(Bio)plastics

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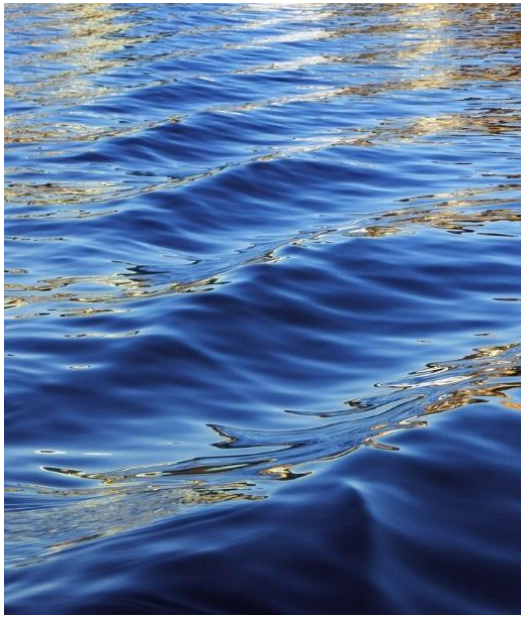


Petrochemical plastics

- The most common types of plastics:

Polyethylene (PE)

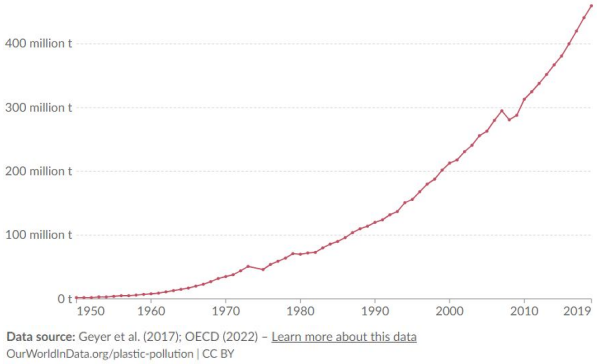
Polyvinylchloride (PVC)

Polypropylene (PP)

Polyurethane (PU)

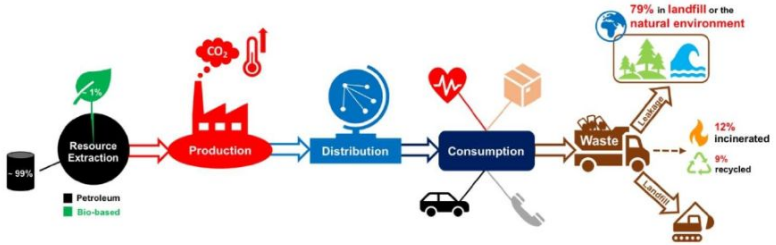
The issue of the plastics

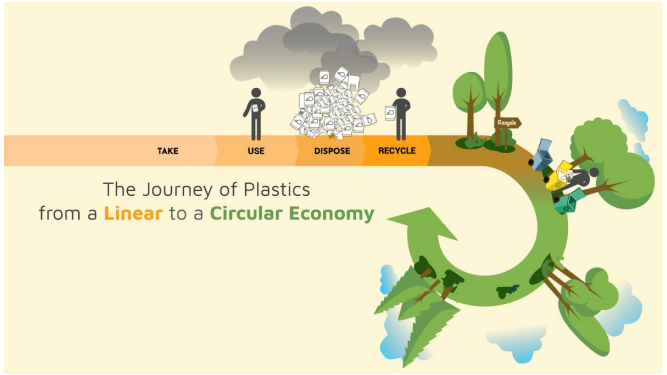
- Environment
  - not a well-established system that can deal with the huge quantity of generated pollutants
  - the petroleum is not renewable and a scarce source
  - transition to a bio-based and biodegradable plastics



