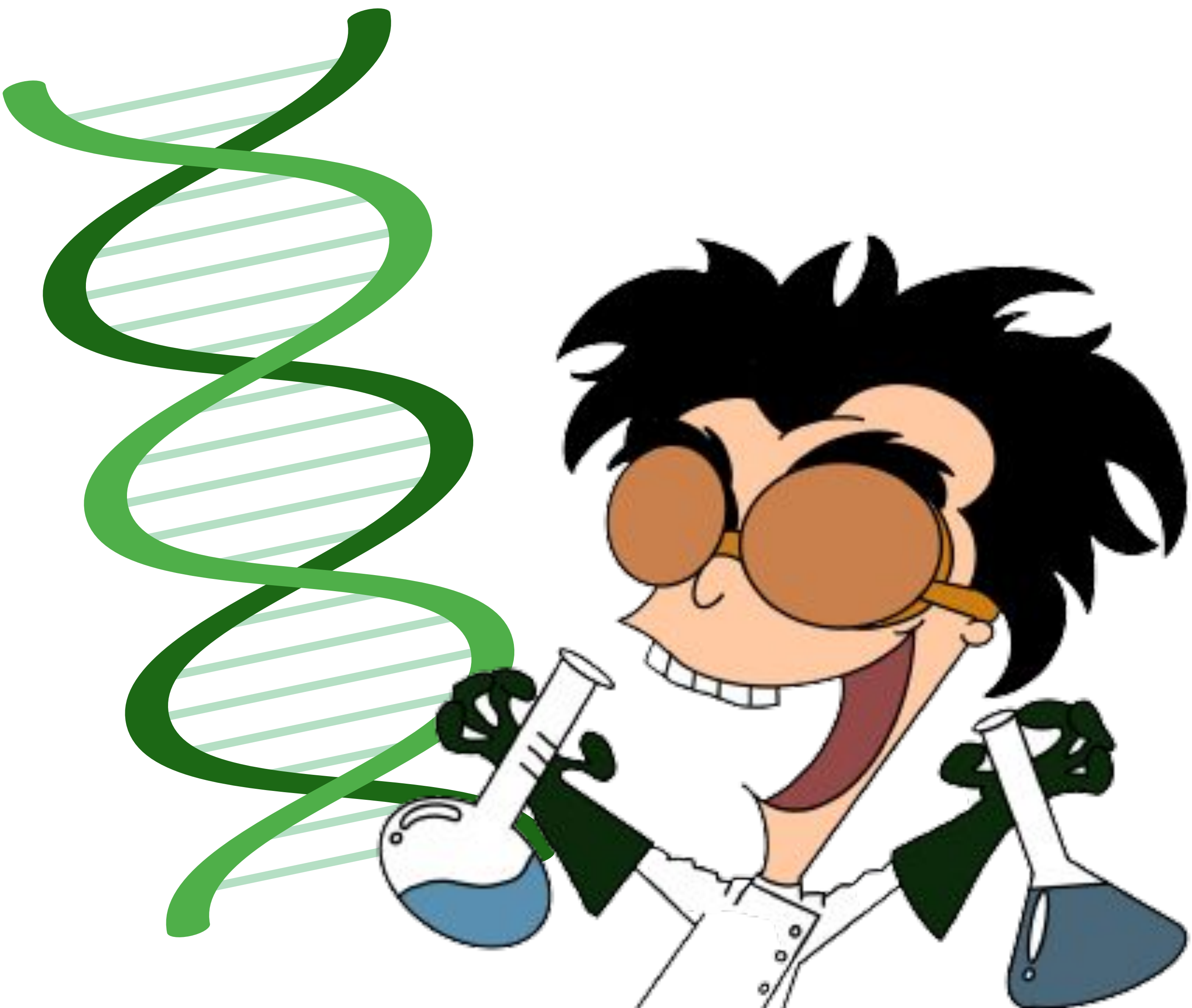
Chapter 1
Introduction of Synthetic Biology

