ECFG15
ROME • ITALY 2020

GINKGO BIOWORKS
THE ORGANISM COMPANY

Biology by Design

Will(Yangxiaolu) Cao
Design Senior Engineer

Intro of Ginkgo

How Ginkgo get started?

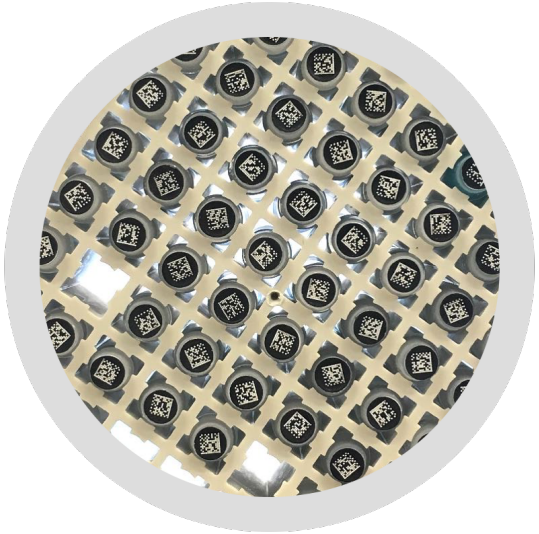
"The **interesting** thing to program in the 21st century isn't going to be computers— it's **biology**."

Ginkgo Founder
Tom Knight

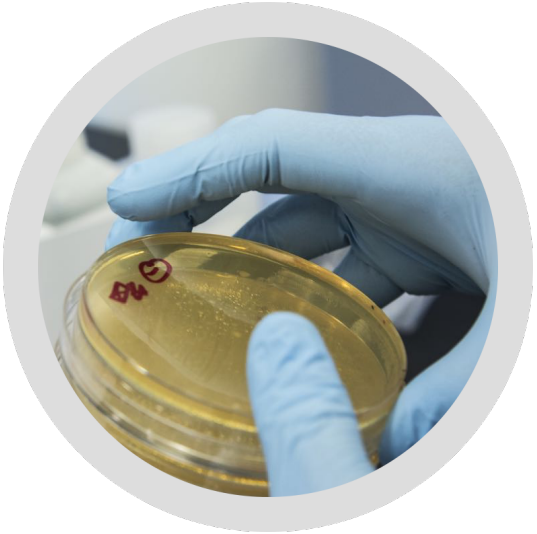

EXIT
300 PEOPLE
>125 ROBOTS
>50 active projects
>25 organisms, 6 fungi species
100,000 SQ FT IN BOSTON
$429M PRIVATE INVESTMENT
Viking
Y
GENERAL ATLANTIC
CASCADE
INVESTMENT GROUP, INC.

What do we do?

Chemicals



Strain Improvement



Enzymes

Foundry

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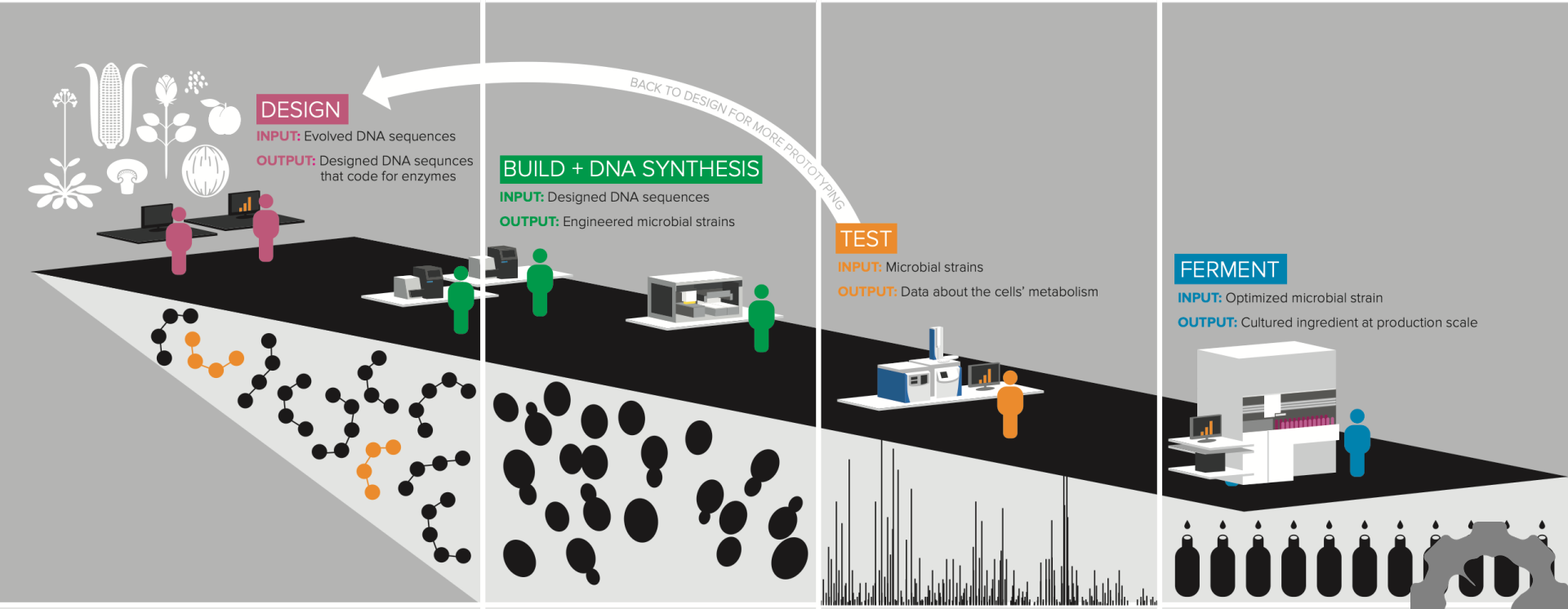
LIVING FOUNDRY PROTOTYPING CULTURED INGREDIENTS



Organism designers get inspration from natural **enzyme pathways** to design DNA sequences

Build engineers use the DNA sequences to engineer the **microbial strains** that produce the cultured ingredients

Test engineers measure **thousands of data points** from the microbial strains simultaneously in order to find the best designs and improve future predictions

The microbial strains that are the most success[illegible] produc[illegible] desired ingredients are utilized for the large sc[illegible] **cultured products**

Foundry

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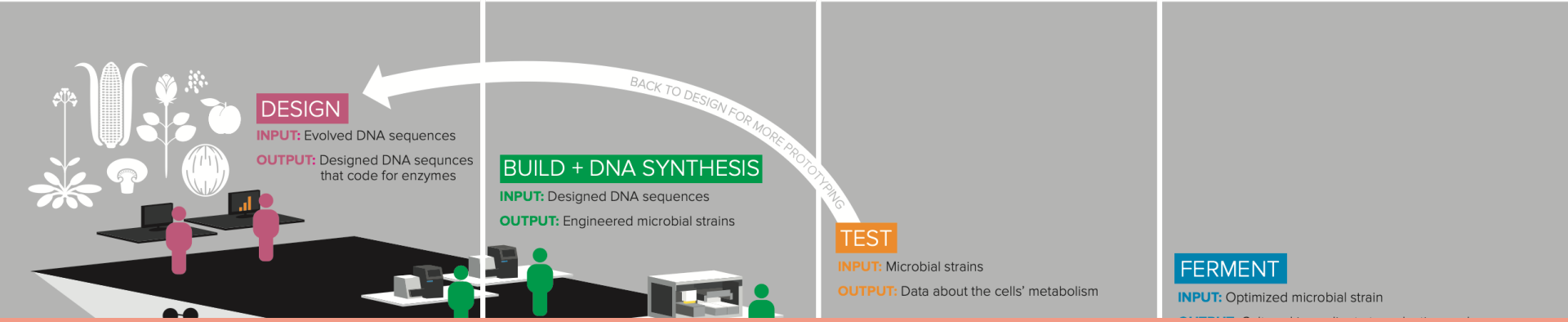
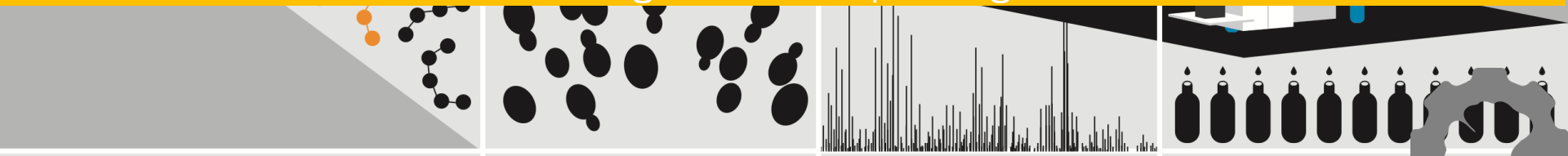
LIVING FOUNDRY PROTOTYPING CULTURED INGREDIENTS



