

## Chapter 7 Metabolism of microorganisms

The biological reactions in all is called metabolism, which include anabolism and catabolism .  
In anabolism, small molecules+ energy+ recucive matters----large molecules  
In catabolism, large molecules ---- small molecules+ energy+ recucive matters  
These two processes depend on each oter.

### Section 1 Energy production microorganisms

#### 1 Ways of energy production of microbes

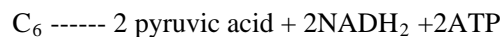
There are four ways in which energy is produced in microbes and they are fermentation, respiration, photosynthesis and oxidation of inorganic matters.

#### 2 Biological oxidation and energy production

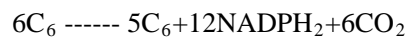
In biological oxidation, organic matters are oxidated in cells and ATP is given off.

##### 1) Four pathways of dehydrogen

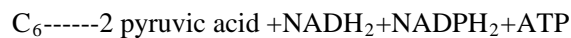
a, Embden-Meyerhof-Parms pathway (EMP, most microbes have this pathway)



b, Hexose monophosphate pathway(HMP)



c, Enter-Douforoff pathway(ED)



d, Tricarboxylic acid cycle( TCA)



##### 2) Passing and receiving hydrogen

In fermentation, under the anaerobic condition, organic matters are oxidated, electrons are passed to the middle stage receiver, and ATP is released.

In respiration, under the aerobic condition, organic matters are oxidated completely, electrons are passed to the oxygen, and ATP is released.

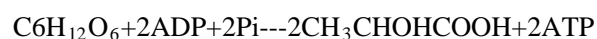
#### 3 Fermentation

glucose---pyruvic acid +2ATP+2NADH<sub>2</sub>

Alcohol fermentation.



Lactic acid fermentation



#### 4 Respiration

Organic matters are completely oxidated and 38ATP generated.

glucose---pyruvic acid +2ATP+2NADH<sub>2</sub>

pyruvic acid -----2ATP+8NADH<sub>2</sub> +2FADH<sub>2</sub>

1NADH<sub>2</sub>---3 ATP, 1 FADH<sub>2</sub>---2 ATP.

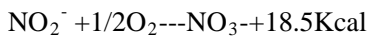
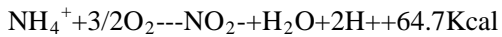
$$10 \times 3 \text{ ATP} + 2 \times 2 \text{ ATP} + 4 \text{ ATP} = 38 \text{ ATP}$$

Totally 38 ATP are produced in the complete respiration.

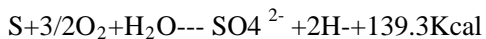
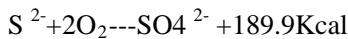
Electron transport chain:  $\text{NAD(P)} \rightarrow \text{FAD}$  (或  $\text{FMN}$ )  $\rightarrow \text{FeS} \rightarrow \text{CoQ} \rightarrow \text{Cytb} \rightarrow \text{Cytc} \rightarrow \text{Cyta} \rightarrow \text{Cyta}_3 \rightarrow \text{O}_2$

## 5 Oxidation of inorganic matter

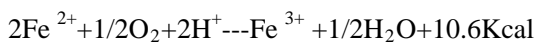
In nitrifying bacteria



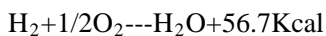
In sulfiding bacteria



In iron bacteria



In hydrogen bacteria



## 6 Photosynthesis

Photosynthesis is the process in which light is converted to ATP in cells.

Main pigments in photosynthesis are chlorophyll and bacterial chlorophyll which constitute photosynthesis center, absorb and convert light energy.

Assistant pigments in photosynthesis are carotenoids and phycobilin which only absorb light energy and convert it to photosynthesis center

In cyclic photophosphorylation,

Chlorophyll  $\rightarrow$  e  $\rightarrow$  Electron transport chain (ATP)

In non-cyclic photophosphorylation,

Pattern 1,

hydrogen sulfide  $\rightarrow$  e  $\rightarrow$  Electron transport chain (ATP)  $\rightarrow$  chlorophyll  $\rightarrow$  e  $\rightarrow$  Electron carriers  $\rightarrow$  NADP  $\rightarrow$  NADPH<sub>2</sub> .

Pattern 2,

H<sub>2</sub>O(light)  $\rightarrow$  1/2 O<sub>2</sub> + e  $\rightarrow$  Electron transport chain (ATP)  $\rightarrow$  chlorophyll  $\rightarrow$  Electron carriers  $\rightarrow$  NADP  $\rightarrow$  NADPH<sub>2</sub> .

## Section 2 Synthesis of organic molecules

### 1 Three prerequisites for biosynthesis

Energy

Small molecules

Reducing power

### 2 Examples for special pathway of microbial anabolism

#### 1) C<sub>2</sub>O fixation

Through Calvin cycle (Calvin), Anaerobic acetyl-CoA pathway, Reverse TCA cycle and Hydroxypropionate pathway, C<sub>2</sub>O is fixed by microbes.

- 2) Biosynthesis of peptidoglycan
- 3) Synthesis of secondary metabolite
- 4) Biological nitrogen fixation

### **Section 3 Regulation of metabolism and fermentation**

#### **1 Regulation of metabolism**

There is a more flexible and exact regulating system of metabolism in microbial cells than in plant or animal cells. It is necessary for the tiny microbial cells to obtain a developed regulation system of metabolism if they survive in the changing environment.

There are two types of regulation:

Regulation of enzymatic synthesis, including induction and repression.

Regulation of enzymatic activity, including activation and feed-back inhibition.

#### **2 Application of regulation of metabolism on fermentation**

- 1) Using auxotrophic mutant
- 2) Using anti-feed-back inhibition mutant
- 3) Control of the permeability of cell membrane