Synthetic Biology

CAU-China 2021

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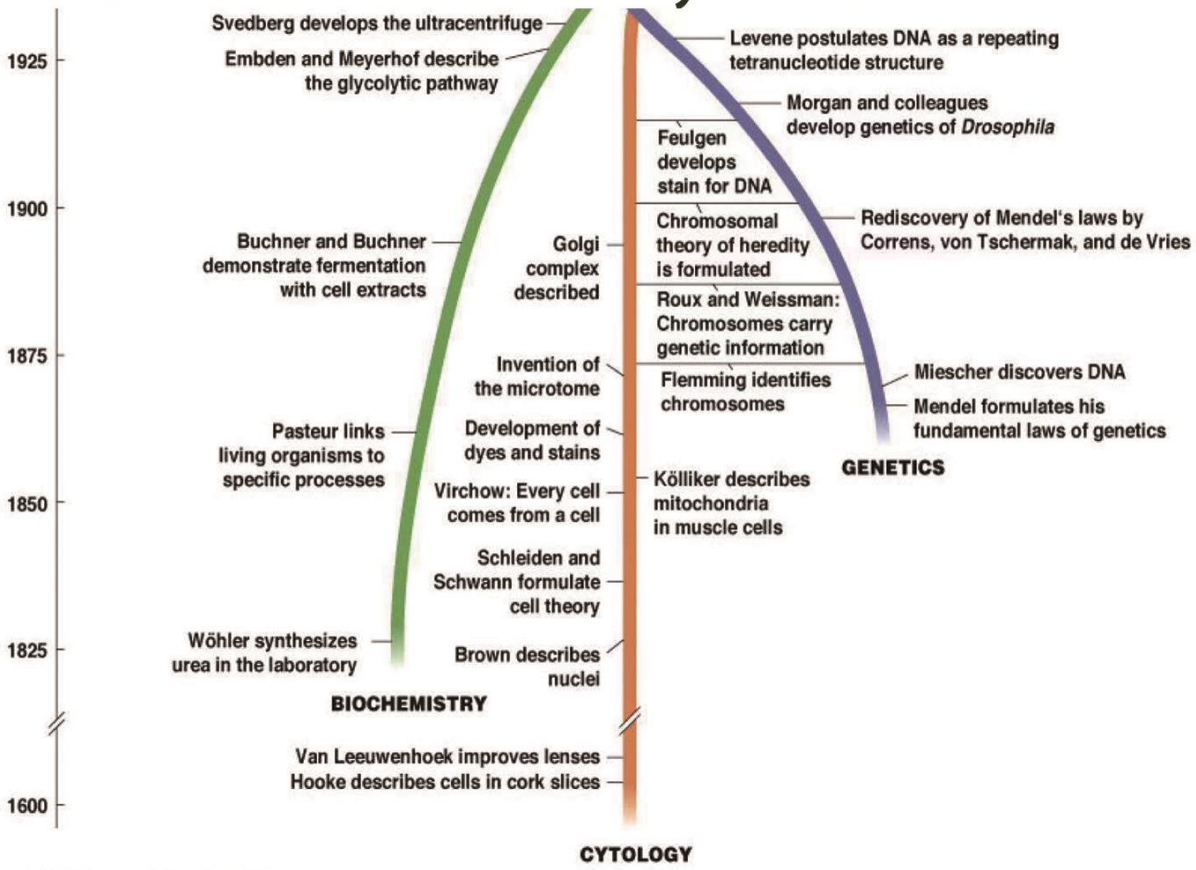
01/Cell

01-1/The Concept of Cell

A cell is like a small house full of magic, with a membranel like a wall, genes to maintain stability and create specific genetic materials, and various energy and transportation and production machines - organelles... They have various forms and functions. Some cells are as round as a leather ball, and some are as sharp as a cloth shuttle, Some are like trees, while others are like columns... They are arranged, combined, stacked and love each other to build a wonderful biological world.

In biology, the common concept of cell is that cell is the basic structural and functional unit of organism. It is known that all organisms except viruses are composed of cells, which can be one cell or many cells. Virus life activities must be carried out in cells.

01-2/The Research History of Cell



01-3/The Structure and Types of Cell

Eukaryotic cell refers to a cell containing eukaryotes (nuclei surrounded by nuclear membranes). It has more than one chromosome and can undergo mitosis. It can also carry out protoplast flow and deformation. Photosynthesis and oxidative phosphorylation were carried out by chloroplasts and mitochondria. Except for the cells of bacteria and cyanobacteria, all animal cells and plant cells belong to eukaryotic cells. In the nucleus of eukaryotic cells, DNA and histone proteins form the chromosome structure, and nucleoli can be seen in the nucleus. There are organelles such as endoplasmic reticulum, Golgi apparatus, mitochondria and lysosomes.

