Industrial bacteria

The bacterial phyla used in industrial microbiology and biotechnology are found in the **Proteobacteria**, the **Firmicutes** and the **Actinobacteria**.

The **Proteobacteria**:

All Proteobacteria are Gram-negative, with an outer membrane mainly composed of lipopolysaccharides. Many move about using flagella, but some are non-motile or rely on bacterial gliding. There is also a wide variety in the types of metabolism. Most members are facultatively or obligately anaerobic and heterotrophic, but there are numerous exceptions. Proteobacteria are divided into five groups: α(alpha), β(beta), γ(gamma), δ(delta), ε(epsilon). The only organisms of current industrial importance in the Proteobacteria are **Acetobacter** and **Gluconobacter**, which are acetic acid bacteria and belong to the Alpha proteobacteria. An organism also belonging to the Alphaproteobacteria, and which has the potential to become important industrially is **Zymomonas**. It produces copious amounts of alcohol, but its use industrially is not yet widespread.

The Acetic Acid Bacteria

The acetic acid bacteria are Acetobacter (peritrichously flagellated) and Gluconobacter (polarly flagellated). They have the following properties:

i. They carry out incomplete oxidation of alcohol leading to the production of acetic acid, and are used in the manufacture of vinegar.

ii. Gluconobacter lacks the complete citric acid cycle and can not oxidize acetic acid; Acetobacter on the on the other hand,

has all the citric acid enzymes and can oxidize acetic acid further to CO_2.

iii. They stand acid conditions of pH 5.0 or lower.

iv. Their property of 'under-oxidizing' sugars is exploited in the following:

- The production of glucoronic acid from glucose, galactonic aicd from galactose and arabonic acid from arabinose;
- b. The production of sorbose from sorbitol by acetic acid bacteria an important stage in the manufacture of ascorbic acid (also known as Vitamin C).

The Firmicutes

The Firmicutes are a division of bacteria, all of which are Gram-positive, in contrast to the Proteobacteria which are all Gram-negative. Fermicutes contain many bacteria of industrial importance and are divided into three major groups:

i. spore-forming,

ii. nonspore forming, and

iii) wall-less (this group contains pathogens and no industrial organisms).

Spore forming firmicutes

Spore-forming Firmicutes form internal spores, unlike the Actinobacteria where the spore-forming members produce external ones. The group is divided into two: ***Bacillus spp,*** which are aerobic and ***Clostridium spp*** which are anaerobic. *Bacillus spp* are sometimes used in enzyme production. Clostridia on the other hand are mainly pathogens of humans and animals.

Non-spore forming firmicutes

The Lactic Acid Bacteria: The non-spore forming low G+C members of the firmicutes group are very important in industry as they contain the lactic acid bacteria. The lactic acid bacteria are rods or cocci placed in the following genera: **Enterococcus**, **Lactobacillus**, **Lactococcus**, **Leuconostoc**, **Pediococcus** and **Streptococcus** and are among some of the most widely studied bacteria because of their important in the production of some foods, and industrial and pharmaceutical products. They lack porphyrins and cytochromes, do not carry out electron transport phosphorylation and hence obtain energy by substrate level phosphorylation. They grow anaerobically but are not killed by oxygen as is the case with many anaerobes: they will grow with or without oxygen. They obtain their energy from sugars and are found in environments where sugar is present. They have limited synthetic ability and hence are fastidious, requiring, when cultivated, the addition of amino acids, vitamins and nucleotides. Lactic acid bacteria are divided into two major groups:

The **homofermentative group**, which produce lactic acid as the sole product of the fermentation of sugars, and the **heterofermentative**, which besides lactic acid also produce ethanol, as well as CO_2. The difference between the two is as a result of the absence of the enzyme **aldolase** in the heterofermenters. Aldolase is a key enzyme in the E-M-P pathway and splits hexose glucose into three-sugar moieties. Homofermentative lactic acid bacteria convert the D-glyceraldehyde 3-phosphate to lactic acid. Heterofermentative lactic acid bacteria receive five-carbon xylulose 5 phosphate from the Pentose pathway. The five carbon xylulose is split into glyceraldehyde 3-phosphate (3-carbon), which leads to lactic

acid, and the two carbon acetyl phosphate which leads to ethanol (Fig.1).

