SHRIMATI INDIRA GANDHI COLLEGE
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TIRUCHIRAPPALLI-02

DEPARTMENT OF MICROBIOLOGY

Course : M.Sc., Microbiology

Subject : Microbial Physiology

Topic : Fermentation

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SYNOPSIS

- INTRODUCTION
- TYPES OF FERMENTATION
  - Carbohydrate fermentation

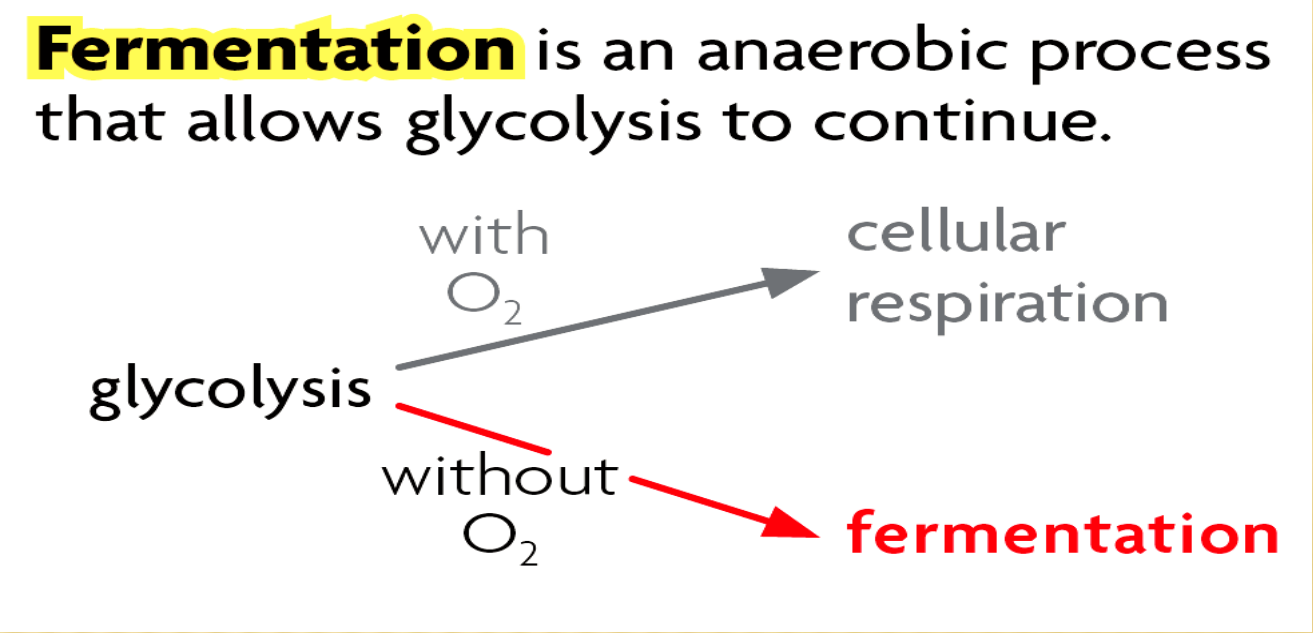
1. Alcohol or ethanol fermentation
2. Lactic acid fermentation
3. Mixed acid fermentation
4. Propionic acid fermentation
5. Butane-diol fermentation
6. Butyric acid fermentation

  - Aminoacid fermentation / Stickland reaction

- CONCLUSION

INTRODUCTION

- Fermentation is an anaerobic energy yielding process that involves a sequence of oxidation-reduction reaction



- ATP generation in fermentation is lower than oxidation
- Louis Pasteur stated that "Fermentation is life without air"
- More substrates are utilized than in respiration
- Based on the substrates and product yielded, fermentation are classified as ethanol, lactic acid, propionic acid, mixed acid, butyric acid and butanediol fermentation