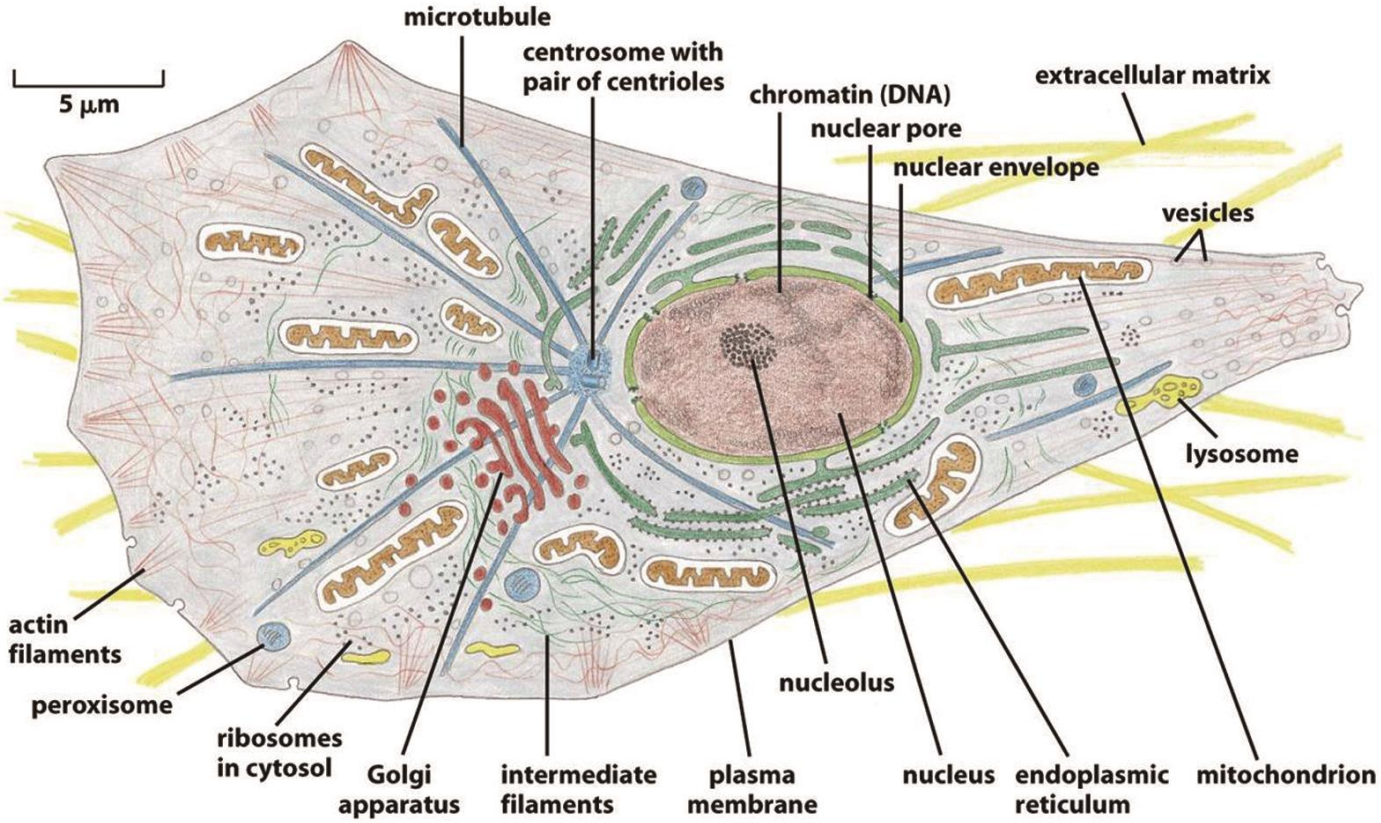
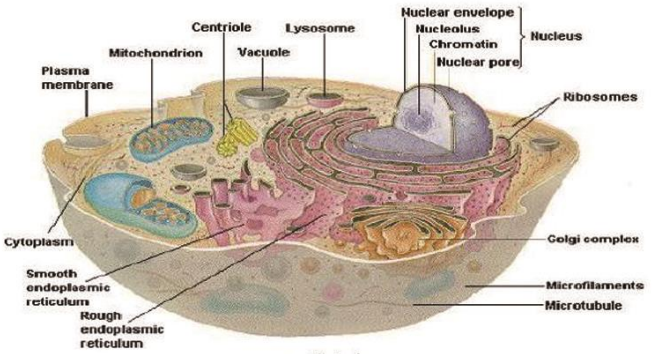
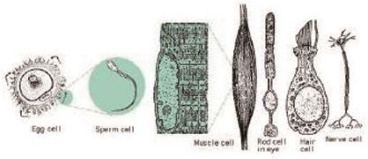


