General Introduction to Biology

Purpose of the laboratory course

- Introduce engineers to basic concepts in biology, biological engineering, biotechnology, and synthetic biology
- Provide hands on laboratory experience to acquire the necessary skills to conduct biological experiments

No prior knowledge in biology is required...

Course Content

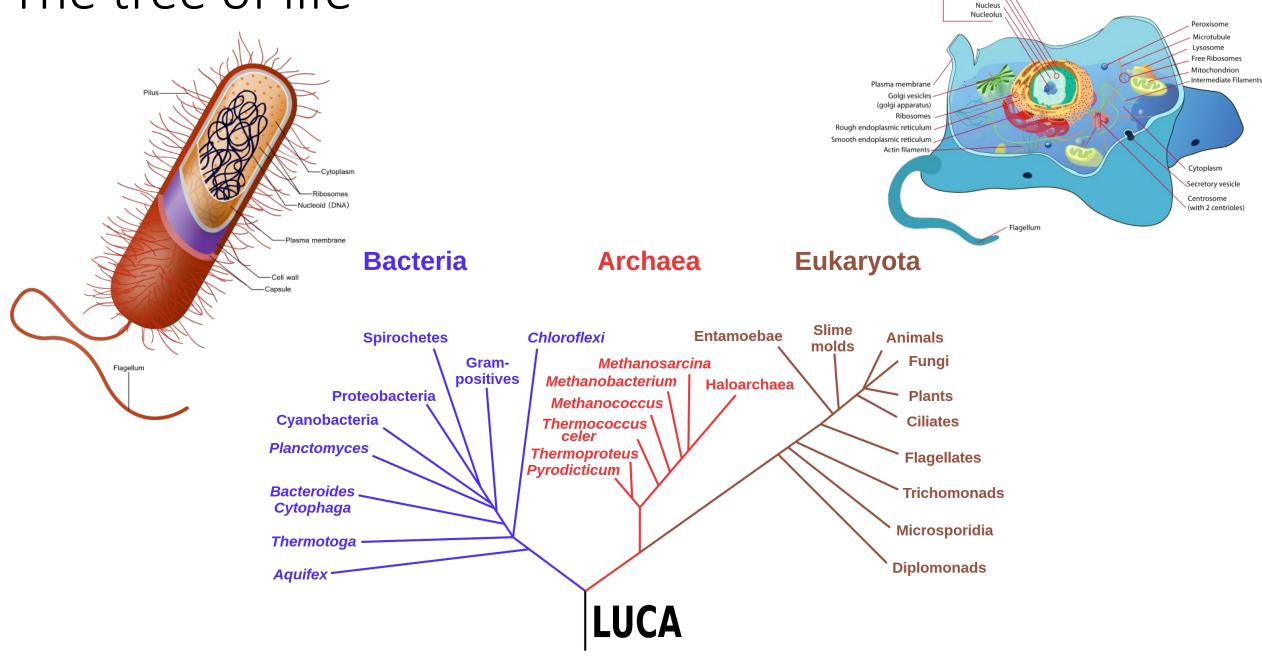
We will cover these main topics:

- Cell culturing techniques
- Molecular Cloning
- PCR
- Protein expression (fermentation)
- Protein purification
- Cell-free transcription-translation (cell-free synthetic biology)

