THE UNIVERSITY OF MELBOURNE

FOOD20006

Food Microbiology & Safety

Helen Billman-Jacobe

Microbial metabolism

Fermentation

Ray and Bhunia Ed 5 Ch8

Intended learning outcomes

Explain how monosaccharides are fermented by microorganisms via different pathways and product different end products

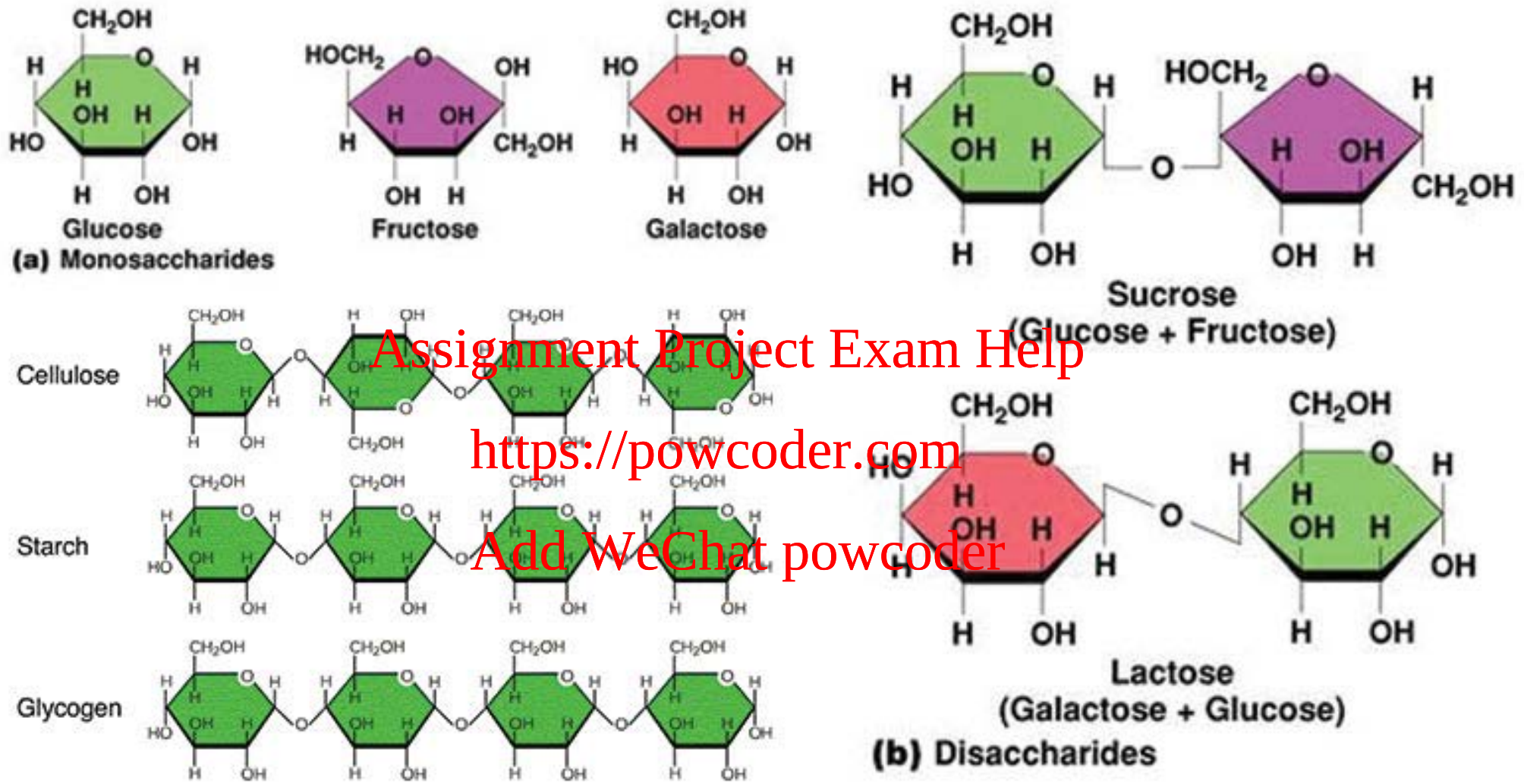
Explain that some metabolic end products are desirable and others are considered undesirable and are considered as spoilage

