Polyhydroxyalkanoates (PHA)

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Introduction

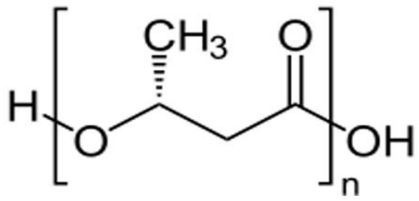
Bacterial Polyesters

- Polyhydroxyalkanoate (PHA)
- Polyhydroxybutyrate (PHB)
- Poly(hydroxy- butyrate-hydroxyvalerate) (PHB/HV)
- Poly(ε-caprolactone) (PCL)

Polyhydroxyalkanoates (PHAs) are a family of biopolyesters

Synthesized as intracellular products by

- Prokaryotic genera
- Eubacteria
- Cyanobacteria

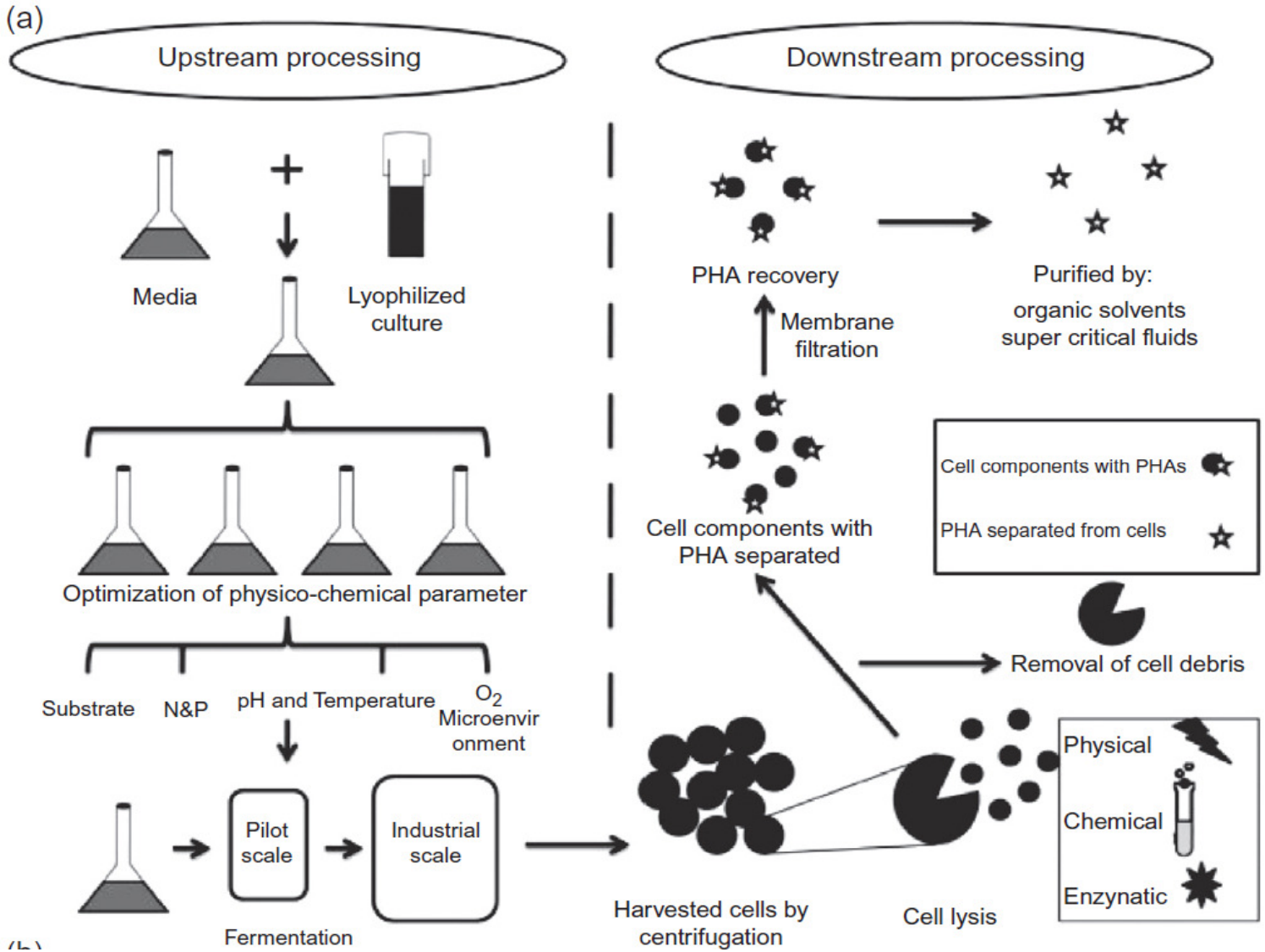


Synthesis of PHA

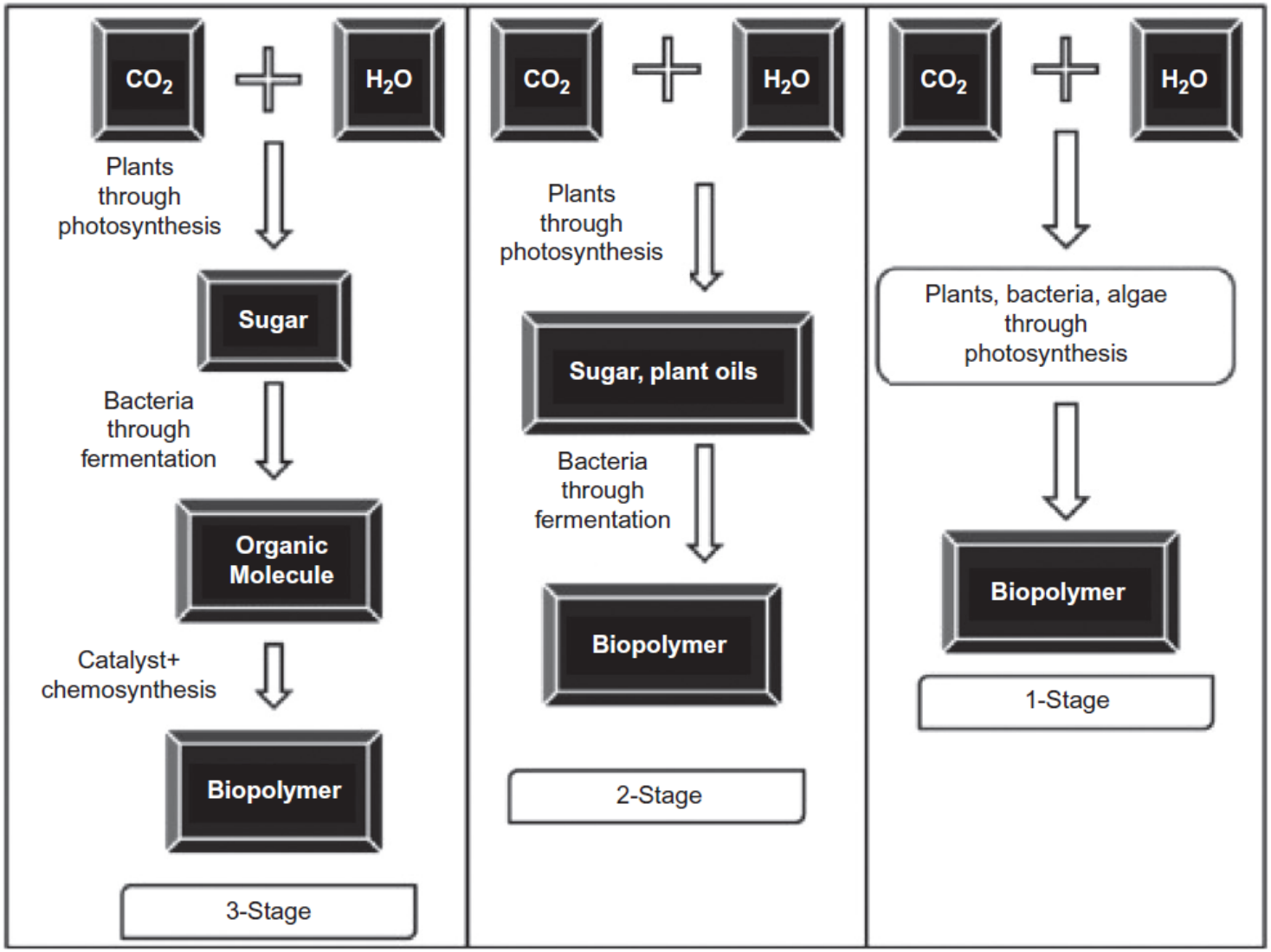
- The first step of the bacterial fermentation process is inoculation
- The bacteria required for the subsequent metabolization process multiply and grow in an aqueous medium enriched with a balanced nutrition supply and air under optimum physical conditions

