



Mahidol University

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SCBT201 - Biotechnology and Society

วททช.201 - เทคโนโลยีชีวภาพกับสังคม

2 (2-0-4) credits

## History and development of Biotechnology

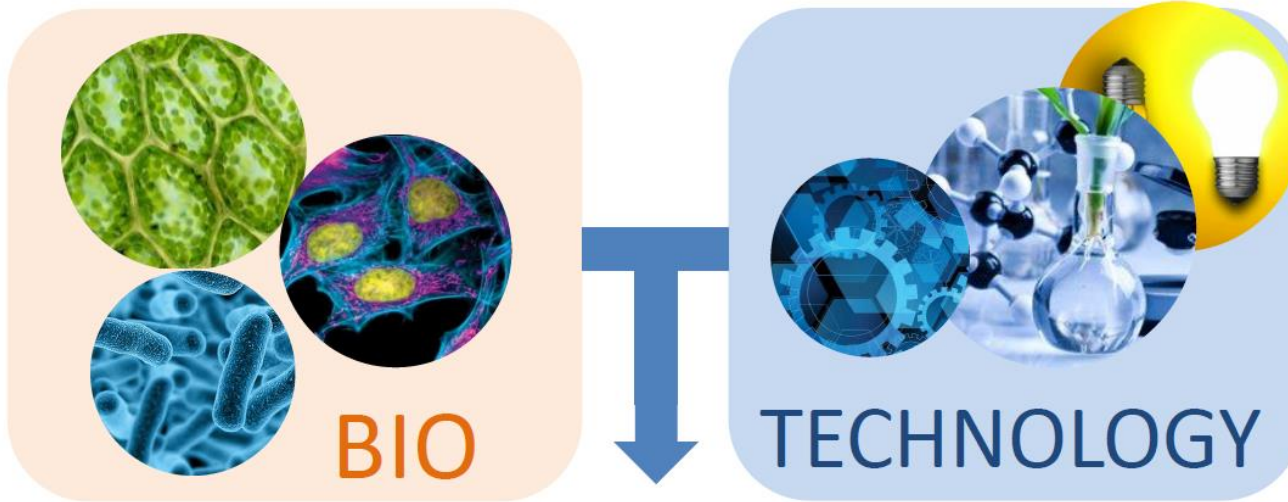
Adisak Romsang, Ph.D.



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# BIOTECHNOLOGY

- a broad discipline in which biological processes, organisms, cells or cellular components are exploited to develop new technologies. New tools and products developed by biotechnologists are useful in research, agriculture, industry and the clinic.



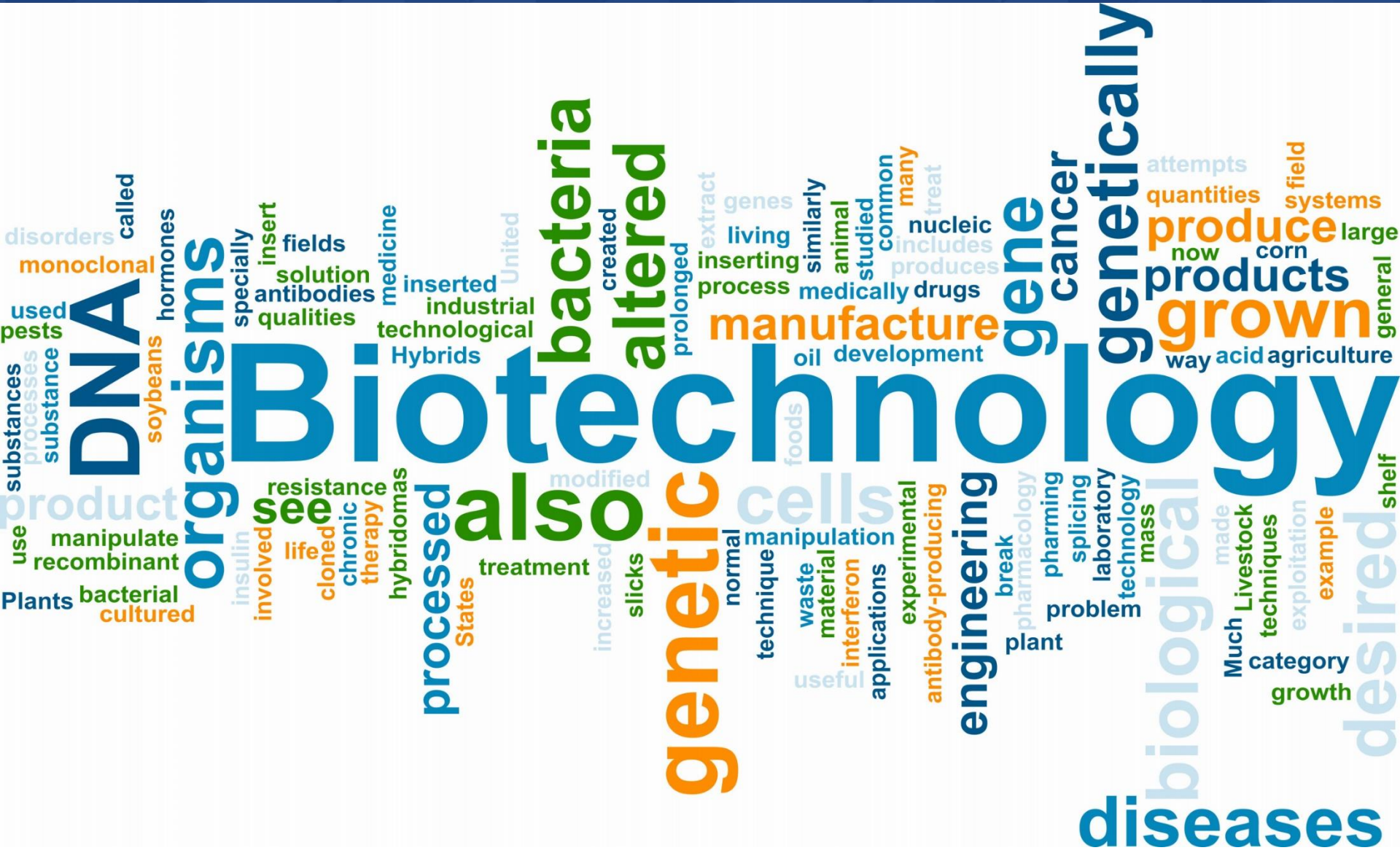
Applications of living things

To improve the quality of human life

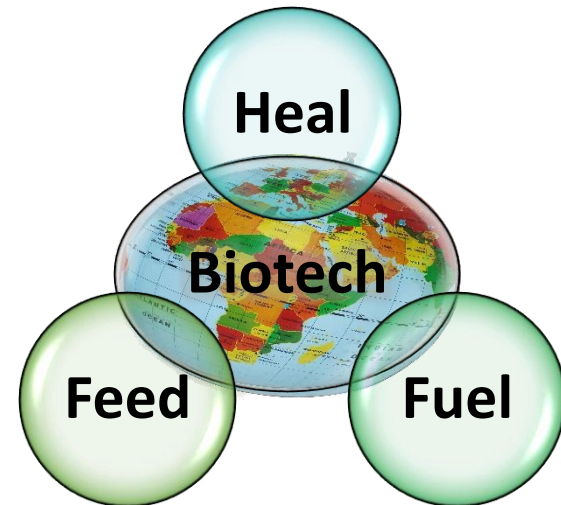
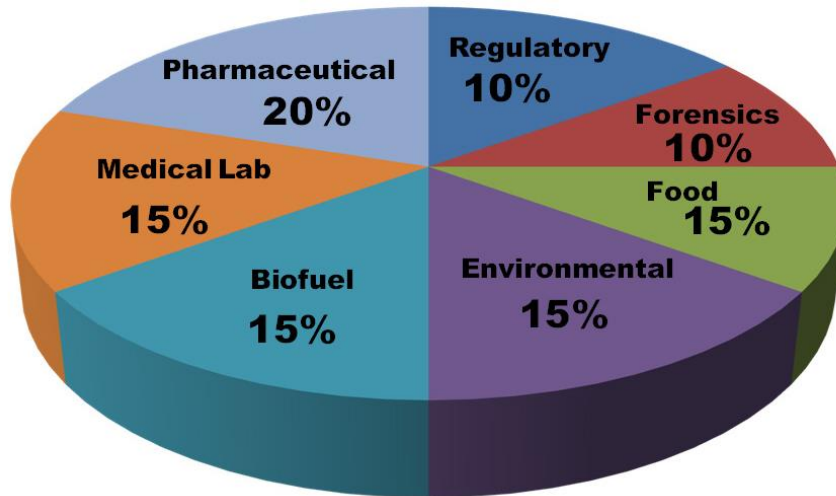




# BIOTECHNOLOGY







- **Biotechnology** is the use of biological processes, organisms, or systems to manufacture products intended to improve the quality of human life.
- > 6000 years for using the microorganisms to make and preserve food
- **Modern biotechnology**
  - > 250 biotechnology health care products and vaccines
  - > 13.3 million farmers use agricultural biotechnology
  - > 50 biorefineries are being built across North USA



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# Microorganism *the tasty side of BT*



BT Seminar 2015







# HISTORY BIOTECHNOLOGY



## Beer and wine

- Yeast as a secret behind alcohol fermentation
- Malt and hops
- Cell work on solar energy
- Highly concentrated alcohol by distillation

## Coffee, cocoa, vanilla, tobacco

- Fermentation for enhanced pleasure
- Pasteurization
- Sausages
- Vinegar

## Cheese production

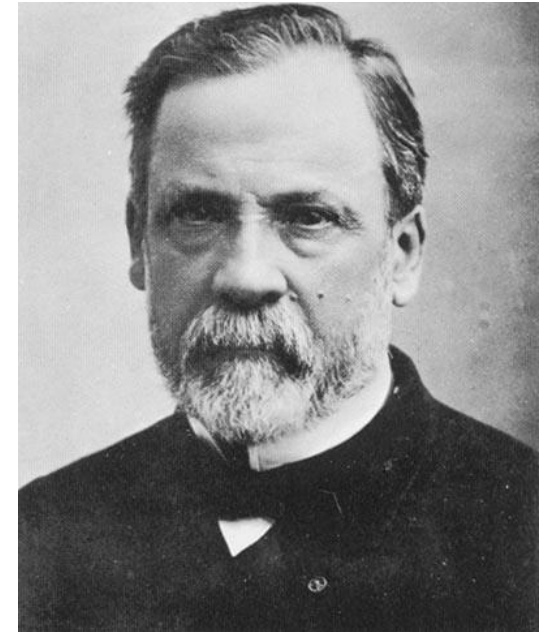
- Alliance of molds and bacteria
- Sour milk
- Yoghurt
- Kefir
- Sour cream butter

## Sake and Soy source

- MSG
- Miso
- Tofu
- Natto
- Angkak
- Tempeh



- Louis Pasteur (1822-1895)
  - Father of modern biotechnology
  - French biologist, microbiologist and chemist
  - principles of vaccination, microbial fermentation and pasteurization