Explain the difference between homolactic and heterolactic fermentation

Explain the process of alcoholic fermentation

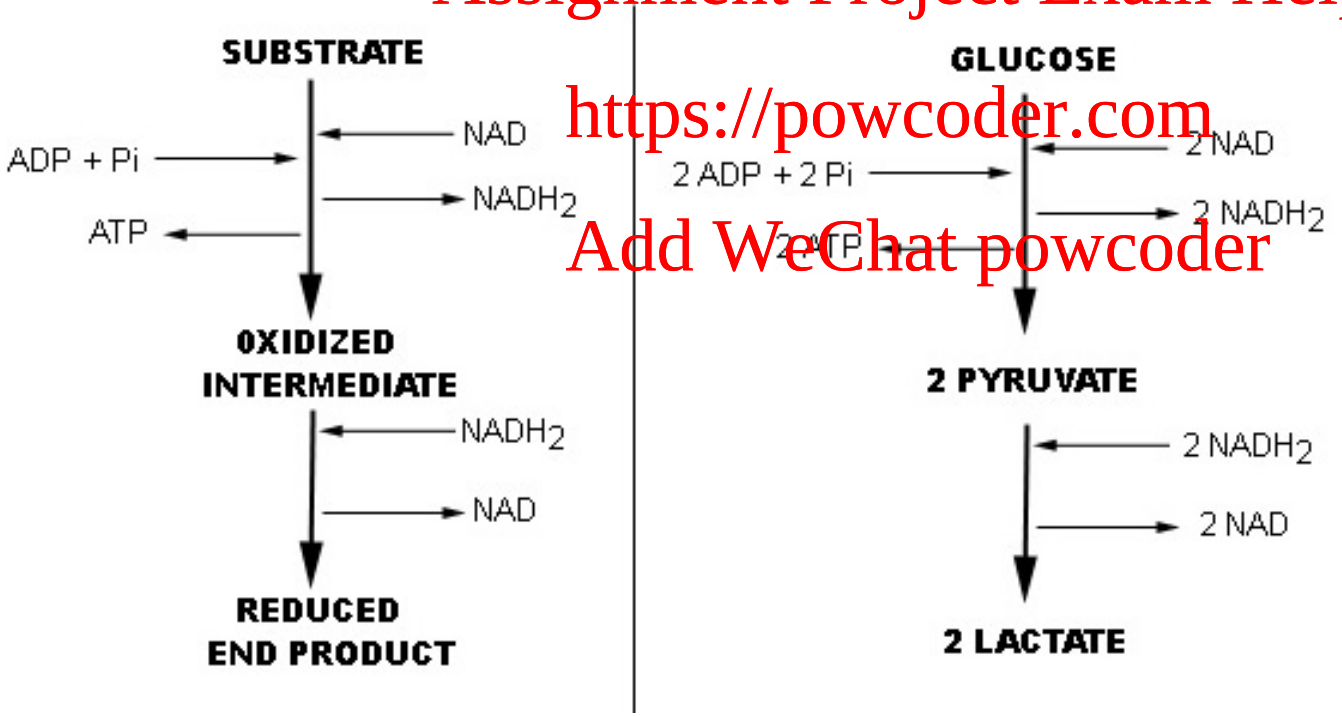
End products of carbohydrate metabolism

microorganism	fermentation	endproducts
Yeasts	Alcohol	Ethanol, carbon dioxide
Lactic acid bacteria (LAB)	Homo fermentative	lactate
Lactic acid bacteria (LAB)	Hetero fermentative	Lactate, acetate, ethanol, carbon dioxide, diacetyl, acetoin
Propionibacteria	Propionic acid	Propionic acid, acetate, CO_2
Enterobacteriaceae	Mixed acid	Lactate, acetate, formate, succinate, CO_2, H_2
Bacillus, Pseudomonas	Butandiol	Lactate, acetate, formate,2,3 butanediol, CO_2, H_2
Clostridium	Butyric acid	Butyrate, acetate, CO_2, H_2, butanol, ethanol, acetone, isopropanol



Fermentation

Fermentation is metabolism in which energy is derived from the partial oxidation of an organic compound using organic intermediates as electron donors and electron acceptors.
No outside electron acceptors are involved; no membrane or electron transport