A brief introduction to biology

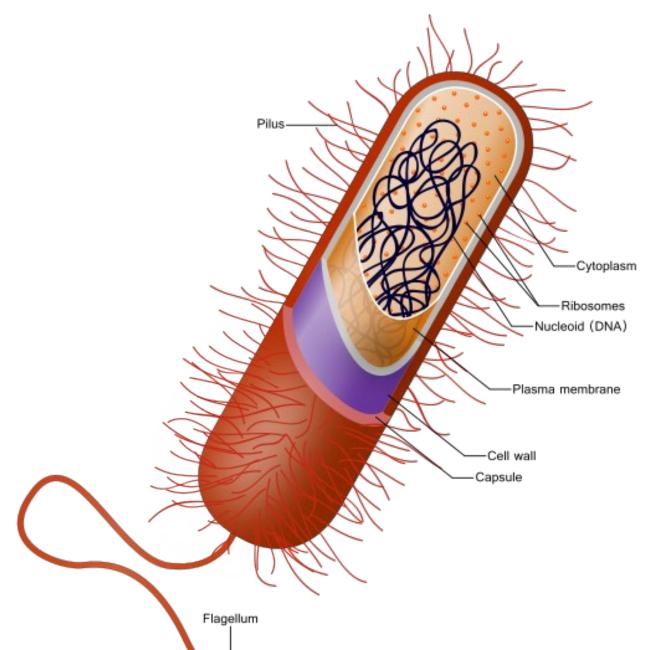


The tree of life

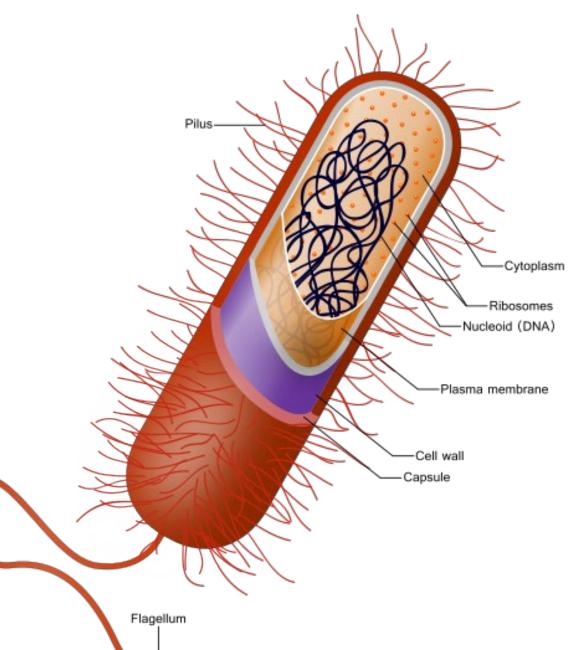


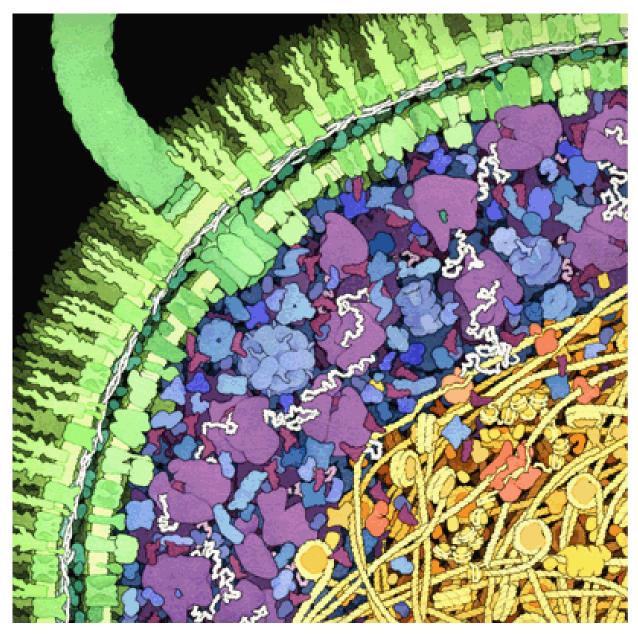
Nuclear pore Chromatin Nuclear envelope

Cell Physiology Prokaryotes

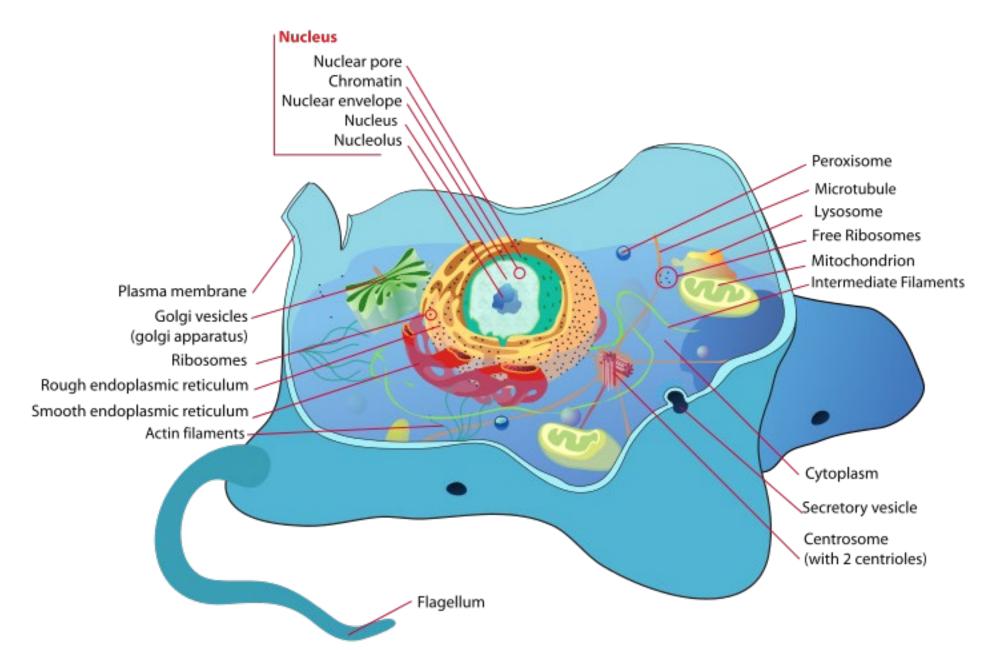


Cell Physiology Prokaryotes

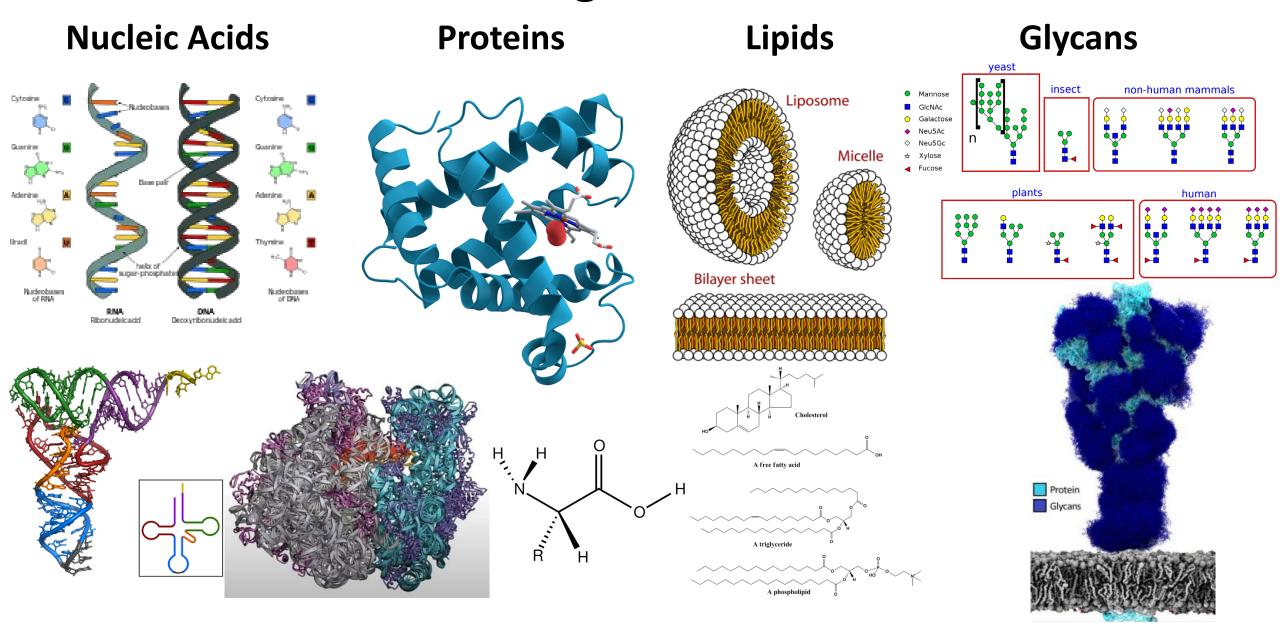




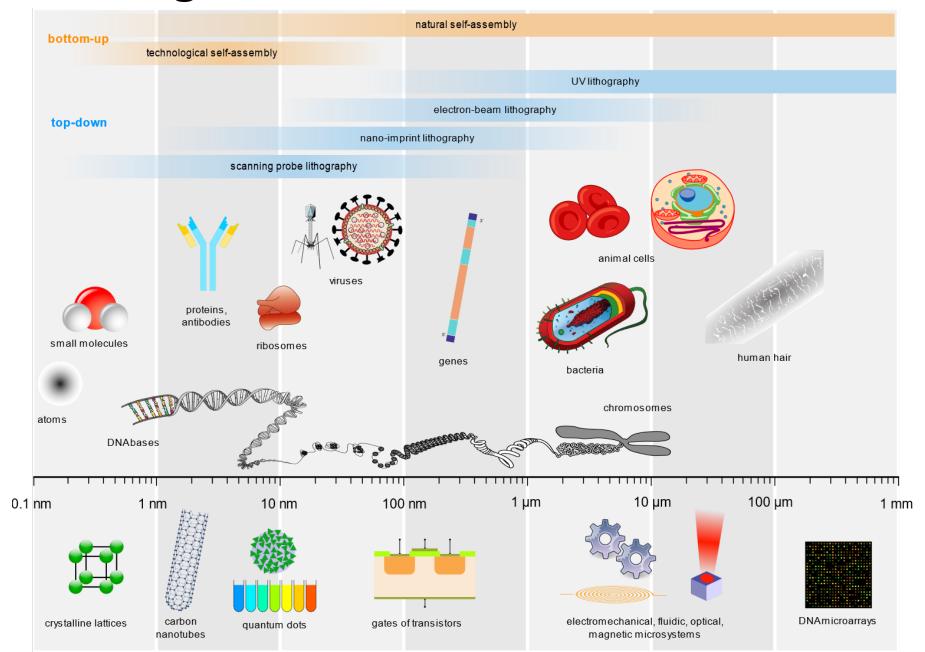
Cell Physiology Eukaryotes



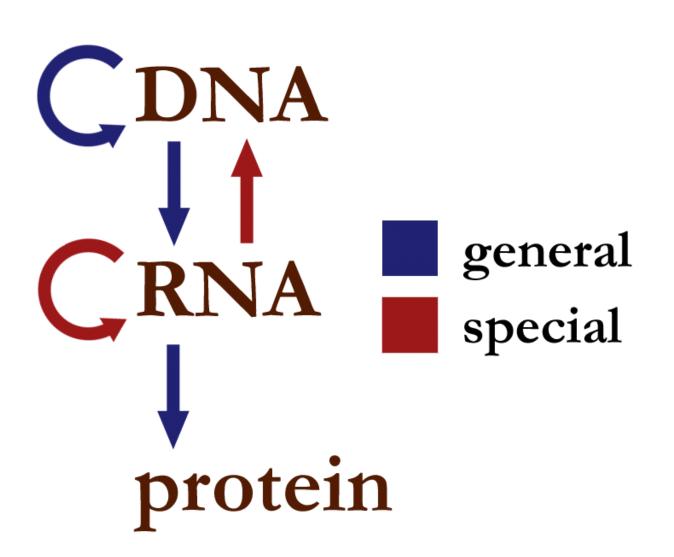
Macromolecular Building Blocks

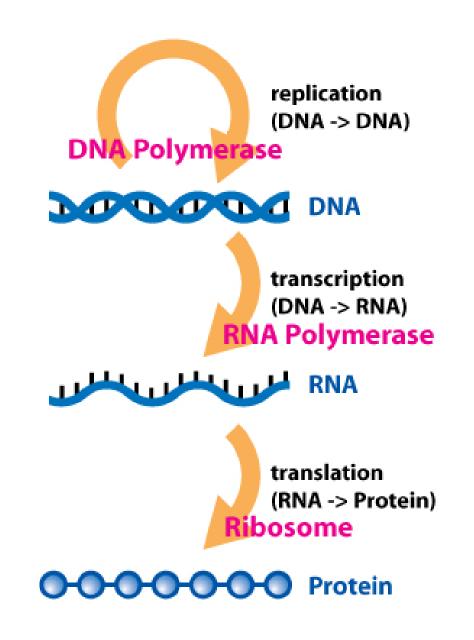


Biological Length Scales

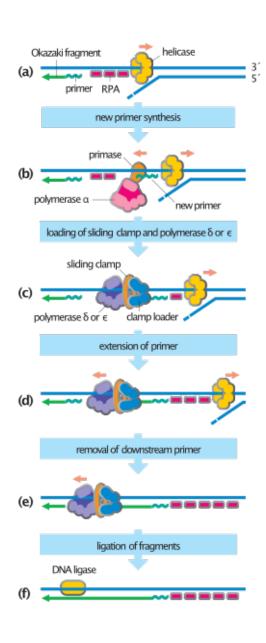


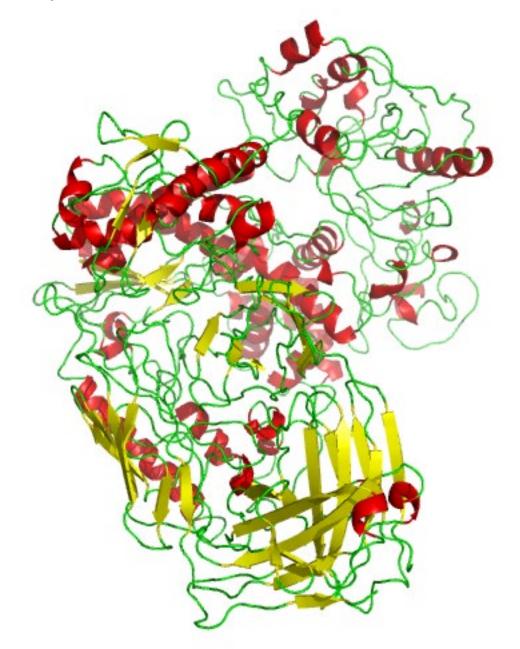
Central Dogma



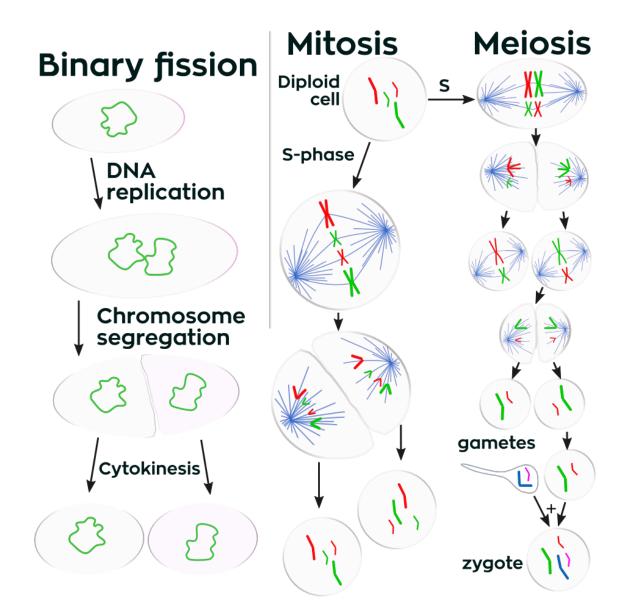


DNA Replication (make DNA)

