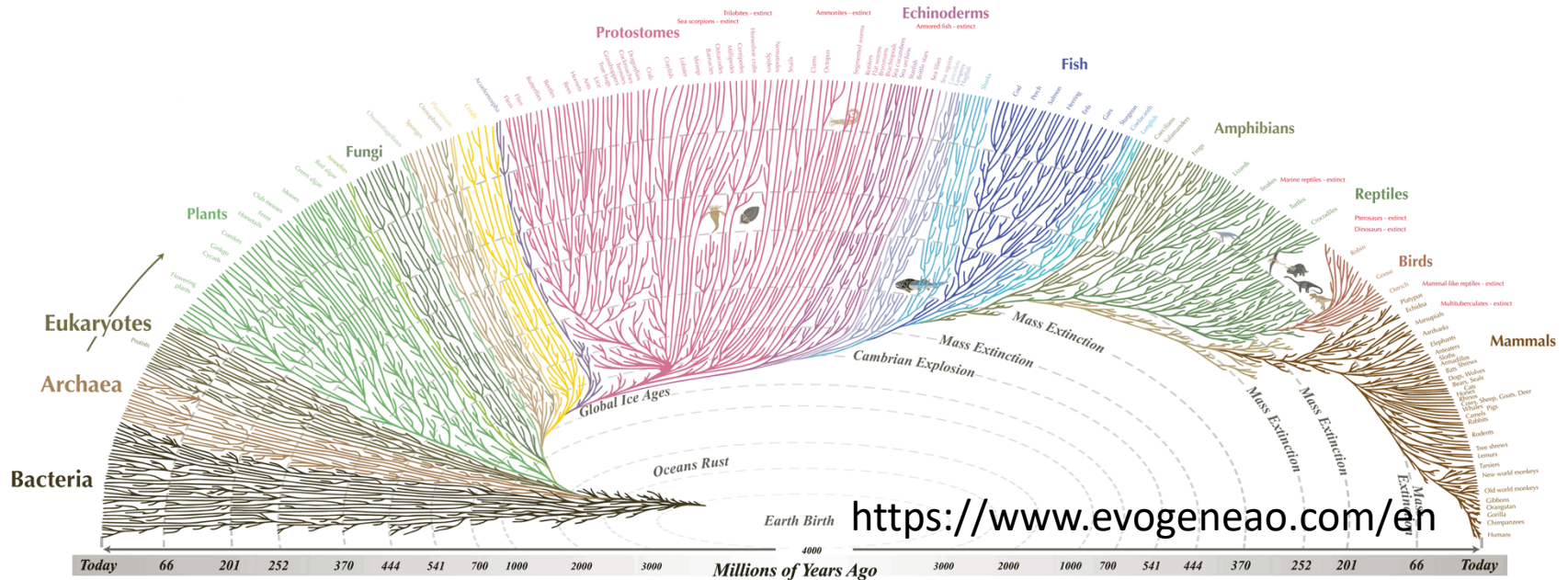


# Synthetic Biology

한국생명공학연구원  
합성생물학전문연구단

김하성

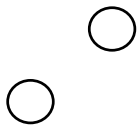
# Complexity in biology



All the major and many of the minor living branches of life are shown on this diagram, but only a few of those that have gone extinct are shown. Example: Dinosaurs - extinct

