EBIC Environmental Biotechnology Innovation Centre

How Synthetic Biology solves the biggest environmental challenges?

Scaling engineering biology for environmental solutions - insights from EBIC



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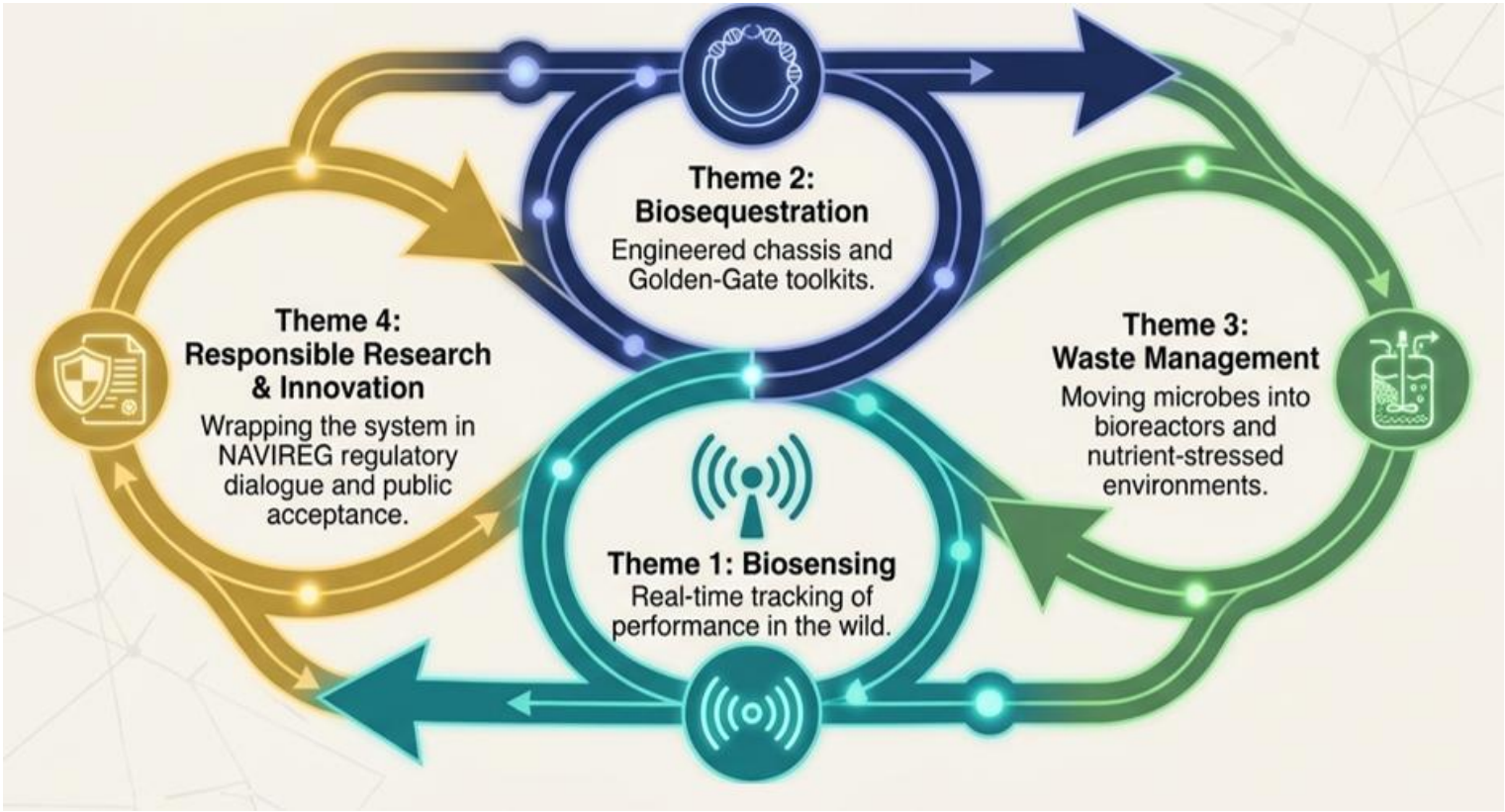
UKRI Natural Environment Research Council
UKRI Biotechnology and Biological Sciences Research Council
UKRI Engineering and Physical Sciences Research Council

What is EBIC about?

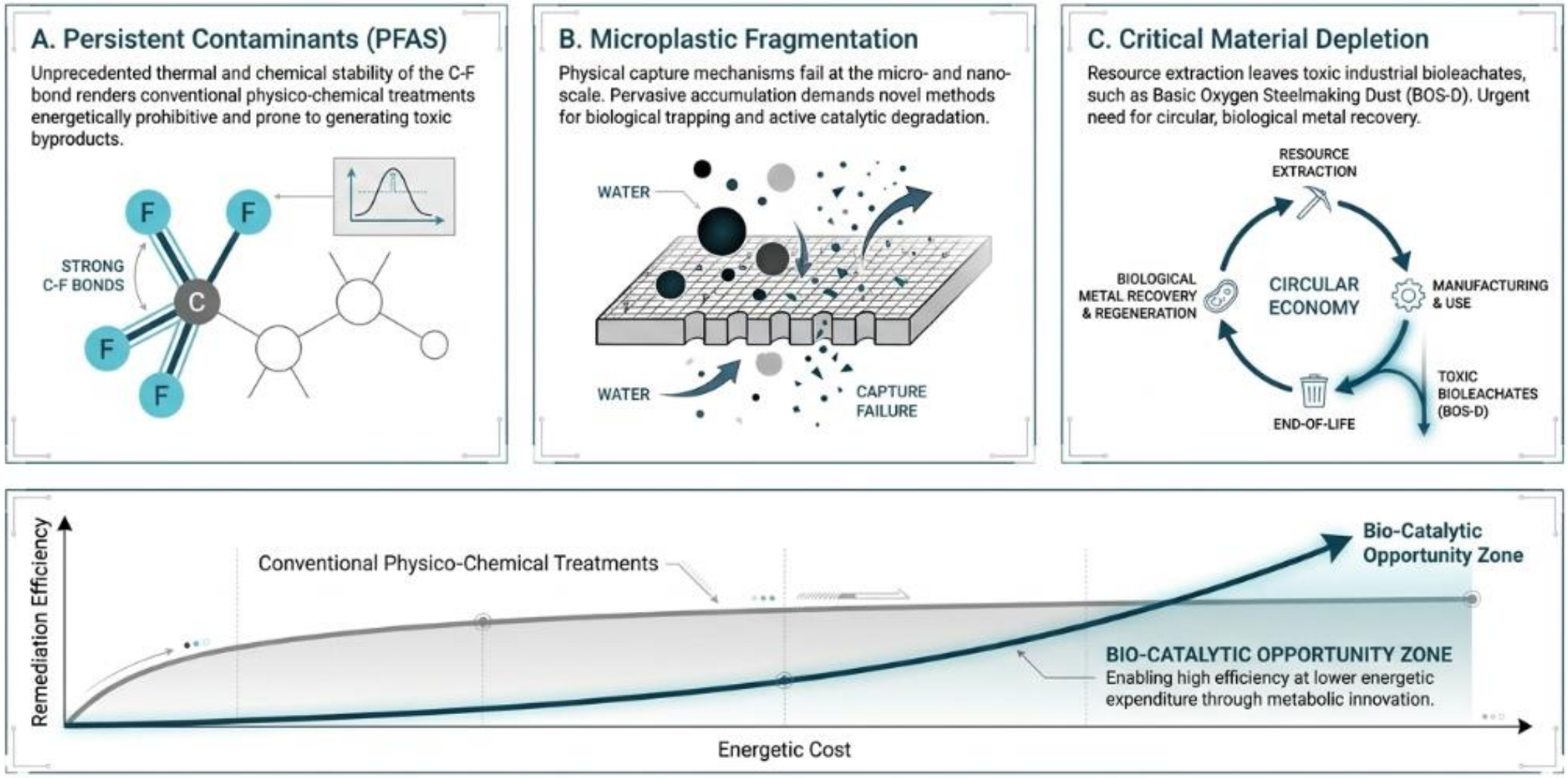
- **The Environmental Biotechnology Innovation Centre** is a UK-wide research and innovation hub led by Cranfield University that was established in 2024 with funding from UKRI's Technology Missions Fund and support from BBSRC.

