AI Enabled New Products from Captured Carbon

SIRIUS BIOTECHNOLOGY

Solving the most Sirius Challenges in Climate Tech with AI/ML | Seed deck

sirius.bio

OPPORTUNITY

Green Chemicals Market to Hit 274.2B$ by 2032

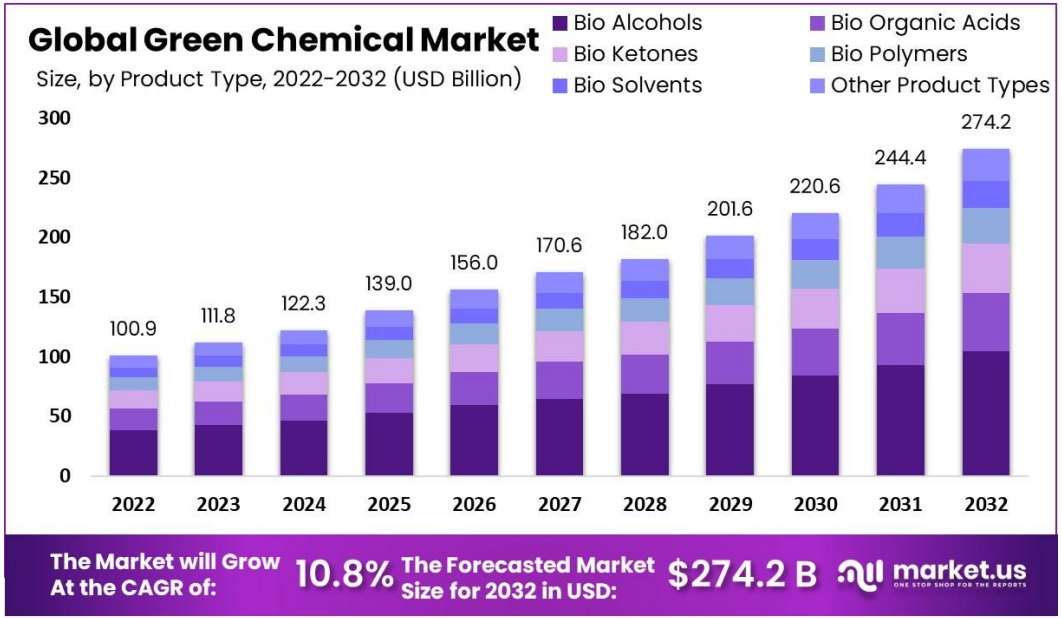
Strong market

10.8% CAGR

But….

Bioproduction companies struggle: Amyris, Solazyme, Zymergen…

Why?



PROBLEM

BIOTECHNOLOGY IS SAID TO OFFER CARBON NEUTRAL/NEGATIVE FOODS, MATERIALS, MEDICINES, & CHEMICALS, BUT:

💵 LIMITED TO MODEL MICROBES

Commonly used expression models such as ecoli, saccharomyces and other bacterial and yeast are limited to certain feedstocks .

🛠️ ADDICTED TO SUGAR

Most bioproduction utilizes sugar, corn, oil seeds or other crops as feedstocks and thus inherits their cost and carbon footprint. 10s of millions wasted trying to adapt model microbes to hydrogen, CO2 or methane.

⏳ SLOW AND ARTISANAL DEVELOPMENT

Time and cost of bioengineering is high and pressure to scale leads to unoptimized production systems

1. High Cost (OPEX)
2. High Carbon Footprint
3. Unsustainable
4. Unoptimized
5. Underperforming

PROBLEM

Waste Carbon is the cheapest and most abundant feedstock

Methane (CH4)

Over 135 MT emitted each year

Carbon Dioxide (CO2)

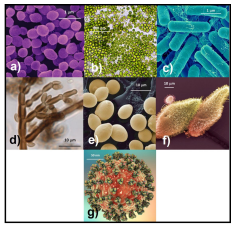
Over 36.8 BT emitted each year

Plastic Waste

Over 400 MT produced each year

MSW

Over 2 BT produced each year



Foods
Chemicals
Materials
Medicines

But to unlock its value we need new model organisms and better bioengineering

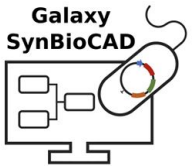
SIRIUS SOLUTION

Sirius Solution: Build on Existing AI/ML Platform

Use our proven AI/ML Bioengineering pipeline to:

1. **Create new model organisms that unlock C1 and other waste carbon feedstocks**
2. **Reduce the number of experiments required to create optimized strains by >50X**
3. **Save customers time, money, headcount while delivering optimized solutions that enable profitability at scale**

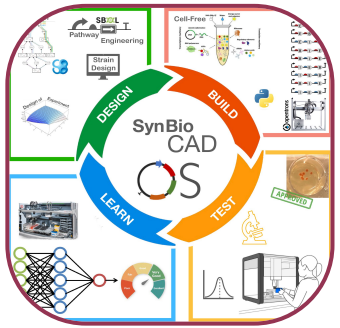
Our SynBioCAD and Hybrid AI/ML infrastructure is the product 22 FTE/yrs of work and >10M€ invested in academic science



USE CASES

Benefits of Sirius Solution and Use Cases

Create better systems via AI /ML driven DBTL cycle for bioengineering and outcome optimization.



Proven cutting edge AI/ML technology for:

- **Bioproduction: Produce Target Chemical of Choice**
- **Biodegradation: Degrade Chemicals**
- **Biotransformation: Transform ‘Bad’ Chemicals to ‘Good’ Chemicals**
- **Media Optimization: Improve Process Titer, Rate and Yield**
- **Microbial and cell-free systems**

50X
required workflows reduction

34X
target production increase

DBTL Pipeline

Improve strains with Hybrid ML/AI: Neural Mechanistic Modeling (NMM) and Active Learning

Bioinformatic/Literature

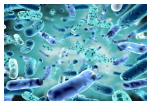
Using bioinformatic sources we have built a library of known Methanotrophs and Hydrogenotrophs SBML/computational Models

Learn and model

Sequence organisms and identify key enzymes. Make SBML/computational Models which are used to construct NMM. Each iteration builds ML training set with **active learning**

New Model Organism

Create chassis microbe ie: Optimized for CH4



Design

AI/ML Pipeline uses Using AMN in a hybrid active learning system to create Design of Experiments and procedure set

New Enzyme

For use as biocatalyst

As a target for improved function/utility

DBTL CYCLE

Bioprospect

Collect samples from best environments with gas systems from start

Screen

Test isolates for growth characteristics. Send for 16s strain identification

Test

High throughput systems to determine best conditions/performance. AI/ML to optimize media, conditions and systems, -omics to determine capabilities and GOIs

Build

High Throughput, automated system, creates variants following DOE

Optimized Process

Improved Titer, Rate, Yield

In our Neural Mechanistic Model (NMM) approach creates a neural network which contains the strain metabolic network. Peer reviewed paper on NMM by Sirius Co-Founder Jean-Loup Faulon PhD. https://doi.org/10.1038/s41467-023-40380-0

SynBioCAD AUTOMATION

SYNBIOCAD: AN AUTOMATION AI/ML SOFTWARE TO SIMPLIFY, AUTOMATE, AND ACCELERATE SYNBIO DESIGN & ENGINEERING

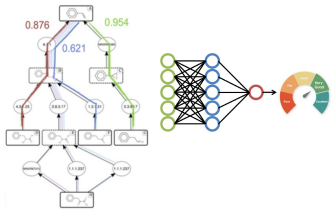
***COMMERCIAL FORK OF SYNBIOCAD OPENSOURCE, CREATED BY OUR CTO**

INPUT

Your target molecule and host organism

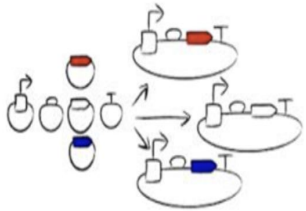
RETROSYNTHESIS

We construct & rank the metabolic pathways to produce the target



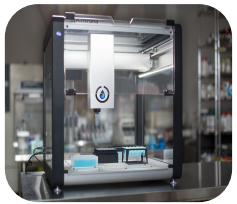
GENETIC DESIGN

We assemble the genetic parts to build the selected pathway



OUTPUT

Automatically get the scripts to automate the robotics & building part



We use active learning (ML) and AI to create superior Design of Experiments which reduces the number of required steps for creating optimized solutions. We deploy this on our existing SynBioCad framework. Peer reviewed paper on SynBioCad by CTO and co-founder Joan Hérisson PhD.
https://www.nature.com/articles/s41467-022-32661-x