Todar

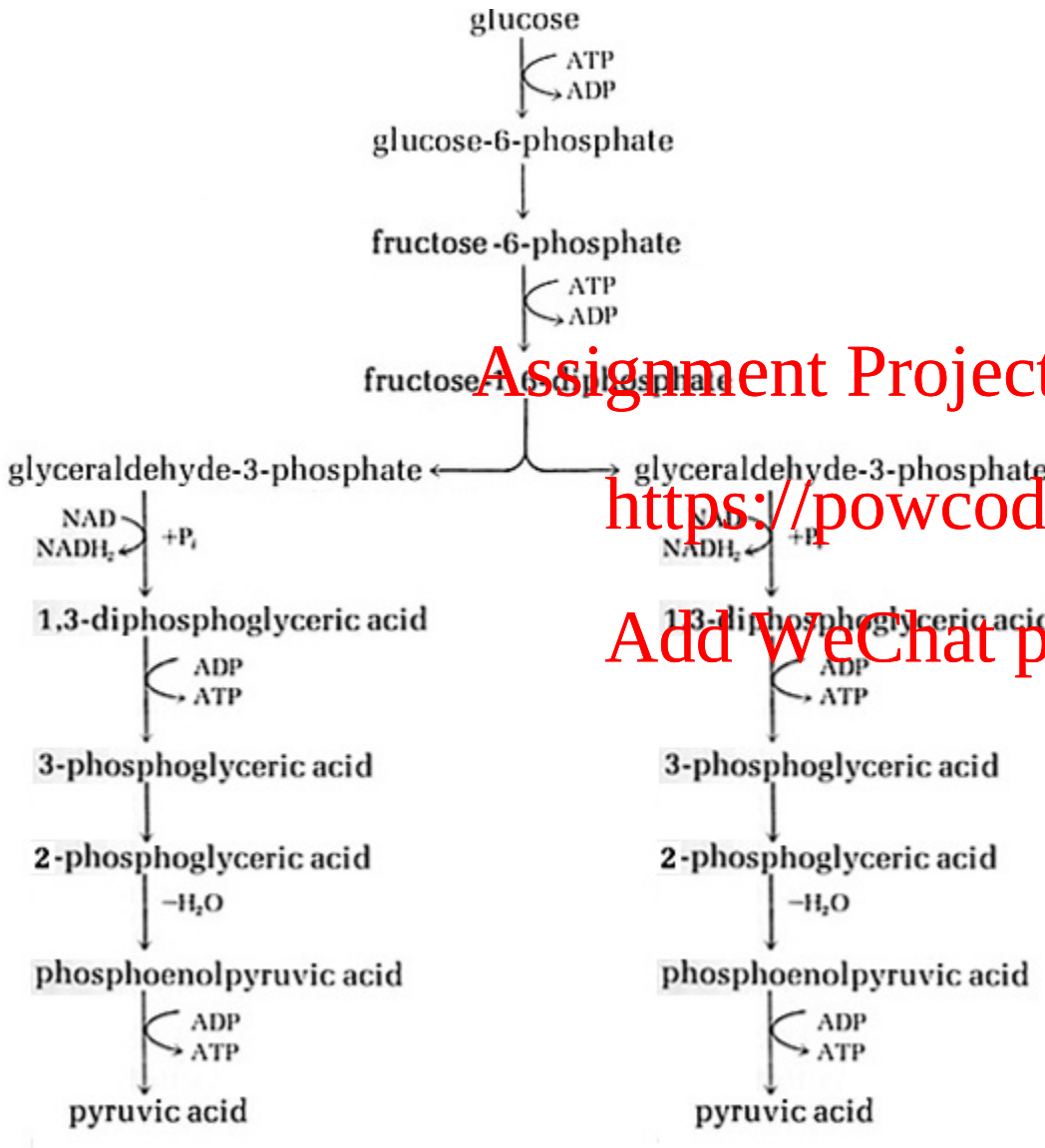
Fermentation

Monosaccharides are fermented by anaerobic and facultative anaerobic microorganisms by one or more of

Five major pathways for degradation of monosaccharides

1. Embden-Meyerhoff-Parnas (EMP) pathway
2. Hexose monophosphate shunt (HMP) pathway
3. Entner-Doudroff (ED) pathway
4. 2 Phosphoketolase (PK) pathways (pentose phosphoketolase and hexose phosphoketolase)