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evogeneao.com

## What about in physics and chemistry?



180 element in  
the periodic table

DNA-RNA-Protein-  
Cell-Organism-Biome

# Discovery vs. Invention



1665년 로버트 훅의 『마이크로그라피아』

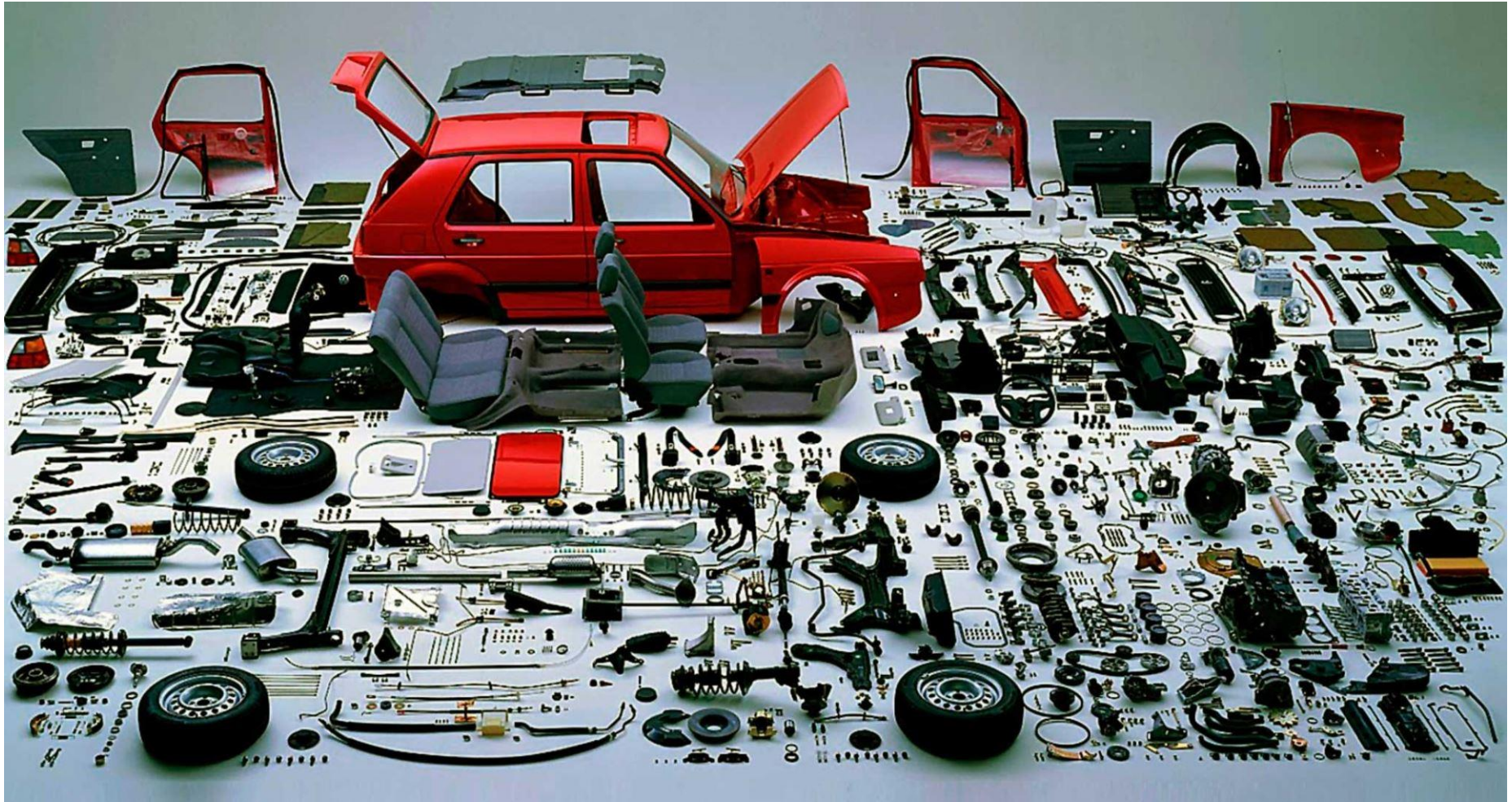
<https://m.blog.naver.com/PostView.nhn?blogId=moeblog&logNo=220400859724&proxyReferer=https:%2F%2Fwww.google.com%2F>