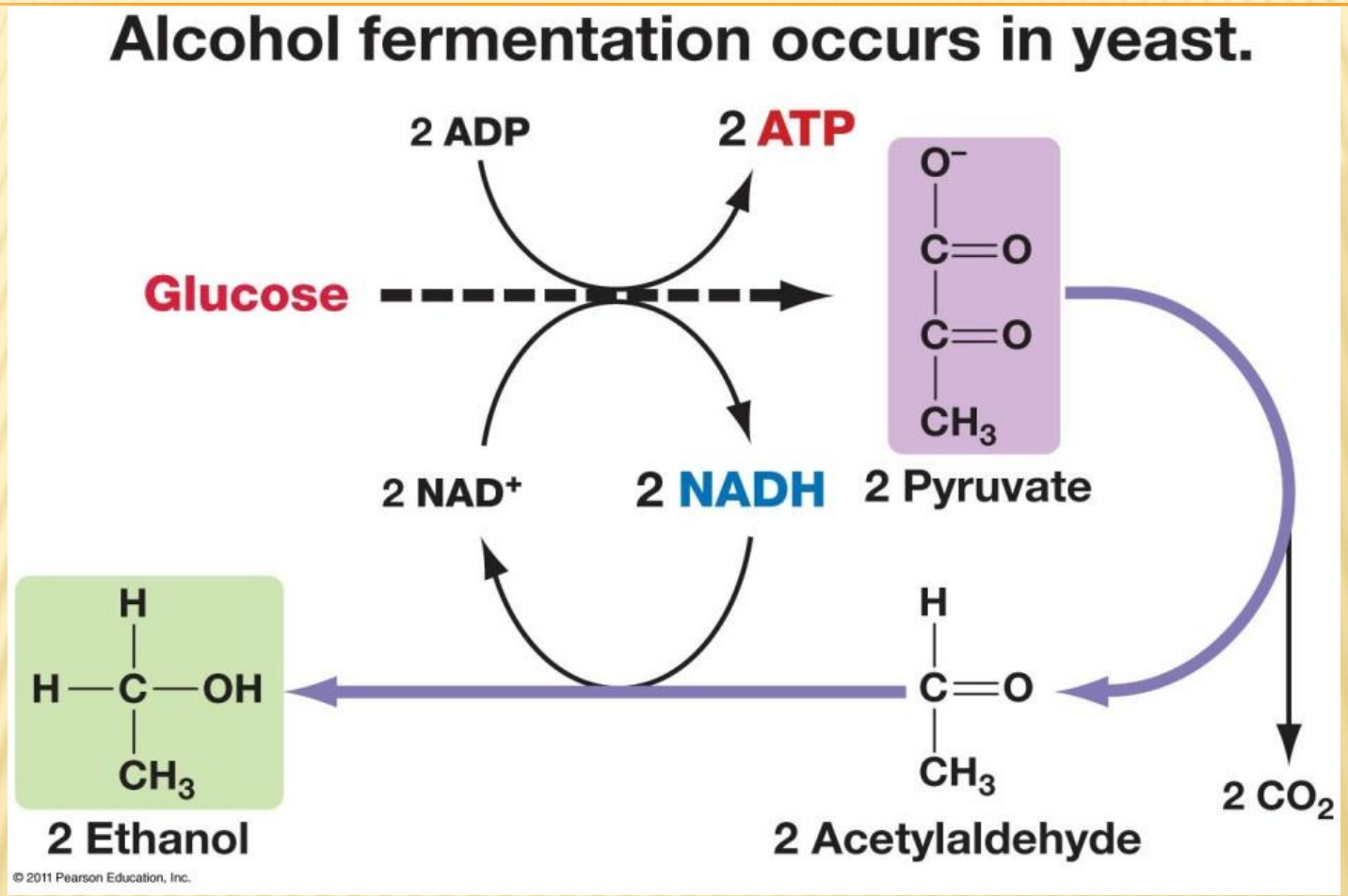
1. Alcohol Fermentation

- Fermentation that results in alcohol production is called ethanol or alcohol fermentation

Glucose + 2ADP + Pi ⟶ 2 ethanol + $2CO_2$ + 2 ATP

- Industrial production of alcoholic beverages like beer, wine etc., are based on alcoholic fermentation

- Eg: ***Saccharomyces cereviseae*** (commonly known as yeast) and ***Zymomonas mobilis*** are actively involved in alcohol fermentation


