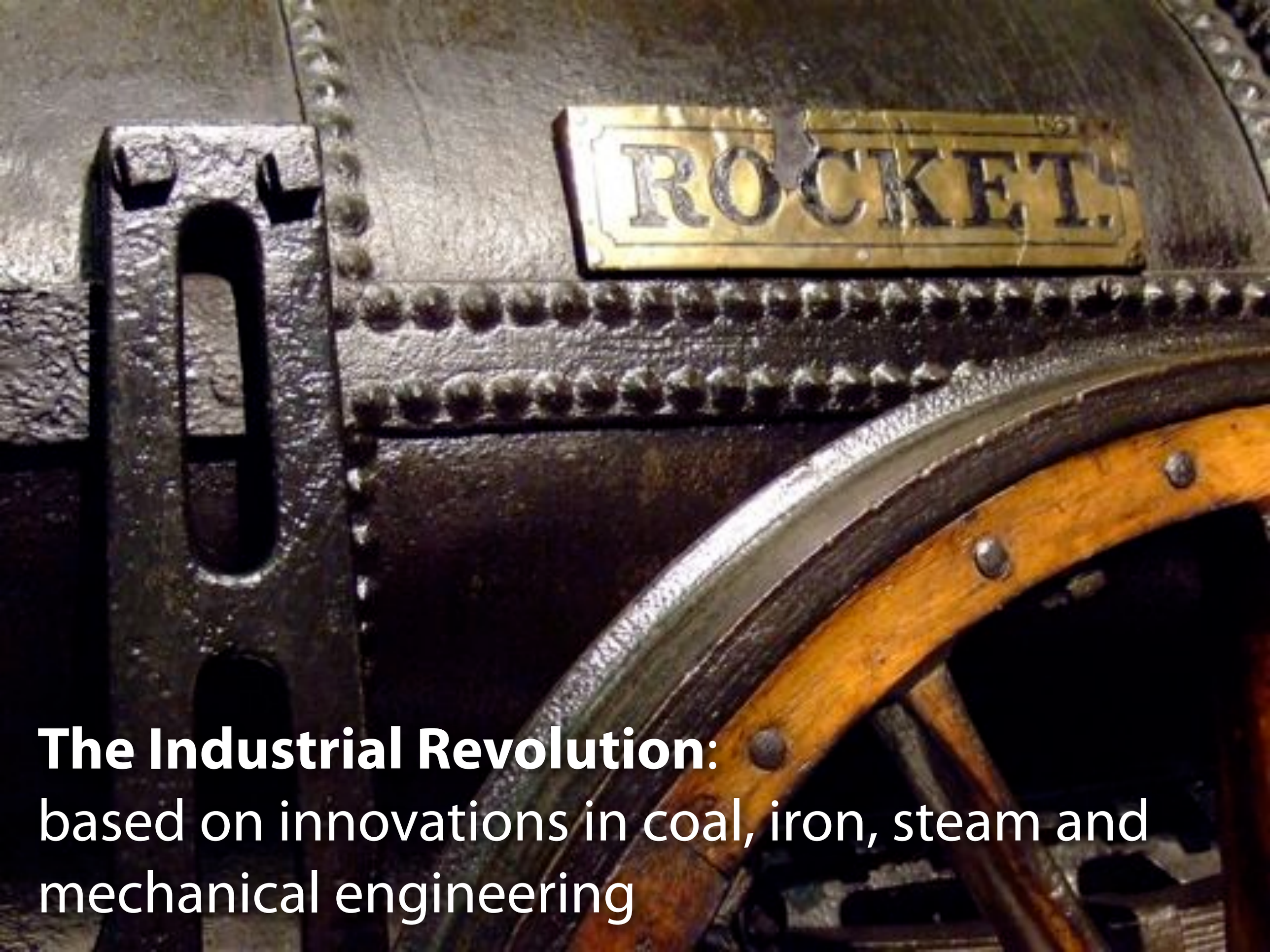
Synthetic Biology

syn·thet·ic [sin-**thet**-ik] –adjective

1. Prepared or made artificially, not of natural origin.

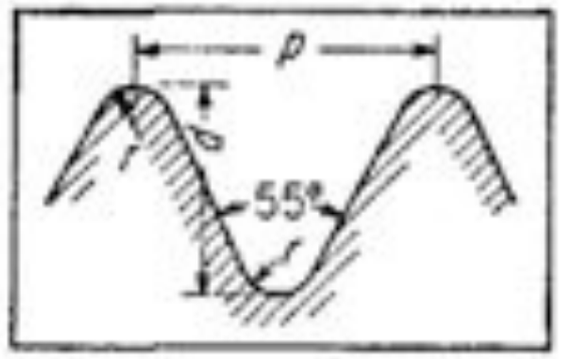
2. Relating to, or involving synthesis
(construction of a coherent whole from separate elements)



The Industrial Revolution:
based on innovations in coal, iron, steam and mechanical engineering

Standardisation of parts for construction


THE
LONDON JOURNAL
OF
Arts and Sciences;
AND
REPERTORY
OF
PATENT INVENTIONS.



"On an uniform system of Screw Threads."

By Joseph Whitworth, Assoc. Inst. C. E.

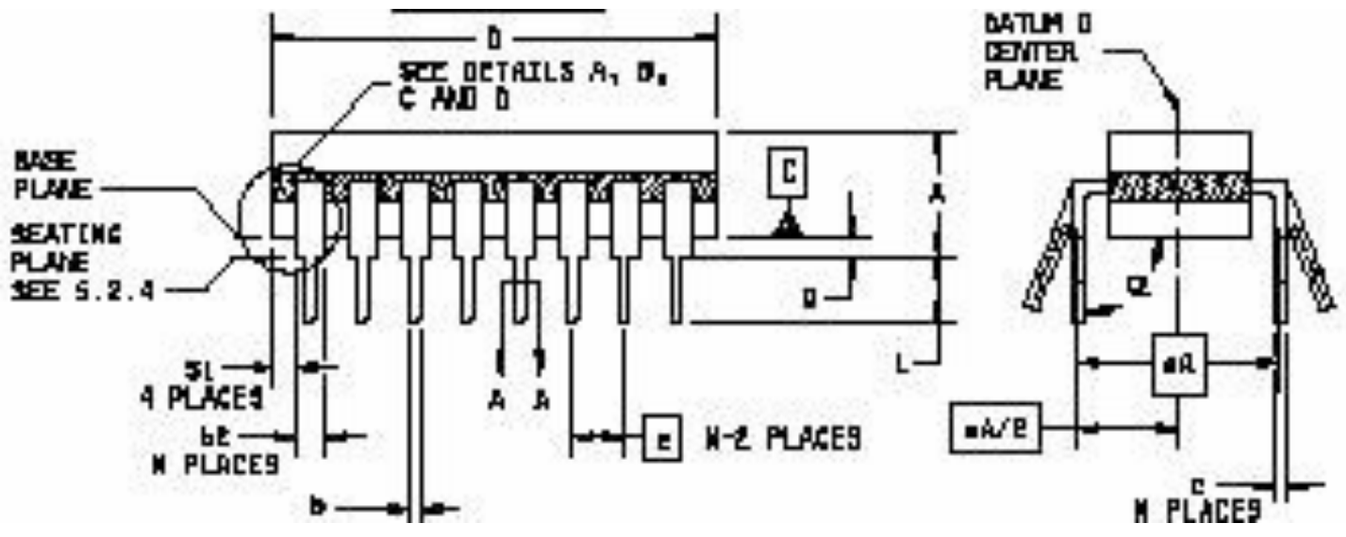
The subject considered in this paper, is the importance of having a constant thread for a given diameter in all screws used in fitting up steam engines and other machinery. It is argued, that uniformity of thread would be productive of economy, both in the use of screwing apparatus, and in the consumption of bolts and nuts. The refitting shop of a railway or steam packet company, affords a striking instance of the advantage to be derived from the application of this principle. If the same system of screw threads were common to the different engines, a single set of screwing tackle would suffice for any repairs.

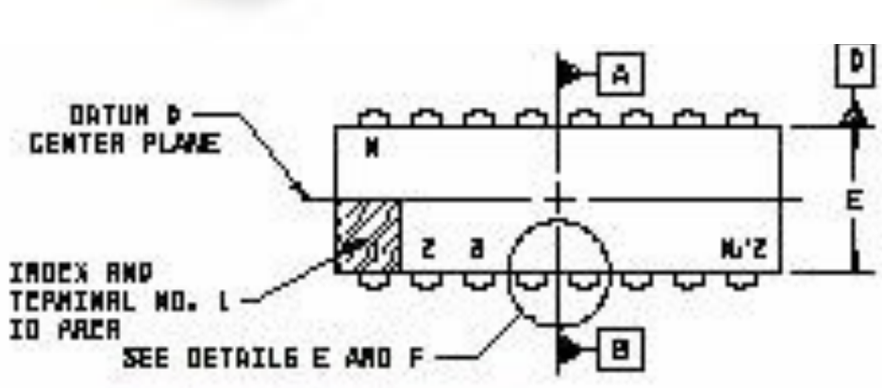
No attempt appears to have been hitherto made to attain this important object. Engineers have adopted their threads without reference to a common standard. Any such standard must be in a great measure arbitrary, and hence its absence may be accounted for.

Joseph Whitworth 1842

Interchangeable parts led to continuous production methods

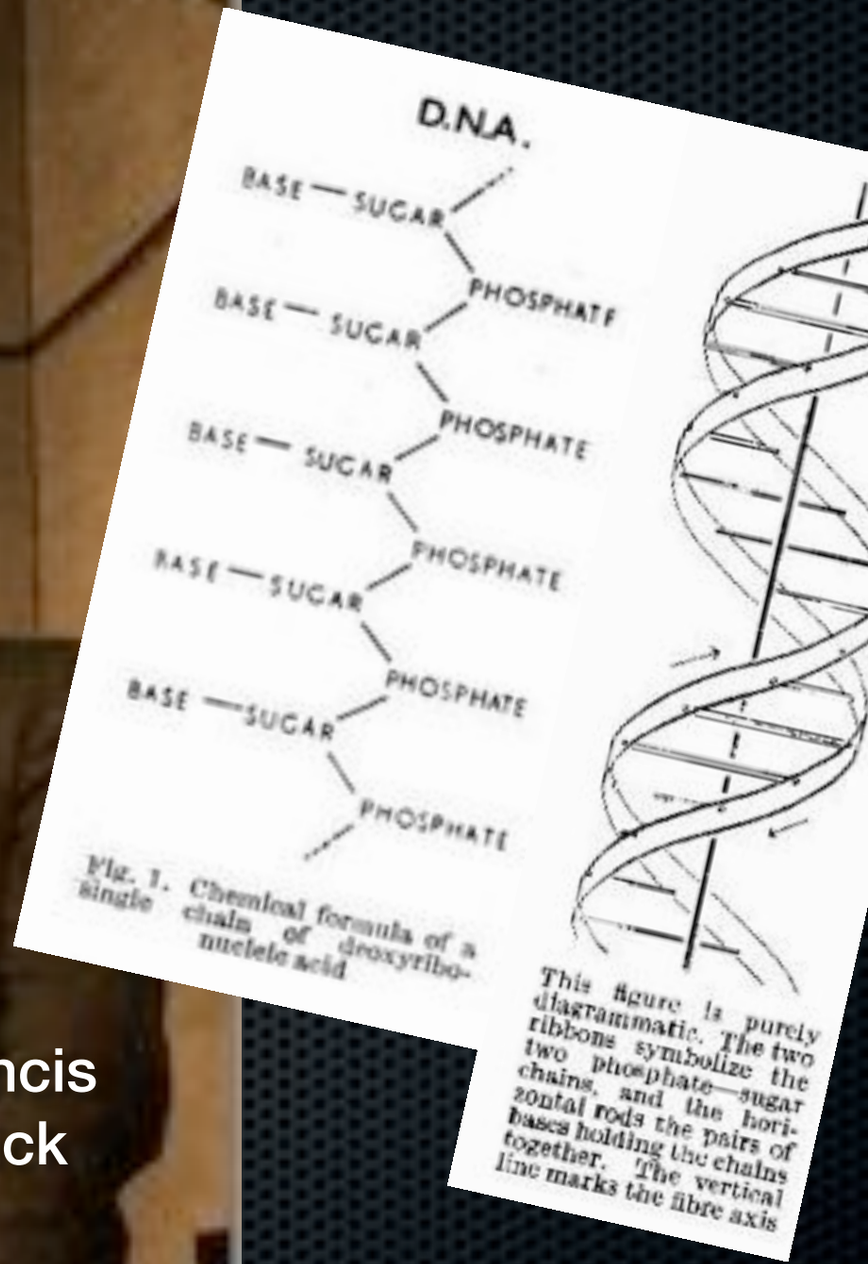
Standardisation of parts for digital electronics





Standard mechanical and electrical interfaces were established for integrated devices by the early1960's, and form the basis for today's microelectronics industry

Meanwhile, in biology...



