Lec3 \ Principles of microbial Biotechnology

قسم علوم التقنيات الاحيائية الطبية
المرحلة الاولى

اعداد

م .م ساره رحيم حمزه

الايميل :
رمز الصف :

قصة (“من عفن الخبز إلى مضاد حيوي”)

- في أحد الأيام من عام 1928، عاد العالم ألكسندر فليمنغ إلى مختبره بعد إجازة قصيرة، ليجد شيئًا غريبًا في أحد أطباق البكتيريا التي كان يدرسها .لاحظ أن بقعة من العفن قد نمت بالصدفة، والأغرب من ذلك أن البكتيريا حول هذا العفن كانت ميتة تمامًا. بدل أن يتجاهل الأمر، طرح فليمنغ سؤالًا بسيطًا لكنه غيّر العالم: لماذا ماتت البكتيريا؟
- اكتشف أن هذا العفن وهو كائن مجهري يُدعى (Penicillium) يفرز مادة تمنع نمو البكتيريا، فأطلق عليها اسم البنسلين. لم يكن يعلم حينها أن هذا الاكتشاف العَرَضي سيكون الشرارة الأولى لثورة هائلة في التكنولوجيا الحيوية. بعد سنوات، طوّر العلماء طرقًا لاستزراع هذا الكائن المجهري داخل مفاعلات حيوية ضخمة، والتحكم بظروفه (الحرارة، الأوكسجين، الغذاء) لإنتاج كميات هائلة من البنسلين.

Introduction

The use of microorganisms (bacteria, fungi, algae, and viruses) to create products and processes that benefit a variety of industries, such as agriculture, medicine, food production, and environmental management, is known as microbial biotechnology. Because of their rapid growth, genetic diversity, and adaptability in producing bioactive compounds, microorganisms are essential to the biotechnological sector.

Microorganisms in Biotechnology:

Microorganisms are critical tools in biotechnology due to their ability to produce a variety of biologically significant products, such as enzymes, antibiotics, Vitamins, amino acids, biofuels, and bioremediation agents.

- Bacteria: *Escherichia coli, Bacillus* species, and *Streptomyces* are commonly used in industrial biotechnology. They can produce a range of proteins, enzymes, and antibiotics..
- Fungi: *Aspergillus, Penicillium, and Saccharomyces* cerevisiae are used for producing enzymes, biofuels, and pharmaceuticals.
- Algae: Cyanobacteria and microalgae can be used for biofuel production and carbon capture.
- Viruses: They are harnessed for gene therapy and as vectors for gene delivery.

Principles of Microbial Biotechnology

a-Metabolic Pathways and Genetic Engineering

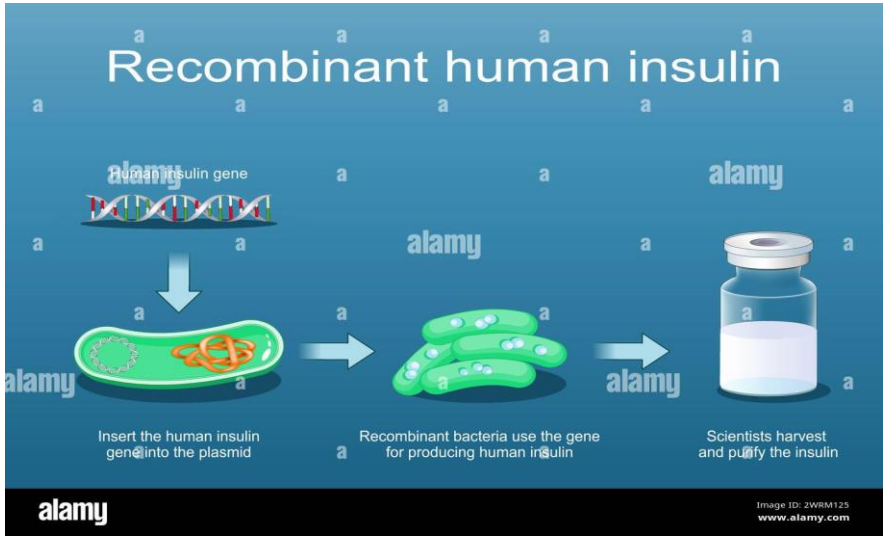
Microbial biotechnology relies primarily on modifying metabolic pathways to produce desired products. Metabolic engineering involves altering the genetic material of microorganisms to improve production processes. This can include the following:

- Gene cloning and expression: Inserting foreign genes into microorganisms to produce therapeutic proteins or enzymes.