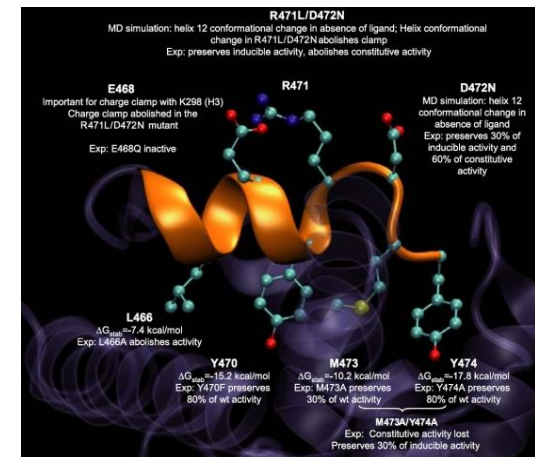
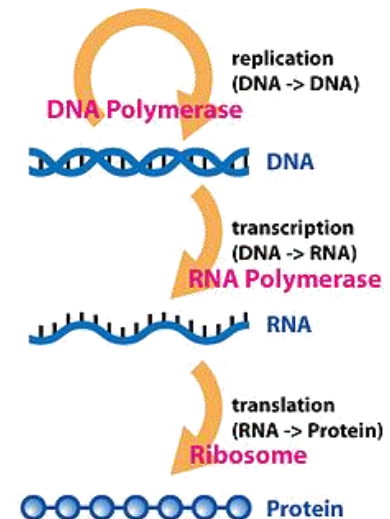


Year	English Title
1866	<i>Studies on Wine</i>
1868	<i>Studies on Vinegar</i>
1870	<i>Studies on Silk Worm Disease</i>
1871	<i>Some Reflections on Science in France</i>
1876	<i>Studies on Beer</i>
1878	<i>Microbes organized, their role in fermentation, putrefaction and the Contagion</i>
1882	<i>Speech by Mr L. Pasteur on reception to the Académie française</i>
1886	<i>Treatment of Rabies</i>





- Lazzaro Spallanzani (1729-1799) and Antoine Ferchault de Re'aumur (1683-1757)
- Cofactors, coenzymes and complex
- Lysozyme by Alexander Fleming (1881-1955: before penicillin discovery)
- Extracellular hydrolases degrading polymers  
(First industrial *Takadiasterase* by Jokichi Takamine 1854-1922)
- Amylases for brewing, baking, and desizing
- Pectinases increase fruit and vegetable juice
- Proteases tenderize meat and tan leather
- Immobilization: phytases managing phosphorus rush
- Glucose isomerase and fructose syrup
- Enzyme membrane reactors
- Protein Engineering
- Immobilized cells

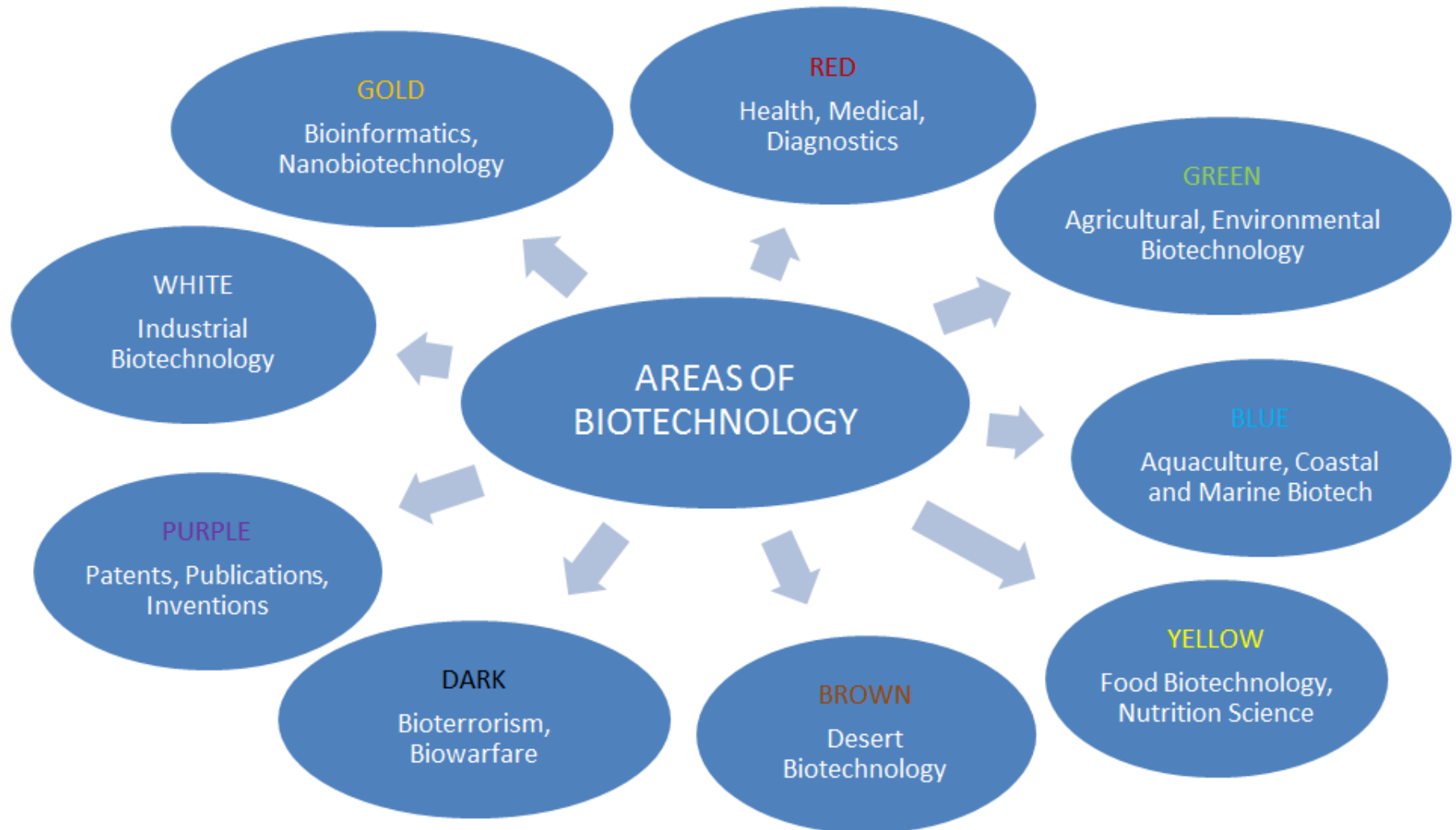






- DNA and RNA: a power of polymerases
  - Gregor Mendel (1822-1884): rule of heredity → Gene
  - DNA structure by James D. Watson (1928) and Francis C. Crick (1916-2004)
  - DNA polymerase by Arthur Kornberg (1918, NP1959)
- Ribosomes, genetic code and genome
- Recombination: genetic reshuffling of cards
- Plasmids: ideal vectors
  - Watanabe in 1960 – plasmids and conjugation
  - Werner Arber, Hamilton D. Smith, Daniel Nathans – bacteriophage
- Endonucleases and ligases
  - 1970, Herbert W. Boyer discovered “EcoRI” first restriction enzyme
- Somatostatin – first biosimilar from bacteria
- Eureka! The first genetically engineered insulin



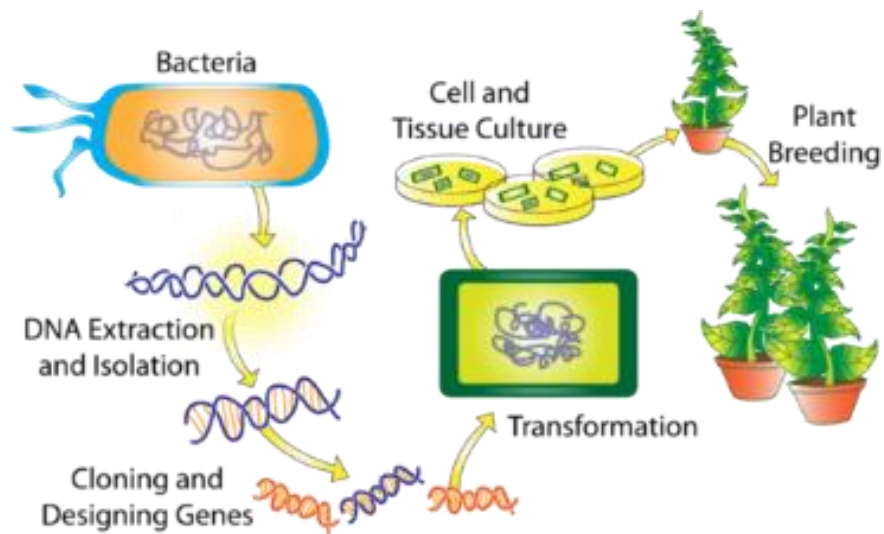




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# GREEN Biotech

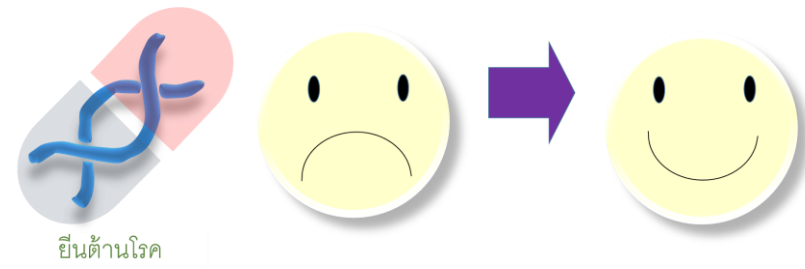
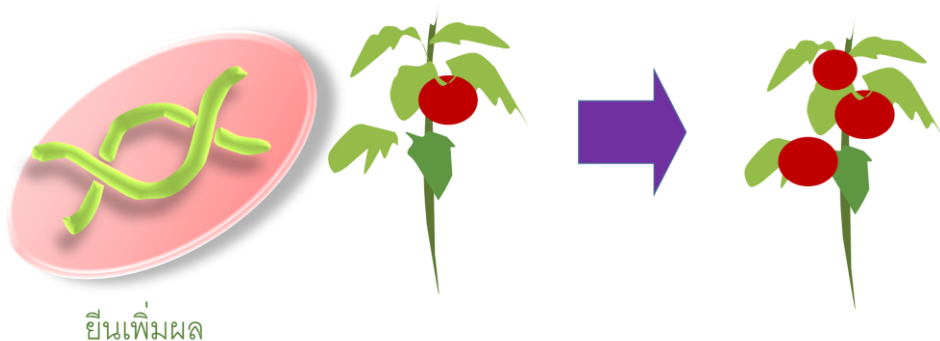
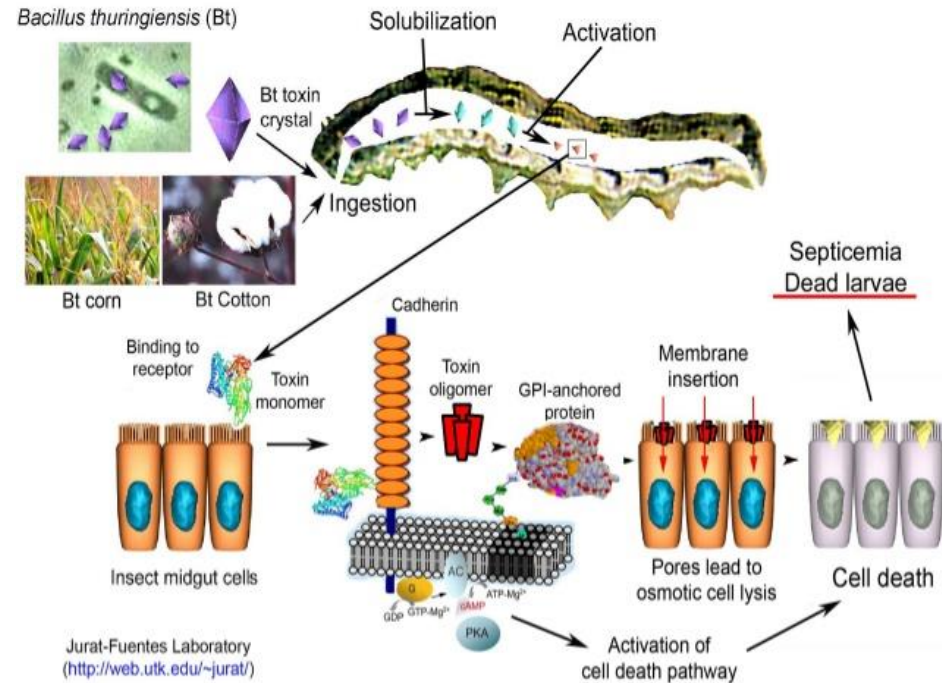
## GREEN : Agriculture, Environmental Biotechnology