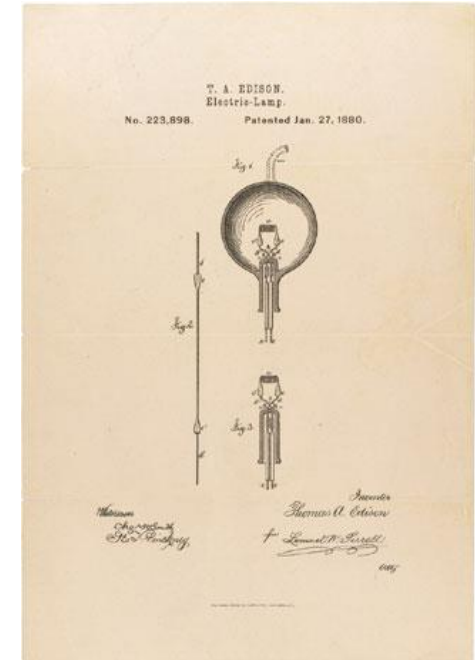
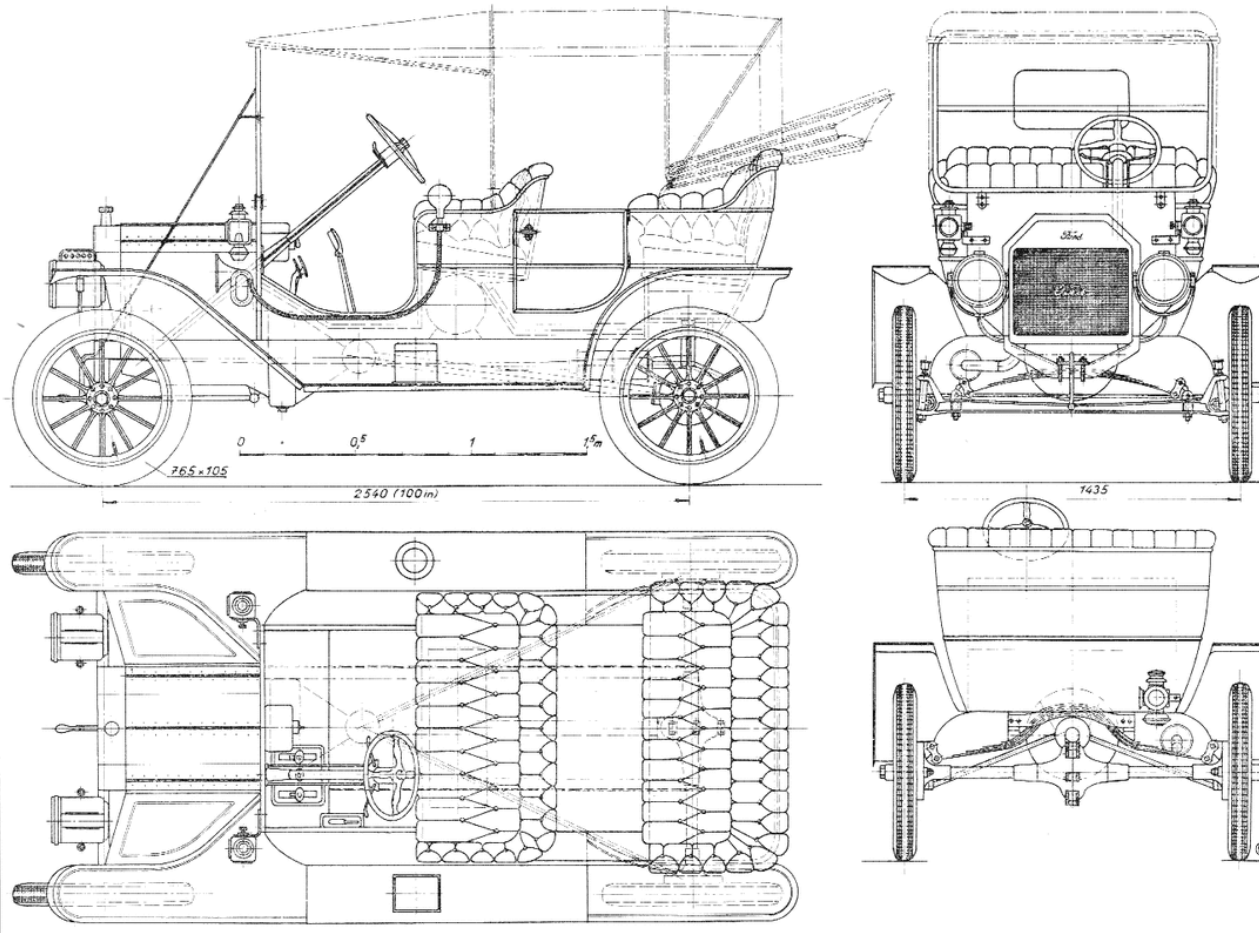
<https://time.com/3517011/thomas-edison/>