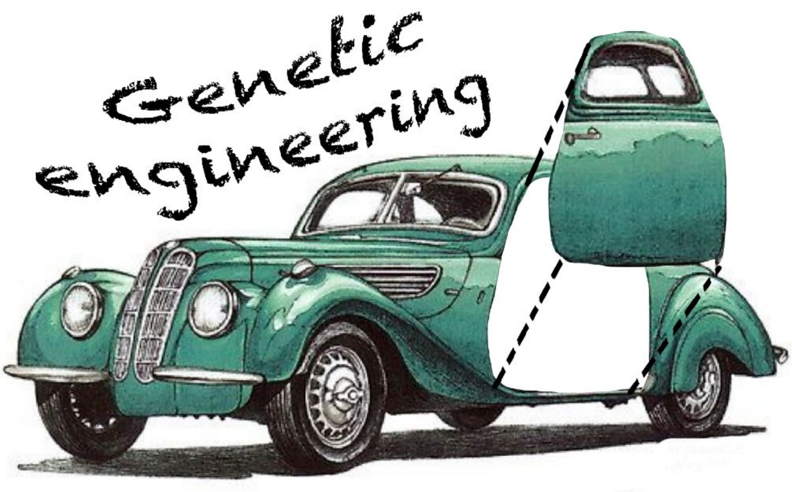


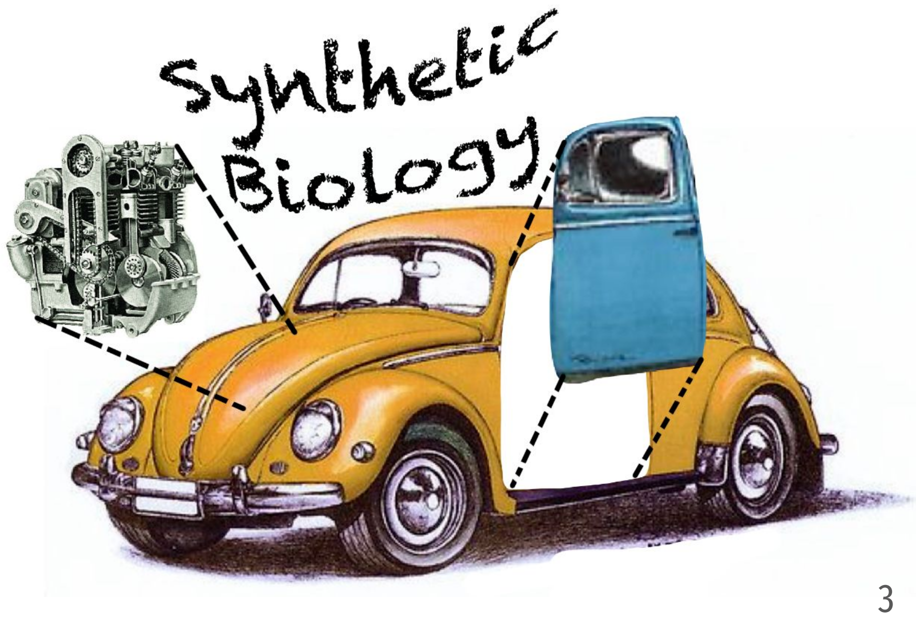
Concept 1.1
What is synthetic biology ?

Synthetic biology is an innovative field of science that involves redesigning organisms for specific purposes by engineering them with new abilities. The power of synthetic biology has been used to solve many problems in biomedicine, agriculture and manufacturing. For instance, microorganisms harnessed for bioremediation to clean pollutants from our water, air and soil, or yeasts engineered to accumulate heavy metal.

Synthetic biology is similar to the term “genetic engineering” as they both involve the changes of the genome. Yet, there are several differences that make the two fields distinct. In synthetic biology, the scientists usually assemble a long stretch of DNA and insert it into the organism. The DNA is often extracted from other organisms, thus the engineered organism is novel. On the other hand, in genetic engineering, scientists often make smaller changes to the organism’s own DNA.

