Synthetic Biology
Advances & Challenges

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BioVision

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Synthetic Biology: Motivation ?

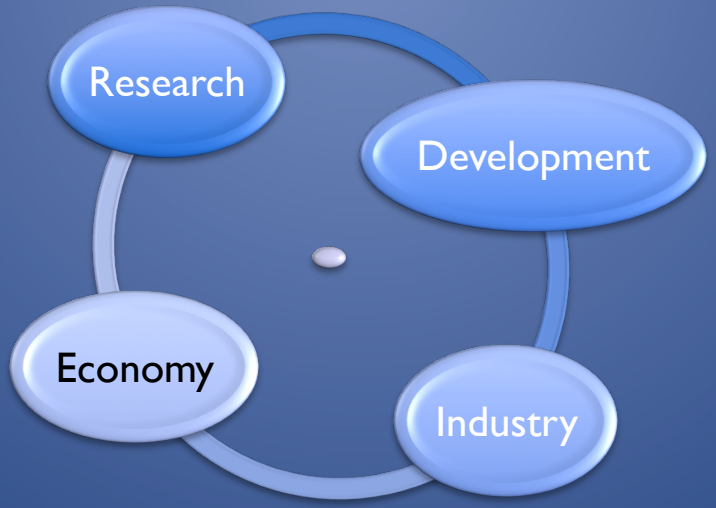
The advanced form of Biotechnology

Reducing:
Cost
Impact
Time to market

Synthetic Biology: Motivation ?

The end of the XIXth Century has witnessed the development of technologies that provided the basis for wealth creation by new industries, *eg* synthetic chemistry. One could also cite computer science / industry for the second half of the XXth Century, or nano-technoscience for the end of the XXth Century.

Synthetic Biology constitutes a wide base of concepts and methods with the same overall potential.