# A complex system with assembled (DNA) parts



# Blueprint



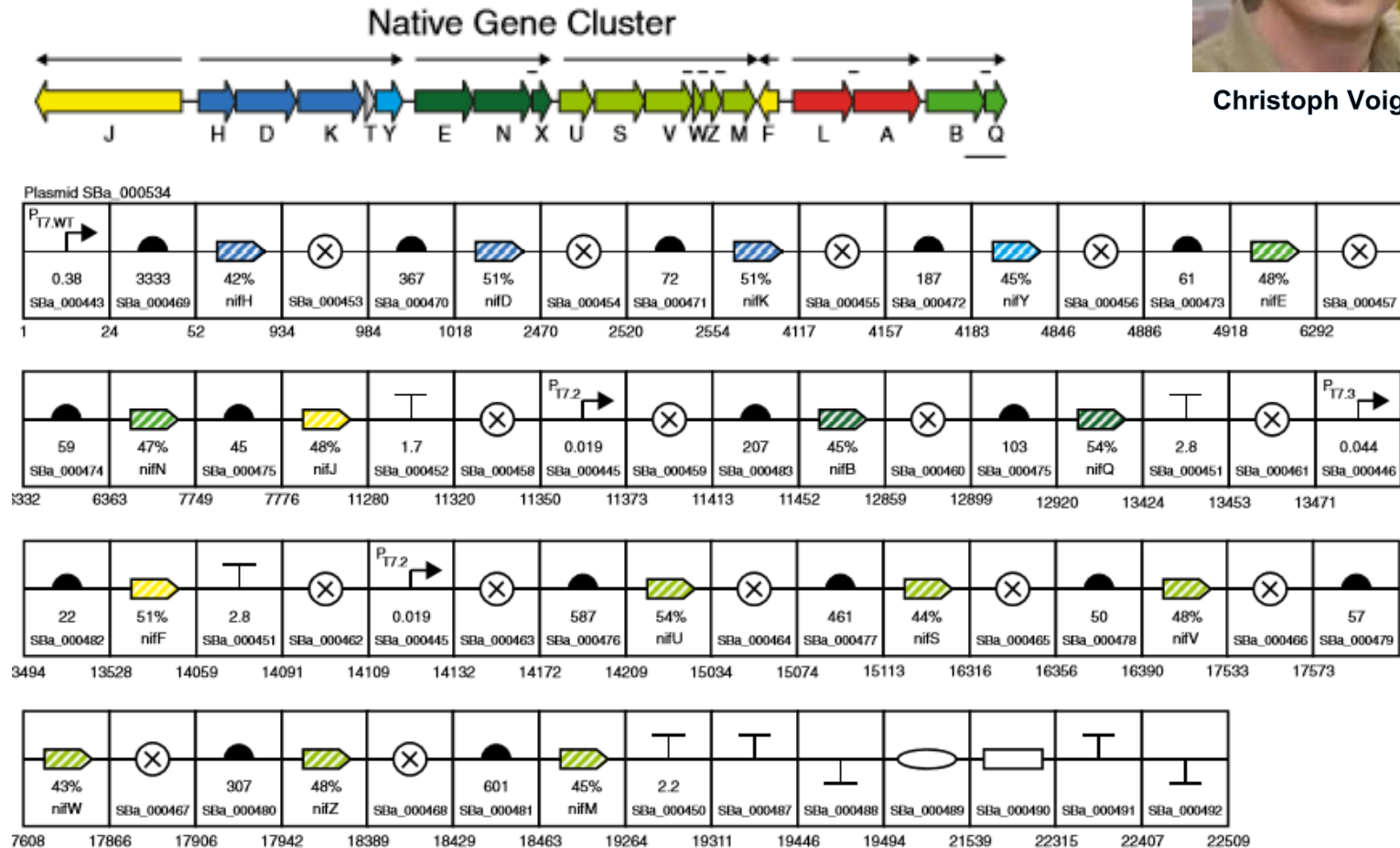
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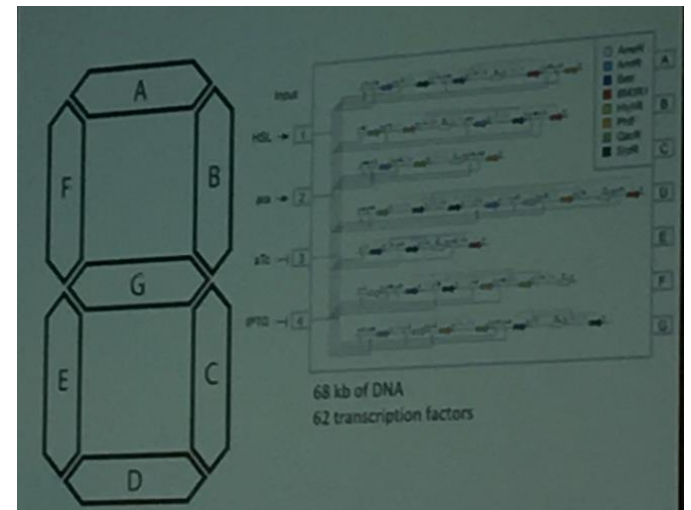
