EBIC Environmental Biotechnology Innovation Centre

Test, learn and secure: EBIC's roadmap for environmental engineering biology

Moving synthetic biology from a lab experiment to an auditable industrial discipline

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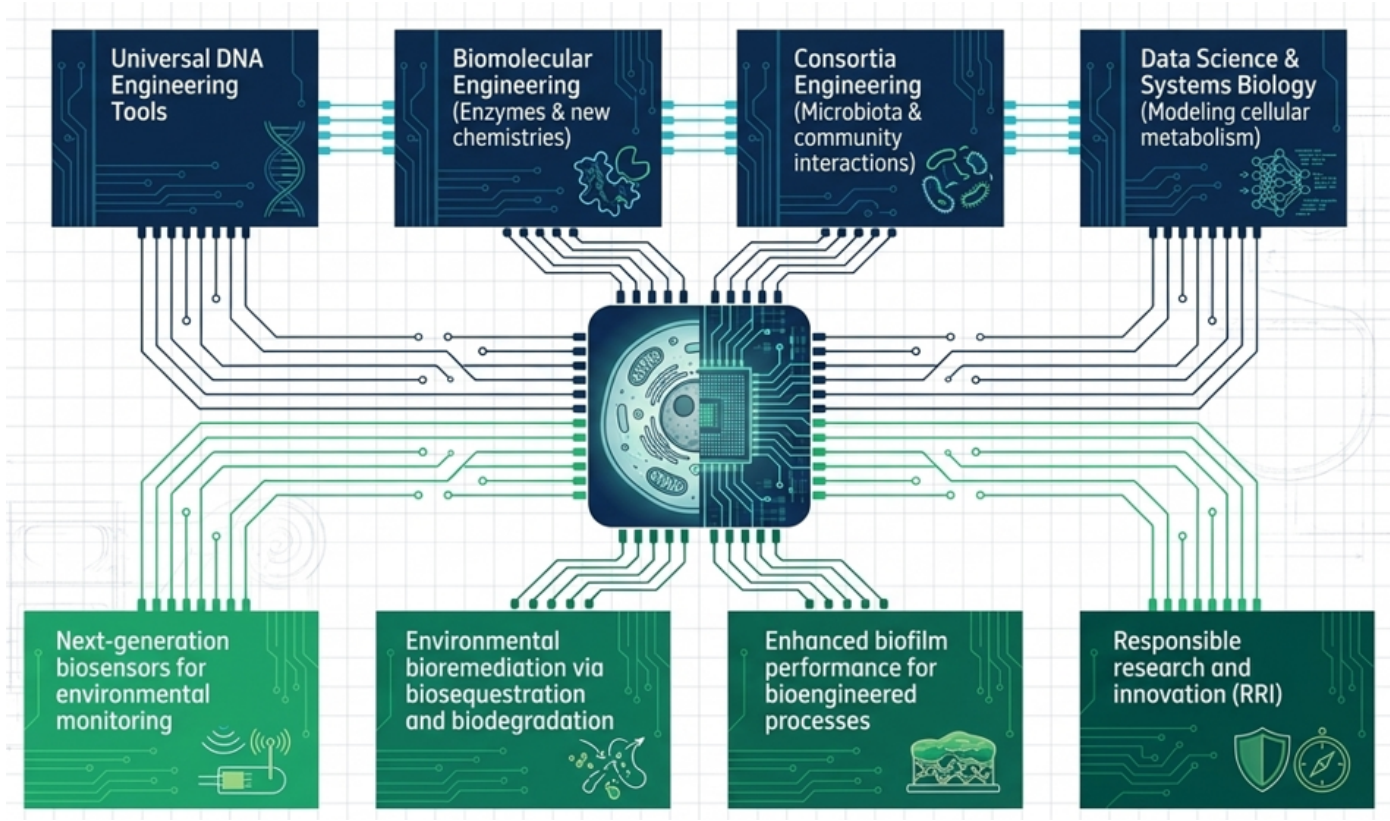
Director of EBIC, Cranfield University.

