

Biotechnology












- is the use of **biological systems** found in organisms or the use of the living organisms themselves to make technological advances and utilize those technologies to various different fields.

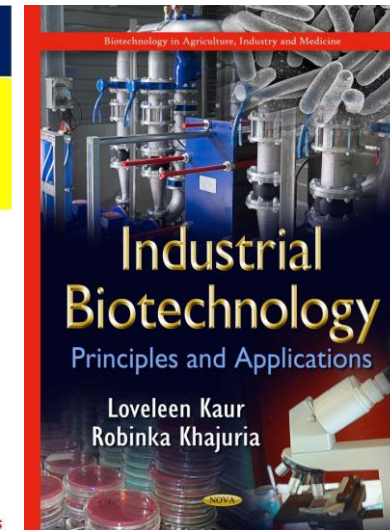


Food Biotechnology

The use of technology to change the genes of the animals and plants we eat.

Before & After Food Biotechnology

Before 	After 	Before 	After 	Before 	After 
Less pesticide usage		Better overall animal health		Greater overall production yield	
Before 	After 	Before 	After 		
Reduction in CO ₂ production		Farmers earn more		Food is more nutritious	

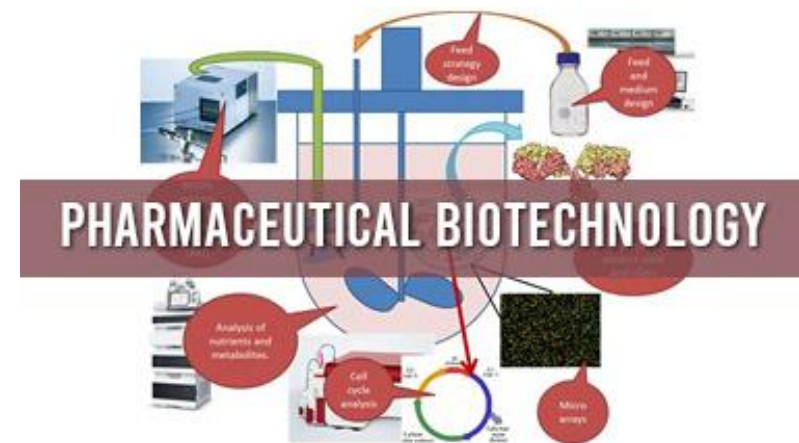
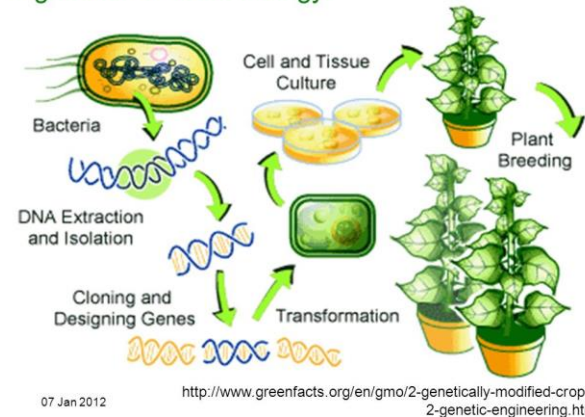


- **biological** processes, organisms, cells or cellular components are **exploited to develop new technologies** that are useful in research, agriculture, industry and medical sector to improve the quality of human life.

Biotechnology

- Is the use of **living systems and organisms to develop or make useful products**
- “any technological application that uses *biological systems, living organisms or derivatives thereof*, to make or modify products or process for specific use.
- European Federation of Biotechnology (EFB) has define biotechnology as “**the integration of natural science and organisms, cells, parts thereof, and molecular analogues for *products and services*.**”

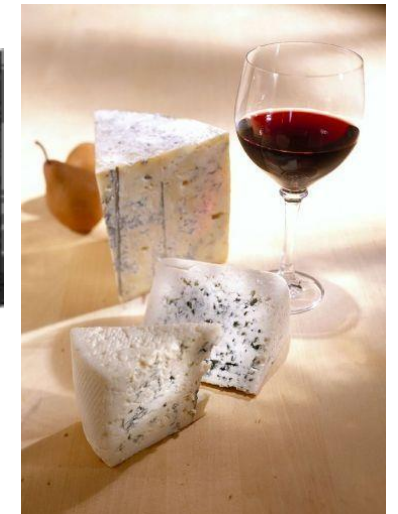
Agricultural Biotechnology:



Stages of Biotechnology

1. Ancient Biotechnology (Pre-1800)

- early history as related to food and shelter, including domestication.
- domestication of plants and animals. Domestication began over 10,000 years ago when our ancestors started keeping plants as a reliable source of food. Rice, barley and wheat were among the first domesticated plants.
- Egyptians used yeasts to bake leavened bread, the Chinese developed fermentation techniques for brewing and cheese making, and the Aztecs used Spirulina algae to make cakes.
- Since ancient times, humans have taken advantage of the natural fermentation process to develop many products, including foods, medicines, and fuels.



Stages of Biotechnology

2. Classical Biotechnology (1800-1945)

- this phase existed from 1800 to almost the middle of the twentieth century. During this period various observations started pouring in, with scientific evidences.
- The basics for the transfer of genetic information are the core of biotechnology. This was, for the first time, deciphered in plants, i.e., *Pisum sativum*, commonly known as Pea plant. These observations were decoded by Gregor John Mendel (1822-1884).
 - 1773-1858: Robert Brown discovered the nucleus in cells.
 - 1802: The word “biology” first appears.
 - 1822-1895: Vaccination against small pox and rabies developed by Edward Jenner and Louis Pasteur.
 - 1855: The *Escherichia coli* bacterium is discovered. It later becomes a major research, development, and production tool for biotechnology.
 - 1870: Breeders crossbreed cotton, developing hundreds of varieties with superior qualities.
 - 1870: The first experimental corn hybrid is produced in a laboratory.
 - 1919: The Hungarian Károly Ereky coined the word “biotechnology” in Hungary to describe a technology based on converting raw materials into a more useful product.
 - 1941: The term “genetic engineering” is first used by a Danish microbiologist.
 - 1942: The electron microscope is used to identify and characterize a bacteriophage- a virus that infects bacteria.
 - 1942: Penicillin is mass-produced in microbes for the first time.

Stages of Biotechnology

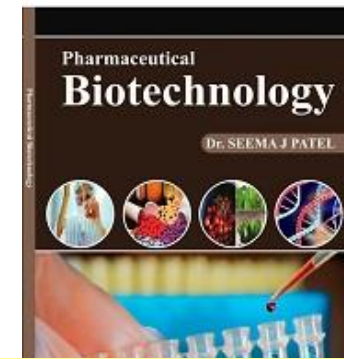
3. Modern Biotechnology (1945-present)

- The origins of biotechnology culminate with the birth of genetic engineering.
- There were two key events that have come to be seen as scientific breakthroughs beginning the era that would unite genetics with biotechnology:
 - 1953 discovery of the structure of DNA, by Watson and Crick,
 - 1973 discovery by Cohen and Boyer of a recombinant DNA technique by which a section of DNA was cut from the plasmid of an E. coli bacterium and transferred into the DNA of another.
 - Popularly referred to as “genetic engineering,” it came to be defined as the basis of new biotechnology.
- Modern biotechnologies involve making useful products from whole organisms or parts of organisms, such as molecules, cells, tissues and organs. Recent developments in biotechnology include genetically modified plants and animals, cell therapies and nanotechnology.