Alcohol fermentation occurs in yeast.
2 ADP
2 ATP
Glucose
2 NAD+
2 NADH
2 Pyruvate
2 Ethanol
2 Acetylaldehyde
2 CO2
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Industrial applications of alcohol fermentation

Industrial production of Beer using *Brewers yeast*

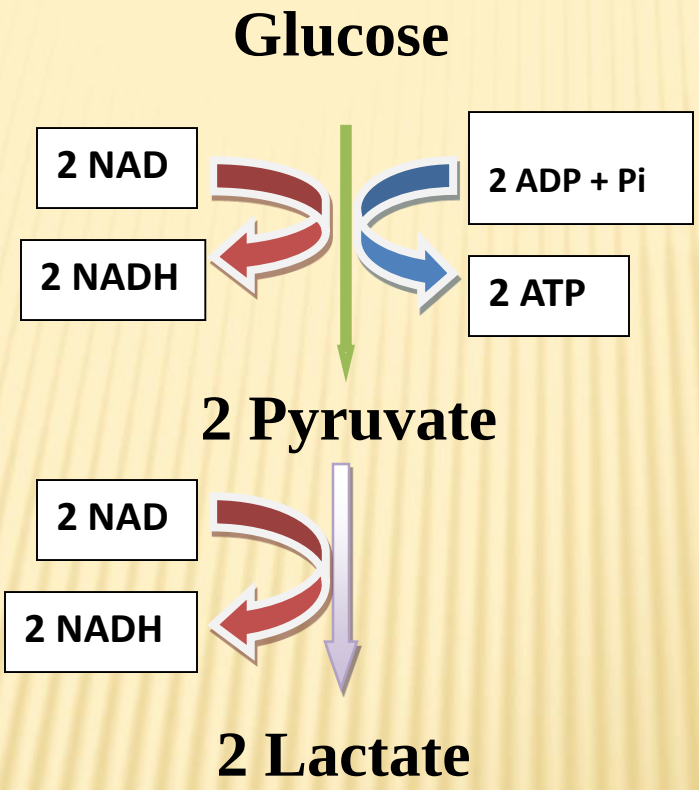
Leavening of bread dough using *Bakers yeast*

2. Lactic acid Fermentation

- Reduction of pyruvate to lactic acid is called lactic acid fermentation
- Two types of lactic acid fermentation are, Homolactic and heterolactic acid fermentation
- Homolactic acid fermentation – End product is only lactate

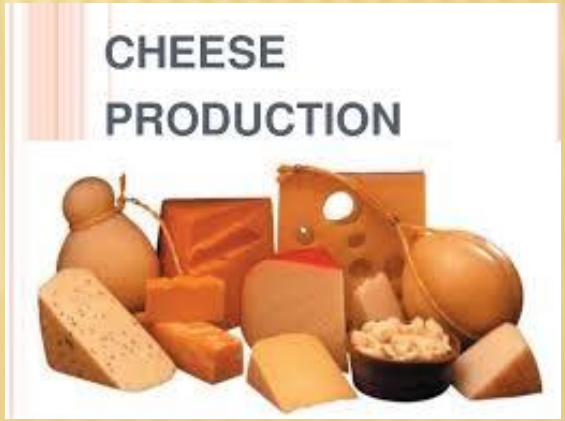
Eg: *Streptococcus, Lactococcus, Lactobacillus, Enterococcus, Pediococcus*

Homolactic acid fermentation



Industrial applications of Lactic acid fermentation

- Homolactic acid fermentation is necessary for industrial purposes
- Food and Dairy industry – preparation of sour milk, production of cheese, yoghurt, paneer, etc.,



- Heterolactic acid fermentation – End product is lactate along with substatial amount of other acid end products

- Produce ethanol and CO_2

- Enterobacteriaceae members are example for heterolactic fermenters

Glucose + ADP + Pi ⟹ Lactic acid + ethanol + CO_2 + ATP

3. Propionic acid Fermentation

- Carried out by *Propionibacterium*
- Uses carbohydrates and lactate to produce Propinic acid
- Industrial Importance – manufacture of perfumes, herbicides, fruit flavors, food and feed preservatives
- Eg: *Propionibacterium freudenreichii, Veilonella sp.*