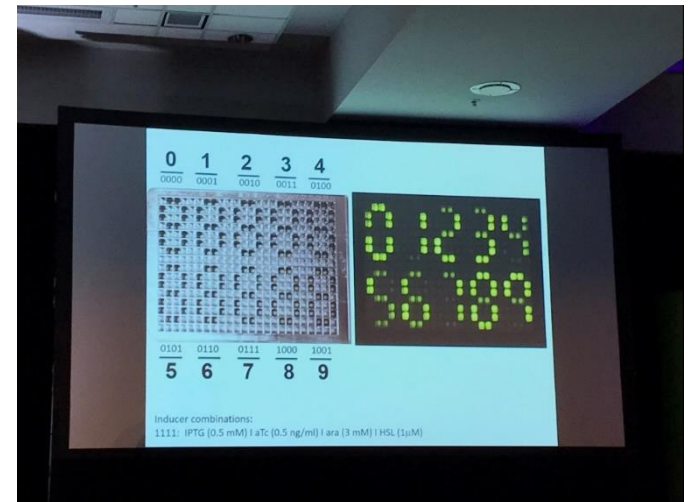
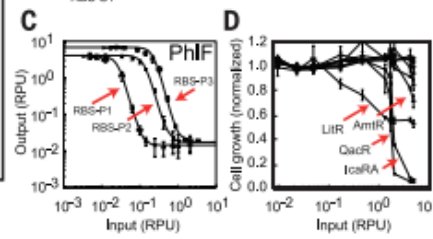
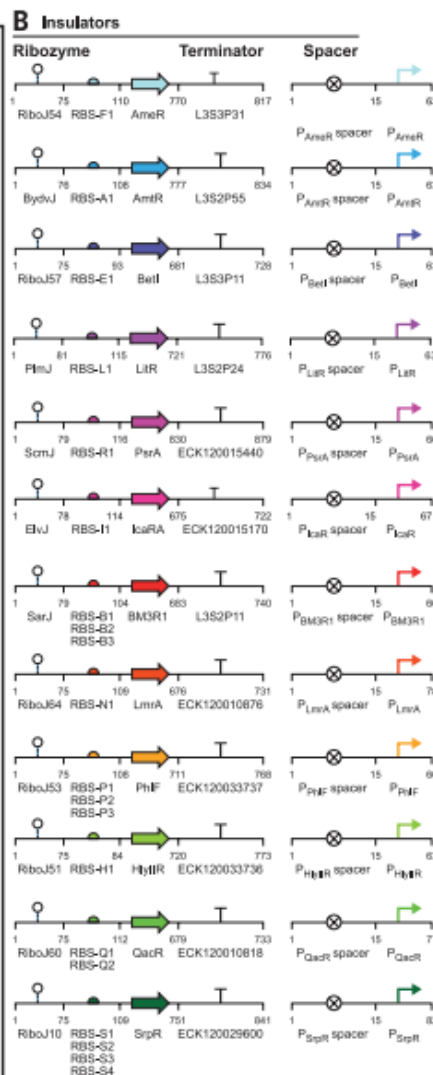
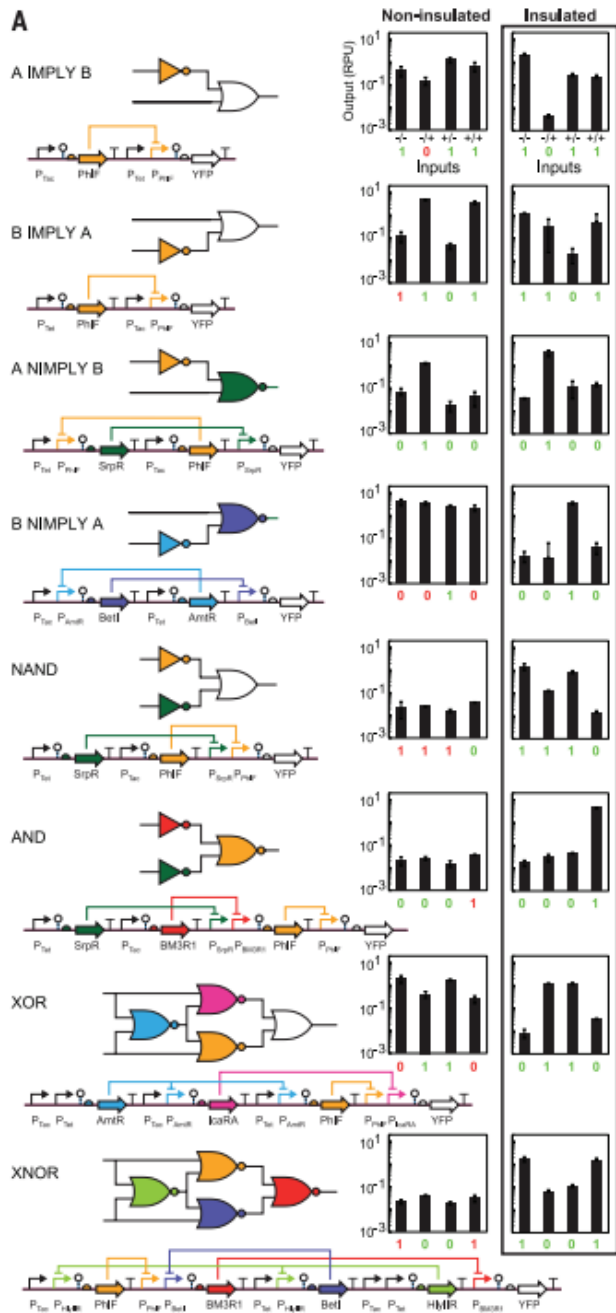
# Blueprint in Synthetic Biology