Figure 1-30 Molecular Biology of the Cell 5/e (© Garland Science 2008)



Cells' Structure
The cells is basic living unit (basic structural and functional) of all organisms.

There are different types of cells such as Egg cell, Sperm cell, Muscle cell and so on.



Cytoplasm
The cytoplasm is basically substance that fills the cell and located out side the nucleus.
It contains organelles and inclusions in An aqueous gel called the **cytoplasmic Matrix.**

Nucleus
Is a membrane bound structure that containes the cell's hereditary information and controls the cell's growth and reproduction.

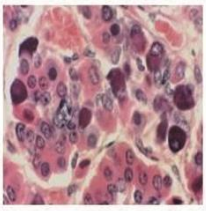
Contains a blueprint for all cell structures and activities encoded in the DNA of the chromosomes.

Functional ribosomes do not occur in the nucleus.

- Tissue components stain more readily with basic dyes are termed basophilic, Those stain better with acidic dyes are termed acidophilic.
- **H & E staining:**

Hematoxylin stains DNA of the cell nucleus and other acidic structures Blue.

Eosin stains other cytoplasmic components and collagen Pink.



Organelles
Is a specialized subunit within a cell that has specific function, and it is usually separately enclosed within its own lipid bilayer.

Inclusions
The materials in cytoplasm and usually not surrounded by a plasma membrane. (eg. secretory granules, Pigment, stored waste products etc.)

Chromatin
In charge for characteristic basophilia of the nucleus.
A combination of DNA and proteins.
- **Heterochromatin** Densely staining material
- **Euchromatin** Lightly staining material

Nucleolus
The place of ribosomal RNA synthesis and initial ribosomal assembly, nonmembranous, Varies in size
And more than 1 nucleolus in some cells.

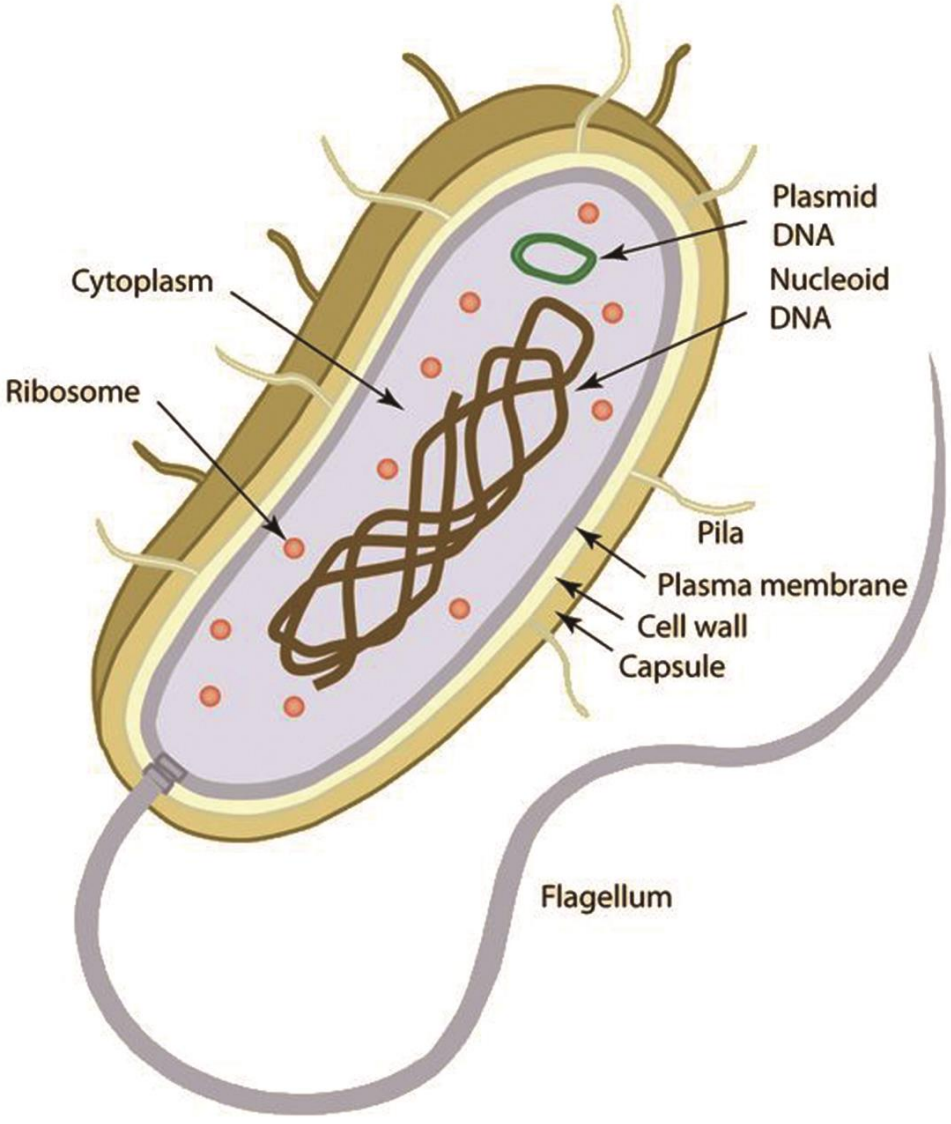
Nuclear envelope
The double layered membrane that envelopes the nucleus of a eukaryotic cell, separating the contents of the nucleus.