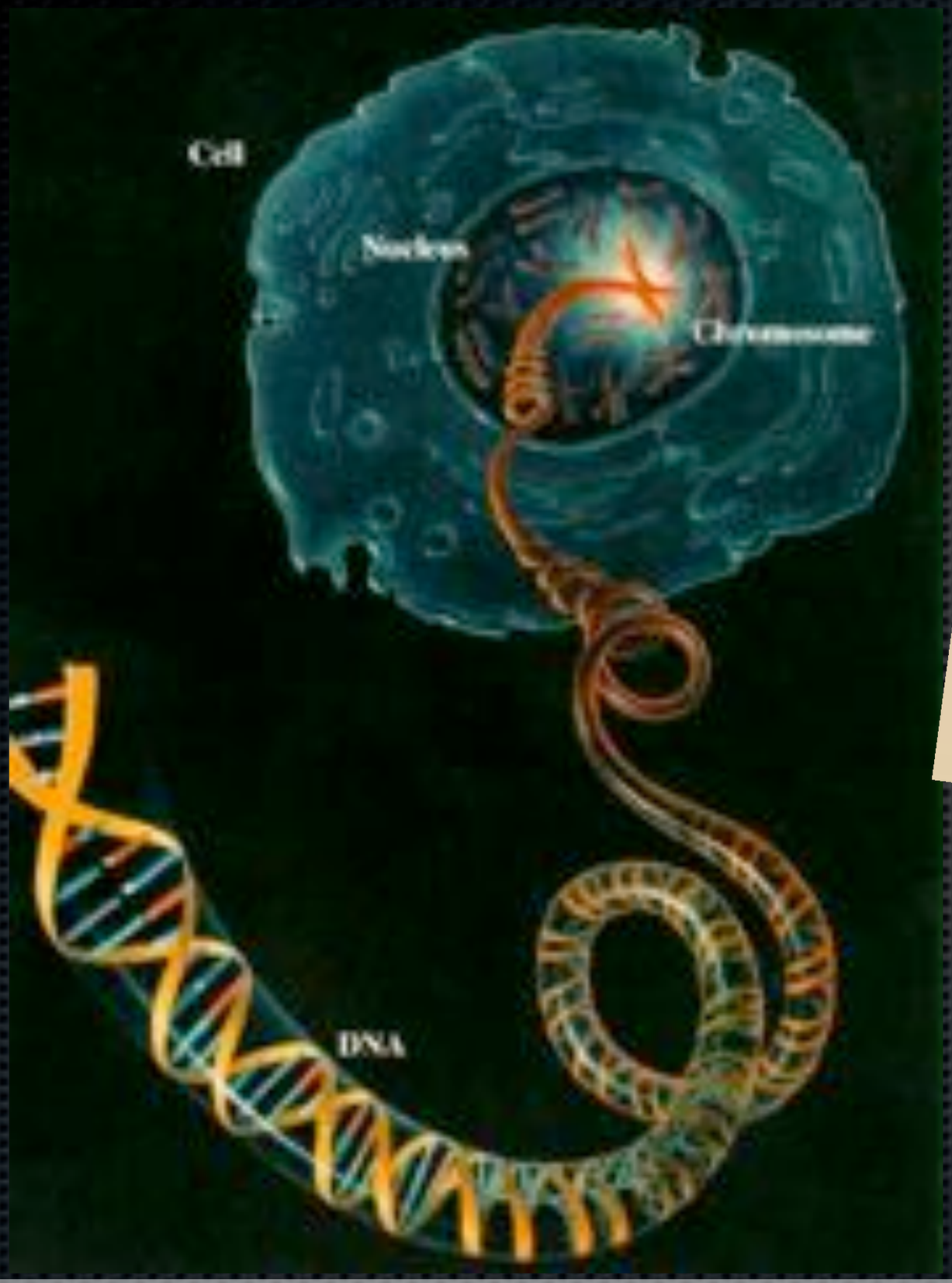
James Watson

Francis Crick

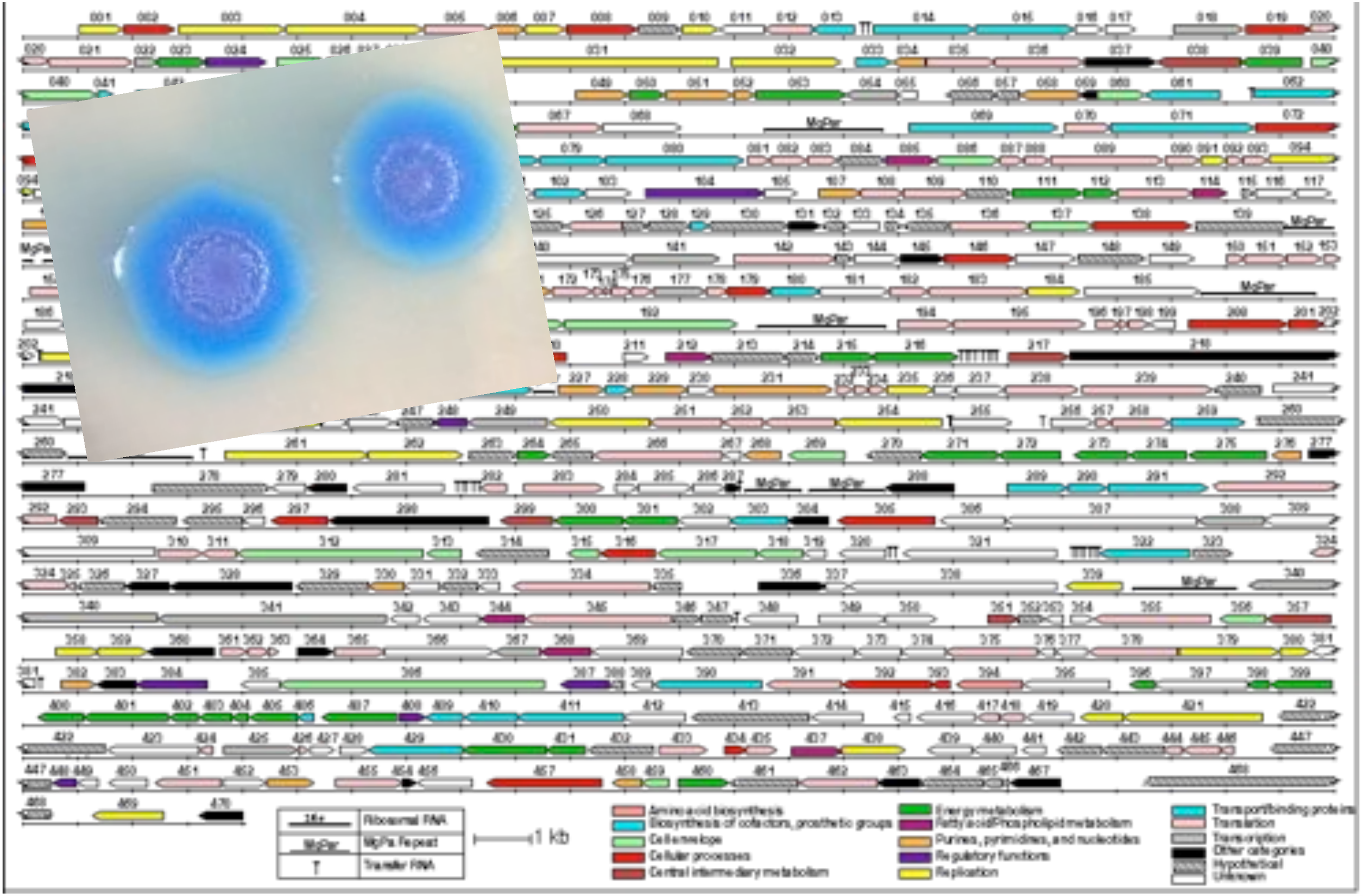
1953 - discovery of the structure of DNA...

Fred Sanger

1975 - invention of DNA sequencing methods...



2001 - sequencing of the human genome...

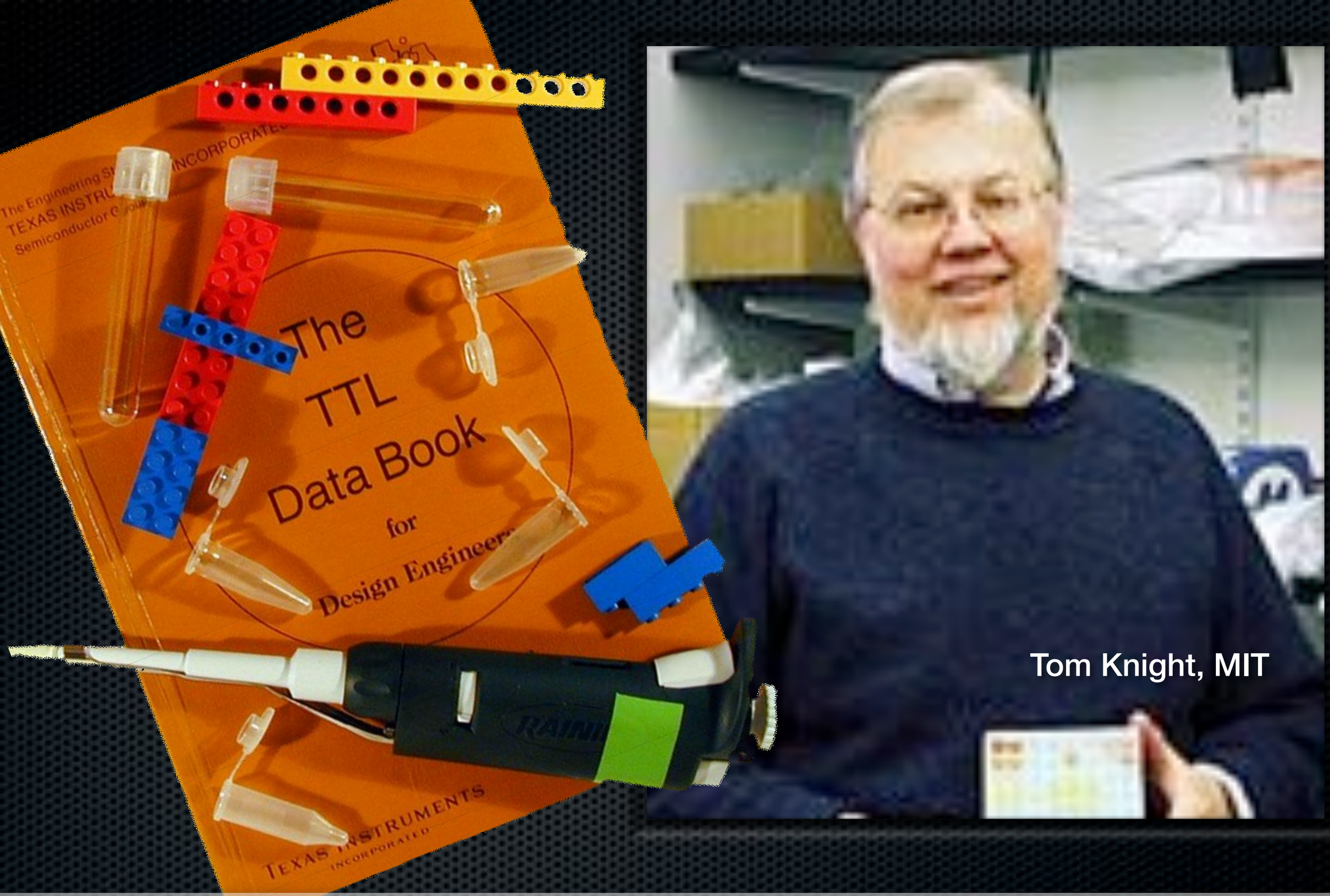


2008 - DNA synthesis of the first bacterial genome...