- **Mission**: Accelerate the translation of engineering biology and environmental biotechnology into solutions for environmental monitoring, remediation, and resource recovery.



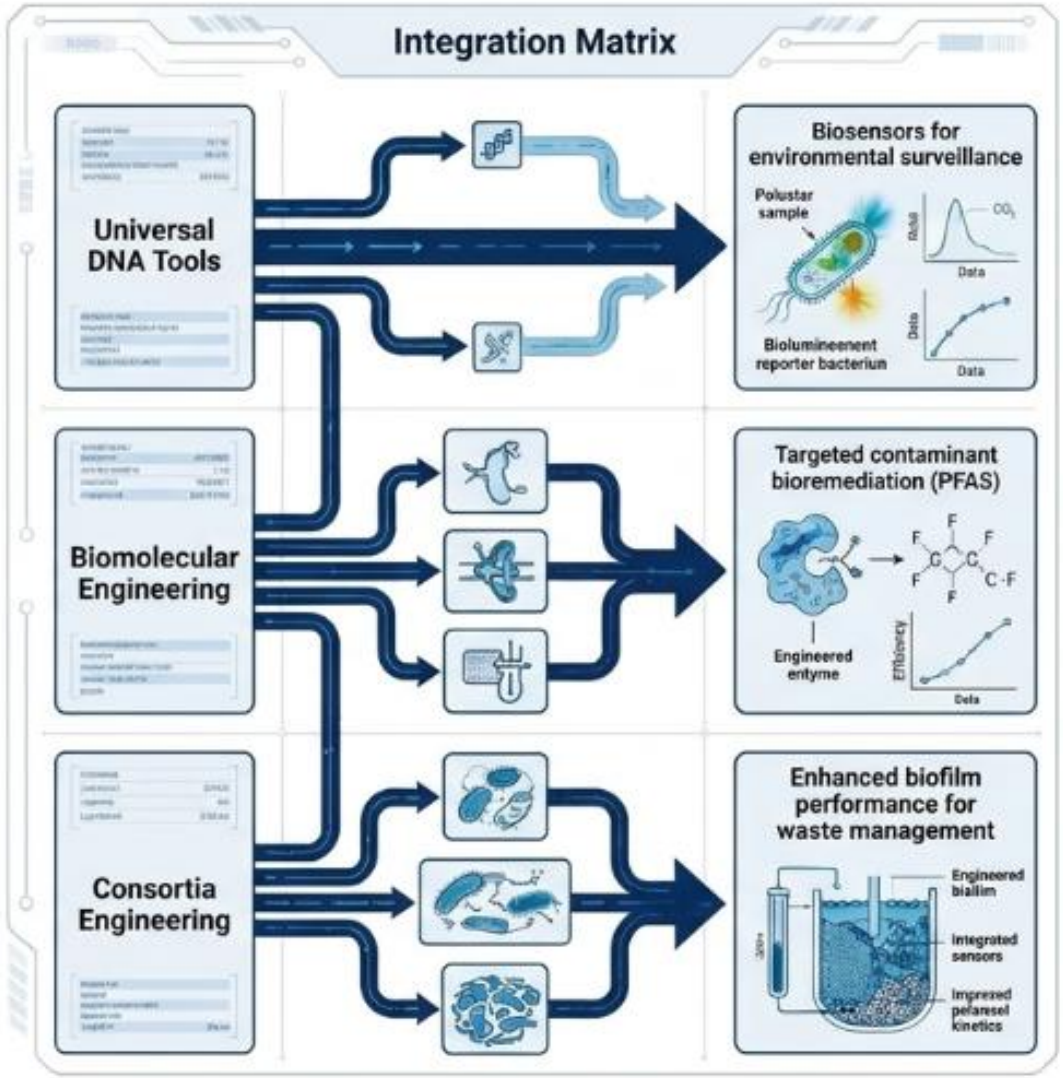


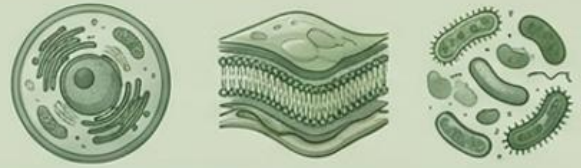
The biological intervention imperative



Physical and chemical treatments have reached their scalable limits for anthropogenic pollutants like PFAS, plastics and heavy metals. Achieving sustainability requires transitioning to bio-based, self propagating interventions

Engineering toolkit and chassis for environmental applications



Enzyme Engineering	Whole-Cell Engineering (GMMs)
	
Mechanism: Rational design & directed evolution.	**Mechanism:** Pathway optimization & synthetic consortia.
Key Trait: High specificity, no living organism release.	**Key Trait:** Self-replicating, adaptive to toxic gradients.
Ideal Application: Ex-situ plastic depolymerization, controlled bioreactors.	**Ideal Application:** In-situ soil/water remediation, continuous biosensing.
Regulatory Friction: Lower (evaluated primarily as chemical products/additives).	**Regulatory Friction:** High (TSCA intergeneric oversight, ecological biocontainment required).

EBIC non-model bacteria & contaminant matrix: cross-evaluating applied pathways

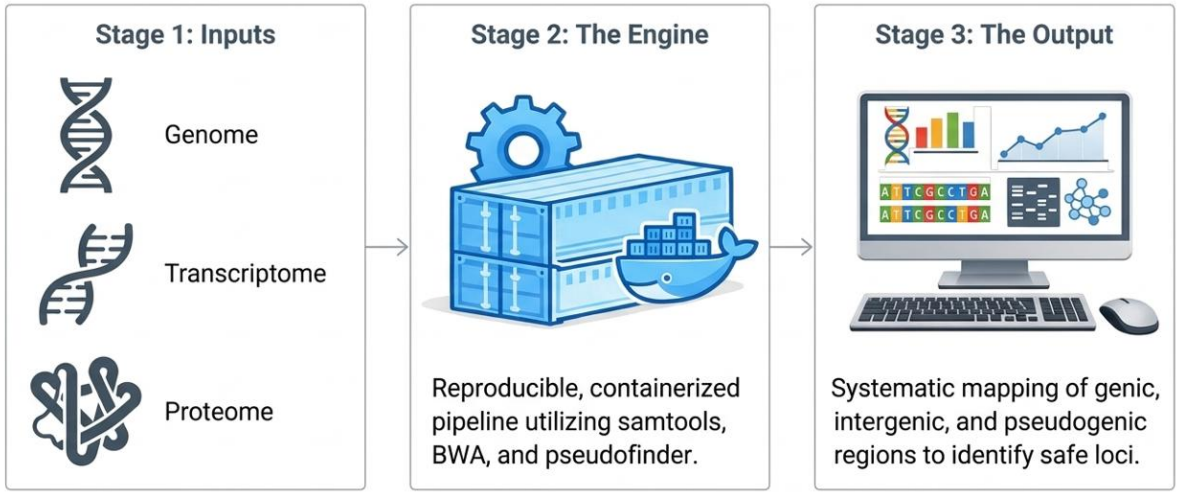
	PFAS	Microplastics	Critical Metals
Target Contaminant Profile	Persistent C-F bonds	Polycaprolactone (PCL)	BOS-D Bioleachates
Biological Chassis & Target Enzyme	*A. borkumensis* AbAlk1	*A. baumannii* AB5075	*M. psychrotolerans*
Core Engineering Strategy	Active site expansion (L311A)	Temp-sensitive biofilm logic gates	Selective iron depletion
Current Bench-Scale Progress	3,000+ mutants screened	Specific degradation enzymes isolated	Biogenic ZnO nanoparticles generated
Primary Deployment Constraint	Biocatalyst stability in mixed waste	Unwanted biofouling control	Scaling continuous flow recovery

