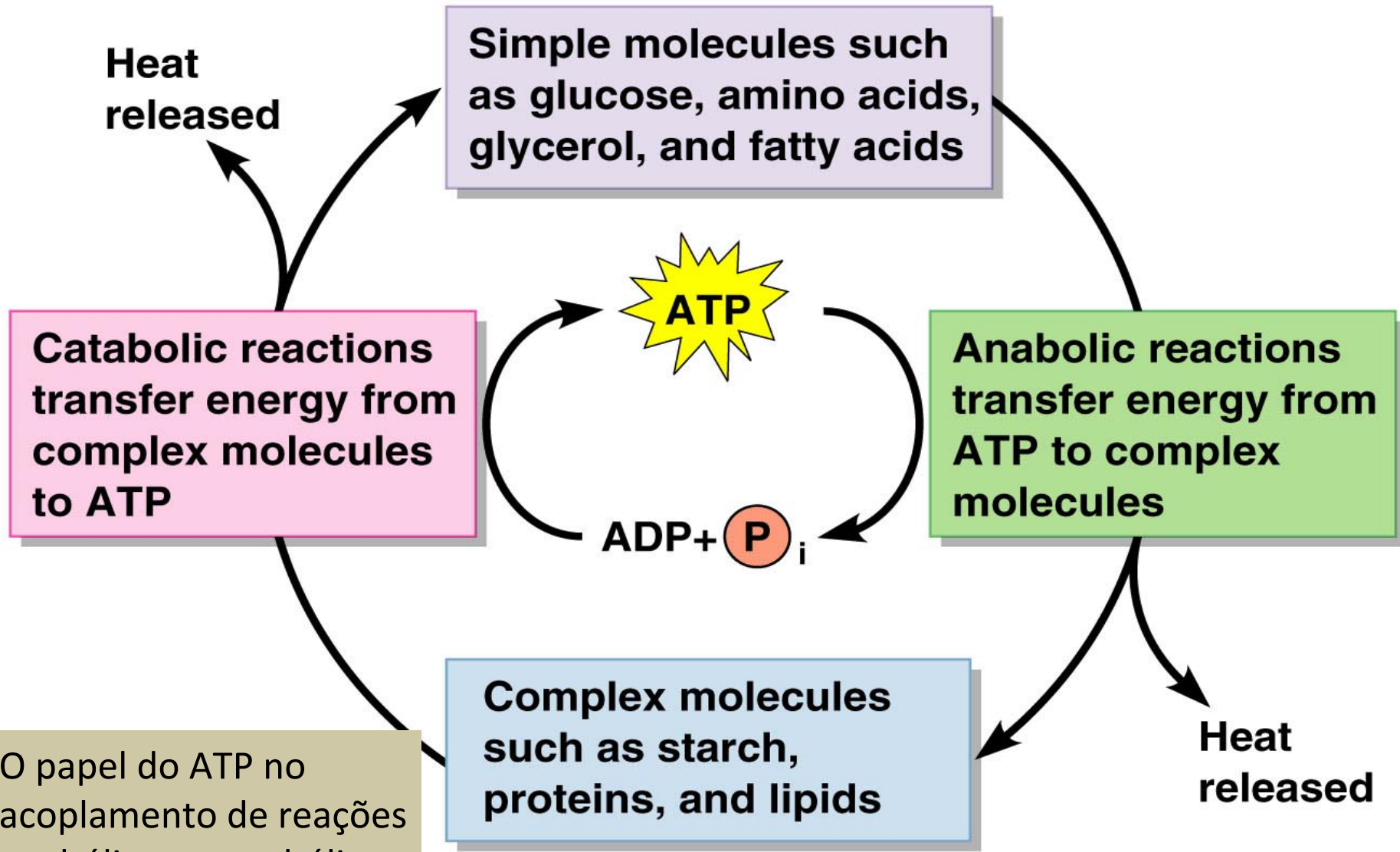


# A5-Metabolismo Bacteriano

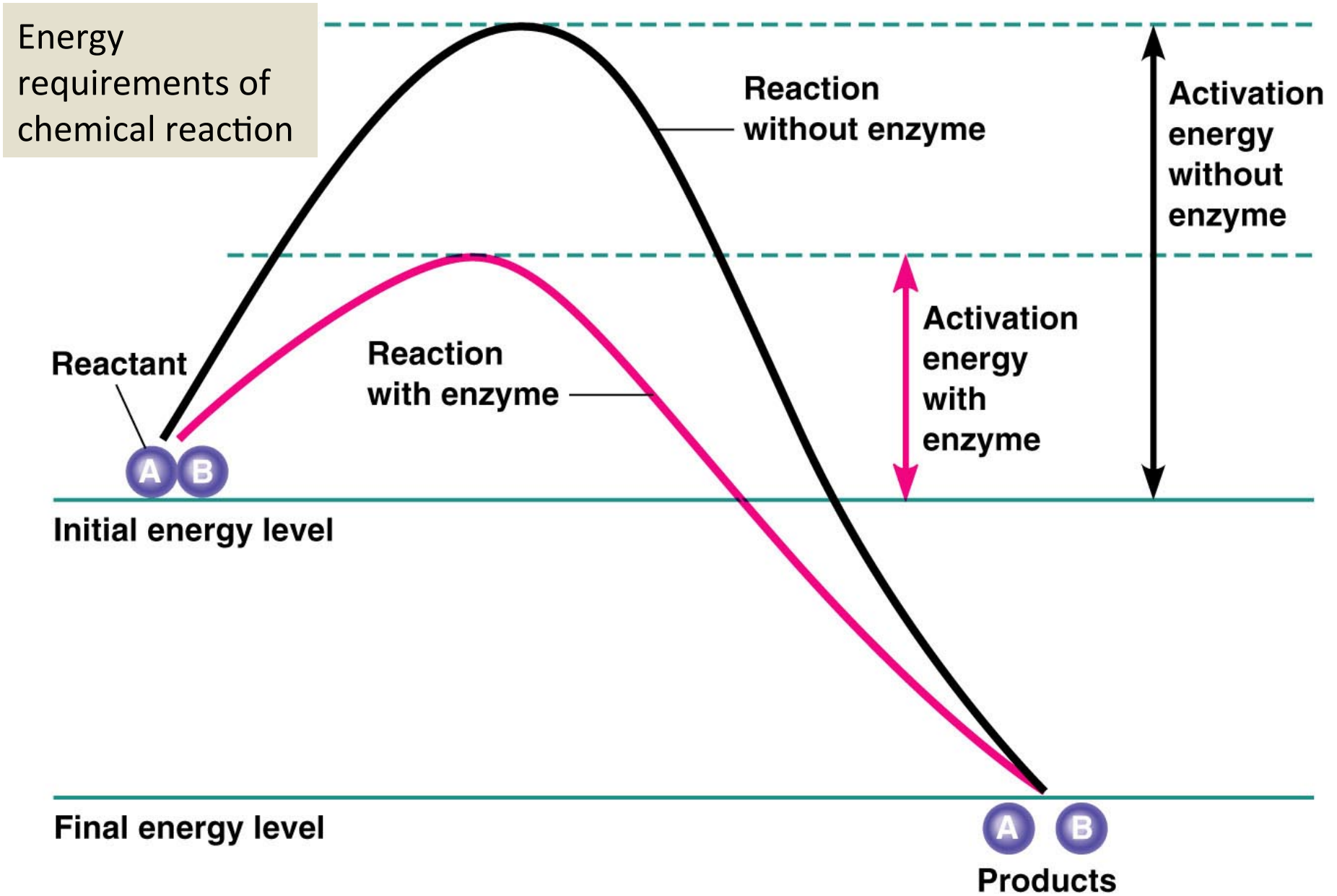
- Diferenciar anabolismo e catabolismo
- ATP
- Enzimas
- Formação estruturas celulares
- Vias metabólicas