SIRIUS BIOTECHNOLOGY

Business Model
Engage with Customers With CDMO Model

Develop New Models for Waste Carbon

Engineer Commercial Strains

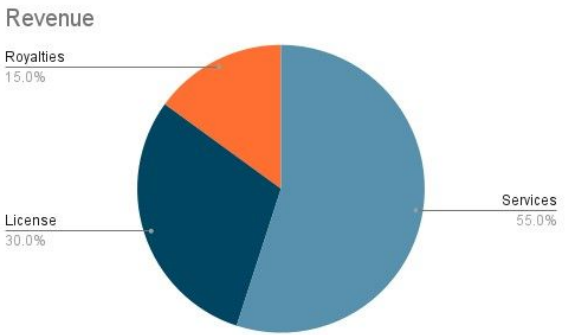
Spin Out

License

Join Venture

Improve Customer Strains and Process

CDMO



Earn Revenue From Mix of Service, License and Royalties

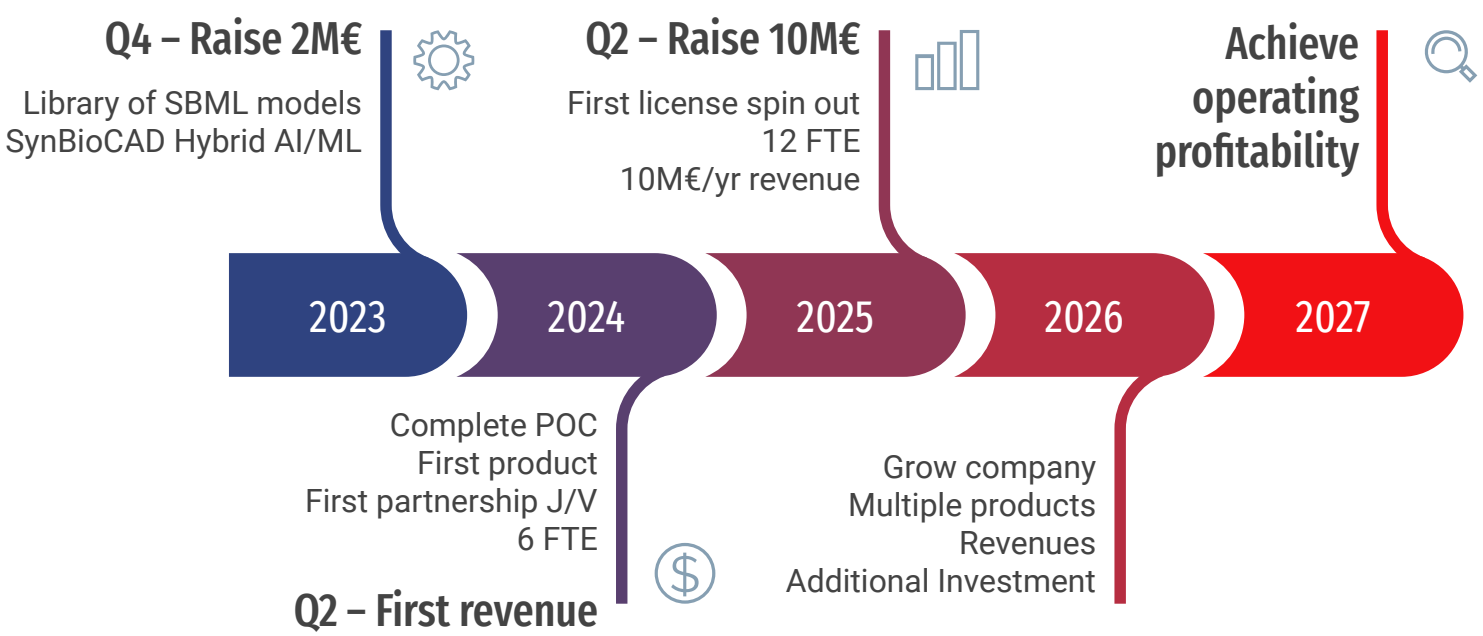
COSTS & PRICING

WE SAVE CUSTOMERS 40% AND 1 YEAR OF WORK

WE WILL COMPETE WITH GINKGO, OTHER CDMOs AND BIOFOUNDRIES

	Cost production of 1 molecule (w/o scale-up)	Cost production of 1 molecule (w/ scale-up)	Success fee	Duration
GINKGO BIOWORKS	$3.6M	$4.7M	$14M	3.5Y
SIRIUS BIOTECHNOLOGY	$2.2M	$2.8M	$8.4M	2.5Y

Timeline



COFOUNDERS

COMPLEMENTARY TEAM OF INDUSTRY EXPERTS

Brian Sefton, MBA
CEO

30 yrs in biotech, pharma, software;
20 yrs as CEO & CTO;
12 yrs experience developing gas fermentation, carbon capture, synbio and biotransformation for climate tech