19th Century: Harnessing Energy
20th Century: Information Flow
21st Century: Assembly of Matter

Promise of biologically driven systems for refinement, conversion and assembly of matter for low-cost manufacturing.

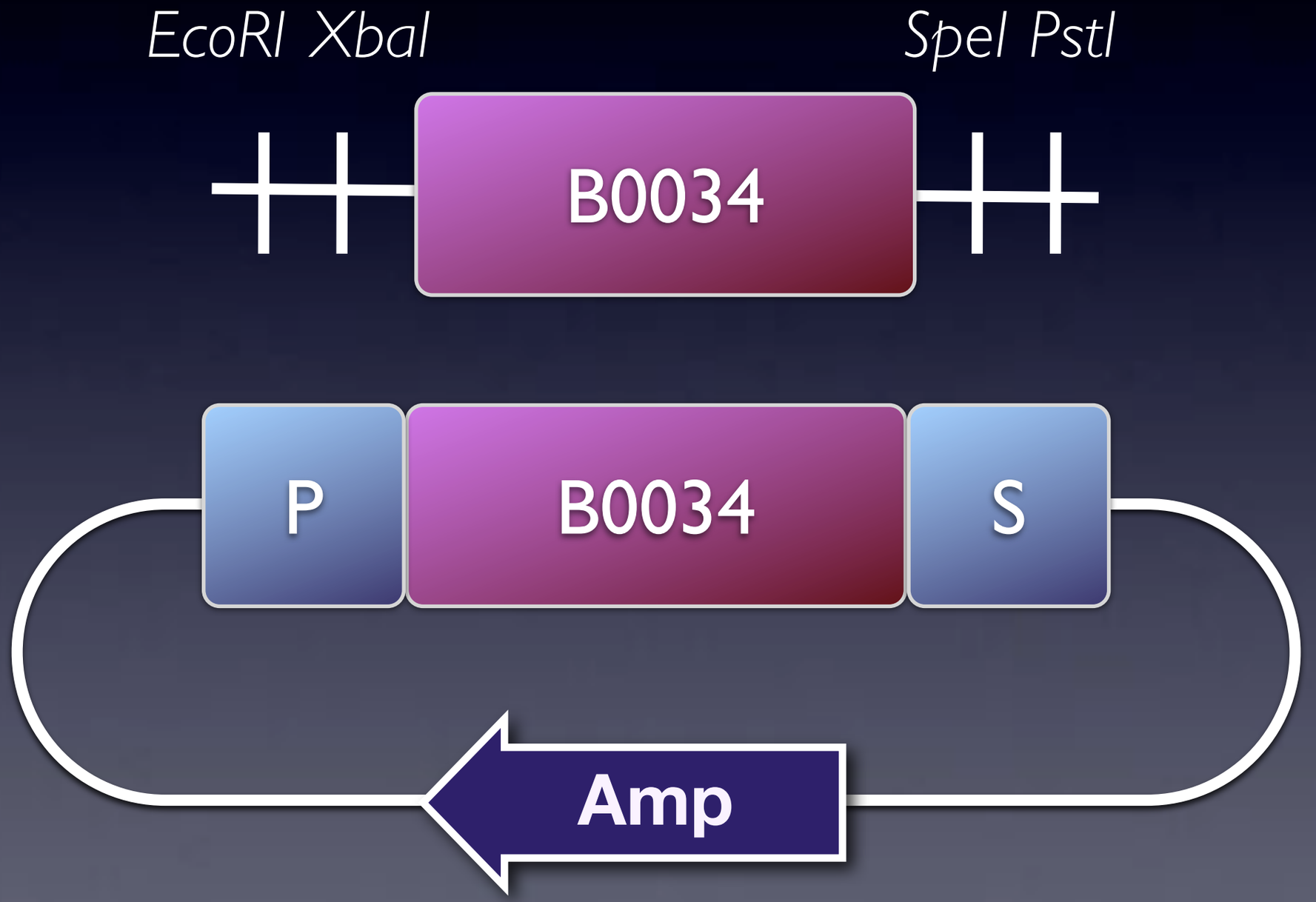
(after Tom Knight, MIT & Ginkgo BioWorks)



Invention of standardised parts for biology...

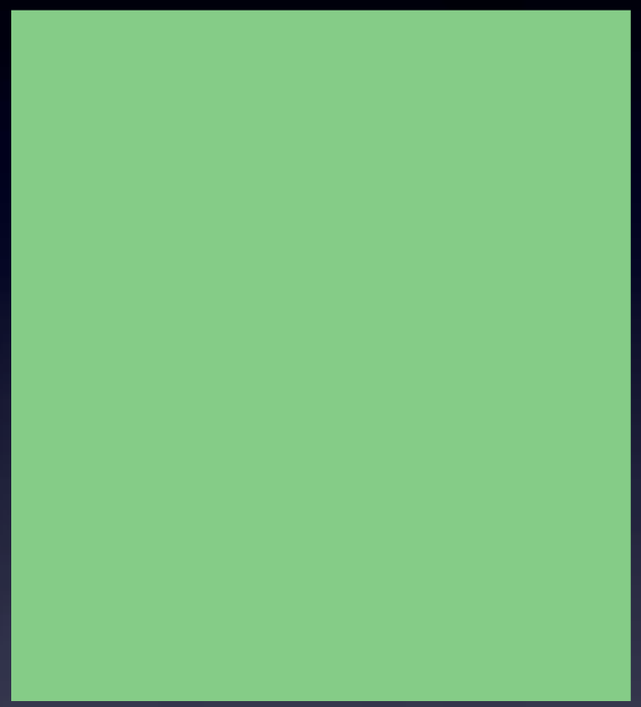
BioBricks

Standardised, interchangeable parts for Biology



Abstraction

Insulate relevant characteristics from process from excessive details



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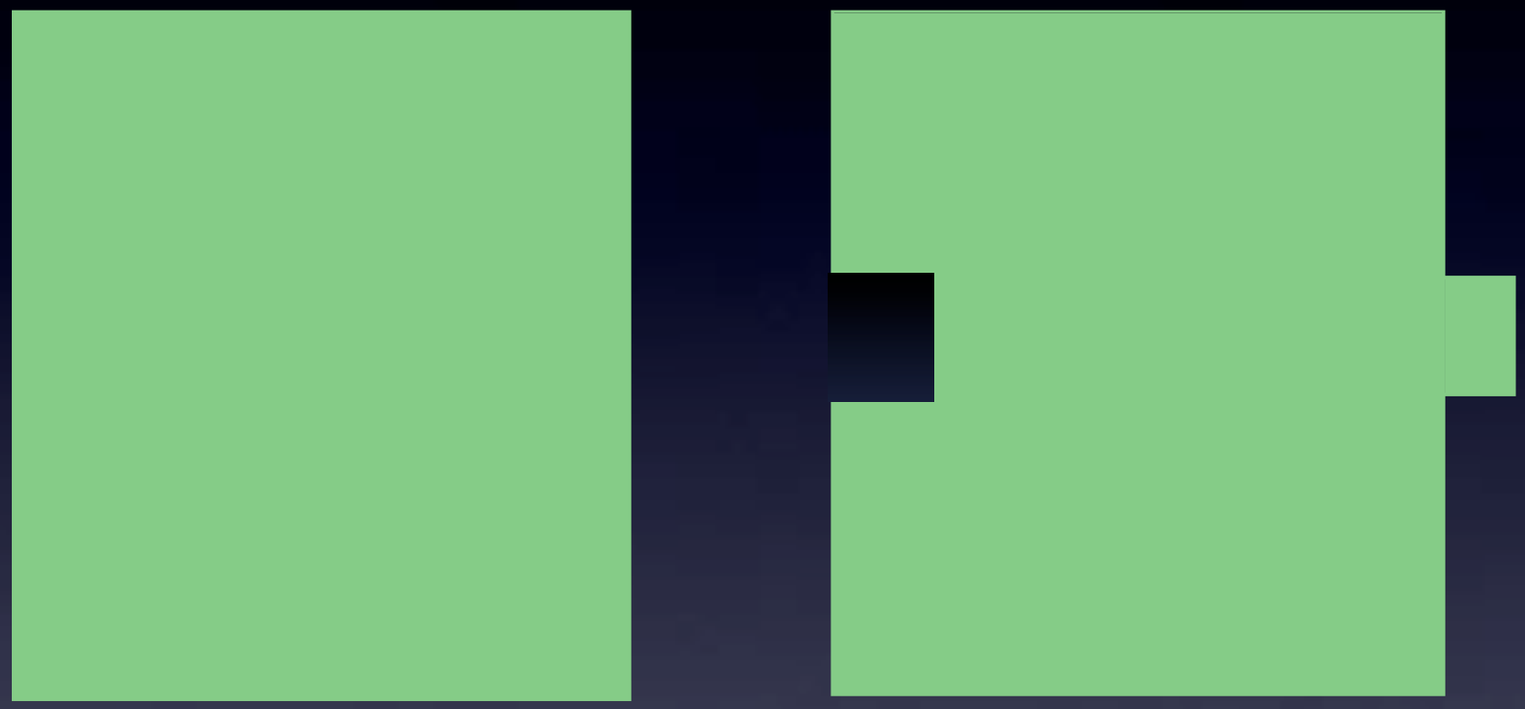
Standardisation

Construction from “off the shelf” parts with known characteristics



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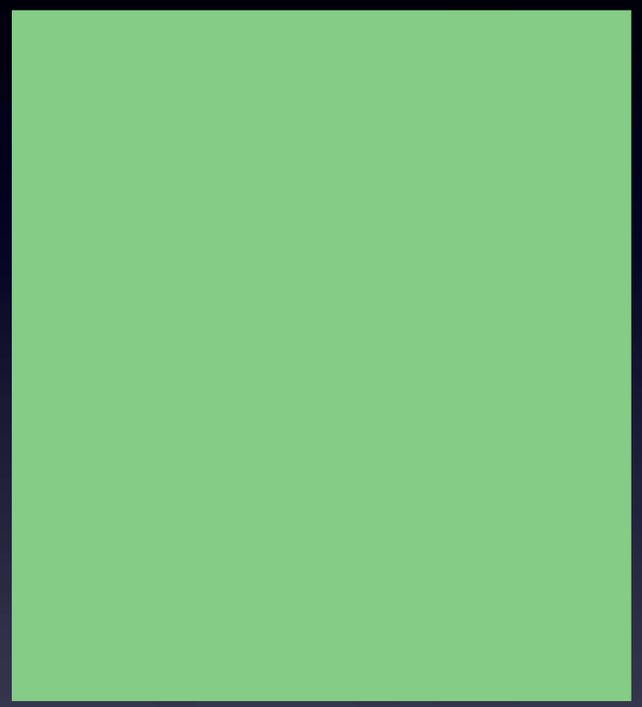
Decoupling

