Acetone-Butanol fermentation

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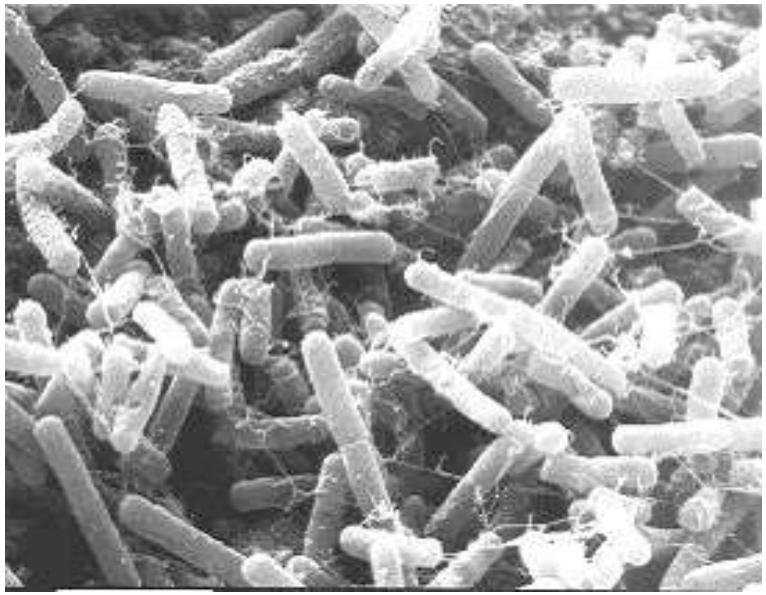
- 1862 Pasteur discovered butanol fermentation in bacteria.
- 1911 Fernbach described several species of bacteria which conduct acetone-butanol-fermentation.

- 1916 acetone-butanol fermentation was developed by **Chaim Weizmann** using *Clostridium acetobutylicum*.

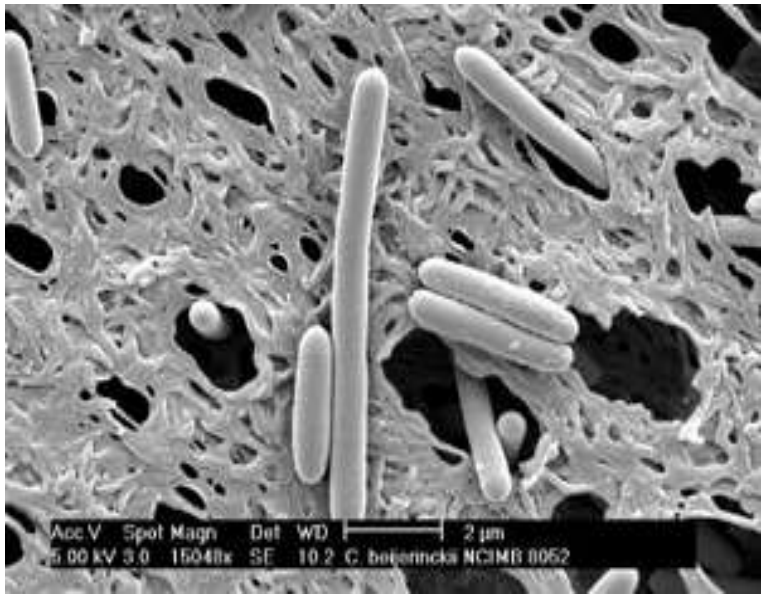
- **Acetone: production of explosives &**
- **Butanol: making synthetic rubbers.**

- In acetone-butanol fermentation, acetone and butanol are produced from glucose using strains of *Clostridia*, which are strictly anaerobic bacteria. Further, ethanol is also produced.
- The ABE fermentation produces solvents in a ratio of **3** parts acetone, **6** parts butanol to **1** part ethanol.
- *Clostridium acetobutylicum* is the most well-studied and widely used species, although *Clostridium beijerinckii* has also been used with good results.