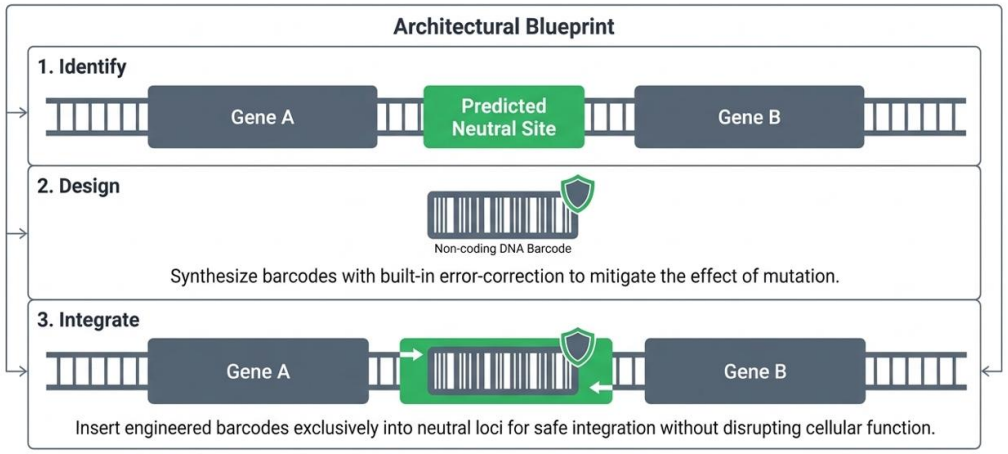
EBIC systematic strain engineering in non-model bacteria

Context
Engineering non-model bacteria for synbio applications (like biosequestration and biodegradation) requires the insertion of DNA barcodes for tracking.



Non-neutral barcode insertion disrupts existing genes.
Result: High instability, compromised strain fitness, and rapid mutation (observed in **A. borkumensis**).





Institute	Research Group	Organism	Predicted Sites
Newcastle	Yuzenkova	PCC11901	92
Newcastle	Krasnogor	PCC11901	18
UEA	Lea-Smith	C. glutamicum	200
Newcastle	Krasnogor	S. albidoflavus	84
Cranfield	Coulon	A. calcoaceticus E1	12
Newcastle	Krasnogor	P. putida	36
Southampton	Ronan	A. baylyi / A. baumannii	28

Future focus: Expanding the federated testing model across specialised non-model bacteria

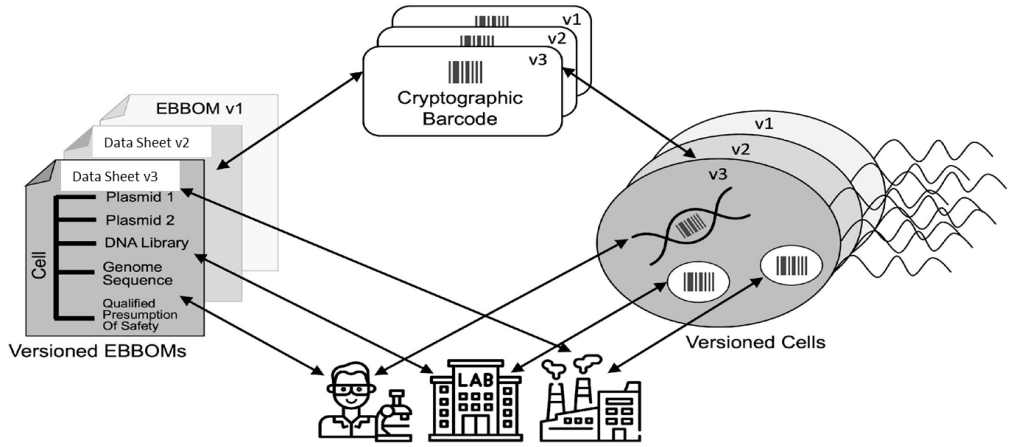
EBIC Versioning and barcoding of engineered biological assets