Insulate design process from fabrication details



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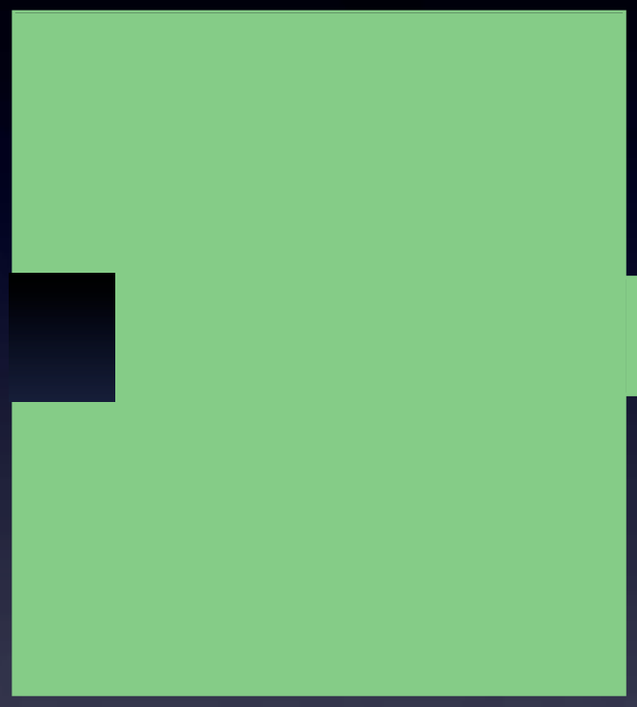

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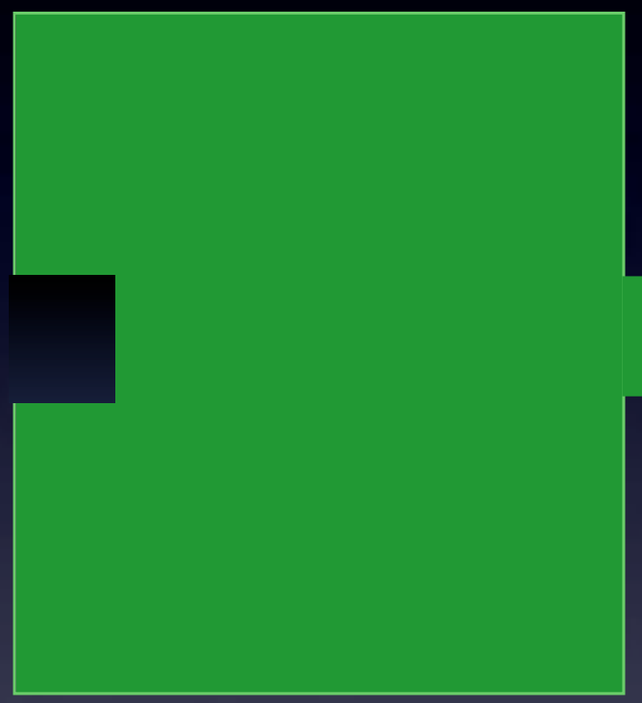

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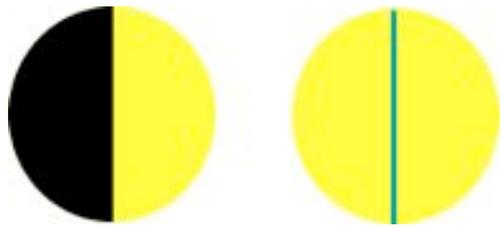
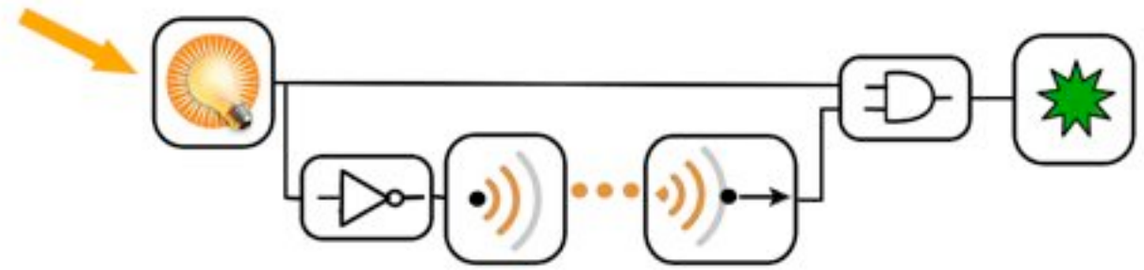
BioBricks for the construction of new genetic systems

Applications

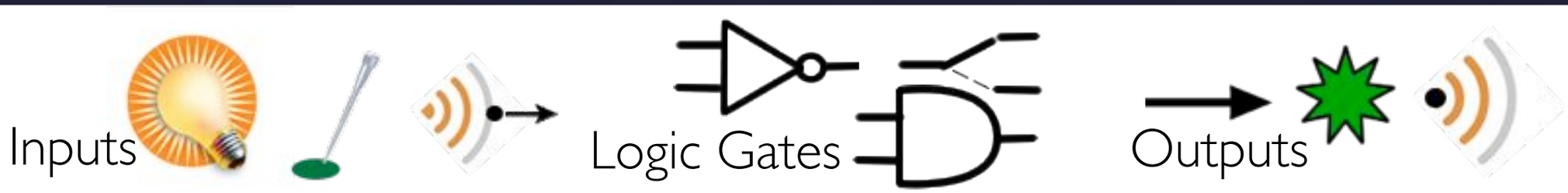


Systems



IF dark
    signal-out
ELSEIF (signal-in AND light-in)
    MAKE Pigment

Devices



Parts

DNA

ATGCTTACCGGTACGTTTACGACTACGTAGCTAGCAT
GCTTACCGGTACGTTTACGACTACGTAGCTAGCATG
CTTACCGGTACGTTTACGACTACGTAGCTAGCATGCT
TACT…

iGEM Genetically Engineered Machine competition

2004: 6 teams
2005: 13 teams
2006: 37 teams
2007: 60 teams
2008: 83 teams
2009: 112 teams
2010: 130 teams

The iGEM2009 Cambridge team produced novel pigment systems for biosensors

Multispectral pigments

7.5 kb synthetic operon for violacein production

Bioluminescence

Cambridge iGEM2010 team: www.cambridgeigem.org

Application of Synthetic Biology

1. Cell autonomous genetic circuits with self-regulating properties

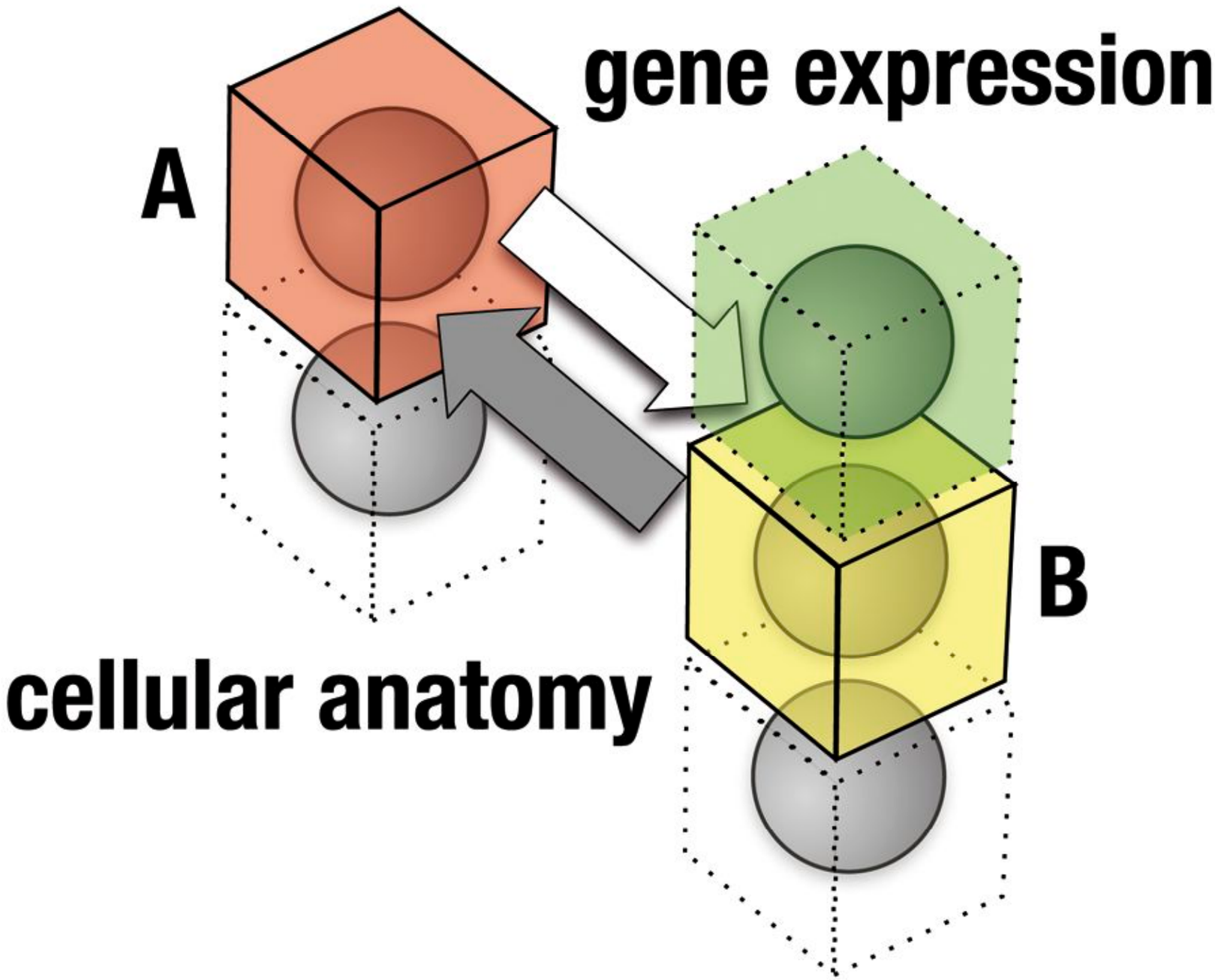
e.g. microbial engineering,
enviromental and biomedical sensors
engineering novel metabolic pathways

2. Morphogenetic circuits with self organising properties

e.g. microbial biofilms or self-organising communities for
bioremediation and bio catalysis
novel plant and algal feedstocks for bioproduction and bioenergy
tissue engineering

