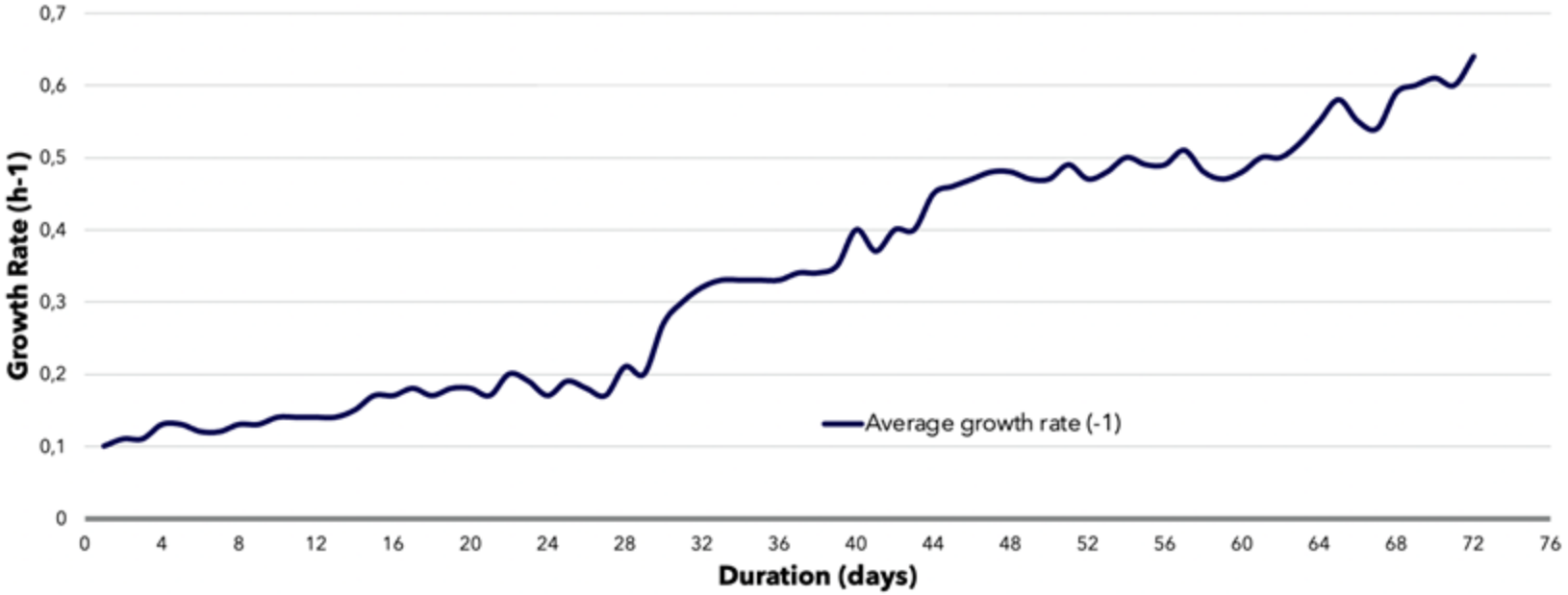
Number of toys you have
Automation (HTP)
Data infrastructure
AI/ML

Grow

Predictability in scale up
Novelty of DSP

Breadth of biology and its capabilities
Infrastructure and Workforce Costs
Unpredictability of biological systems
Bespoke nature of the opportunity space

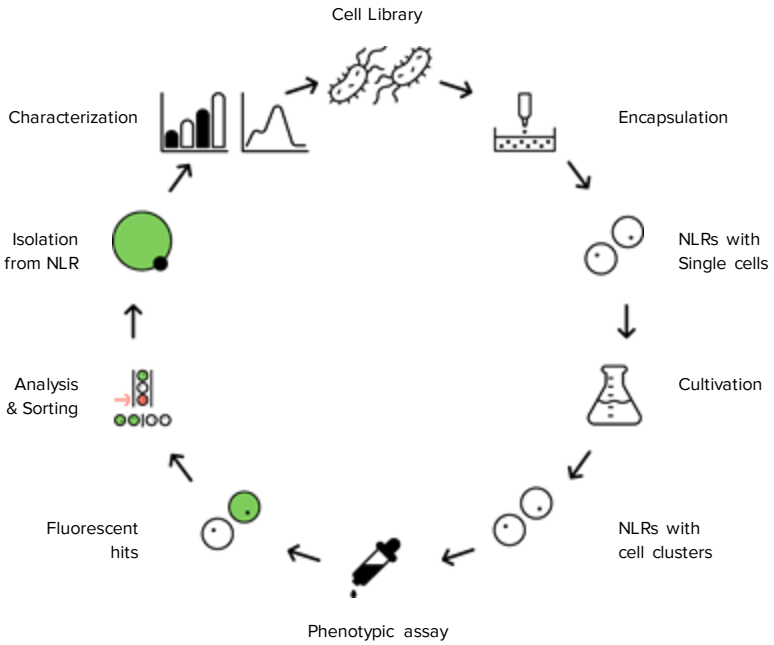
ALE (Adaptive Laboratory Evolution) combines the powers of natural selection and automation to deliver improved strain fitness faster.



Arrived in 2022 with the acquisition of Altar, a French biotech with an advanced platform for implementing ALE with proprietary automated fluidic technology.

Supports continuous and indefinite bacterial cultivation. Selective conditions are automated to maximize adaptation to environmental stress or new feedstocks.

Has a proven track record delivering strain improvements across diverse applications and microbes (bacteria, yeast, microalgae).



EncapS sorts microcolonies in Nanoliter Reactors (NLRs) to find complex phenotypes including secreted factors.