# Chemical processes that form the basis of all cellular metabolism

- Enzyme-mediated catalysis
- Reaction coupling
- Energy harvesting by redox reactions
  - organic substrates
  - inorganic substrates
  - photochemical reactions
- Use of membranes to form charge gradients and chemical concentration



O papel do ATP no acoplamento de reações anabólicas e catabólicas



# *Escherichia coli* K12

Genome

4 639 221 bp

4377 genes

4290 proteins

87 RNAs

**Table 5.2** Gene products of *Escherichia coli* associated with various metabolic processes

<b>Functional category</b>	<b>No. of genes</b>
<b>Metabolism of small molecules</b>	
Degradation and energy metabolism	316
Central intermediary metabolism	78
Broad regulatory function	51
Biosynthesis	
Amino acids and polyamines	60
Purines, pyrimidines, nucleosides, and nucleotides	98
Fatty acids	26
<b>Metabolism of macromolecules</b>	
Synthesis and modification	406
Degradation	69
Cell envelopes	168
Cell processes	
Transport	253
Other, e.g., cell division, chemotaxis, mobility, osmotic adaptation, detoxification, and cell killing	118
Miscellaneous	107
<b>Total</b>	<b>1,894</b>

**Envelope**

**Pili**

Proteins

**Outer membrane**

Proteins  
Phospholipids  
Lipopolysaccharide

**Capsule**

Complex polysaccharide

**Wall**

Peptidoglycan

**Periplasm**

Proteins

**Cell membrane**

Proteins  
Phospholipids

**Flagella**

Proteins

**Cytoplasmic contents**

**Nucleoid**

DNA  
Associated proteins

**Cytoplasm**

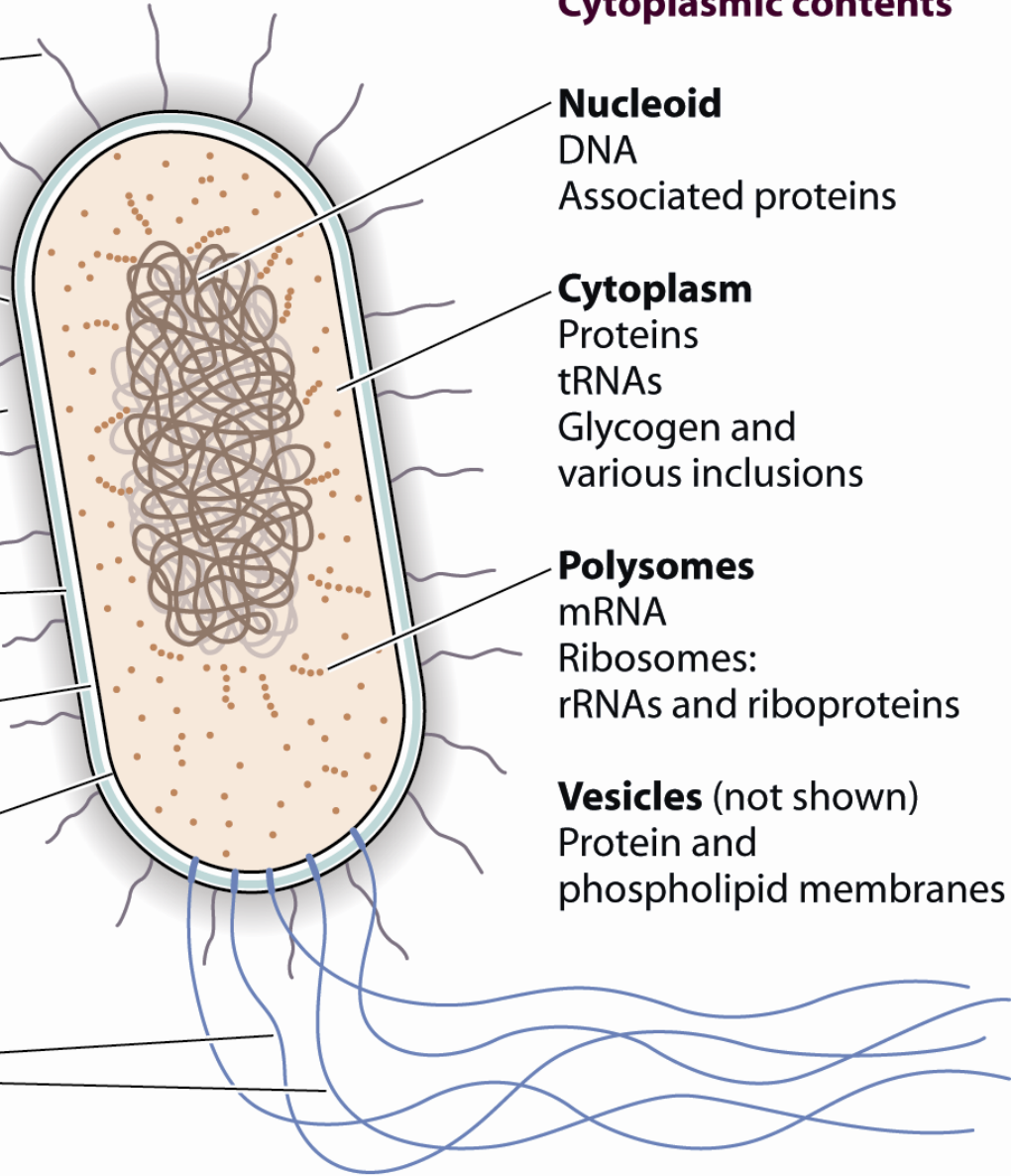
Proteins  
tRNAs  
Glycogen and  
various inclusions