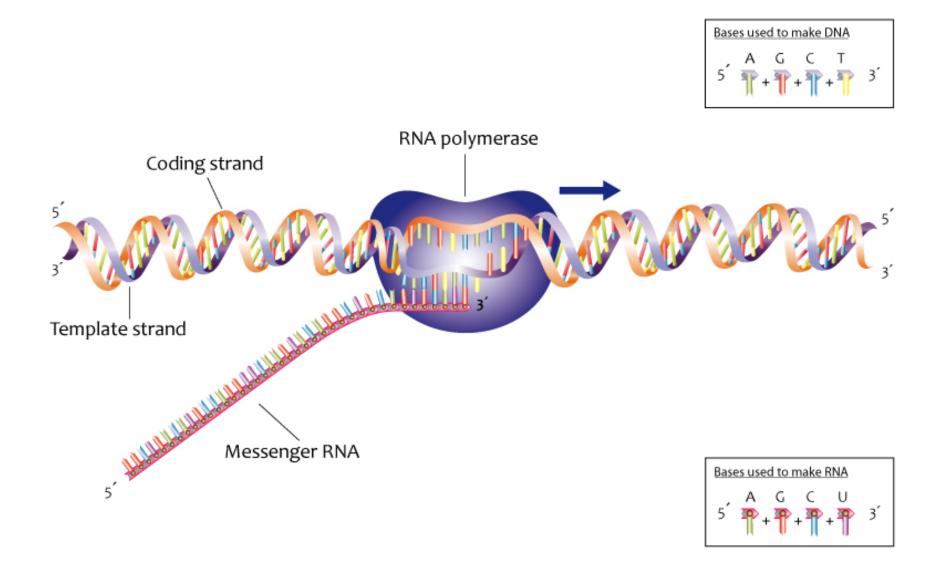




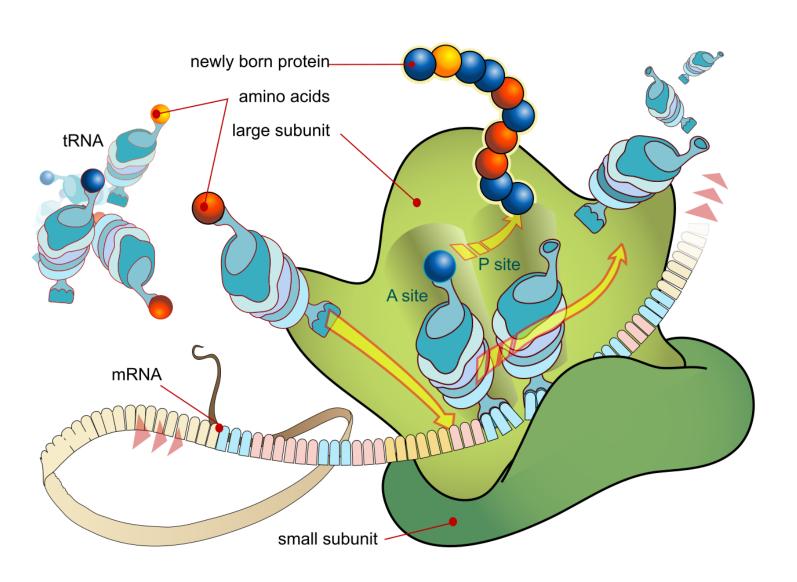
Cell Division

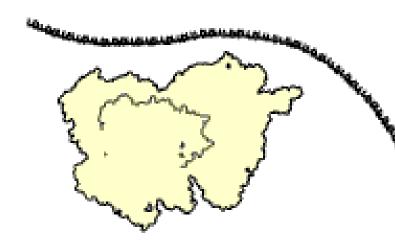


Transcription (make mRNA from DNA)



Translation (make protein from mRNA)





Genetics (genomes, chromosomes, genes, etc.)

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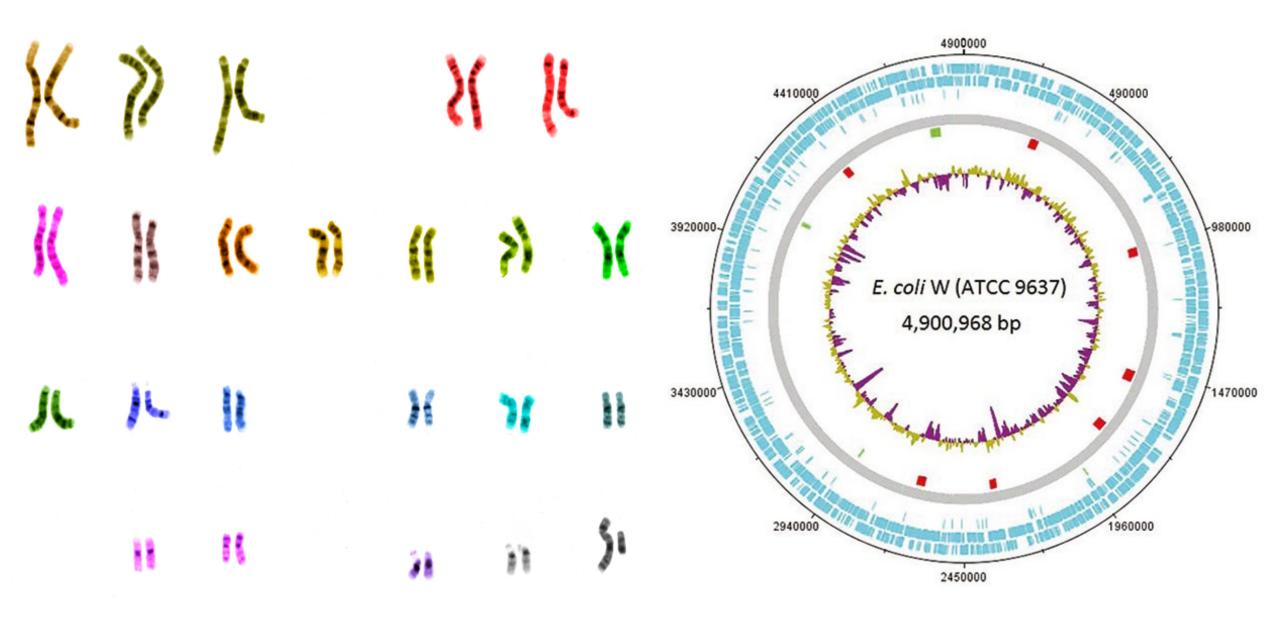
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CTAGGTATTCACGCAACCGTCGTAACATGCACTAAGGATAACTAGCGCCAGGGGGGCATACTAGGTCCCGGAGCTCTAGGTATTCACGCAACCGTCGTAACATGCACTAAGGATAACTAGCGCCAGGGGGGCATACTAGGTCC AAAGACTACCCTATGGATTCCTTGGAGCGGGGACAATGCAGACCGGTTACGACACAATTATCGGGATCGTCTAGAAAAGACTACCCTATGGATTCCTTGGAGCGGGGACAATGCAGACCGGTTACGACAATTATCGGGATC

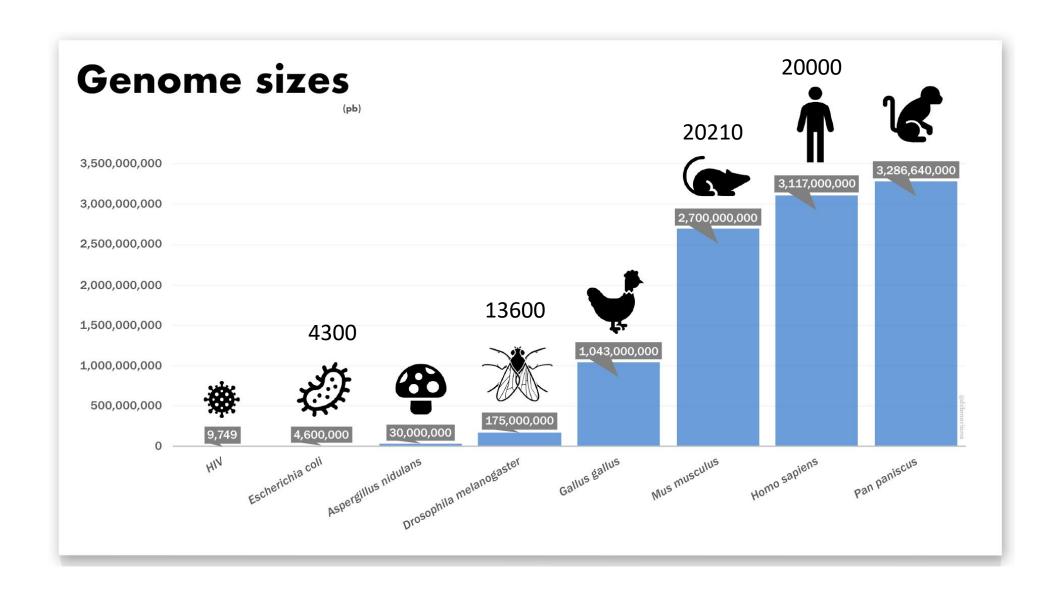
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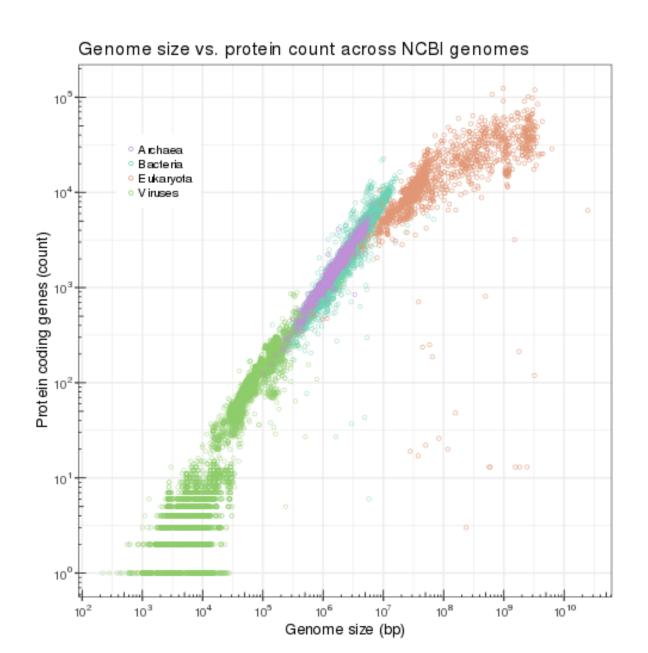
Genomes and Chromosomes