The issue of the plastics

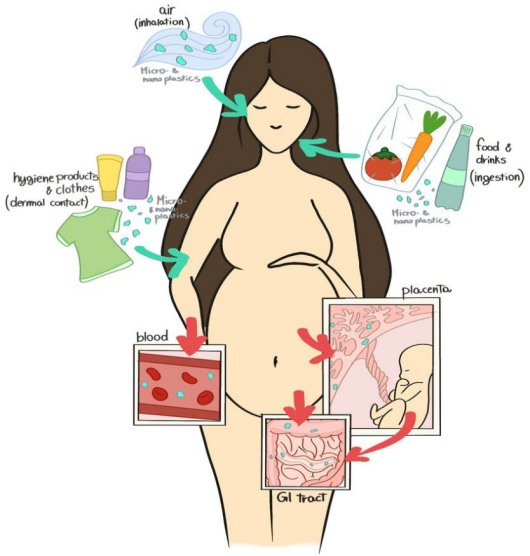
- Economy
  - The linear plastic system
    - based on “Take-Make-Dispose”
    - 3 ways for the disposal of plastic
      - mechanical recycling
      - landfilling
      - incinerating
  - The circular plastic system
    - based on “Closed-Loop Economy”
    - Reducing, Reusing, Recycling

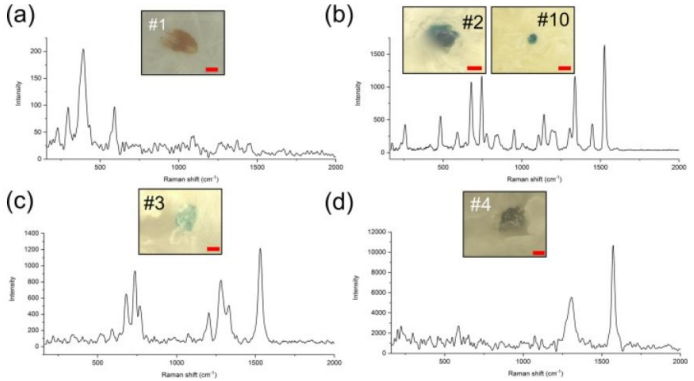




The issue of the plastics

- Effect on Health
  - intake of around 250 grams of microplastics per year
  - the pigmented microplastics were found in 4 placentas out of 6
    - possible the transgenerational effect on metabolism and reproduction





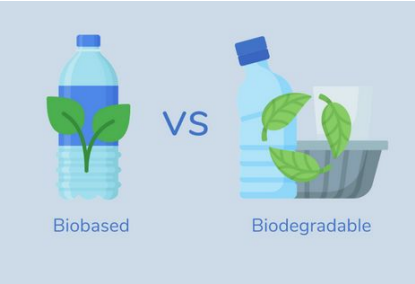
#1 - oxide yellow; #2, #3, #10 - copper phthalocyanine; #4 - violanthrone

Bioplastics

2 types based on degradability:

a) Non-biodegradable (Bio-based)

- biological origin but not biodegradable include
- completely similar properties to traditional plastics
- made from natural materials
  - starches will be converted into ethanol
  - then synthesized to ethylene/propylene
  - polymerization to traditional PE and PP plastics

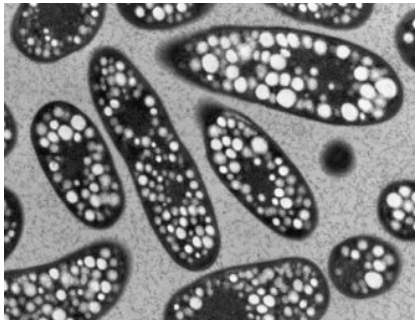


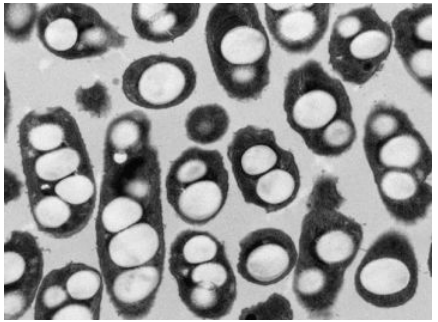
b) Biodegradable

- completely transformed into CO_2, H_20, biomass
- PLA (polylactic acid)
  - biological raw material
  - the production of plant starches
- PHAs (polyhydroxyalkanoates)
  - microbial origin

Polyhydroxyalkanoates (PHAs)

- good candidates in replacement of petrochemical plastics
- biodegradable, biocompatible, renewable, sustainable
- similar properties with conventional plastics
- synthesized by prokaryotes under conditions with high content of carbon source and limited nutrients (nitrogen)
- PHA granules functions
    - carbon and energy storage
    - stress resistance (UV radiations, high temperatures, etc.)