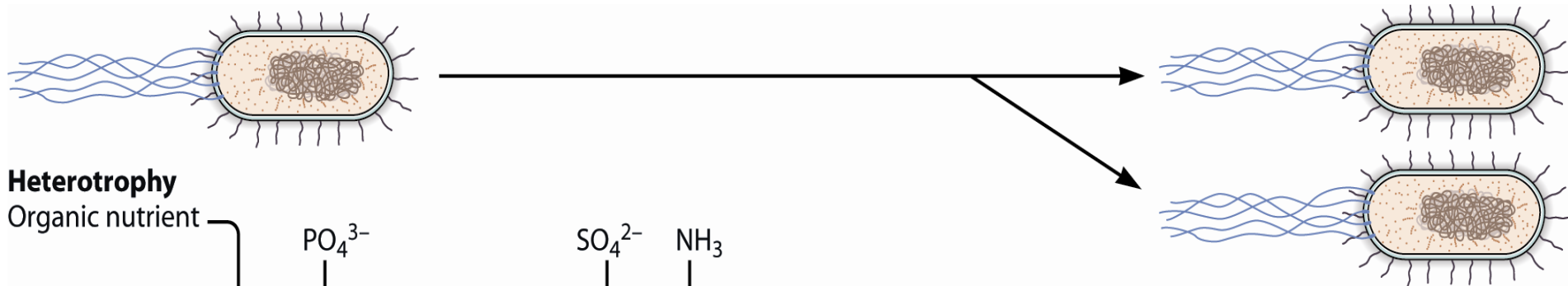
**Polysomes**

mRNA  
Ribosomes:  
rRNAs and riboproteins

**Vesicles** (not shown)

Protein and  
phospholipid membranes





**Heterotrophy**

Organic nutrient

**Autotrophy**

CO<sub>2</sub> + inorganic energy source

CO<sub>2</sub> + light



Fueling

**Fueling products**

Biosynthesis

**Building blocks**

Polymerization

**Macromolecules**

Assembly

**Structures**

**Energy**

ATP, PMF

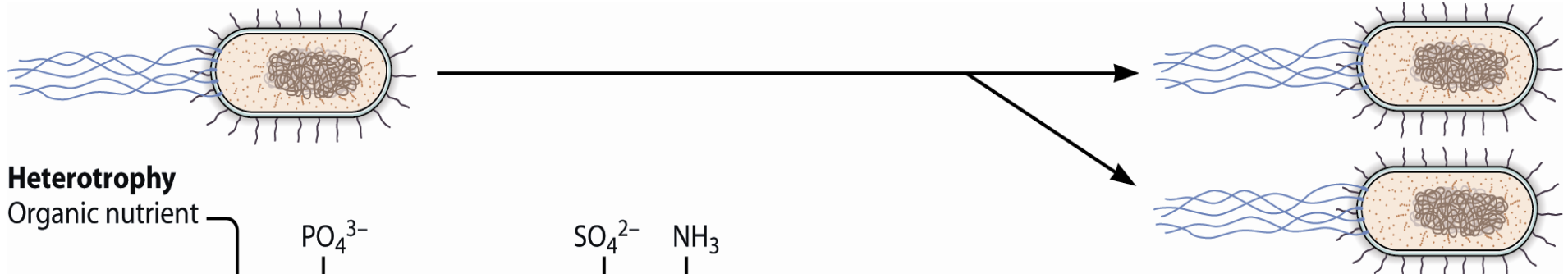
**Precursor metabolites**

- Glucose-6-phosphate
- Fructose-6-phosphate
- Pentose-5-phosphate
- Sedoheptulose-7-phosphate
- Erythrose-4-phosphate
- Triose phosphate
- 3-Phosphoglycerate
- Phosphoenolpyruvate
- Acetyl coenzyme A
- 2-Oxoglutarate
- Succinyl coenzyme A
- Oxaloacetate
- Pyruvate

**Reducing power**

NAD(P)H





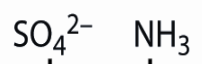
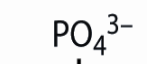
**Heterotrophy**