Christoph Voigt (MIT)



*K. oxytoca* nitrogen fixation gene cluster



Christoph Voigt (MIT)

2016 SB7

# DNA Parts

## SBOL (synthetic biology open language)

<http://sbolstandard.org/>

### Nucleic Acid Glyphs

Aptamer	Assembly Scar	Blunt Restriction Site	(recommended) CDS	(alternate) CDS	Composite	Engineered Region	3' Overhang Sticky End
5' Overhang Sticky End	3' Sticky Restriction Site	5' Sticky Restriction Site	Insulator	No Glyph	Non-Coding RNA	Omitted Detail	Operator
ORI	ORI-T	Poly-A Site	Primer Binding Site	Promoter	Ribosome Entry Site	Signature	Recombination Site
Terminator	(recommended) Unspecified	(alternate) Unspecified	(recommended) DNA Location	(recommended) RNA Location	(recommended) Protein Location	(alternate) DNA Location	(alternate) RNA Location
(alternate) Protein Location	DNA Cleavage Site	RNA Cleavage Site	Protein Cleavage Site	DNA Stability Element	RNA Stability Element	Protein Stability Element	



## Registry of Standard Biological Parts



tools catalog repository assembly protocols help search



### Promoters/Catalog/Ecoli/Positive

All the promoters on this page are *E. coli* promoters that are **positively regulated** meaning that increased levels of at least one transcription factor (other than the sigma factor) will increase the activity of these promoters.

#### Contents

- 1 Positively regulated *E. coli*  $\sigma^{70}$  promoters
- 2 Positively regulated *E. coli*  $\sigma^S$  promoters
- 3 Positively regulated *E. coli*  $\sigma^{32}$  promoters
- 4 Positively regulated *E. coli*  $\sigma^{54}$  promoters



### Positively regulated *E. coli* $\sigma^{70}$ promoters

This section lists promoters that are recognized by *E. coli*  $\sigma^{70}$  RNAP.  $\sigma^{70}$  is the major *E. coli* sigma factor so there should be RNAP present to transcribe these promoters under most growth conditions (although maximally during exponential growth).

[More...](#)

Name	Description	Promoter Sequence	Positive Regulators	Negative Regulators	Length	Doc	Status
<a href="#">BBa_I0500</a>	Inducible pBad/araC promoter	... gttctccataccggttttttgggctagc			1210	3742	In stock
<a href="#">BBa_I1051</a>	Lux cassette right promoter	... tgttatagtcgaatacctctggcggtgata			68	1263	It's complicated
<a href="#">BBa_I12006</a>	Modified lambda P <sub>rm</sub> promoter (repressed by 434 cl)	... attacaaactttctgtatagatttaacgt			82	798	In stock
<a href="#">BBa_I12007</a>	Modified lambda P <sub>rm</sub> promoter (OR-3 obliterated)	... attataaatagtggtgatagatttaacgt			82	828	In stock
<a href="#">BBa_I12036</a>	Modified lambda P <sub>rm</sub> promoter (cooperative repression by 434 cl)	... ttctgtatagatttacaatgtatcttgt			91	927	In stock
<a href="#">BBa_I12040</a>	Modified lambda P(RM) promoter: -10 region from P(L) and cooperatively repressed by 434 cl	... ttctgtatagatactacaatgtatcttgt			91	1018	In stock
<a href="#">BBa_I12210</a>	plac Or2-62 (positive)	... cttatgcttcggctcgatgttggtgg			70	939	In stock
<a href="#">BBa_I13406</a>	Pbad/AraC with extra REN sites	... tttttgggctagcaagctttaccatggat			1226	817	Not in stock
<a href="#">BBa_I13453</a>	Pbad promoter	... gttctccataccggttttttgggctagc			130	3744	In stock