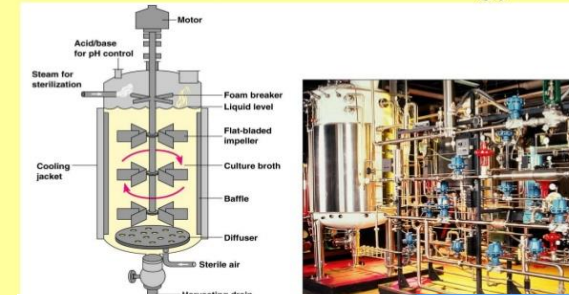


Uses of Biotechnology

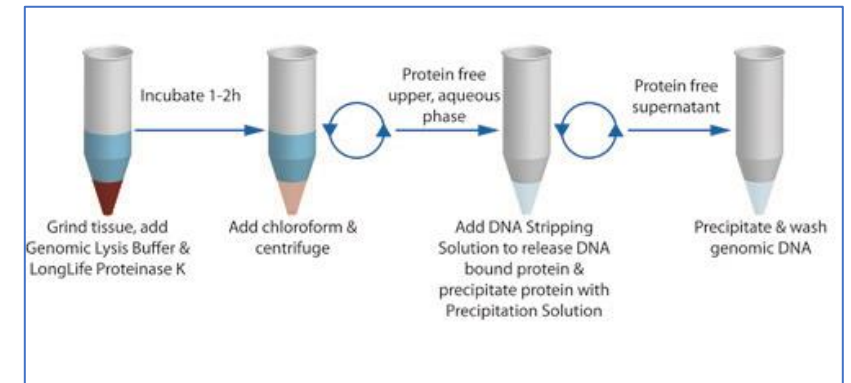
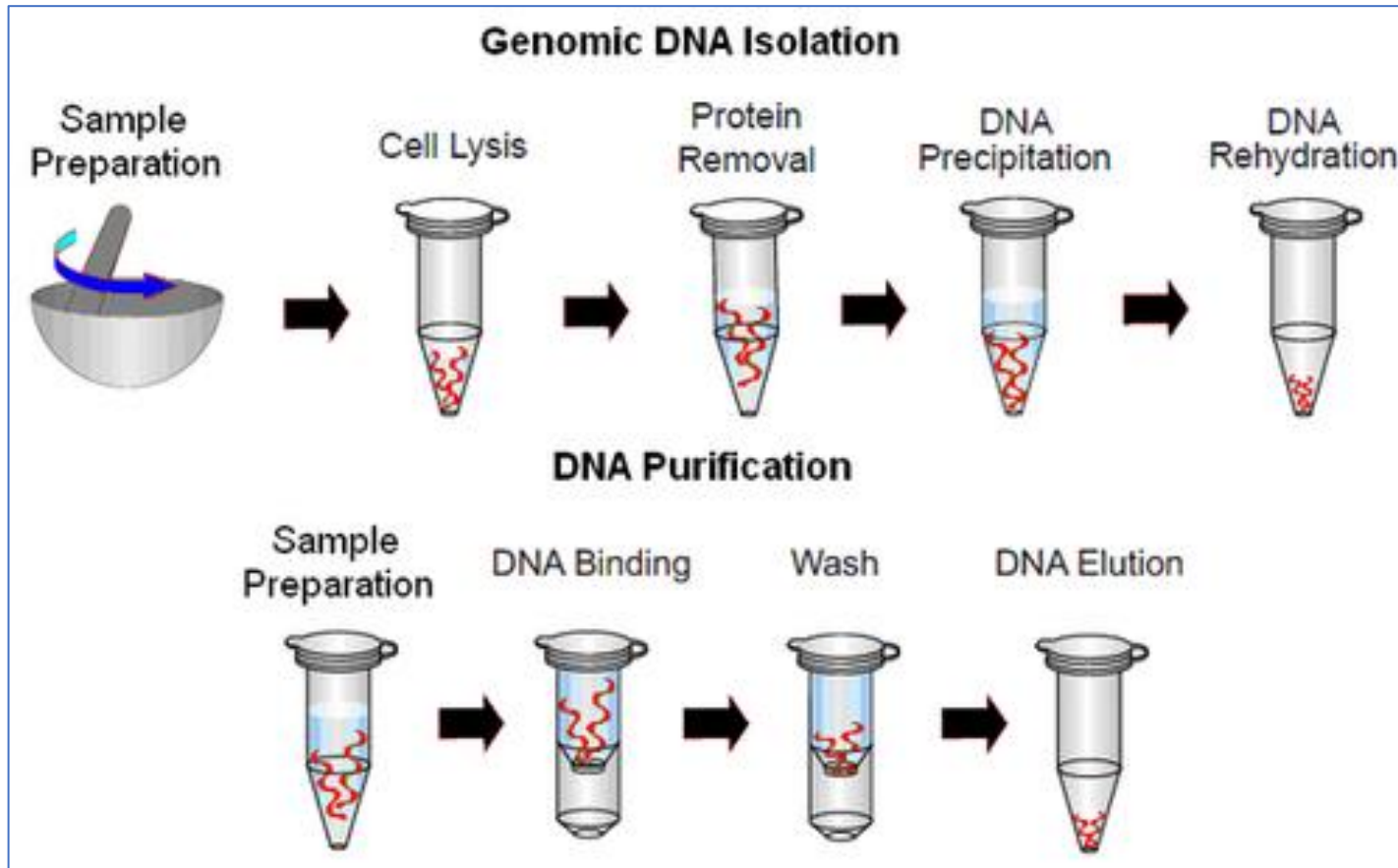
- a. **Pharmaceutical industry** uses biotechnology to find cures for diseases, understand human cell biology and DNA, develop **vaccines and manufacture antibiotics**.
- b. Chemical manufacturing engineers can use biological processes, such as **fermentation and the use of enzymes or microbes**, to streamline chemical manufacturing, reduce operational costs and reduce chemical emissions.
- c. **Biofuels** can be created by altering natural resources, such as corn, to produce **combustible fuel**.
- d. **Nutrient supplementation** can involve biotechnology as some foods are infused with necessary added nutrients to aid in diet planning or medical treatment.
- d. **Plants and crops** can be bred to handle external stresses, such as minimal space or extreme weather conditions, through biotechnology.