- CRISPR-Cas9 technology: Gene-editing tools like CRISPR are used to precisely modify the genetic makeup of microorganisms to enhance their metabolic capabilities.

a-Metabolic Pathways and Genetic Engineering

Example: Recombinant DNA technology in Escherichia coli allows the production of human insulin.



Principles of Microbial Biotechnology

b-Fermentation Technology:

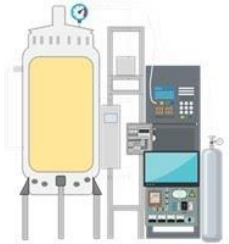
Fermentation is a biochemical process where microorganisms convert organic substrates into valuable products under controlled conditions. It is used to produce antibiotics, vitamins, biofuels, and other secondary metabolites.

- **Batch Fermentation: A closed system where microorganisms are cultivated in a fixed volume of nutrient-rich media until product accumulation ceases.**

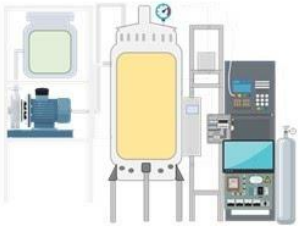
- **Continuous Fermentation: Microorganisms are continually supplied with fresh media while products are continuously harvested.**

Operation modes of bioreactors

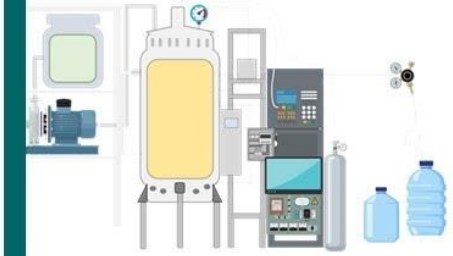
Batch process



Fed-Batch process

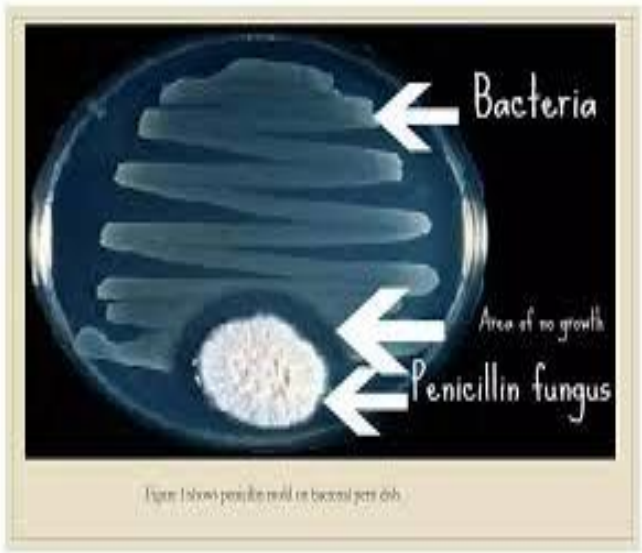


Continuous process



b-Fermentation Technology:

Example: Penicillin production by Penicillium chrysogenum uses submerged fermentation to produce high yields



سؤال جماعي للمناقشة

اذكروا أي منتج أو تقنية في حياتنا اليومية تعتقدون أنها تعتمد على الأحياء المجهرية ؟