## GREEN : Agriculture, Environmental Biotechnology



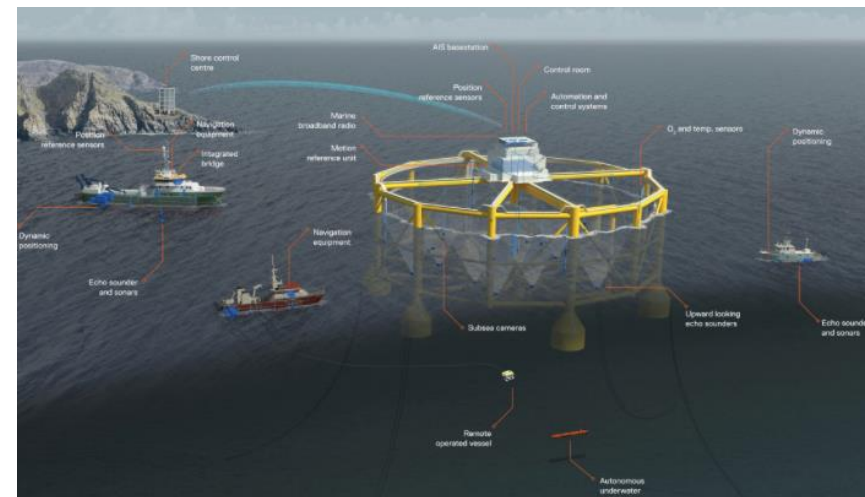
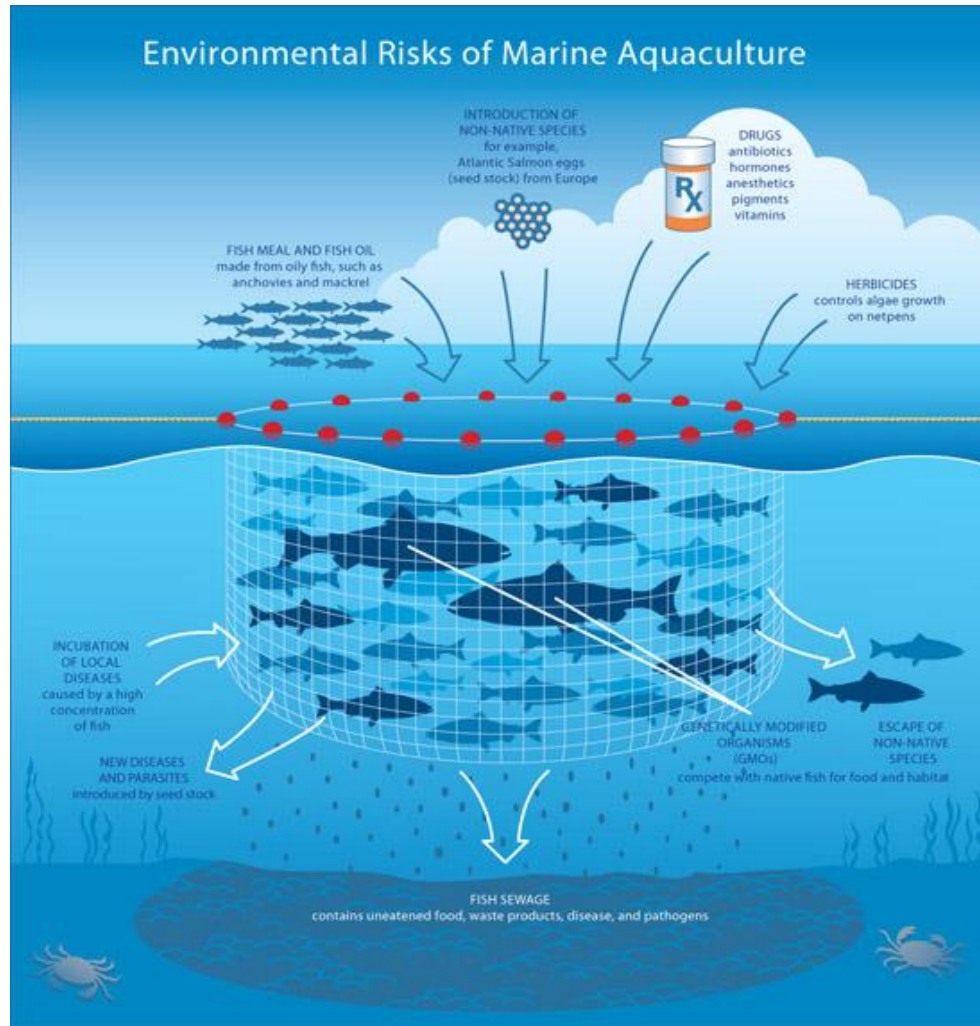


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BLUE Biotech

## BLUE : Aquaculture, Coastal and Marine Biotech

### Environmental Risks of Marine Aquaculture







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# YELLOW Biotech

## YELLOW : Food Biotechnology, Nutrition Science

### GMO Foods

**Tomato**  
Tomatoes have been genetically modified, but they are not being grown commercially at this time

**Rice**  
GMO rice has been approved but is not yet being used commercially

**Sweet Corn**  
More than 70 percent of corn grown in the United States has been genetically engineered

**Alfalfa**  
GMO alfalfa is contaminating non-GMO alfalfa crops at a rapid rate

**Wheat**  
Unapproved GMO has contaminated wheat fields, and we don't yet know the extent of it

**Cotton**  
At least half of cotton grown in the world is GMO

### Summer Squash

Farmers don't like GMO squash but some experts say GM squash have blended with wild squash

**Salmon**  
GMO salmon has not been approved by the FDA, but it will be very soon

**Soy**  
More than 93% of soybeans the United States produces are genetically modified

**Peas**  
Peas have been genetically modified but are not approved or available

### Canola Oil

87% of canola grown commercially, and 80% of wild canola is GMO

**Yeast**  
GMO yeast for wine has been approved

**Hawaiian Papaya**  
Most Hawaiian papaya is GMO, even many organic crops are contaminated

For more information go to [olmag.co/gmo-foods](http://olmag.co/gmo-foods)

organic lifestyle  
MAGAZINE







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# WHITE Biotech

## WHITE : Industrial Biotechnology

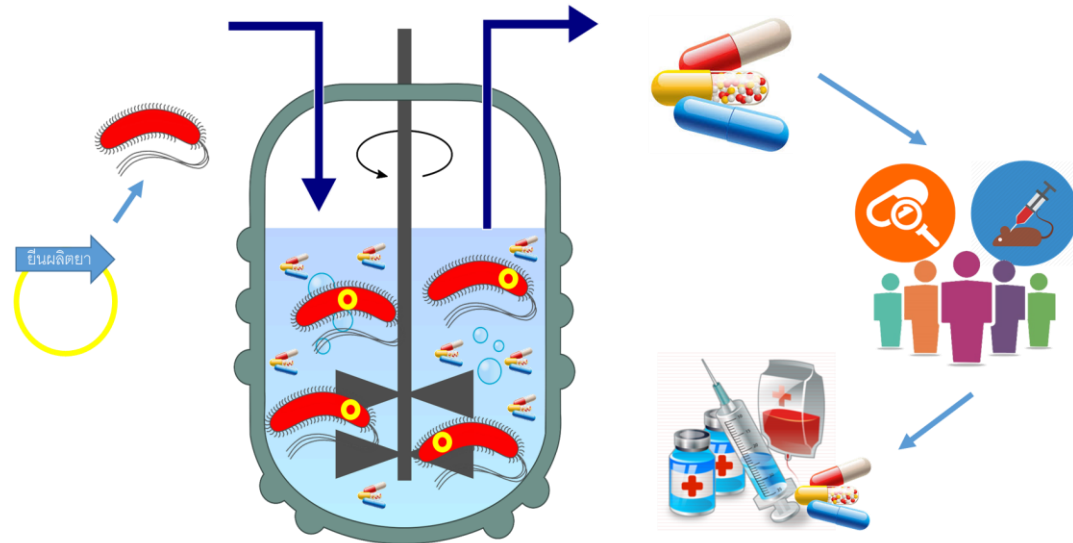
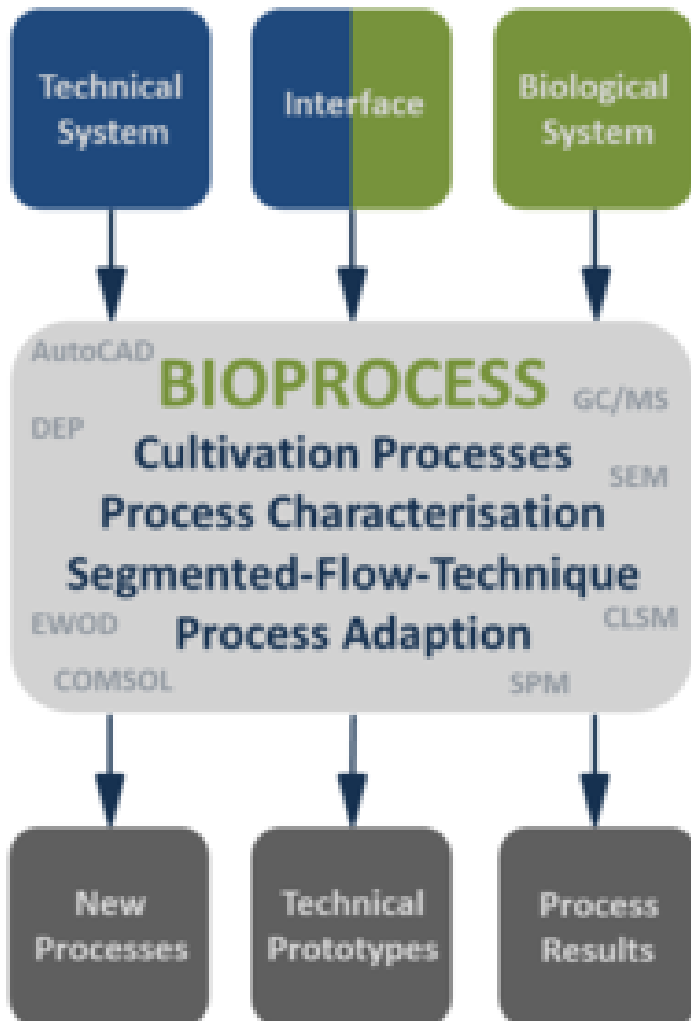