software

automation

next generation sequencing



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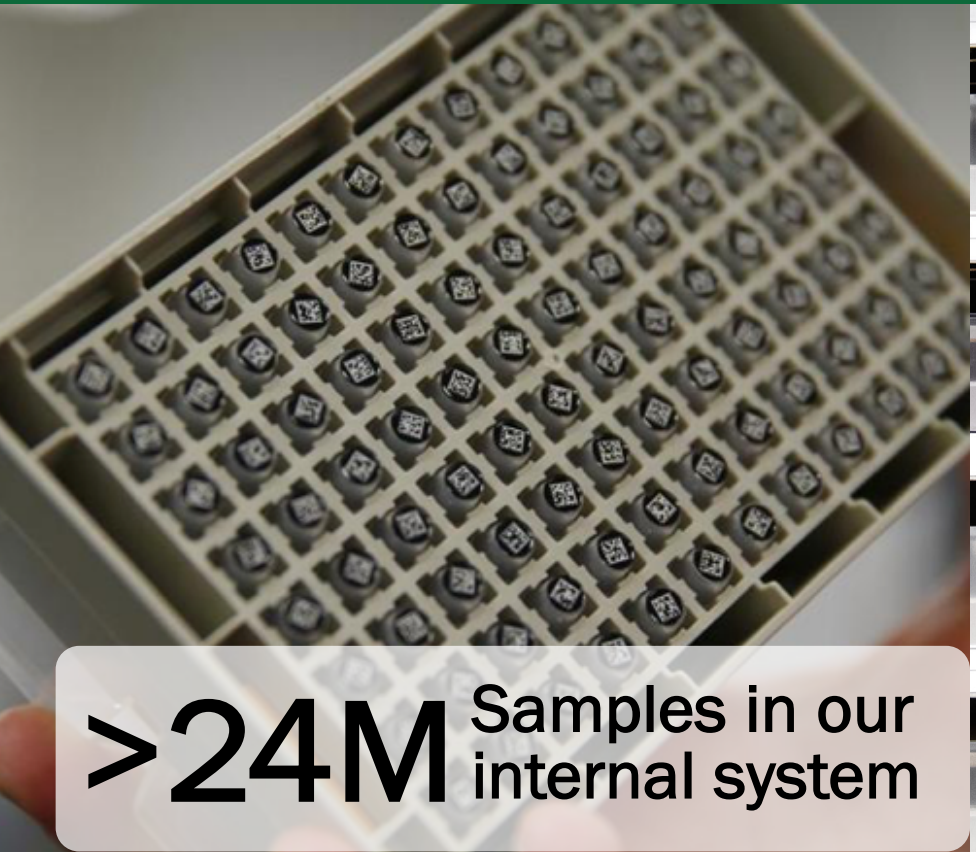
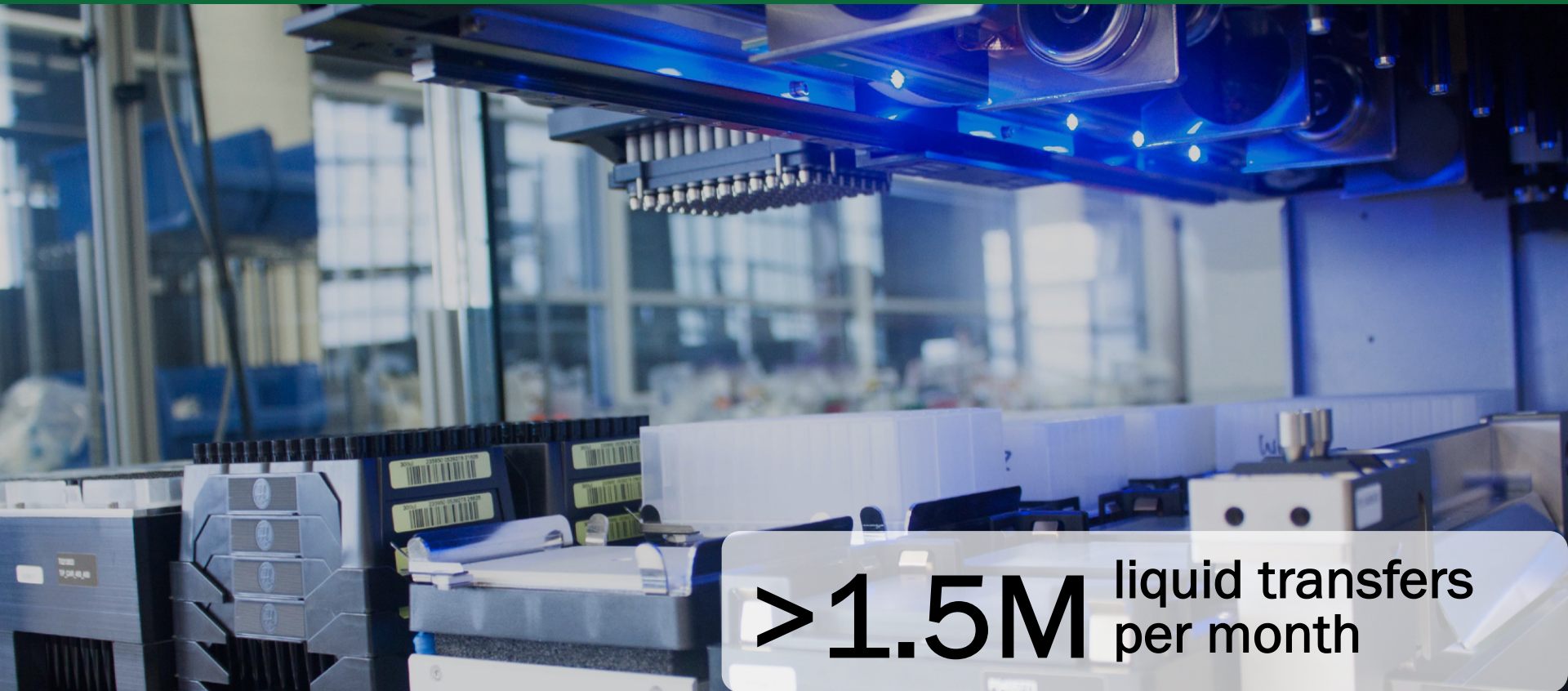
BIOLOGY AT SCALE

Logistics are managed using barcoding and proprietary Information Management System