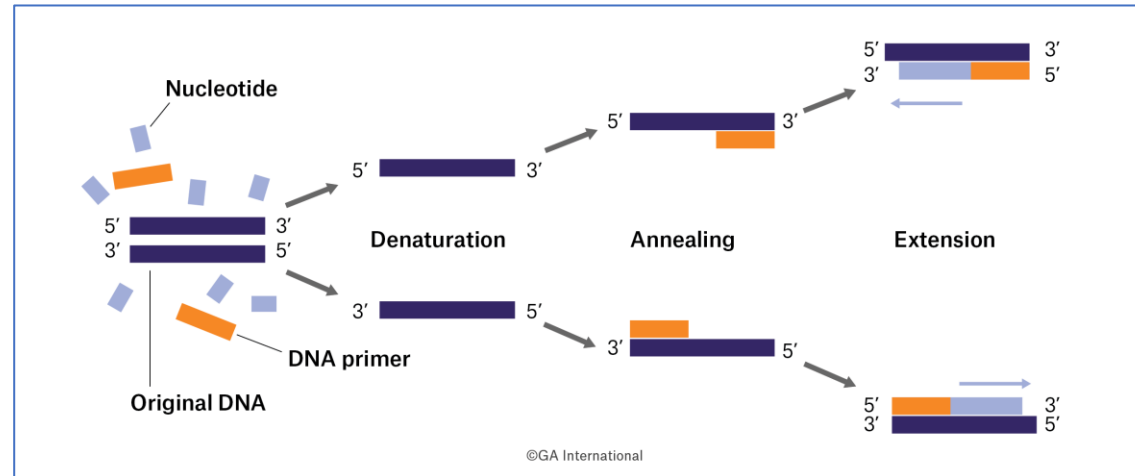
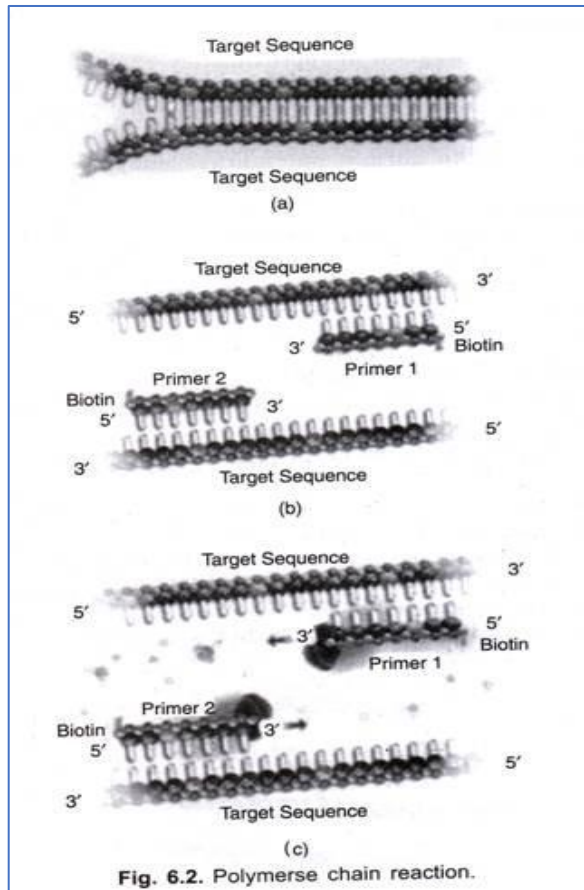
Fermentation Technology



1. DNA extraction is a routine procedure used to isolate DNA from the nucleus of cells. The ability to **extract DNA** is of primary importance to studying the genetic causes of disease and for the development of diagnostics and drugs. It is also essential for carrying out forensic science, sequencing genomes, detecting bacteria and viruses in the environment



2. Polymerase chain reaction (PCR) is a method widely used in molecular biology to **make several copies of a specific DNA segment**. Using **PCR**, copies of DNA sequences are exponentially amplified to generate thousands to millions of more copies of that particular DNA segment.



3. Genetic engineering is the process of using recombinant DNA (rDNA) technology to **alter the genetic makeup of an organism**. Traditionally, humans have manipulated genomes indirectly by controlling breeding and selecting offspring with desired traits.

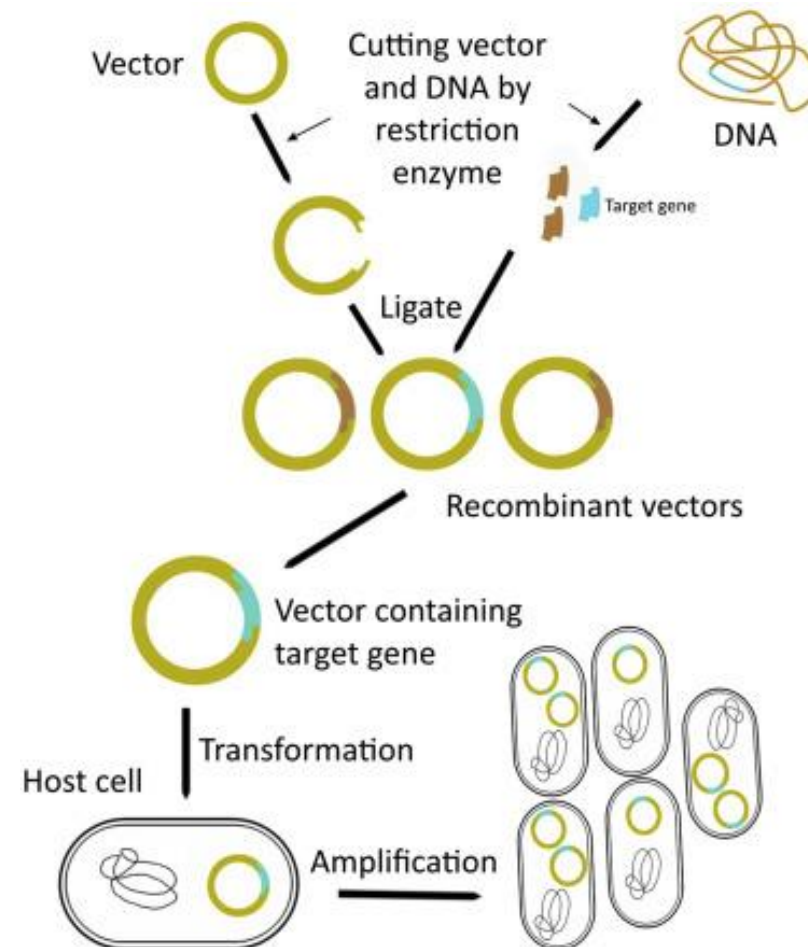
It is an important tool in research that allows the function of specific genes to be studied. *Drugs, vaccines and other products have been harvested from organisms engineered to produce them.* Crops have been developed that aid food security by increasing yield, nutritional value and tolerance to environmental stresses.



Genetic engineering based on recombination was pioneered in 1973 by American biochemists Stanley N. Cohen and Herbert W. Boyer, who were among the first to cut DNA into fragments, rejoin different fragments, and insert the new **genes**

4. Recombinant DNA is used to identify, map and sequence genes, and to determine their function. It is employed in analyzing gene expression within individual cells, and throughout the tissues of whole organisms.

