synthetic biology - holds promises? needs dry techniques!

at a cross-road:

- tangible enthusiasm, as huge societal impact could be in the making, and new science needs to be done
- at the same time there are concerns

- scales?
- what medium?
- will bio engineering diverge from sysbio?

[new parts/models, or is it all about picking and simplifying natural ones]

- what tools? [MD, PDEs, ... Boolean circuits]
- dry synbio?
- does it not need new foundations/computational tools?

[specifically of interest to the purpose of this course]

who?

We seek to be useful to different profiles of undergrads, grads, and post-docs:

- [dry] theoretically inclined students who want to understand which tools & theories from maths, physics, ... informatics they could contribute to bring to bear on which computational aspects of synbio

- [wet] synthetic biologists in the making who want to know the extant such tools (cellular automata, multiscale,...), how to use them to minimise cost, time, failure in wet work

synbio a def

emerging engineering discipline that draws its components and technologies from life

synbio = biology considered as a computational medium

ground biochemical level: synthesis of entire pathways, organisms and ecosystems is now conceivable!

expectations/SotA

wide range of applications

- bioremediation (detection, recycling and degrading of heavy metals, pesticides and other toxic substances)
- carbon reclaim
- cheaper or cleaner energy sources "oil 2.0"
- drug synthesis, smart drug delivery using biosensors
- smart matter (loosely connected independent agents)
- general computing (as in Adleman's earlier DNA computing).

- bacteria take pictures,
- blink at a given frequency
- smell of banana when the temperature goes up
- fight each other in a synthetic prey-predator system.

problems!

programmable, scaleable and modellable (all aspects of a same coin)???

key additional degree of freedom:
one may select the instruction sets (a different game than sysbio)

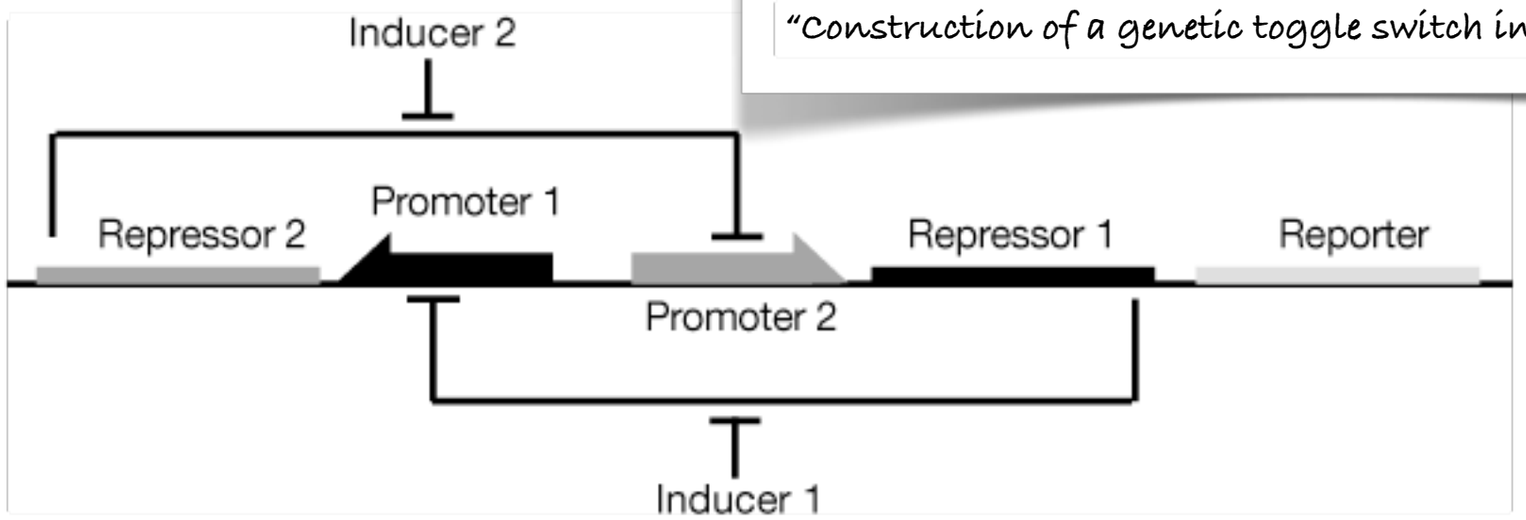
so which?

what are those parts one needs to build systems going to be?