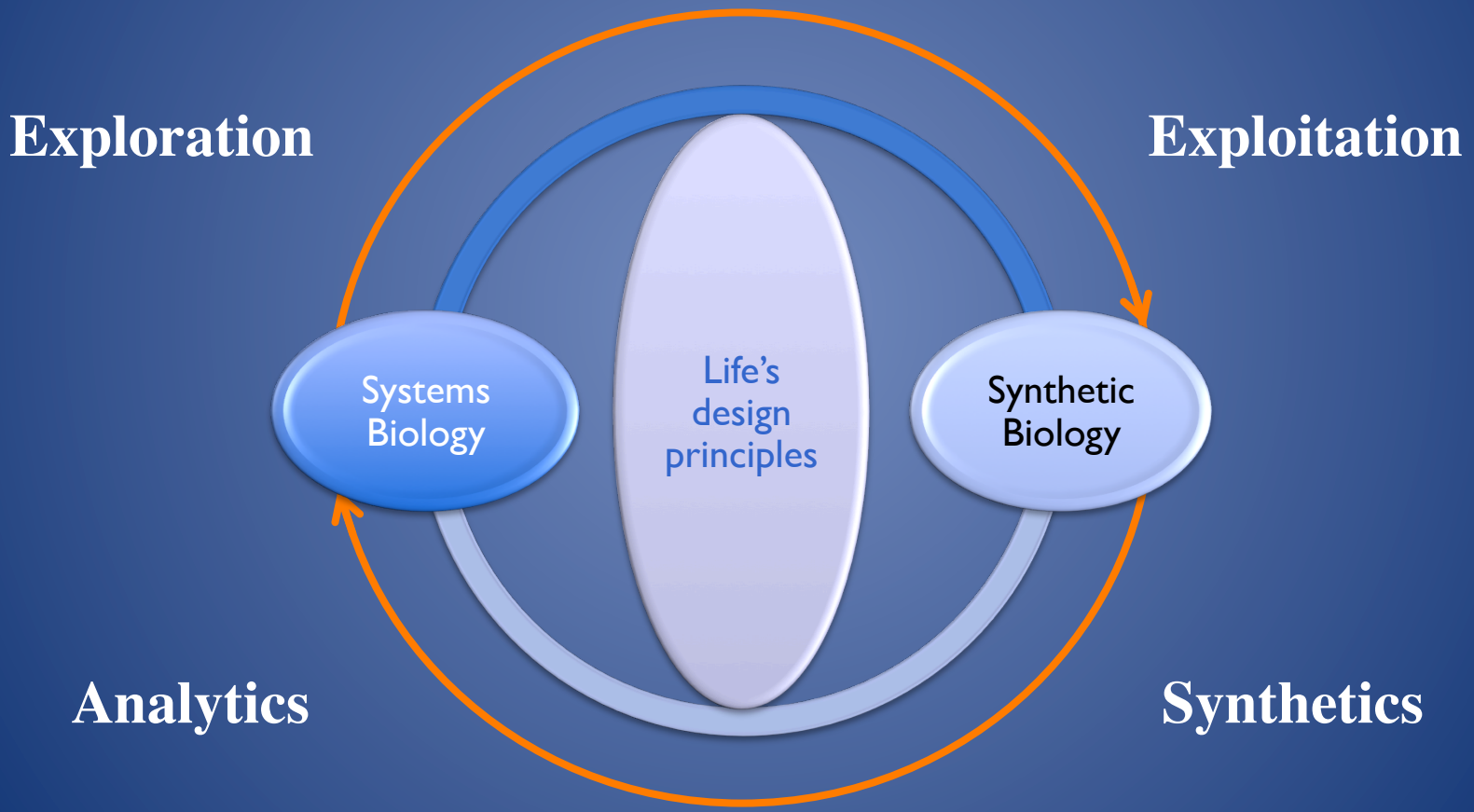


Interface of Biology to other disciplines

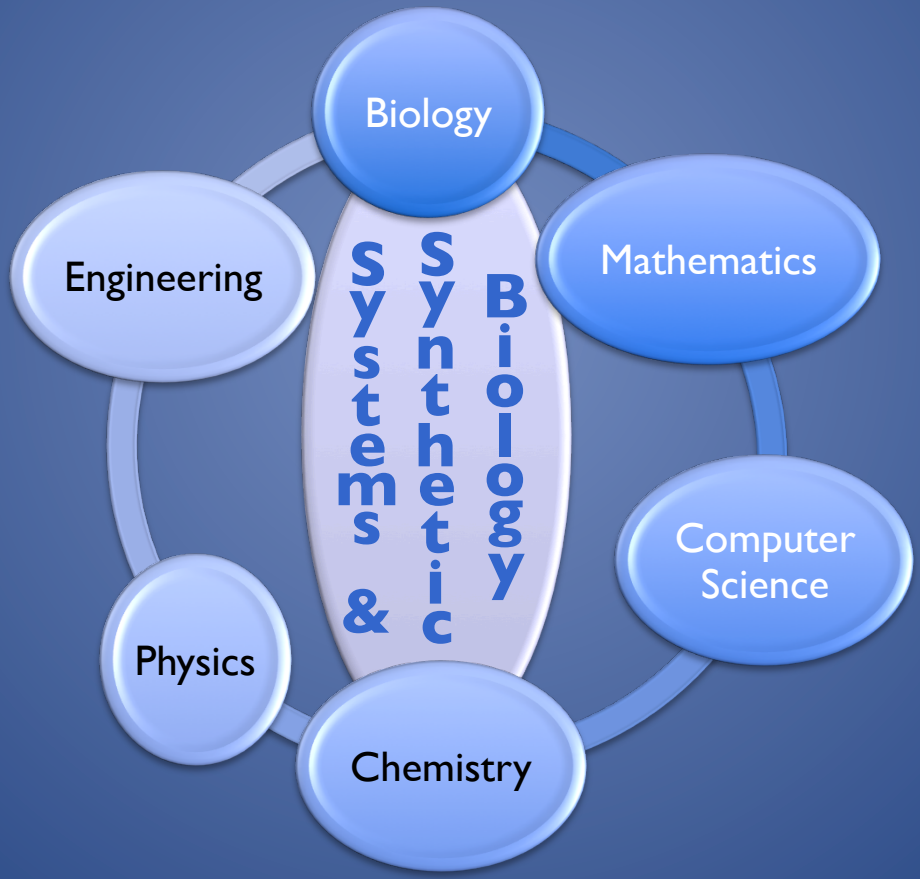
Systems Biology: Science of the systemic analysis of the dynamic and spatial behavior of networks of interactions among bio-molecules.

Synthetic Biology: the engineering of biology: the deliberate (re)design and construction of novel biological and biologically based systems to perform new functions for useful purposes, that draws on principles elucidated from biology and engineering (ERASynBio).