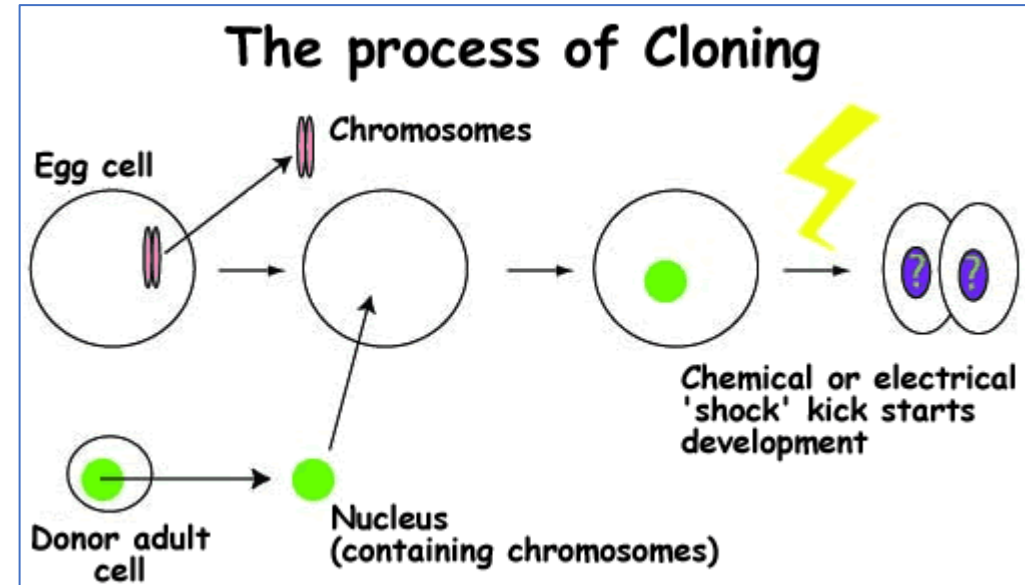
Recombinant DNA technology, involves the group of techniques used to **cut up and join together genetic material, especially DNA from different biological species**, and to introduce the resulting hybrid **DNA** into an organism in order to form new combinations of heritable **genetic** material.



5. Cloning is the process of producing genetically identical individuals of an organism either naturally or artificially. Cloning in biotechnology refers to **the process of creating clones of organisms or copies of cells or DNA fragments.**

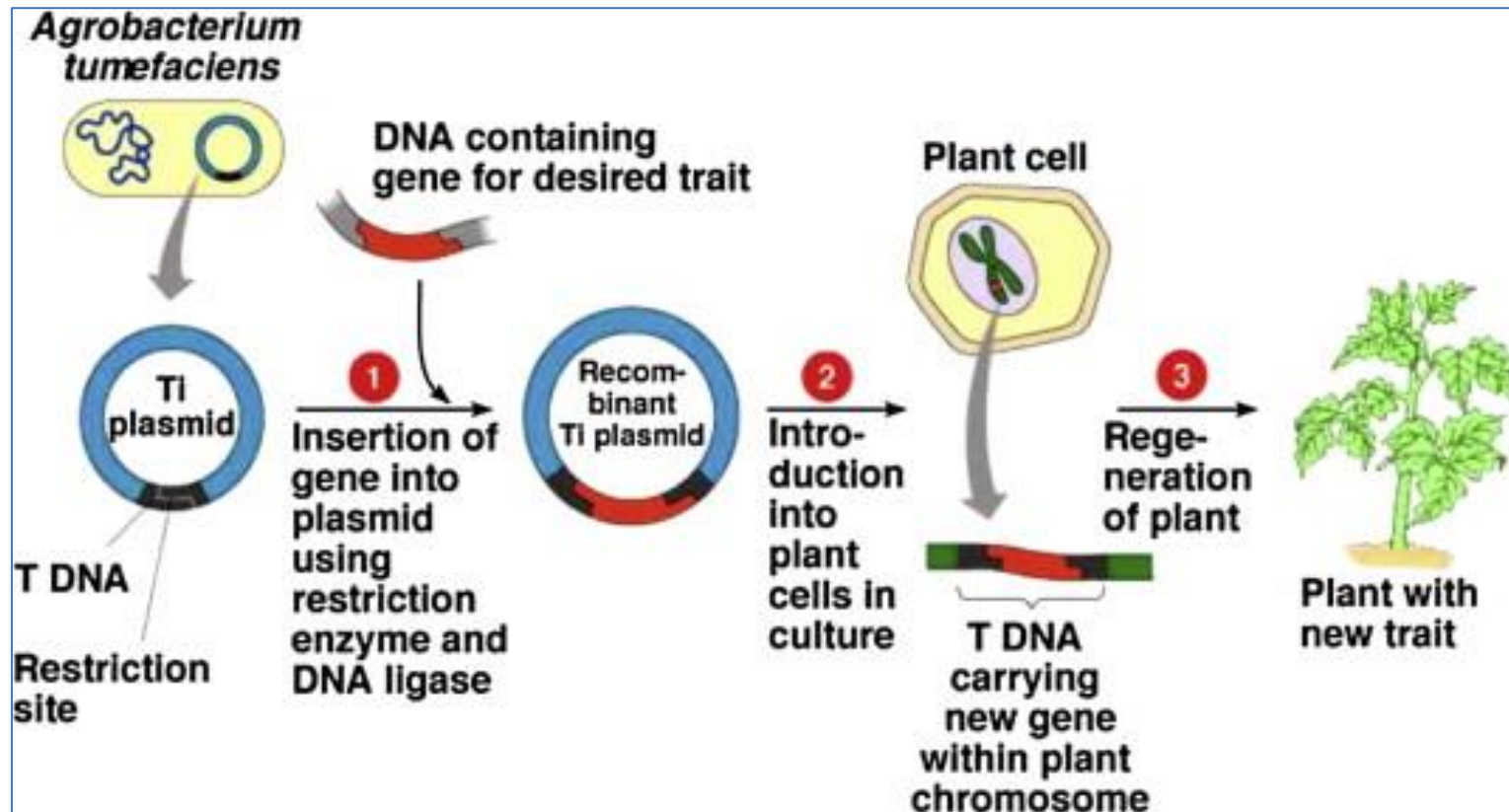
Three types of cloning:

- **Gene cloning**, also called **DNA cloning**, creates copies of **genes**, or segments of DNA.
- **Reproductive cloning** makes duplicates of whole animals.
- **Therapeutic cloning** creates embryonic stem cells, which are used to create tissues that can repair or replace damaged tissues.