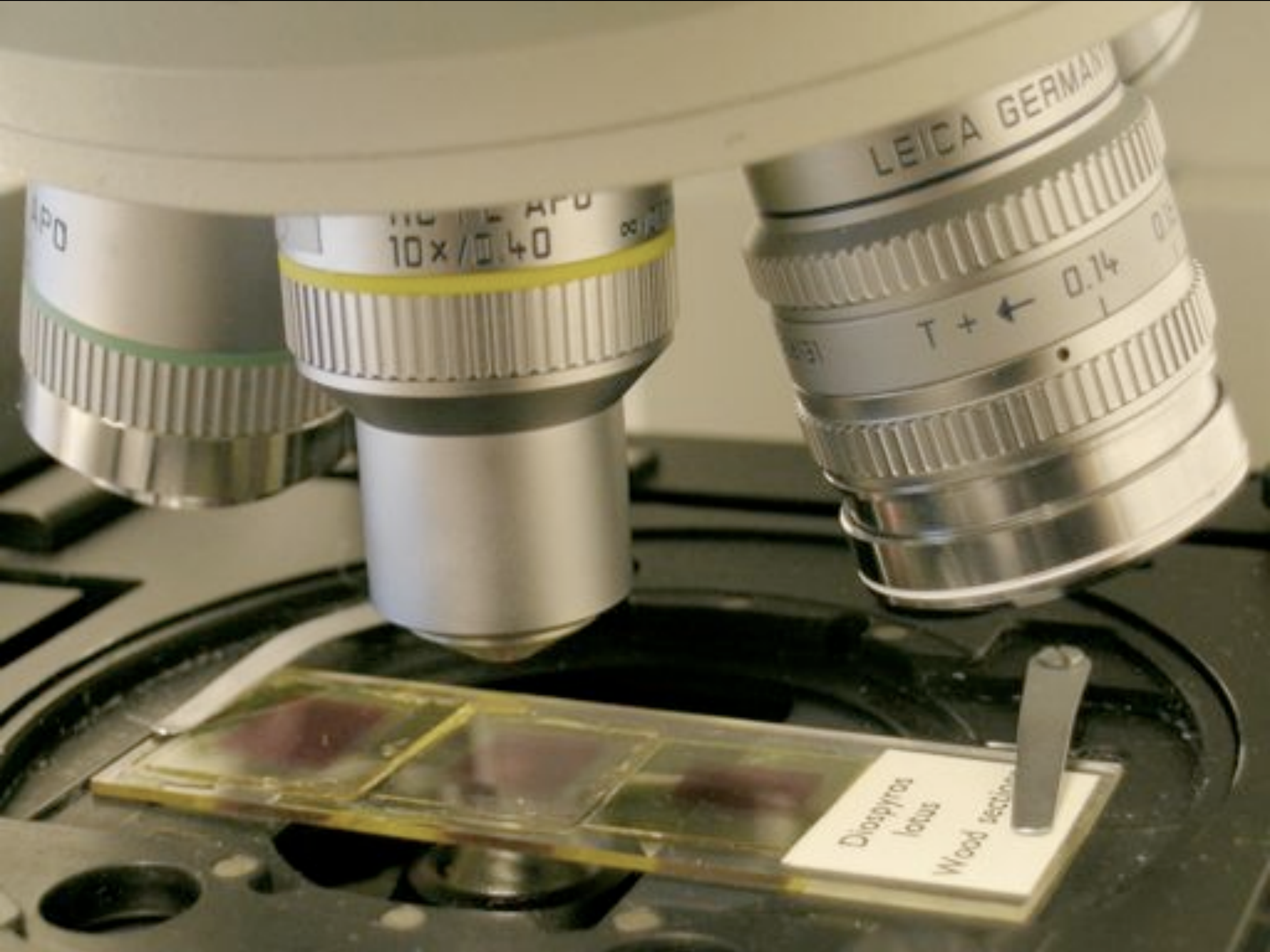
BBC

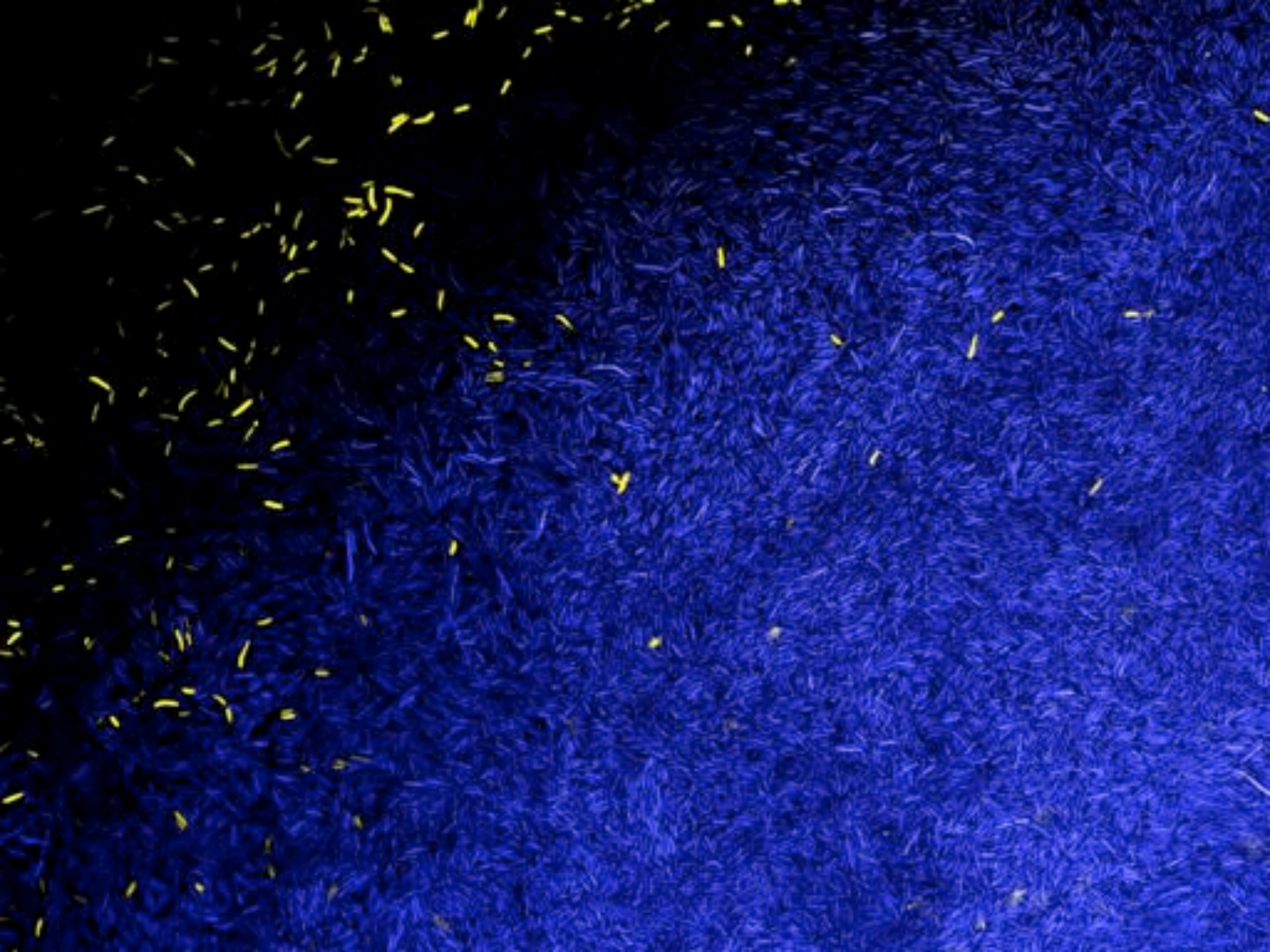
Self-organisation and morphogenesis result from feedback between highly parallel genetic and physical systems



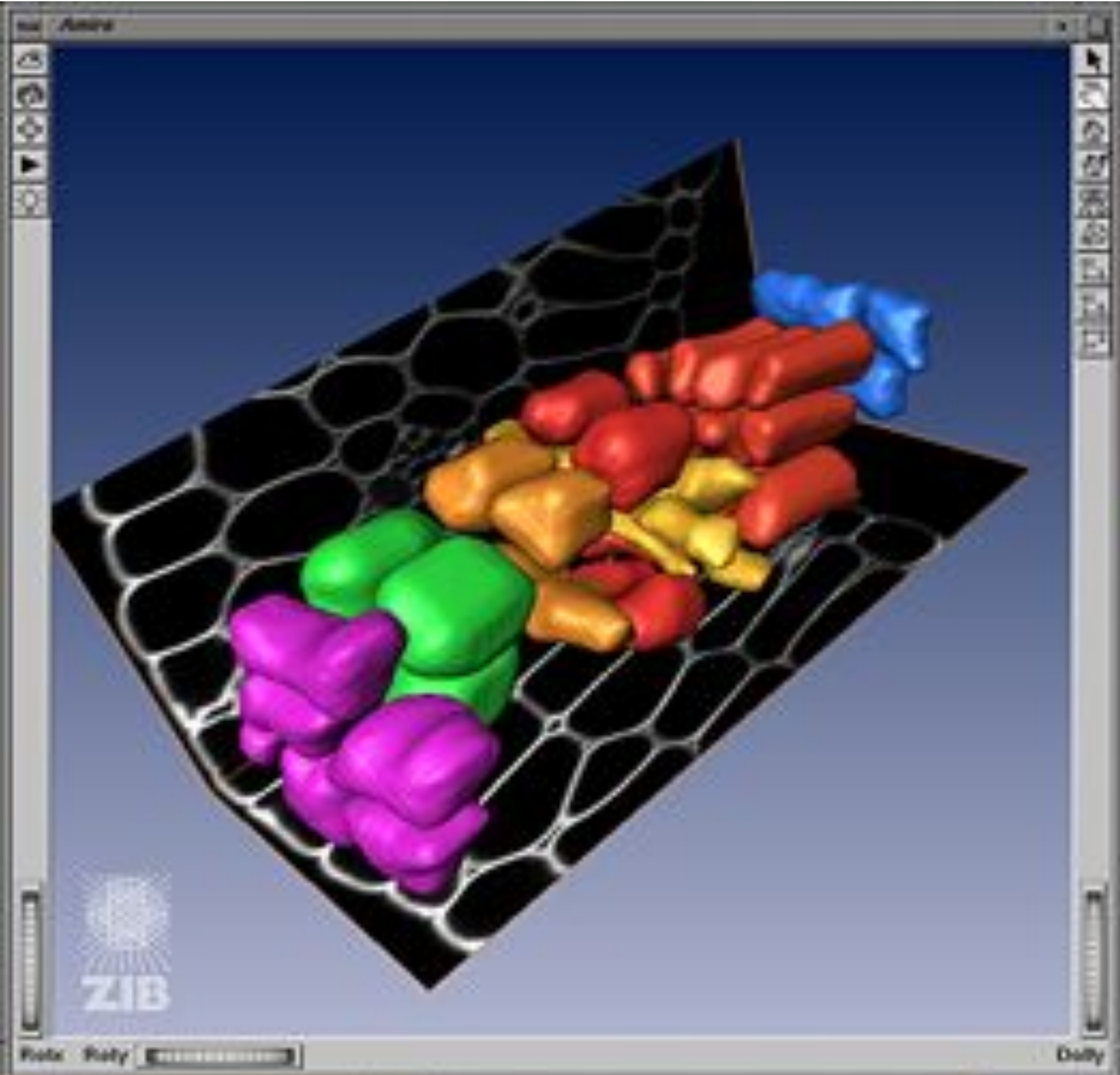
Engineering self-organising systems

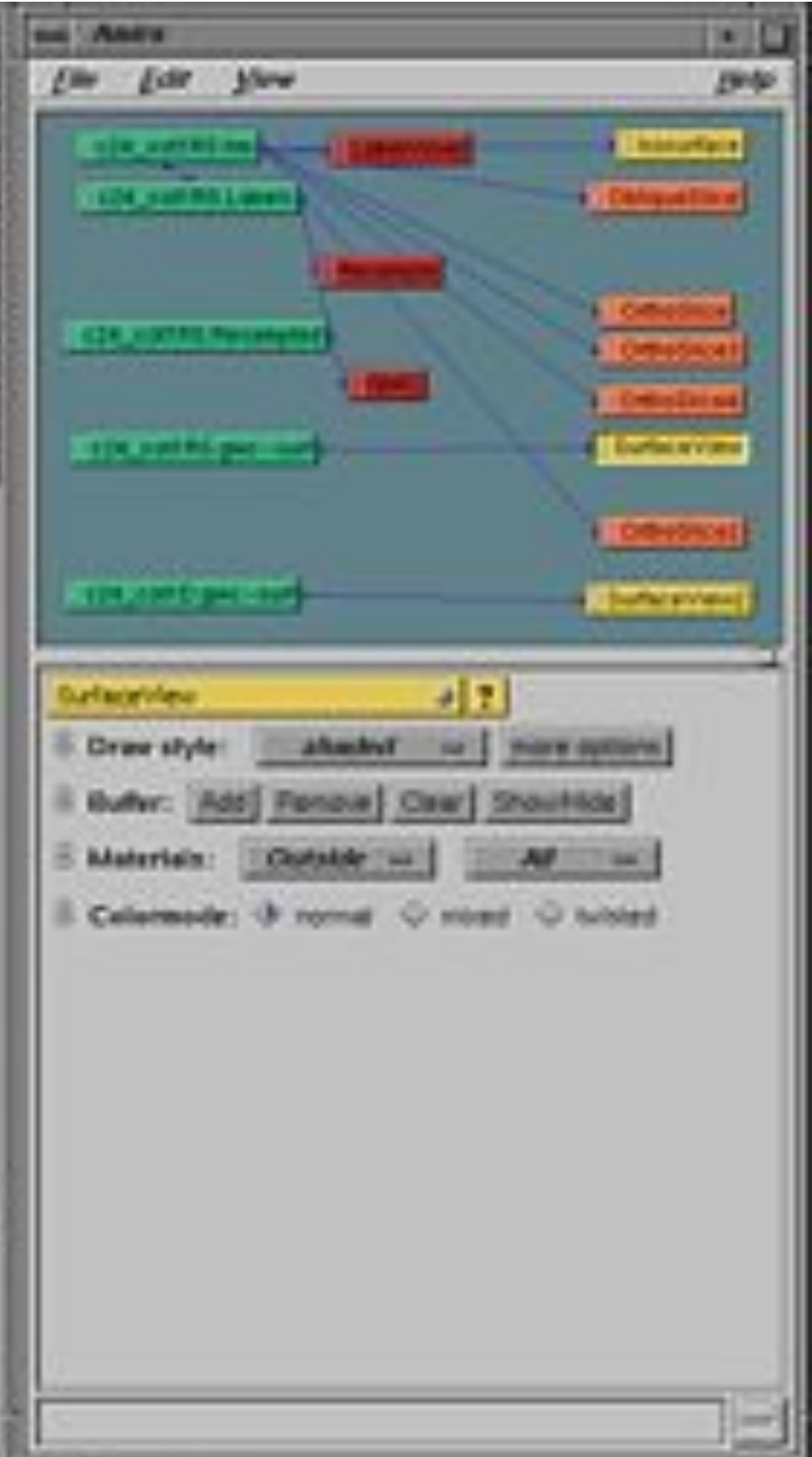
1. Visualise cellular architecture
2. Computational models for cell dynamics and biophysics
3. “Social Engineering” - genetic systems to reprogram cell cohorts