(prok-) transcriptional logic

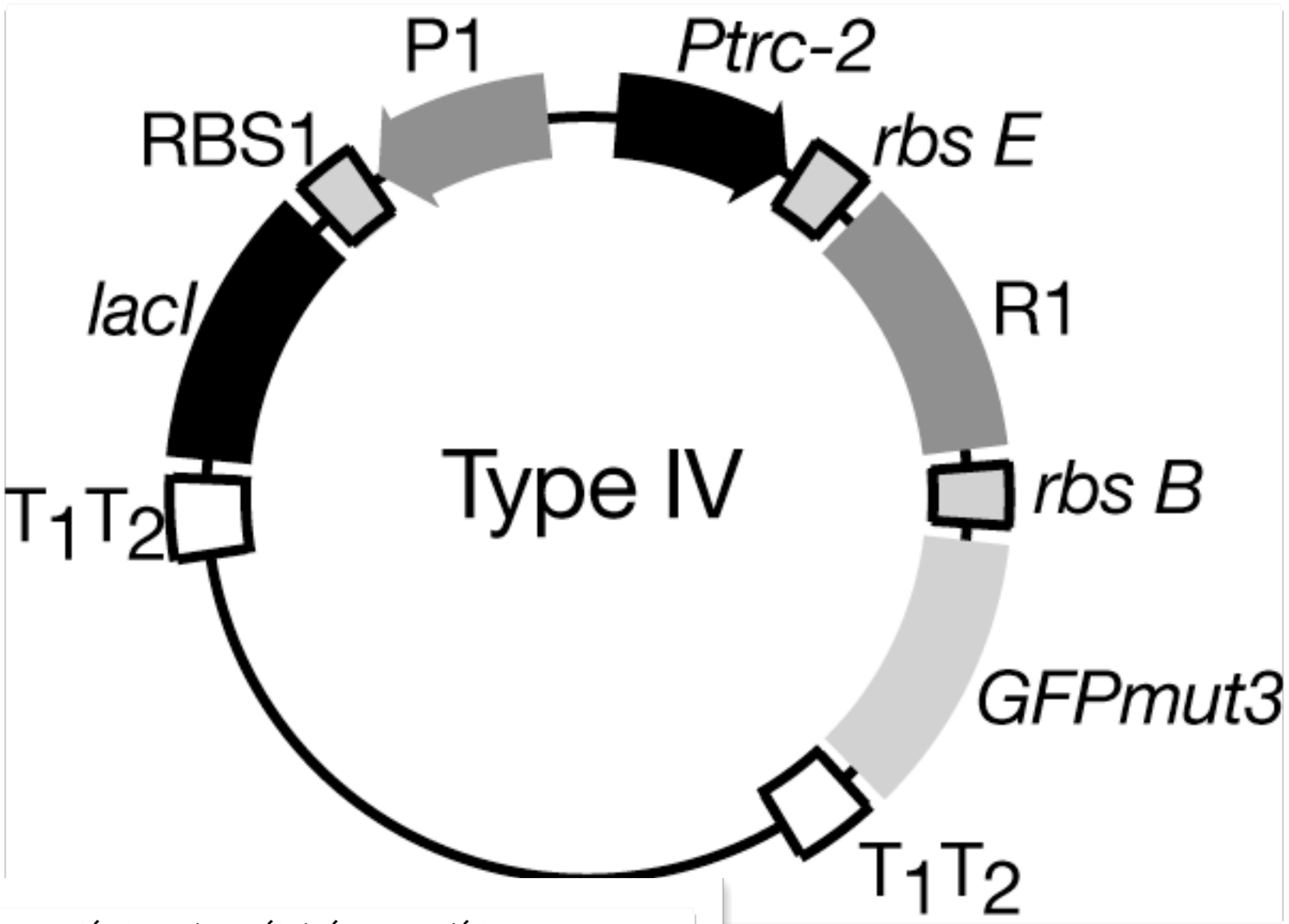
- inducible/controllable transcription factors (TFs):

- lots of small circuits have been realised (we'll see the classics)
- a dozen of "inducers" to switch a few well-known TFs -> activate or repress the synthesis of certain genes
- more promoters (the DNA/TF interfaces) can be derived using combinatorial techniques
- tractable Boolean semantics but that does not always work
- there are more accurate models than Boolean



"Construction of a genetic toggle switch in E. coli" Nature 2000

transcriptional logic/biobricks/DNA



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other logics

- synthetic protein networks (most expressive medium?)
- bacterial ecosystems
- riboswitches
- DNA hairpins, single-stranded DNA

search

the design space for parts is hard to search:
- made of DNA sequences of which an unfeasible number

- develop low-level physics models of the "logic"
- combinatorial sampling (a la Elowitz)
- directed evolution methods