الخبز

اللبن

المضادات الحيوية

اللقاحات

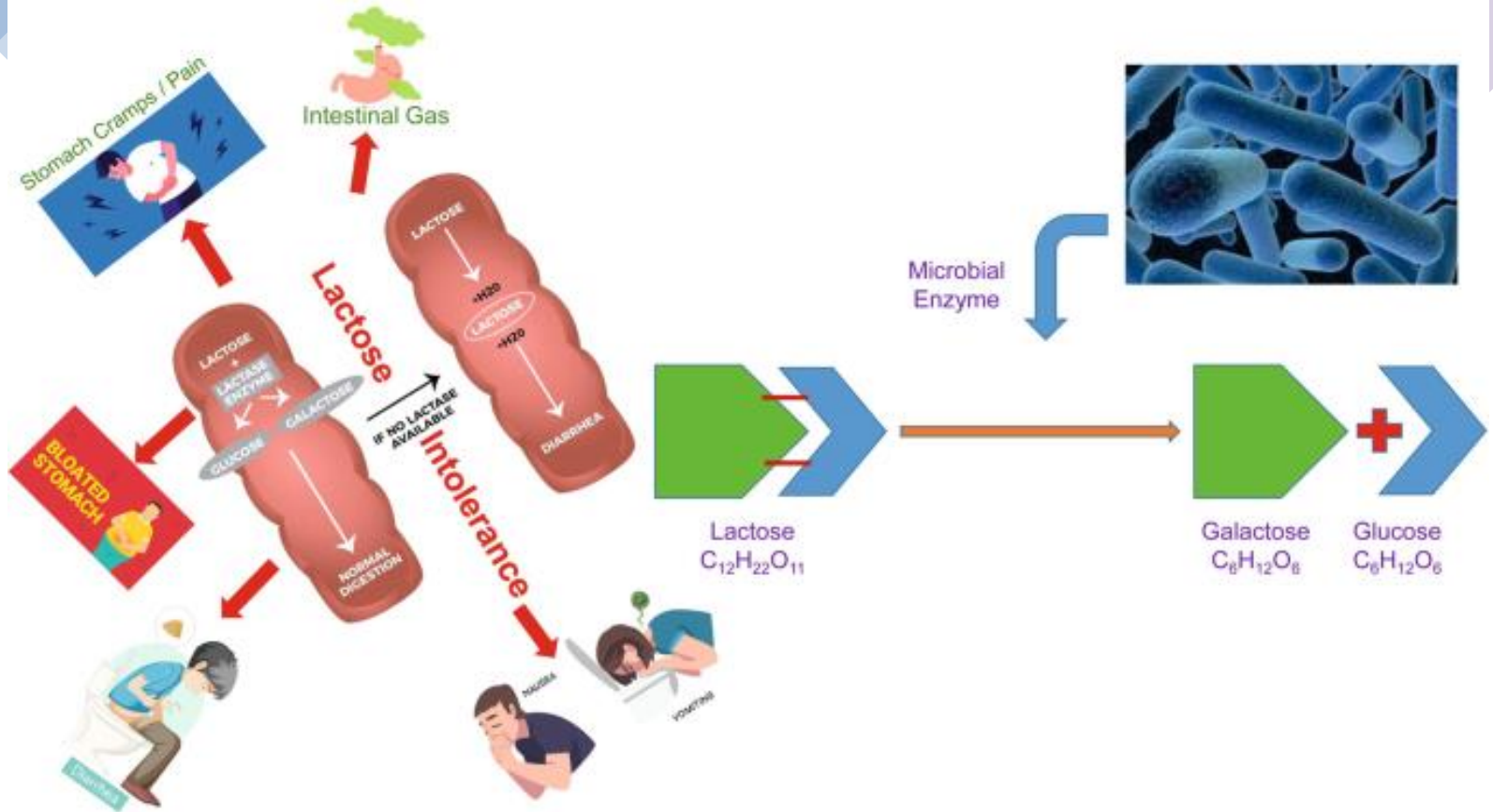
فحص DNA

الهندسة الوراثية

C-Microbial enzymes

Microbial enzymes are widely واسع used in industrial processes. They catalyze biochemical reactions and are often **more efficient** and **cost-effective** than **chemical** catalysts.