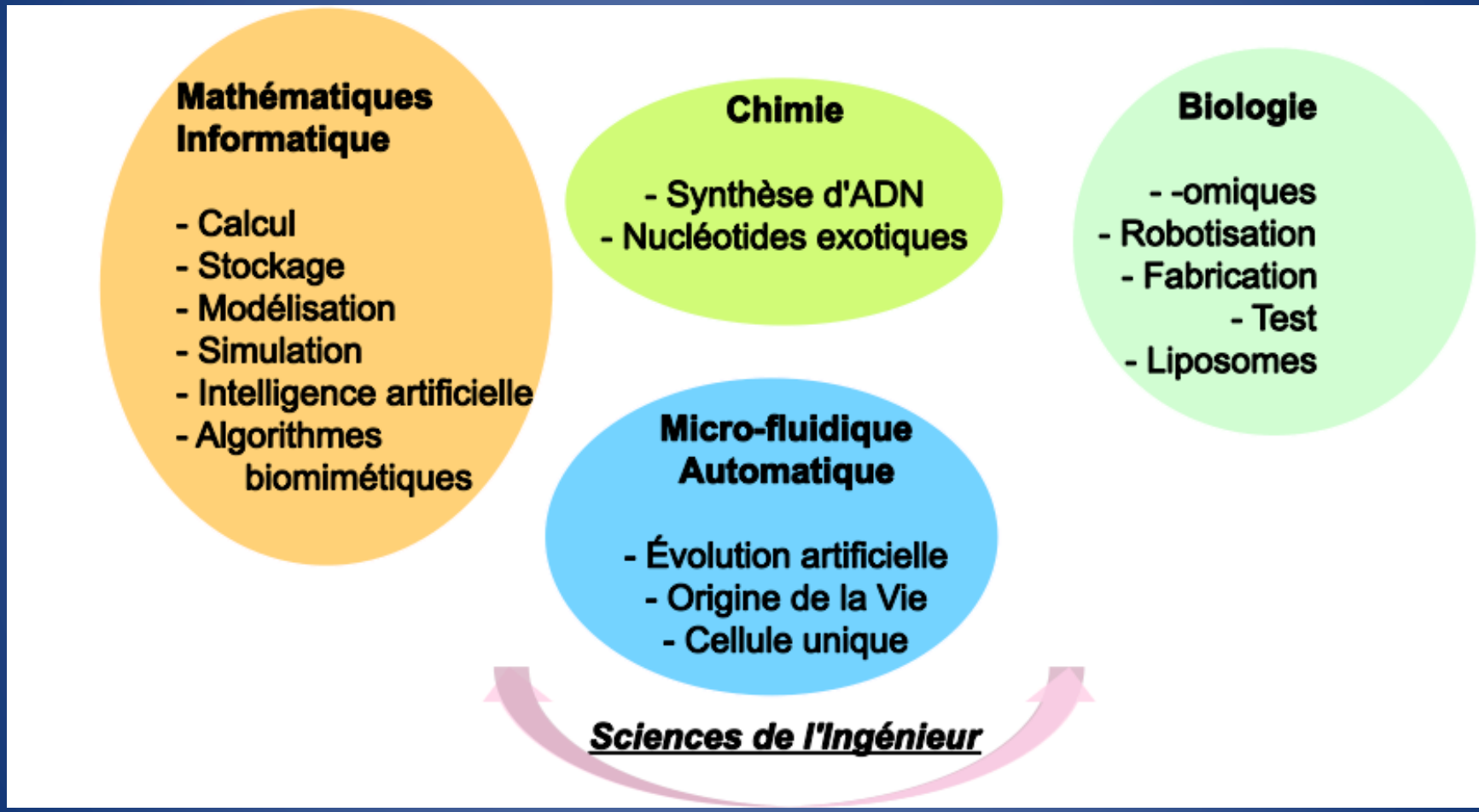
Coupling analytics and synthetics



Coupling disciplines



Emergence


Mathématiques
Informatique
- Calcul
- Stockage
- Modélisation
- Simulation
- Intelligence artificielle
- Algorithmes biomimétiques
Chimie
- Synthèse d'ADN
- Nucléotides exotiques
Biologie
- -omiques
- Robotisation
- Fabrication
- Test
- Liposomes
Micro-fluidique
Automatique
- Évolution artificielle
- Origine de la Vie
- Cellule unique
Sciences de l'Ingénieur

Perspective

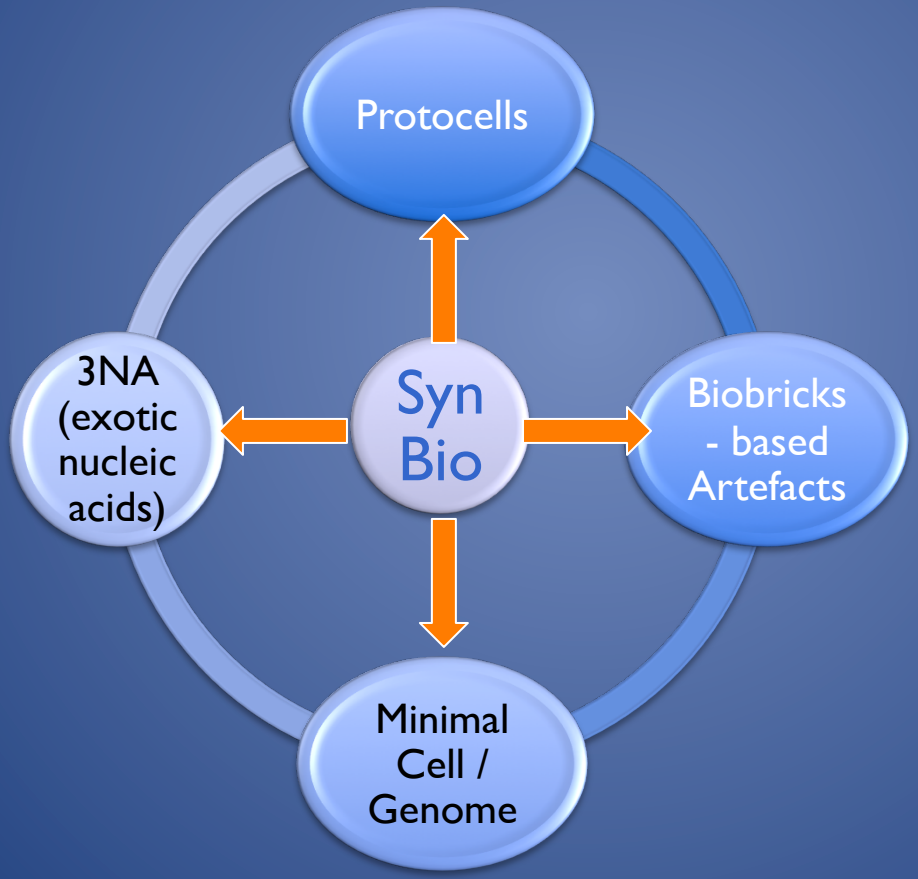
Synthetic Chemistry

Synthetic Biology

XX th Century

XXI th Century

Contents



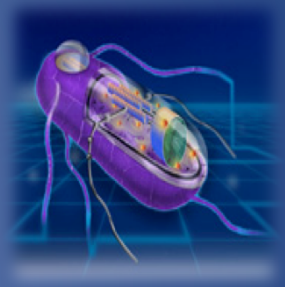
Synthetic Chemistry

Genetic Engineering

Design levels

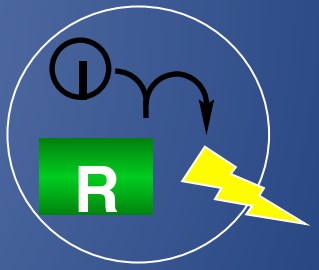
SYSTEMS

- Organism; Châssis; Nanomachine



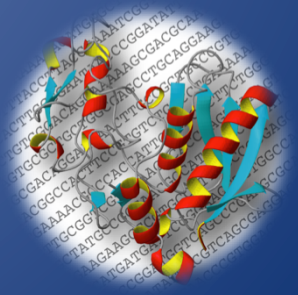
DEVICES

- Regulatory circuit; Metabolic pathway



BIO-BRICKS

- Protein; RNA



Minimal Cell / Genome: a deconstructivist scheme

CHASSIS

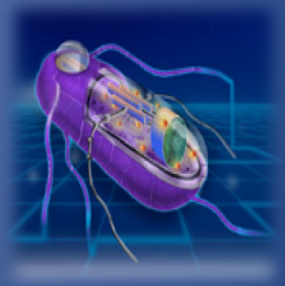
- A miniature factory or a live test tube