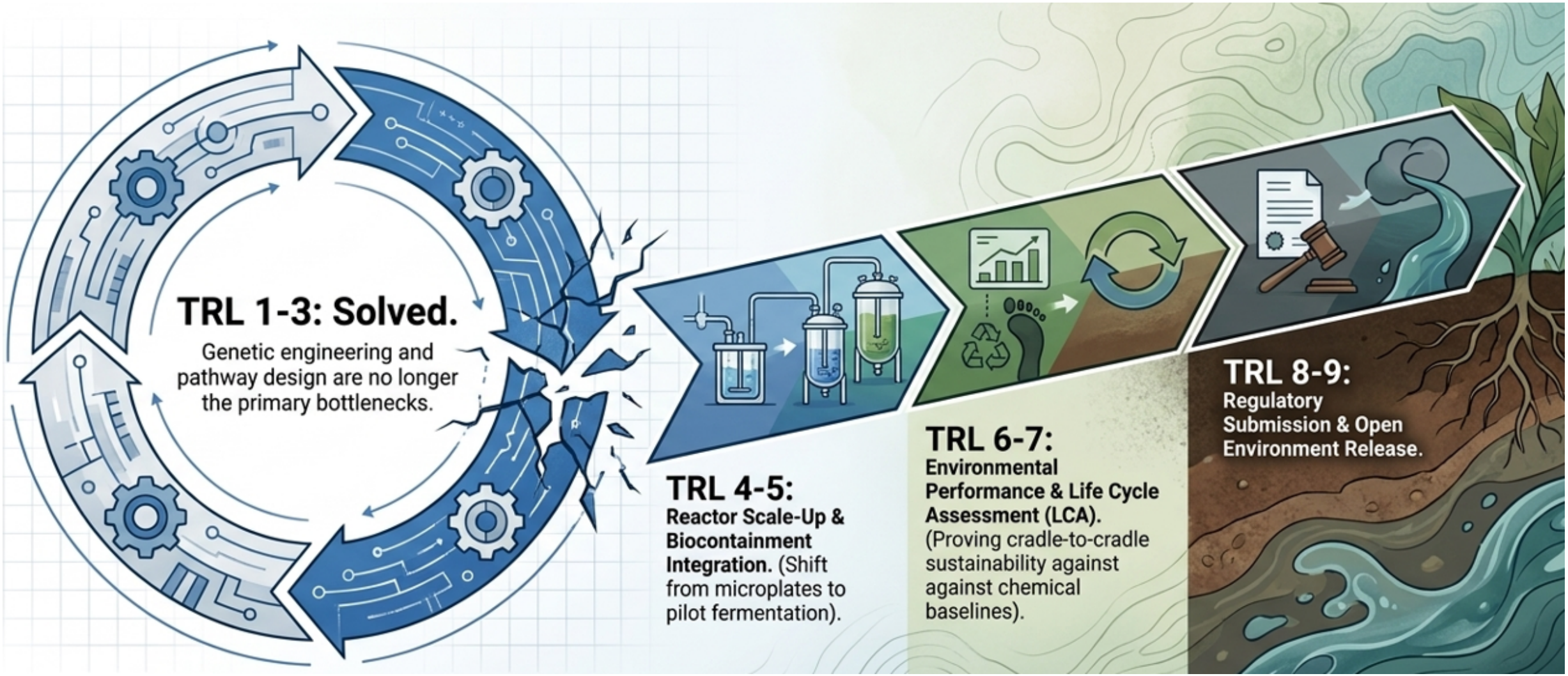
What is EBIC?

- **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 innovation pipeline: beyond the DBTL loop

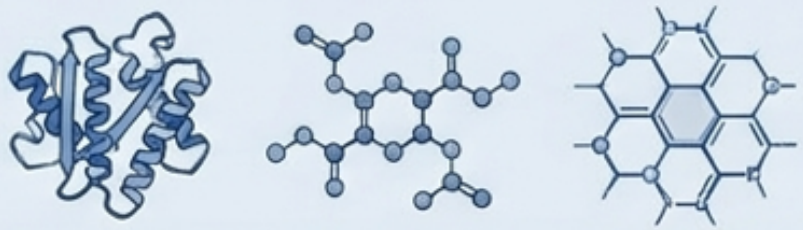


The modern bottleneck is the integration of digital twins and LCA before moving to pilot scale

The 5 scientific failure modes: the scale-up cliff

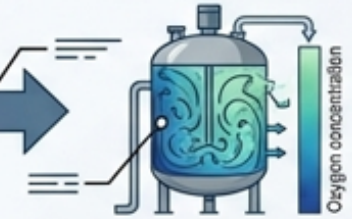
The 2L Lab Flask		The 100,000L Bioreactor	
1. Yield Gap	Perfect environment	1. Yield Gap	Drastic underperformance
2. Genetic Stability	Stable for days	2. Genetic Stability	Evolutionary sweep of non-producers
3. Mixing Dynamics	Homogenous dissolved oxygen & pH	3. Mixing Dynamics	Wild spatial heterogeneity
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

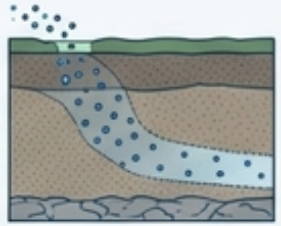
The engineering toolkit: choosing the right chassis

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).