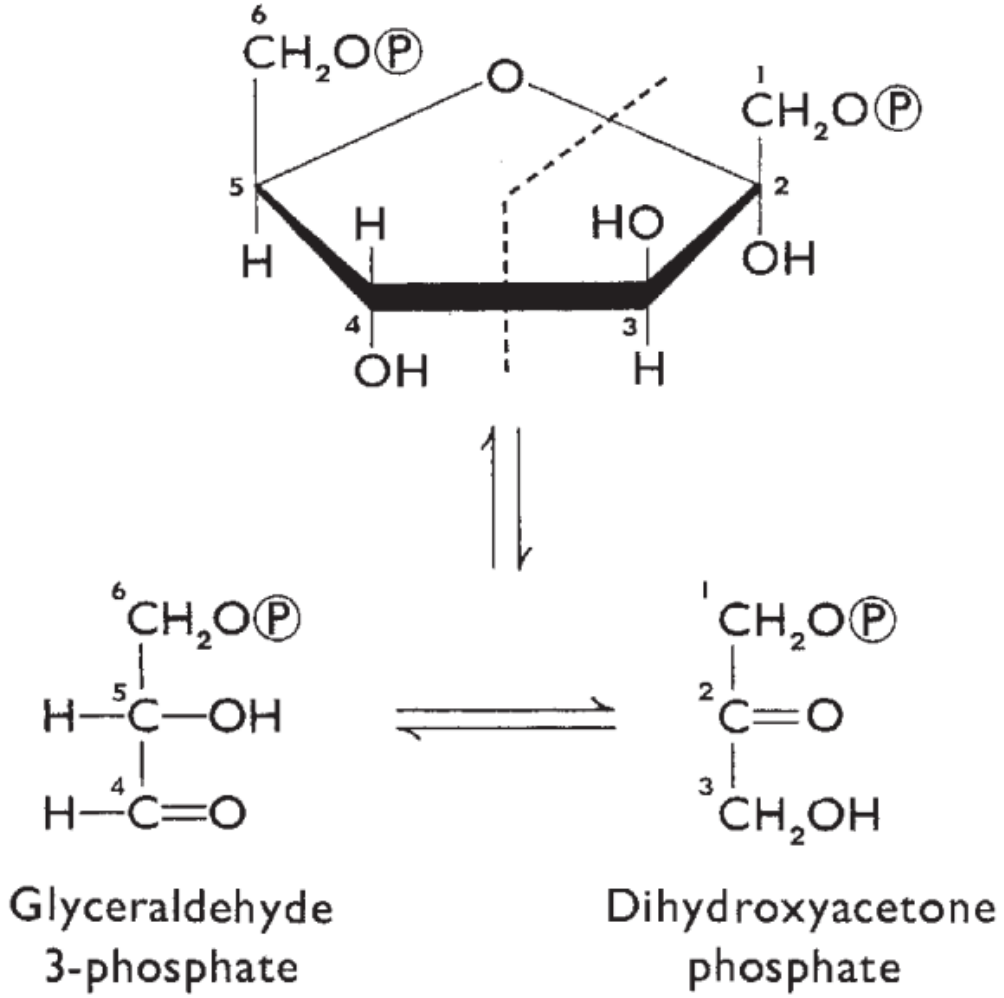

Fig. 1 Splitting of 6-carbon Glucose into Three-carbon Compounds by the Enzyme Fructose Diphposphate Aldolase

Use of Lactic Acid Bacteria for Industrial Purposes:

The desirable characteristics of lactic acid bacteria as industrial microorganisms include

a. their ability to rapidly and completely ferment cheap raw materials,
b. their minimal requirement of nitrogenous substances,

c. they produce high yields of the much preferred lactic acid
d. ability to grow under conditions of low pH and high temperature, and
e. ability to produce low amounts of cell mass as well as negligible amounts of other byproducts.

Table 1 Characteristics of the lactic acid bacteria

S/No	Group	Description	Habit	Importance
1	*Streptococcus*	Cocci in pairs or short chains	Some in respiratory tract, mouth, intestine; others found in fermenting vegetable and silage	Some cause sore throat; non-pathogenic strains used in yoghurt manufacture
2	*Enterococcus*	Cocco-bacilli usually in pairs; previously classified Streptococcus Lancefield Group D	Found as commensals in the human alimentary canal; sometimes cause urinary tract infections	Can be used to monitor water quality, (like *E. coli*)
3	*Lactococcus*	Coccoid, usually occuring in pairs; hardly form chains	Plant material and alimentary canals of animals	Used as starter in yoghurt manufacture; Used as probiotic for intestinal health; Produces copious amounts of lactic acid.
4	*Pediococcus*	Growth in tetrads	Found on plant materials	Spoils beer; but required in special beers such as lambic beer drunk in parts of Belgium
5	*Leuconostoc*	Cocco-bacili	Associated with plant materials	Tolerates high con-centrations of salt and sugar and involved in the pickling of vegetables; produce dextrans from sucrose