Organic nutrient

**Autotrophy**

CO<sub>2</sub> + inorganic energy source

CO<sub>2</sub> + light



Fueling

**Fueling products**

Biosynthesis

**Building blocks**

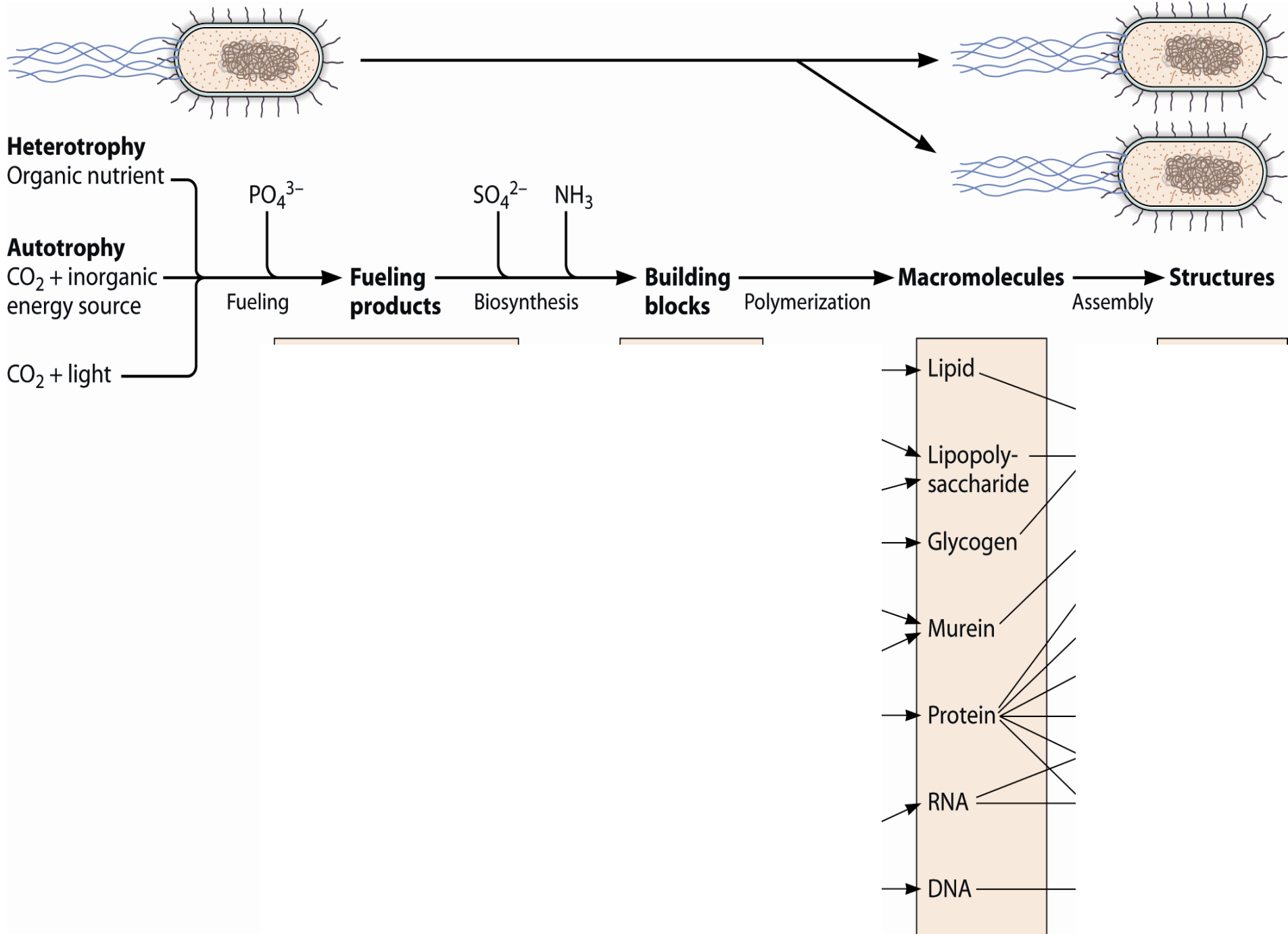
Polymerization

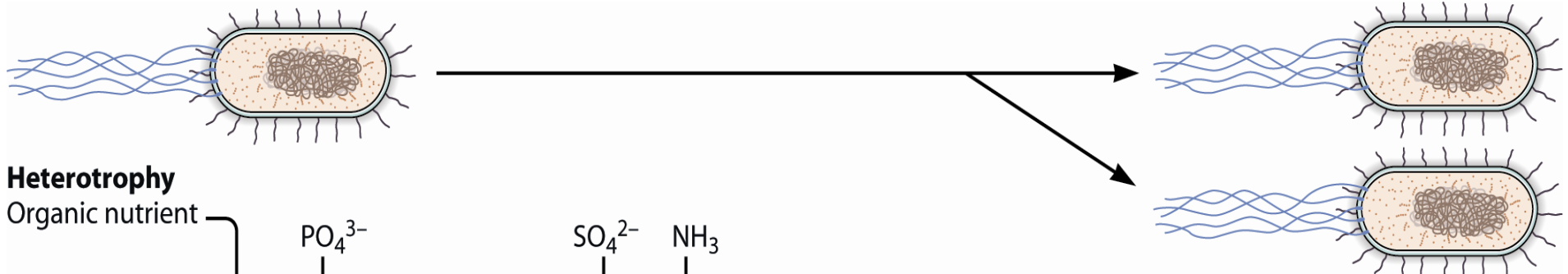
**Macromolecules**

Assembly

**Structures**

- Fatty acids (~8)
- Sugars (~25)
- Amino acids (~21)
- Nucleotides (~8)





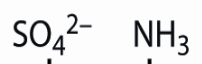
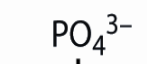
**Heterotrophy**

Organic nutrient

**Autotrophy**

CO<sub>2</sub> + inorganic energy source

CO<sub>2</sub> + light



Fueling

**Fueling products**

Biosynthesis

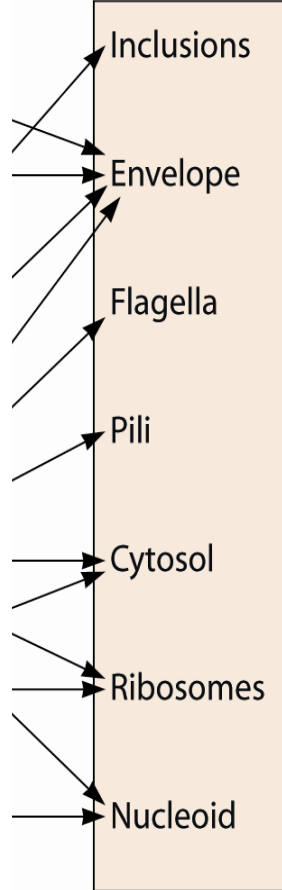
**Building blocks**

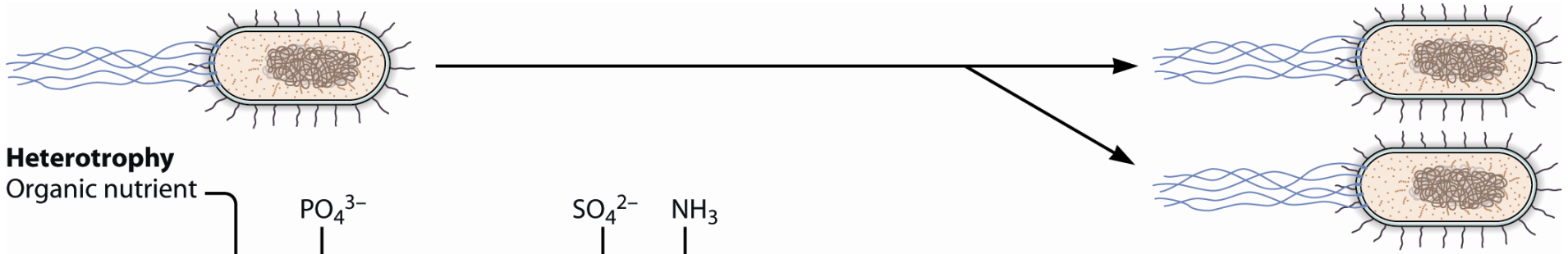
Polymerization

**Macromolecules**

Assembly

**Structures**





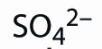
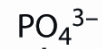
**Heterotrophy**