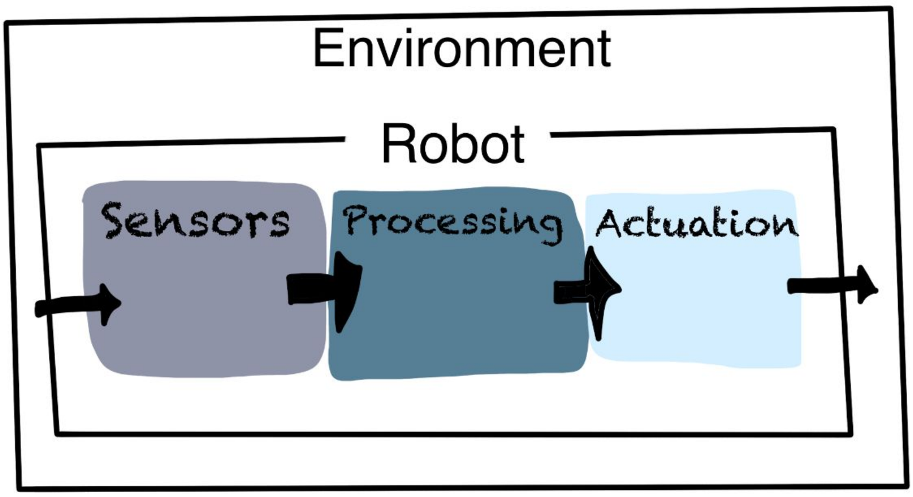
In conclusion, let’s look at the reification of these two concepts to better distinguish both. Genetic engineering is more like using the existing part from the original manufacturer to fix the machine. Synthetic biology is more like design and creating an entire new engine.