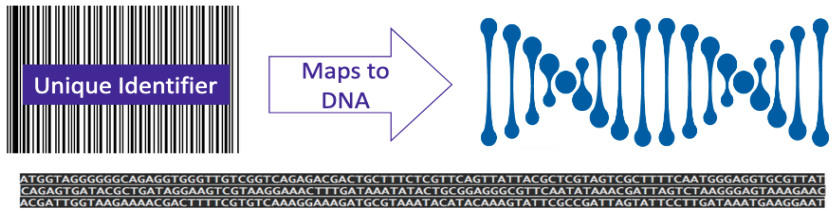
Documentation

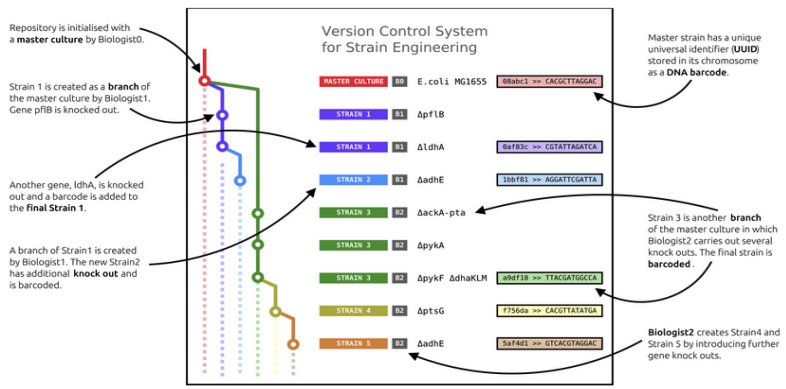
Reproducibility

Traceability

Protection/RRI



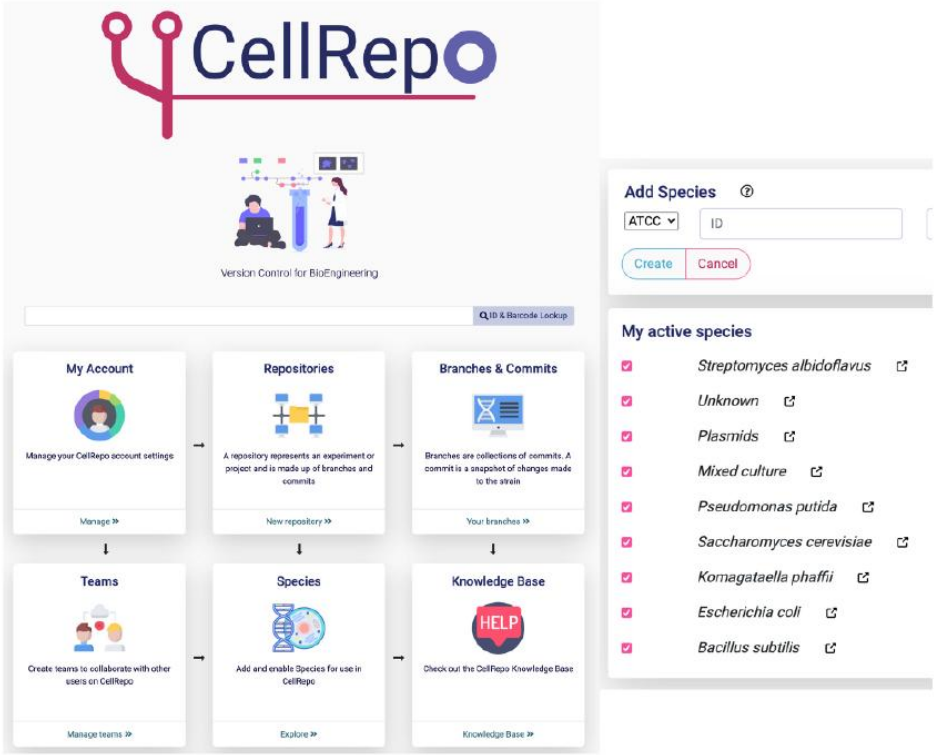




Written to Cell

Cell has immutable record of its engineering history





https://www.cellrepo.com/

- **Bind the physical sample to a verifiable digital state**
- **Enable practical identity and authenticity checks at handoff points**
- **Strengthen traceability throughout the engineered-asset supply chain**
- **Provide auditable evidence for compliance and incident investigation**

Application 1: Biosensors for environmental monitoring



The Technology:

Multiplexed microfluidic sensors utilizing engineered microbes to detect heavy metals, hydrocarbons, and emerging contaminants in real-time.

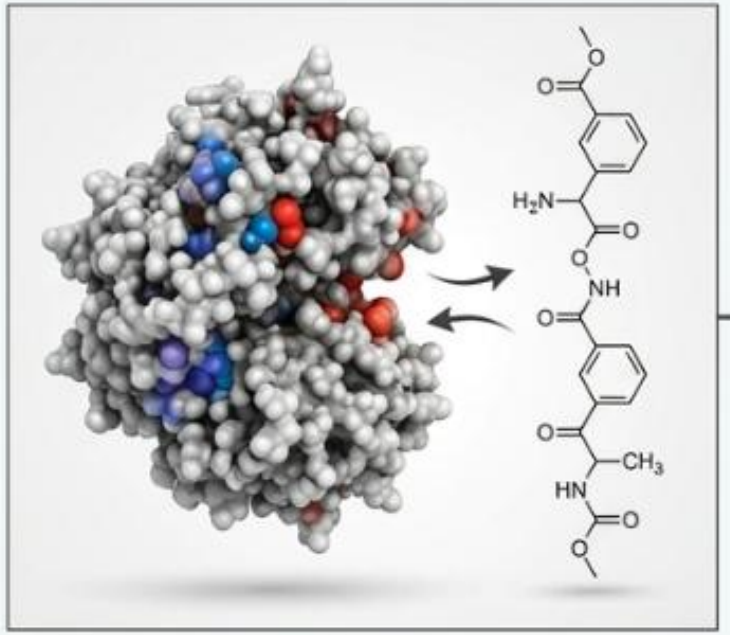
Deployment Horizon (EBIC Roadmap):

- 2025–2027 (TRL 4-5): Lab-scale development, multiplexing, data acquisition integration.
- 2027–2030 (TRL 6-7): Field trials in environmental matrices; design for manufacturability.
- 2030–2033 (TRL 8-9): Commercial-scale production.

Primary Barrier:

Regulatory acceptance of bio-sensor data for legal environmental compliance reporting.

Application 2: Enzyme engineering for plastics and PFAS



The Technology: Utilizing directed evolution to design enzymes with extreme thermostability and substrate specificity for solid-liquid plastic interfaces



The Process: Integrating biological depolymerization with existing mechanical, chemical, and thermal pretreatment systems



The Goal (2032-2035 Target): Full-scale industrial deployment of enzymatic PET depolymerization to recover pure monomers, establishing a true circular economy

Primary barrier: cost of enzyme production much reach parity with virgin monomer synthesis

Application 3: Microbiota engineering:
Trap & degrade systems for microplastics capture

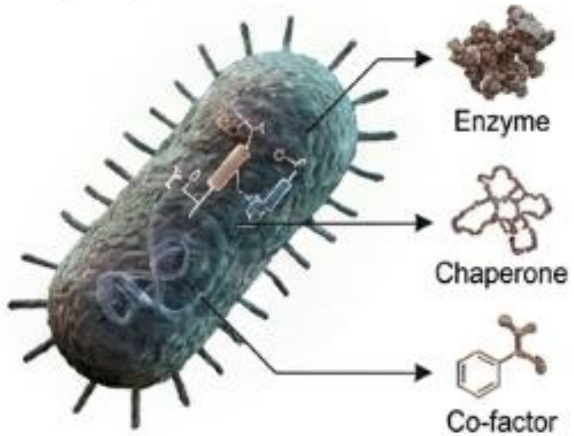
The Chassis & Target

Southampton / Brunel University London

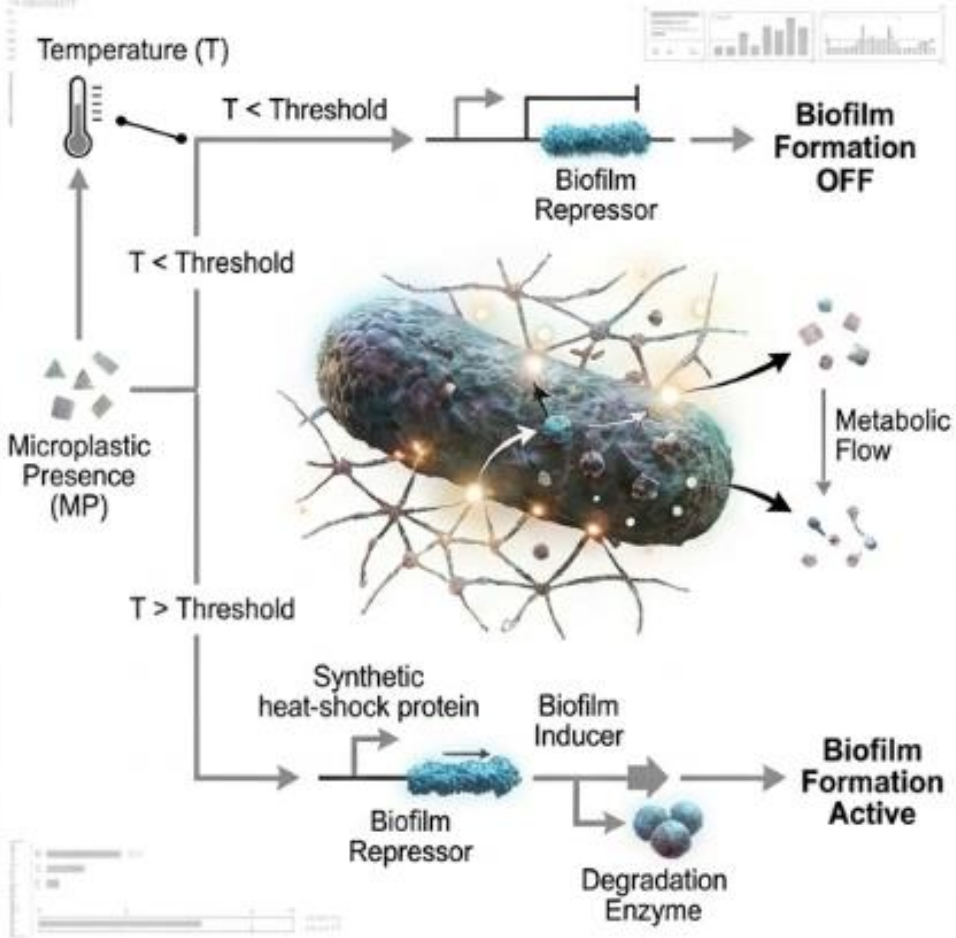
Target Organism: *Acinetobacter baumannii* AB5075