Organic nutrient

**Autotrophy**

CO<sub>2</sub> + inorganic energy source

CO<sub>2</sub> + light



**Fueling products**

**Building blocks**

**Macromolecules**

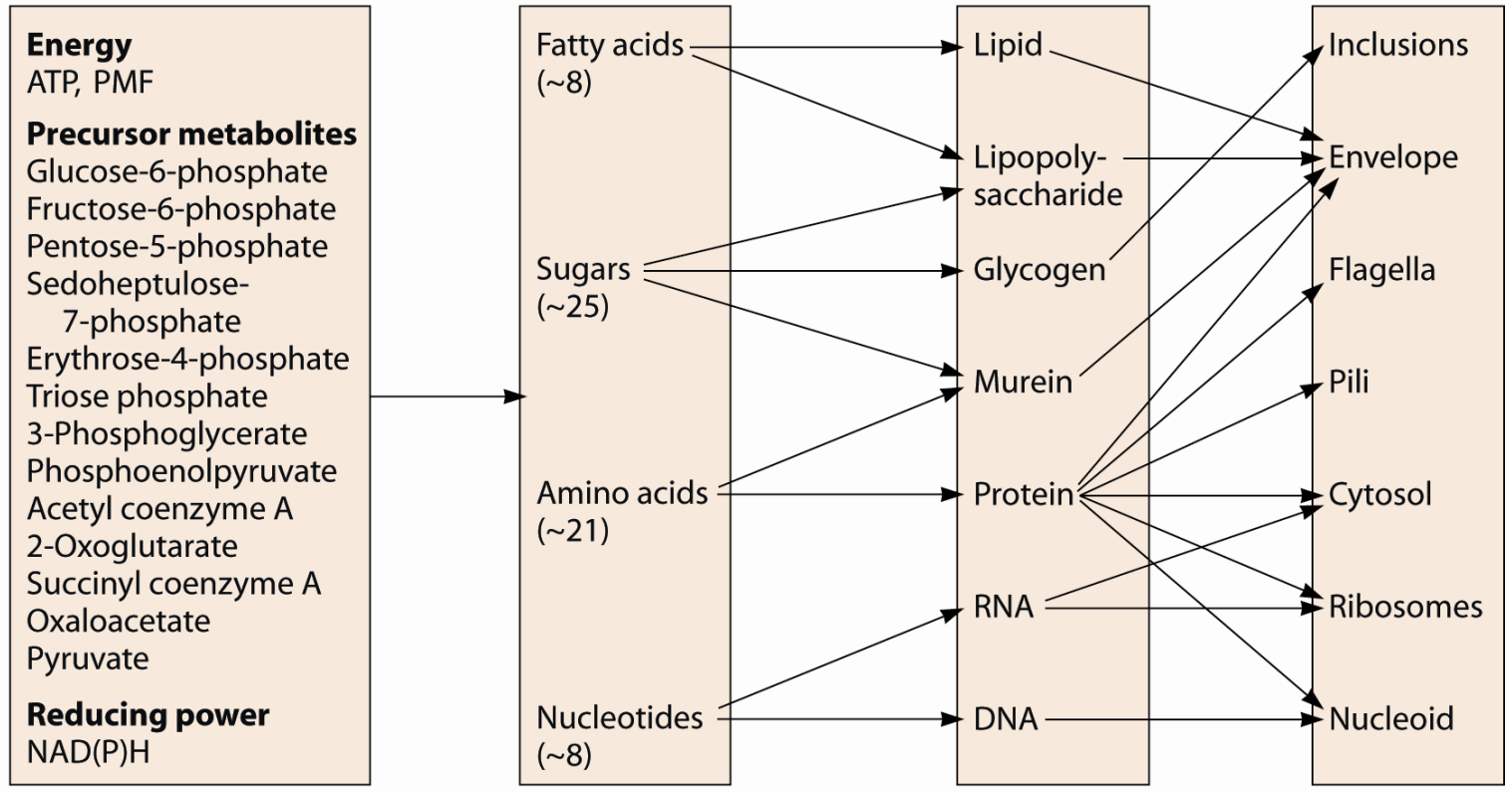
**Structures**

Fueling

Biosynthesis

Polymerization

Assembly



**Table 5.4** Some cellular activities requiring energy

---

**Cellular activity**

---

**Growth related**

---

Entry of nutrients

Biosynthesis of building blocks

Polymerization of macromolecules

Modification and transport of macromolecules

Assembly of cell structures

Cell division

**Growth independent**

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Motility

Secretion of proteins and other substances

Maintenance of metabolite pools

Maintenance of turgor pressure

Maintenance of cellular pH

Repair of cell structures

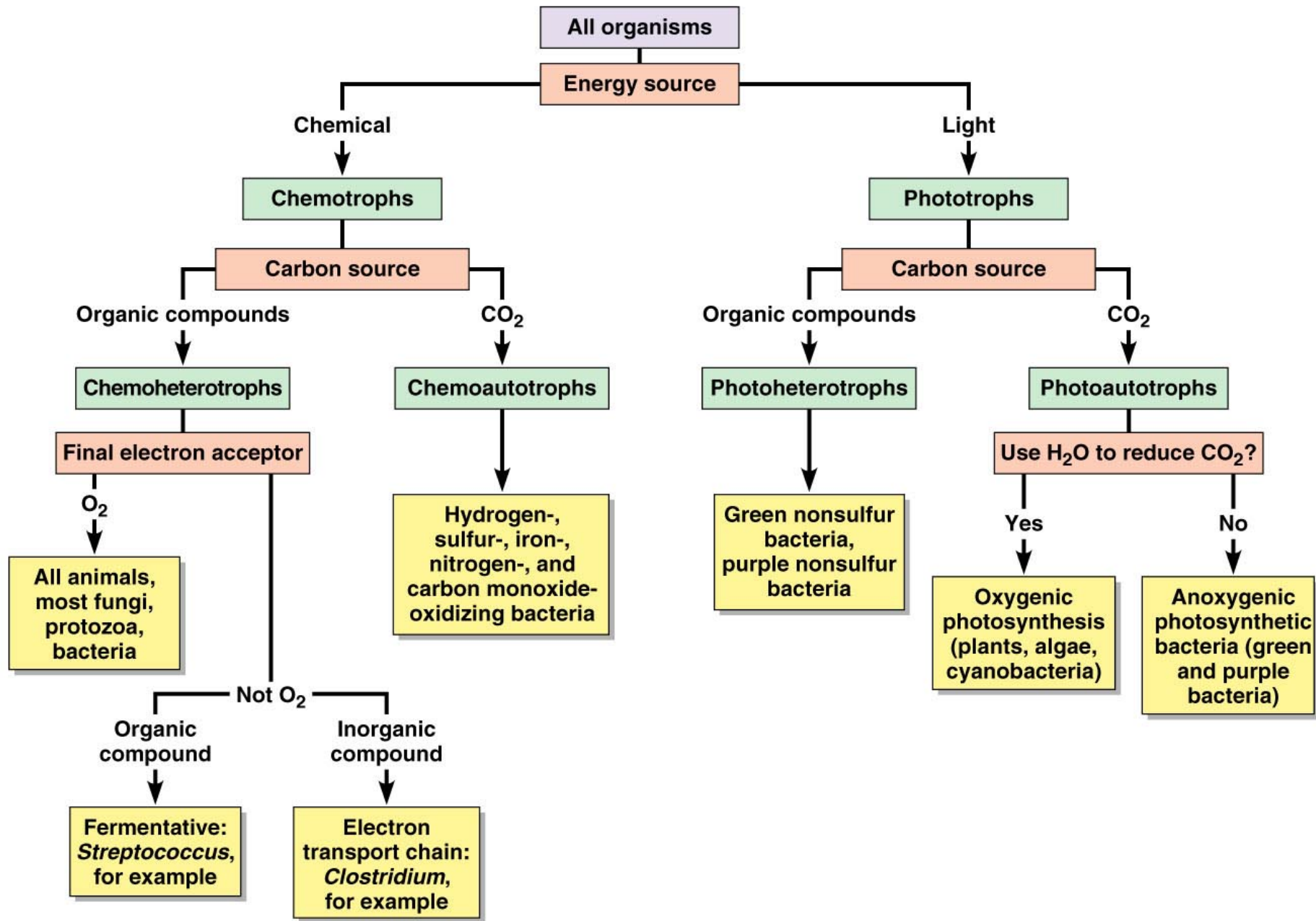