TEST: bridging the scale-up gap

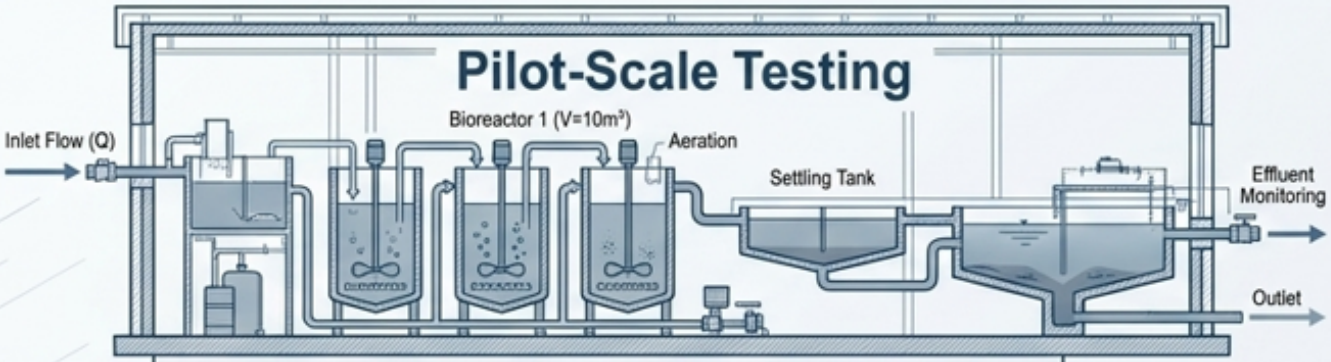
	Lab Reality	Field Reality
1. Mixing & Dynamics	**Perfect mixing, stable DO.** Idealized conditions, uniform distribution.	**Turbulent fluid dynamics**; severe oxygen gradients.
2. Contaminant Kinetics	**Rapid degradation** in controlled media. Idealized conditions, fast rates.	





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

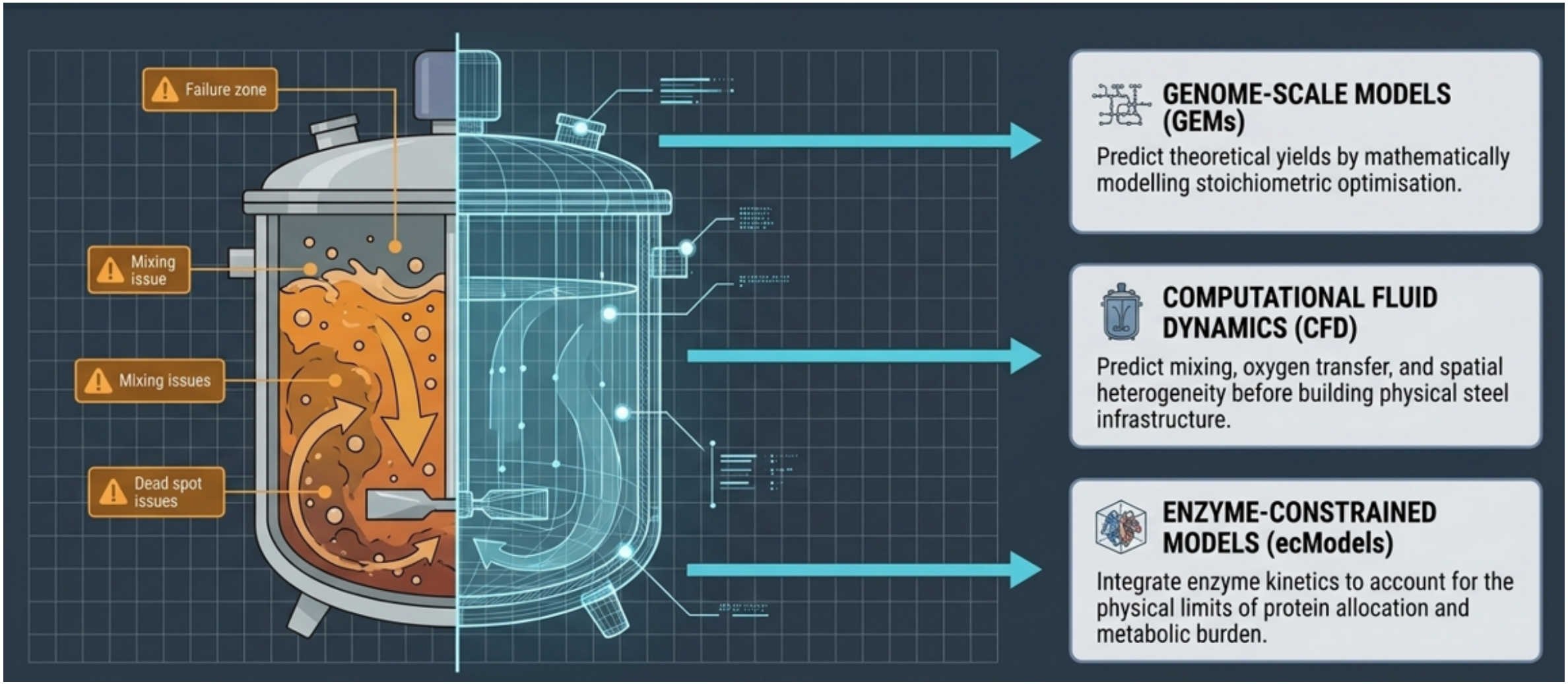


EBIC utilizes the Cranfield National Research Facility to test interventions under near-industrial conditions.