- Used for commercial fermentation in Europe and America until the 1970s, currently only in China.
- An obligately anaerobic, Gram-positive and endospore- forming rod.
- Not pathogenic or toxigenic to humans, animals, or plants.

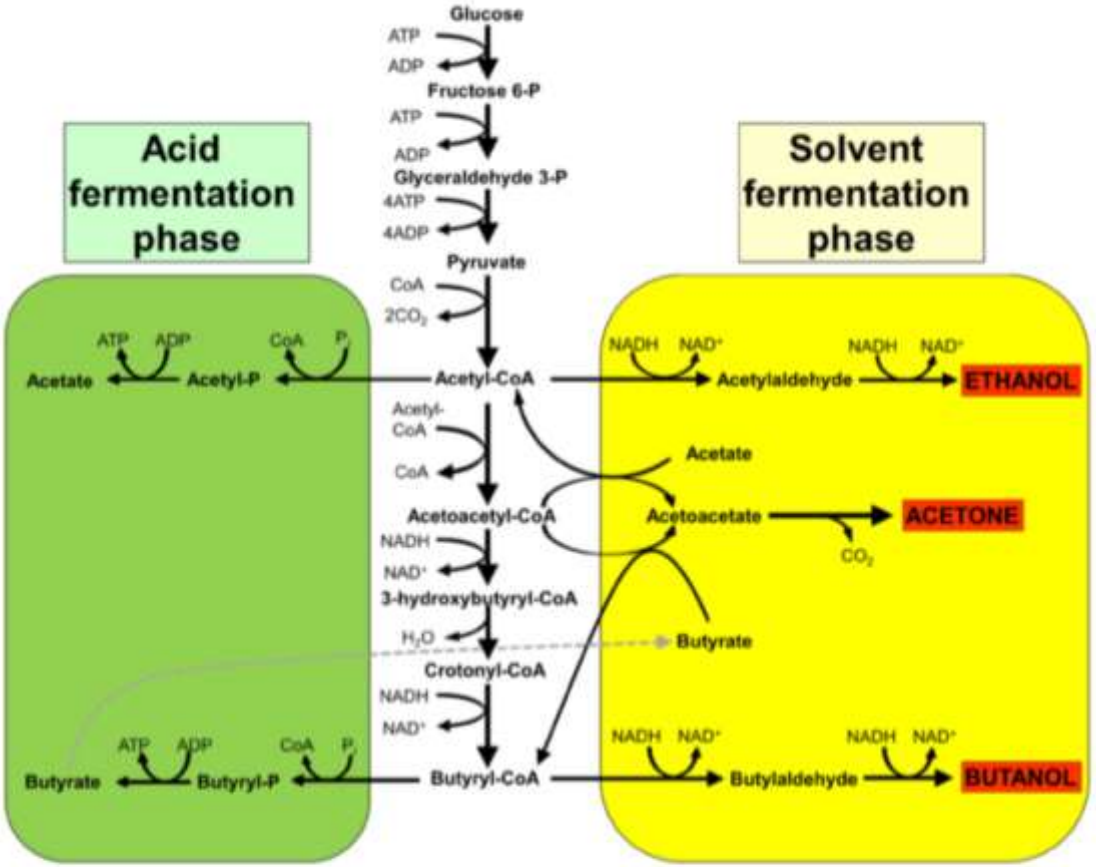


Clostridium acetobutylicum



Clostridium beijerinckii

- Metabolic pathways of A.B.E. fermentation comprise two characteristic phases: **Acidogenesis** and **Solventogenenis** .



This figure shows pathway of acetone–butanol–ethanol fermentation by clostridia.

Table 13.1 *Acetone/butanol/ethanol fermentation of corn cobs, corn stalk and wood* [Walton and Martin (1979)].