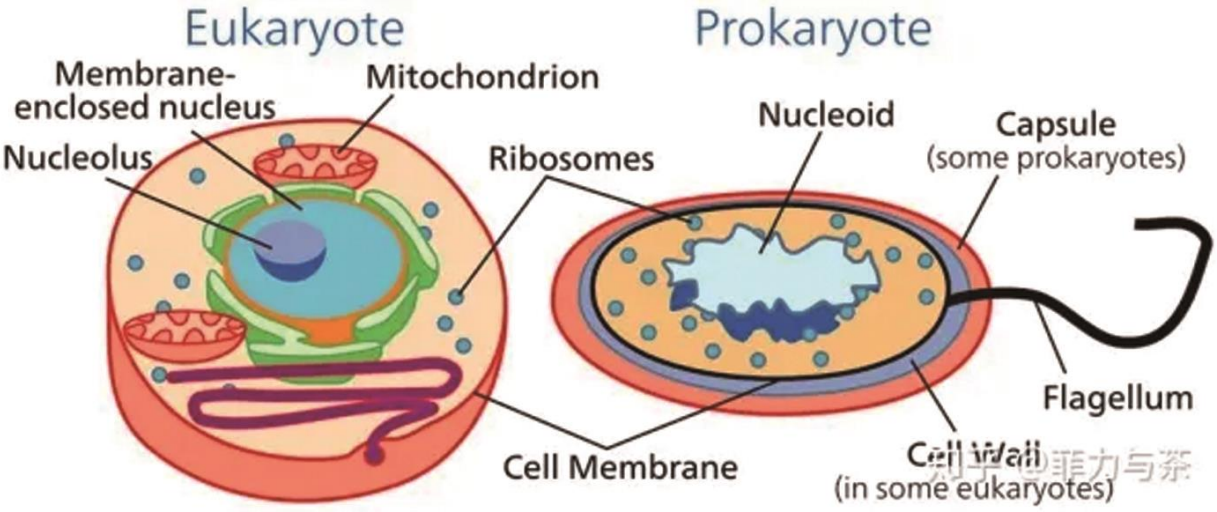
Nuclear skeleton

Nucleoplasm

Prokaryotic cell

Without nuclear membrane, genetic material is concentrated in a low electron density region without clear boundary, which is called pseudonucleus. DNA is a bare ring molecule and usually has no binding protein. The organisms composed of prokaryotic cells are called prokaryotes, which are single celled organisms.





Archaebacteria mostly live in extreme ecological environment. It has some characteristics of prokaryotes, such as non nuclear membrane and intimal system; It also has the characteristics of eukaryotes, such as the synthesis of protein initiated by methionine, the similarity between RNA polymerase and eukaryotic cells, DNA with intron and binding histone; In addition, it also has characteristics different from prokaryotic cells and eukaryotic cells, such as no peptidoglycan and no cell wall acid in cell wall.