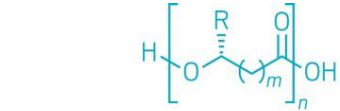
Polyhydroxyalkanoates

- mechanical and technological properties of PHAs depend on the monomer composition
    - homopolymers (PHB)
    - **copolymers** (PHBV) - generally better properties

- production of bioplastics in 2020 was 2.11 million tons, which is less than 1% of the total annual production of plastics (368 million tons in 2020)

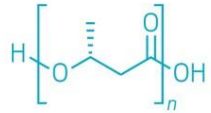
- only 1.7% of the bioplastics produced in 2020 were PHAs

    - issues:
        1. high production cost
        2. limited polymer diversity

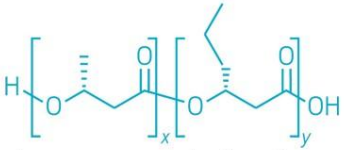


Polyhydroxyalkanoate

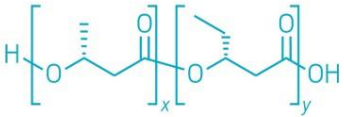
R = alkyl



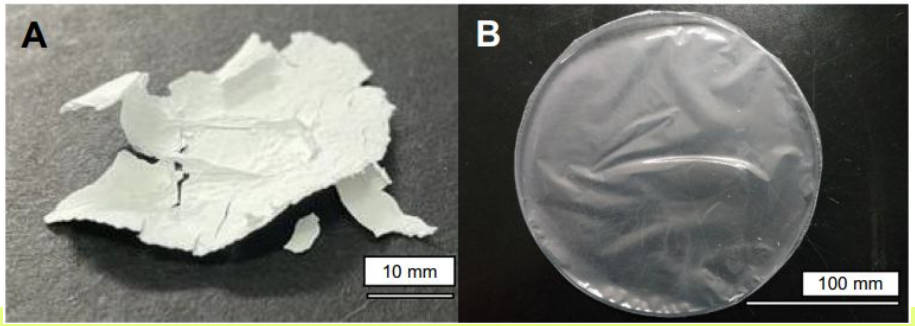
Poly-(*R*)-3-hydroxybutyrate (PHB)



Poly(3-hydroxybutyrate-*co*-3-hydroxyhexanoate) (PHBH)



Poly(3-hydroxybutyrate-*co*-3-hydroxyvalerate) (PHBV)



Substrates

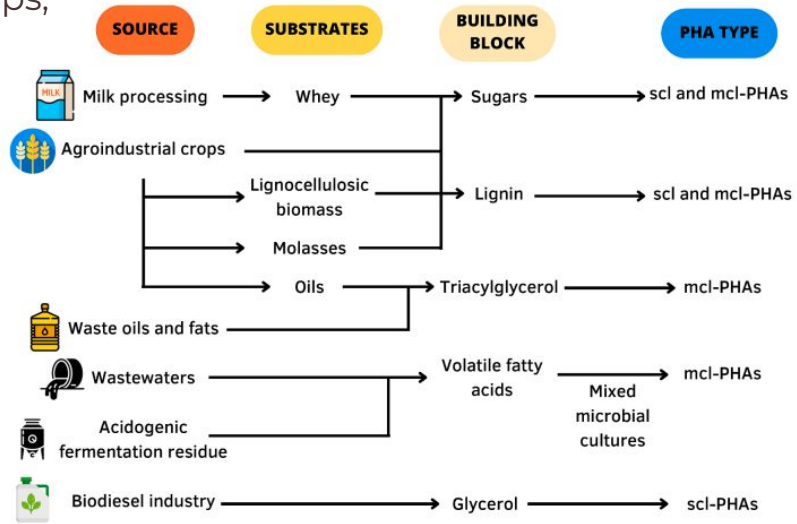
- its choice depends mainly on the organism metabolic routes, substrate cost and availability
- different substrates lead to specific types of PHAs
    - affects polymer properties and its applications

Oils and sugars from agriculture plants: starch-based crops, sugarcane, beetroot,...