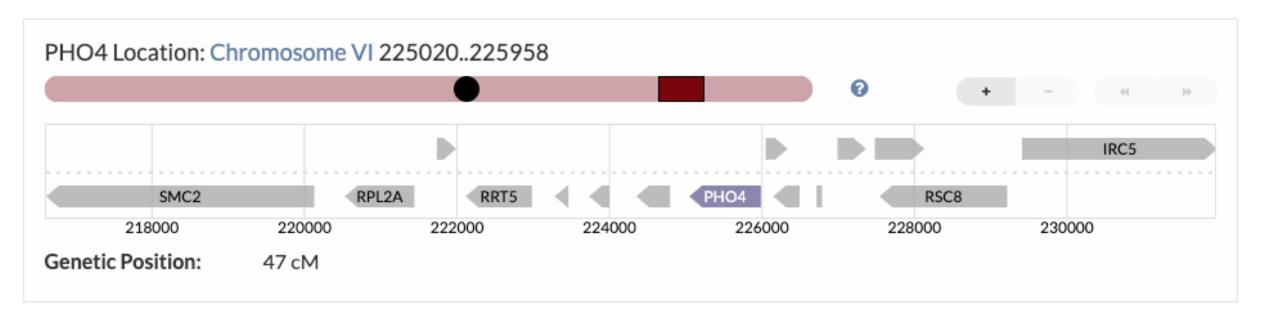


Genome sizes



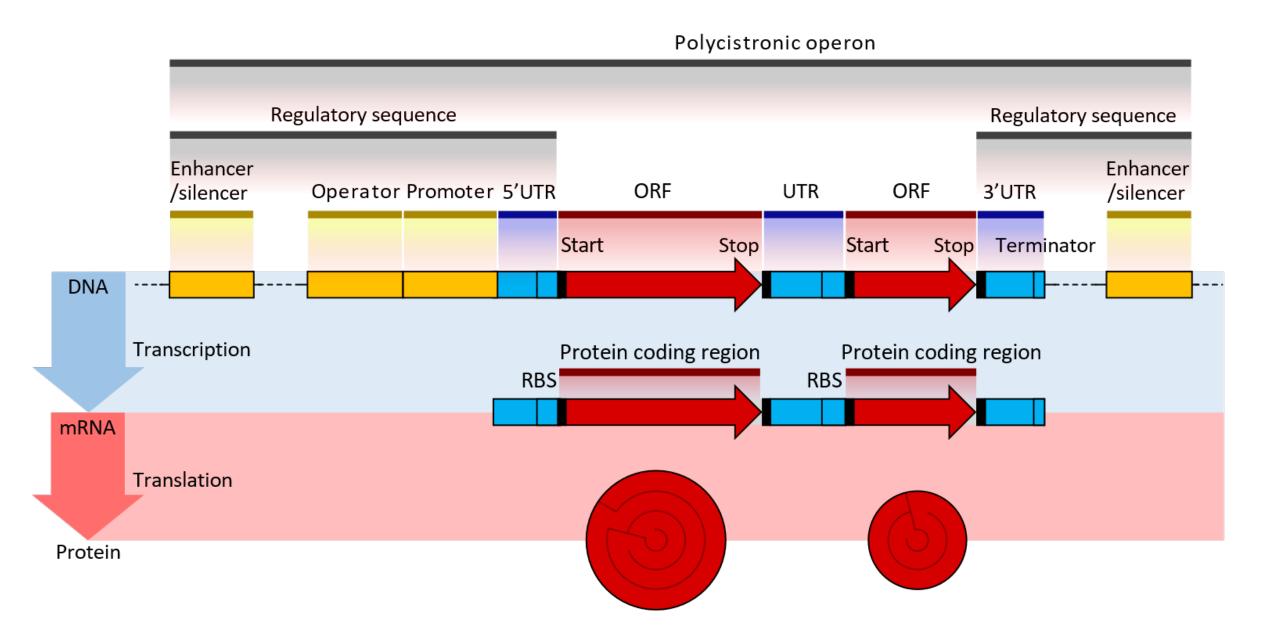
Genome sizes

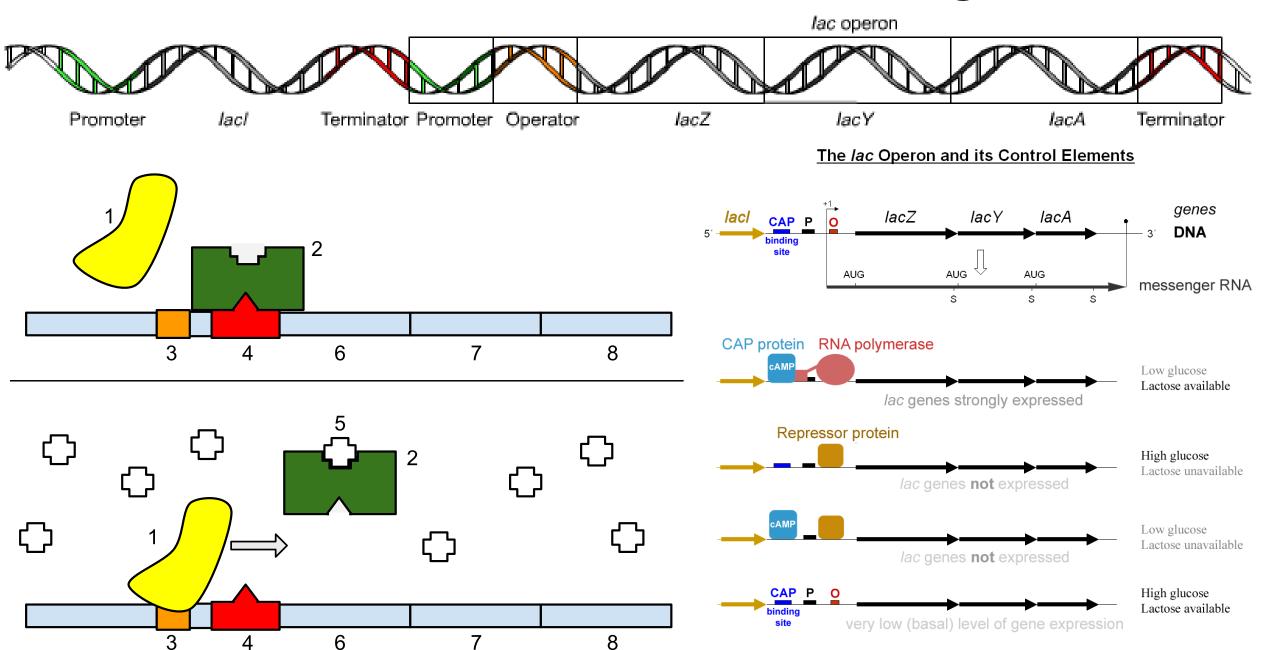




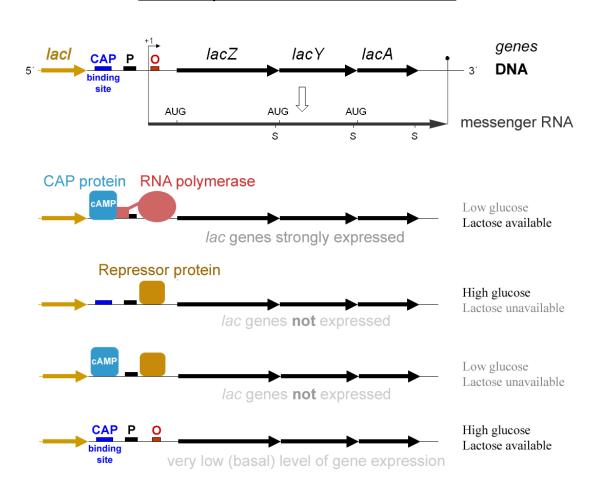
"A gene is a DNA sequence that codes for a diffusible product. This product may be protein (as is the case in the majority of genes) or may be RNA (as is the case of genes that code for tRNA and rRNA). The crucial feature is that the product diffuses away from its site of synthesis to act elsewhere."

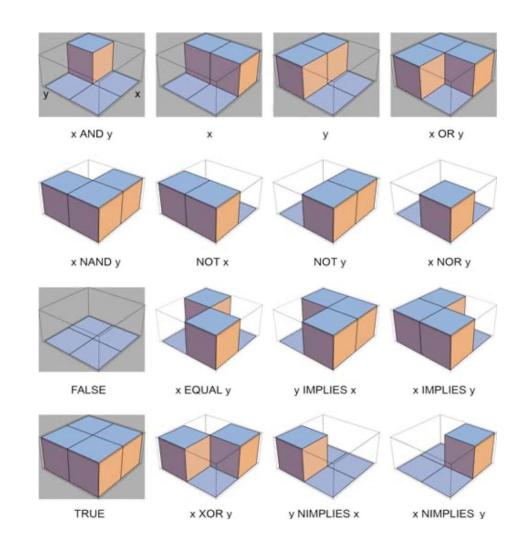
Lewin B (2004). *Genes VIII*. Upper Saddle River, NJ, USA: Pearson/Prentice Hall.