Founder @ NovoNutrients (foods & fine chemicals via CO2 capture.
Author of multiple issued patents in synthetic biology, gas fermentation, carbon capture and conversion, bioengineering.

novonutrients food and feed from CO_2 | Berkeley UNIVERSITY OF CALIFORNIA

Joan Hérisson PhD.
CTO

20 yrs in computational biology, bioinformatics, and synbio;
SynBioCAD technical creator;
Previously:
Deputy Director & **Head of Synthetic Biology Labs** @ Evry University.
10 Years as development and programming lead for multiple bioinformatics, AI/ML and bioengineering tools and applications

université evry | université PARIS-SACLAY | Galaxy SynBioCAD

Jean-Loup Faulon PhD.

Pioneer with **30 yrs in synbio, AI and ML**;
Global expert with **+150 papers**;
Senior Research Director @ INRAE;
Head of SynBio Master @ University of Paris-Saclay;
French Government Advisor for **national** bio-production **strategy**.

INRAE science for people, life & earth | MANCHESTER 1824 The University of Manchester

BRIAN SEFTON
Founder & CEO
bsefton@sirius.bio

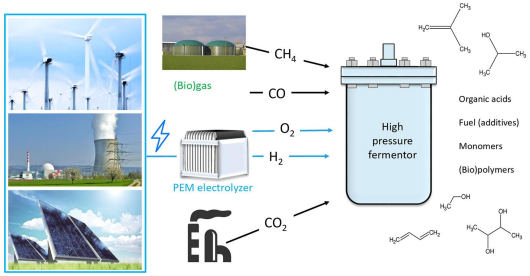
sirius.bio

Key Technologies

Sirius Founders are Domain Experts In All Key Technologies

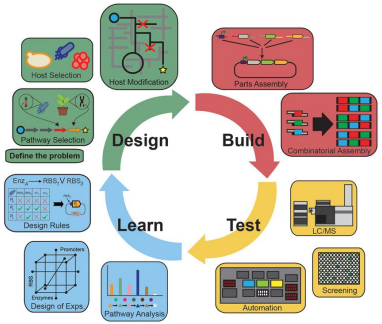
Bioprospecting

Smart sampling
C1 and other Metabolism
Selecting



Fermentation

Gas Fermentation
High Throughput
Micro scale
Reactor design
Process Scale Up



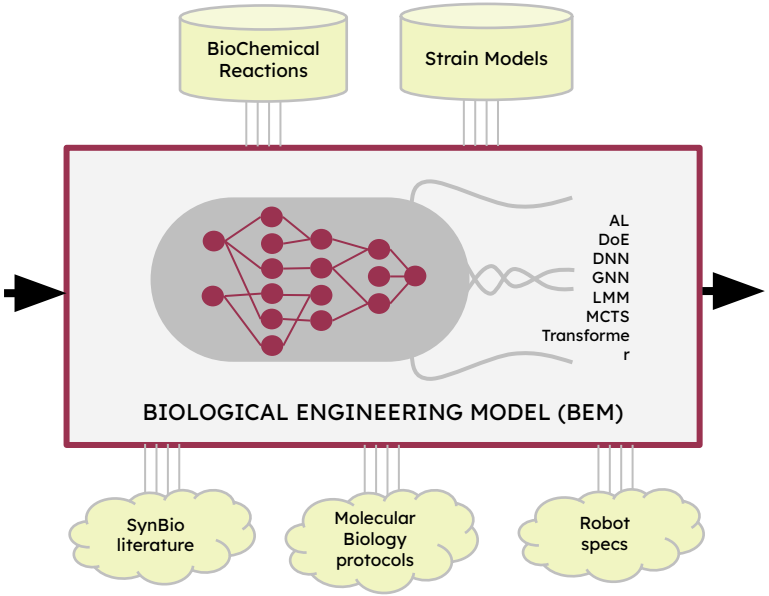
High throughput DBTL Pipeline ML/AI

Bioinformatics
Automation
Synbio
Media optimization
System optimization
SBML and Metabolic network model creation