02/Gene

02-1Gene in Cell

There are many fine structures with special functions in the internal construction of cells, which ensure a high degree of programming and self-control of cell life activities.

For a better understanding, we compare cells to a small town. Each organelle is like a small town. Each building has different functions. Although each district of the town has different functions, its basic structure is not much different. It is built of steel bars, cement and other materials. So are the organelles. Although they have different functions, they are built by biological molecules such as protein, water and sugar.

So how was this town built? First of all, this construction drawing determines all the presentation forms of the whole building. This drawing is the gene. Gene is a double helix deoxynucleotide fragment with genetic effect. It encodes all the information in the process of race, blood type, pregnancy, growth, apoptosis and so on. The drawings are huge, and there will be various specific requirements to guide the construction of the building. Different sequences in genes guide all forms of the whole building. Different genes can guide the synthesis of proteins with different functions and build organelles with different structures and functions.

02-2/The Structure and Function of Gene

In structure, the gene is divided into coding region and non coding region. The coding region DNA can be transcribed to produce mRNA (messenger RNA) for the synthesis of corresponding proteins. The coding region of eukaryotes is discontinuous, which is divided into exons and introns. In the process of transcription, introns will be cut off and exons will be spliced to form transcripts. In prokaryotes, genes are continuous, that is, there are no exons and introns.

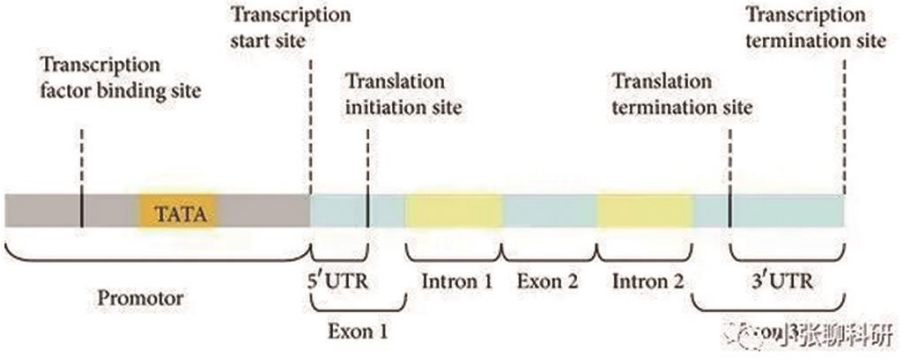
1. Coding region

（1）Exon

Exon is the part of DNA that is retained after pre-RNA is cut or modified, and finally appears in the gene sequence of mature RNA.

（2）Intron

In eukaryotes, as a DNA sequence that blocks the linear expression of genes, introns are DNA sequences that are excised after pre RNA is cut or modified.



2. Noncoding area

Noncoding regions play an important role in the regulation of gene expression, such as promoters, enhancers and terminators. Do not underestimate noncoding regions. Noncoding regions account for more than 90% of human genes. Some of them can be transcribed into functional RNA and regulate the coding region.

(1) Promoter

The promoter is the DNA region transcribed by a specific gene. Just like the station, RNA polymerase starts from here to synthesize RNA. The promoter is generally located at the transcription initiation site of the gene, upstream of the 5 'end, and the promoter is about 100-1000 bp long. During transcription, RNA polymerase and transcription factors can recognize and specifically bind to promoter specific DNA sequences (generally conserved sequences) to initiate transcription.