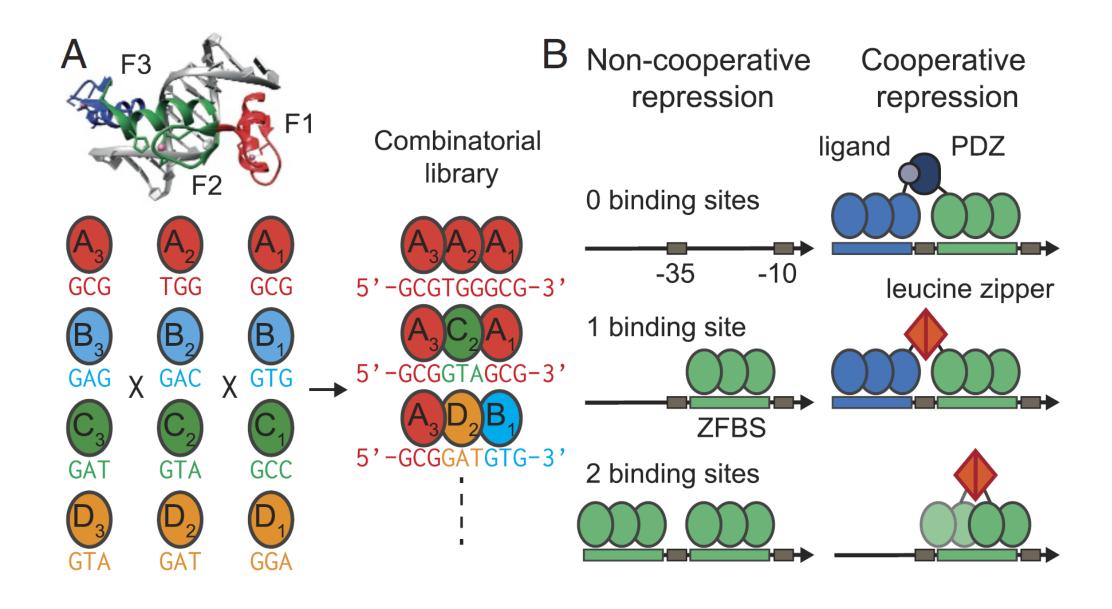




The lac Operon and its Control Elements

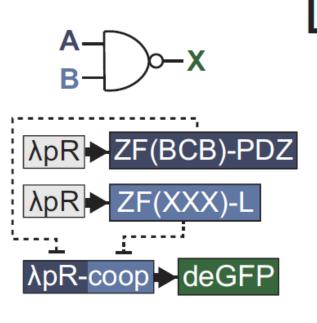


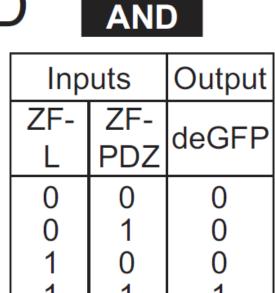


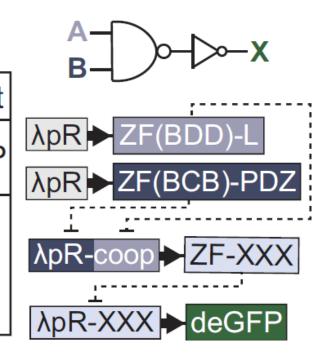




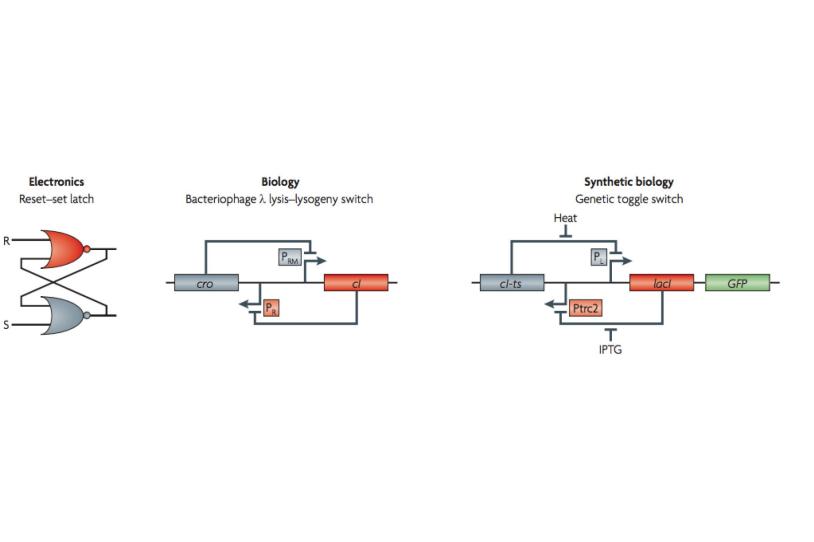
Inputs			Output
ZF BC		ZF- XXX	deGFP
0		0	1
0		1	1
1		0	1
1		1	0