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# WHITE Biotech

## WHITE : Industrial Biotechnology



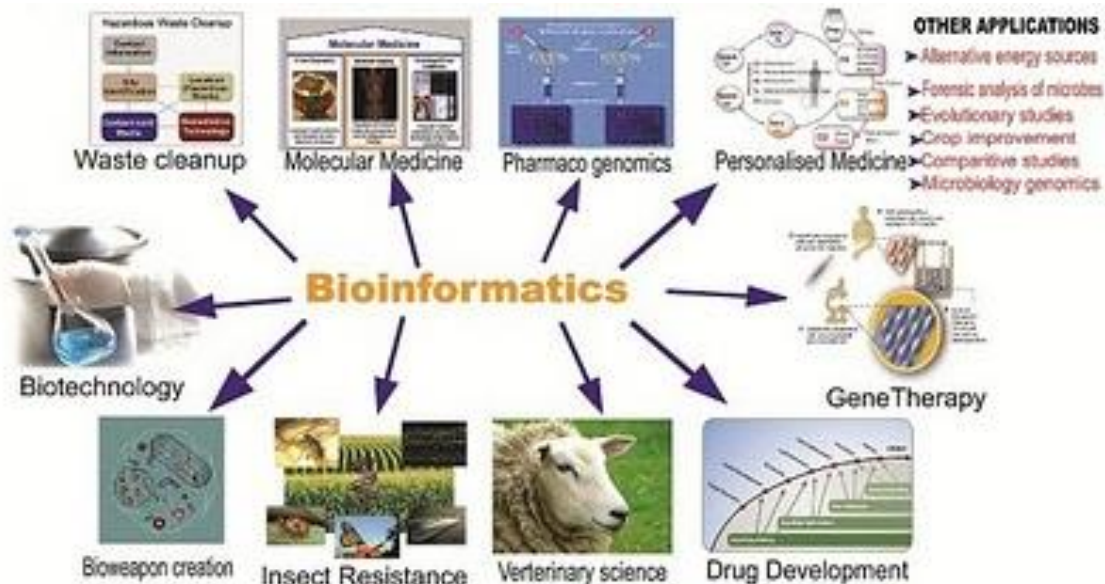
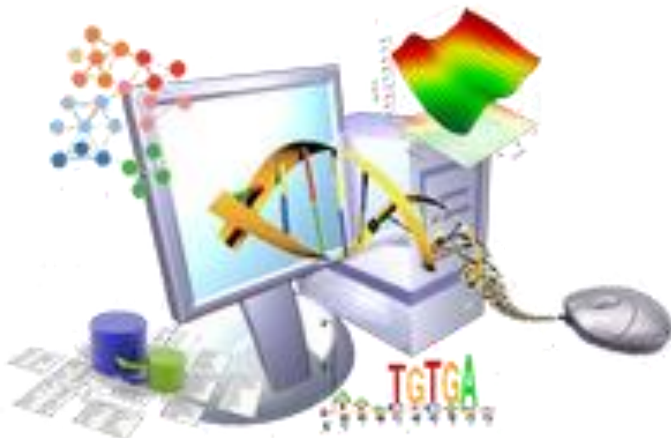




# GOLD Biotech

The diagram illustrates the relationship between DNA sequence, protein structure, and function. A DNA double helix is shown on the left, with a hexagonal grid background. Five blue hexagonal callouts point to specific DNA sequences, each followed by a corresponding protein structure (represented by a cluster of spheres) and a brief description of its function.

DNA Sequence	Protein Structure	Function
CTAAAGATGATCTTTAGTCCGGTTTCGAA TCCTTAGTCCCGGTTGATAACACCAACGAC GTAATACCAACCGGGACATAAGATCCCG GGGACTAAAGTCCCACCCCTATATATATG	[Protein Structure]	Protein structure visualization
TTCAAAATTCCTCAAAAAGAGGGGAG GTGATTACATACAAATCGGAGGTGCCTA TTTGTCACTACATTTGCACCATGTGTTT GTAAGTTGATGAGAGAGAAATGTGTGT	[Protein Structure]	Protein structure visualization
TTTGCTAAACAAGGTTTTATAAAATATGTG AAATAATAGAAAACAACATAATGAAAT TATTACTTAACAAATAGTTTTAAGAATTAT AATAAGATATCTTATAATTATGTATGACT	[Protein Structure]	Protein structure visualization
ACGGTTTTTTTGACTCATGTAGATGGATC AGAGTTTATTGACGGCGTGCACTATTTTT TTTTATTGTGTCCCATGCATAAAGTGAA TATTCATTCCACTTGTTTGAGTCGGGGT	[Protein Structure]	Protein structure visualization

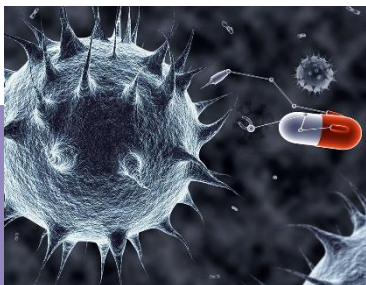




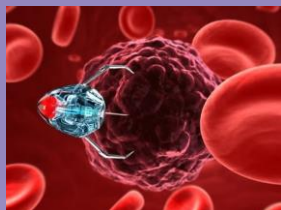


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# GOLD Biotech



Molecular recognition  
Self-assembly



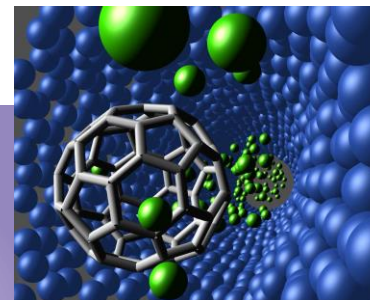
Bottom-up  
nanobiotechnology

Cyclodextrin  
Crown ether  
Nanotube capsule  
Artificial membrane  
Liposome  
Fine particles, etc.

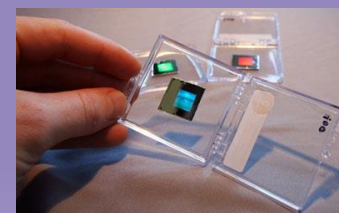
Supramolecular  
chemistry

DNA  
RNA  
Protein  
Sugar chain  
Metabolites  
Cells, etc.

Biotechnology



Nanofabrication  
Nanomanipulation



Top-down  
nanobiotechnology

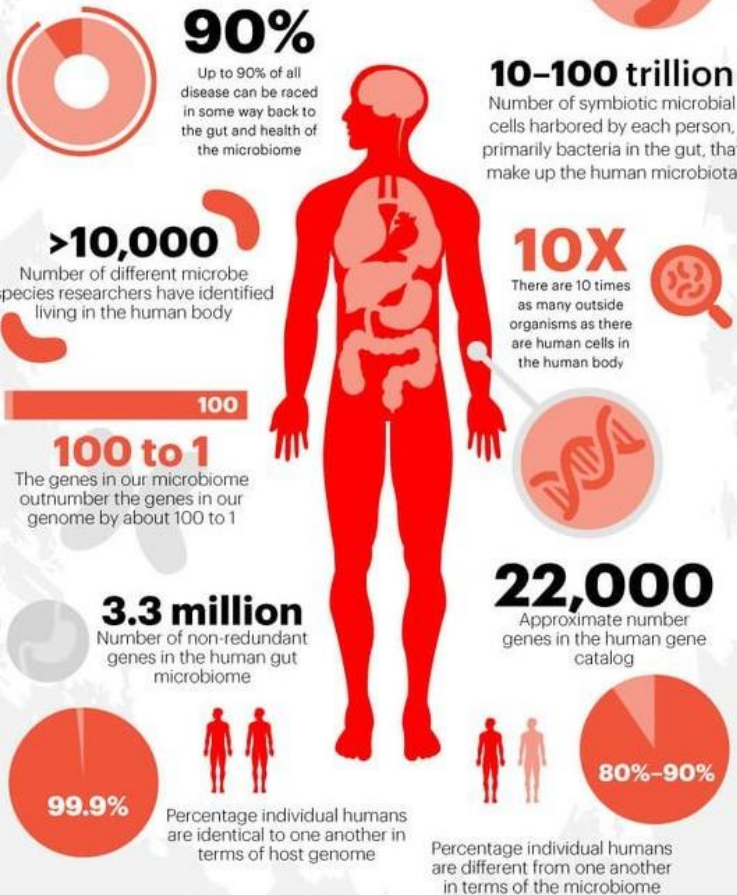
MEMS  
NEMS  
Nanolithography  
Nanoimprint  
Etching, etc.

Microfabrication  
technology

Technologies for observation, measurement and  
manipulation at the nanoscale

# MICROBIOME

## The Importance of the MICROBIOME by the Numbers



## Intestinal Flora Affects Your Health

The microbes that live inside your intestines influence your health in beneficial and harmful ways

### Immunity

Providing a physical barrier to invasive microbes, our gut flora enhances the functionality of the immune system.

### Vitamins

Bacteria in the gut plays a direct role in the synthesis of vitamins B and K as well as the absorption of calcium and iron.

### Metabolism

Metabolic activity of the gut flora allows our body to utilize food that would otherwise not be digested.

### Obesity

In 2009, Dr. Krajmalnic-Brown discovered gut bacteria of obese patients differs significantly from normal individuals.

### Inflammation

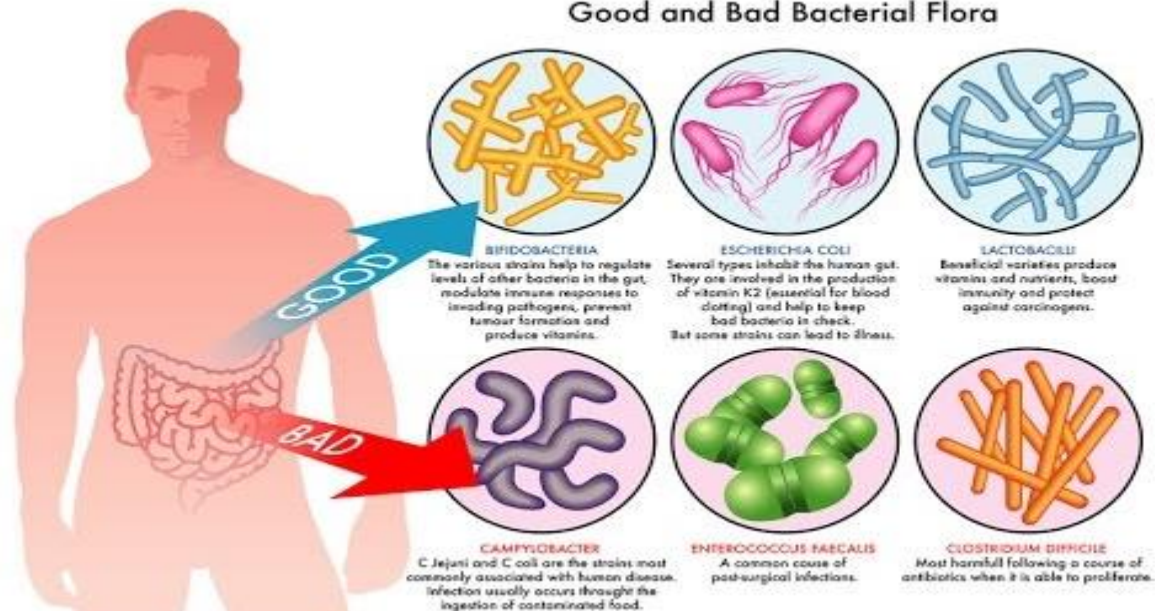
Gut flora likely plays a major role in the development of various inflammatory diseases including IBD and colitis.

