Synthetic Biology: Starting our Third Decade of Activity

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Synthetic Biology: Reprogramming Life



Synthetic Biology: Engineered Gene Networks





Programmable Cells: Living Technology



Synthetic Probiotics: Living Diagnostics & Therapeutics



N Mao et al., Science Translational Medicine, 2018

Combating Cholera w/Natural & Engineered Probiotics



Synlogic (NASDAQ: SYBX)

A New Strategy to Treat Disease

Synlogic is harnessing synthetic biology to design smart living biotherapeutics, medicines programmed with specific genes and molecular components, to address dysregulation and other drivers of disease. Synthetic Biotic[™] medicines have the potential to treat a range of conditions including rare diseases, metabolic conditions, autoimmune and inflammatory diseases and cancers.

Synthetic Biotic[™] Medicines: Novel Class of Living Medicines

Clinical Programs: Rare Metabolic Diseases Inflammatory Bowel Disease Immuno-Oncology



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Synthetic Probiotics: Sparing the Gut Microbiome



 β -lactamase as a public good

Synthetic Probiotics: Refunctionalizing Microbiomes

The Human Microbiome Project

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Harnessing Tardigrades to Enhance Living Medicines



From Kids Discover



Four-to-ten fold improvements in survival percentage were observed in the engineered probiotics.

Living Medicines: Synthetic Sentinels



PASSCODE Kill Switch for Living Medicines





CTY Chan et al., Nature Chemical Biology, 2016

Potential for Synthetic Gene Networks



Ecological Monitoring



Freeze-Dried, Cell-Free Synthetic Biology





+

KAN

CAT

SMR

+

AMP

Shelf-Stable, Low-Cost, Paper-Based Dx



Paper-Based Synthetic Biology: Rapid POC Diagnostics

PROGRAMMABLE PAPER

Delivering diagnostic and therapeutic gene circuits on pocket-sized slips of paper





Rapid Responses to Global Outbreaks



Rapid, Low-Cost Detection of Water Contaminants



Rapid, Low-Cost Detection of Water Contaminants



Freeze-dried ROSALIND produces visible signal



ROSALIND can detect copper in environmental samples



MEF (µM FITC)



Freeze-Dried, Cell-Free Synthetic Biology

Flexible platform for synthetic gene networks



Wearable Synthetic Biology



Wearable Synthetic Biology



Winner of the 2018 "Labcoat of the Future" Challenge Award Sponsored by Johnson Johnson INNOVATION JLABS

Wearable Synthetic Biology

Smart fabrics for pathogen and toxin detection/neutralization using synthetic biology





ESCHERICHIA COLI (E.COLI)

MYCOBACTERIUM TUBERCULOSIS KLEBSIELLA PNEUMONIAE



DNA Targets (Most dangerous pathogens

causing HAIs)

Freeze-Dried, Cell-Free Synthetic Biology

Flexible platform for synthetic gene networks





K Pardee et al., Cell, 2016b

Cell-Free, Freeze-Dried Antimicrobial Peptides



K Pardee et al., Cell, 2016b

Portable Vaccine Production



Time (day)

Portable, On-Demand Biomolecular Manufacturing



K Pardee et al., Cell, 2016b

Freeze-Dried, Cell-Free Synthetic Biology

Flexible platform for synthetic gene networks



BioBits: Synthetic Biology Educational Kits



A Huang et al., Science Advances, 2018 J Stark et al., Science Advances, 2018

Fluorescent Proteins as Visual Ouputs



Fragrance-Generating Enzymes as Olfactory Ouputs



Hydrogel-Generating Enzymes as Tactile Outputs





Fibrin Hydrogels



Fibrin Hydrogels



Sortase-PEG Hydrogels



Sortase-PEG Hydrogels











SynBio Breadboard for Prototyping Genetic Circuits



RNA Switch-Based Environmental Sensing



Synthetic Biology: Driven by Computation



Synthetic Biology: Driven by Computation



Synthetic Biology: Driven by Computation

A synthetic oscillatory network of transcriptional regulators

Michael B. Elowitz & Stanislas Leibler



MB Elowitz and S Leibler, Nature, 2000

Computational Biology and Synthetic Biology Origins

"... the kind of modeling needed to understand intracellular networks that underlie most biological functions comes straight from engineering control theory. As shown by two papers in last week's issue it is becoming possible not just to analyse naturally occurring networks in this spirit, but also to design and build biological networks to implement desired functions."

Nature, 27 January 2000



"Other researchers are starting to apply mathematical models to the manipulation of biological systems. For example, biomedical engineer James Collins at Boston University and his colleagues have used differential equations to design ... a genetic toggle-switch."

Nature, 21 December 2000

Synthetic Biology: Design-Build-Test Cycle



Deep Learning for Synthetic Biology





collinslab.mit.edu