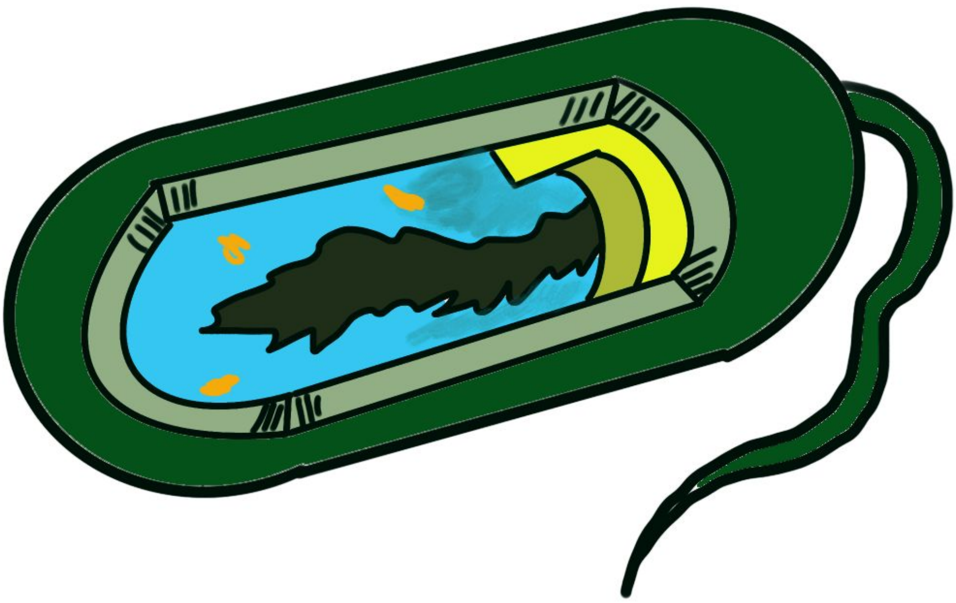




Concept 1.2
Compare organism engineering to robotic programming

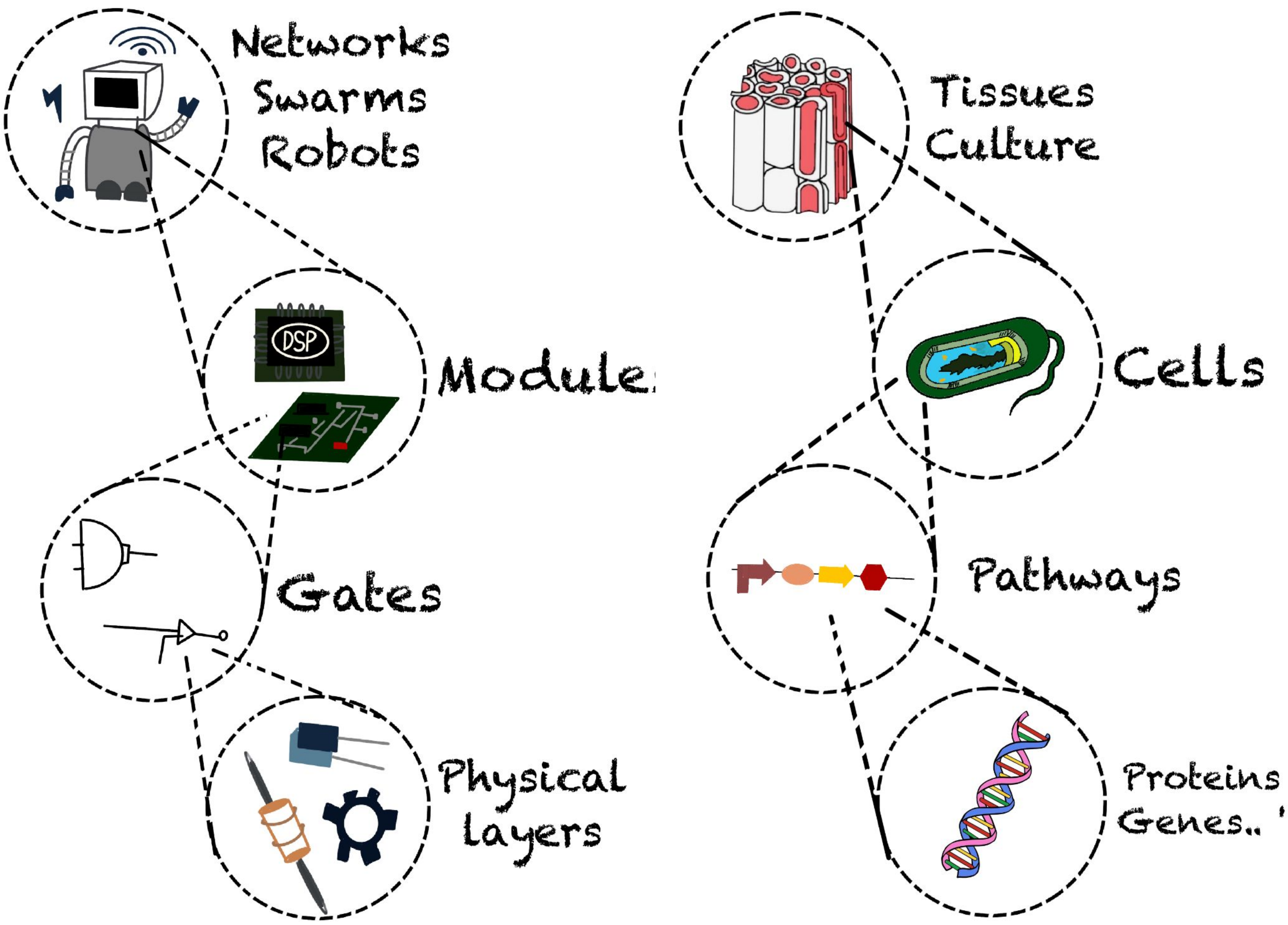
To briefly understand the principles of synthetic biology, we could compare organism engineering to robotic programming. A programmed robot is able to sense the environment surrounding it, process the information it receives, and actuate and react. Similarly, we expect the engineered organism to do the same as a robot does.





The operation of a robot relies on the electrical circuits that form the network within the device. The fundamental components will be organized into modules carrying specific functions. These modules further integrate into a complex system that forms the network, imparting the robot with multi-functionalities. (figure 3)