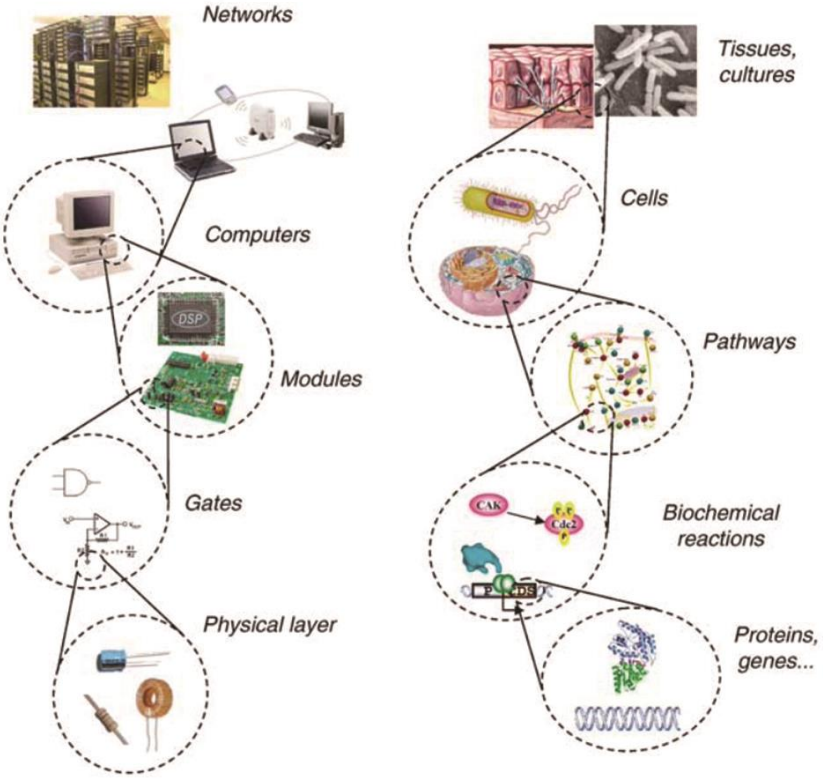
(2) Enhancer

Like a guide, the polymerase is directed to the promoter to enhance gene transcription, which widely exists in prokaryotic and eukaryotic gene structures.

03/Synthetic Biology

03-1/What is Synthetic Biology?

At present, there is no unified and unique definition of synthetic biology. Generally speaking, synthetic biology in a broad sense is to reassemble different elements and genes from different organisms to obtain pathways with target functions.

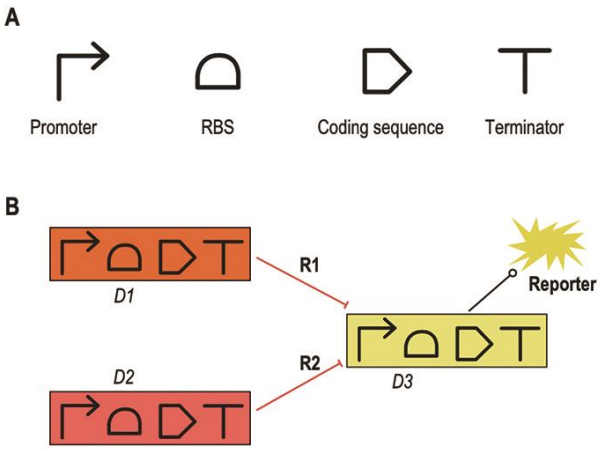


Just like our project, the gene for synthesizing glutamic acid in Bacillus subtilis is introduced into Corynebacterium glutamate, so Corynebacterium glutamate can use this gene to produce synthetic glutamic acid, and then synthesize the polyglutamic acid we need under the guidance of the gene for synthesizing polyglutamic acid.

In synthetic biology, genetic devices synthesized by various regulatory elements and regulated genomes can express gene products adjustable, timed and quantitatively under given conditions.

03-2//The Development of Synthetic Biology

In the 1990s, some researchers used the method of describing the relationship between electrical components in electromagnetics to propose the gene pathway, which is used to study and express the relationship between genes and various components in synthetic biology.



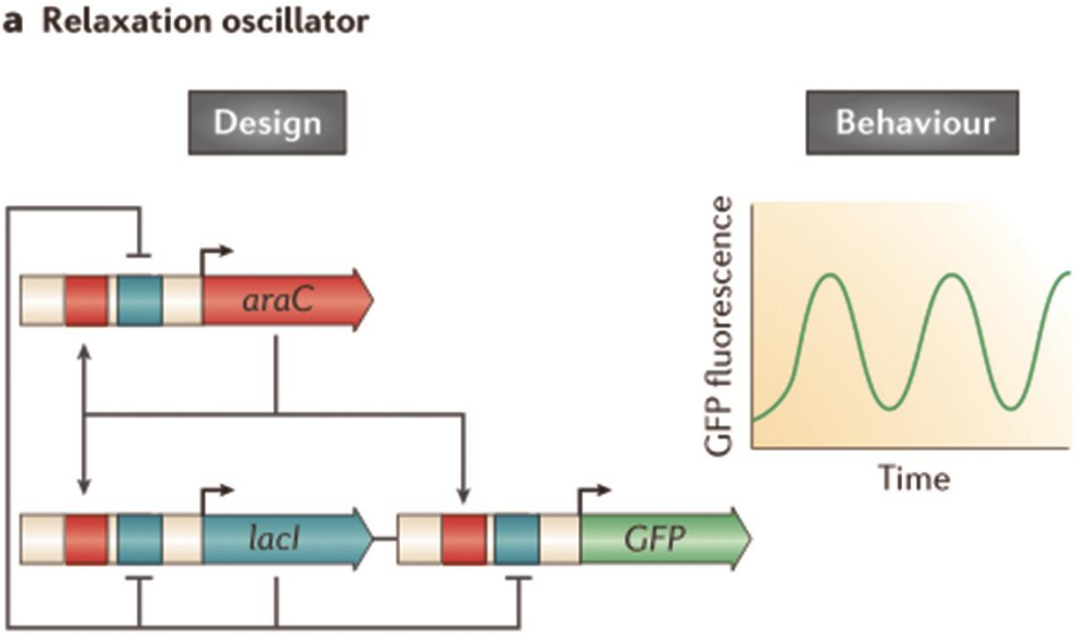
2002-2003 E. coli -- an ideal test platform