- PHA synthesis
- The PHAs are usually stored in intracellular inclusion bodies

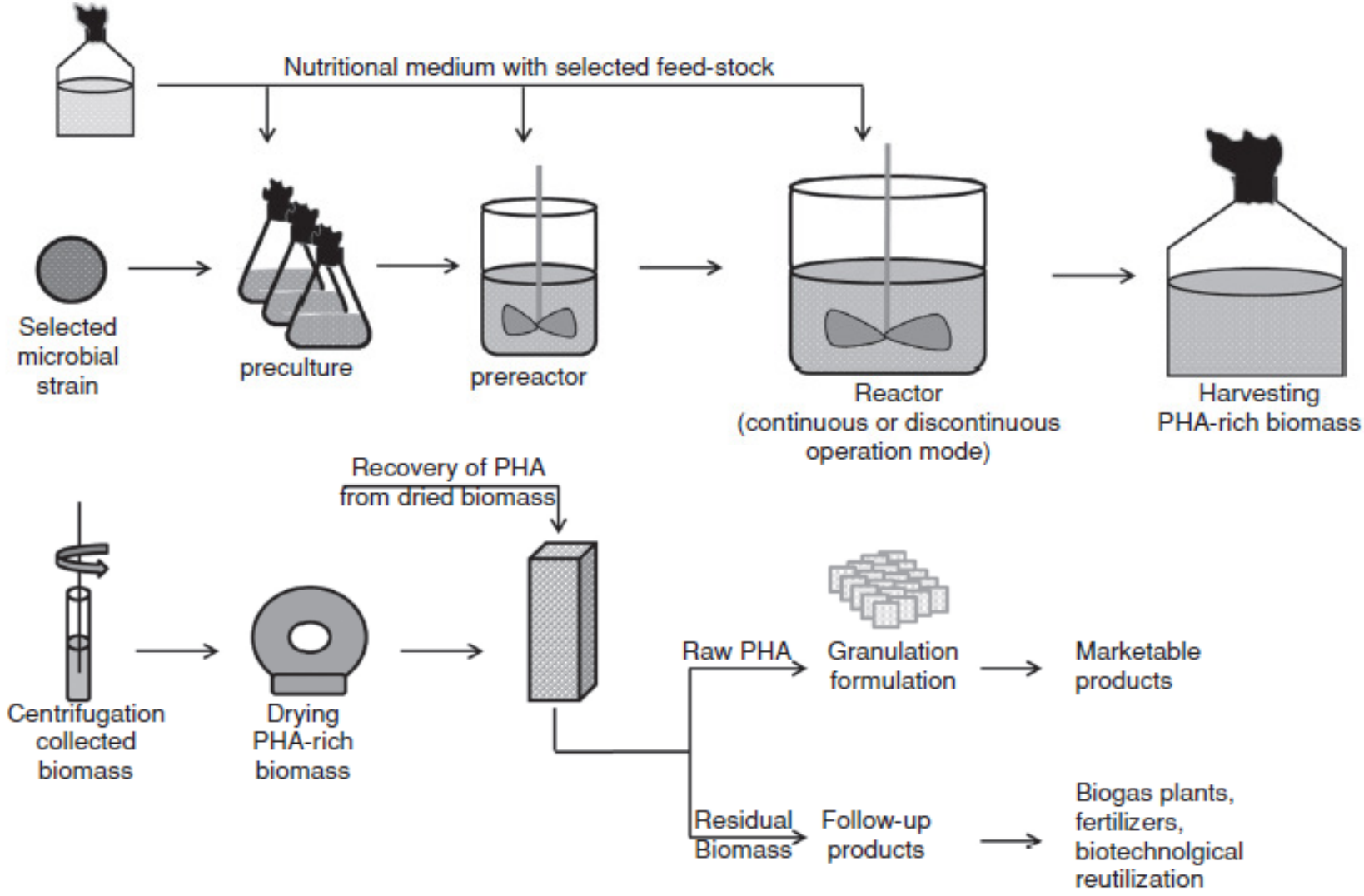
Synthesis of PHA



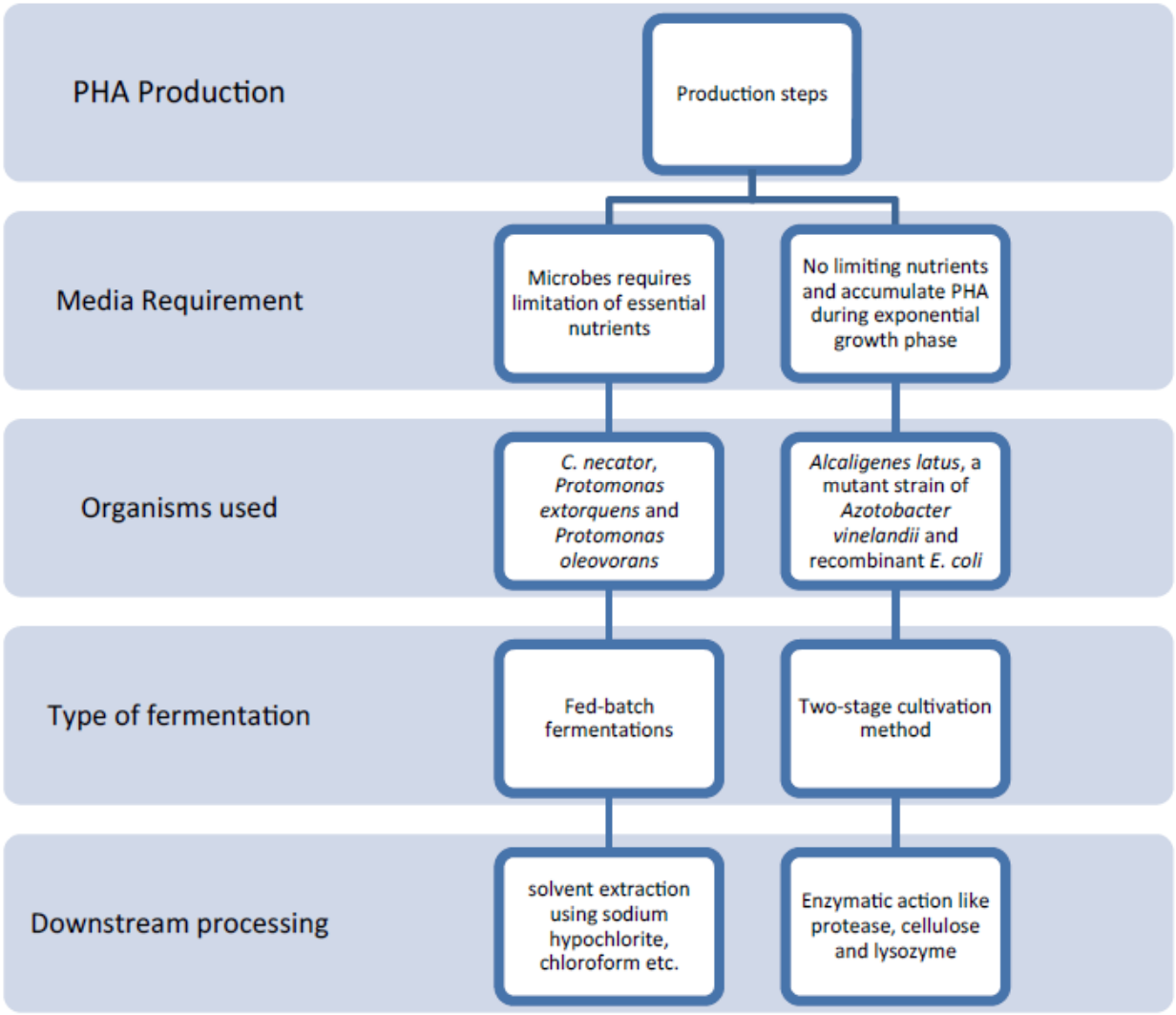
Synthesis of PHA…



PRODUCTION


Nutritional medium with selected feed-stock
Selected microbial strain
preculture
prereactor
Reactor (continuous or discontinuous operation mode)
Harvesting PHA-rich biomass
Recovery of PHA from dried biomass
Centrifugation collected biomass
Drying PHA-rich biomass
Raw PHA
Granulation formulation
Marketable products
Residual Biomass
Follow-up products
Biogas plants, fertilizers, biotechnolgical reutilization

PRODUCTION…


PHA Production
Production steps
Media Requirement
Microbes requires limitation of essential nutrients
No limiting nutrients and accumulate PHA during exponential growth phase
Organisms used
C. necator, Protomonas extorquens and Protomonas oleovorans
Alcaligenes latus, a mutant strain of Azotobacter vinelandii and recombinant E. coli
Type of fermentation
Fed-batch fermentations
Two-stage cultivation method
Downstream processing
solvent extraction using sodium hypochlorite, chloroform etc.
Enzymatic action like protease, cellulose and lysozyme

GENERAL CHARACTERISTICS

- Water insoluble and relatively resistant to hydrolytic degradation
- Good ultraviolet resistance but poor resistance to acids and bases
- Soluble in chloroform and other chlorinated hydrocarbons
- Biocompatible and hence suitable for medical applications
- Sinks in water, facilitating its anaerobic biodegradation
- Nontoxic
- Less sticky than traditional polymers when melted

PROPERTIES

Property (units)	Values
Glass transition temperature, T_g (°C)	2
Melting temperature, T_m (°C)	160–175
Degree of crystallinity, X_{cr} (%)	40–60
Young's modulus, E (GPa)	1–2
Tensile strength, σ (MPa)	15–40
Elongation at break, $\mathcal{E}$ (%)	1–15
Water vapor transmission rate, WVTR (g mm/m^2 day)	2.36
Oxygen transmission rate, OTR (cc mm/m^2 day)	55.12

APPLICATIONS