Culture	*Substrate(s)*	*Time* (h)	*Yield* (%)	*Solvent Composition (%)* *Butanol*	*Acetone*	*Ethanol*
Clostridium acetobutylicum S_{25}	Hydrolyzate of corncobs (7%)		26·2			
	Hydrolyzate of sawdust (7%)		22·2			
C. acetobutylicum 314	Hydrolyzate of corn cobs (40–60%, 3·7% total), molasses (40–60% sugar)	48–72	40	67·5		
Butyl culture	1 part hydrolyzate of corn stalks, 3 parts molasses	50–55	31–37			
	Pentoses (13·5%)		25·4	67	33	
	Hydrolyzates of wood and plants (8%)		35·5	62	32	6

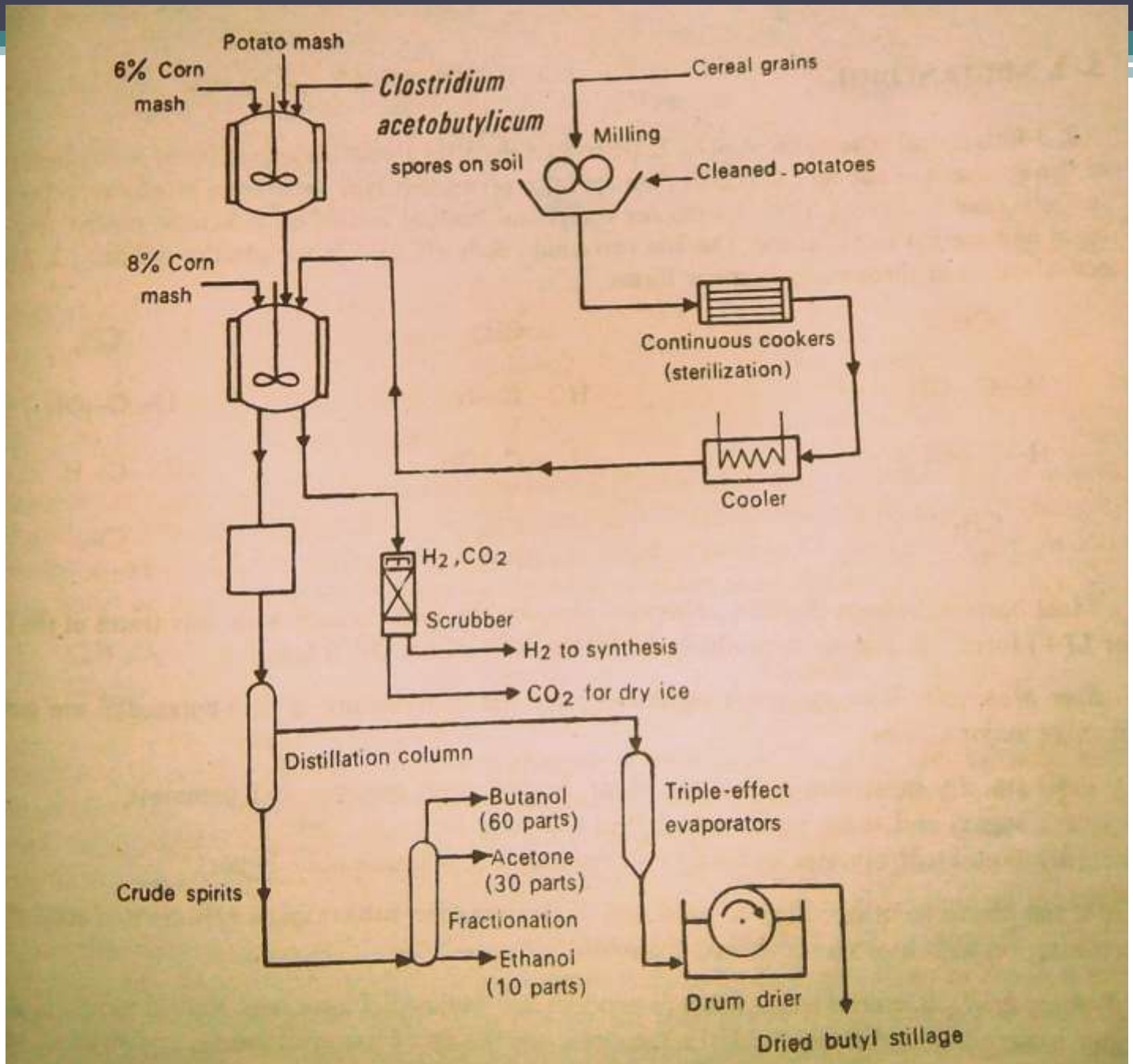


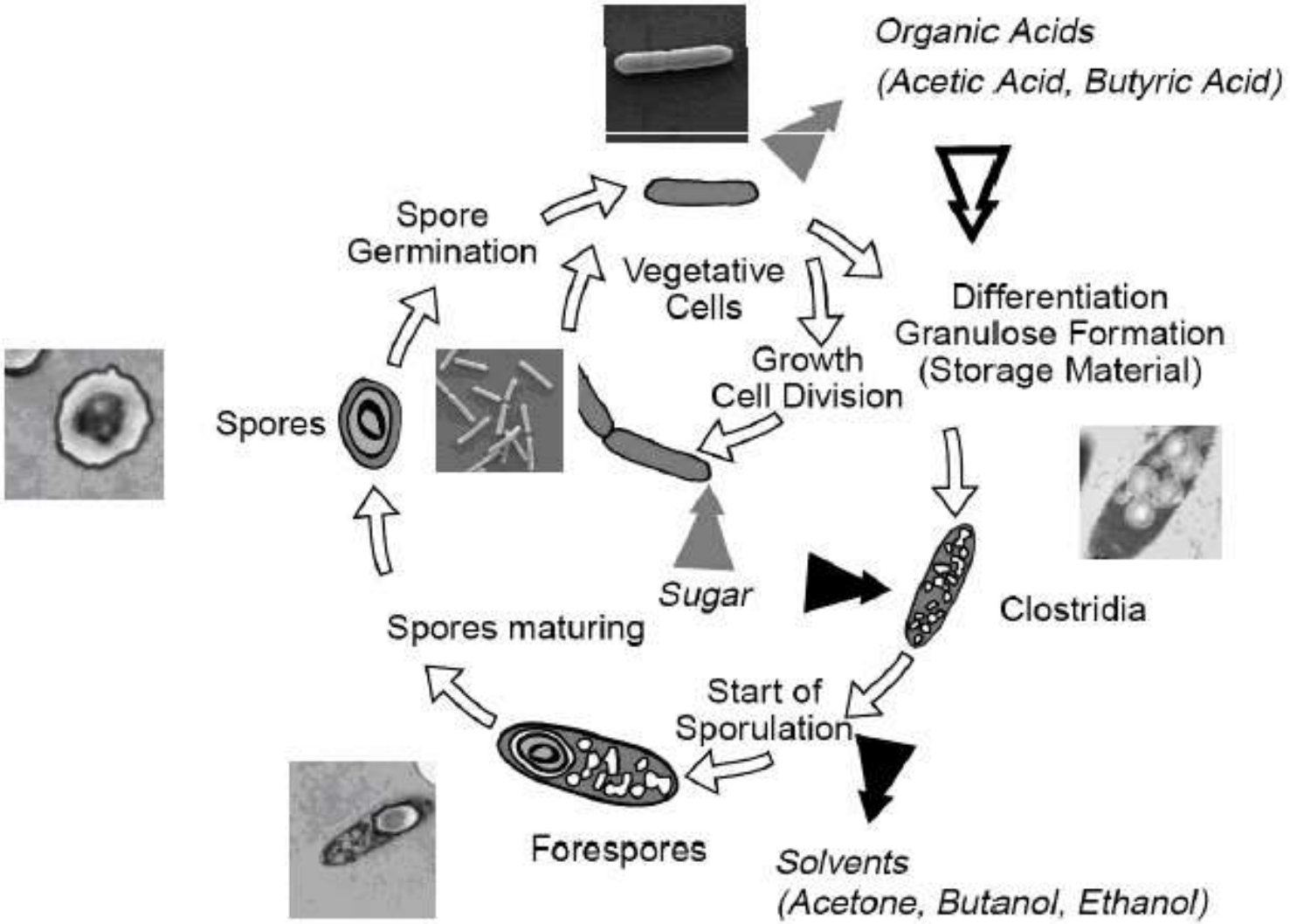
Fig. 13.4. Flow diagram of a typical acetone-butanol fermentation using starch products (Beesch, 1953).