Screened >10,600 transposon mutants to uncover:

1. Specific plastic degradation enzyme
2. Associated chaperone
3. Co-factor for polycaprolactone (PCL) breakdown



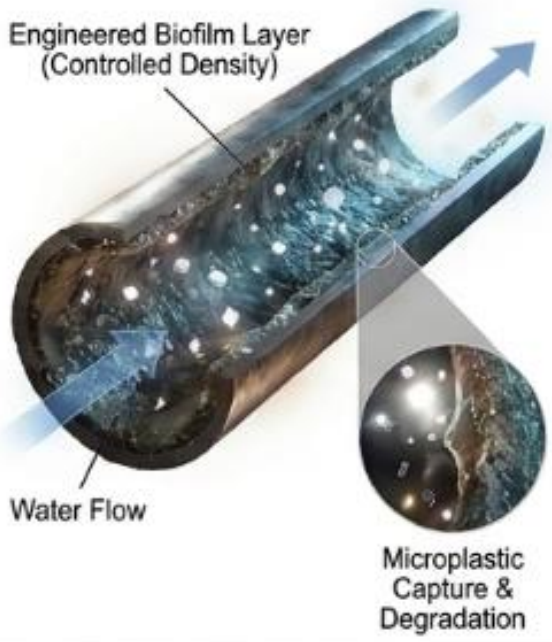
The Trap & Degrade Circuit: Temperature-sensitive synthetic modulation of biofilm formation



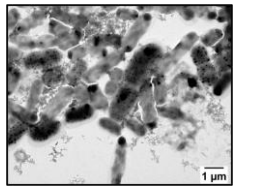
Environmental Application

Controlling biofilm density prevents unwanted biofouling during deployment in drinking water treatment systems.

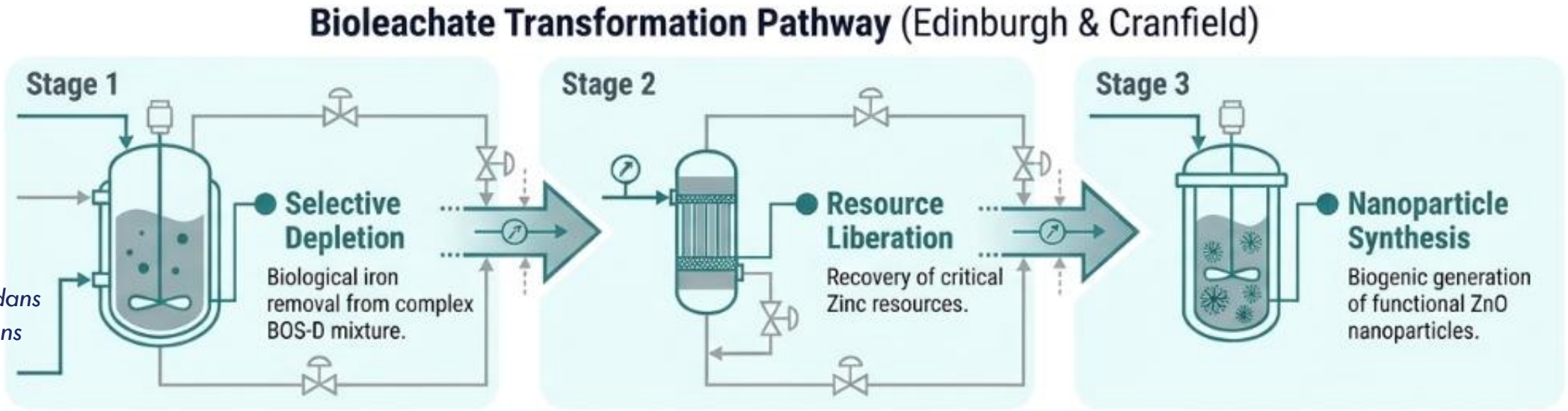
Solves a critical infrastructure scaling constraint.



Application 4: Metabolic engineering for resource recovery and circularity



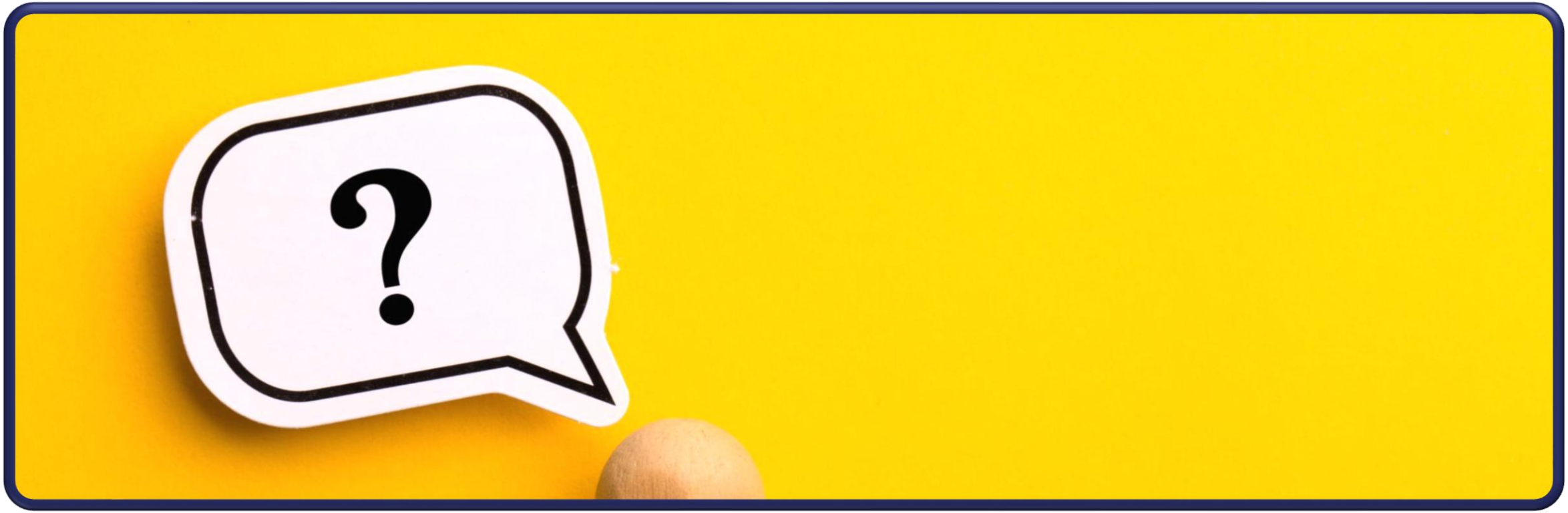
Shewanella oneidensis
Acidithiobacillus ferrooxidans
Morganella psychrotolerans