Embden-Meyerhoff-Parnas (EMP) pathway



This is the pathway of glycolysis

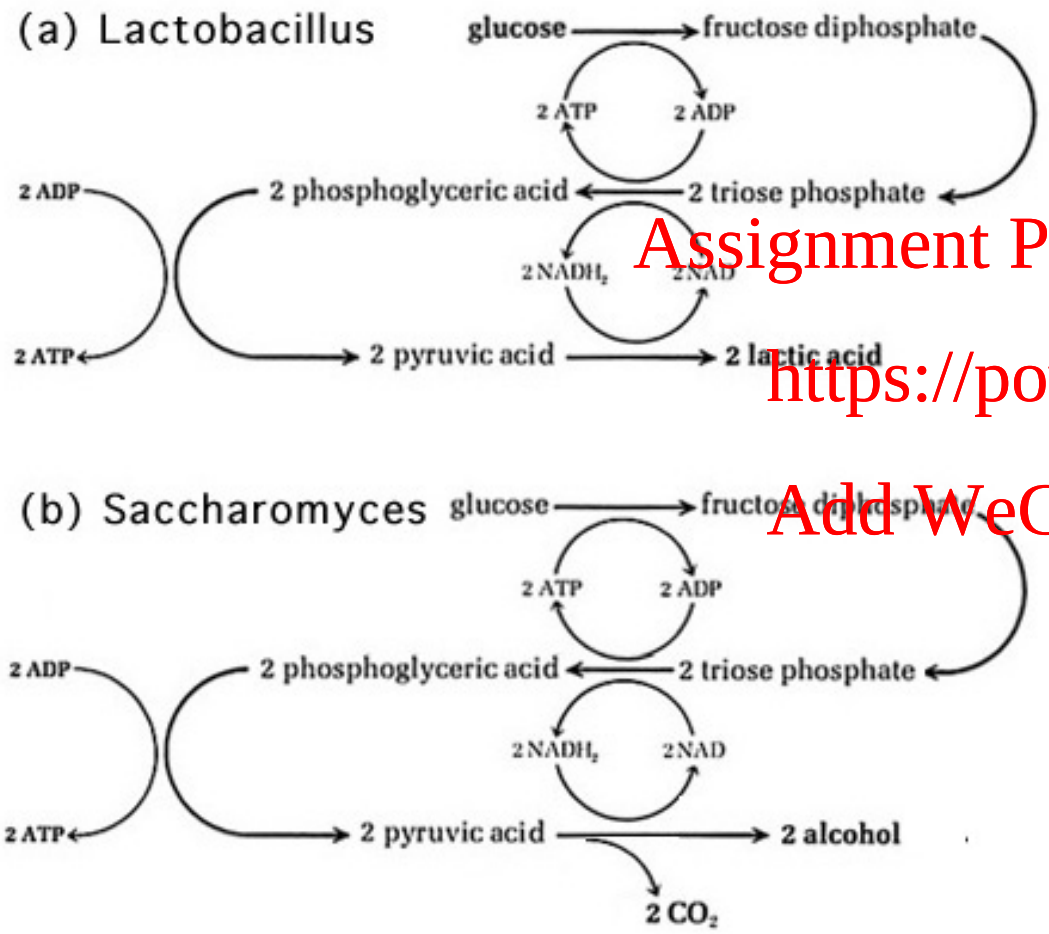
glucose → pyruvic acid + ATP

Lactic acid bacteria reduce the pyruvate to lactic acid (lactate)

Yeast reduce the pyruvate to alcohol (ethanol) and CO_2

2 ways of reducing pyruvate so different endproducts

Embden-Meyerhoff-Parnas (EMP) pathway



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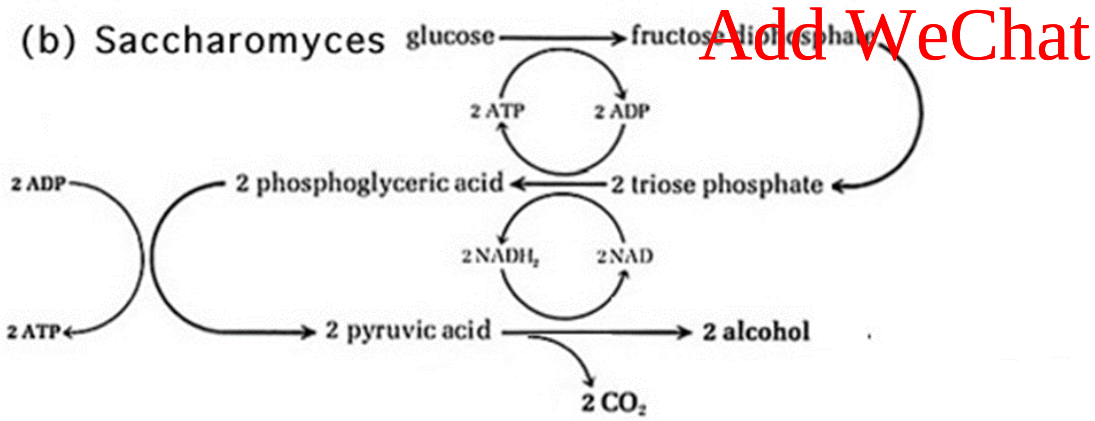
2 ways of reducing pyruvate so different endproducts

Embden-Meyerhof fermentations in bacteria can lead to a wide array of end products depending on the pathways taken in the reductive steps after the formation of pyruvic acid.