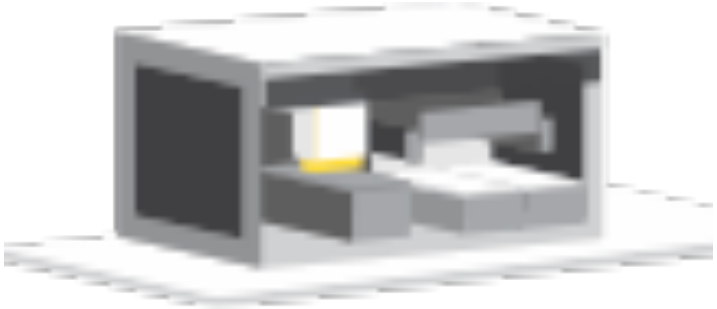


>24M Samples in our internal system

Automated processing of DNA, proteins, cells, and compounds



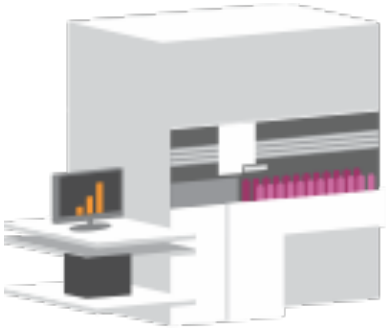
Foundry snapshot in Jan 2020



>1 million foundry operations per month

>80K strain tests per month

>10K bacterial genomes per week



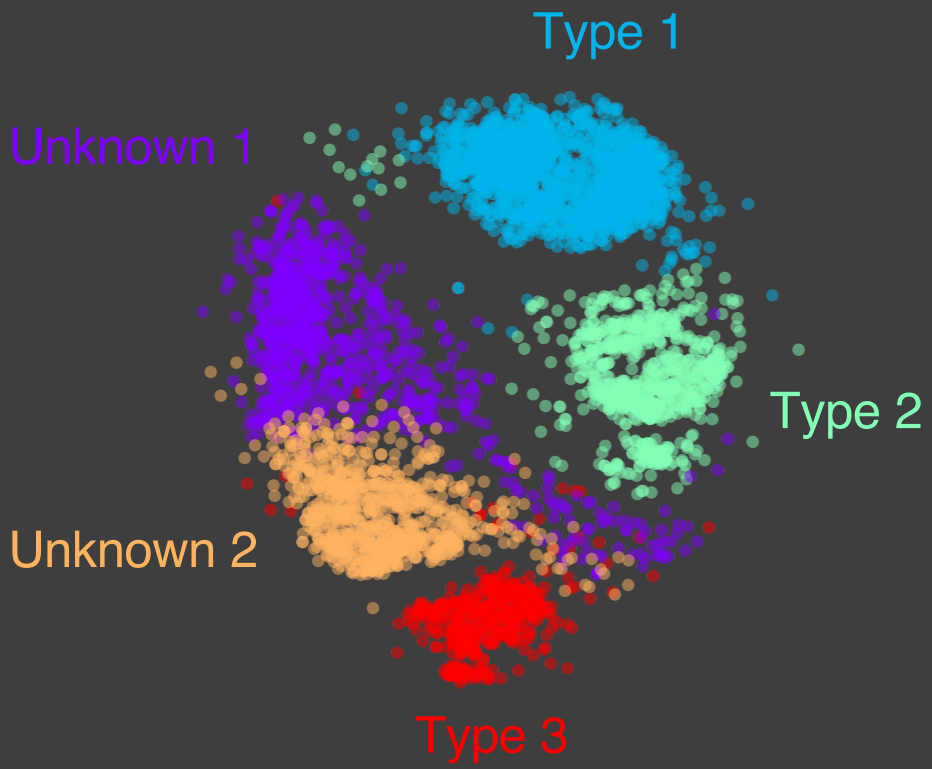
>8K new strains

A case study : enzyme sourcing

SEARCHING ENZYME SPACE

Enzyme Discovery

EXPLORING BIODIVERSITY AT FOUNDRY SCALE



Sequence similarity space of 5449 enzyme homologs

Enzyme Discovery

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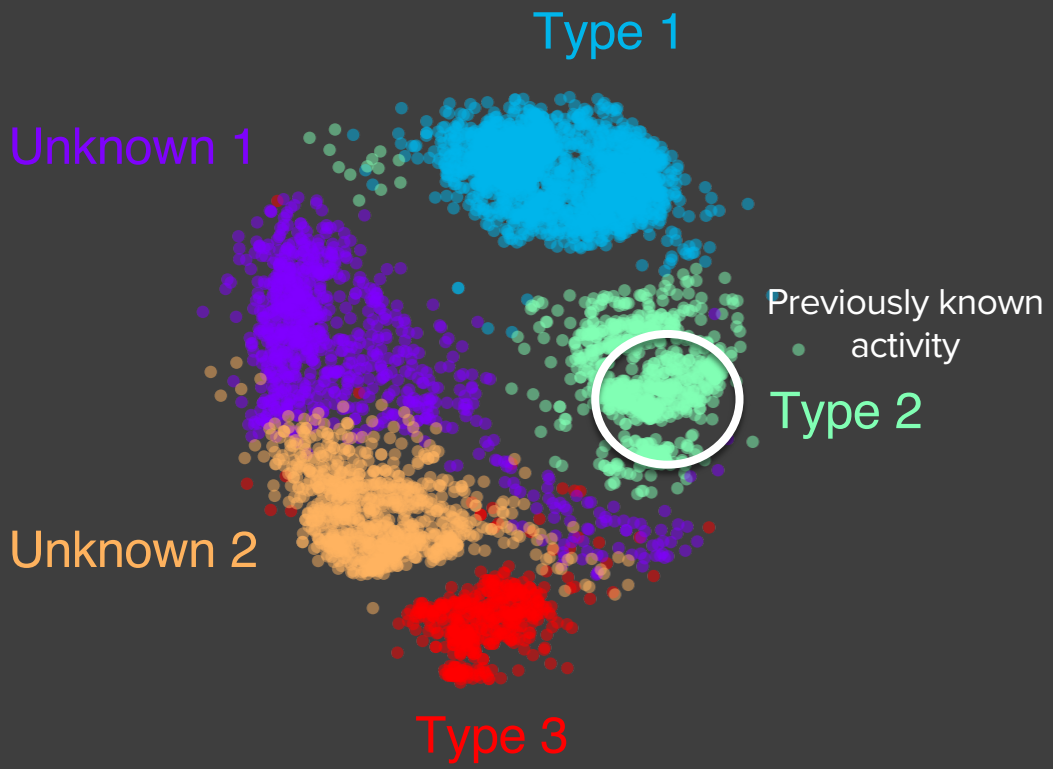

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Enzyme Discovery

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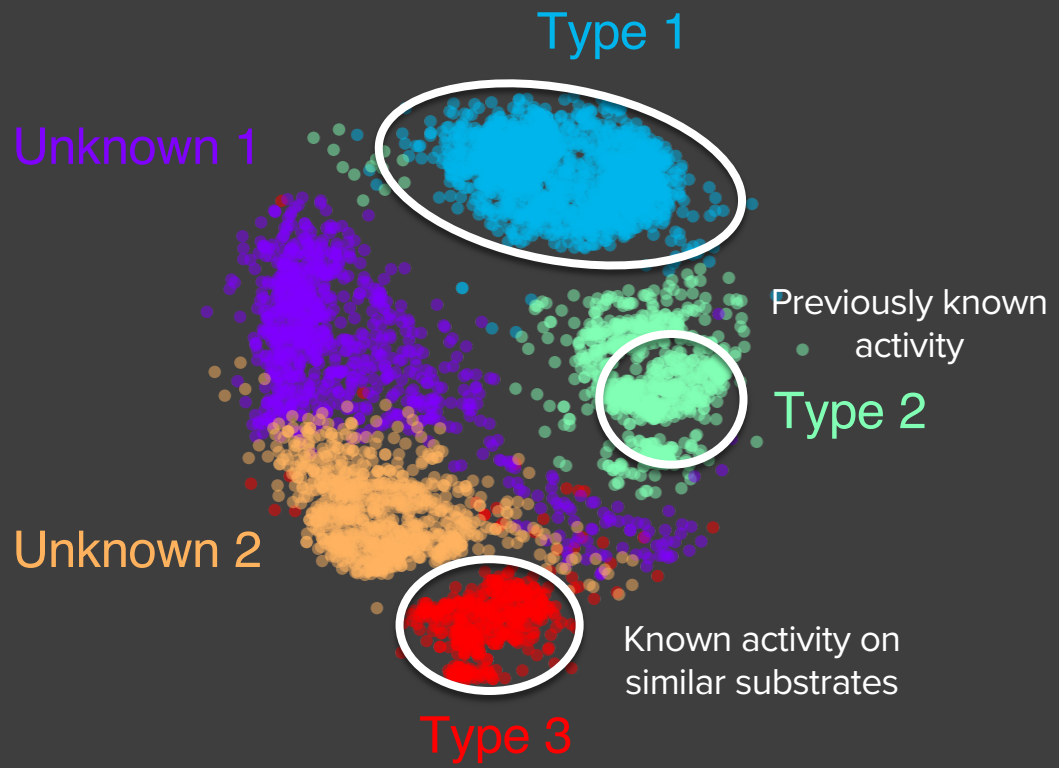
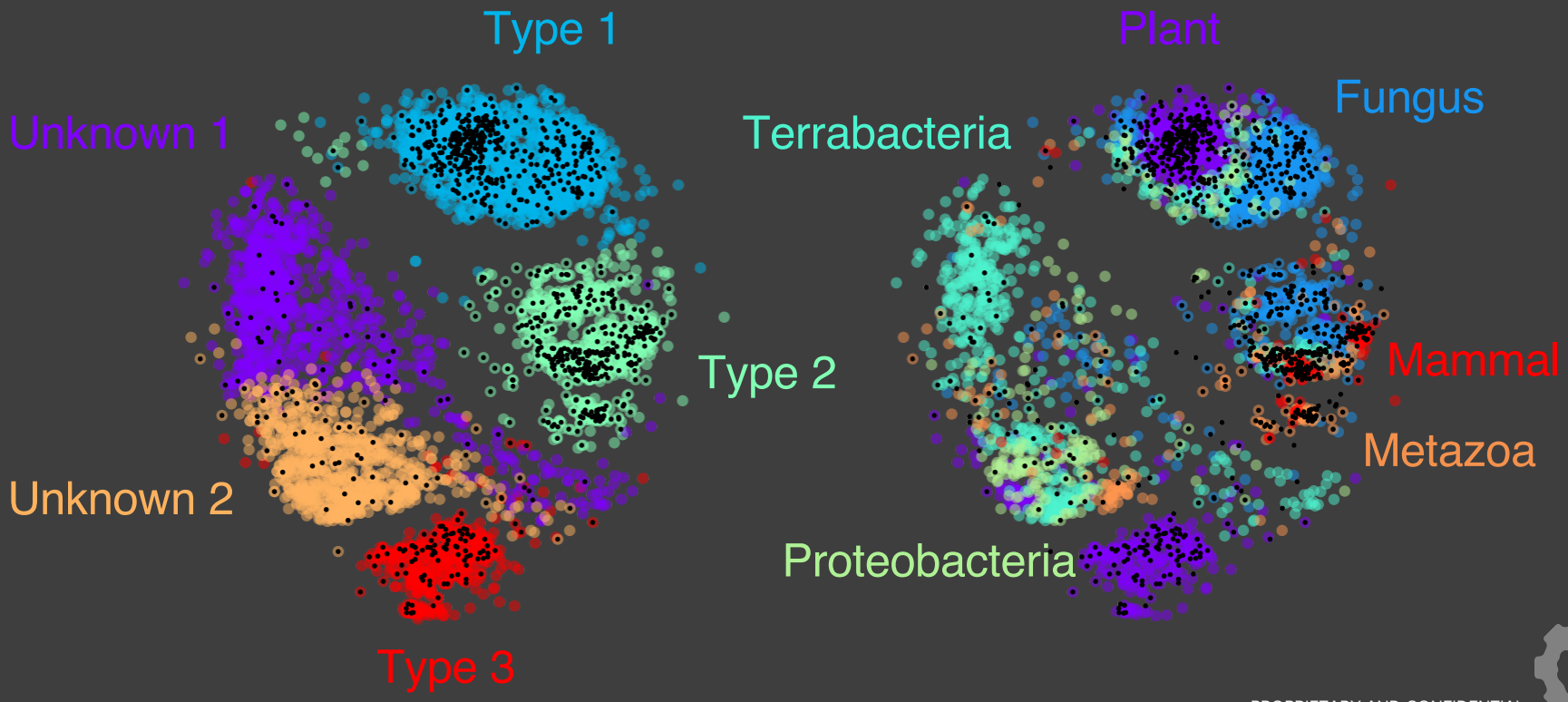