Reactions of Propionic acid Fermentation

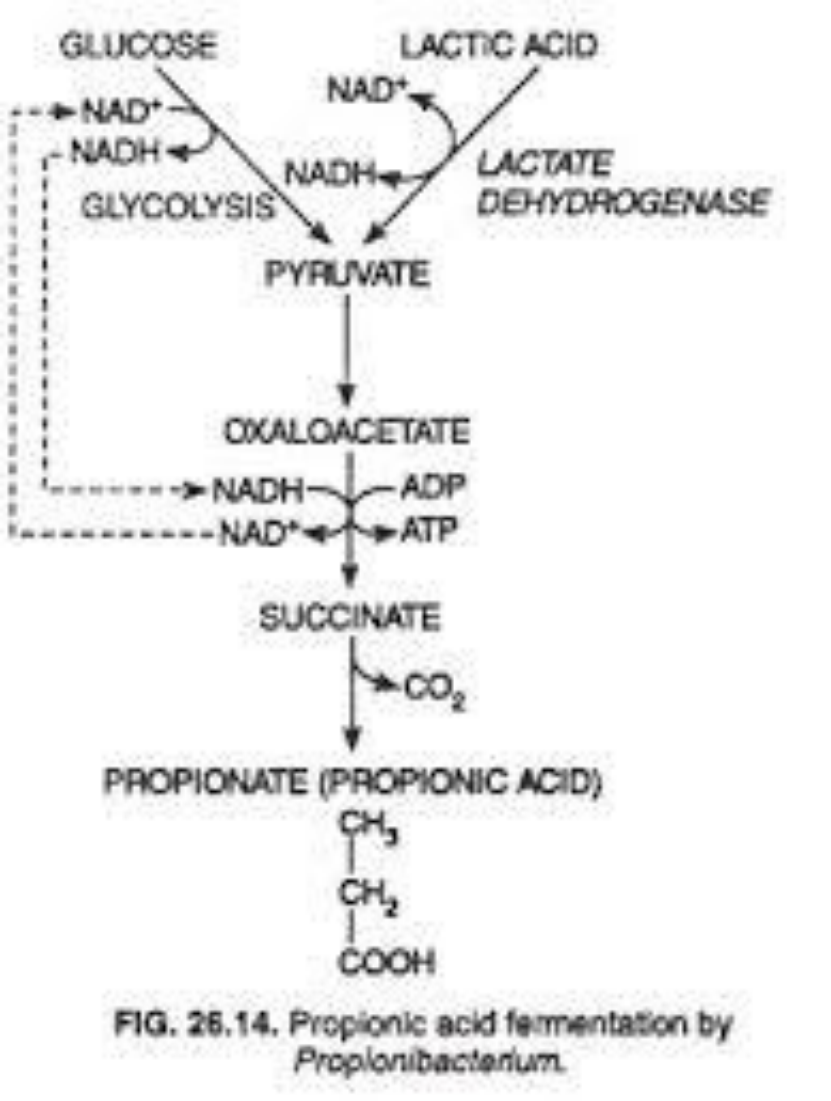


FIG. 26.14. Propionic acid fermentation by *Propionibacterium*.