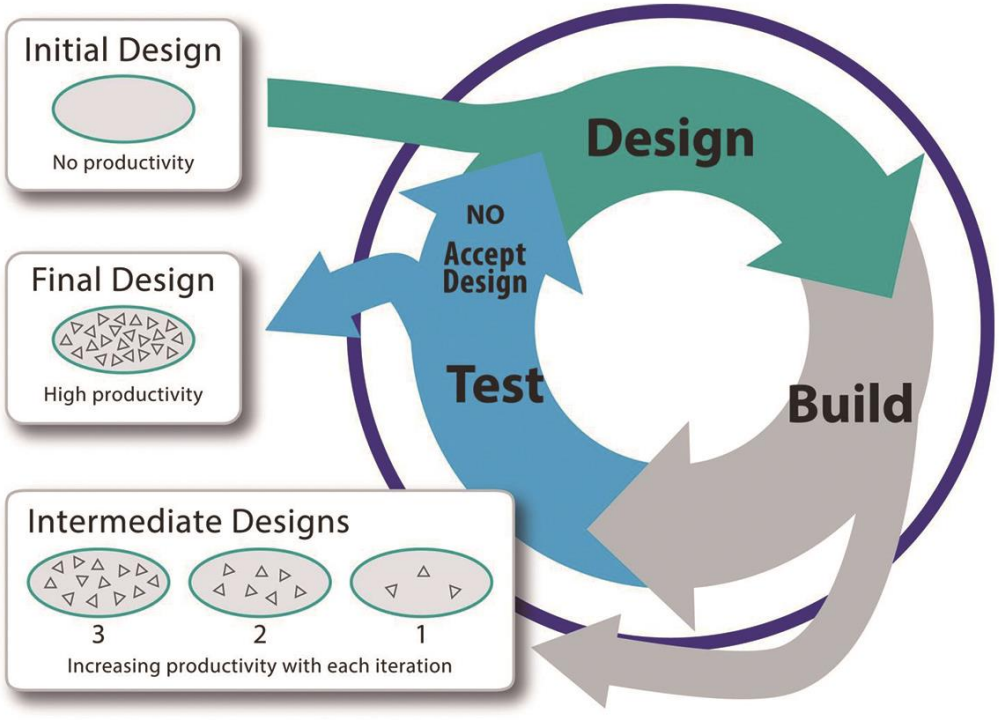
E. coli is easy to operate and has a clear genetic background. There are a large number of fully studied gene regulation systems, which provide a convenient initial source for the basic "elements" of the system.

In January 2000, the first reports on gene circuits were published.

Synthetic biology has been developing continuously in recent years. It is mainly reflected in: more complex lines - more extensive and better characterized component construction - show more accurate and diverse behaviors.