### Autism

New research by Dr. Krajmalnic-Brown suggests a link between autism and decreased gut bacterial diversity.



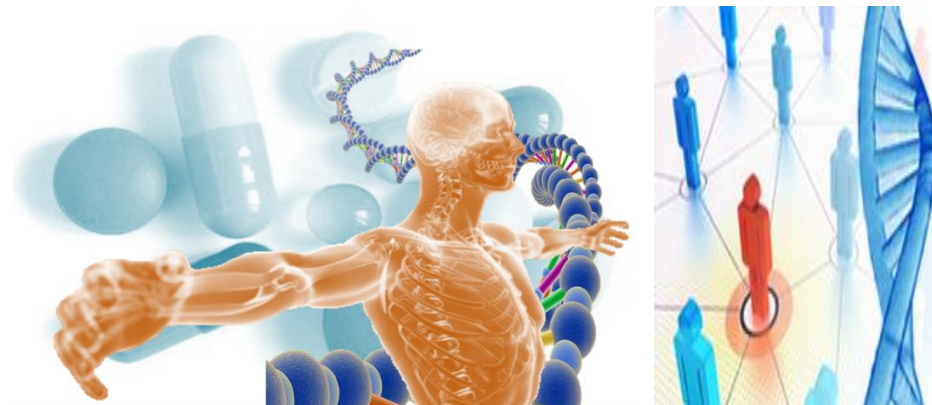
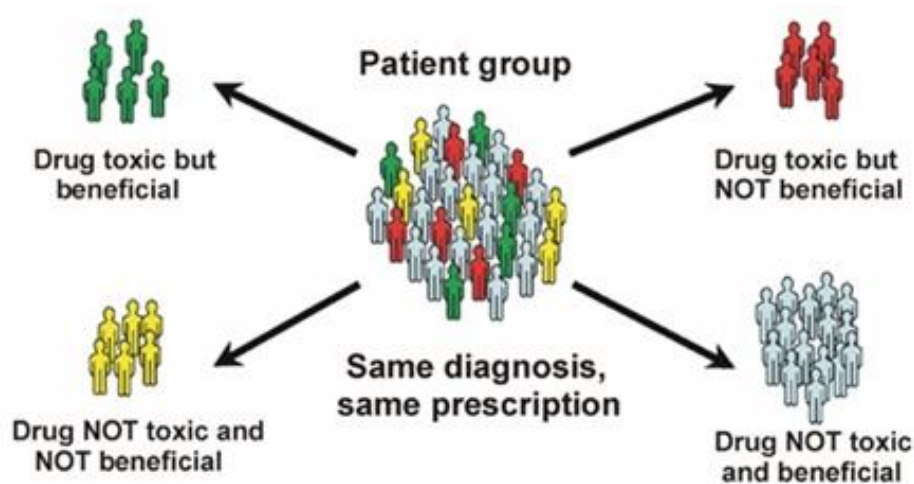
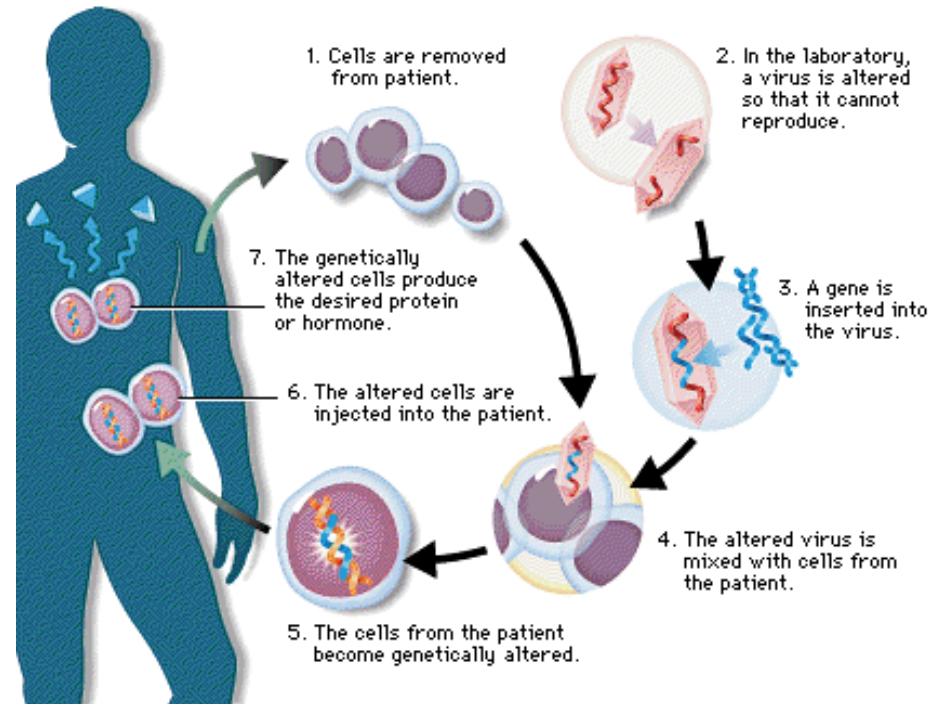
## Good and Bad Bacterial Flora







## RED : Health, Medical, Diagnostics







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# Genetic Engineering

## genetic engineering new horizons in medicine

Since genetic engineering (also known as **recombinant DNA technology** or **genetic modification**) was first developed in the 1970s, scientists have discovered more and more ways in which this new technology can be used in human medicine. The same basic technique is used in modifying the genetic material of bacteria, plants and animals.

### Pharming



Microorganisms, animals and plants can be genetically modified to produce medically useful products. These transgenic organisms are already used regularly to produce substances such as human insulin, human growth hormone and blood clotting factors for haemophiliacs.

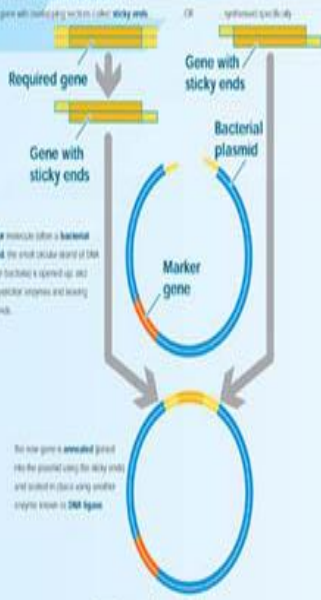
### Diagnostic tests and targeted drugs



Genetic engineering is opening up opportunities to produce very specific and sensitive diagnostic tests for many diseases using engineered genes. The new technology is also opening up new ways of designing medicines to specific targets.

### The basic steps in the genetic engineering of a bacterium

The required gene is either cut from the DNA of an organism using enzymes called **restriction endonucleases** which leave the gene with **overhanging** sections called **sticky ends**.



The recombinant plasmid is inserted into a bacterial cell in a process known as **transformation**. It is then replicated whenever the bacterium cell replicates, and goes about the manufacture of a new protein.

### Gene therapy

Gene therapy is still in its very early stages. It involves modifying human DNA either to repair it or to replace a faulty gene. The idea of gene therapy is to overcome the effects of a mutation which causes a genetic disease. Cystic fibrosis is the first genetic disease where gene therapy has been tried. There have been no long-term successes - yet!



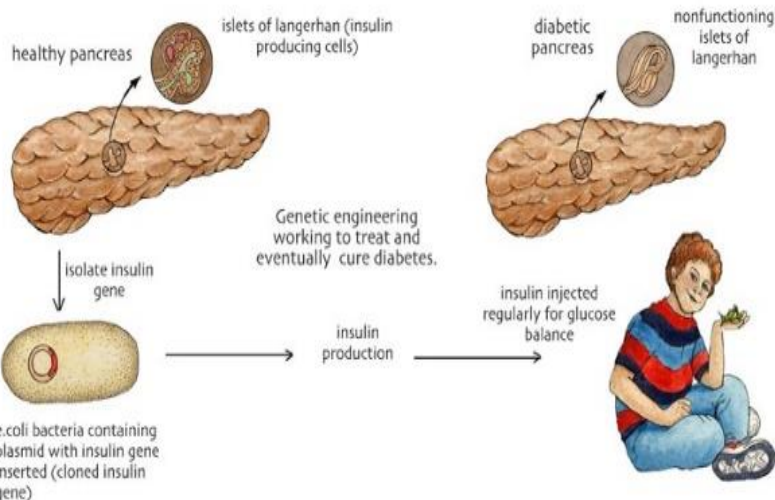
### Vaccines



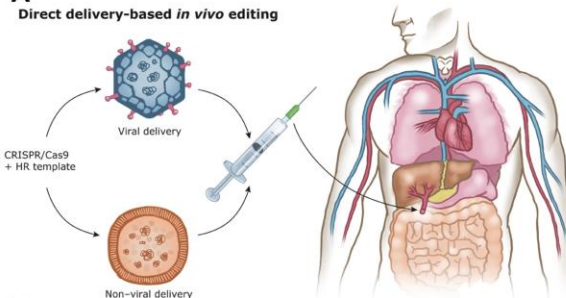
Some vaccines are very dangerous to make using conventional methods. Genetically engineered microbes can be used to produce the antigens needed in a safe and controlled way. The use of genetically modified genes can also produce a vaccine against the hepatitis B virus but has been a major success story.

### Xenotransplantation

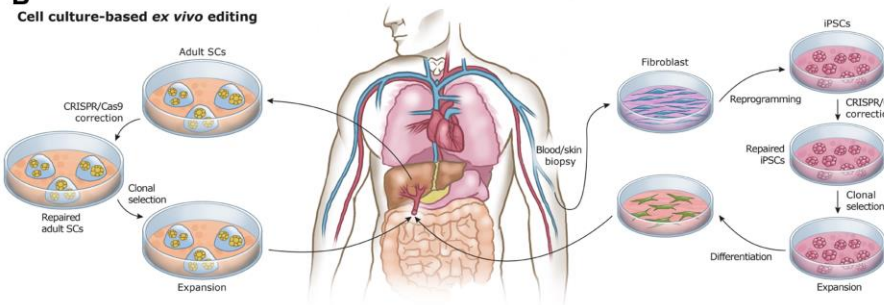
The DNA of pigs has been modified using recombinant DNA technology so that pigs develop without certain genes which trigger the human immune response. The hope is that these genetically modified organs might be accepted by a human recipient, so that pig organs may one day be used to replace human organs - but there are many ethical and safety questions of to be answered in the area of genetic engineering.