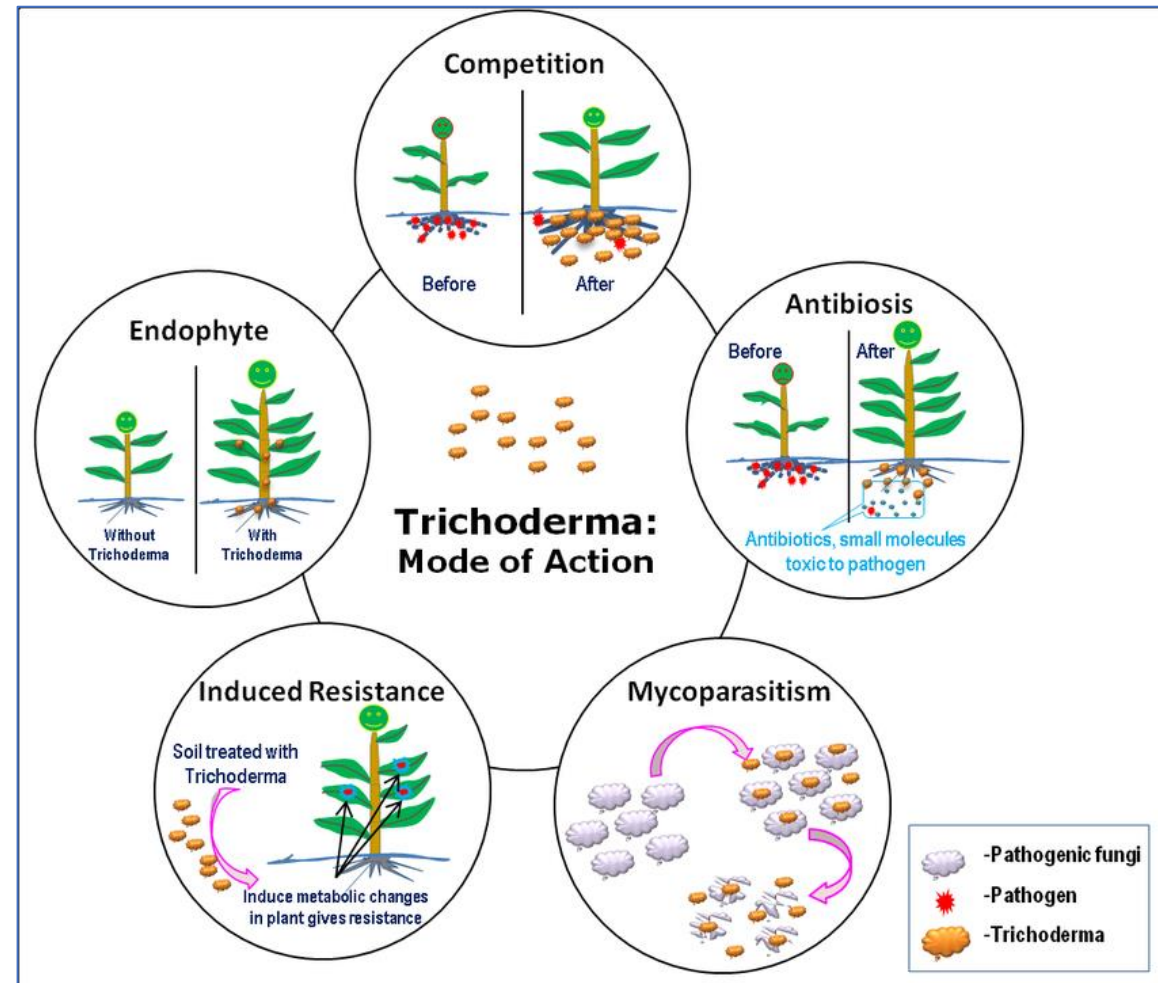
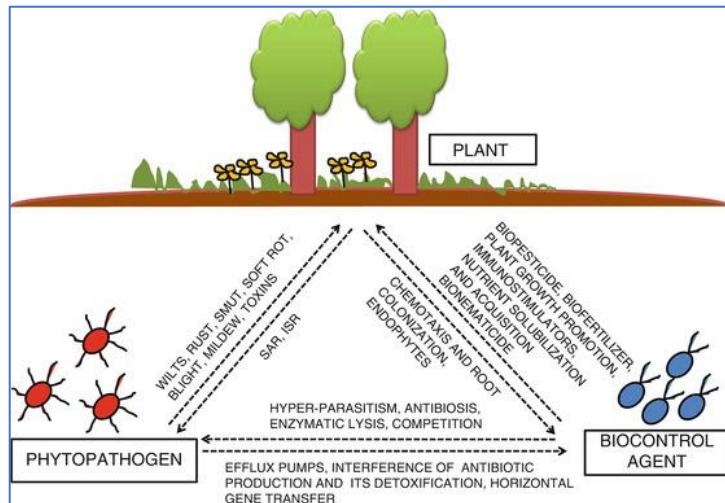
6. Transgenic is a term that describes an **organism containing genes from another organism put into its genome through recombinant DNA techniques.**

A **transgenic organism** is one that contains a gene or **genes which have been artificially inserted** instead of the organism acquiring them through reproduction.



7. Biological control, the use of living organisms to **control** pests. A natural enemy or organism is introduced into the environment of a pest or, if already present, is encouraged to multiply and become more effective in reducing the number of pest organisms.

It relies on predation, parasitism, herbivory, or other natural mechanisms, but typically also involves an active human management role.

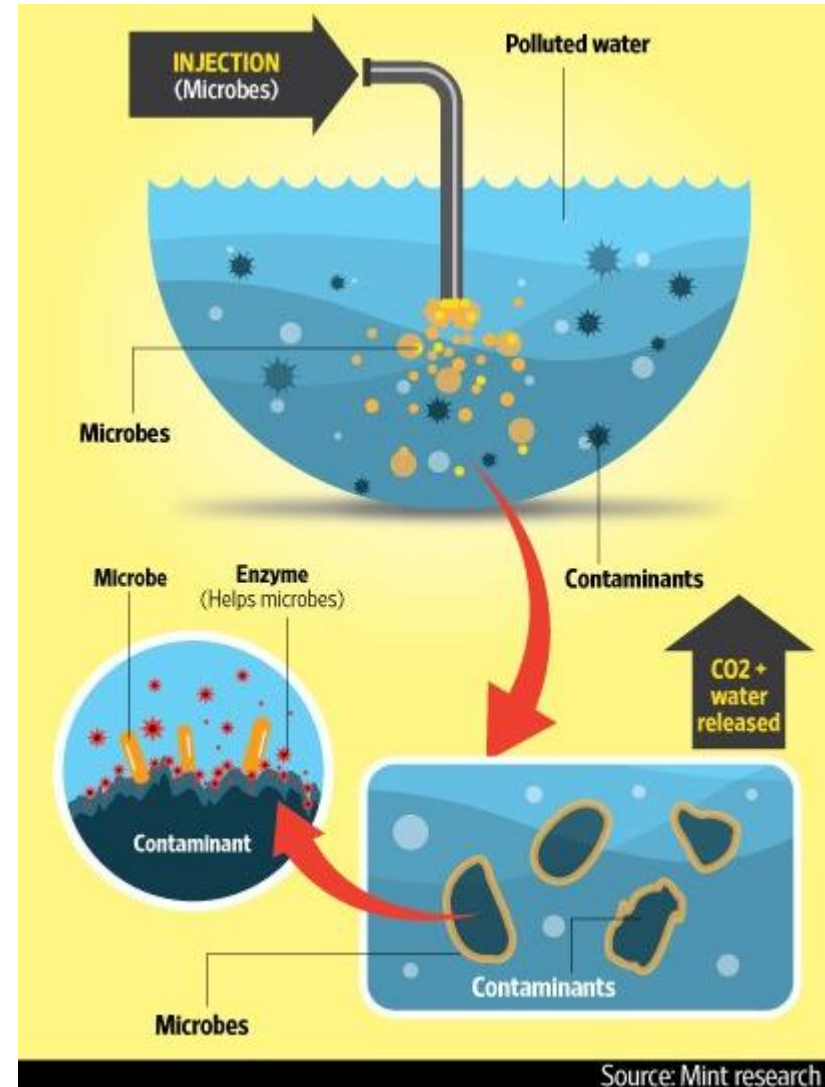


8. Bioremediation makes use of living organisms to break down the pollutant into harmless, natural compounds.

It is a process used to **treat contaminated media**, including water, soil and subsurface material, by the use of either naturally occurring or deliberately introduced microorganisms or other forms of life to consume and break down environmental pollutants, in order to clean up a polluted site.