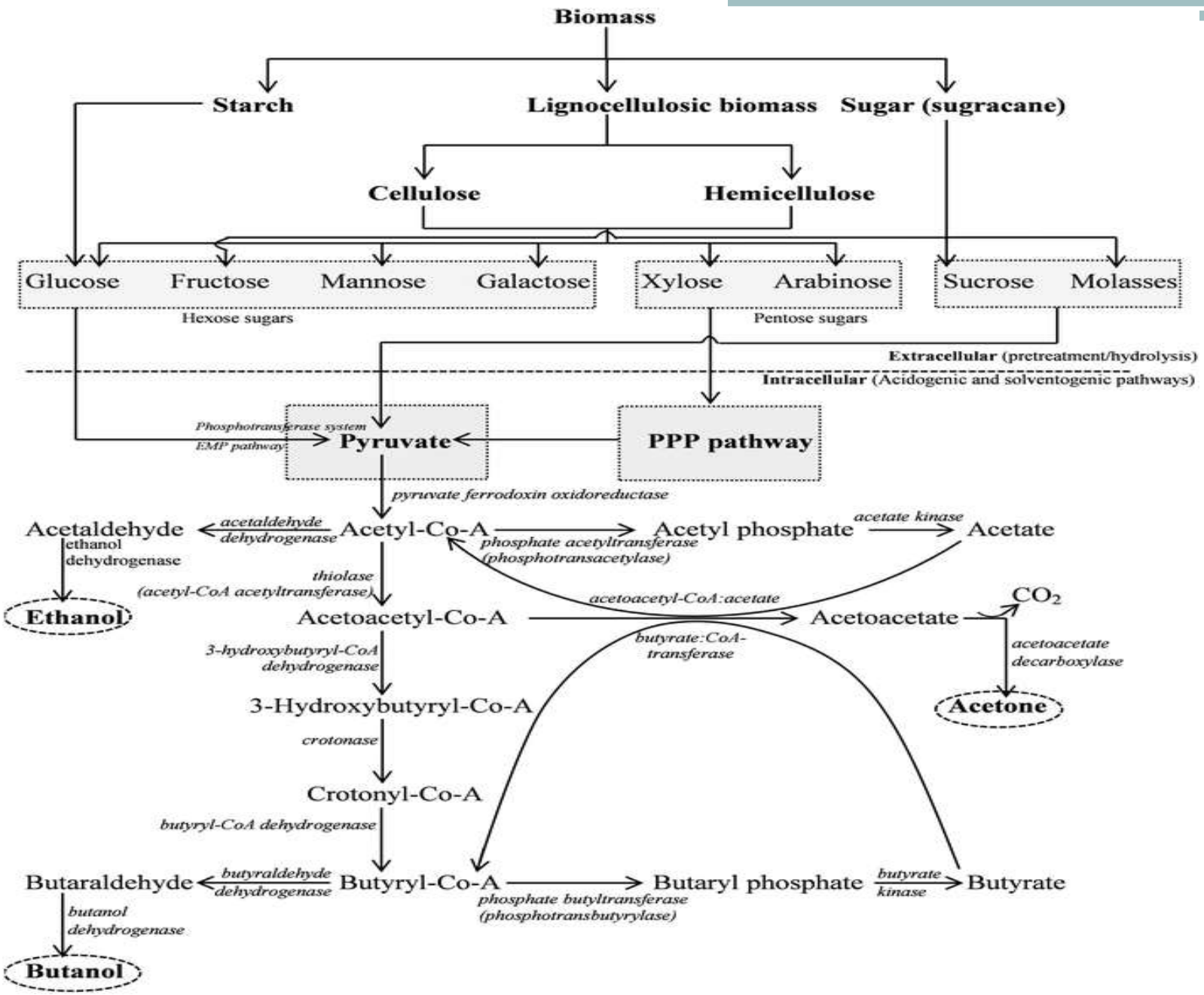
Organism:

1. ***Clostridium acetobutylicum*** – 1st organism – industrial production of acetone from starch.
2. ***Clostridium saccharoacetobutylicum*** – convert molasses into acetone & butanol.

- submerged cultures
- **Substrate**: sterile diluted molasses or cooked corn meal.
- **pH** : 7.2
- **Type of fermentation**: anaerobic
- **By-products** : CO_2(preparation of dry ice) & H (fuel)
- **Product recovery** : fractional distillation

- Large bioreactors – 200000-1000000 Lr
- CO_2 was bubbled through the culture to ensure that O_2 was excluded.
- Fermentation – biphasic → **Acidogenesis**
  → **Solventogenenis**
- Acidogenesis – forming acetate , butyrate , hydrogen , and CO_2.
- Solventogenesis – forming butanol, acetone , and ethanol.
- After 40-60 hrs – 12-20gm/L of solvent(6B:3A:E1).
- The solvents was removed by distillation.
- The remaining microbial dried solids were used as high nutrient animal feed.


Organic Acids
(Acetic Acid, Butyric Acid)
Spore
Germination
Vegetative
Cells
Differentiation
Granulose Formation
(Storage Material)
Growth
Cell Division
Spores
Sugar
Clostridia
Spores maturing
Start of
Sporulation
Forespores
Solvents
(Acetone, Butanol, Ethanol)


Biomass
Starch
Lignocellulosic biomass
Sugar (sugracane)
Cellulose
Hemicellulose
Glucose
Fructose
Mannose
Galactose
Xylose
Arabinose
Sucrose
Molasses
Hexose sugars
Pentose sugars
Extracellular (pretreatment/hydrolysis)
Intracellular (Acidogenic and solventogenic pathways)
Phosphotransferase system
EMP pathway
Pyruvate
PPP pathway
pyruvate ferrodoxin oxidoreductase
Acetaldehyde
acetaldehyde dehydrogenase
Acetyl-Co-A
Acetyl phosphate
acetate kinase
Acetate
ethanol dehydrogenase
phosphate acetyltransferase (phosphotransacetylase)
thiolase (acetyl-CoA acetyltransferase)
acetoacetyl-CoA:acetate
CO2
Ethanol
Acetoacetyl-Co-A
Acetoacetate
butyrate:CoA-transferase
3-hydroxybutyryl-CoA dehydrogenase
acetoacetate decarboxylase
3-Hydroxybutyryl-Co-A
Acetone
crotonase
Crotonyl-Co-A
butyryl-CoA dehydrogenase
Butaraldehyde
butyraldehyde dehydrogenase
Butyryl-Co-A
Butaryl phosphate
butyrate kinase
Butyrate
phosphate butyltransferase (phosphotransbutyrylase)
butanol dehydrogenase
Butanol

uses:

- **Butanol** is a valuable solvent for the production of lacquer(used to prepare the finish of automobiles),latex,enamels….
- Used as biofuel(it has similar physical properties to gasoline).
- Used as an additive to plastics to keep them flexible.
- Used as a solvent in the manufacture of antibiotics , vitamins , and hormones.
- **Acetone** is important in making cordite.


Thank
you