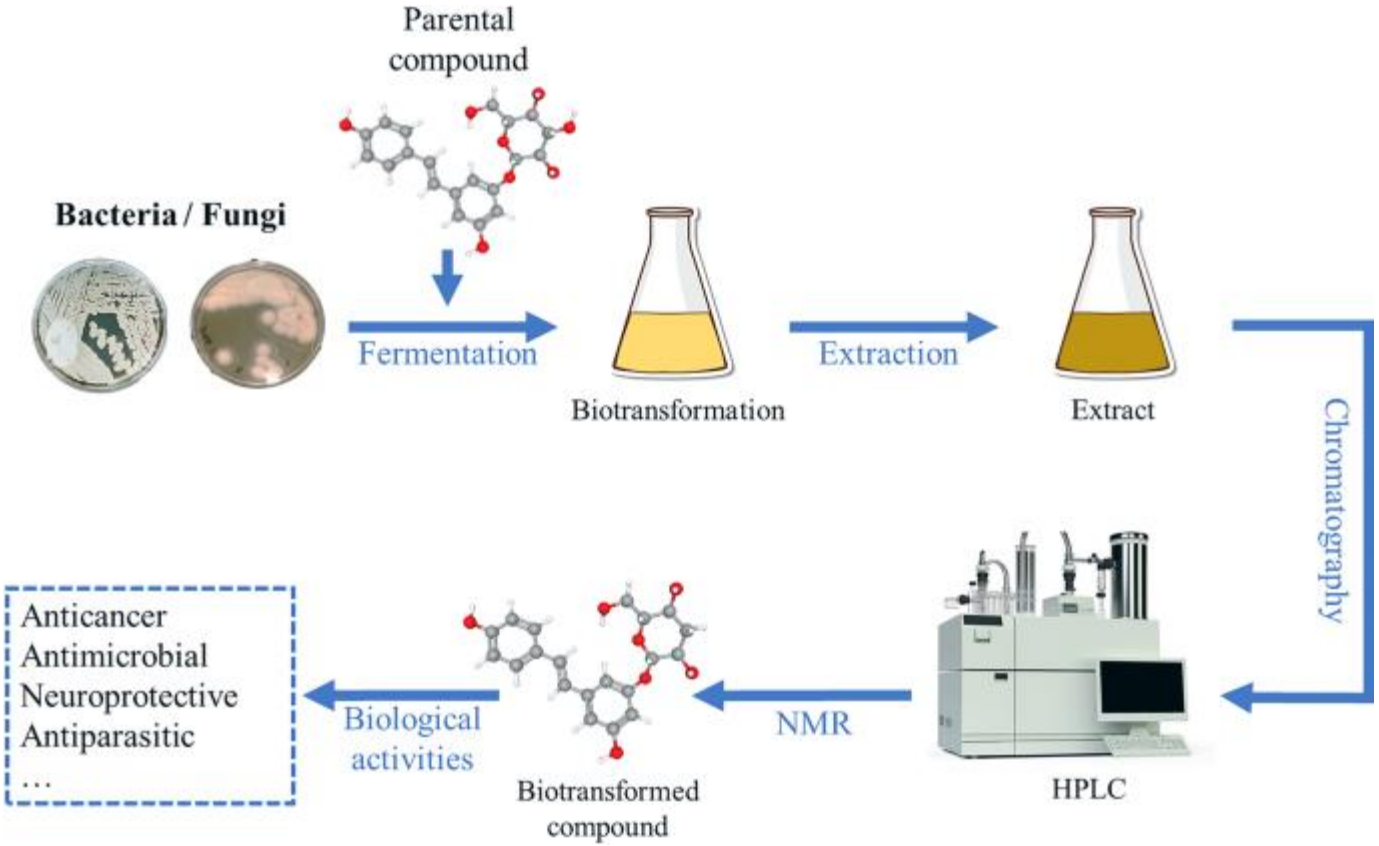
- **Amylase**: Produced by *Bacillus* subtilis and used in the food industry for starch hydrolysis.
- **Protease**: Produced by *Aspergillus* species for detergent and leather processing.