Below are several specific bacteria species known to participate in bioremediation.

- *Pseudomonas putida*.
- *Dechloromonas aromatica*.
- *Deinococcus radiodurans*.
- *Methylibium petroleiphilum*.
- *Alcanivorax borkumensis*.
- *Phanerochaete chrysosporium*.




Source: Mint research

9. Antibiotics, also known as antibacterials that destroy or slow down the growth of disease-causing bacteria. They include a range of powerful drugs and are used to treat diseases caused by bacteria

Antibiotics Vs Probiotics

<ul style="list-style-type: none">● Antibiotics:● Emergence of antibiotic resistance micro-organisms● Unpleasant side effects	<ul style="list-style-type: none">● Probiotics:● Non- invasive● Preventive● Free from undesirable side effects
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10. Probiotics are defined as a group of **live bacteria which are known to bring health benefits to the host.** It stimulates the growth of microorganisms with beneficial properties used to treat diarrhea, inflammatory bowel disease, irritable bowel syndrome, etc. Usually found in cultured milk products like yogurt, cheese and probiotic drinks.

11. Vaccine is a biological preparation that provides active acquired immunity to a particular disease. A **vaccine** typically contains an agent that **resembles a disease-causing microorganism and is often made from weakened or killed forms of the microbe**, its toxins, or one of its surface proteins.

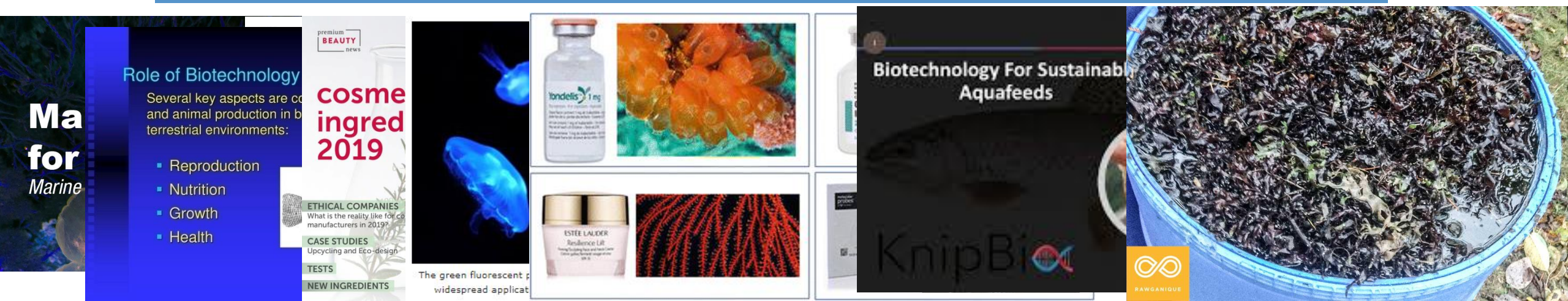
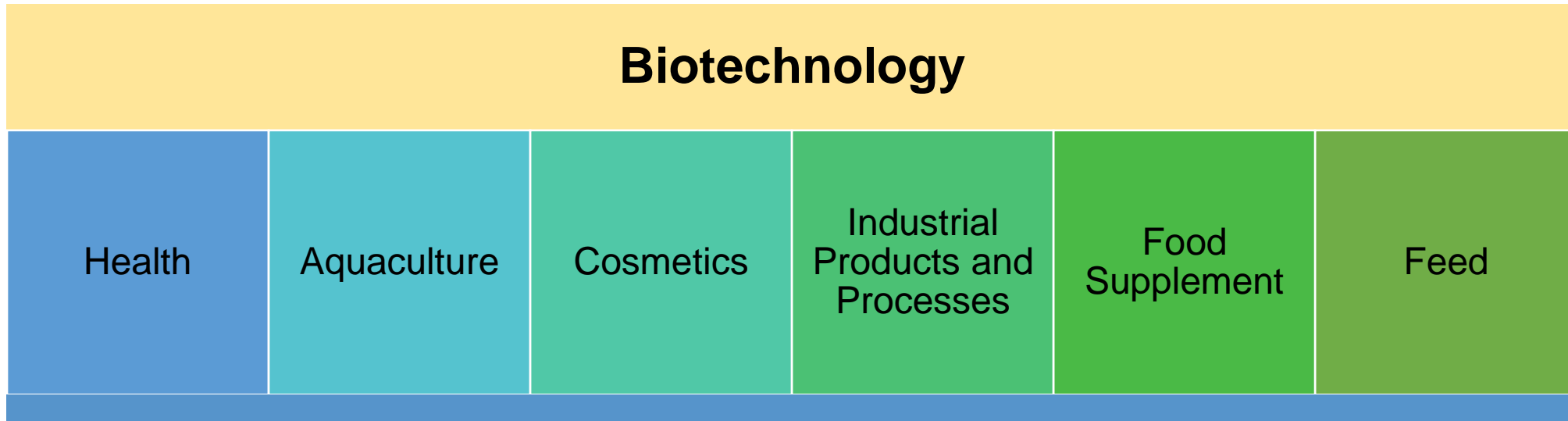
There are 4 main types of vaccines:

- Live-attenuated vaccines.
- Inactivated vaccines.
- Subunit, recombinant, polysaccharide, and conjugate vaccines.
- Toxoid vaccines.