Sensing the surroundings

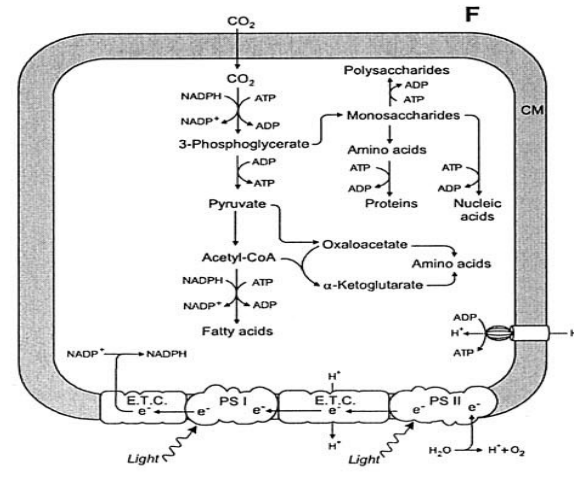
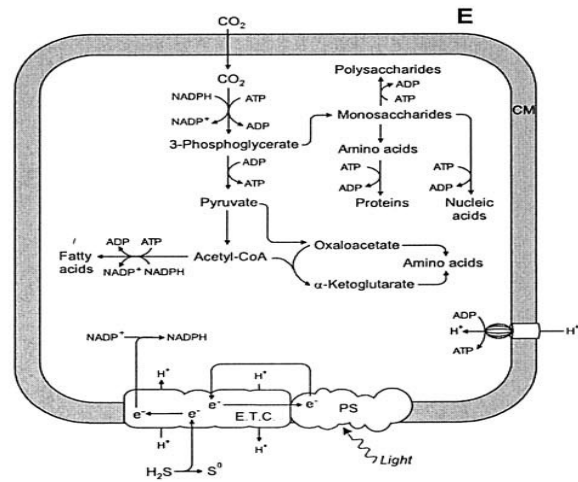
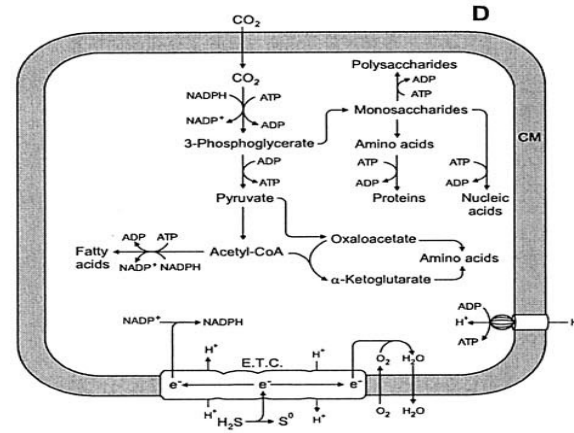
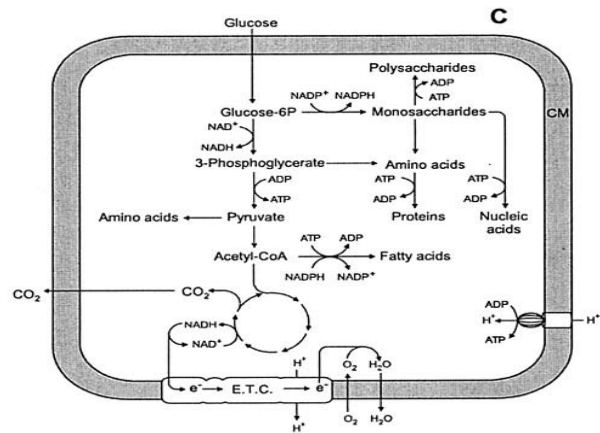
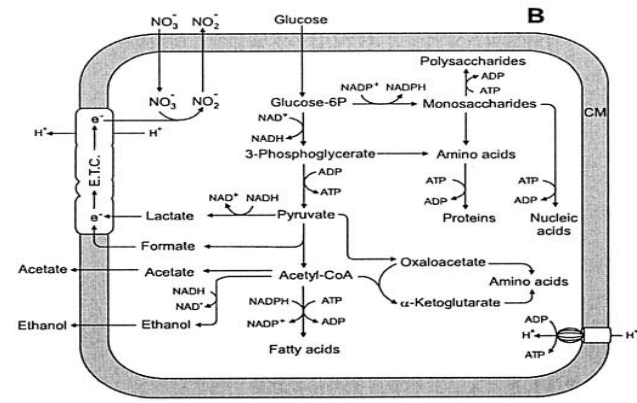
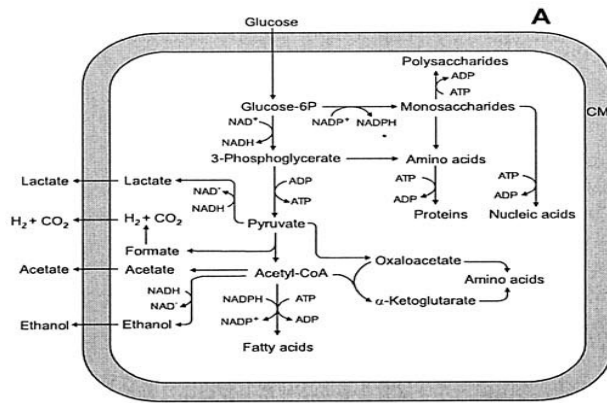
Communication among cells

---

**Table 5.3** Overall composition of an average *Escherichia coli* cell

<b>Substance</b>	<b>% of total dry wt</b>
<b>Macromolecules</b>	
Protein	55.0
RNA	20.4
23S RNA	10.6
16S RNA	5.5
5S RNA	0.4
Transfer RNA (4S)	2.9
Messenger RNA	0.8
Miscellaneous small RNAs	0.2
Phospholipid	9.1
Lipopolysaccharide	3.4
DNA	3.1
Murein	2.5
Glycogen and other storage material	2.5
<b>Total macromolecules</b>	<b>96.1</b>
<b>Small molecules</b>	
Metabolites, building blocks, vitamins, etc.	2.9
Inorganic ions	1.0
<b>Total small molecules</b>	<b>3.9</b>