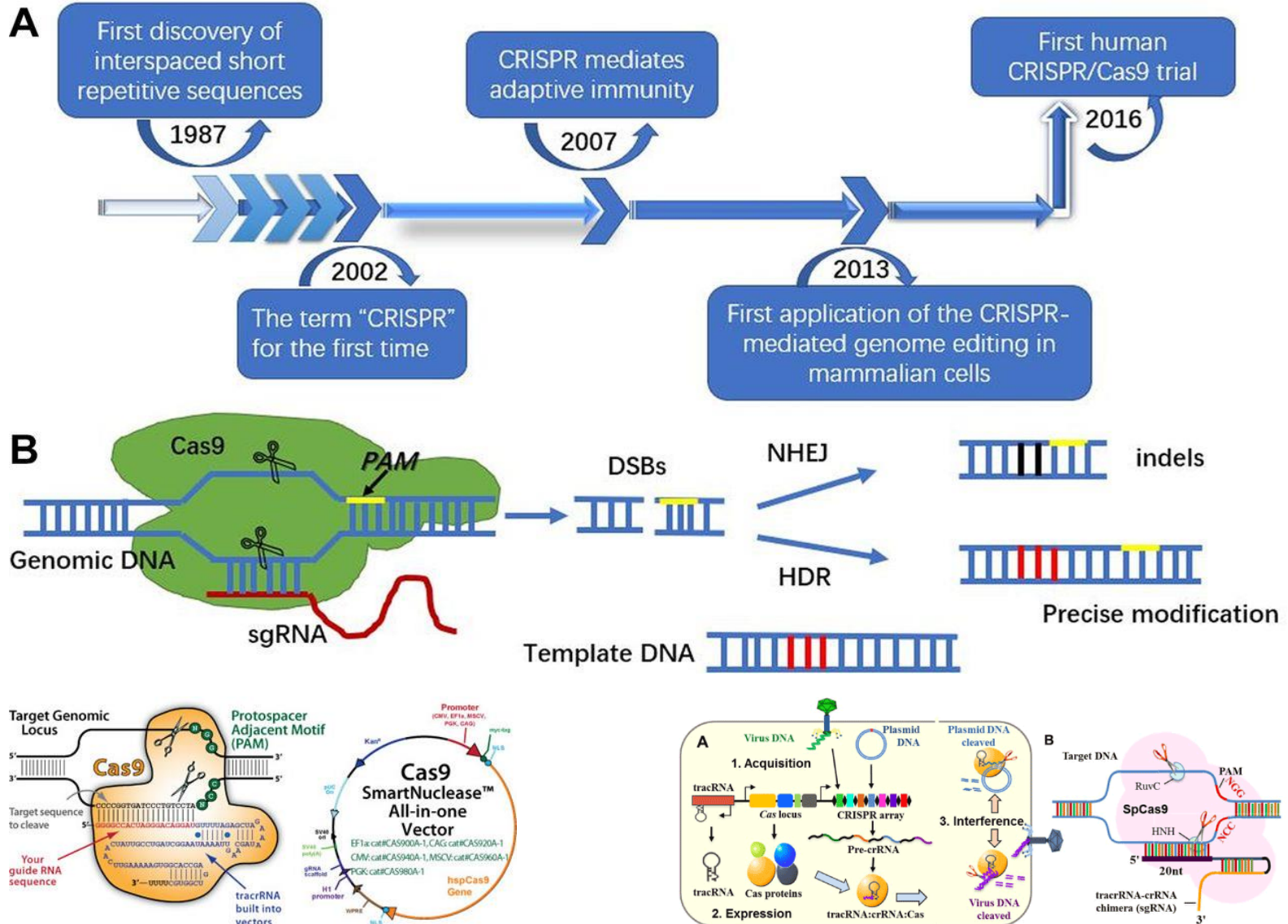


### A Direct delivery-based *in vivo* editing

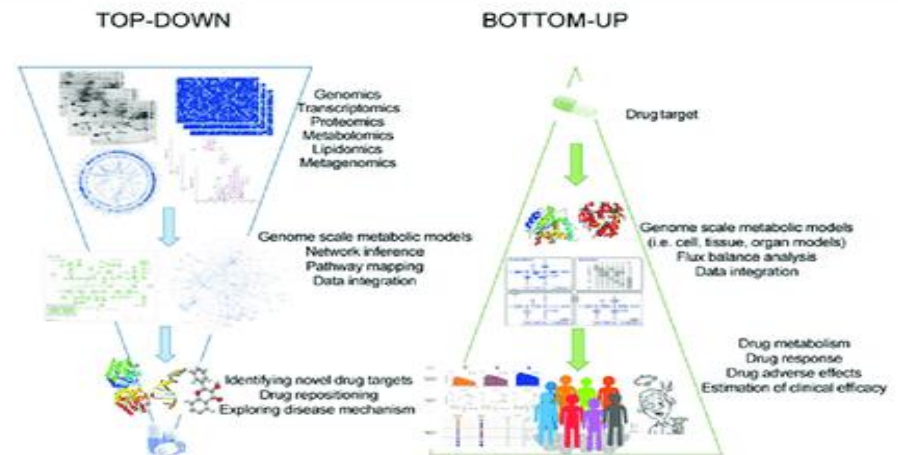
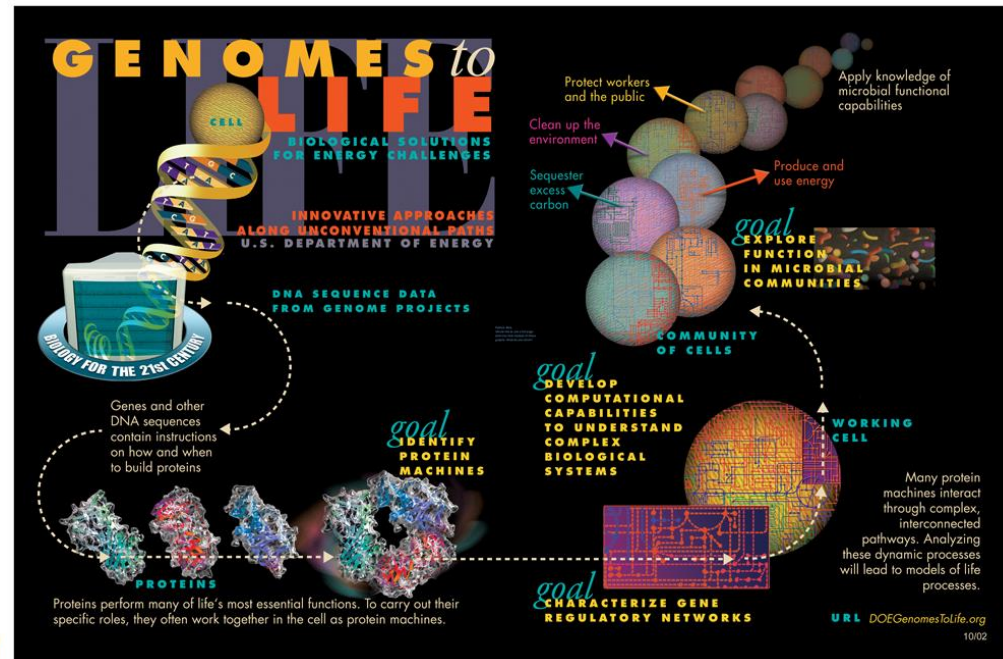
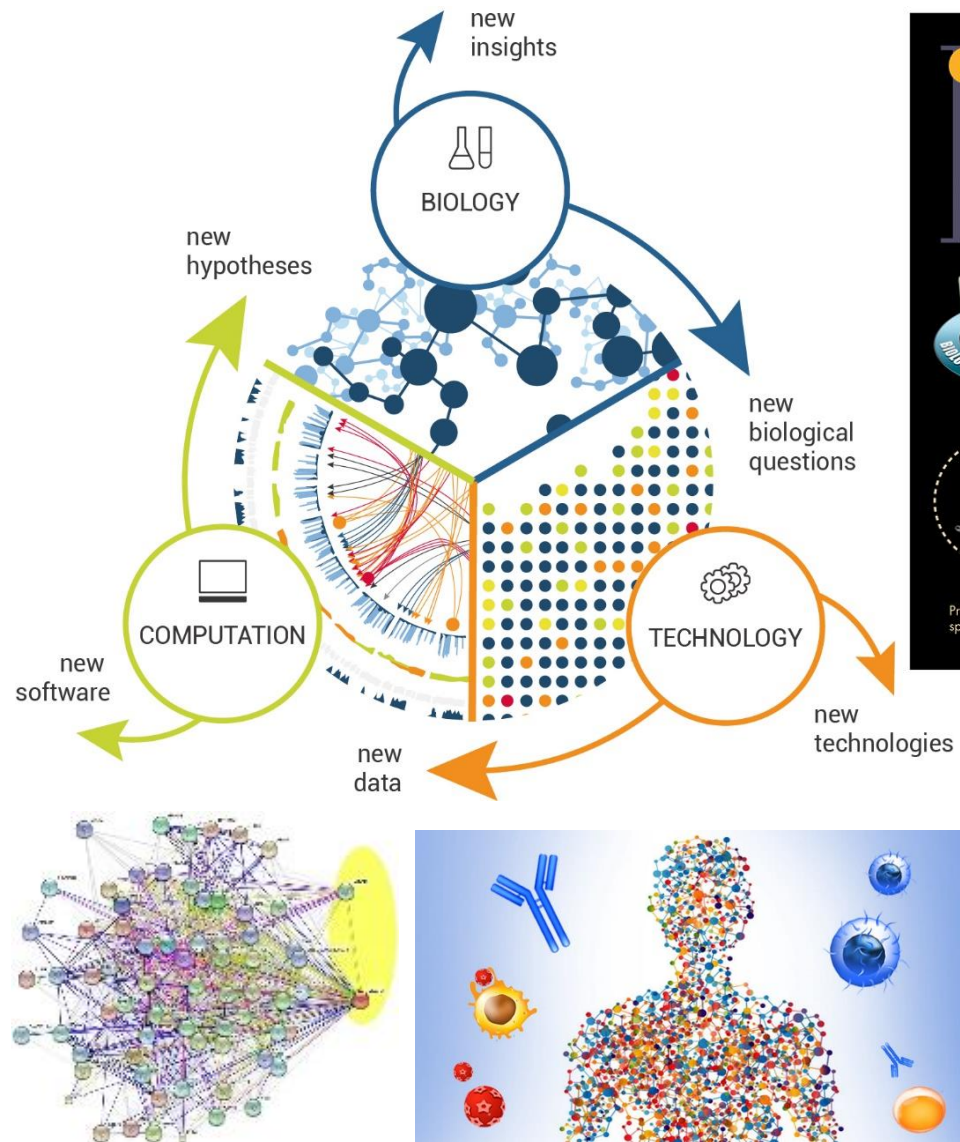