Engineering Biology not merely as remediation, but as the biomanufacturing of value-added materials for recalcitrant industrial waste

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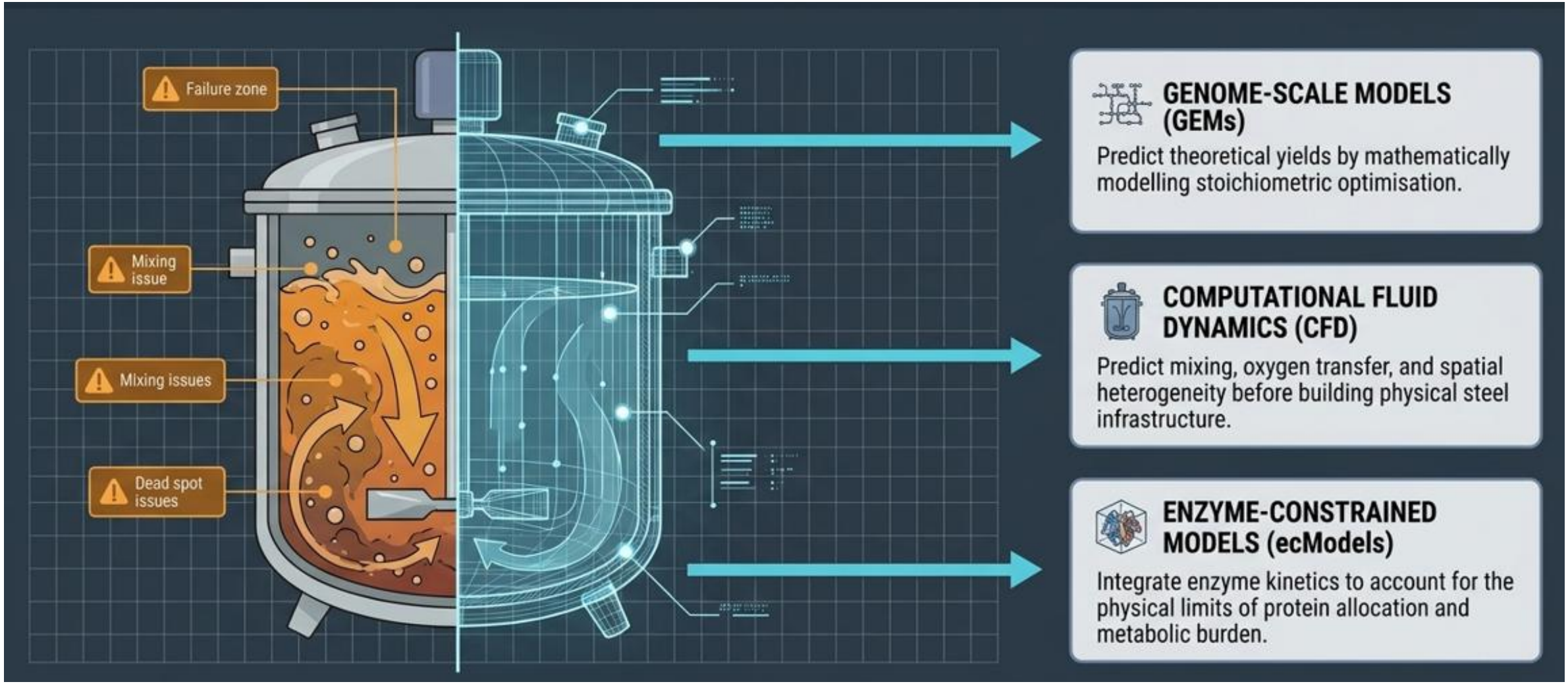
What’s next ?



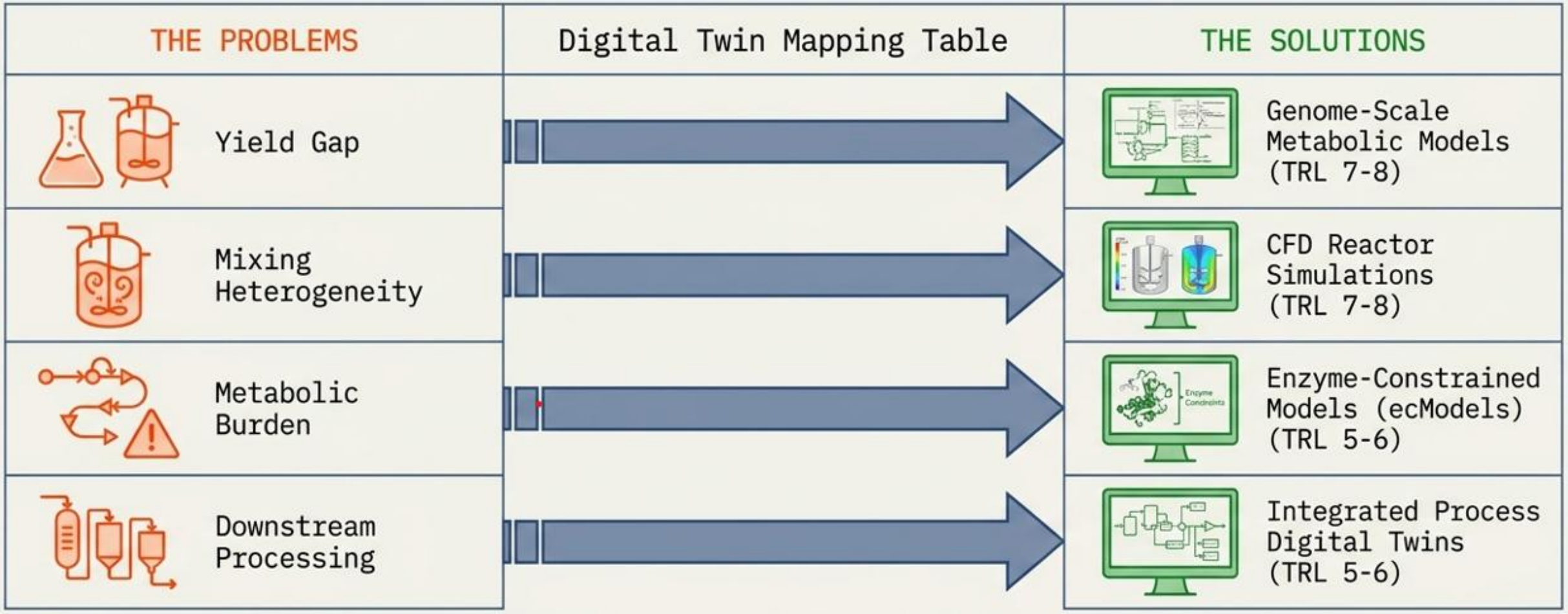
The 5 scientific failure modes: the scale-up cliff

The 2L Lab Flask		The 100,000L Bioreactor		
1. Yield Gap	Perfect environment	1. Yield Gap		Drastic underperformance
2. Genetic Stability	Stable for days	2. Genetic Stability		Evolutionary sweep of non-producers
3. Mixing Dynamics	Homogenous dissolved oxygen & pH	3. Mixing Dynamics		Wild spatial heterogeneity
4. Metabolic Burden	Managed through selection	4. Metabolic Burden		Crippling cellular tax & overflow metabolism
5. Downstream Processing	Handled via lab centrifuge	5. Downstream Processing		Linear costs destroy economies of scale

LEARN: bridging the gap before building using digital twin



LEARN: bridging the science gap with in silico prediction



The frontier: Genetic instability prediction remains at TRL1-2, representing the industry's most critical blind spot for Biofoundry success