EPIGENOME

- A rationale conception

GENOME

- A full synthesis



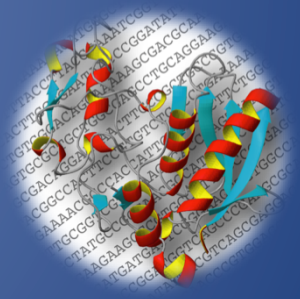
Artificial Life:
a more fundamental slant

PROTOCELLS

- Liposomes; Microfluidics; Artificial life

INNOVATIVE CHEMISTRIES

- Third-type nucleic acids; New aminoacids; New metabolisms



INFORMATION RECODING

- Genetic code; Gene expression code

Keywords

Standardization

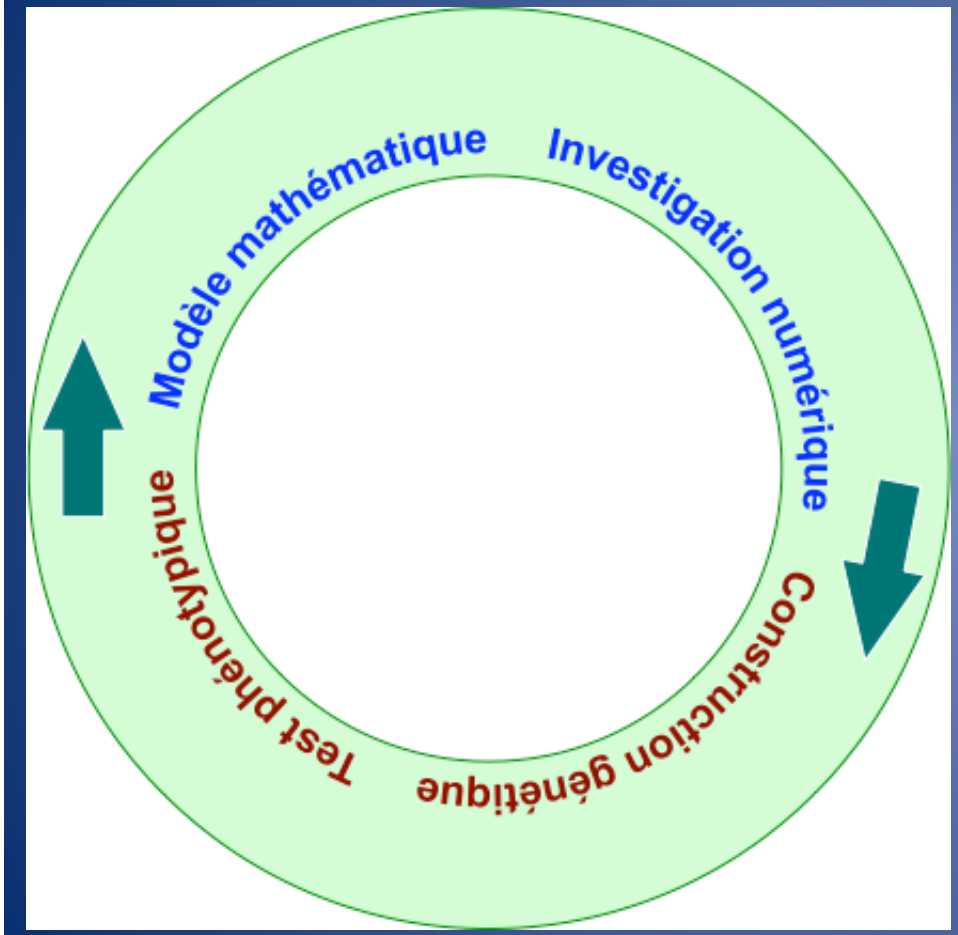
Re-utilization

Decoupling conception and fabrication

Orthogonality and modularity

Hierarchy

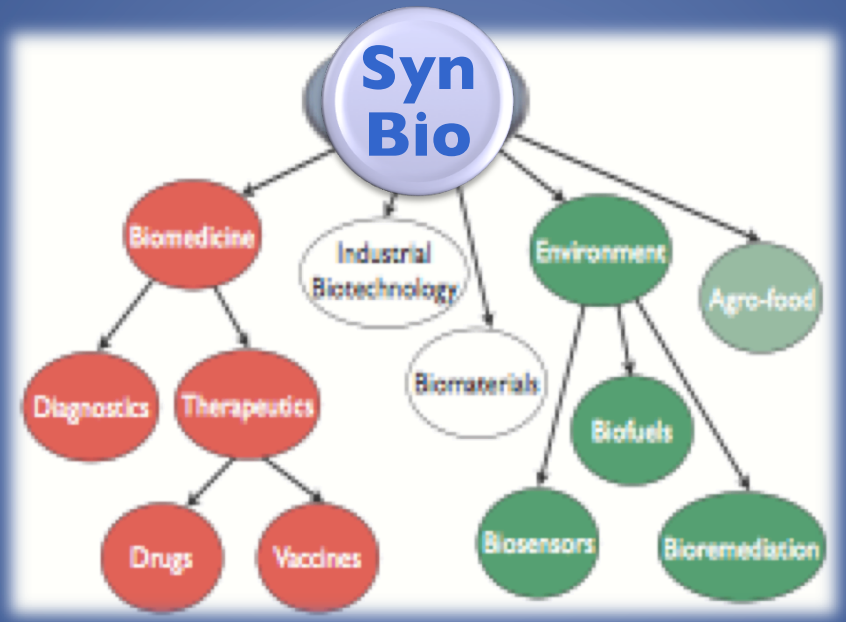
Engineering Biology?