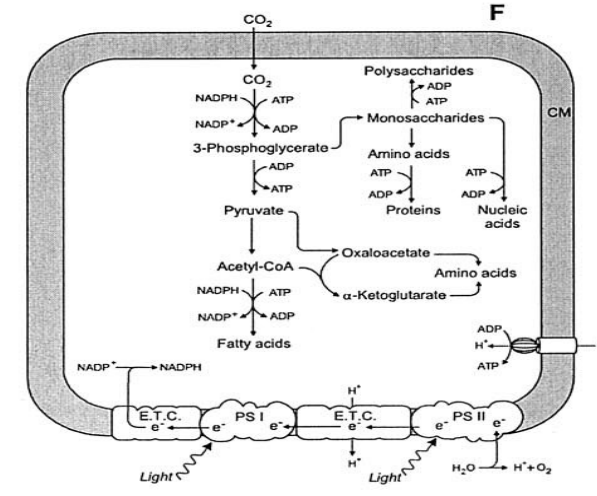
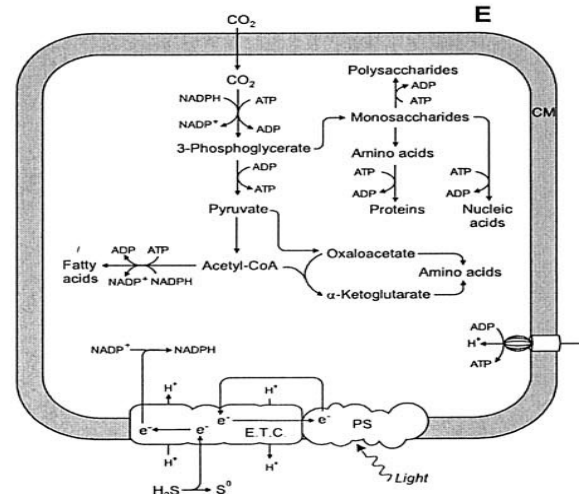
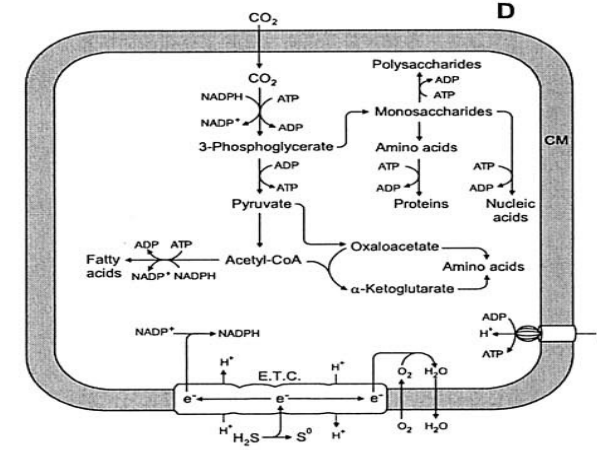
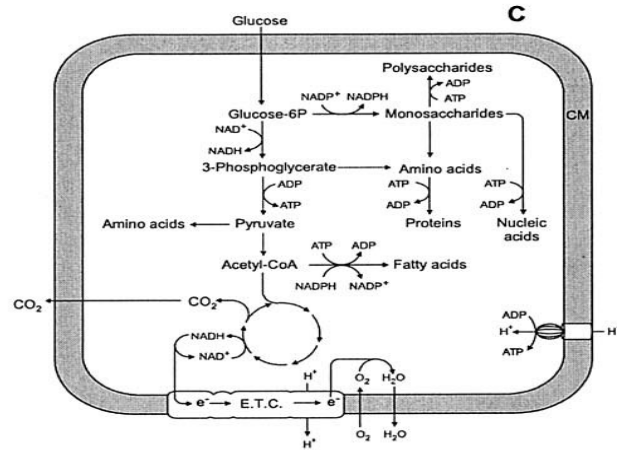
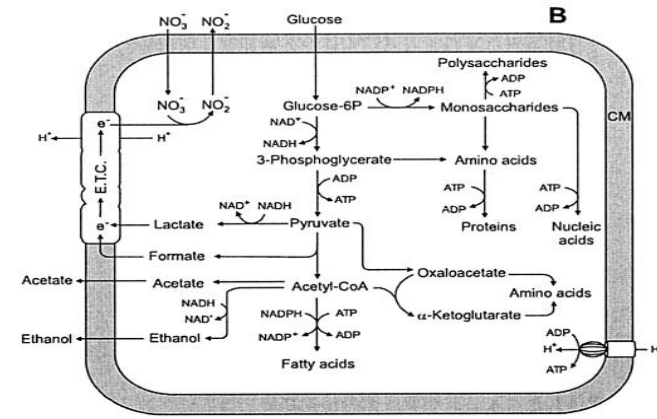
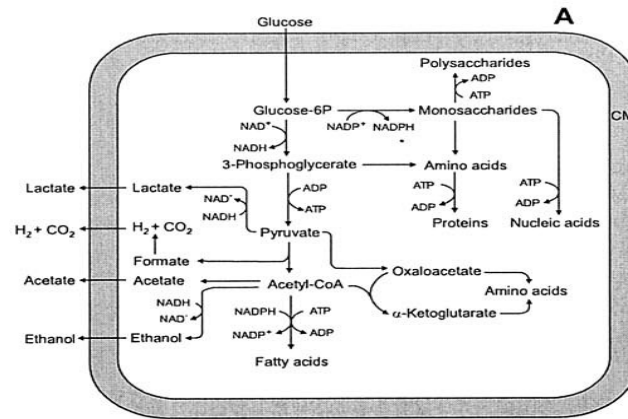
ATP pode ser obtido por:

A,B,C

Quimiorganotófica-oxidação de compostos orgânicos, D, quimiolitotrófico, oxidação compostos inorgânicos