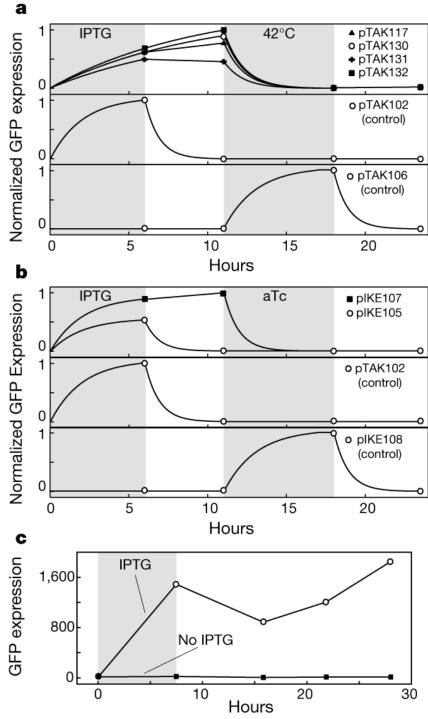




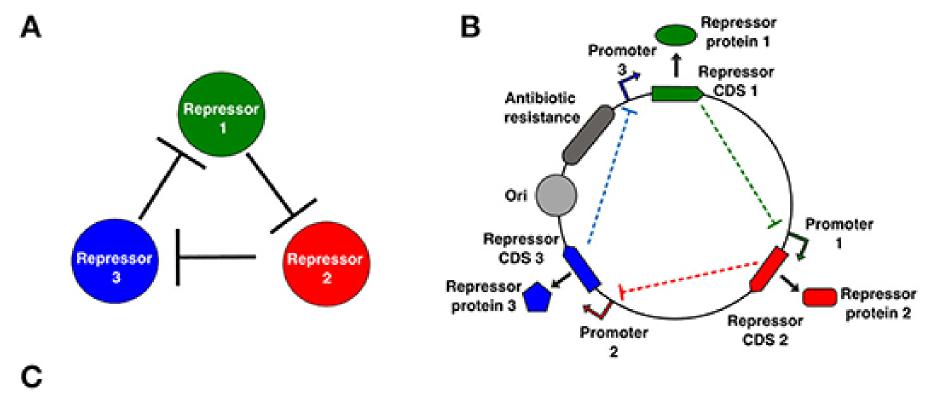


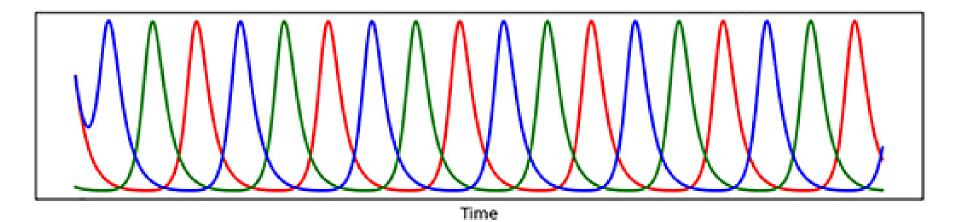
Systems



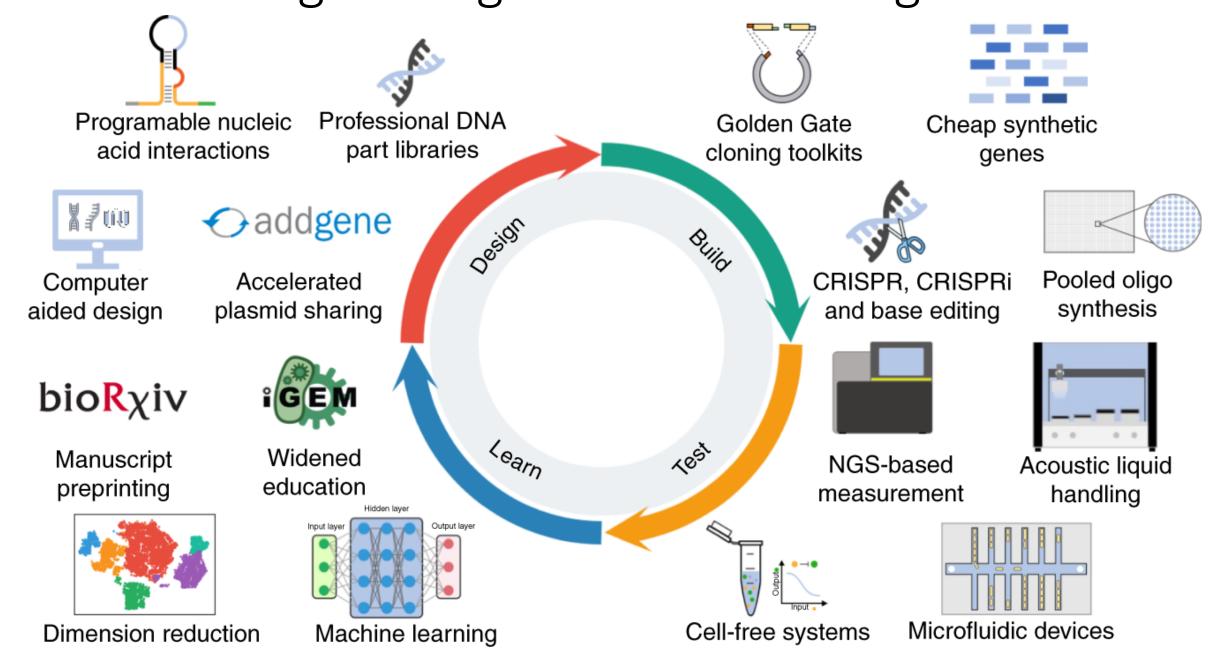


Systems

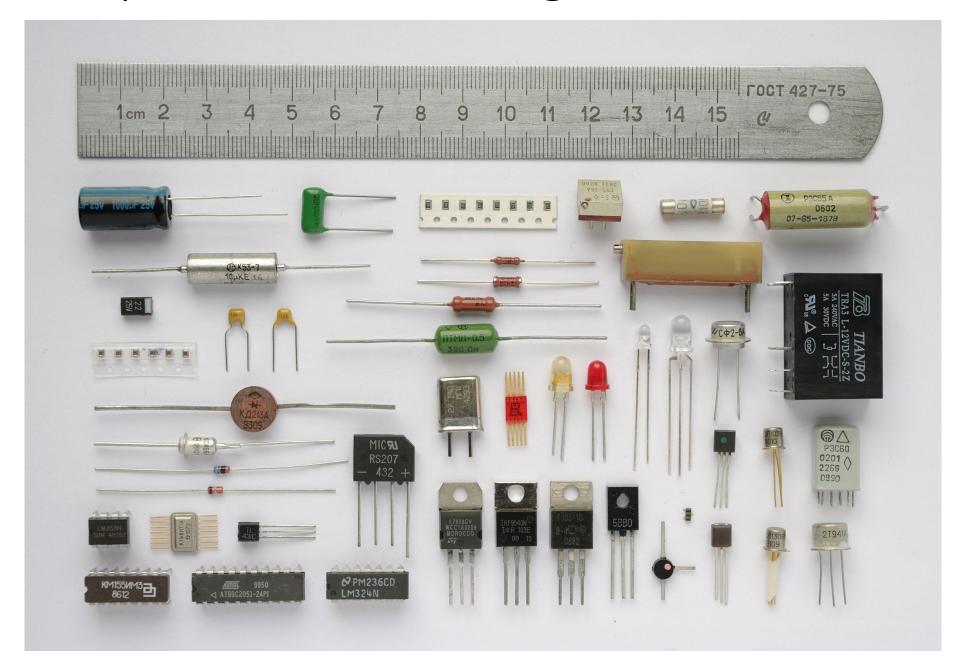




How do biological engineers make things?



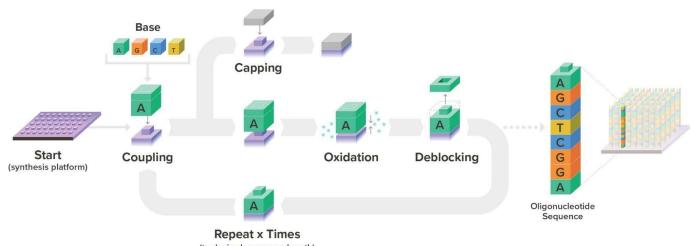
One needs parts to build things...



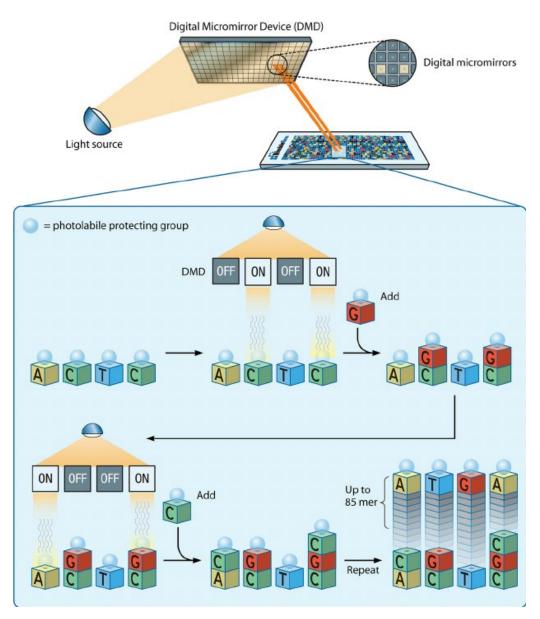
Oligonucleotides:

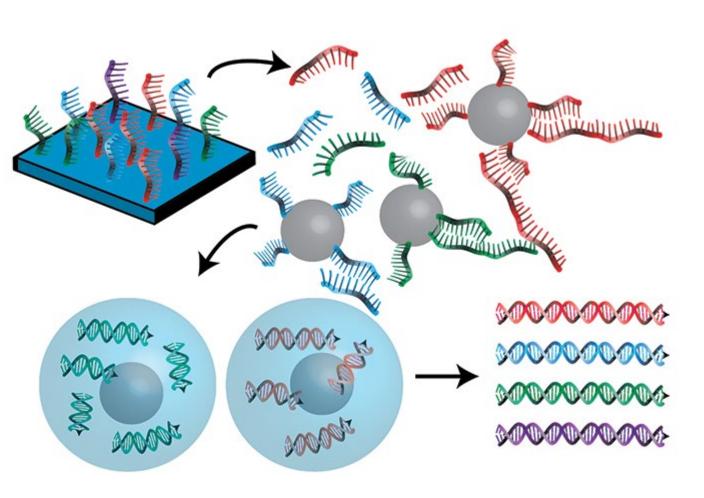
- Single stranded DNA
- Up to 200 bases in length
- Made by chemical synthesis
- Custom sequences can be ordered
- Oligos can be used in PCR and assembled into longer double stranded DNA