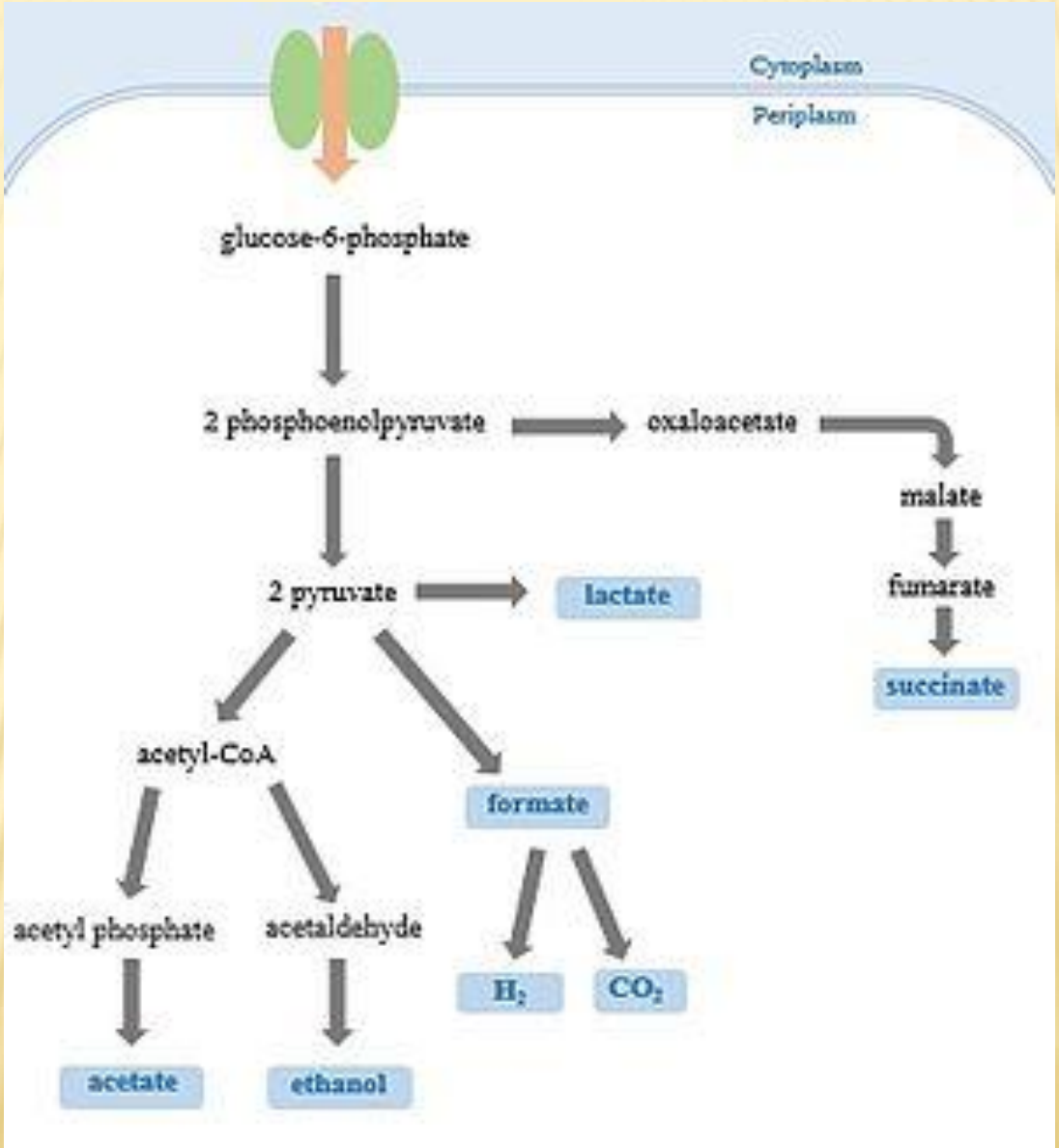
4. Mixed acid Fermentation

- **Mixed acid fermentation** is the biological process by which a six-carbon sugar e.g. glucose is converted into a complex and variable mixture of acids.

- It is characteristic for members of theEnterobacteriaceae, a large family of Gram-negative bacteria that includes *E. coli*.

- The mixture of end products produced by mixed acid fermentation are lactate, acetate, succinate, formate, ethanol and the gases H_2 and CO_2.

Reactions of Mixed acid Fermentation



- The end products of mixed acid fermentation can have many useful applications in biotechnologyand industry. For instance, ethanol is widely used as a biofuel

- It is detected in laboratory by MR test or Methyl Red test

- Eg: *E.coli, Proteus, Salmonella* and other gas-producing bacterial species.