The improvement spiral in synthetic biology repeats the cycle shown here, until satisfying the initial specifications.

Applications

in red, green, and white Biotechnologies



"A bioeconomy is an economic system in which biological resources like forests, agricultural and aquatic ecosystems provide not just food, feed and fibre, but also chemicals, energy and materials as well as environmental benefits such as green gas emission reductions."

The Versant™ diagnostics

Monitors 400 000 patients per annum, afflicted with 1 or 2 viral infections (AIDS and hepatitis)

Siemens®

A good example of collaboration between synthetic chemistry and synthetic biology

The Hydrocortisone drug

Anti-inflammatory drug.
Several hormones.

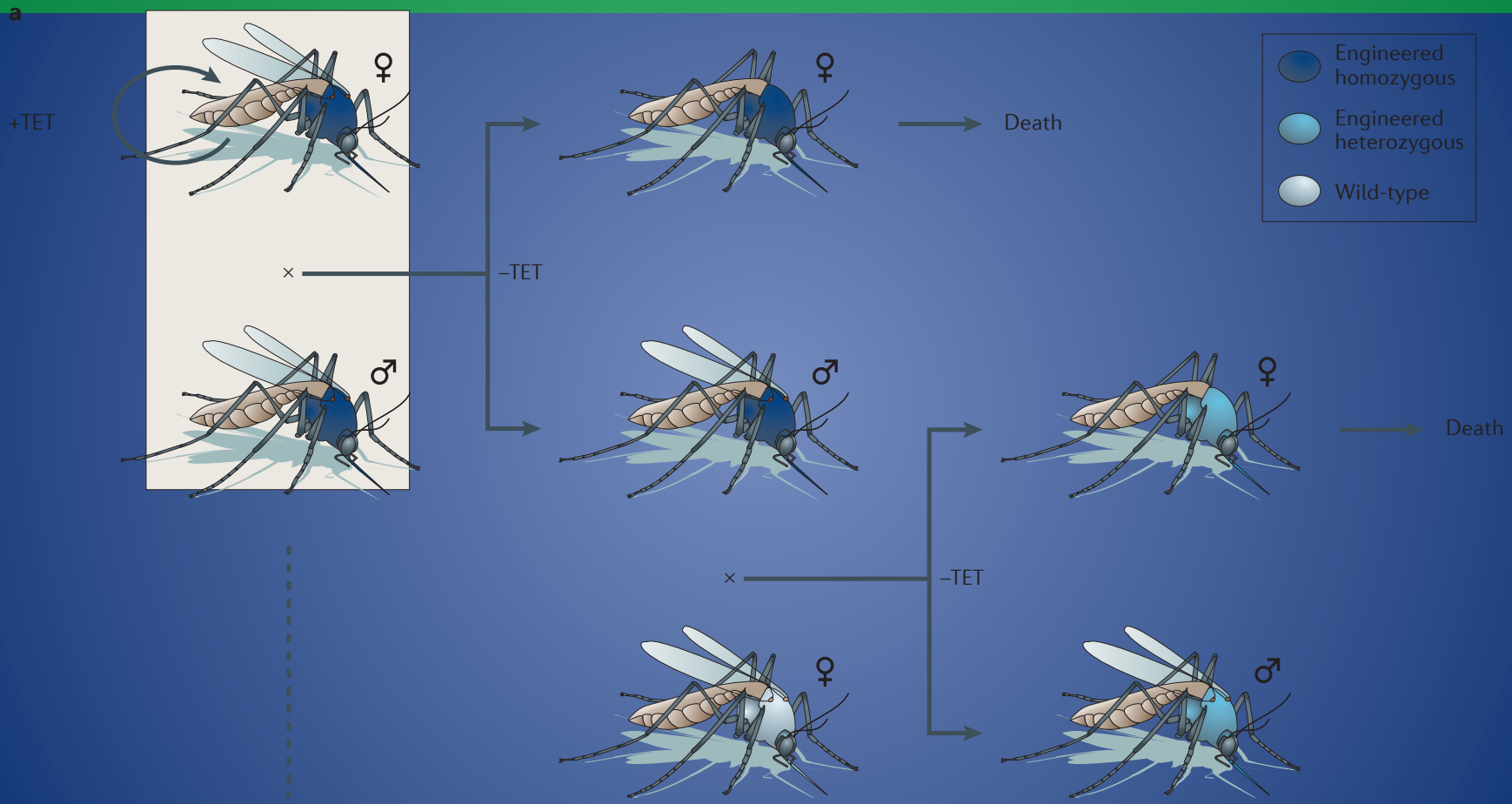
Sanofi – start production in 2015

The Artemisinin drug

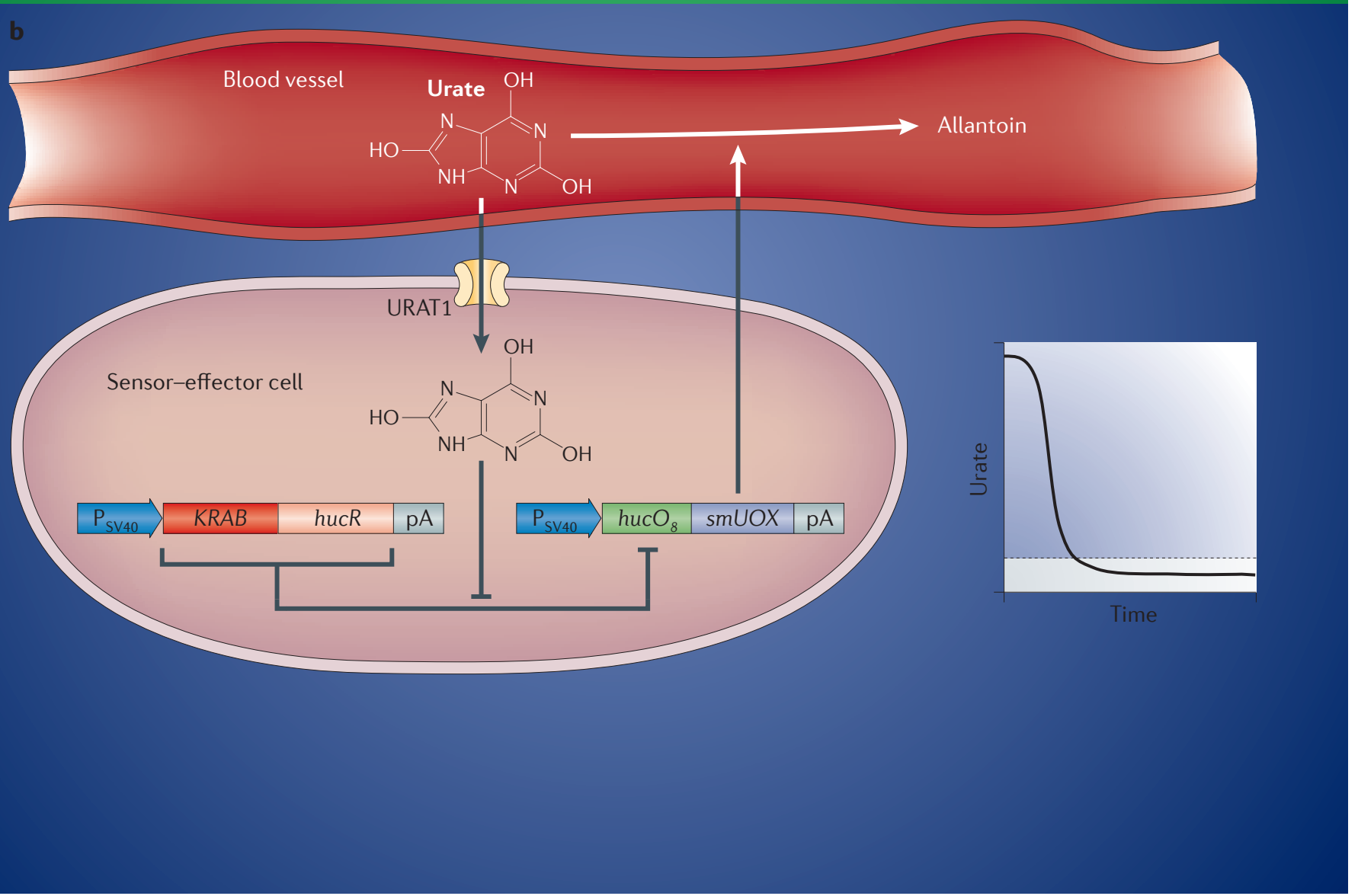
Anti-malaria drug.
Synthetic Biology allowed to decrease price and free from variability in quantity and quality.
Synthetic chemistry was not an option.

Amyris Technology (US), license to Sanofi – started production of 60 tons per year in 2013

Mosquitoe Control



Urate Homeostasis (gout)



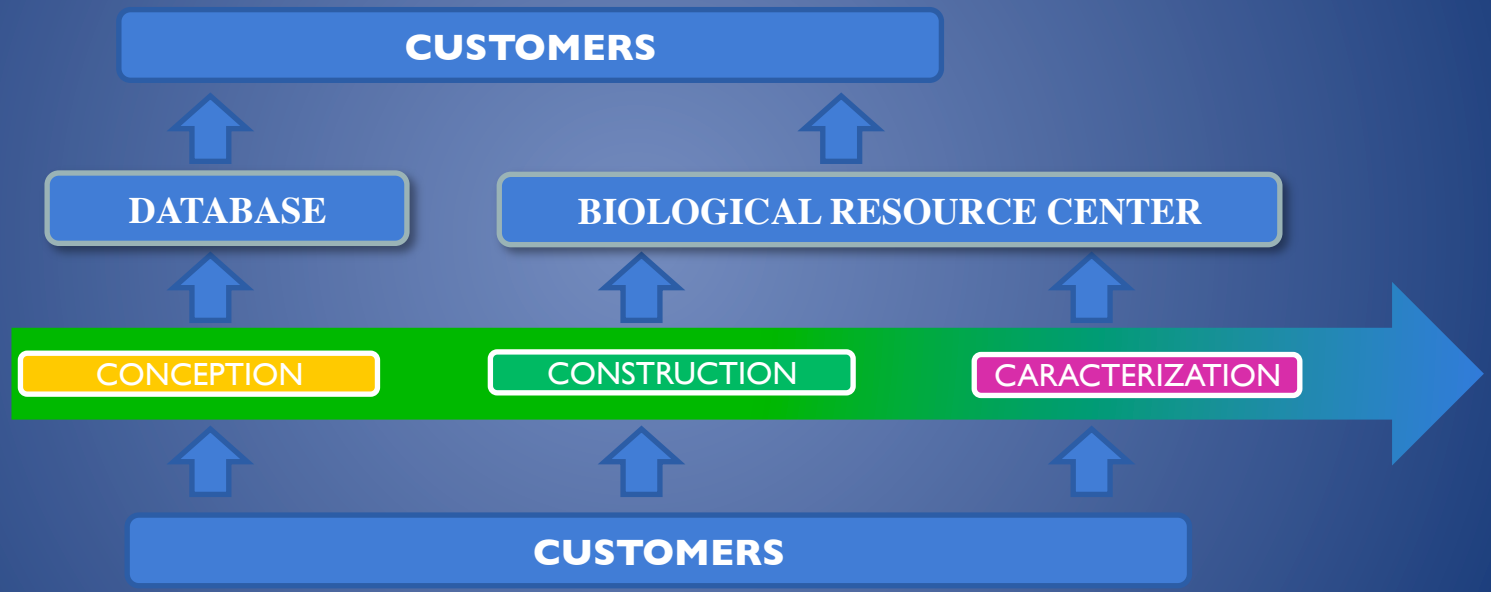
Other types of interventions in the biomedical domain