APO
10x/0.40
LEICA GERMANY
T+
0.14
Diospyros
lotus
Wood section



Beech wood


Amira
ZIB
Roty
Dolly


Amira
File
Edit
View
Help
Draw style:
more options
Buffer:
Add
Remove
Clear
Show/Hide
Materials:
All
Colormode:
normal
mixed
twisted


Media Recorder
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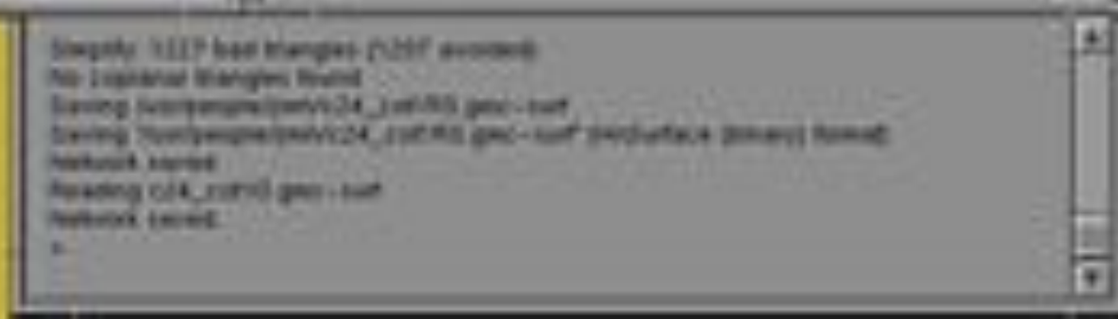
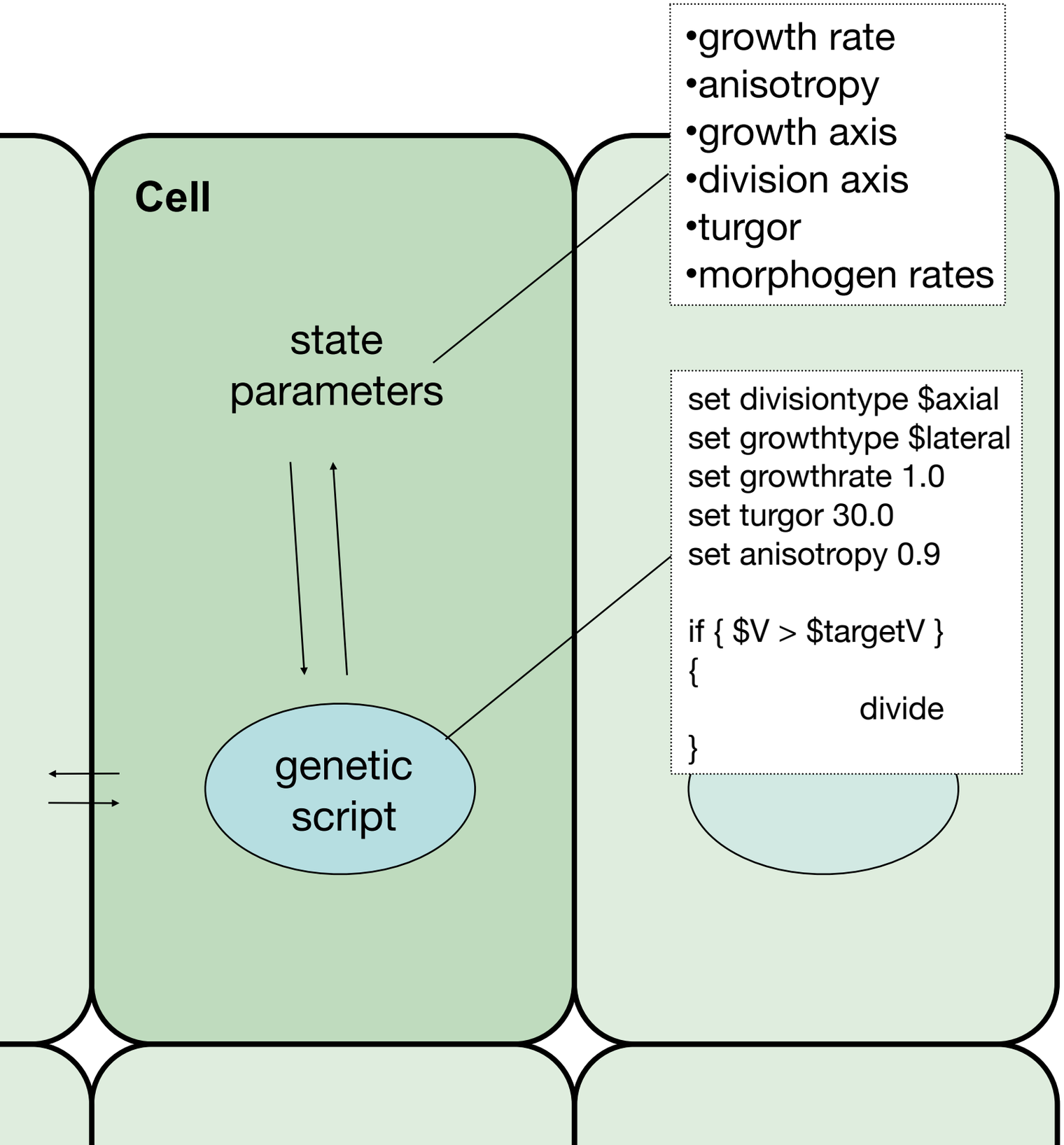
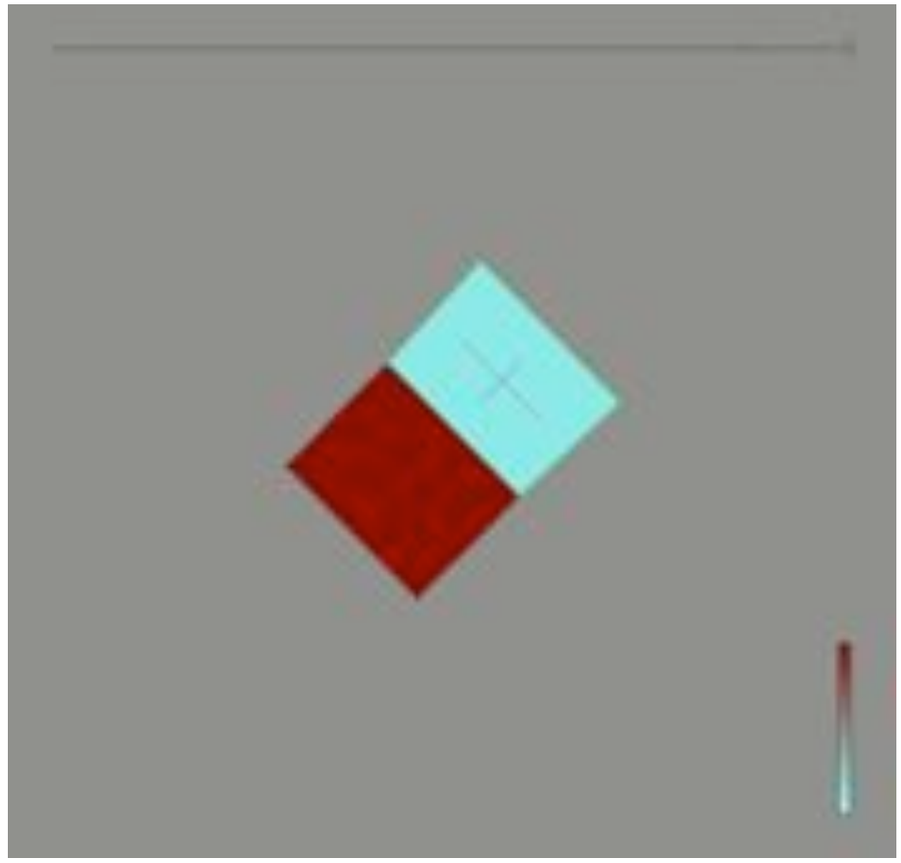


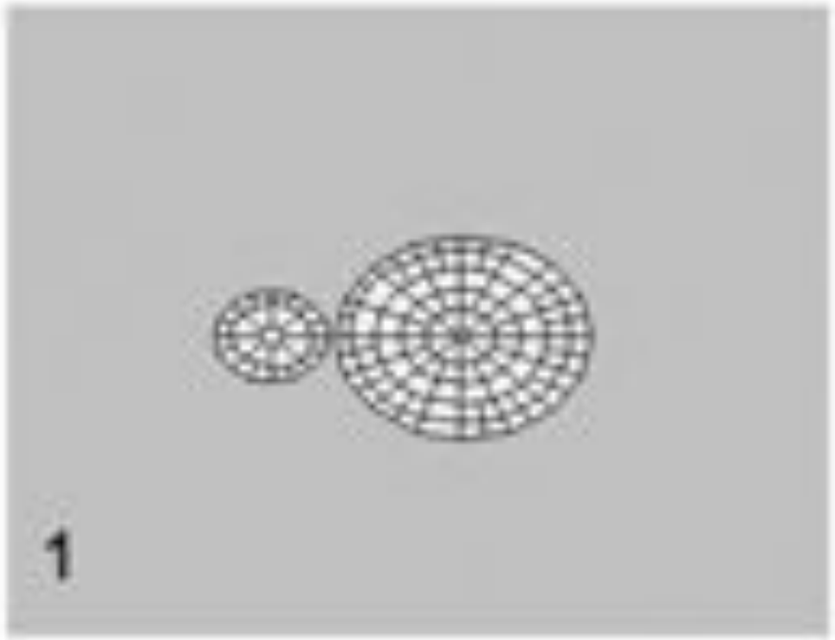
Cellular automata models for plant morphogenesis