>20,000 DNA parts

# DNA assembly



```
cagttaatacgcactcactataggggtgggagcgctcccatcacacaggaaacagcatatgagcaaaggtgaagaactgtttaccggcggtgtgccgat
gtcaattatgctgagtgatattccaccctcgcgagggtagtggtgtccttgtcgtatactcgtttccacttcttgacaaatggccgcaacacggcta
```

Table 1 | Summary of physical standards in DNA assembly

Physical standards	Underlying methodology					Limitations		Workflow		
	Restriction and ligation	HE	Type IIS RE	SSR	Long overlap	PCR required*	Forbidden restriction sites†	Number of assembly tiers	Multipart assembly§	Hierarchical assembly
BioBrick <sup>13</sup> and BglBrick <sup>15</sup>	✓					No	4	1	No	Yes
iBrick <sup>21</sup>		✓				No	0	1	No	Yes
HVAS <sup>22</sup>		✓		✓		No	0	2	Yes; no	No <sup>  </sup>
MoClo <sup>29</sup>			✓			No	3	2	Yes; yes	Yes
GoldenBraid 2.0 (REF. 30)			✓			No	3	≥2	Yes; no	Yes
GreenGate <sup>32</sup>			✓			No	1	2	Yes; no	Yes
Binder <i>et al.</i> <sup>31</sup>			✓			No	3	2	Yes; yes	Yes
PSA <sup>37</sup>			✓			No	0	1	No	Yes
DNA assembler <sup>53</sup>					✓	Yes	0	2	Yes; yes	No
MODAL <sup>9</sup>					✓	Yes	0	1	Yes	No
BASIC <sup>58</sup>			✓		✓	No	1	1	Yes	Yes
Torella <i>et al.</i> <sup>55¶</sup>	✓				✓	No	≥4 <sup>#</sup>	2	No; yes	No
Guye <i>et al.</i> <sup>59</sup>		✓		✓	✓	No	0	2	Yes; yes	Yes
PaperClip <sup>56</sup>					✓	No	0	1	Yes	No

Casini, A., Storch, M., Baldwin, G. S., & Ellis, T. (2015). Bricks and blueprints: Methods and standards for DNA assembly. *Nature Reviews Molecular Cell Biology*, 16(9), 568–576. <https://doi.org/10.1038/nrm4014>

- ( What to make?
- How to make?
  - Too many parts (none characterized)
  - Laborious DNA assembly

$10^{82}$  vs.  $20^{170}$  vs.  $10^{7284000}$



# iGEM (international Genetically Engineered Machine)



2003 an independent study course at (MIT)

2015 - 259 teams,

2016 – 299 teams,






















2017 – 312 teams,

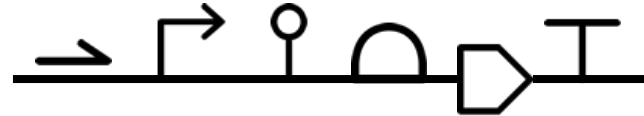
2018 – 343 teams, 5,000 participants (3,000 students), 45~50 countries



# DNA parts

## Basic Components (Parts)

		<b>Promoters (?)</b> : A promoter is a DNA sequence of the downstream DNA sequence.
		<b>Ribosome Binding Site/about (?)</b> : A ribosome can bind and initiate translation.
		<b>Protein domains (?)</b> : Protein domains make up a protein coding sequence. Some parts target the protein for cleavage, or enable function.
		<b>Protein coding sequences (?)</b> : Protein coding sequences are the sequence of a protein from start codon to stop codon. Note that some protein coding sequences also include regulatory elements.
		<b>Translational units (?)</b> : Translational units are the sequence of a protein from start codon to stop codon. They begin at the site of translation initiation.
		<b>Terminators (?)</b> : A terminator is an RNA sequence that causes transcription to stop.
		<b>DNA (?)</b> : DNA parts provide functional sites, spacers, recombination sites, and other elements.
		<b>Plasmid backbones (?)</b> : A plasmid is a circular DNA molecule that replicates within the cell independently of the chromosomal DNA. Plasmid sequences begin with the EcoRI site and end with the BioBrick prefix.
		<b>Plasmids (?)</b> : A plasmid is a circular DNA molecule that replicates within the cell independently of the chromosomal DNA. Plasmids can propagate or assemble plasmid backbones. Registry plasmids are only available as circular plasmids that these plasmids largely do not contain.
		<b>Primers (?)</b> : A primer is a short single-stranded DNA sequence used for DNA sequencing. Although primers are not considered as DNA parts, primer sequences are included here.
		<b>Composite parts (?)</b> : Composite parts are DNA sequences that are composed of multiple DNA parts.