### B Cell culture-based *ex vivo* editing



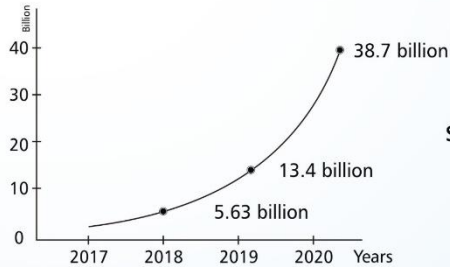






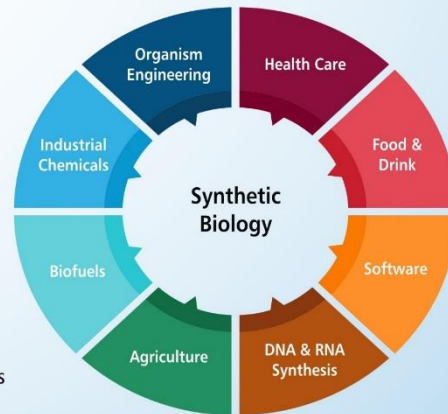
# RISE OF SYNTHETIC BIOLOGY INNOVATIONS

## Synthetic Biology Market Size & Growth



- More than 500 startups in 2016
- Over 1 Billion USD investments in 40 startups

## Synthetic Biology Innovations : Key Application Segments

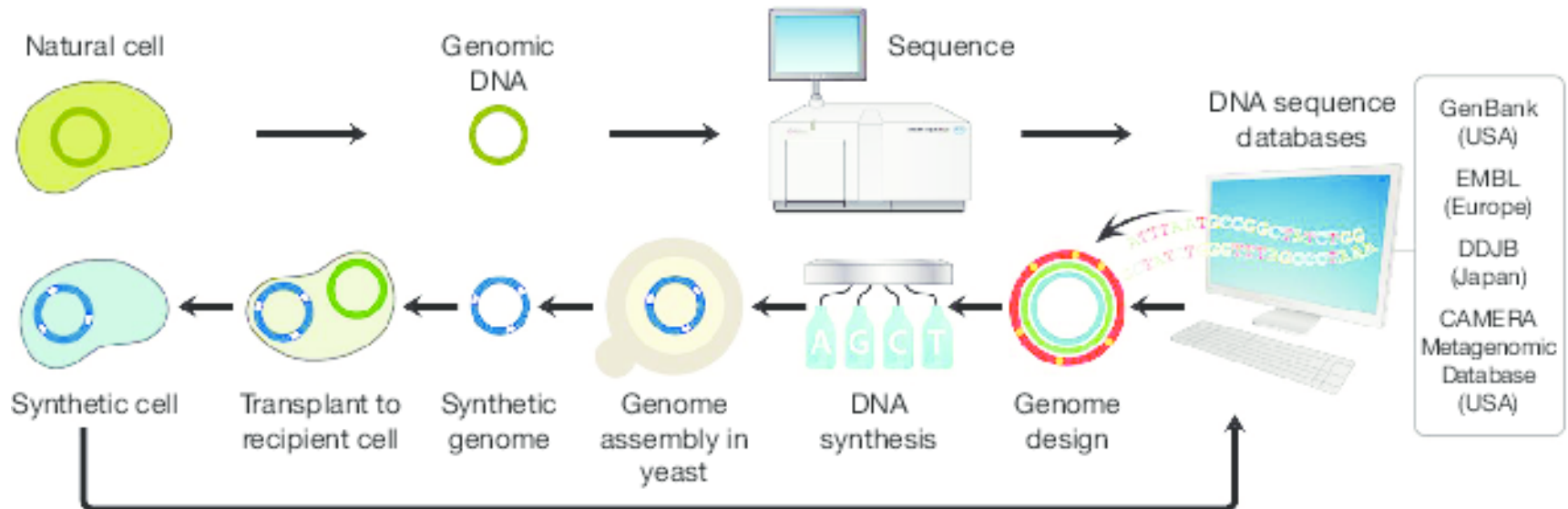
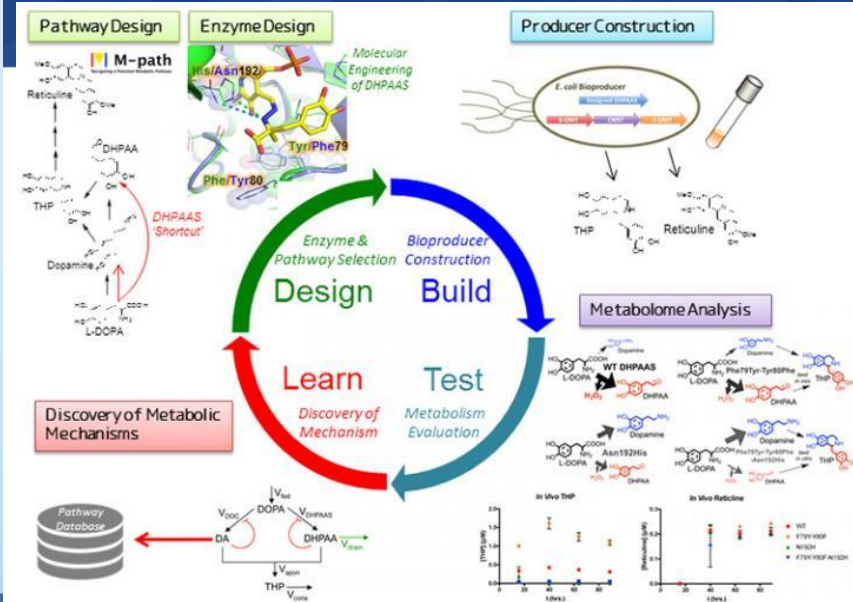


## Top Players

- Intrexon
- Novozymes
- Synthetic Genomics
- Thermo Fisher Scientific
- Amyris
- Integrated DNA Technologies
- Agrivida
- Twist Bioscience
- LanzaTech
- Solazyme
- Metabolix
- Verenium
- Halozyyme
- Joule
- Sapphire Energy
- Modular Genetics
- Apta Biosciences

For more information, Visit - <https://www.pintels.com> for email : [contactus@vajrasoftinc.com](mailto:contactus@vajrasoftinc.com)

# Synthetic Biology



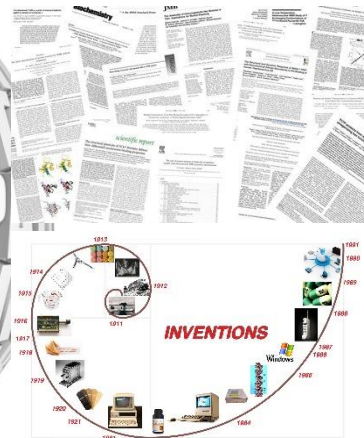
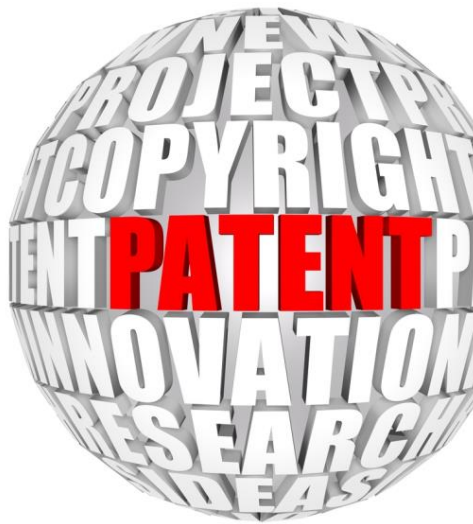




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# OTHERS in Biotech

**BROWN : Desert Biotechnology**



**PURPLE : Patents, Publications, Inventions**

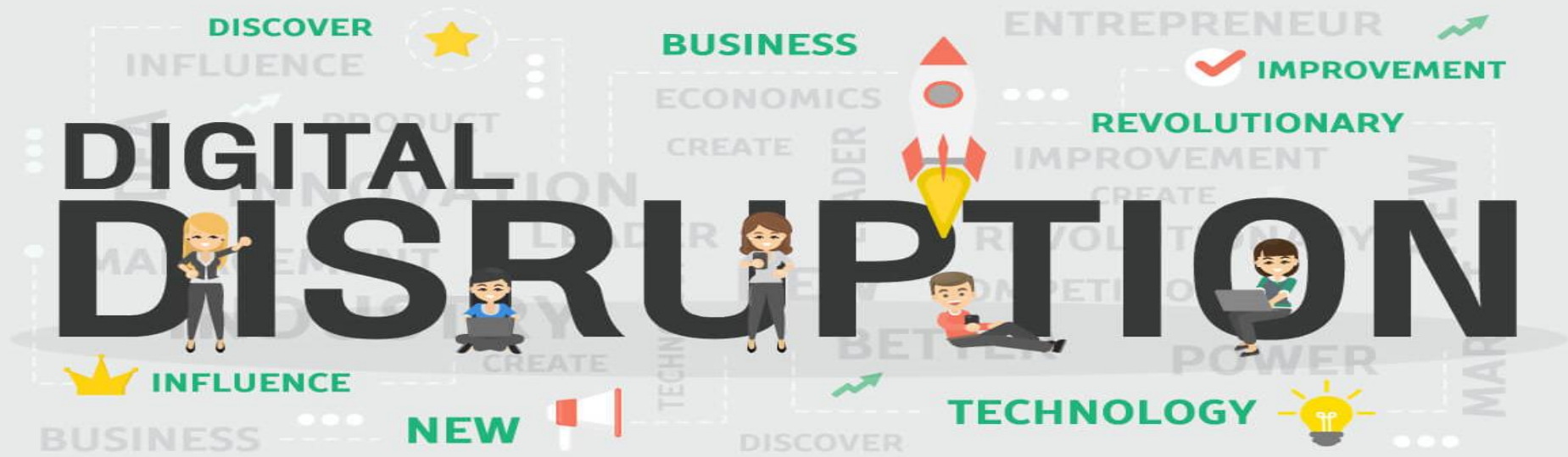


**DARK : Bioterrorism, Bio-warfare**



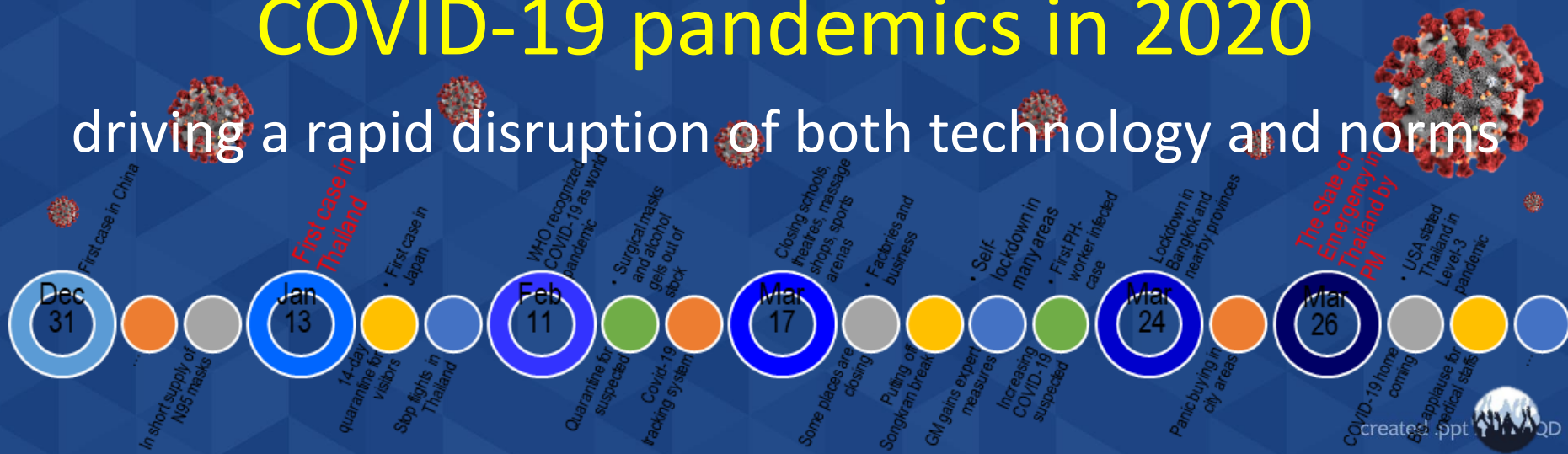


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## COVID-19 pandemics in 2020