Sequence similarity space of 5449 enzyme homologs

ENZYME DISCOVERY

EXPLORING BIODIVERSITY AT FOUNDRY SCALE



Enzyme Discovery

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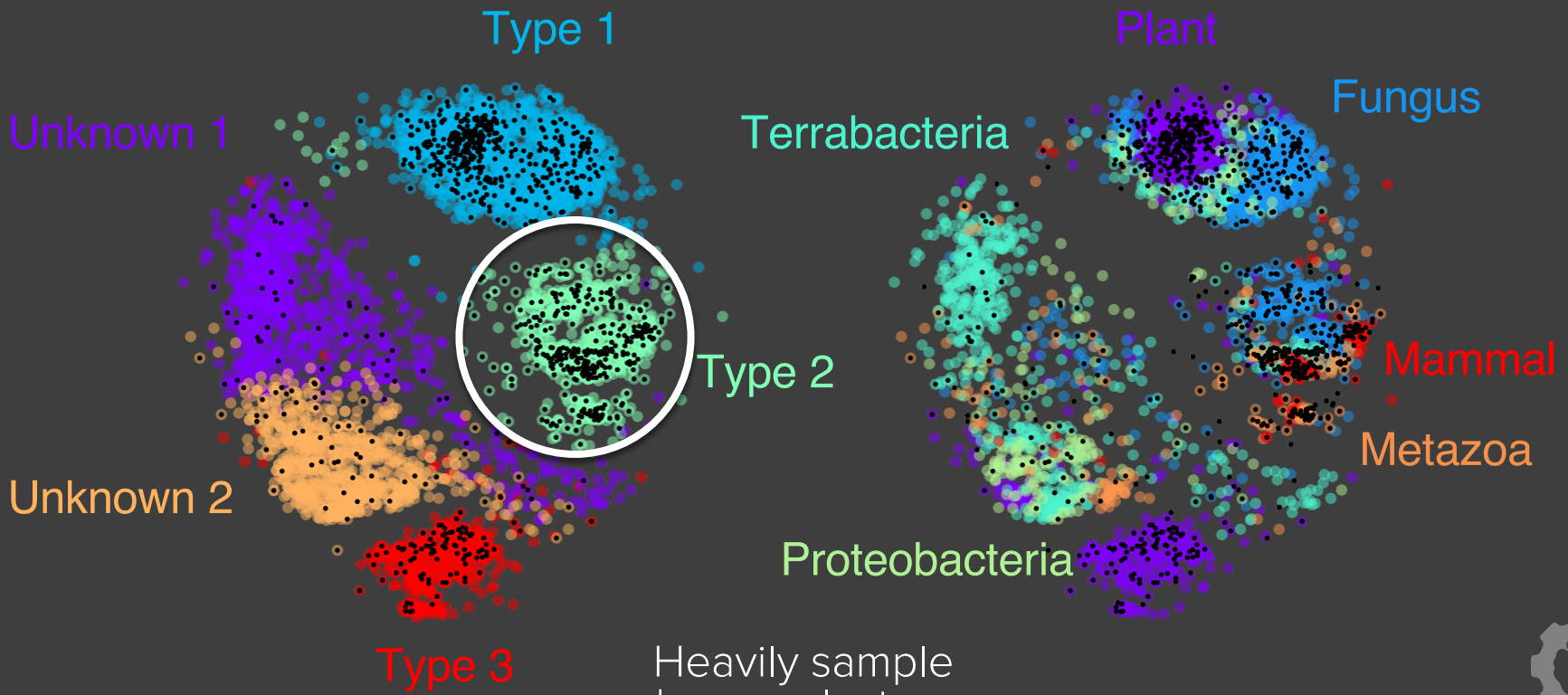
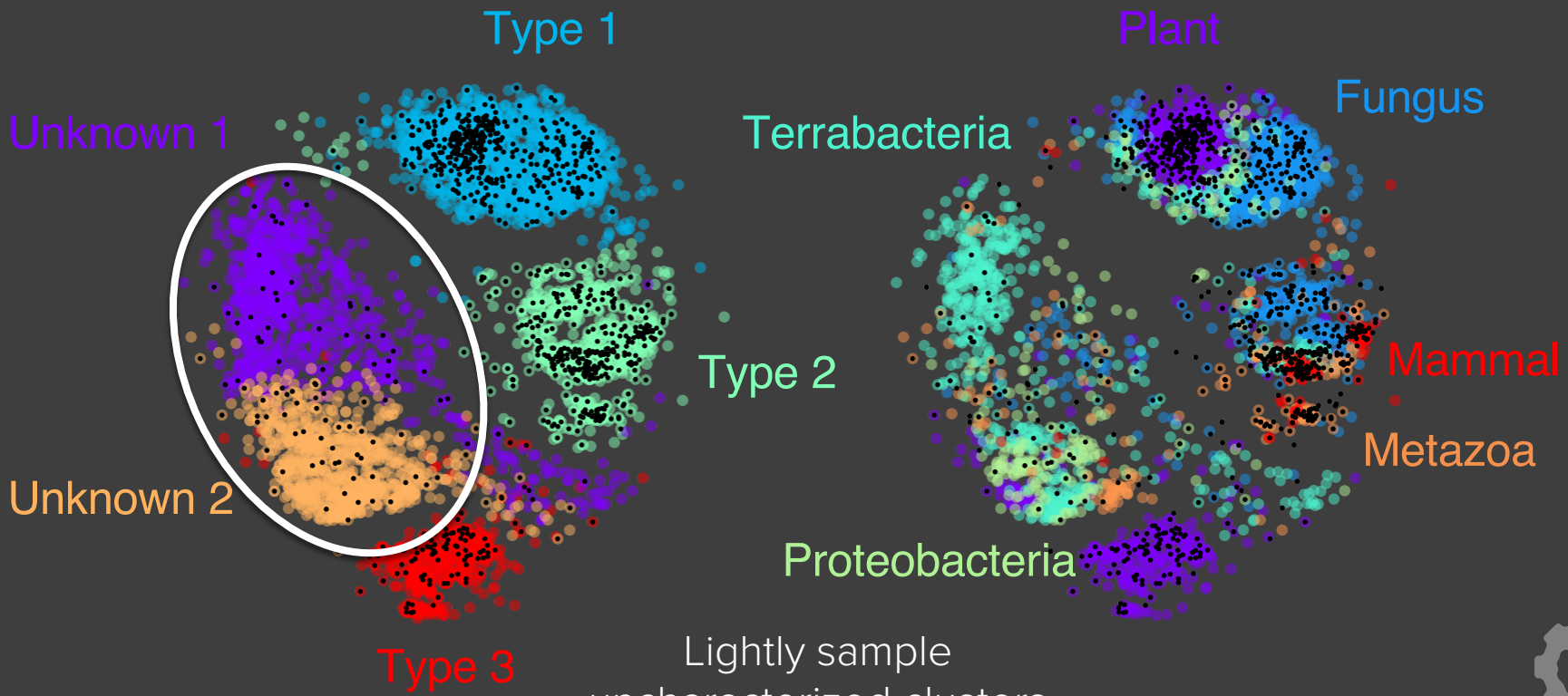