Todar

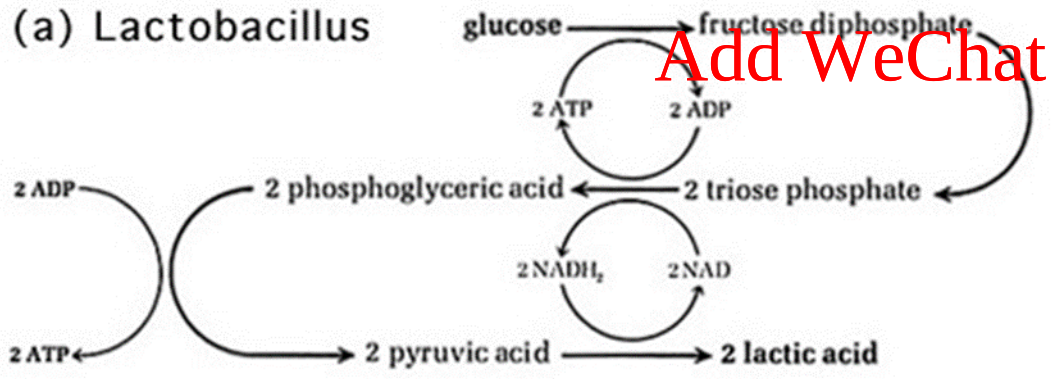
Alcoholic fermentation

Yeasts produce ethanol and CO_2 by alcoholic fermentation product in the manufacture of beer, wine, bread and variety of fermented products.