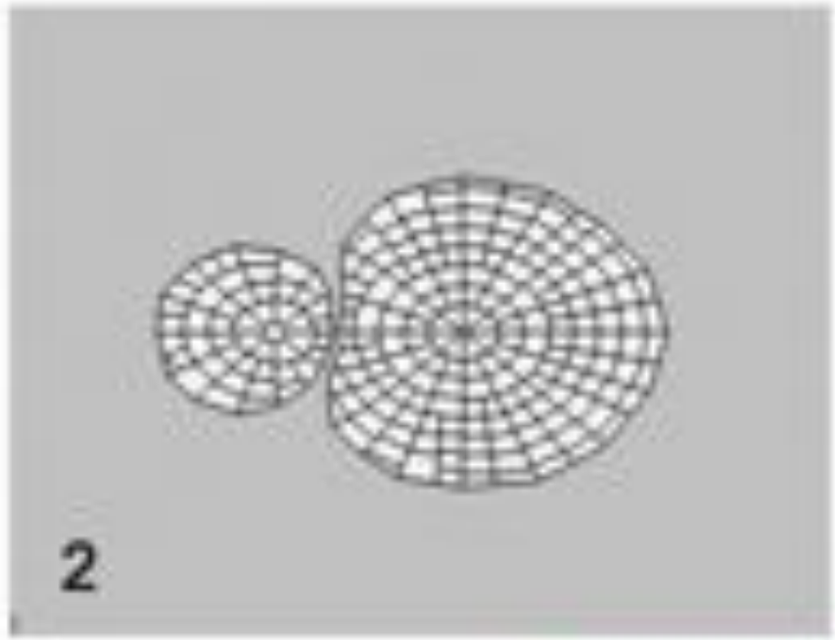


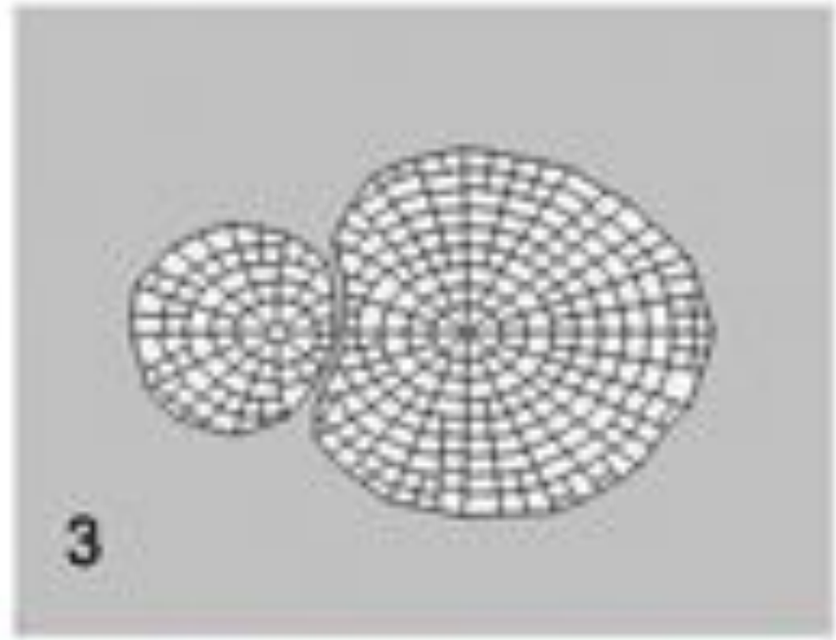


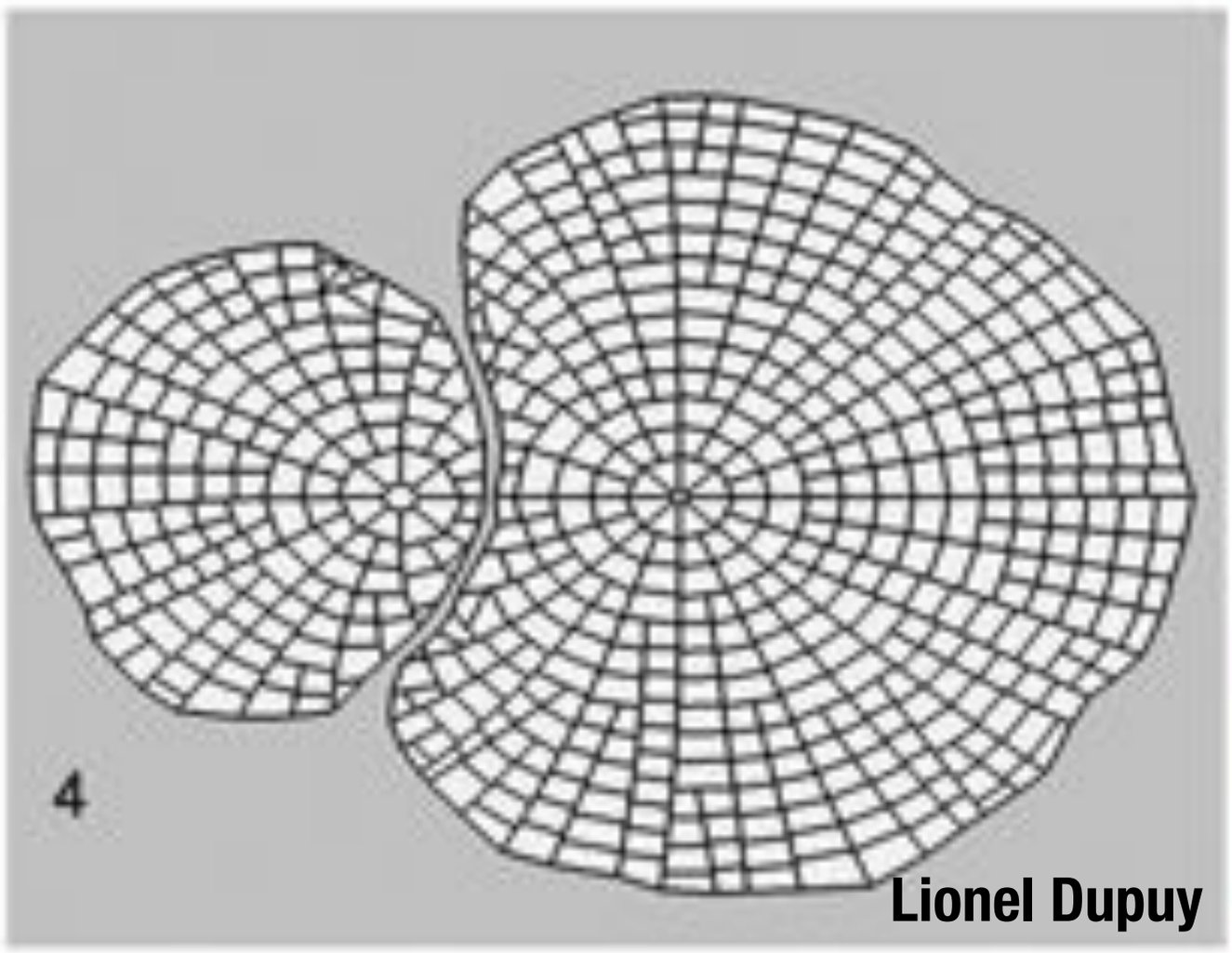
Tim Rudge, Jonathan MacKenzie & Lionel Dupuy