PRODUCT: DBTL

BEM: A SIMPLIFIED LOOK

INPUT:
Strain
Target



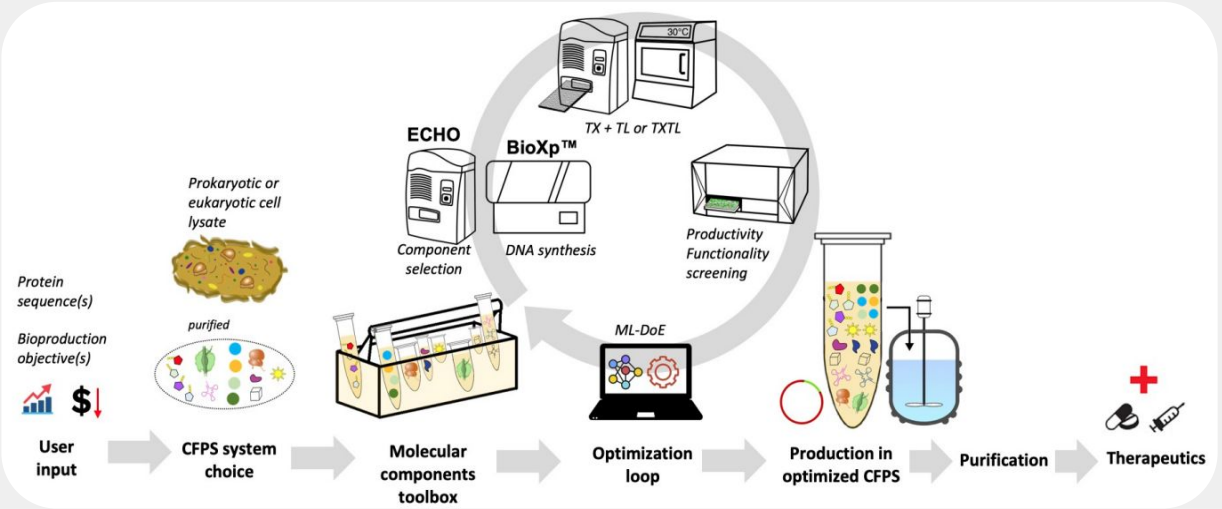
OUTPUT:
A library of engineered target-producing strains

AI

OPTIMIZED SOLUTIONS VIA ML

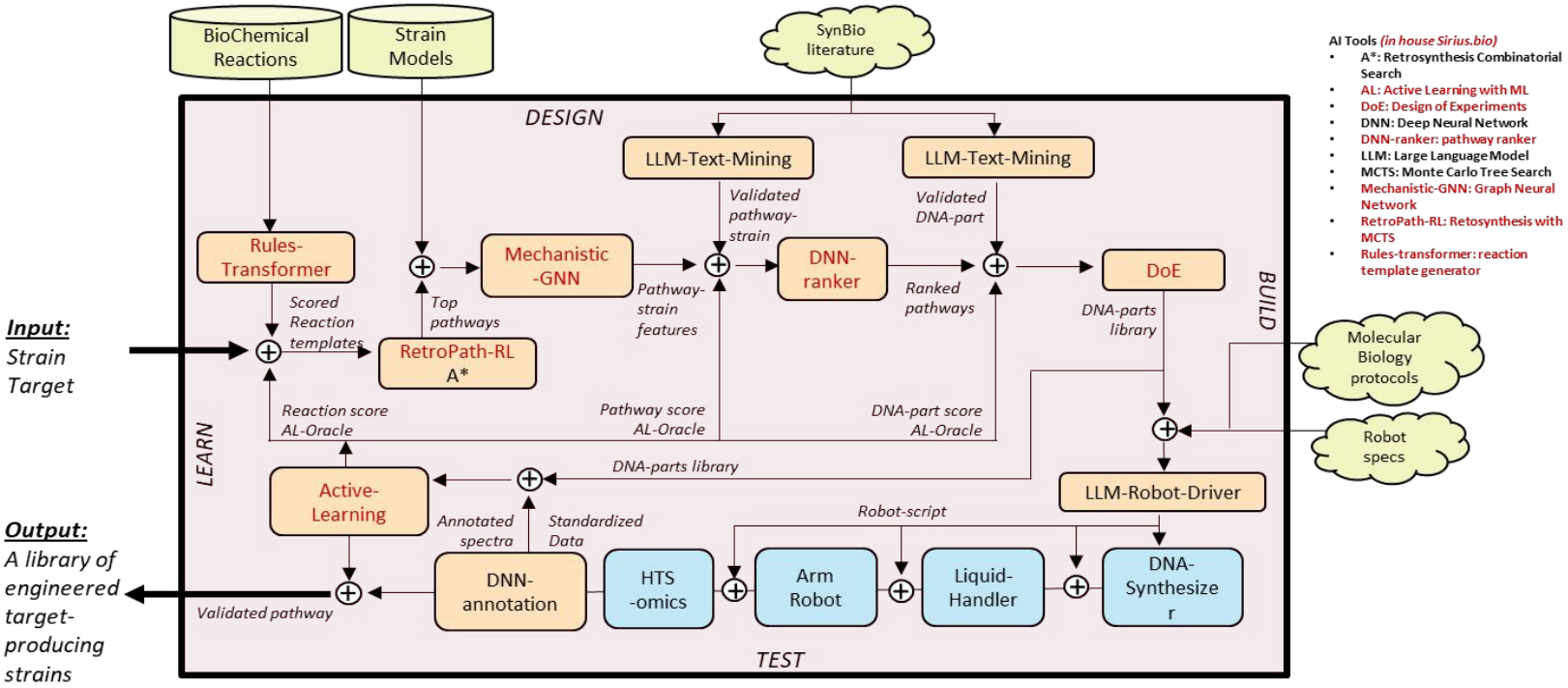
1° round:
Initial configurations generated by Latin-Hypercube Sampling, tested at bench