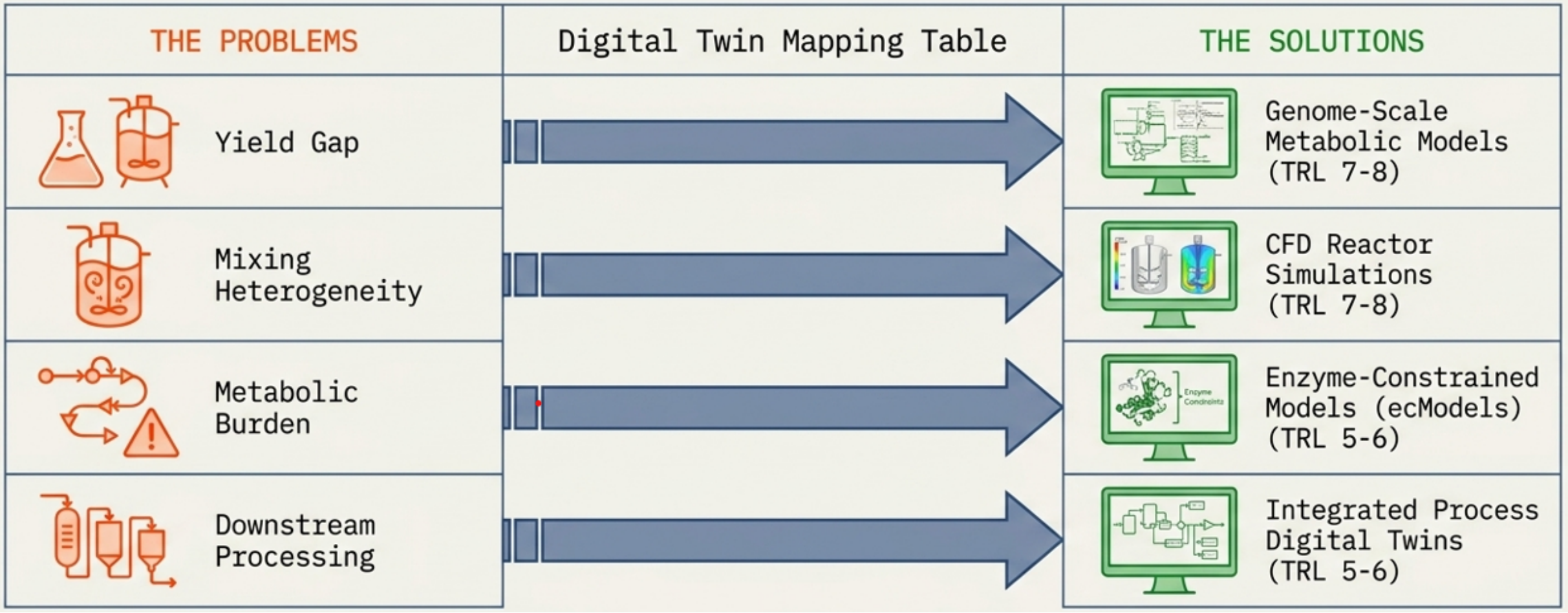
Real-World Variables

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

LEARN: bridging the gap before building using digital twin



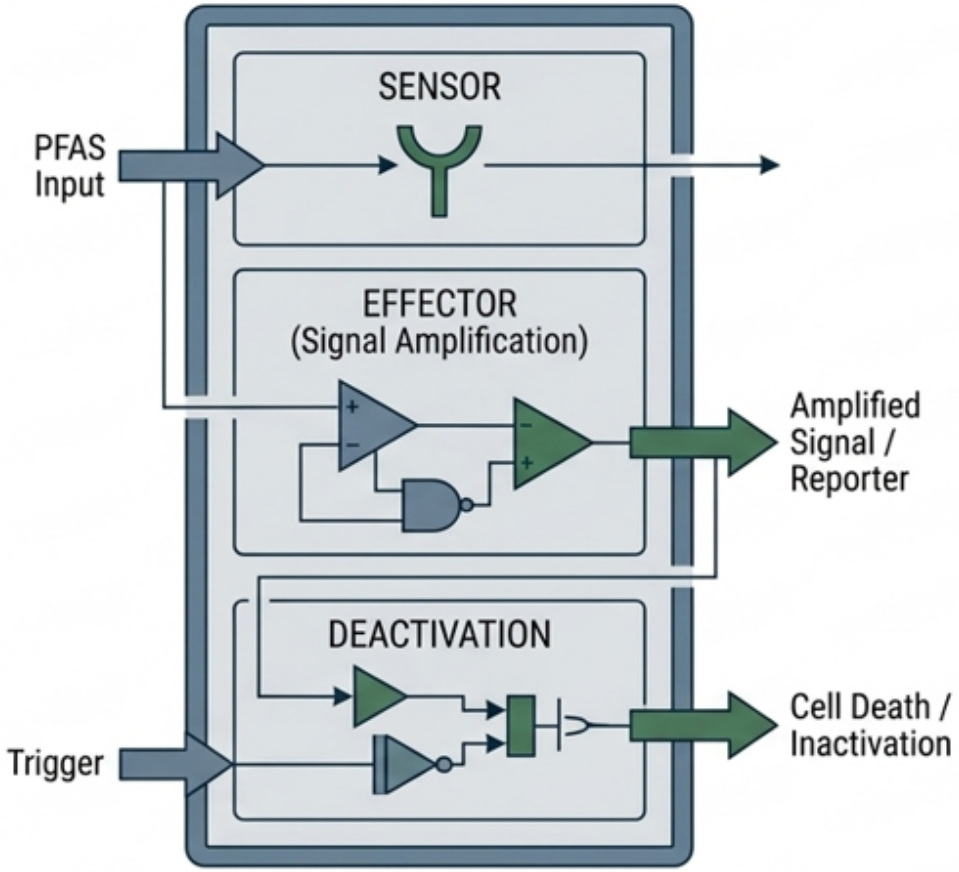
LEARN: bridging the science gap with in silico prediction