Heavily sample known clusters

Enzyme Discovery

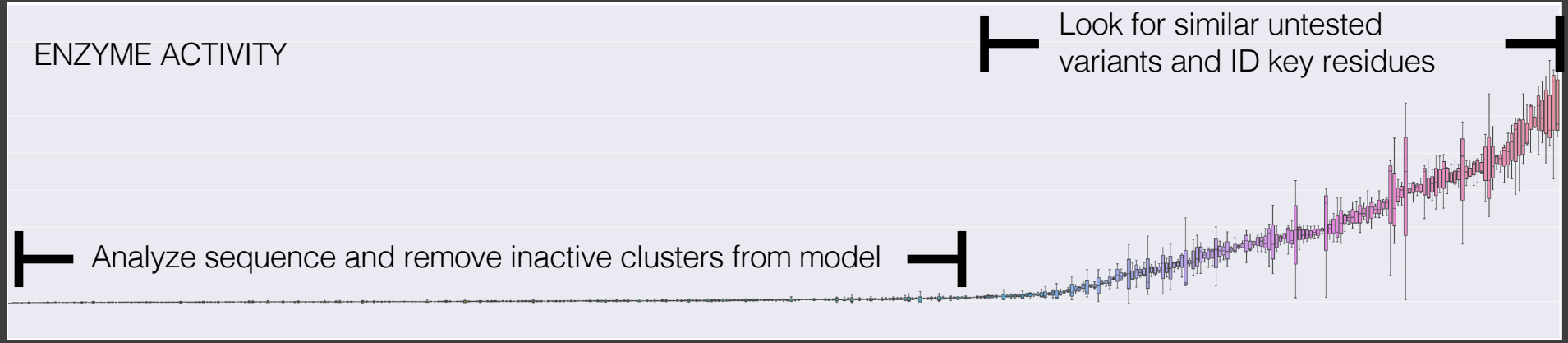
EXPLORING BIODIVERSITY AT FOUNDRY SCALE



Lightly sample
uncharacterized clusters

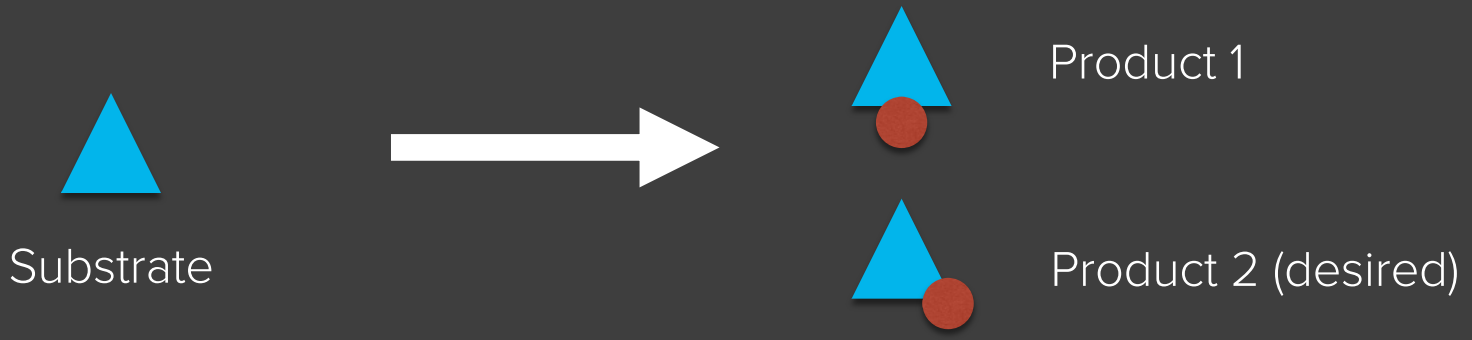
Enzyme Discovery

EXPLORING BIODIVERSITY AT FOUNDRY SCALE



Enzyme Discovery

METABOLOMICS FOR SPECIFICITY



Enzyme Discovery

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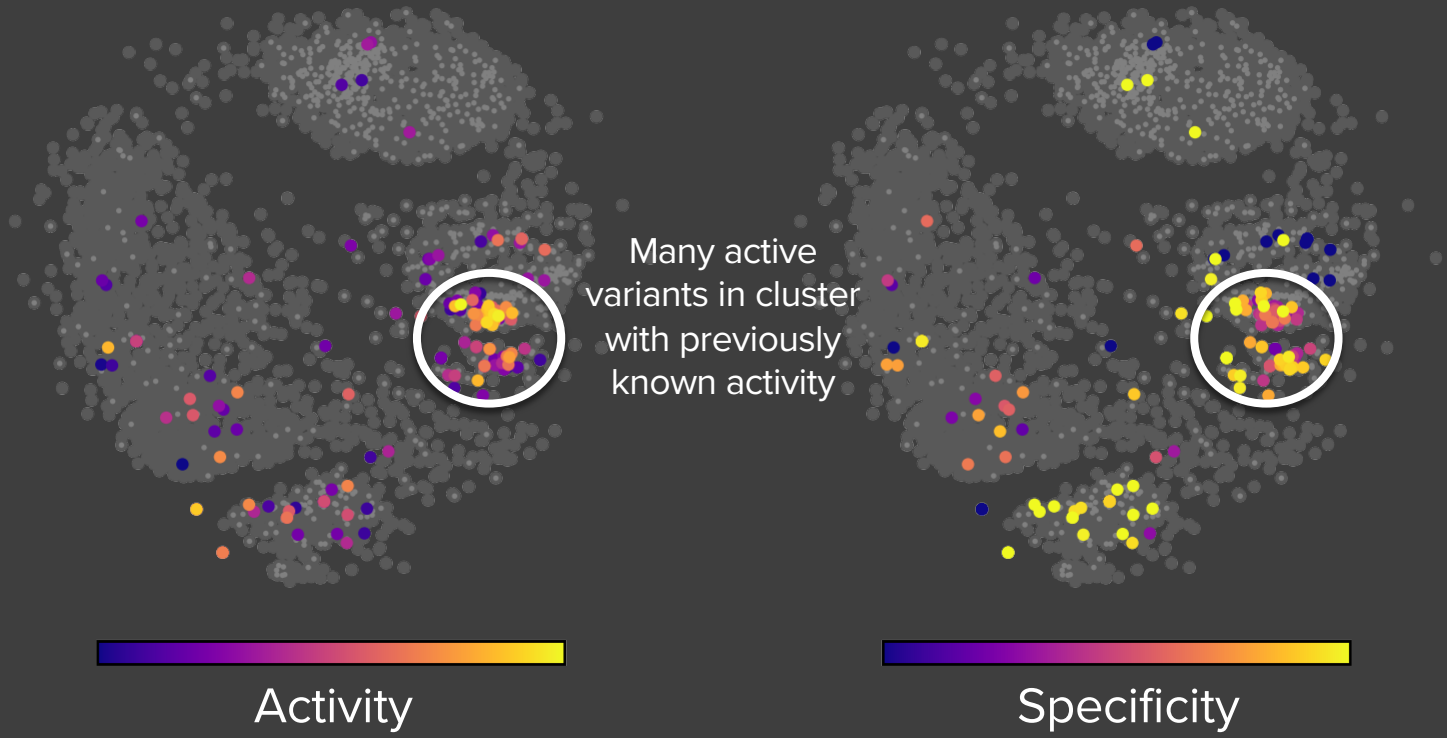
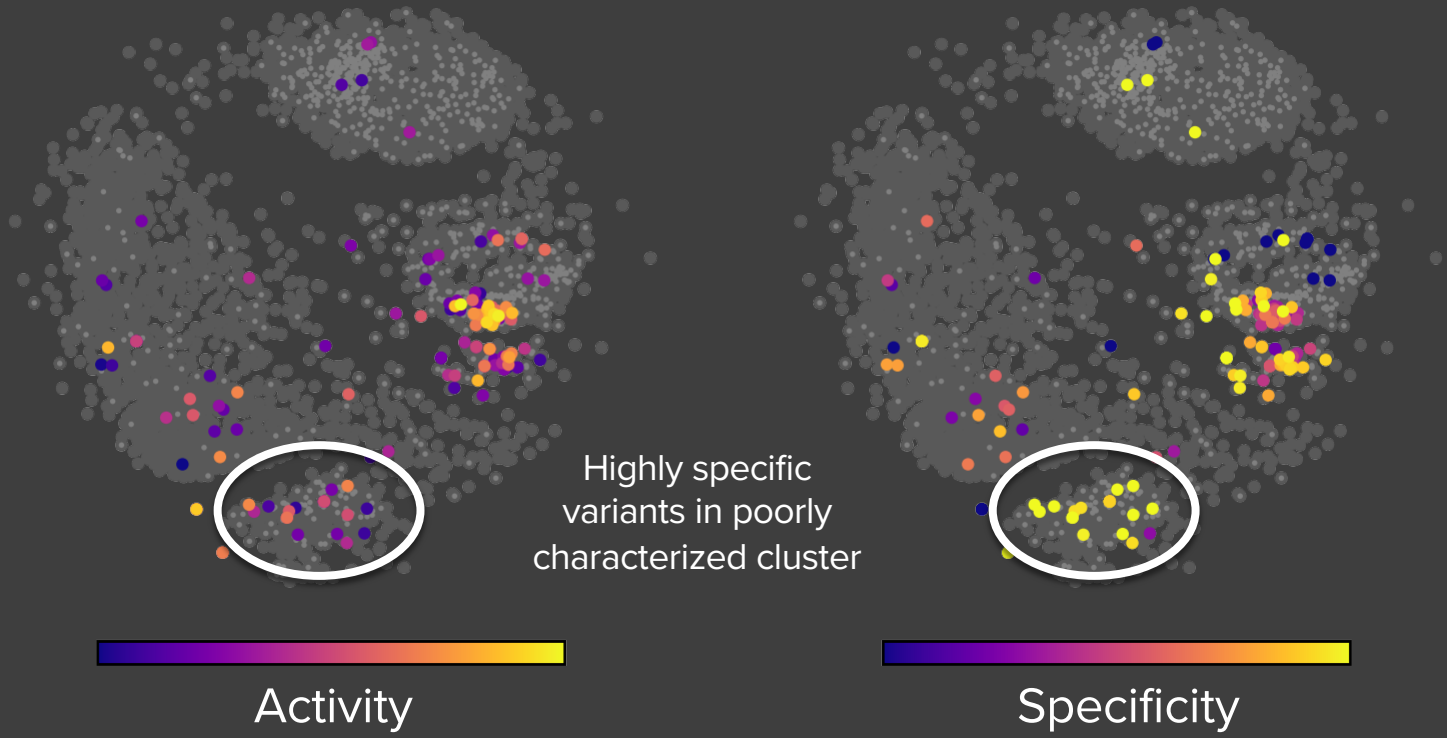