5. Butyric acid Fermentation

- Also known as Butanol fermentation.
- Butyrate is the final end product
- Carried out by obligate anaerobic bacteria
- Eg: *Clostridium butyricum, Clostridium pasteurianum,*
  Fusobacterium nucleatum

Butyric acid Fermentation

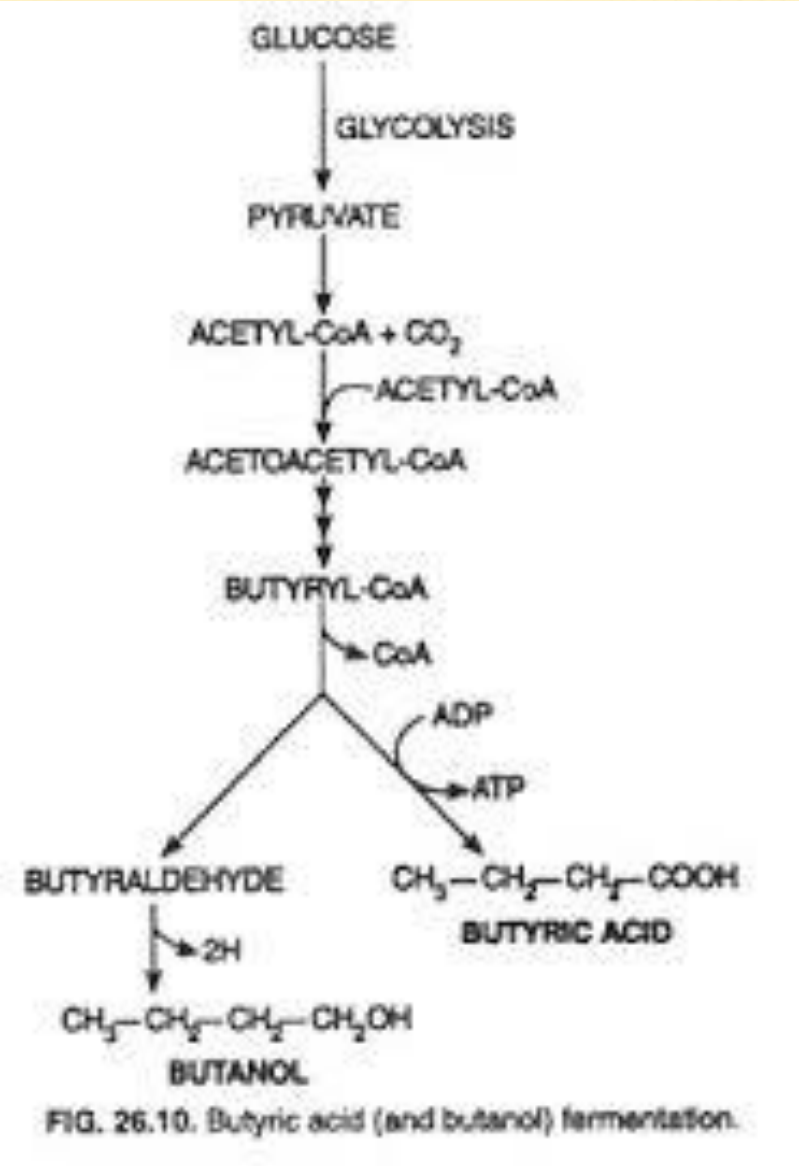
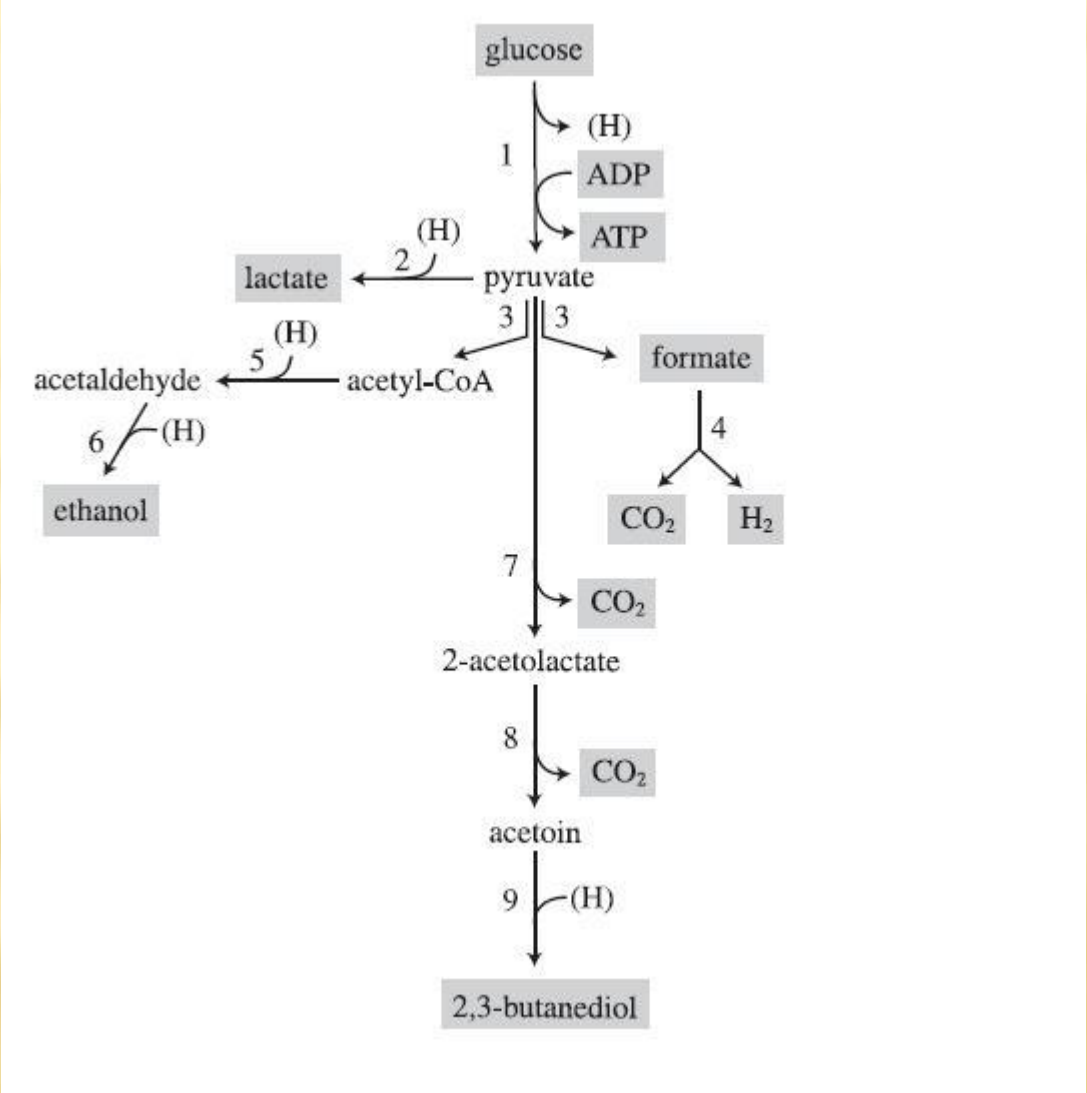