Stomach Cramps / Pain
Intestinal Gas
Lactose
Intolerance
LACTOSE
LACTASE ENZYME
GLUCOSE
GALACTOSE
NORMAL DIGESTION
BLOATED STOMACH
IF NO LACTASE AVAILABLE
LACTOSE
+H2O
LACTOSE
+H2O
DIARRHEA
NAUSEA
VOMITING
Microbial Enzyme
Lactose
$C_{12}H_{22}O_{11}$
Galactose
$C_6H_{12}O_6$
Glucose
$C_6H_{12}O_6$

d-Microbial biotransformation

Microbial biotransformation involves using microorganisms to convert one compound into another, often to produce high-value chemicals, drugs, or metabolites that would be difficult to synthesize through traditional chemical methods.

- **Steroid transformation: Microorganisms like Rhodococcus رودوكوكوس are used for the biotransformation of steroids to produce pharmaceutical intermediates.**


Parental compound
Bacteria / Fungi
Fermentation
Biotransformation
Extraction
Extract
Chromatography
HPLC
NMR
Biotransformed compound
Biological activities
Anticancer
Antimicrobial
Neuroprotective
Antiparasitic
…

e-Biofuel and Bioremedation

- **Biofuels: Microbial biotechnology plays a significant role in the production of bioethanol, biodiesel, and biohydrogen as renewable energy sources.**

Example: *Saccharomyces* cerevisiae (yeast) is used for ethanol production from sugars.

تُستخدم خميرة Saccharomyces cerevisiae لإنتاج الإيثانول من السكريات

- **Bioremediation المعالجة الحيوية: Microorganisms are used to break down or detoxify environmental pollutants such as oil spills, heavy metals, and organic pollutants.**

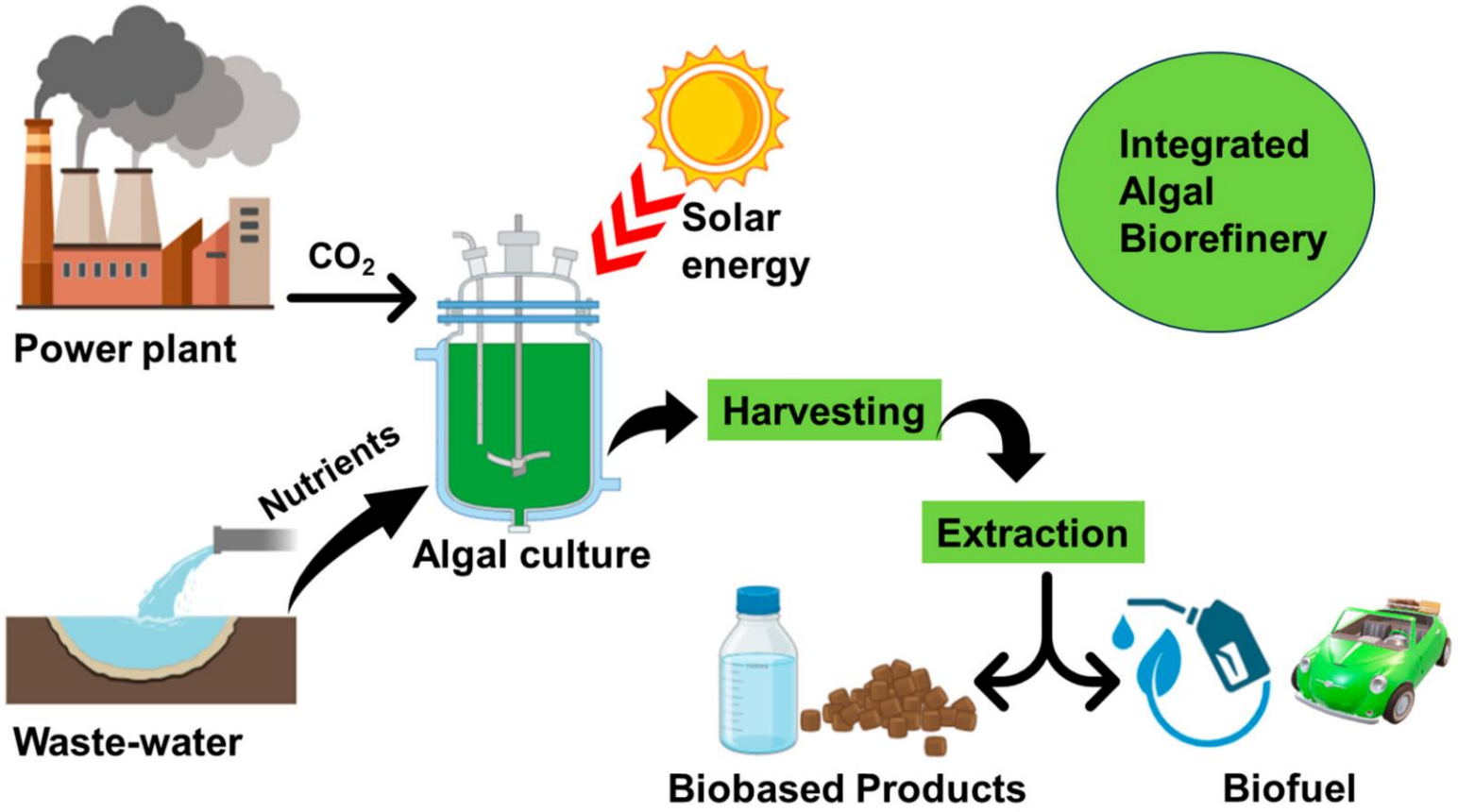
Example, certain types of Pseudomonas bacteria can break down hydrocarbons in oil-contaminated soil.يمكن لأنواع بكتيريا الزائفة تحليل الهيدروكربونات في التربة الملوثة بالنفط .