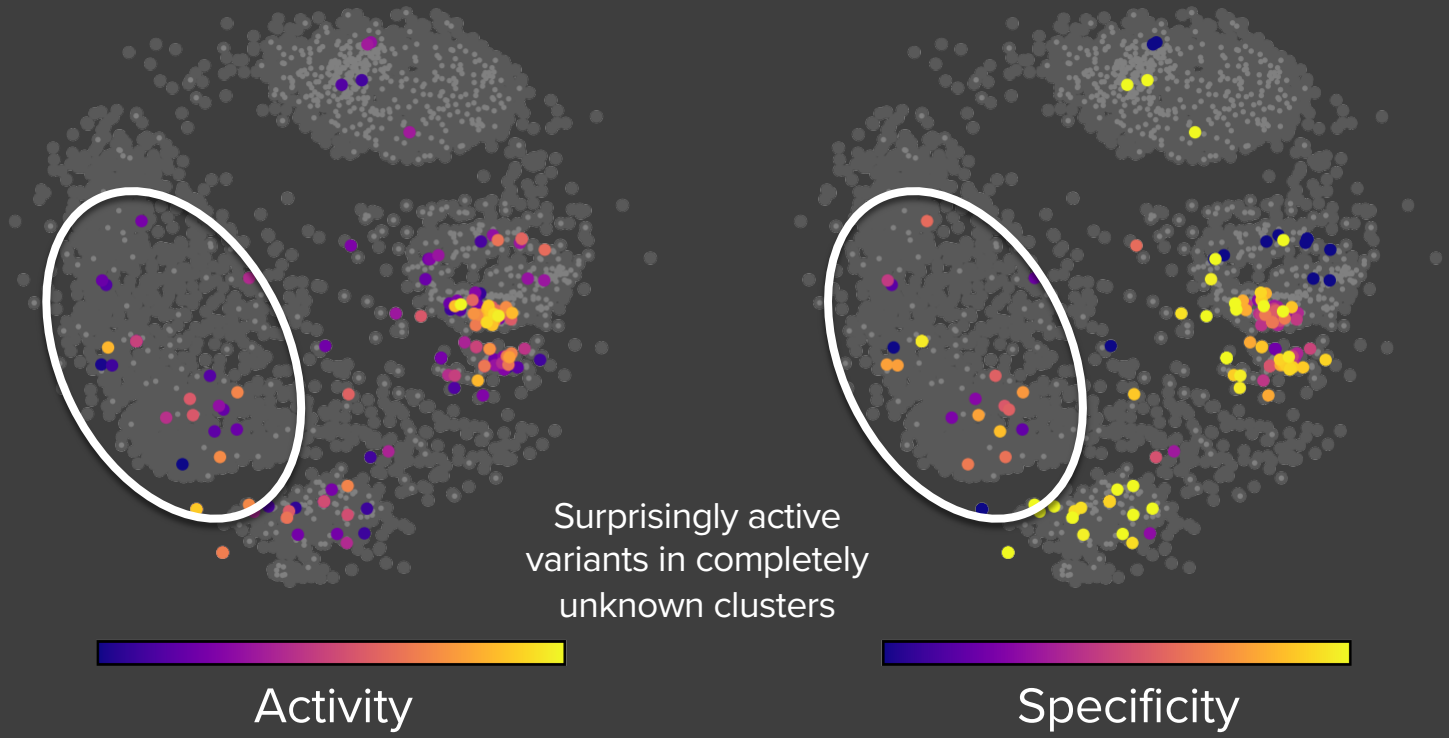
Enzyme Discovery

METABOLOMICS FOR SPECIFICITY



ENZYME DISCOVERY

METABOLOMICS FOR SPECIFICITY



Enzyme Discovery

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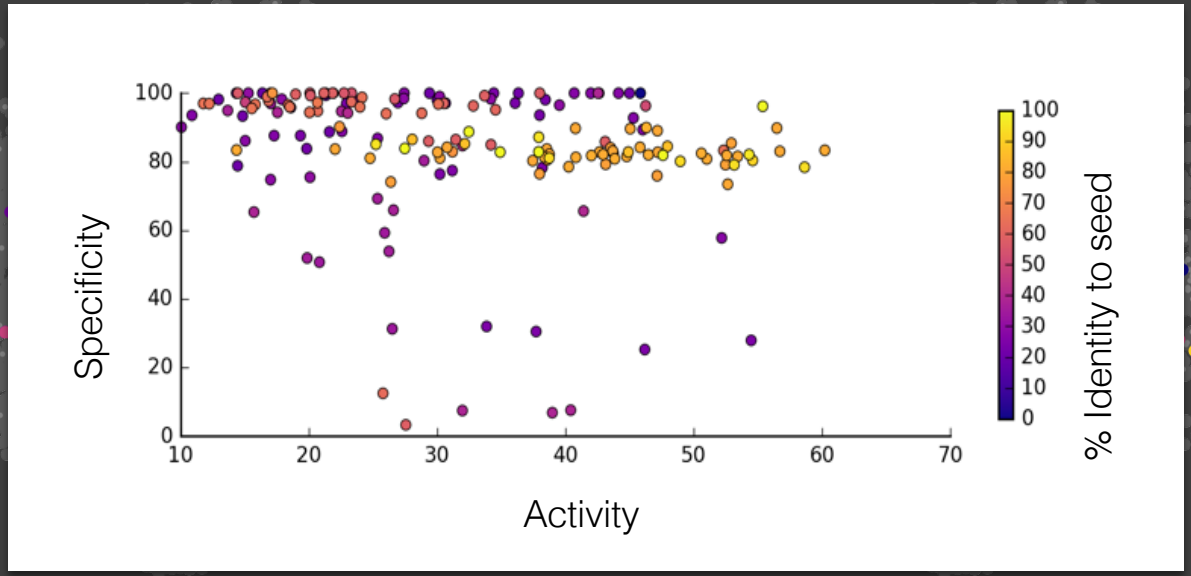
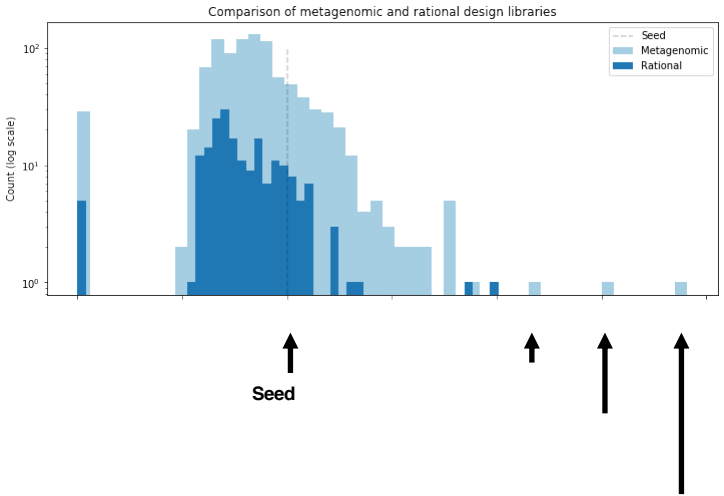