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

Innovation spotlight: PFAS sensors and plastic degradation

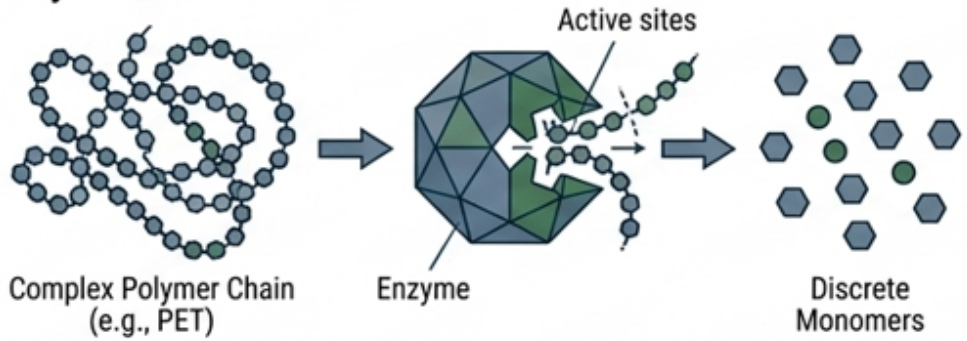
Next-Gen Sensing



Developing modular PFAS whole-cell sensors that include "deactivation modules" (kill switches) for built-in biosafety.