Biotechnology In Fisheries

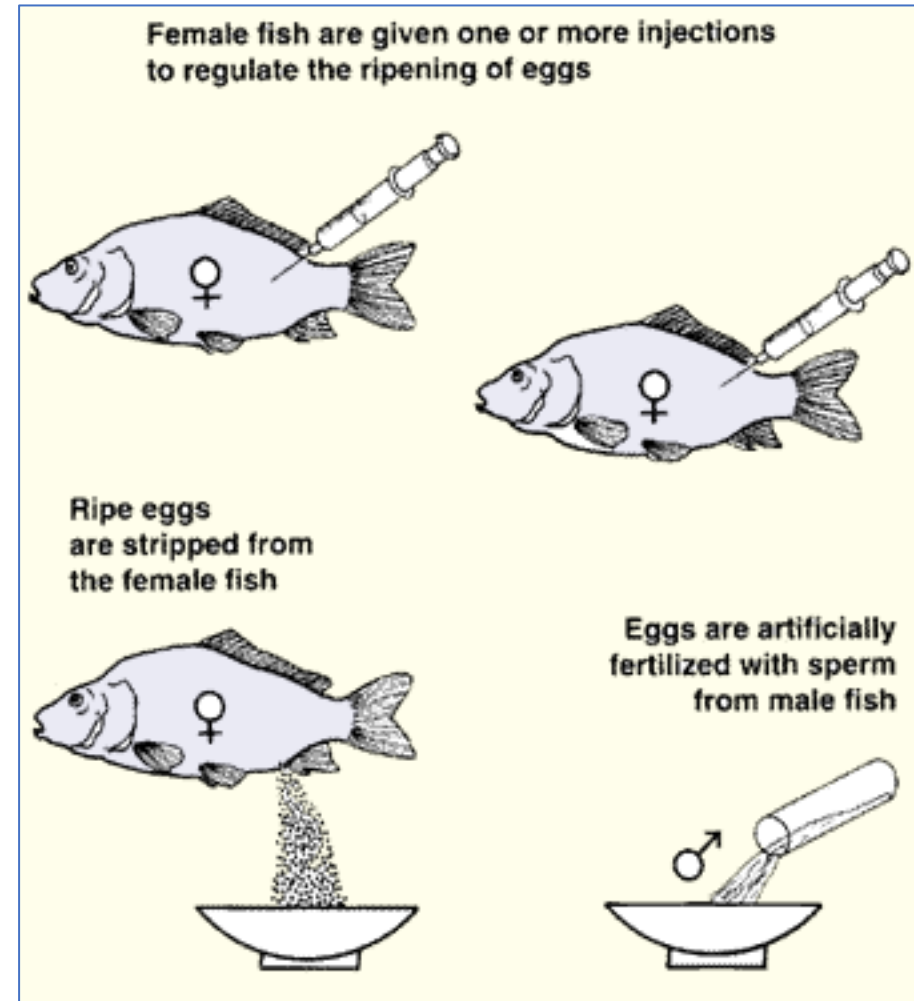
- is the creation of products and processes from **fishery resources** through the application of biotechnology, molecular and cell biology, and bioinformatics for development of new pharmaceutical drugs, chemical products, enzymes, and other products and processes.



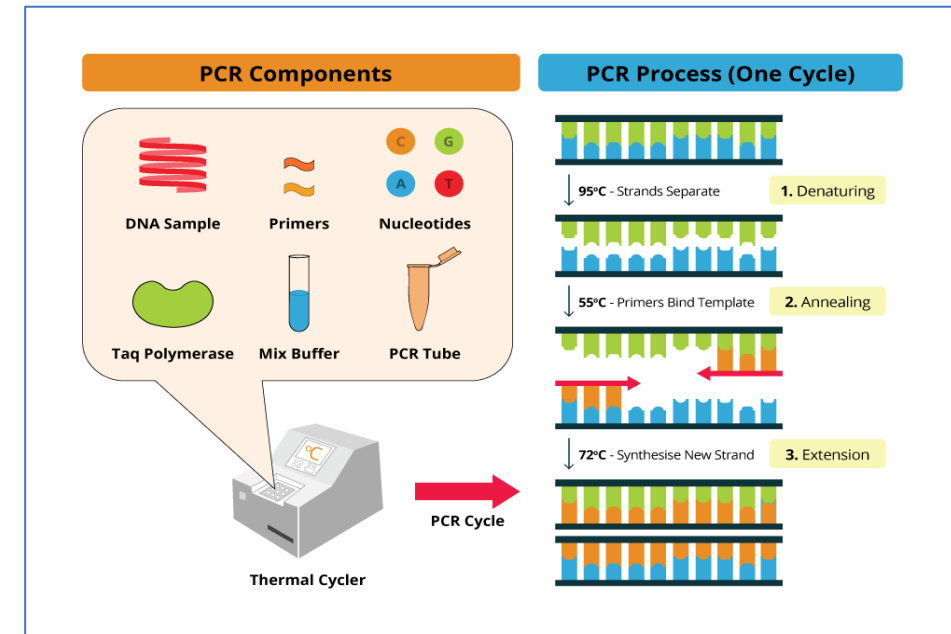
Applications of Biotechnology in Fisheries

1. Fish Reproduction. Fish gonadotropin, a group of hormones stimulate reproduction. **Highly purified gonadotropin** can be produced in the laboratory through **recombinant DNA technology**.

2. Nutrition. Trash fish or wild fish species for fish meal as protein source for aquafeeds are very limited. **Carbohydrate metabolism of salmonid fish was enhanced through genetic engineering.**



3. Health Management. Traditional disease diagnosis involves analysis of cells and tissues of organisms, which takes a long time to be done. Modern methods like use of **PCR enables accurate identification of pathogens in marine organisms** even without visual symptoms of the disease.



4. Growth Promotion.

Transgenic fish with altered growth traits reach maturity in a shorter span of time than non-transgenic fish and exhibit better feed conversion efficiency - translate to **shorter production cycle, lower production costs, and reduced pollution in aquaculture facility.**

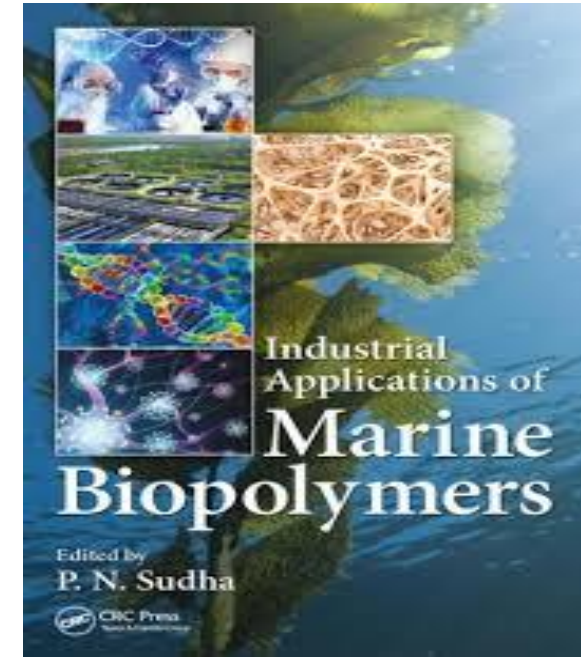
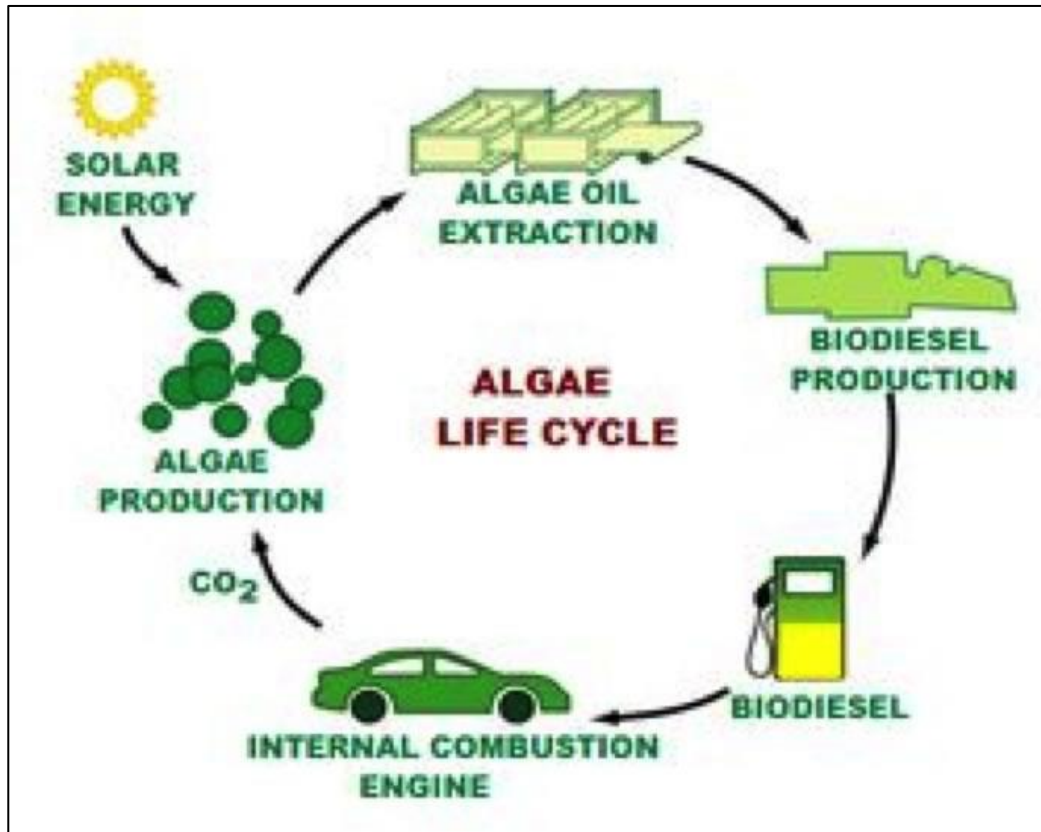