FIG. 26.10. Butyric acid (and butanol) fermentation.

6. Butane diol Fermentation

- Butanediol is a natural end product of cabohydrate fermentation
- Acetoin / Acetyl methyl carbinol is an intermediate product which is detected by Voges-Proskauer (VP) test
- Characteristic feature of *Enterobacter, Serratia, Erwinia* and *Klebsiella* sp.

Butane diol Fermentation



Aminoacid Fermentation / Stickland Reaction

- Most of the organisms carryout carbohydrate fermentation
- Some members of the genus *Clostridium carryout aminoacid fermentation*
- *Eg: Clostridium sporogenes &*

  Clostridium botulinum

Stickland Reaction Cont...

- In this reaction one aminoacid is oxidized and the second aminoacid acts as electron acceptor

- It is utilized to oxidize aminoacids such as alanine, leucine, isoleucine, valine, phenylalanine, tryptophan and histidine

Stickland Reaction Cont...

Alanine

↓

Pyruvate

↓

Acetyl CoA

↓

Acetyl phosphate

↓

Acetate

Probable Questions

2 Marks

1. Fermentation
2. Yeast
3. Stickland reaction

5 Marks

1. Alcohol fermentation
2. Butyric acid fermentation
3. Butanediol fermantation

10 Marks

1. Lactic acid fermentation

Thank You