Oligonucleotide Synthesis



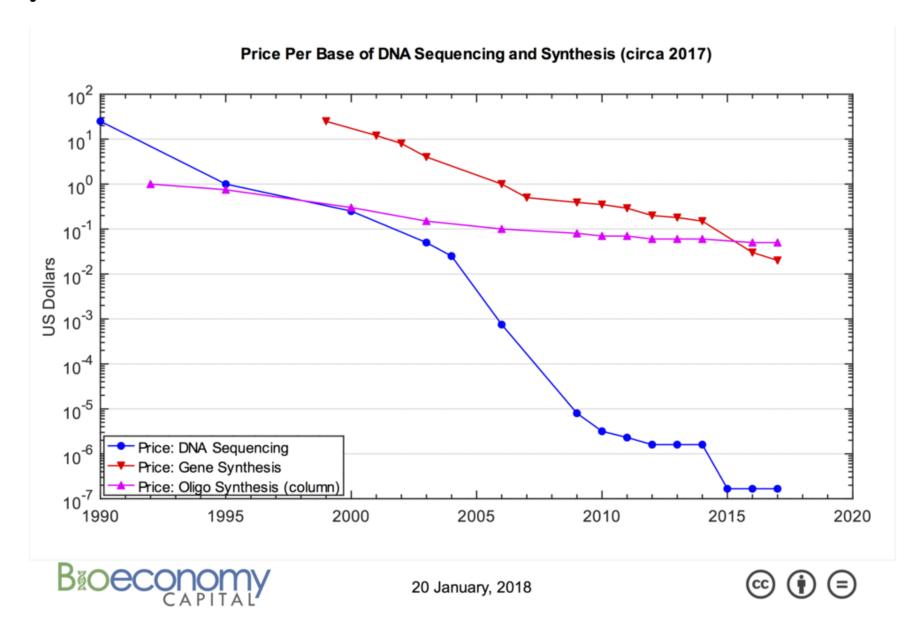


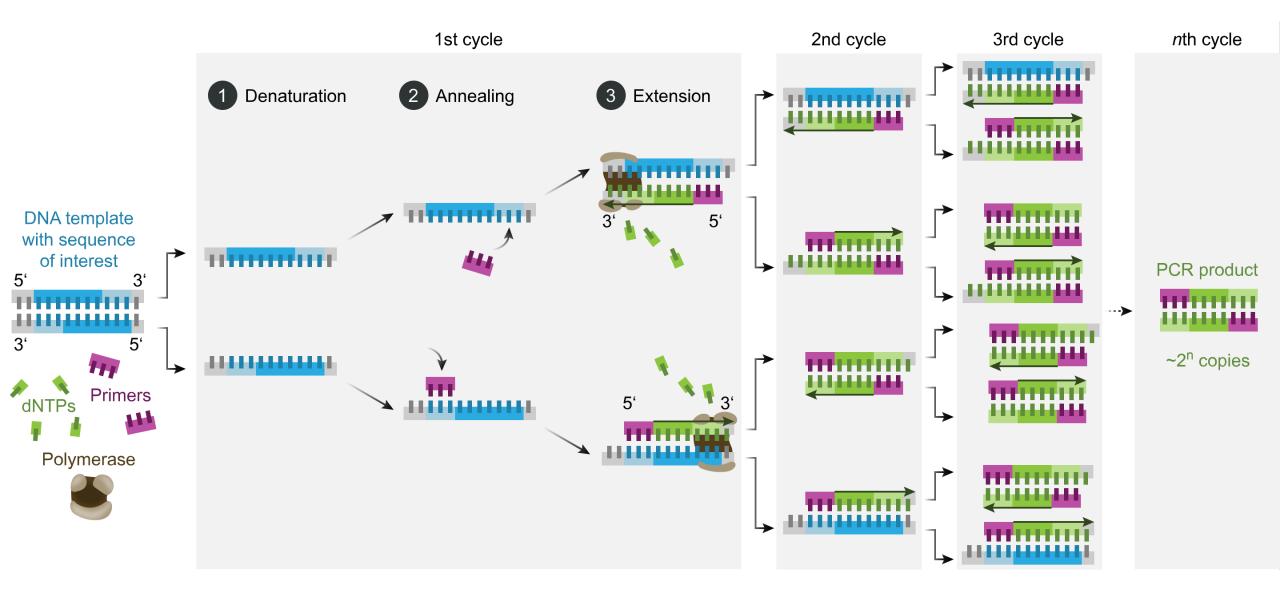




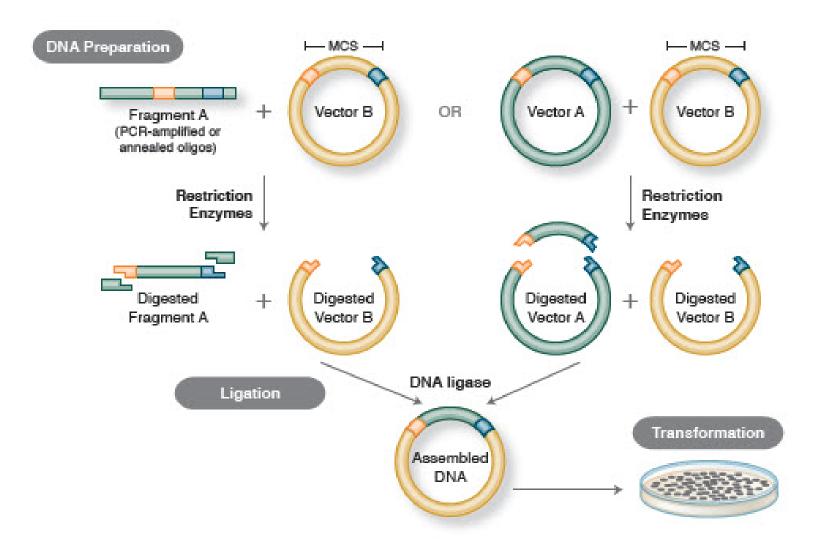
Oligonucleotides:

- Double stranded DNA up to ~5kb in length
- Available as linear templates or cloned into a plasmid





Cloning



Restriction Digest

 Use a restriction enzyme that cuts dsDNA at specific sequences

De-Phosphorylation

 Use a phosphorylase to remove phosphate group from the cut sites, this prevents re-ligation of the cut vector

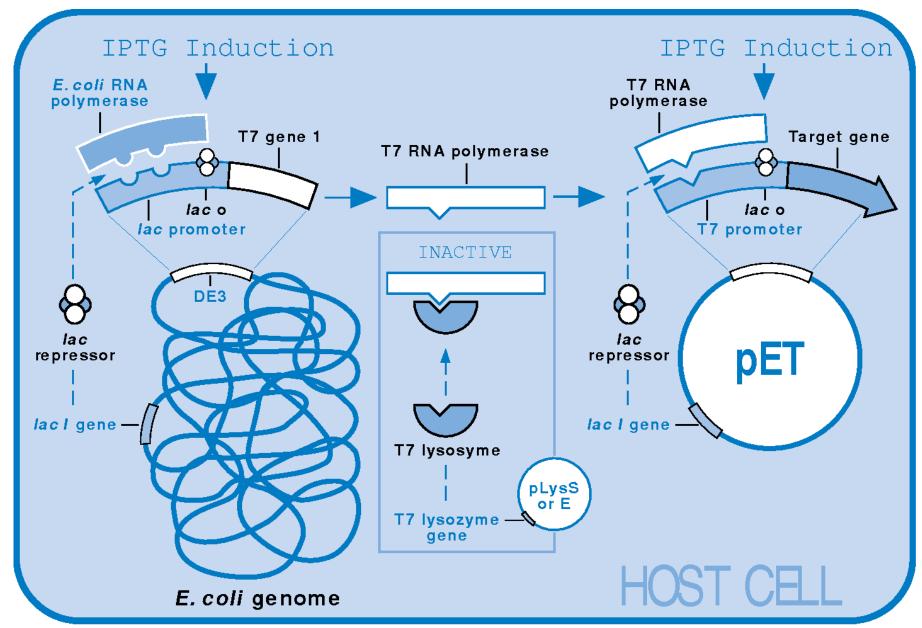
Ligation

 Use an enzyme called a ligase to link two pieces of DNA to one another

Transformation

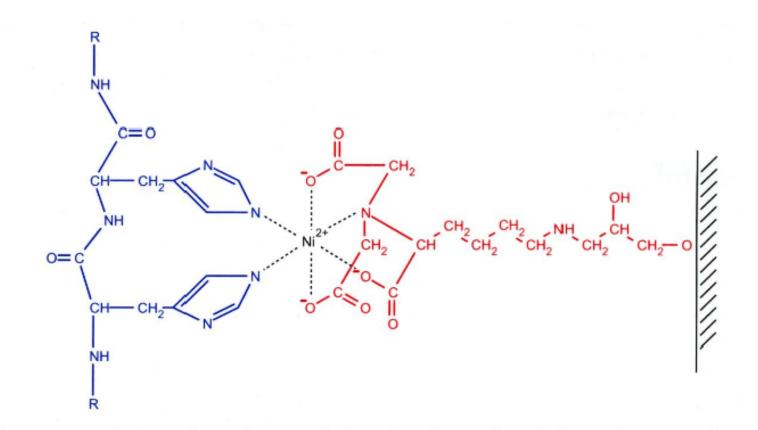
 The cloned vector is then put into E. coli cells which amplify the vector

Protein Expression and Purification

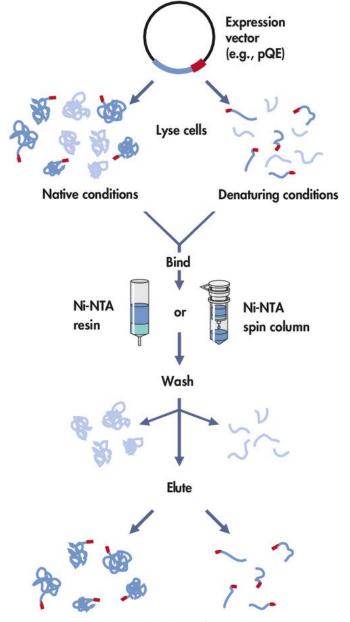


Eigura 1 Control alamante of the nET System

Protein Expression and Purification



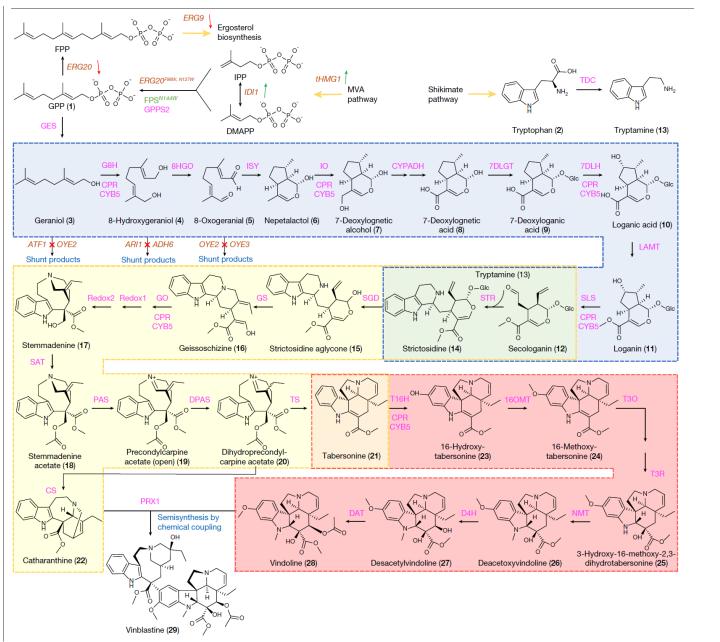
Protein Purification with the Ni-NTA Protein Purification System

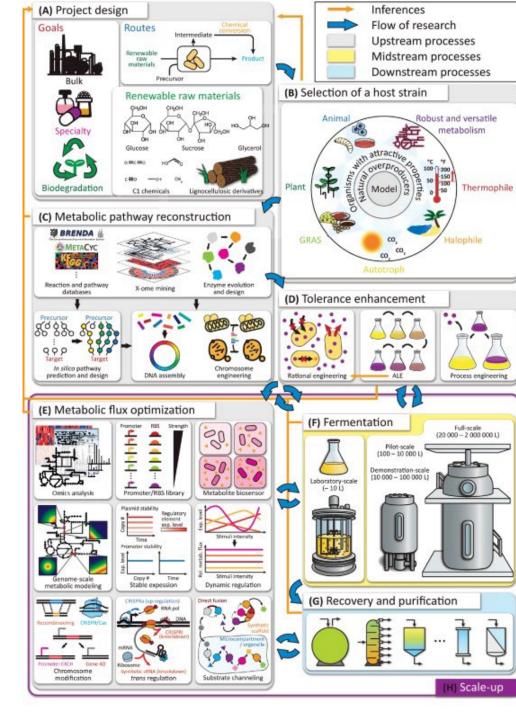


Pure 6xHis-tagged protein

What is Biological Engineering good for?