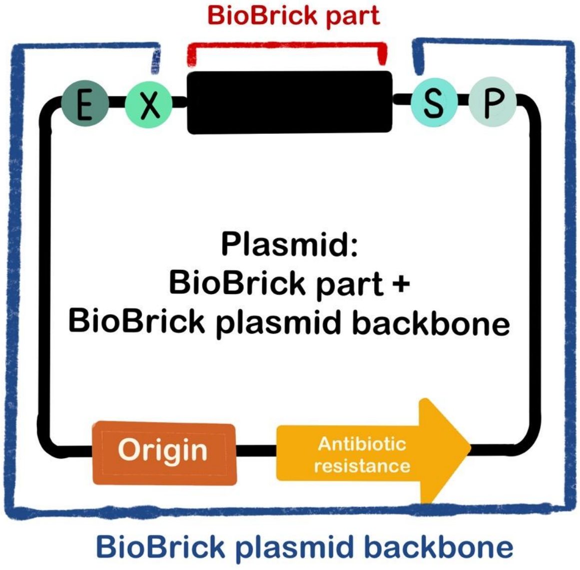
To further extend the concept in an organism, the basic parts could be the protein and genes with specific functions or be part of a chemical reaction. Different sets of chemical reactions can further form pathways within a cell, and further expand into a complex system. So, how can we achieve this? Can we really program a cell like the way we do to a robot? What challenges may we face in engineering?

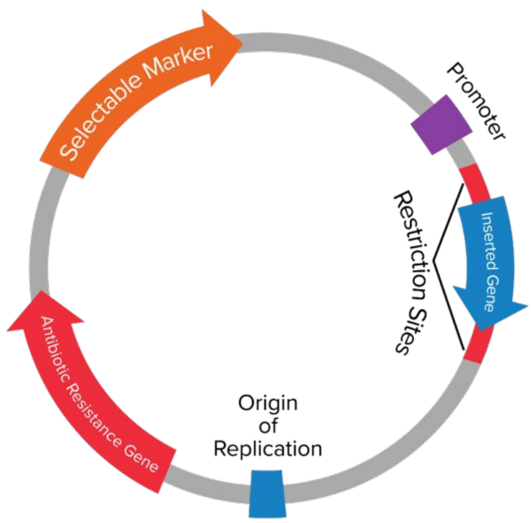


Concept 1.3
Biobrick - A standardized system of synthetic biology

To build a complicated system within the organism, scientists started to use synthetic genetic circuits to control and program cells. At first, the construction required a lot of effort to insert the gene of interest into the plasmid. Not until Tom Knight from MIT invented a system that standardized the biological parts did the approach become efficient. These parts are called biobricks, which work as legos that are able to fit in the modular construction.

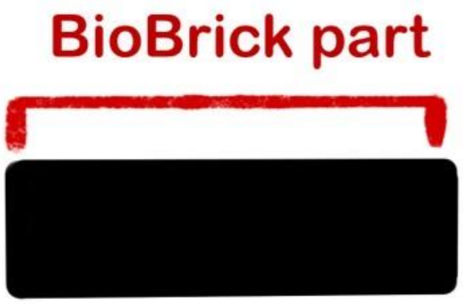
A BioBrick is a DNA part that carries out a defined function and adheres to prescribed standards. Most biobricks in iGEM are maintained in plasmids. Plasmids are circular, double-stranded DNA molecules typically containing a few thousands of base pairs that replicate within the cell independently of the chromosomal DNA. In iGEM Registry, a plasmid consists of two parts, **biobrick part and biobrick plasmid backbone.**

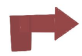




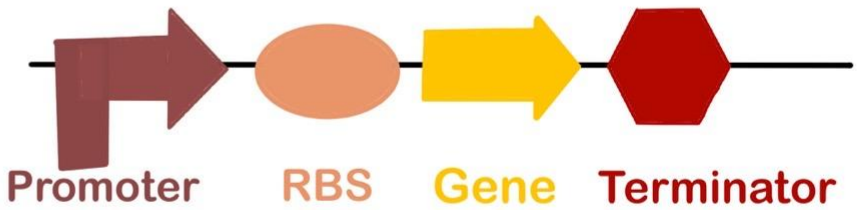
Concept 1.4
Biobrick - Biobrick parts & Biobrick plasmid backbone

Biobrick parts are stretches of functional DNA sequence. Different biobrick parts have different functions, and they are symbolized in different figures.