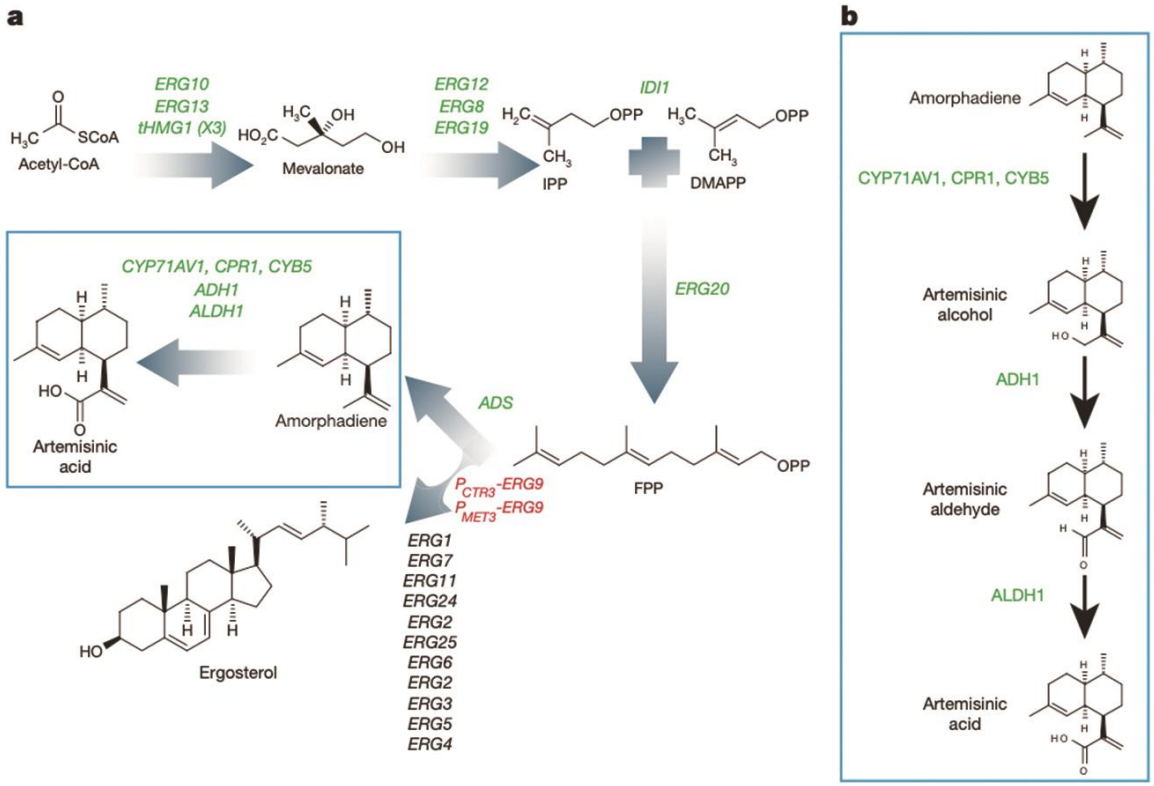
Now synthetic biology follows an effective strategy: "design build test learn" (DBTL).



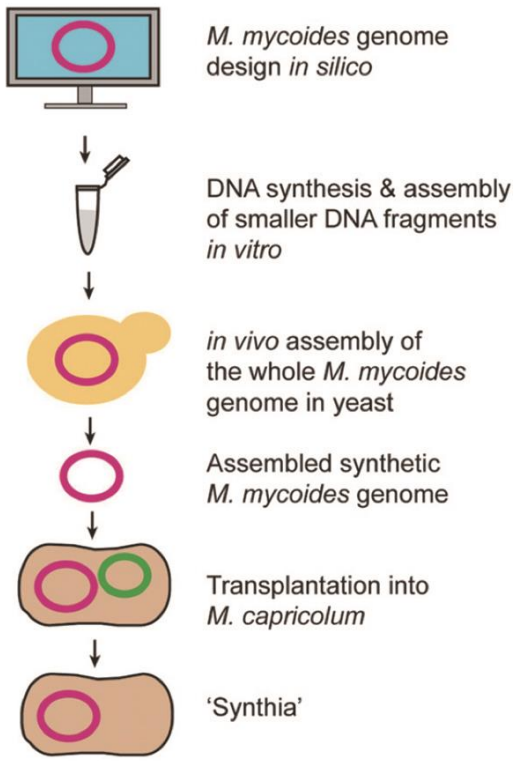


03-3/Application of Synthetic Biology

Production of artemisinin in yeast by synthetic biology



In 2010, Craig Venter and others synthesized new chromosomal DNA by redesigning the genome of M. mycoides and implanted it into M. capricolum to obtain a new mycoplasma, named M. laboratory, also known as Synthia.



Synthetic biology is of great scientific significance in understanding life, exploring the mystery of life, redesigning and transforming biology.

04/About iGEM

The international genetic engineering machine competition is an international top university science and technology competition in the field of synthetic biology. It was founded by MIT in 2003 and developed into an international event in 2005. The final competition is held at MIT every October.

The long-term goal of the international genetic engineering machine competition is to adopt the mode of academic competition:

Realize the systematization and engineering of biology; Promote the open source and transparent development of biological tools; Help build an engineering system that can safely and effectively apply biotechnology.