Metabolic Engineering





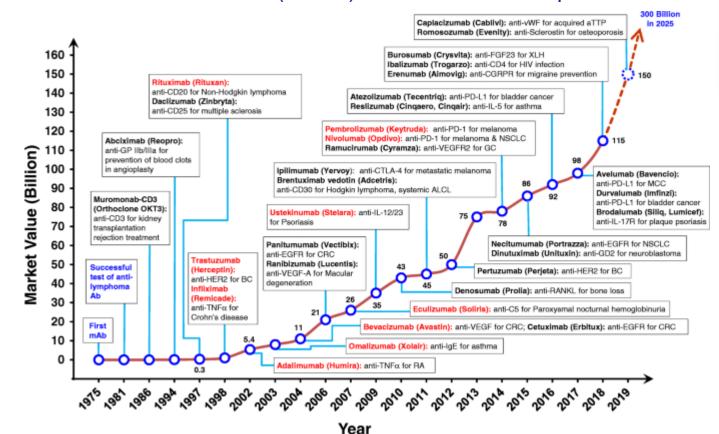
Antibody Therapeutics \$188.18 billion

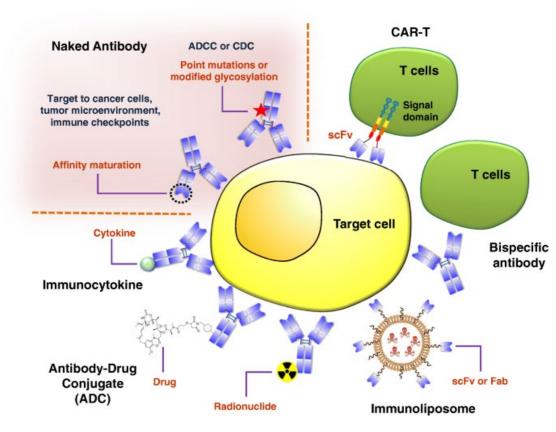
The global monoclonal antibodies (MAbs) market size is expected to grow from \$168.70 billion in 2021 to

\$188.18 billion in 2022 at a compound annual growth rate (CAGR) of 11.5%.

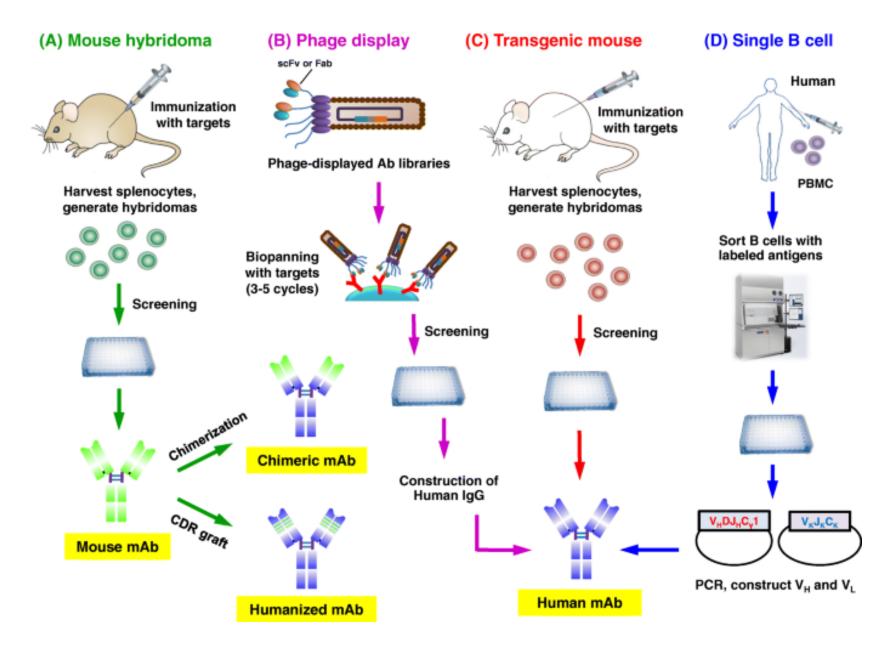
https://www.thebusinessresearchcompany.com > report

Monoclonal Antibodies (MAbs) Global Market Report 2022

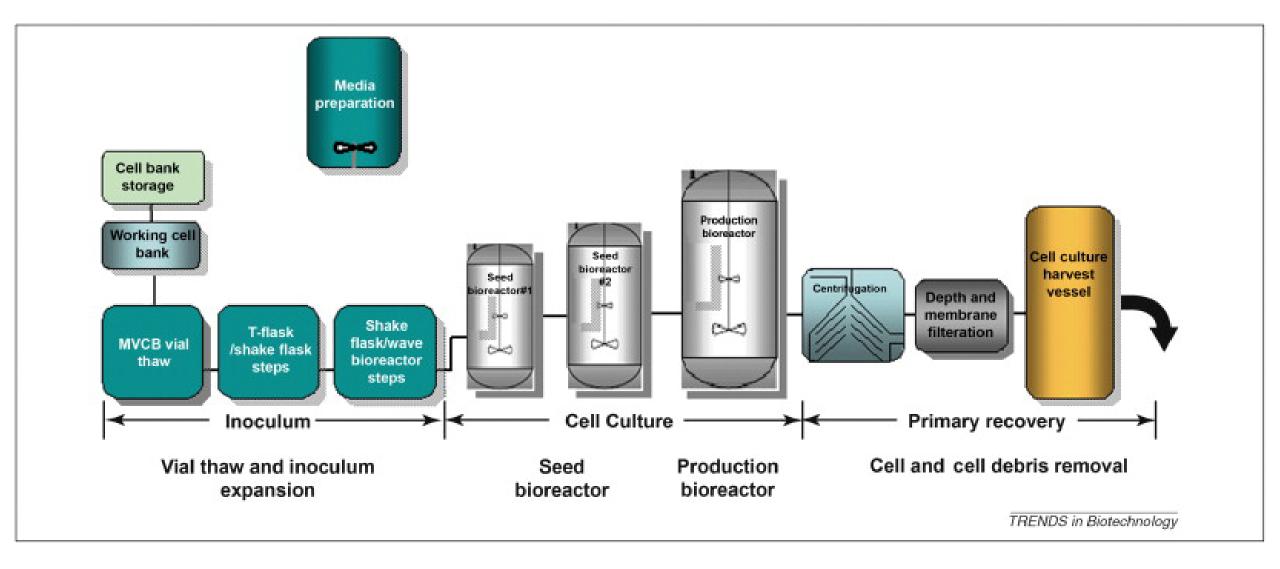




Antibody Discovery



Antibody Production

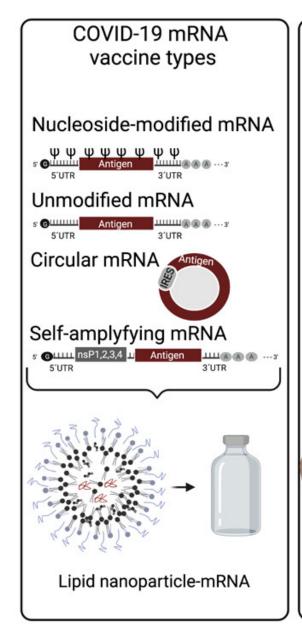


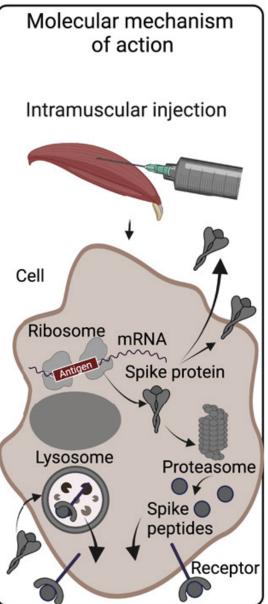
Antibody Production

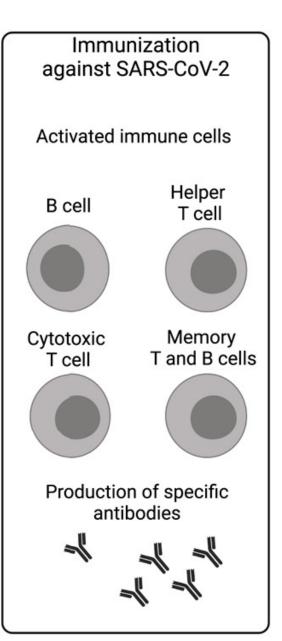




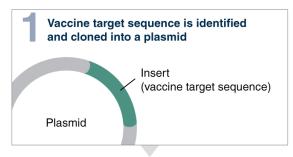
mRNA Vaccines



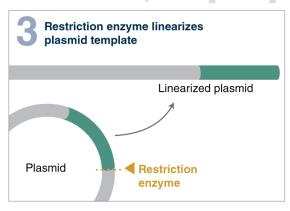


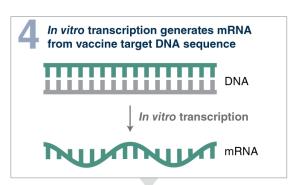


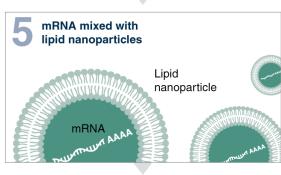
mRNA Vaccines how do you make them?

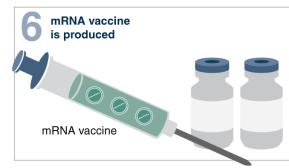












Lab-scale (in microliters or mililiters)

mRNA

LNP-mRNA

Scale-up (in liters)