- Drug Discovery
- Cancer type classifiers
- Strategies for the control of the expression of mammalian genes (in gene therapy)

iSSB
Genopole®, CNRS, U. Evry

Platform

2009: Design
2010: Opening with regional funding
2011: Enlargment



***Partners*:**
Academic: Genoscope, URGV, …
Industrial: Imagene, Isthmus, Biométhodes, …
Technological: Genethon BRC, Genopole® Bioproduction Center, …

Laurent Jannière
Mohamed Elati
Laura Adam (co-VirginiaTech)
Thibaut Lepage
Brian Jester
Costas Bouyioukos
Romain Bodinier
Charles Winterhalter
Jacopo Bertolini
Noémie Brisemeur
Rémy El Halaby
Jorgelindo Da Veiga Moreira
Konstantinos Koutroumpas
François Képès

the MEGAlomaniacs

NIDDK / NIH
Ann Dean
Ryan Dale

Collaborations

The problem at hand

Bioproduction of non-proteic molecules

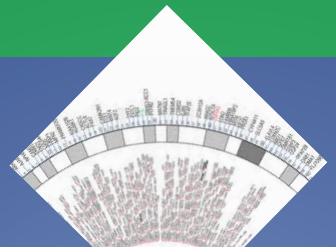
- State of the art: 10-14 enzymes in production pathway (100 person-year, 10 years, 30 M$)
- Long trial-and-error process – not rationalized
- Production triggered by several stimuli
- Production strains not robust for scale-up