<http://sbolstandard.org/>



BioBrick, iGEM

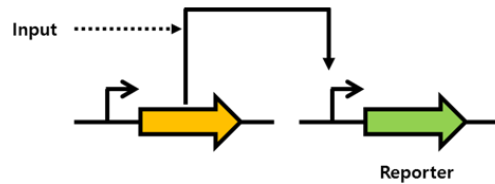
Since 2003, 2015 - 259 teams, 2700 students

Over 1200 high-quality parts / 20,000 documents

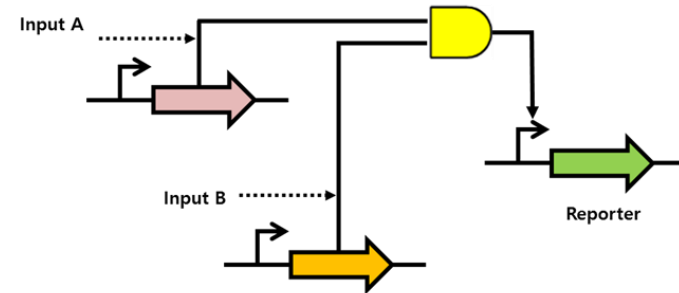
<http://parts.igem.org/Catalog>

# Genetic circuits

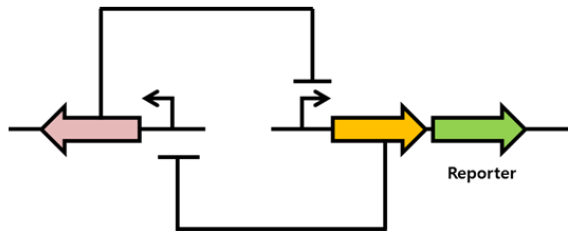
(A) Single input / Invertor



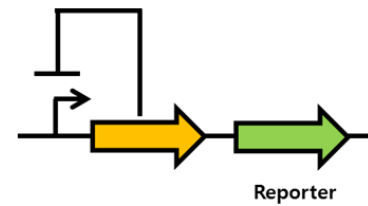
(B) Multi input



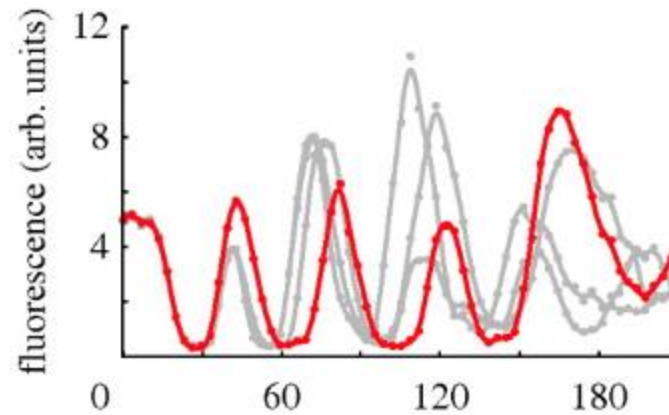
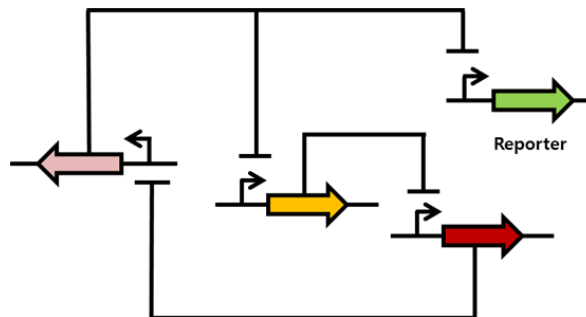
(C) Toggle switch



(D) Autoregulator



(E) Repressilator / oscillator



[https://2020.igem.org/Main\\_Page](https://2020.igem.org/Main_Page)

[illegible]

**CONGRATULATIONS TO ALL iGEM 2020 PARTICIPANTS!**

Thank you to everyone who participated in the 2020 season of the International Genetically Engineered Machine Competition. The Competition is now over. Please see below for **results!**