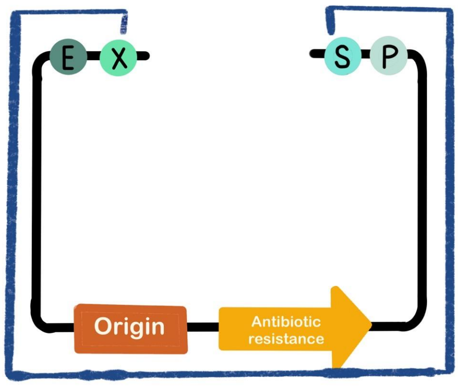


Symbol	BioBrick parts
	Promoter
	RBS
	Cloning gene
	Terminator
	Protein domains

Be aware that the basic protein expression requires at least 4 biobrick parts, namely a promoter, a RBS, gene and a terminator.



Biobrick plasmid backbone must include 3 key features, replication origin, antibiotic resistance, and cloning site.

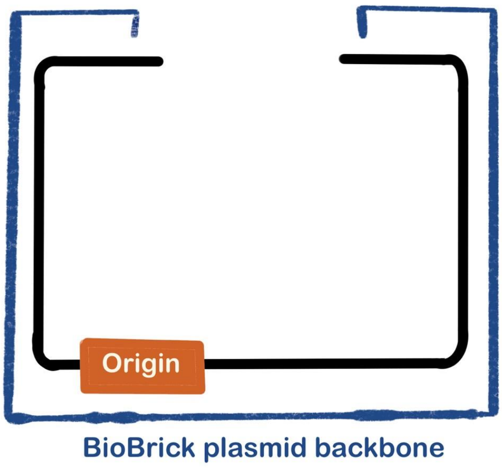


BioBrick plasmid backbone

Symbol	Backbone features
E X S P	Cloning site
Antibiotic resistance	Antibiotic resistance marker
Origin	Replication origin

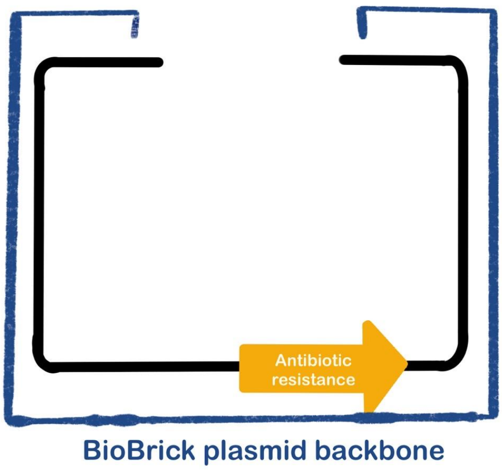
- Replication origin

  The genetic element responsible for the replication of plasmids during cell growth and division is called a replication origin. Different replication origins differ in their plasmid copy number per cell (how many molecules of the plasmid are maintained in the cell), mechanism of copy number control, cell-to-cell copy number variation, and even the degree of coiling of the physical DNA.