TEST: bridging the scale-up gap

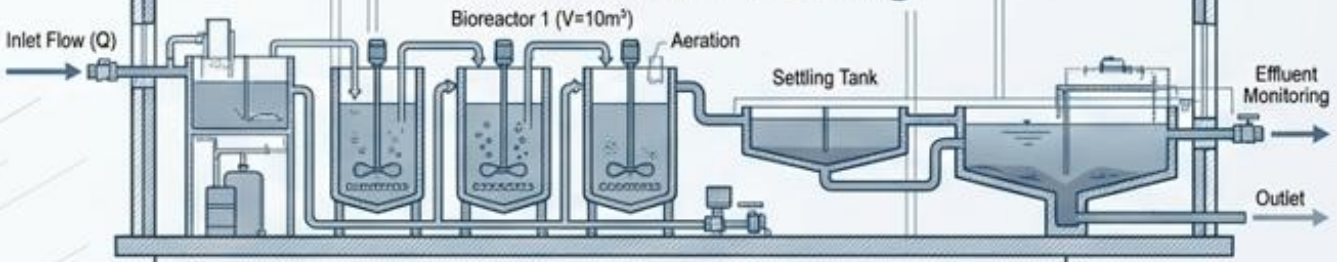


	Lab Reality	Field Reality
1. Mixing & Dynamics	**Perfect mixing, stable DO.** Idealized conditions, uniform distribution.	**Turbulent fluid dynamics**; severe oxygen gradients.
2. Contaminant Kinetics	**Rapid degradation** in controlled media. Idealized conditions, fast rates.	

The Reality of Scale:
Contaminant half-lives measured in the field are often **4 to 10 times longer** than laboratory results due to mass transfer limits and environmental heterogeneity.



Pilot-Scale Testing



EBIC utilizes the Cranfield National Research Facility to test interventions under near-industrial conditions.

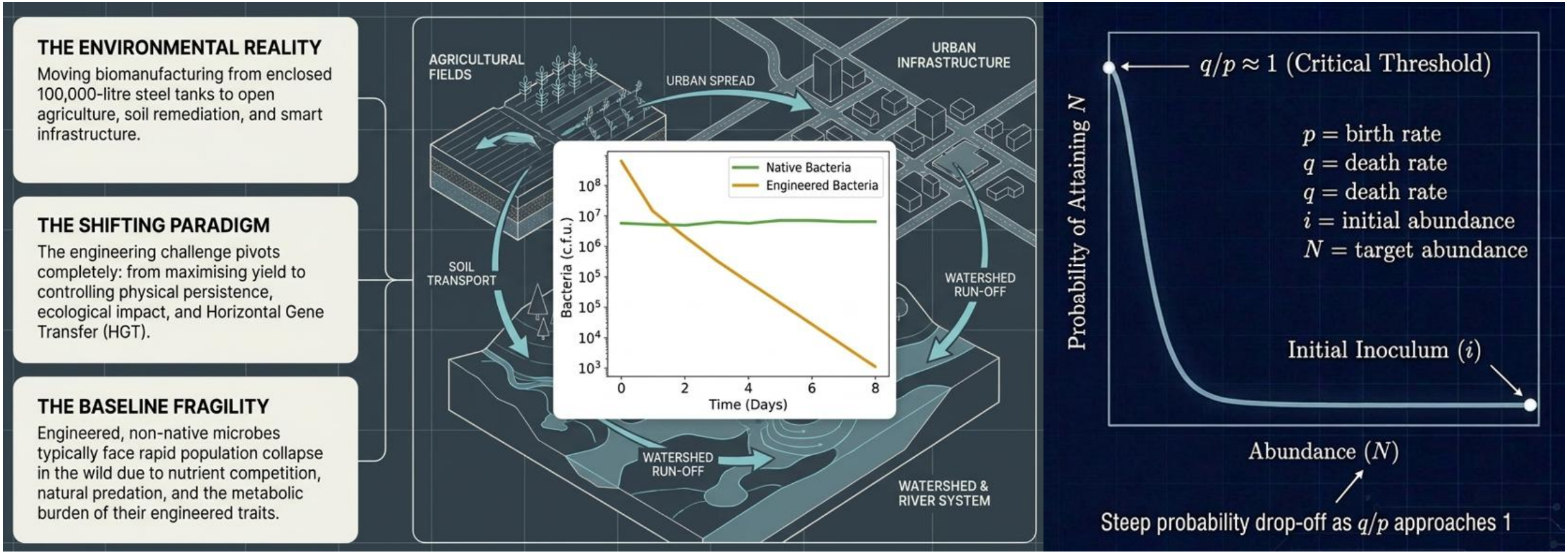
Real-World Variables

- Accounting for variations in flow, load, and background toxins before expensive environmental release.

UK Collaboratorium for Research on Infrastructure and Cities (UKCRIC) as part of £80m National Urban Water Infrastructure Facility

TEST: piloting reality

Predictive community dynamics: The Gambler's ruin



Curtis et al., 2026, ISME, wrag195

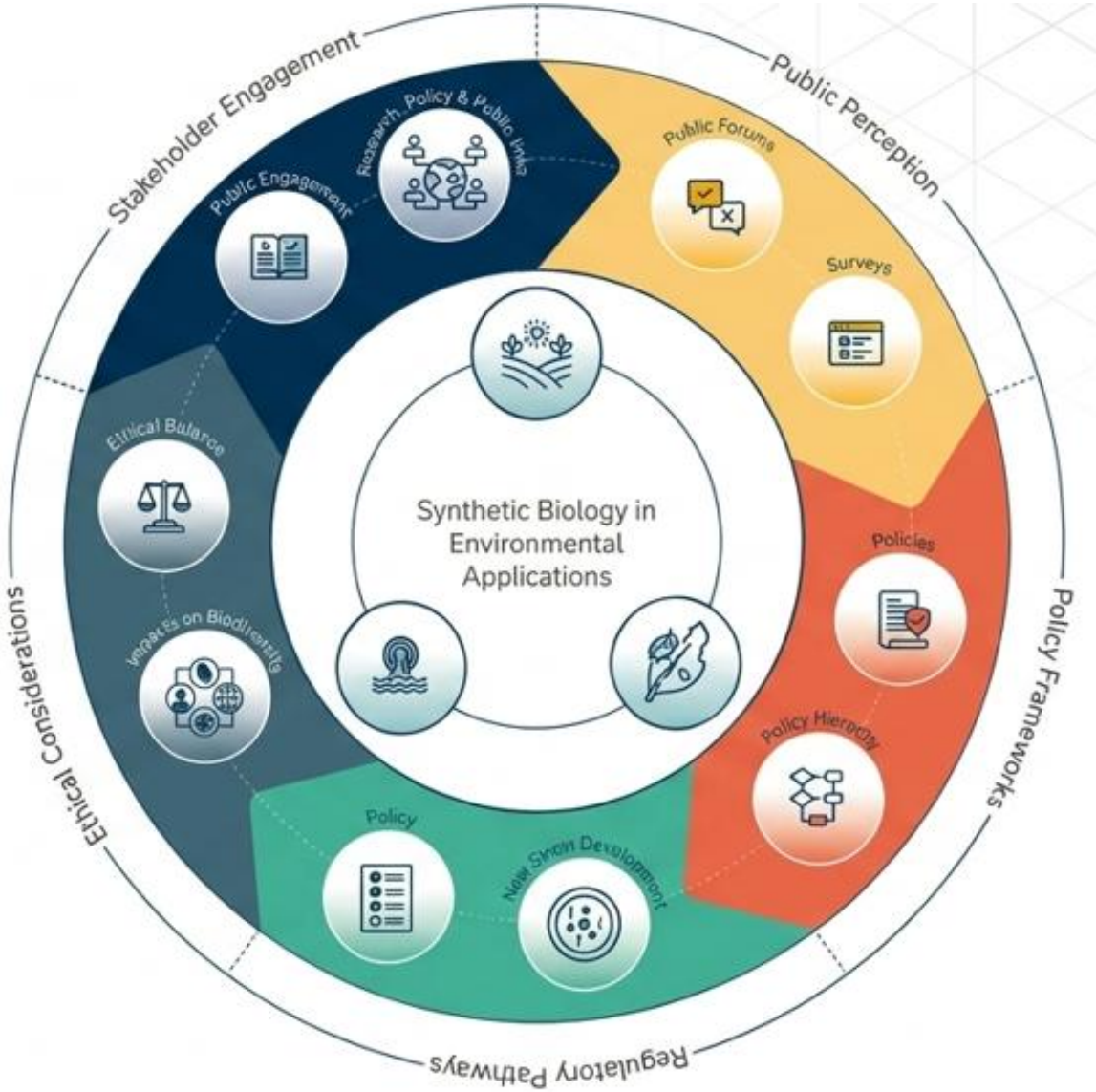
SECURE: traceability and social containment