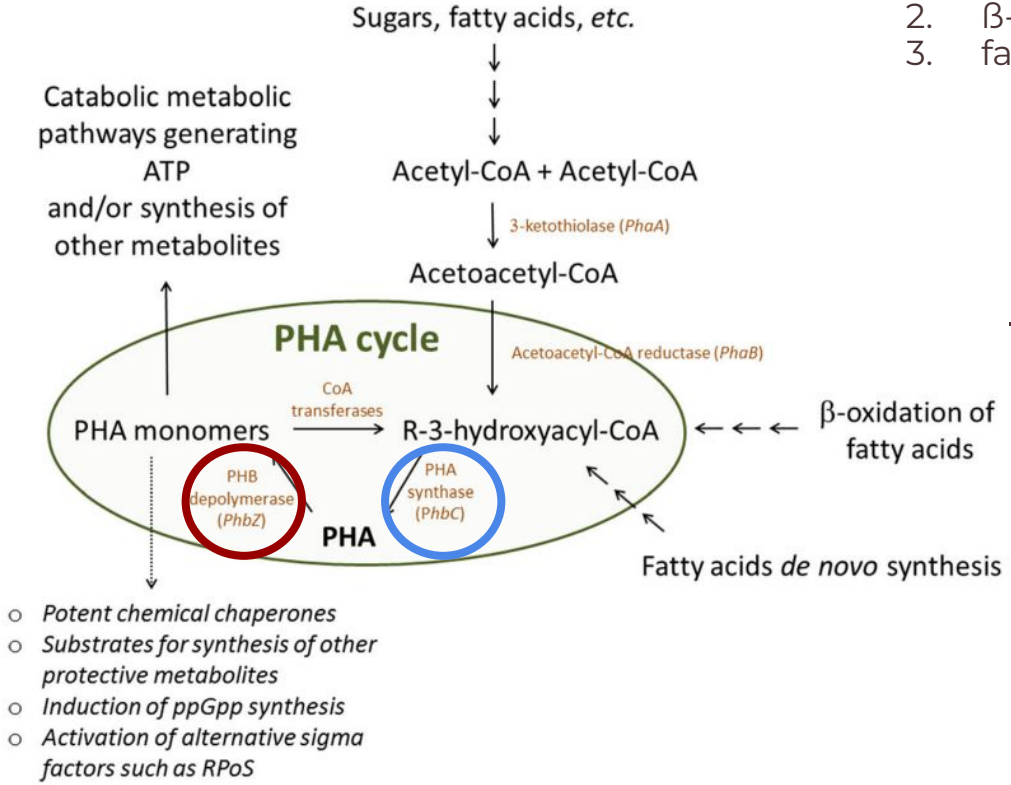
Waste materials like lignocellulosic biomass, waste oils, wastewater, spent coffee grounds,...

- lignocellulosic - very popular in last years, but its pretreatment can be tricky

Inorganic substrates - **CO_2**



Metabolism



Main pathways:

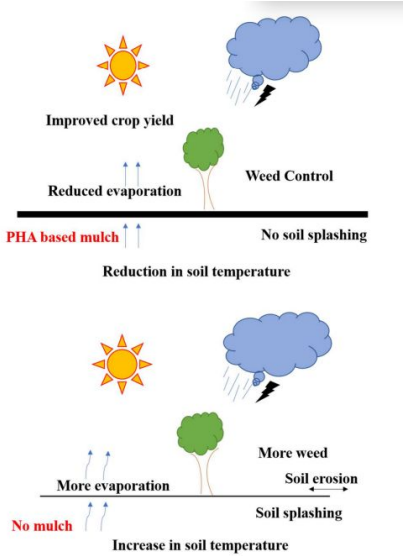
1. 3 reactions catalyzed by PhaA, PhaB and PhaC
2. ß-oxidation of fatty acids
3. fatty acids *de novo* synthesis