5. Medicine - Extracts from marine organisms were used as medicine. **Cod liver oil** is one of the famous nutritional supplements.

Table 1. Drugs derived from marine organisms^{1, 10, 11}

Product	Source	Application
Cephalosporin	Fungi (<i>Cephalosporium</i>)	Antibiotic
Squalamine	Spiny dogfish (<i>Squalus acanthus</i>)	Antibiotic
Vidrabine/Ara-A	Caribbean sponge (<i>Tethya crypta</i>)	Antiviral
Cytarabine/Ara-C	Caribbean sponge (<i>Tethya crypta</i>)	Anticancer
Ziconotide	Cone snail (<i>Conus magus</i>)	Analgesic
Trabectedin	Caribbean tunicate (<i>Ecteinascidia turbinata</i>)	Anticancer
Eribulin mesylate	Marine sponge (<i>Halichondria okada</i>)	Anticancer

6. Environment - marine organisms produce eco-friendly chemicals like biopolymers which can be used in environmental waste management. Biopolymers are used for packaging, edible films, and emulsions. Immobilized cells of bacterium *Pseudomonas chlororaphis* produce pyoverdinin, which hastens the breakdown of toxic organotin compounds in seawater.



7. Biofuels - from microalgae is one of the economically viable ways to reduce fossil fuel consumption. Microalgae are considered better sources of biofuels than higher plants because of their high oil content.

- Microalgae provide a viable biomass feedstock for biofuel production as the global market for biofuels rises.
- Biodiesel made from biomass is usually regarded as one of the best natural substitutes to fossil fuels and a sustainable means of achieving energy security and economic and environmental sustainability.

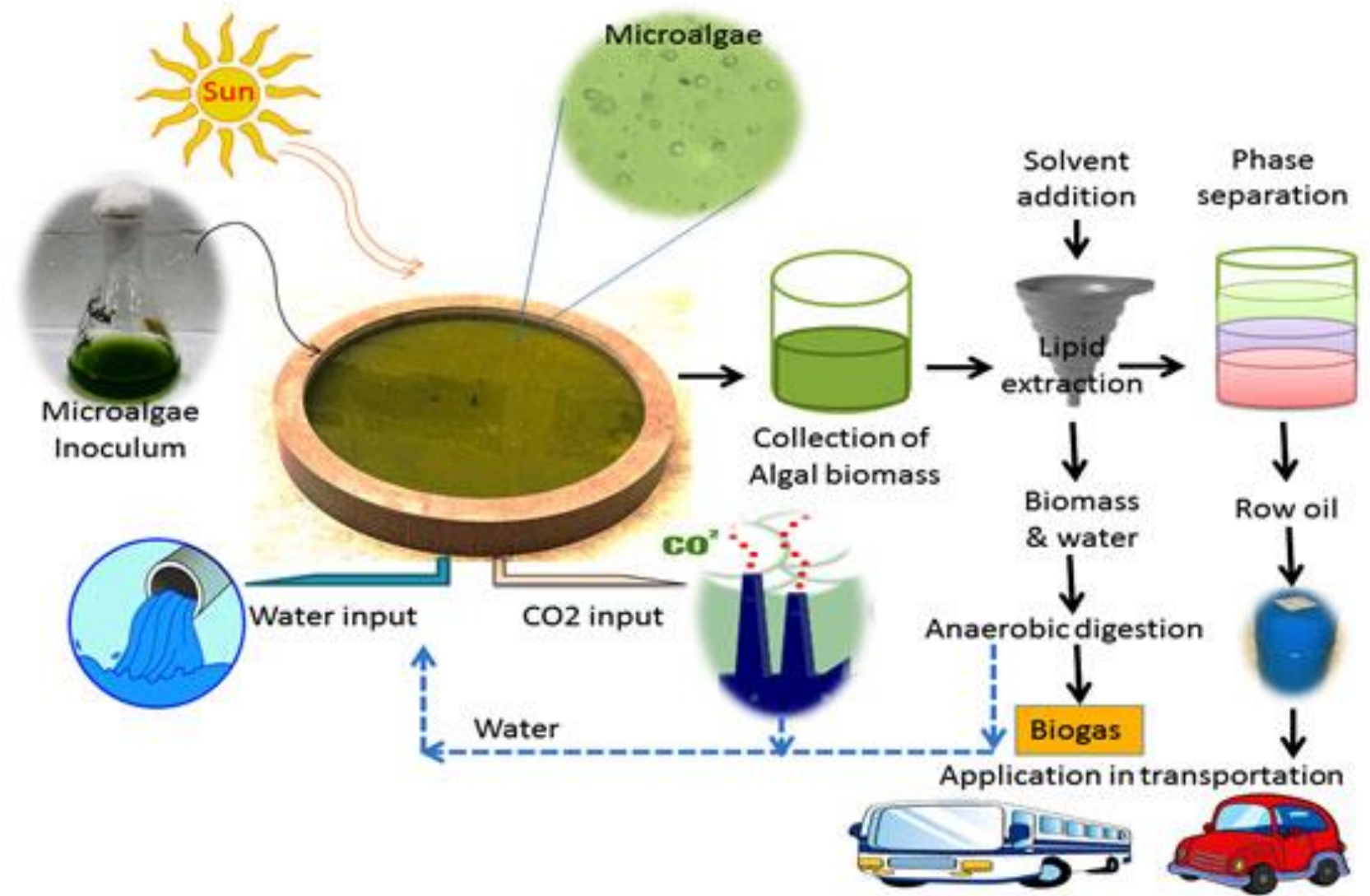


Figure 1: Overview of the Biofuel Production from the Microalgae.