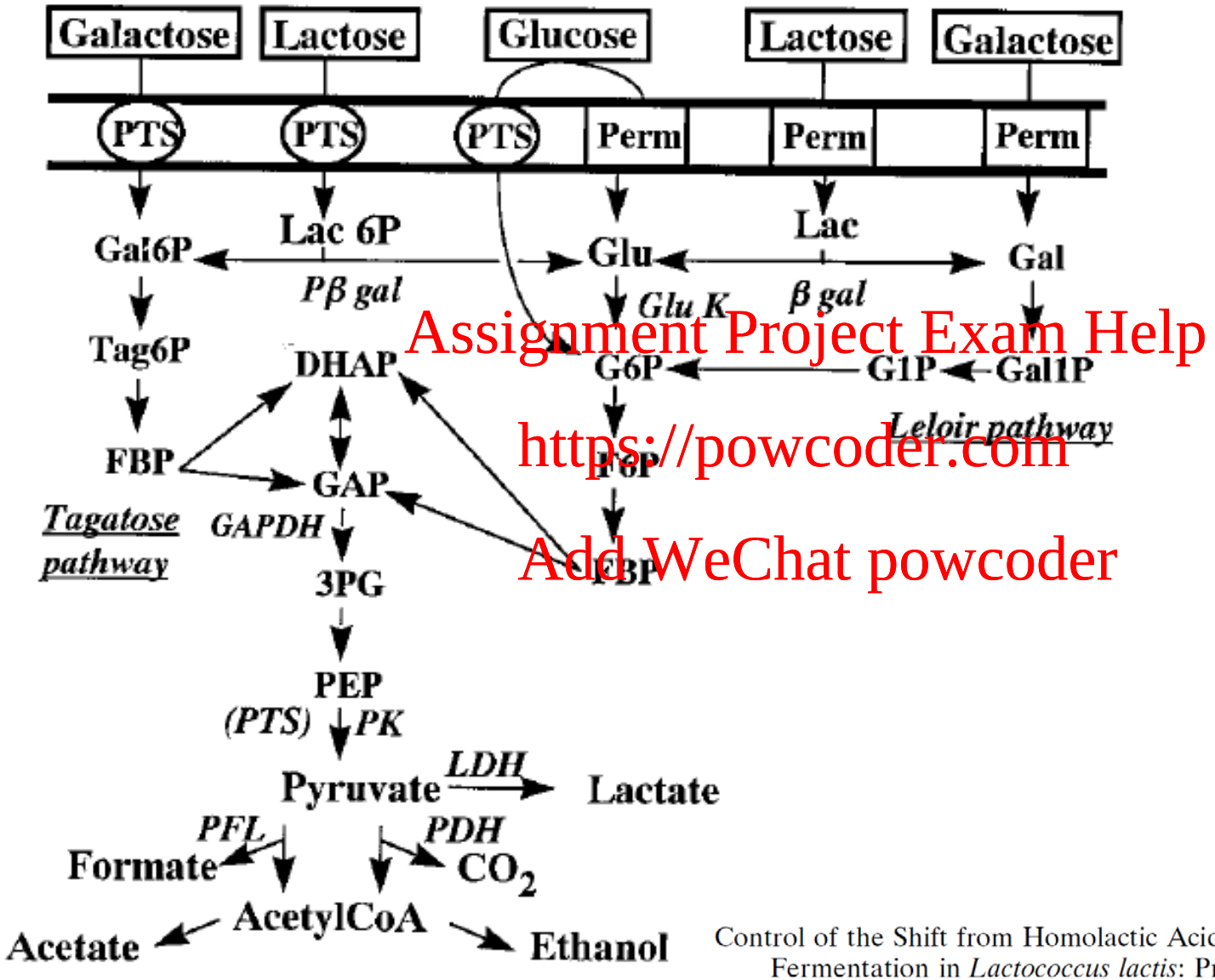


Homolactic Fermentation

Lactic acid is the sole end product. Pathway of the homolactic acid bacteria (*Lactobacillus, Lactococcus* and most streptococci). The bacteria are used to ferment milk and milk products in the manufacture of yogurt, buttermilk, sour cream, cottage cheese, cheddar cheese, and most fermented dairy products.