Important enzymes:

- PHA synthase (PhaC)
  - connects all pathways
  - polymerization
- PHA depolymerase
  - degradation
  - extracellular and intracellular

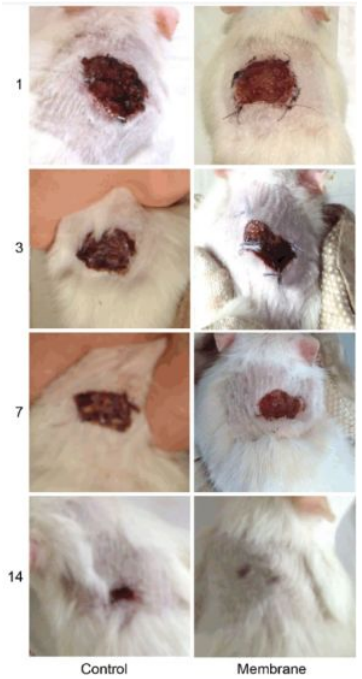
PHAs in Agriculture

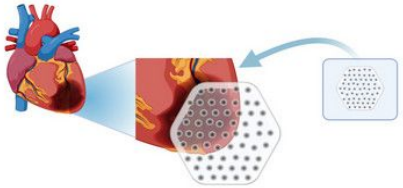
- can be used to make soil friendly compostable greenhouse films
- mulch aids in better soil integrity, pollution control, moisture retention, and weed control

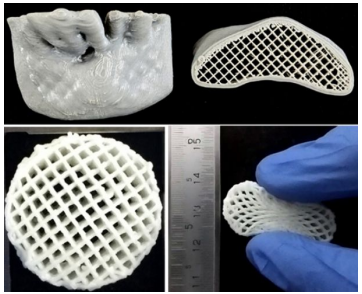


PHAs in Medical Devices

- Implant material
  - biodegradable, biocompatible, nontoxic
  - tissue friendly with blood, bone and human cell lines
- Various therapeutics
  - **cardiovascular patches**
    - providing repair and support to the infarcted tissue post myocardial infarction
  - **wound dressing**
    - can reduce the inflammation, enhance the angiogenic properties of the skin, and facilitate its healing
  - **3D custom-made bone marrow scaffolds**
    - combine 3D printed bone tissue engineering scaffolds with stem cells

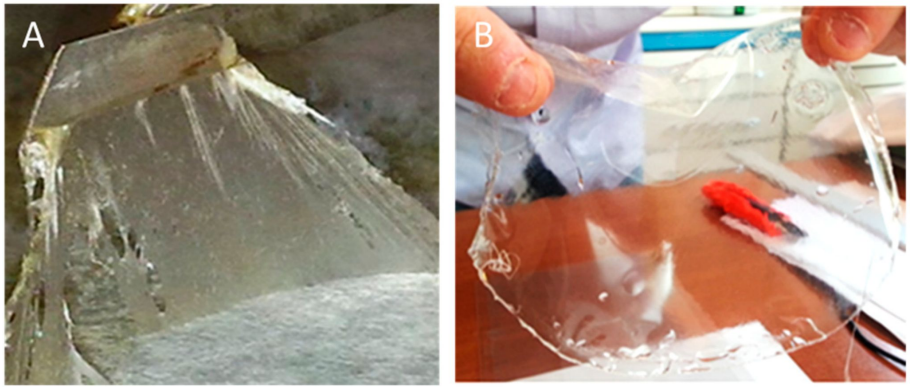






PHA as a Coating Agent

- their distinctive characteristics suggest a potential application as a softener in biopolymeric blends
- water resistant makes them perfect for packaging materials such as milk cartons, sanitary towels, shampoo bottles etc.
- antimicrobial PHA materials containing silver nanoparticles



Thank you for your attention!