Applications of Microbial Biotechnology:

a-Pharmaceuticals :

Microbial biotechnology has revolutionized the production of antibiotics, vaccines, and other biopharmaceuticals.

- **Antibiotics: Microorganisms like *Streptomyces* species produce a variety of antibiotics, including penicillin and tetracycline.**
- **Vaccines: Recombinant microorganisms are used to produce vaccines against diseases like hepatitis and influenza.**


Integrated Algal Biorefinery
Power plant
CO_2
Solar energy
Nutrients
Waste-water
Algal culture
Harvesting
Extraction
Biobased Products
Biofuel

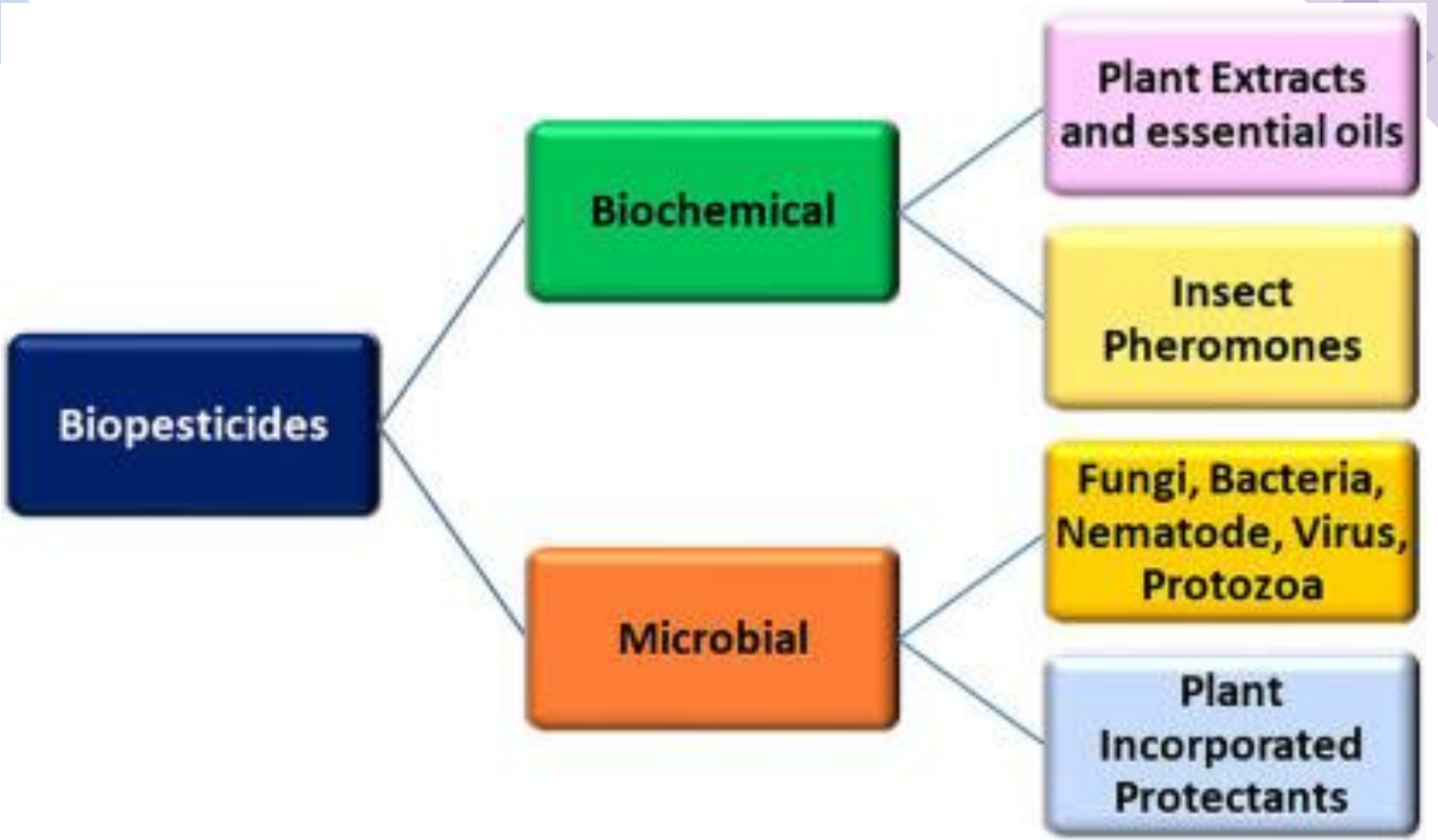
Applications of Microbial Biotechnology:

b- Agricultural Biotechnology :

Microbial biotechnology helps in enhancing agricultural productivity through biological control, nitrogen fixation, and biopesticides.

- **Biofertilizers الأسمدة الحيوية** : **Certain bacteria like *Rhizobium* الريزوبيوم help in fixing atmospheric nitrogen, promoting plant growth.**
- **Biopesticides المبيدات الحيوية** : ***Bacillus*** **thuringiensis produces proteins toxic to insect pests, reducing the need for chemical pesticides.**


CO_2
N
P
K


Biopesticides
Biochemical
Plant Extracts and essential oils
Insect Pheromones
Microbial
Fungi, Bacteria, Nematode, Virus, Protozoa
Plant Incorporated Protectants

Applications of Microbial Biotechnology:

c-Food and Beverage Industry:

Microbial biotechnology is fundamental in food fermentation processes that produce products like cheese, yogurt, bread, beer, and wine. Microorganisms such as *Lactobacillus* and *Saccharomyces* cerevisiae are commonly used.

Applications of Microbial Biotechnology:

d. Environmental Biotechnology:

Microbial biotechnology plays a crucial role in environmental conservation through waste treatment, bioremediation, and bioenergy production.

- **Wastewater treatmentمعالجة مياه الصرف الصحي : Microorganisms break down organic matter in sewage to reduce environmental pollution.**
- **Carbon sequestrationعزل الكربون : Microorganisms like algae are explored for their potential in capturing atmospheric CO2.**

Challenges and Future Directions

- **Strain improvement تحسين السلالات**: There is always a need for better microbial strains that can increase product yield and reduce by-products.
- **Safety concerns مخاوف السلامة**: Genetically modified organisms (GMOs) must be carefully monitored to avoid unintended consequences.
- **Cost-effectiveness فعالية التكلفة:** Scale-up processes for microbial biotechnology can be expensive. Efforts are ongoing to improve efficiency and reduce costs.


تذكر دائما أنك
قادرا على تحقيق
النجاح