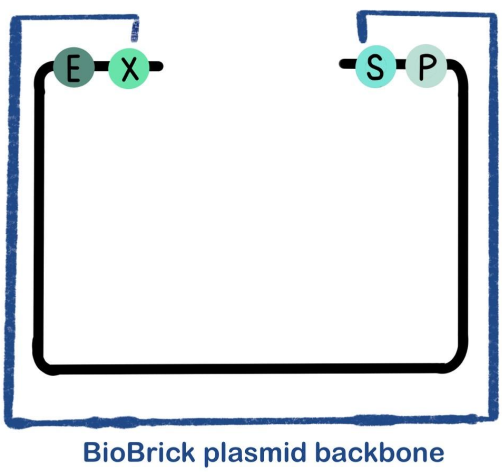
- Antibiotic resistance marker

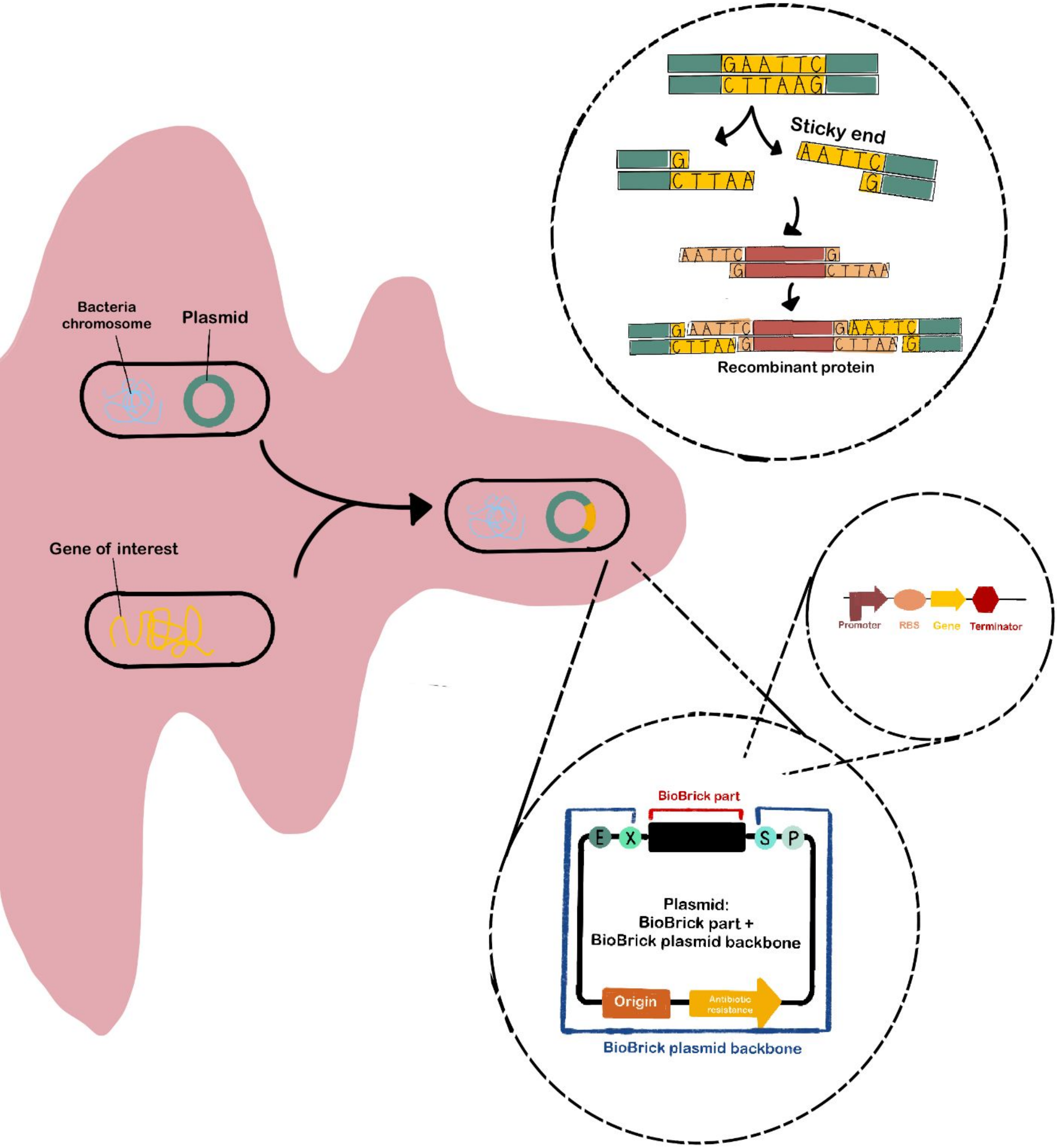
  Function of the antibiotic resistance marker is to allow the cell to grow even in the presence of a particular antibiotic. Plasmid backbones include antibiotic resistance markers because the markers allow you to select for cells that contain your plasmid.



- Cloning site

  The cloning site is the location on the plasmid backbone where BioBrick parts are inserted. All BioBrick parts are inserted at the BioBrick cloning site between the enzyme recognition sites, BioBrick prefix (EcoRI and XbaI) and BioBrick suffix(SpeI and PstI).





GAATTC
CTTAAG
Sticky end
G
CTTAA
AATTC
G
AATTC
G
G
CTTAA
GAATTC
CTTAAG
GAATTC
CTTAAG
Recombinant protein
Bacteria chromosome
Plasmid
Gene of interest
Promoter
RBS
Gene
Terminator
BioBrick part
E
X
S
P
Plasmid:
BioBrick part +
BioBrick plasmid backbone
Origin
Antibiotic resistance
BioBrick plasmid backbone

Reference & Sources

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