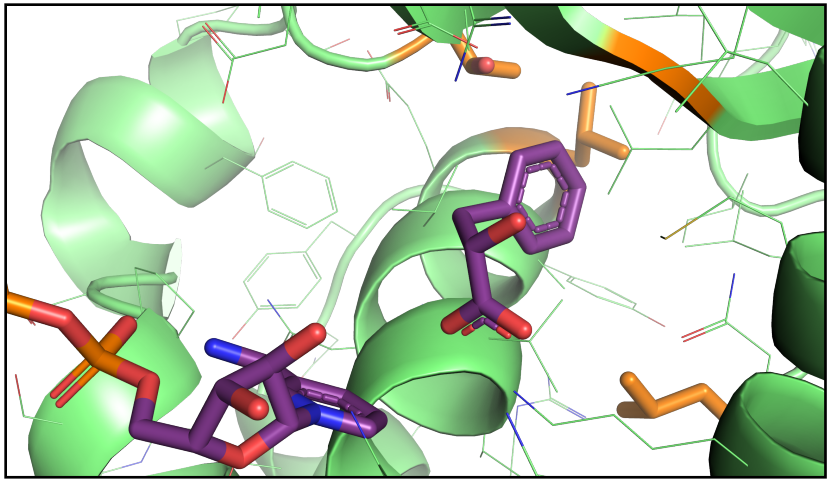
Activity

Specificity

Enzyme Discovery+ Engineering

INCORPORATING RATIONAL PROTEIN DESIGN

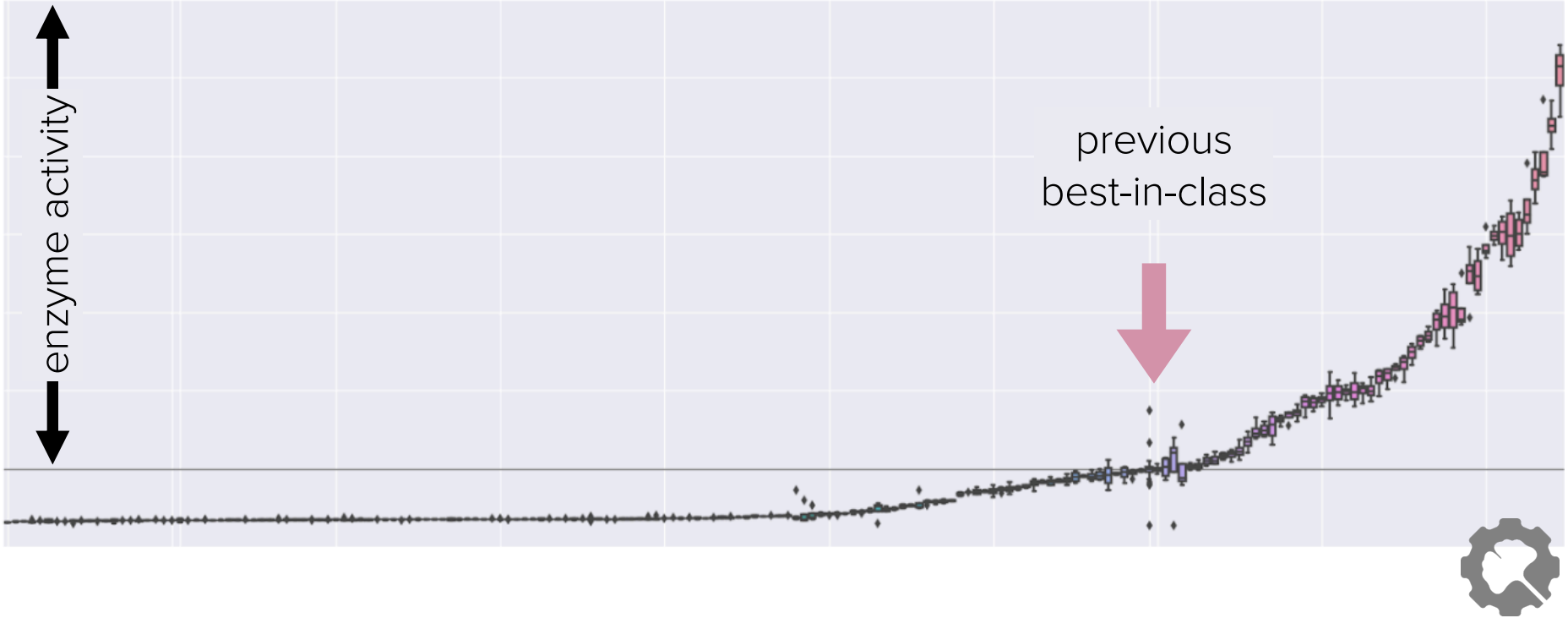




15 positions targeted for site-directed mutagenesis; 4 key positions shown

Enzyme Discovery

METAGENOMIC SCREENING



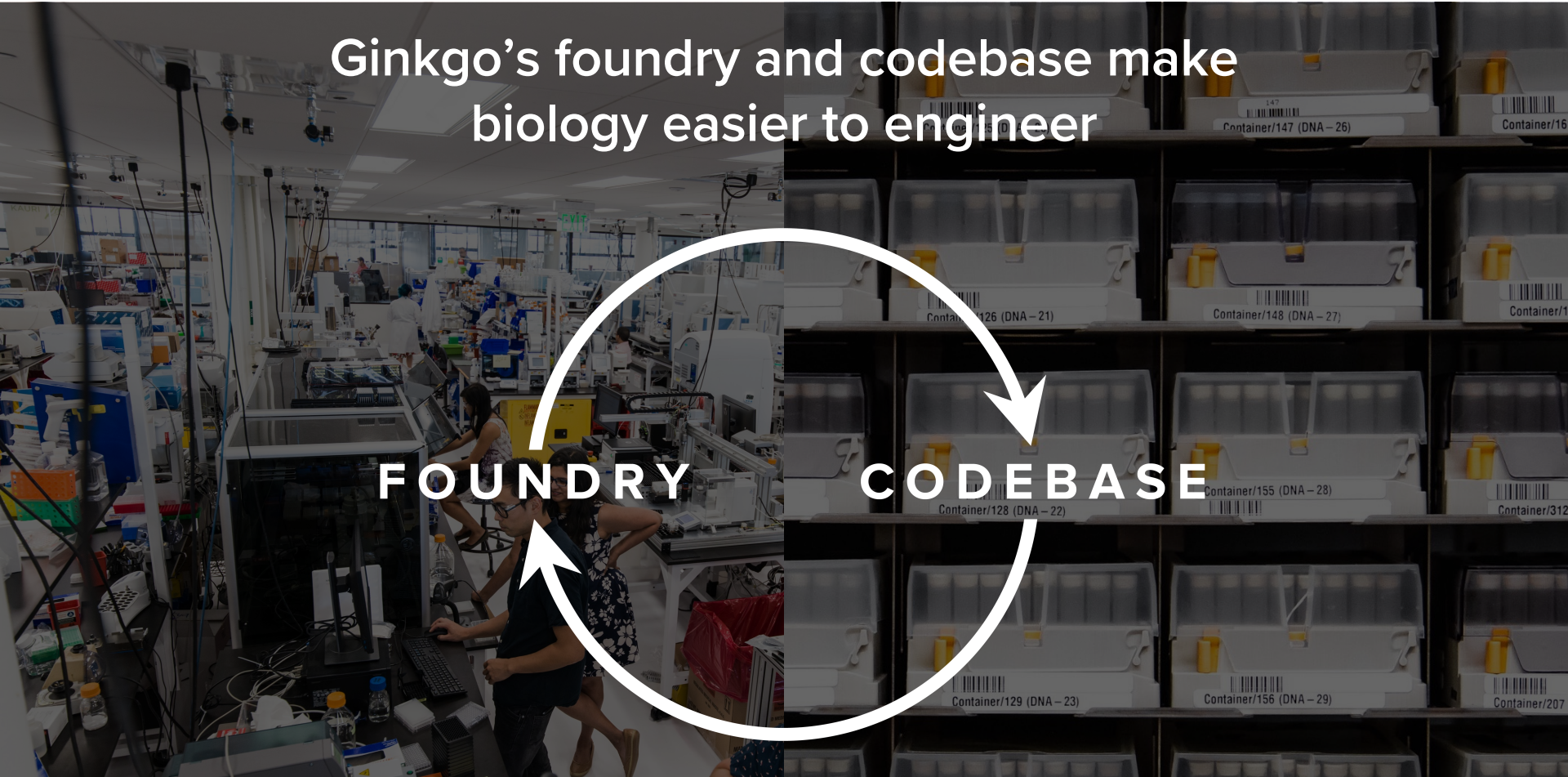
Pathway balance

SEARCHING PATHWAY SPACE

Pathway design

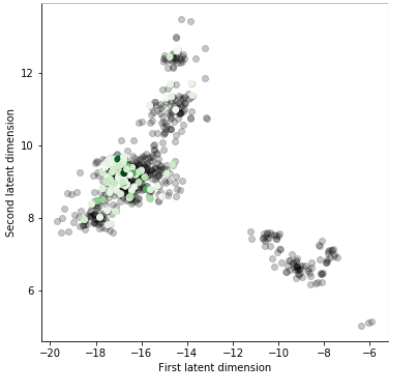
DESIGN	Programmatic design of multiple operon architectures with standard parts
BUILD + SYNTHESIS	500 kb of synthesis Assembly in low-copy vectors
TEST	LC-MS metabolomics + 13C fluxomics
FERMENT	Validation of strain performance in scale-down model

CodeBase

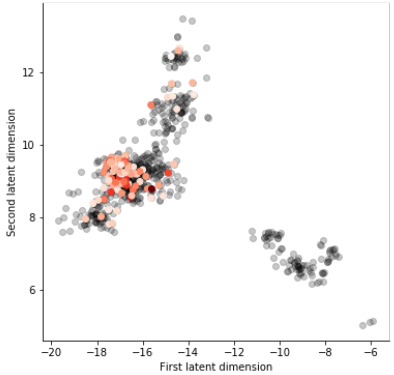

Ginkgo's foundry and codebase make biology easier to engineer
FOUNDRY
CODEBASE
Container/147 (DNA – 26)
Container/148 (DNA – 27)
Container/128 (DNA – 22)
Container/155 (DNA – 28)
Container/129 (DNA – 23)
Container/156 (DNA – 29)