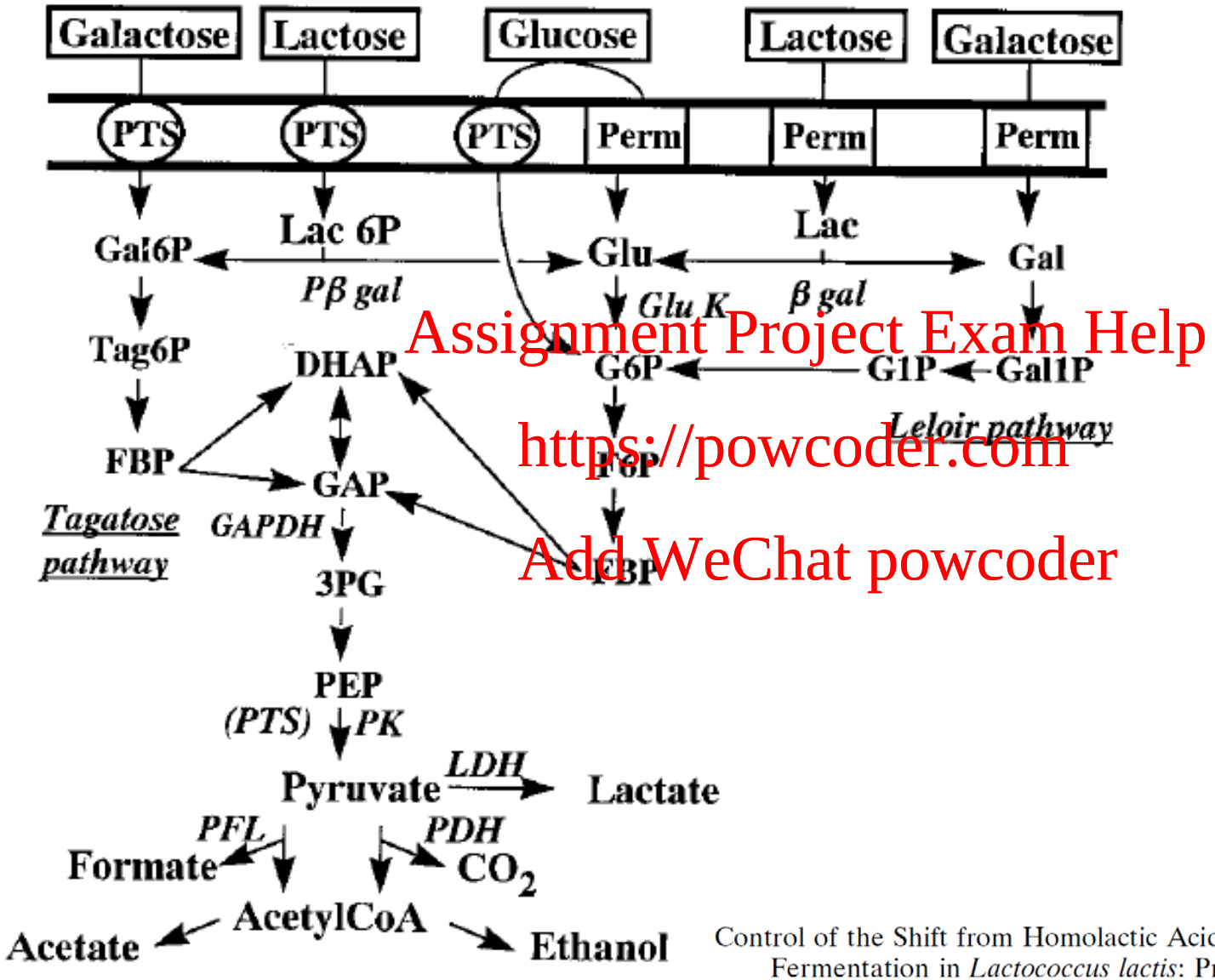
Heterolactic vs homolactic fermentation



Control of the Shift from Homolactic Acid to Mixed-Acid Fermentation in *Lactococcus lactis*: Predominant Role of the NADH/NAD$^+$ Ratio

CHRISTEL GARRIGUES, PASCAL LOUBIERE,* NIC D. LINDLEY, AND MURIEL COCAIGN-BOUSQUET

Heterolactic vs homolactic fermentation



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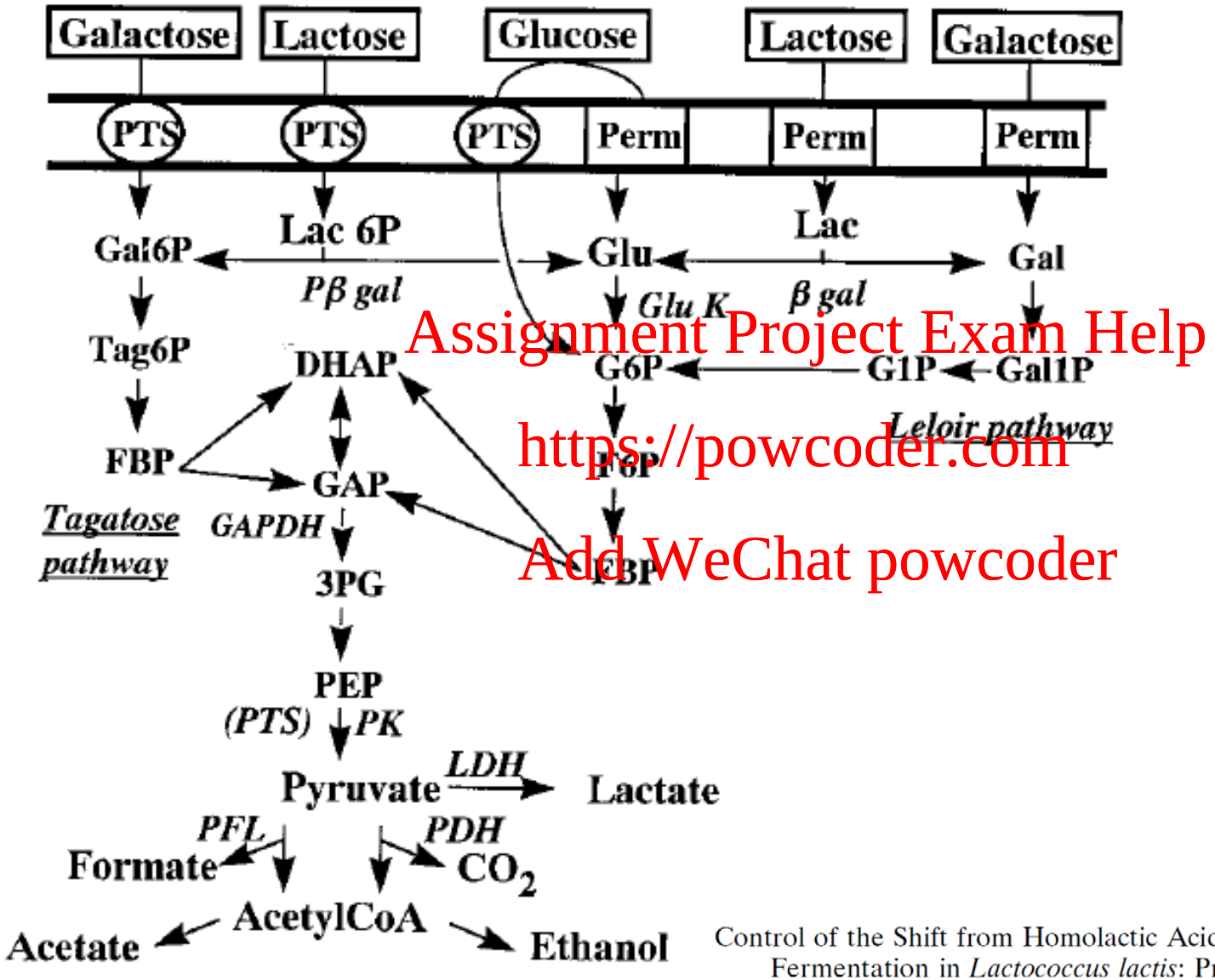