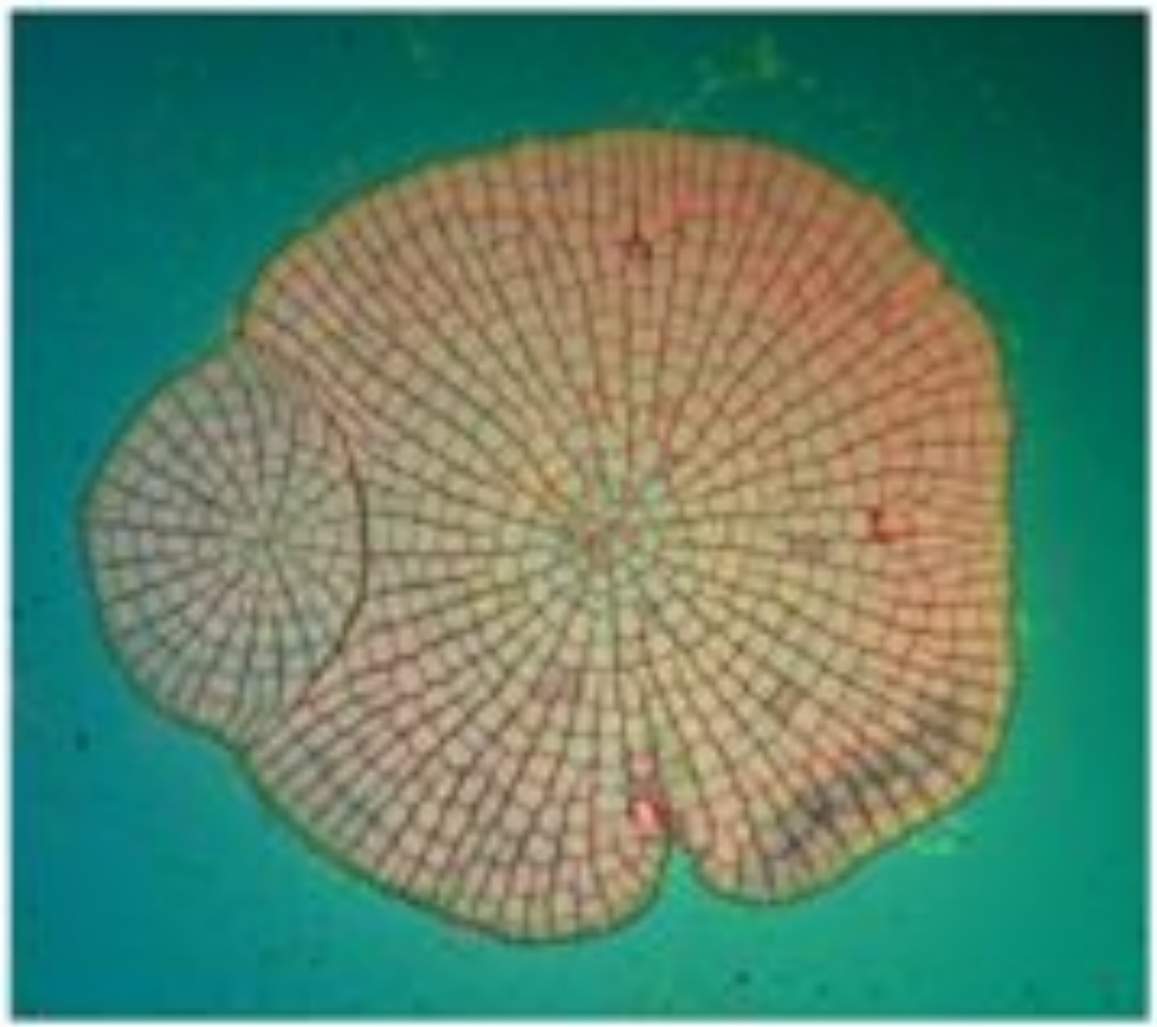
Modelling growth of Coleochaete

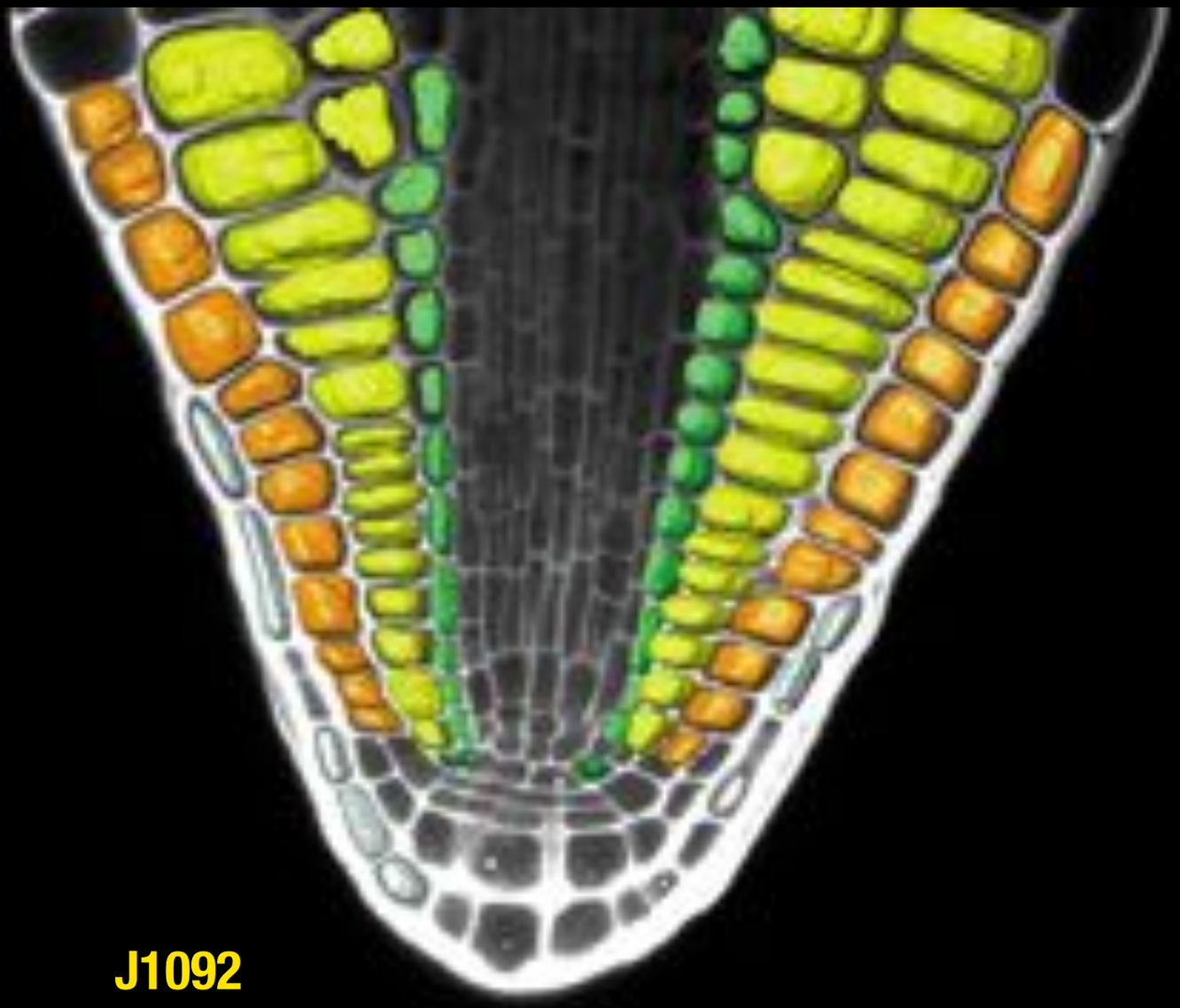




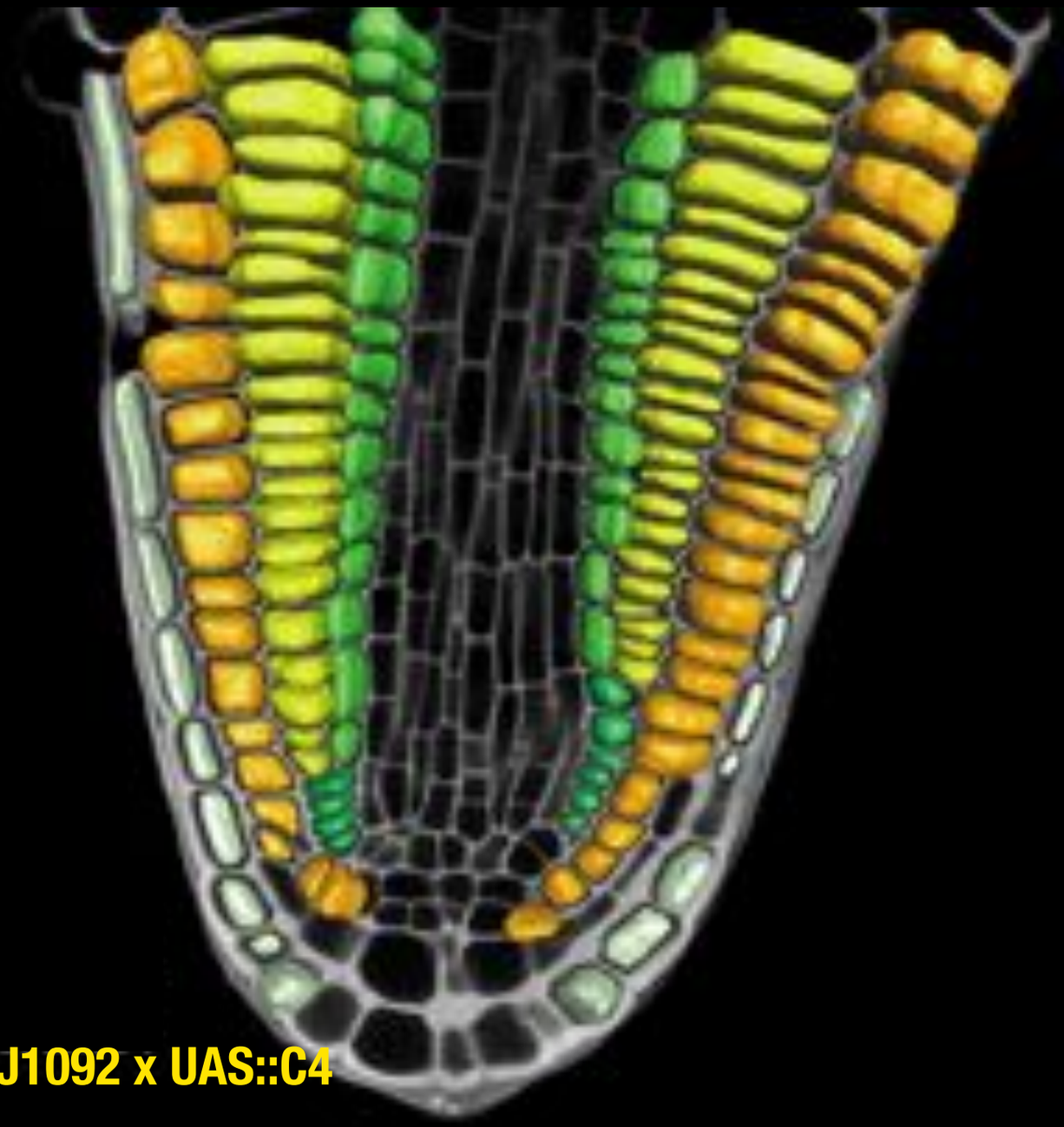








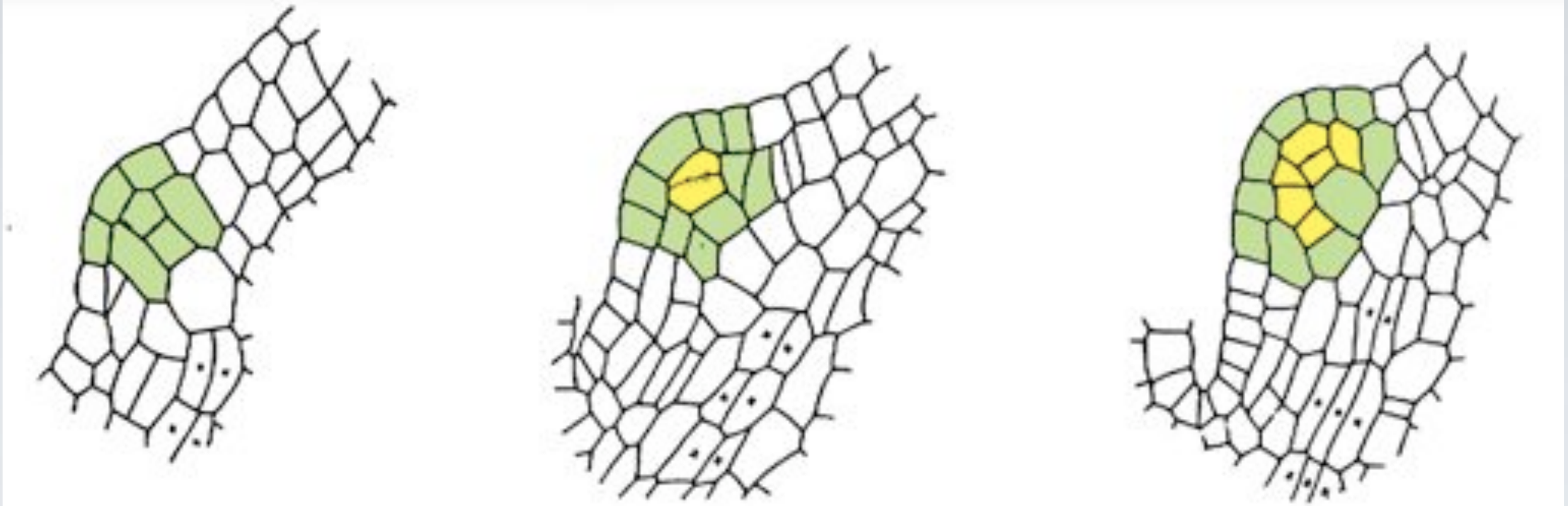
J1092

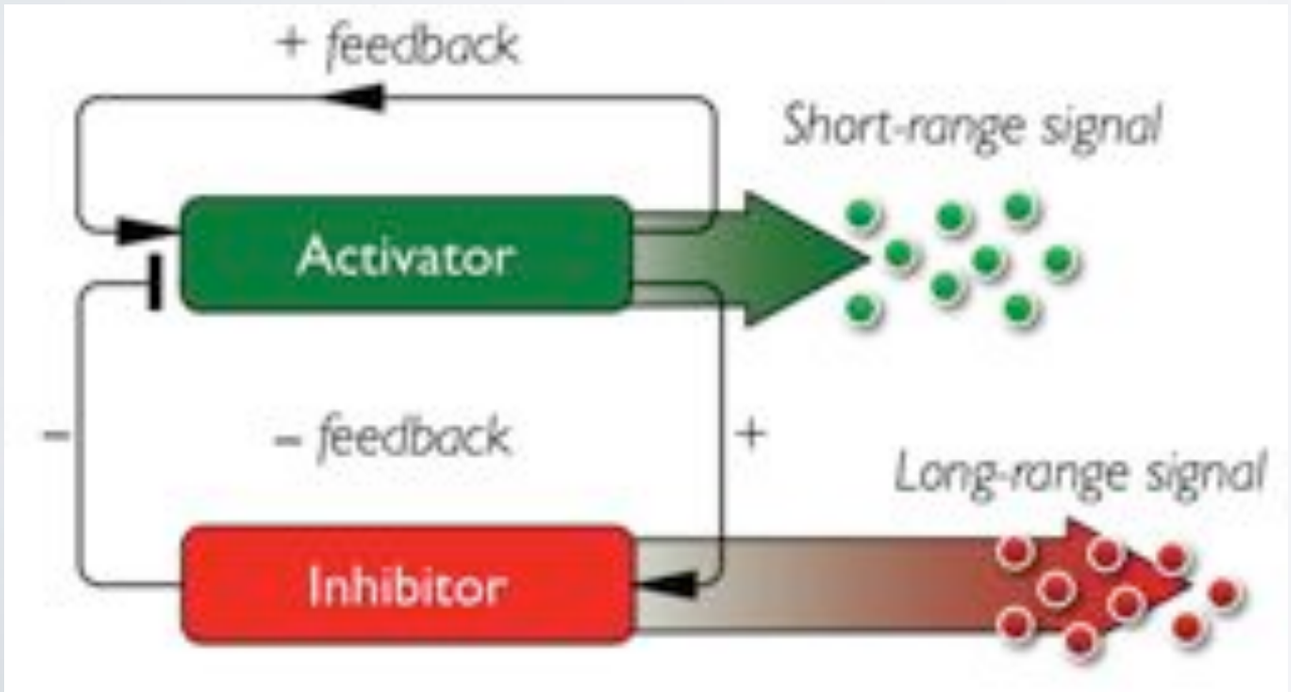


J1092 x UAS::C4

GAL4 targeted proliferation of the root cap during embryogenesis

Engineering of neomorphic structures





Trigger: initiate expression of a novel gene circuit during development

Patterning: define cohort of proliferating cells via intercellular signalling

Differentiation: confer new cell fates using endogenous regulators

Modern crop plants are derived from their natural ancestors by thousands of generations of selection and breeding.

What if we could reprogram the distribution of existing cell types in living systems?