Machine and Deep learning

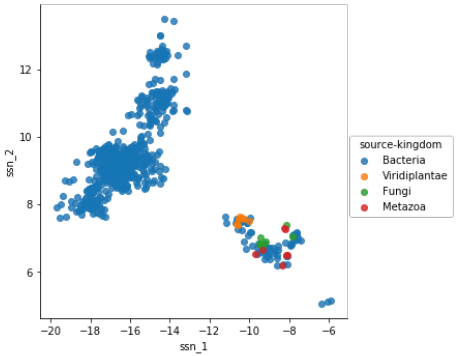
Specificity



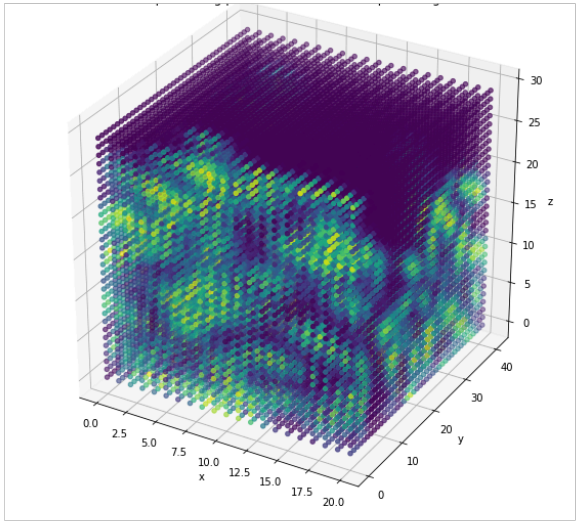
Activity



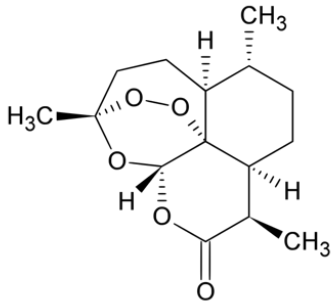
Origin



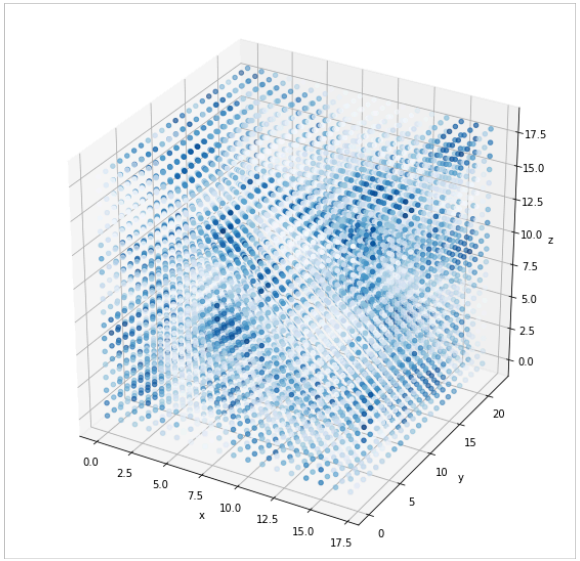
Machine and Deep learning



Active site representation of enzyme



Target molecule

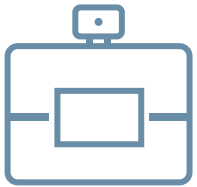


Convolutional kernel tensor

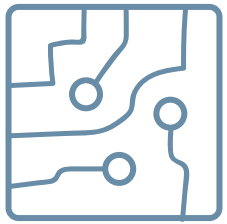
Codebase benefits

Codebase enables Ginkgo to work across industries more efficiently

FRAGRANCE - ELECTRONICS - BAKING



Enzyme library developed for a fragrance application



Data from fragrance work used to refine and expand the library for an application in electronics

Enzyme library again leveraged to find enzymes for baking applications

FOOD

THERAPEUTICS

AGRICULTURE

MATERIALS

CULTURED INGREDIENTS

CONSUMER ELECTRONICS

SWEETENERS

INDUSTRIAL BIOTECH

ENERGY & ENVIRONMENT

BIODEFENSE

CNN BUSINESS

Burger King plans to roll out Impossible Whopper across the United States

CNBC

Ginkgo Bioworks joins hunt for next Impossible Burger with billionaire investors, including Gates, Bezos and Bloomberg

FAST COMPANY

This food tech startup just raised $90 million to make it easier to invent new plant-based meats

motif

IMAGE CREDIT: KAREN INGRAM

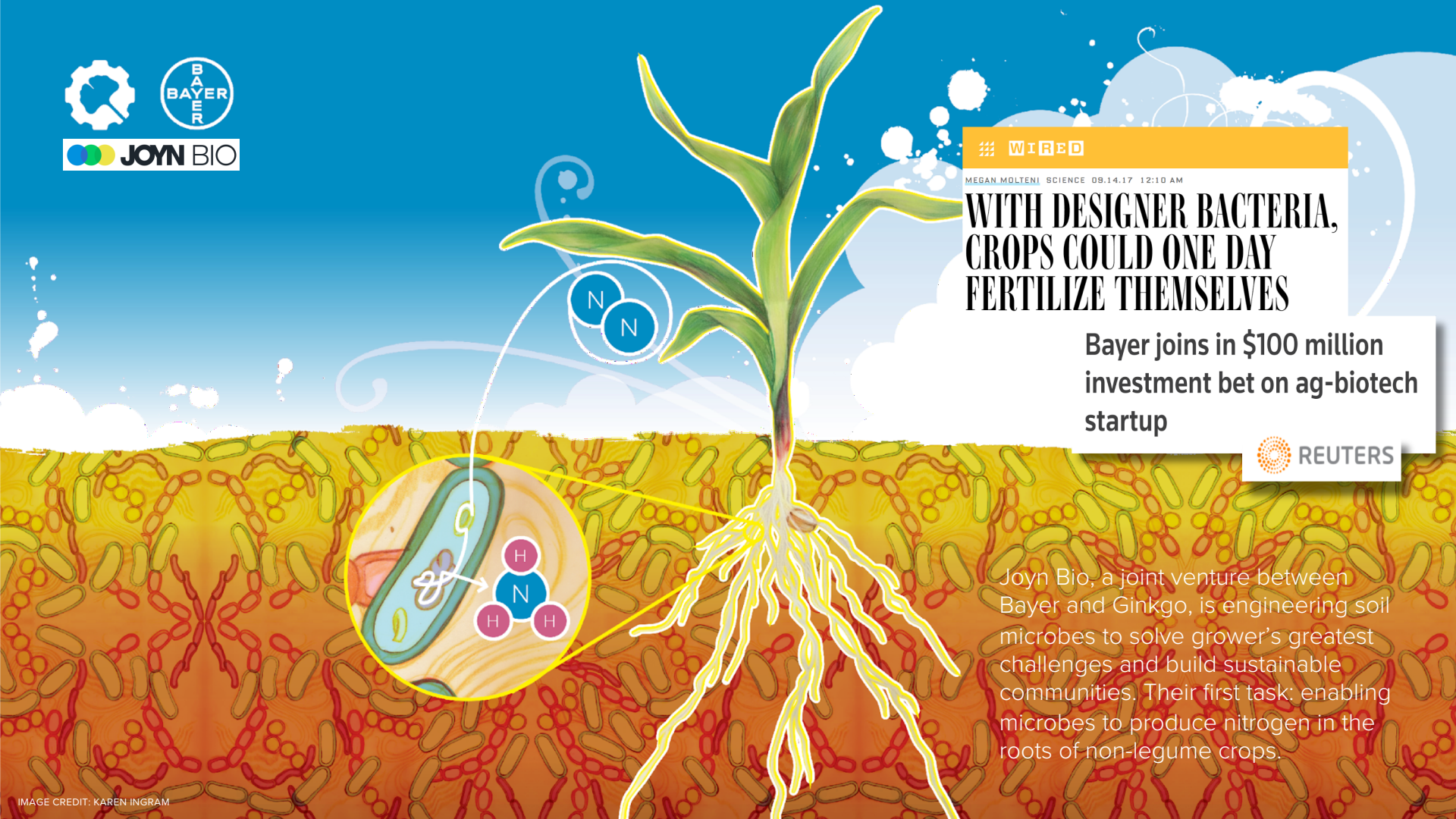


IMAGE CREDIT: KAREN INGRAM

IMAGE: JESSE COSTA/WBUR

FERMENTED CANNABINOIDS

Enable access to hard-to-source medicinal cannabinoids

Engineered production enables more cost-effective and consistent high-quality supply compared to farm-based approaches

CRONOS GROUP

+

Search

Bloomberg

Business

Cronos Partners With Ginkgo to Develop Lab-Grown Cannabis

BUSINESS INSIDER

TECH FINANCE POLITICS STRATEGY LIFE INTELLIGENCE ALL

A startup with ties to Bayer has inked a $122 million deal to make lab-grown marijuana — and it's eyeing the pharma industry

Forbes

Microbe-Hacker Ginkgo Bioworks Pushes Further Into Medicine With Acquisition Of Genome Mining Platform And Antibiotics Discovery Deal With Roche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