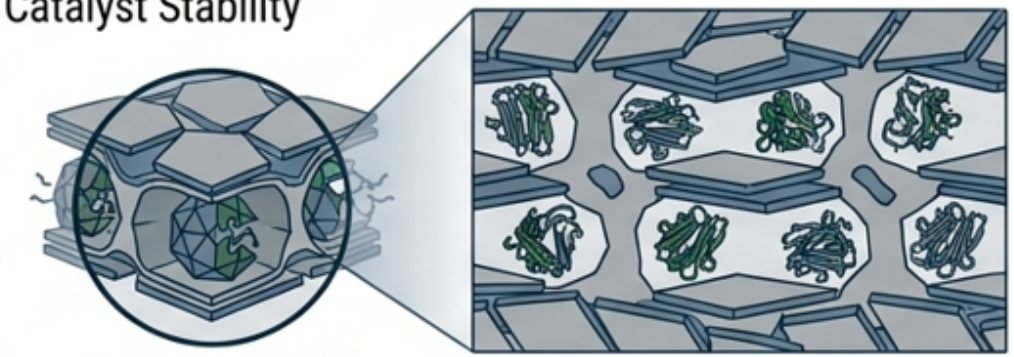
Materials Engineering

Enzyme Evolution



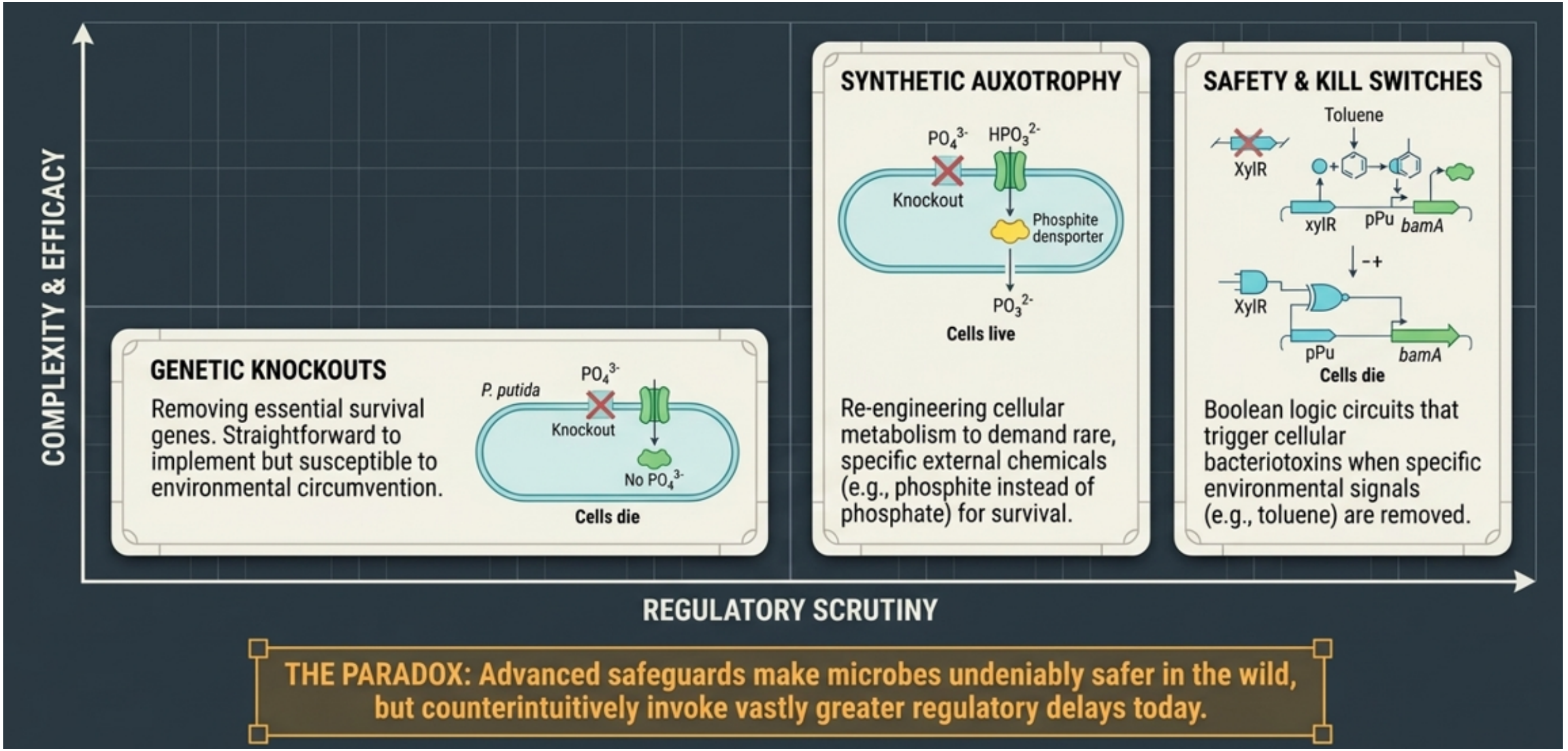
Engineering enzymes for the depolymerisation of persistent plastics (PET) and the remediation of radionuclides.