***i*th round:**
From round i-1 results, Active Learning gives
1. the best solution
2. the next configurations to test



PRODUCT: DBTL

BIOLOGICAL ENGINEERING AI MODEL ARCHITECTURE



AI Tools *(in house Sirius.bio)*

- A*: Retrosynthesis Combinatorial Search
- AL: Active Learning with ML
- DoE: Design of Experiments
- DNN: Deep Neural Network
- DNN-ranker: pathway ranker
- LLM: Large Language Model
- MCTS: Monte Carlo Tree Search
- Mechanistic-GNN: Graph Neural Network
- RetroPath-RL: Retosynthesis with MCTS
- Rules-transformer: reaction template generator

SYNBIOCAD

QUICKER, CHEAPER, BETTER

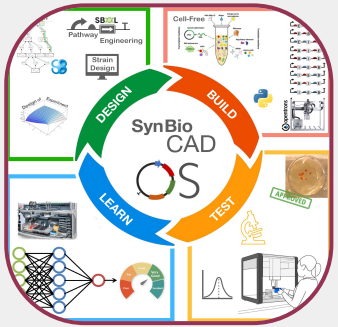
Our SynBioCAD infrastructure is already delivering optimized bioproduction, biodegradation, biosensors, and cell-free systems in biofoundries

AUTOMATED DBTL = LOWER OPEX, CAPEX, TIME

for all biotechs: therapeutics, materials, chemicals, and foods.

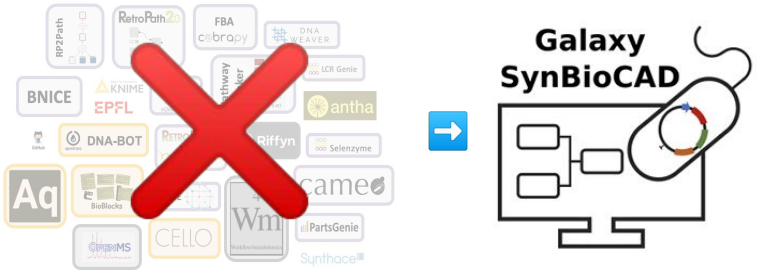
50X
required workflows reduction

34X
target production increase



ALL-IN-ONE = COMPLEXITY REMOVED

Tools consolidation & new features APIs for accelerated development, service expansion, and better customisation.



Our SynBioCAD and AI/ML infrastructure represent decades of work and >10M€ investment

Non-model Strains: The Enzymes Enable the Feedstocks and Products

*Renewable hydrogen use creates a route from renewable electrical energy to food and chemical energy.

Methane (CH4)

Methanotrophic Bacteria
Grow with methane as sole carbon and energy source

Methane Monooxygenase
$CH_4 + O_2 \Rightarrow CH_3OH$

Carbon Dioxide (CO2) + H2

Hydrogen Bacteria
Grow off Hydrogen and CO2. *

Hydrogenase
NiFe to capture CO2 and H2
$CO_2 + H_2 \Rightarrow CH_2O$

Carbon Dioxide (CO2) + H2 or Light

Photosynthetic Hydrogen Bacteria
Grow off Hydrogen and CO2. *
Grow off sunlight and CO2
Can make Hydrogen from organics and sunlight

Hydrogenase
NiFe to capture CO2 and H2
$CO_2 + H_2 \Rightarrow CH_2O$
FeFe to make H2
$CH_2O \Rightarrow H_2 + CO_2$