driving a rapid disruption of both technology and norms







$10^{180}$

An upper estimate of the number of possible molecules

$10^{80}$

Estimated number of atoms in the universe

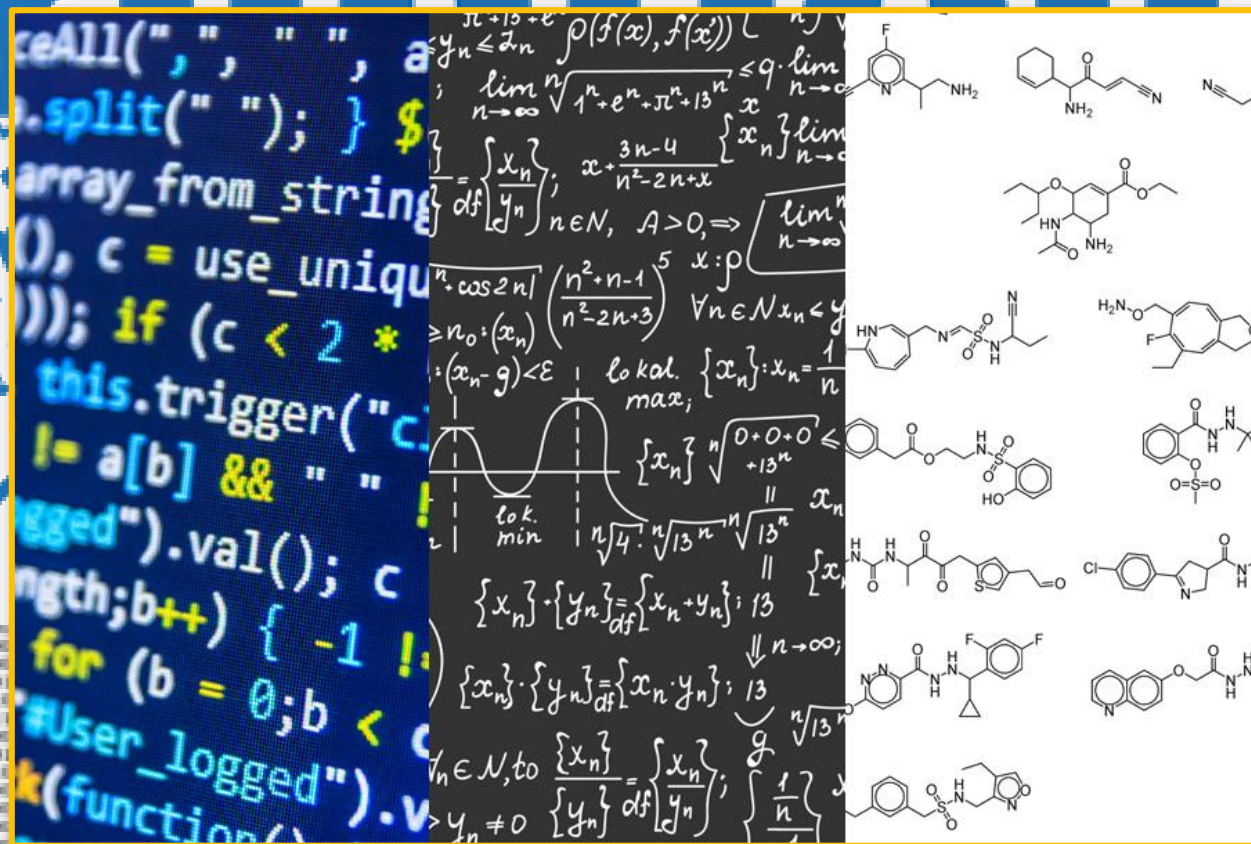
$10^{60}$

An estimate of the number of possible small organic molecules

$10^8$

The number of organic and inorganic substances in the CAS database

Sources: *Current Topics in Medicinal Chemistry* 2006, DOI:

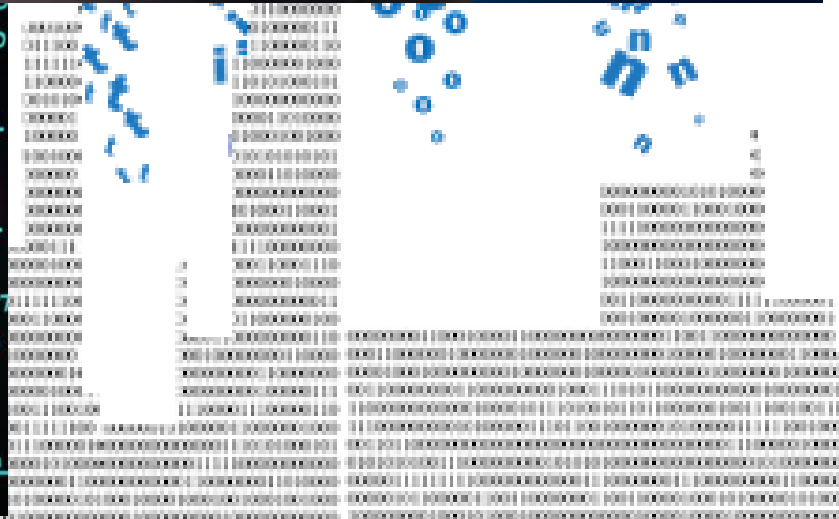
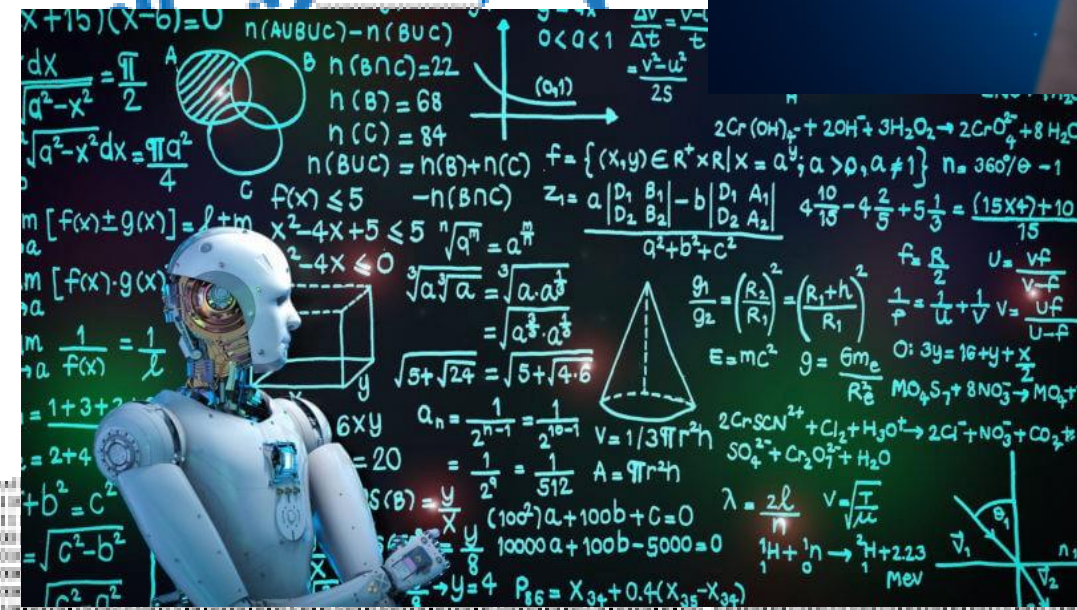




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2020 .....

DIGITAL  
disrupt





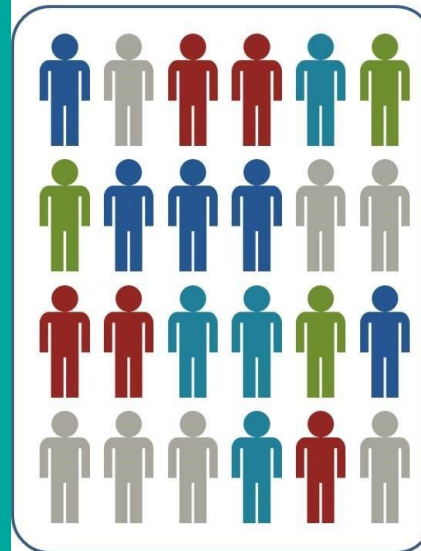


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2020 .....

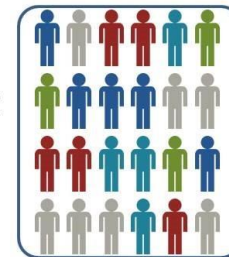


### Patient population



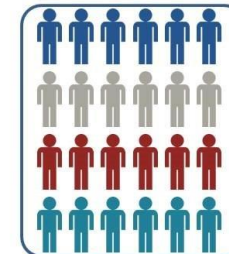
### Treatment

Standard approach

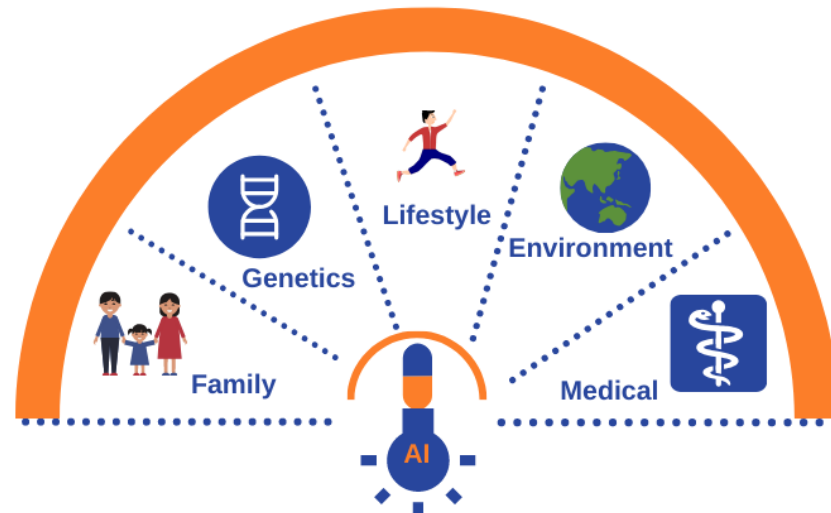


Treatment A  
(effective in 20% of  
target population;  
80% is waste)

Tailored approach



Treatment A  
Treatment B  
Treatment C  
Treatment D



### 90+ Healthcare AI Startups To Watch

#### Imaging & Diagnostics



#### Drug Discovery



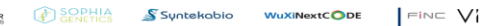
#### Predictive Analytics & Risk Scoring



#### Genomics



#### Fitness



#### Hospital Decision Support



#### Virtual Assistant



#### Clinical Trials



#### Nutrition



#### Compliance



#### Mental Health



#### Remote Monitoring





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# SCBT201

## History and Development of Biotechnology

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