Catalyst Stability

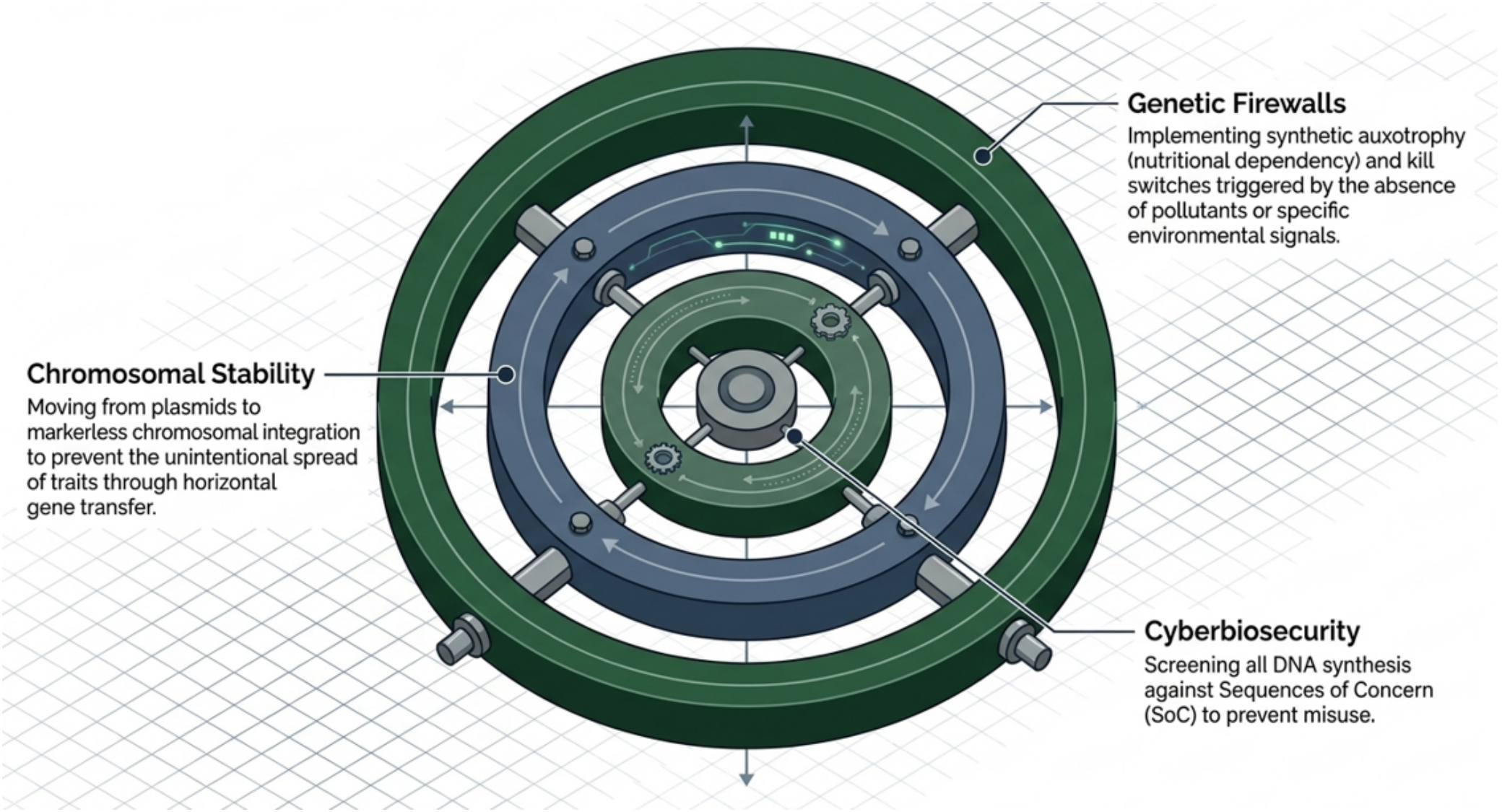


Using immobilization on nanoclays or hydrogels to ensure functional longevity in harsh, non-sterile field conditions

SECURE: technical and biocontainment safety



SECURE: Technical biocontainment and safety



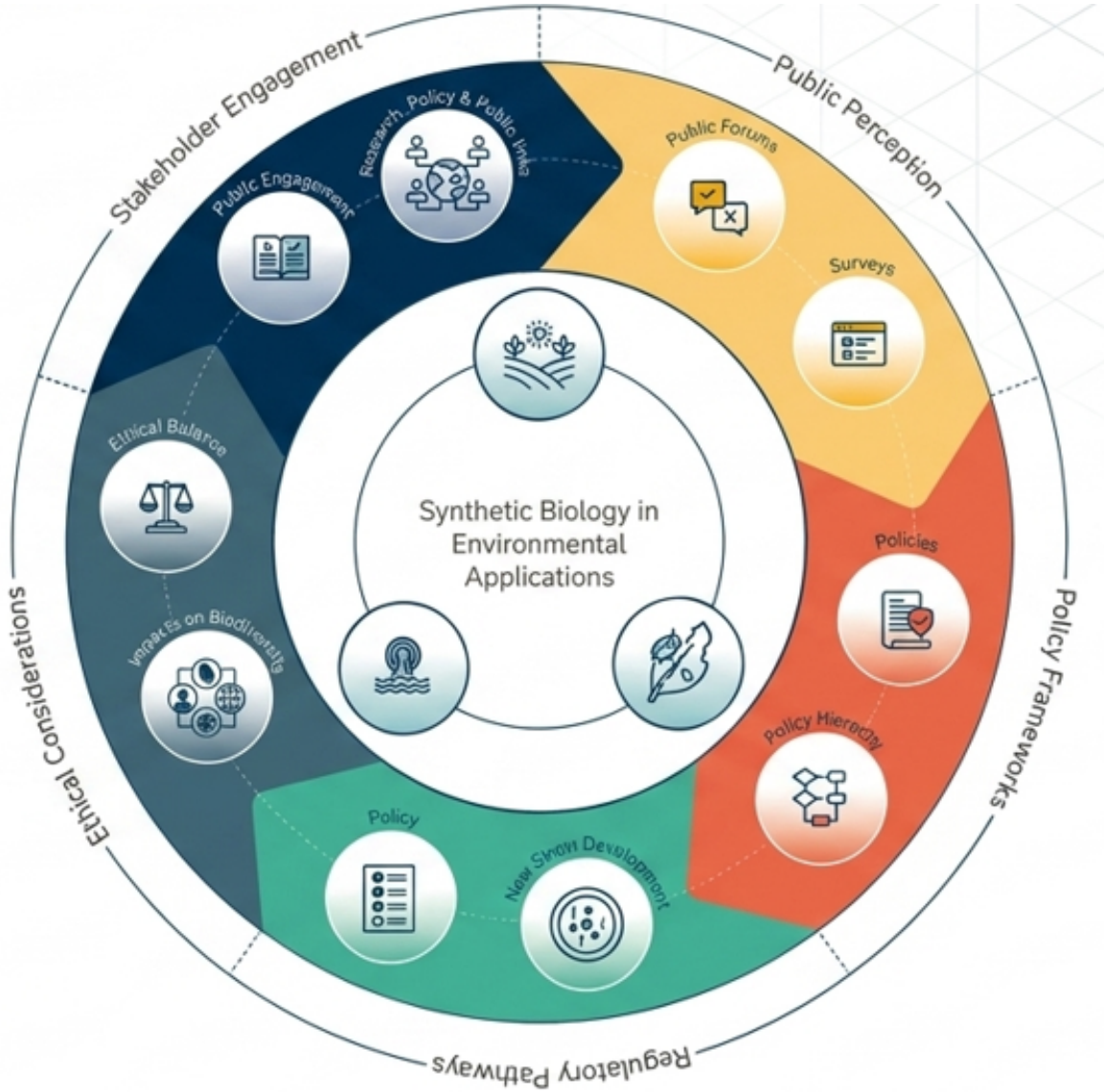
SECURE: traceability and social containment