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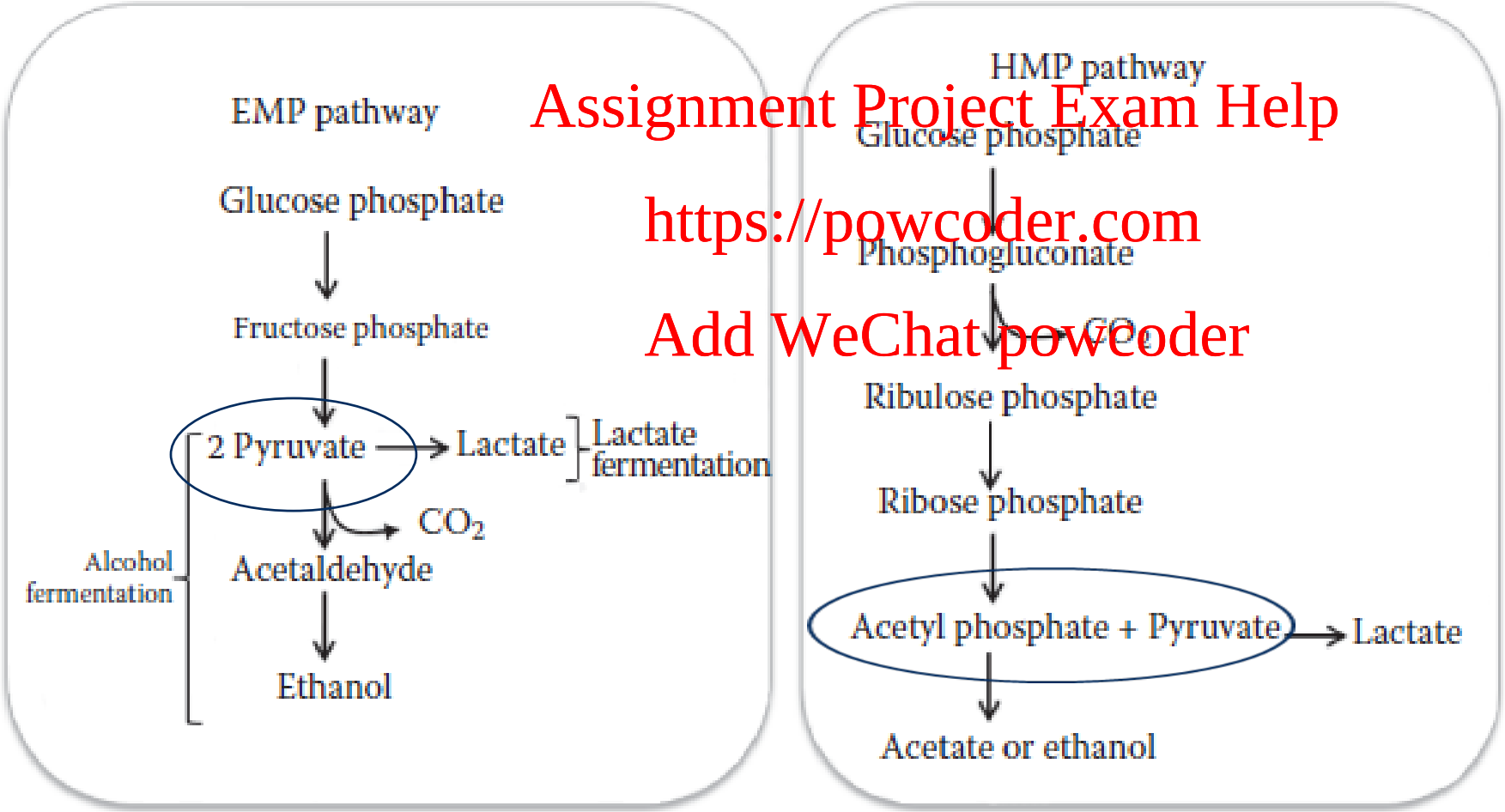
Pyruvate is a key metabolite. Diff endproducts

Embden-Meyerhoff-Parnas pathway
Used by **homofermentative** LAB, yeasts and some *Bacillus sp*

Hexose monophosphate shunt pathway
Used by **heterofermentative** LAB, *Bacillus sp* and *Pseudomonas*



Ray and Bhunia