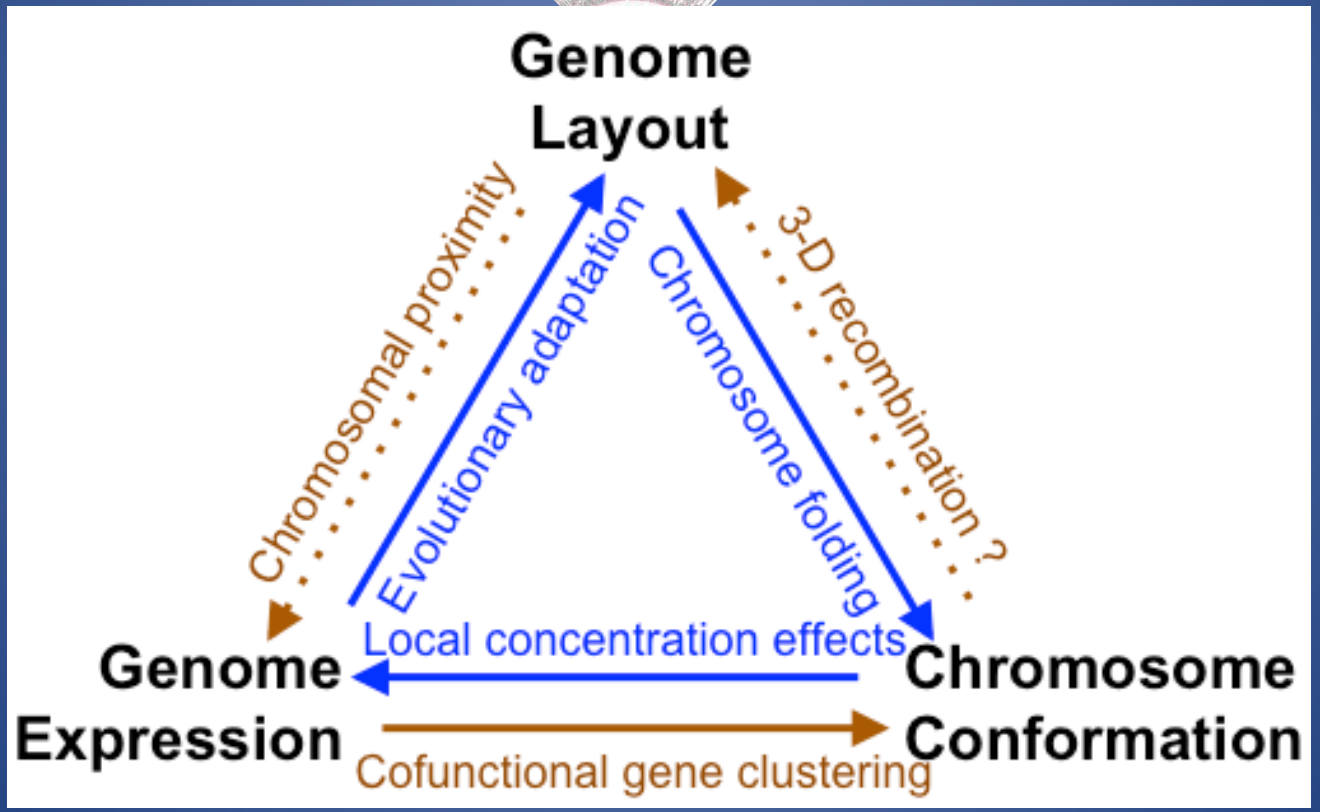
The (potential) solution at hand

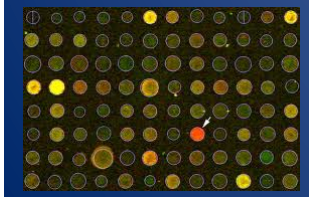
Bioproduction of non-proteic molecules

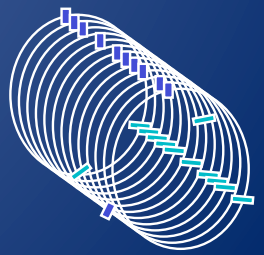
- Rational conception of microbial genomes
- Break ceiling of maximal number of co-regulated genes
- Intense, single-stimulus triggering of gene co-regulation
- Work directly on main chromosome, not episomes

Layout, Conformation and Expression



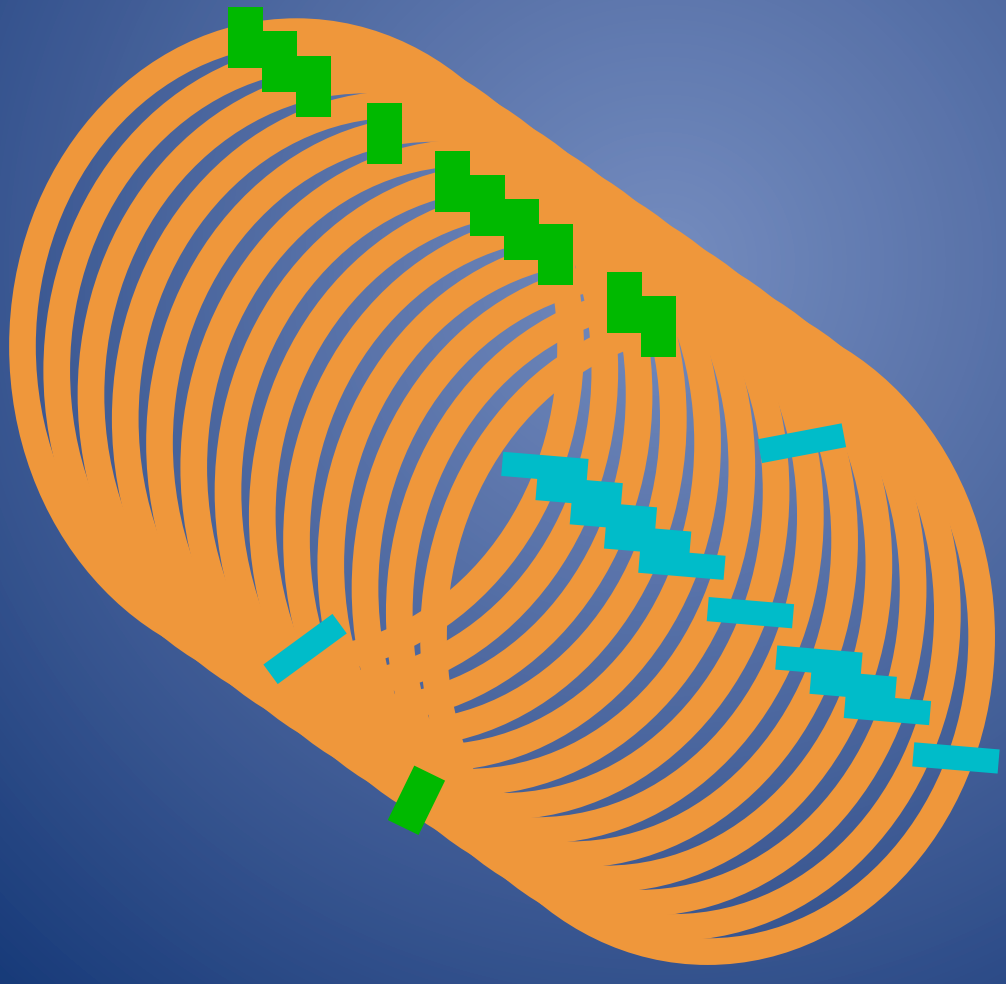


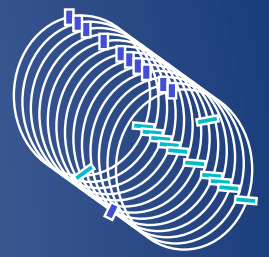


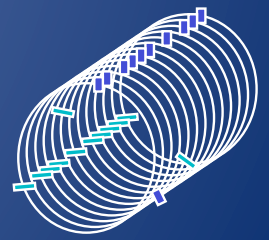


The cofunction-based solenoidal model of chromosomes

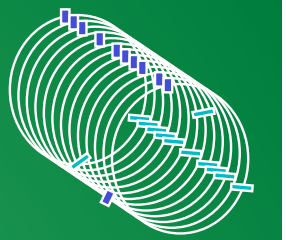
Is there a collective transcriptional scheme in cells?







Thank you !



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dépasser les frontières

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