Immutable Records
Using genomic barcoding to write a cell's engineering history directly into its DNA, providing auditable evidence for regulatory compliance.

Standardization
EBIC is leading the development of BSI PAS Standards for biological assets to ensure transparency across supply chains.

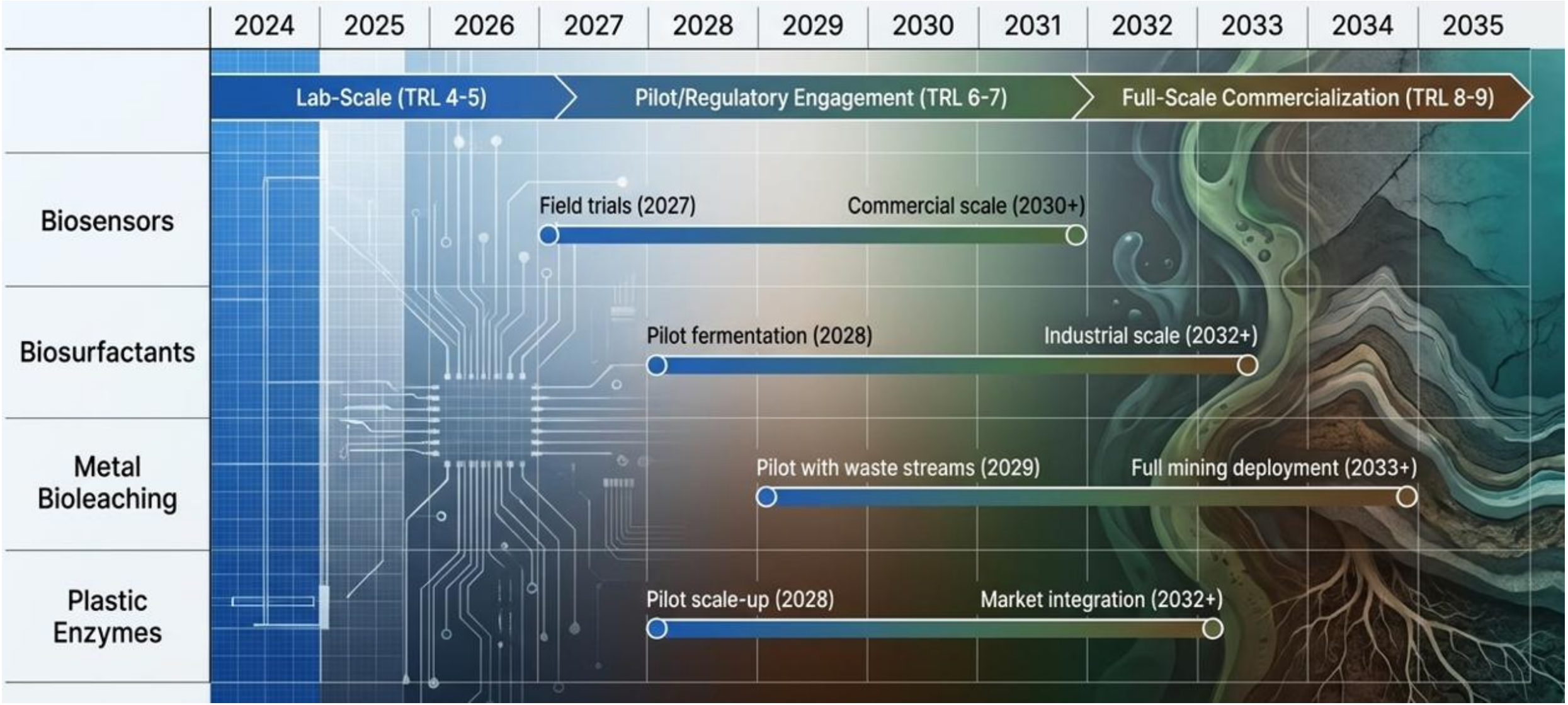
Social Containment
Building public trust through community engagement and respecting a 'community right of refusal'.

Risk-Managed Design
Treating risk as a design variable from day one, making all assumptions explicit and contestable.



Lea-Smith et al. (2025) Nature Communications, 16:3538

EBIC's deployment horizon



Engaging with EBIC

Newsletter

EBIC produces a quarterly newsletter with exciting updates on our work, SynBio & Engineering Biology related news-stories, events and much more! You can sign up to join our mailing list below.

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And more!

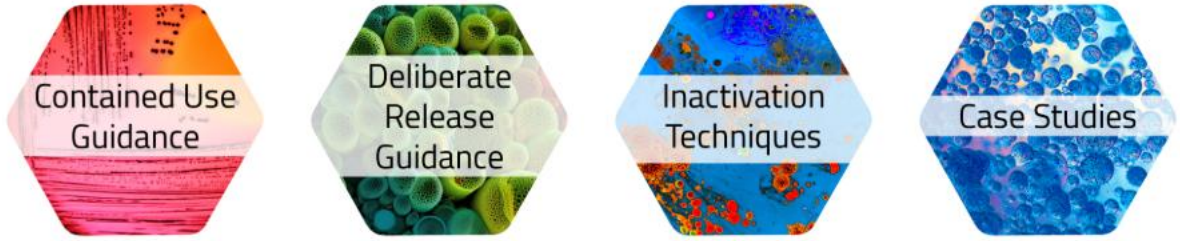
Funding calls

Research Highlights from EBIC and beyond

Events

Guidance on Regulatory Approval of GMMs for Environmental Applications

These guidance documents are intended for engineering biology companies, start-ups, researchers and technology developers working on environmental applications of genetically modified microorganisms. They may also be useful to investors, funders, consultants and other stakeholders seeking to understand the regulatory considerations associated with bringing environmental biosolutions to market. The guidance relates to the status of such organisms as genetically modified. There may be additional sector or use specific approvals required for a specific application.



To download the EBIC Guidance Document as a single report, **click here**

Suggested Citation: EBIC (2026) Guidance on Regulatory Approval of Genetically Modified Microorganisms (GMMs) for Environmental Applications (1st Ed.). Environmental Biotechnology Innovation Centre, Cranfield.

https://ebicentre.co.uk/ebic-guidance-documents/