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.

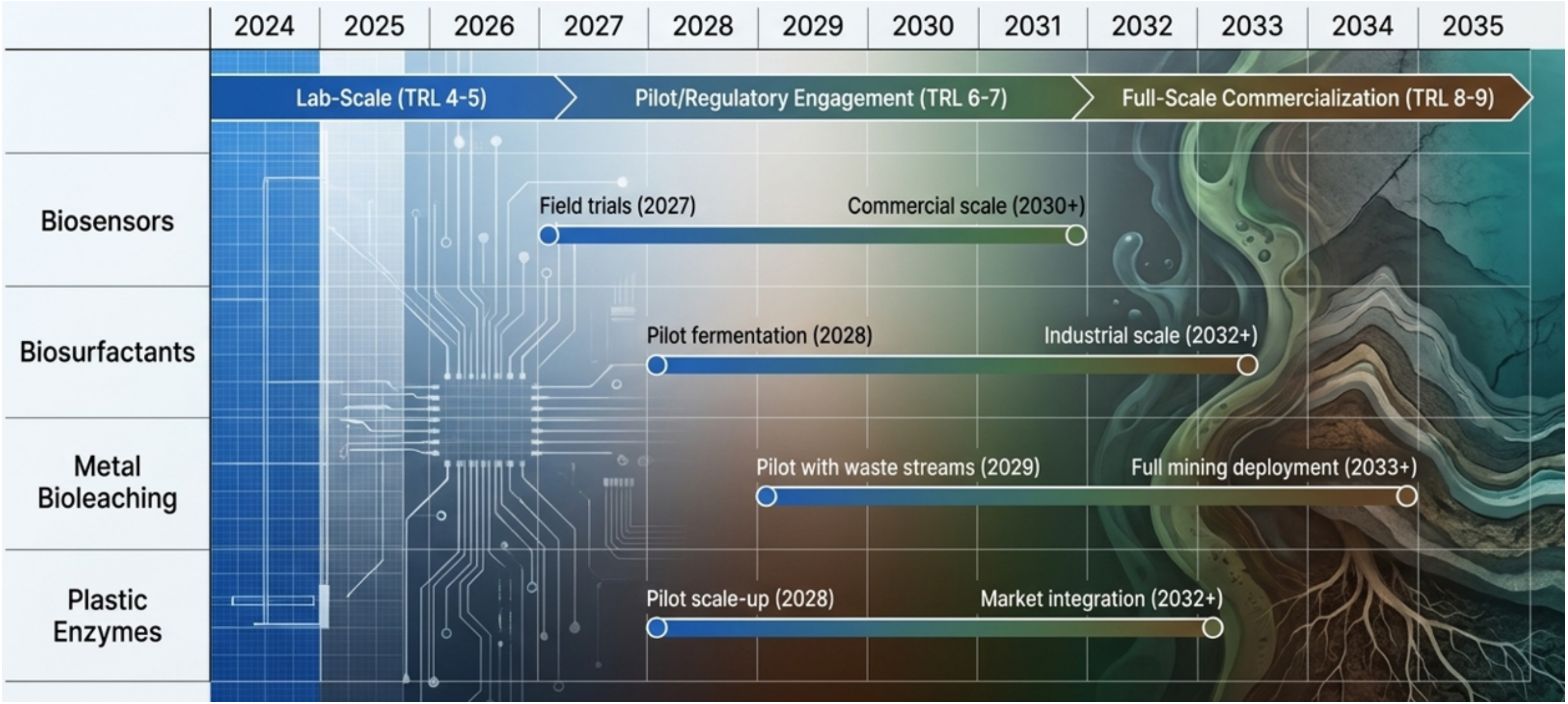


Lea-Smith et al. (2025) Nature Communications, 16:3538

Towards environmental probiotics?

- **A paradigm shift**: Rebranding GE releases as environmental probiotics, moving away from one-off product releases
- **Stewardship**: Transitioning to long-term stewardship models grounded un traceability and care
- **Final call**: To secure our future, we must integrate Test, Learn and Secure into every stage of the biotechnology lifecycle

EBIC's deployment horizon



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Thank you

Prifysgol Bangor University

Brunel University London

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Newcastle University

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