E, fototróficos; energia luminosa sem produção oxigênio

F, fototróficas; energia luminosa com oxigênio



# Tipos de metabolismo:

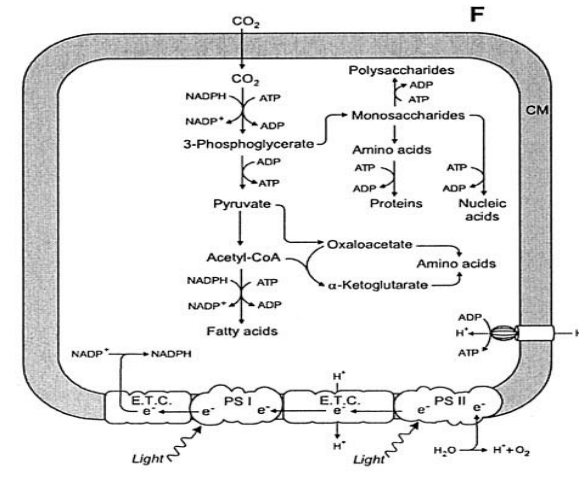
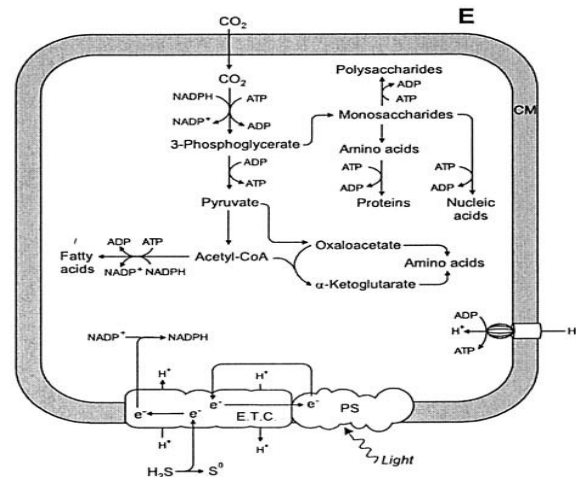
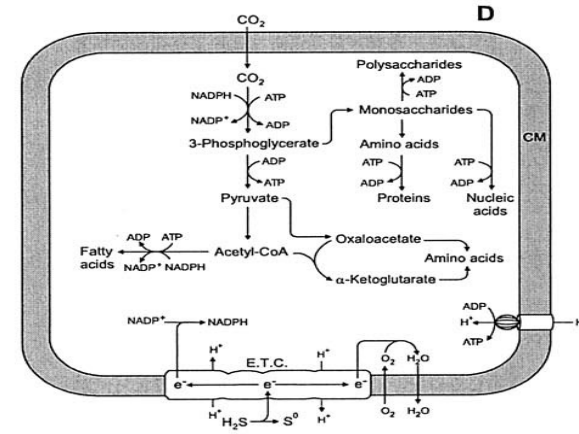
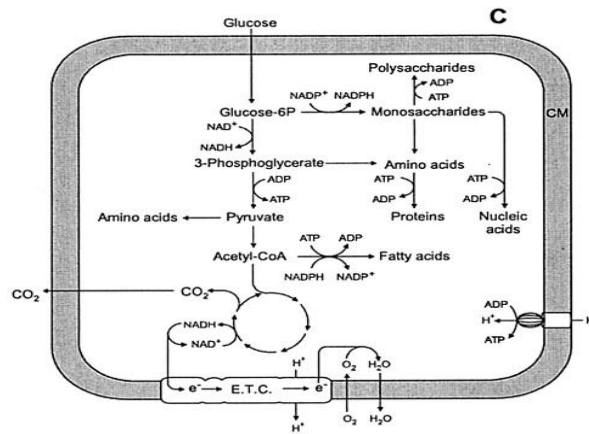
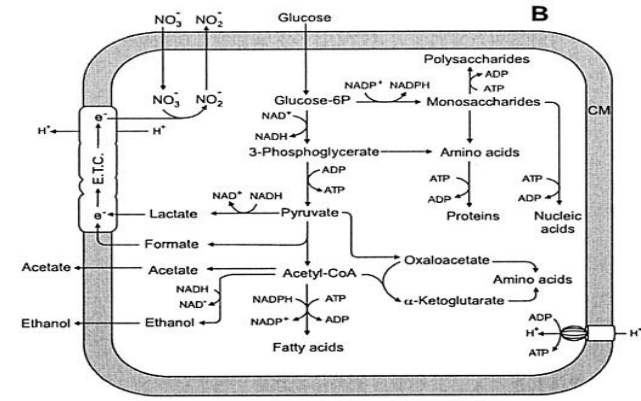
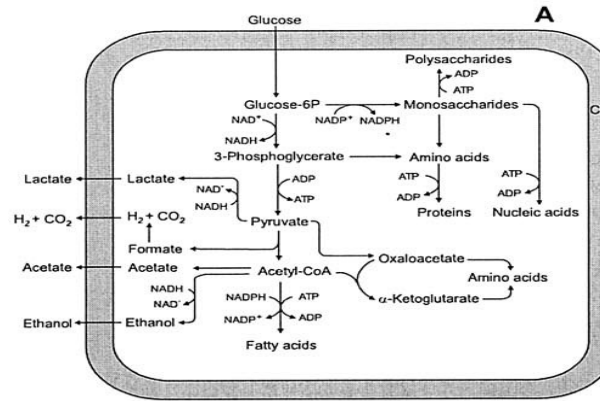
A,B,C heterotrófico;

D,E,F autotrófico

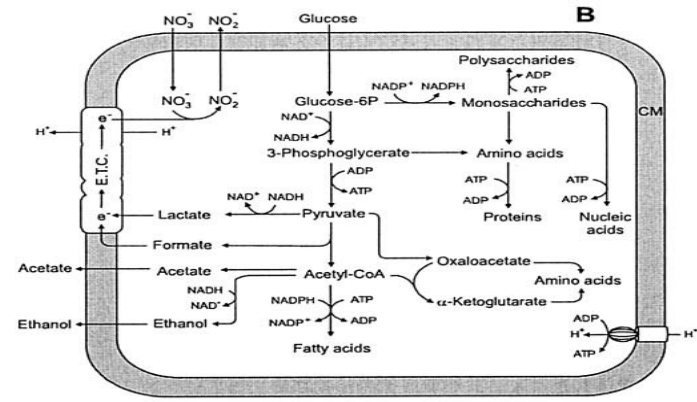
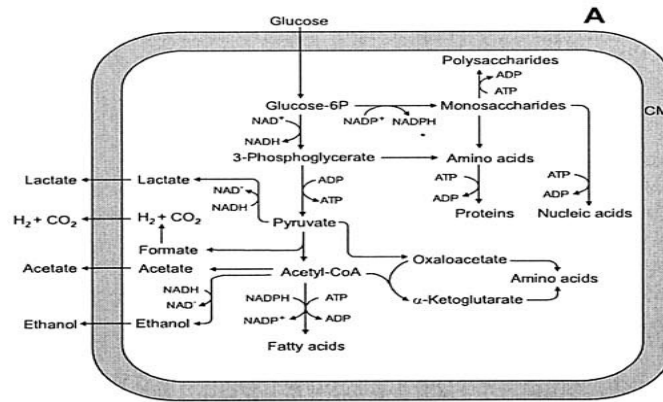
A, B, C, D quimiotrófico

E, F fototrófico

- Redução  $\text{NADP}^+$   
➔  $\text{NADPH}$

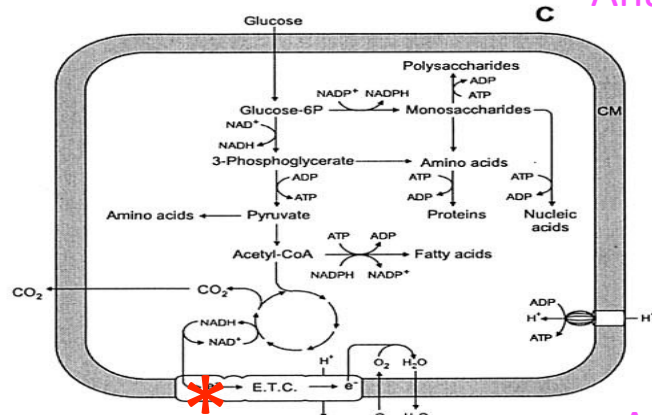


Fermentação



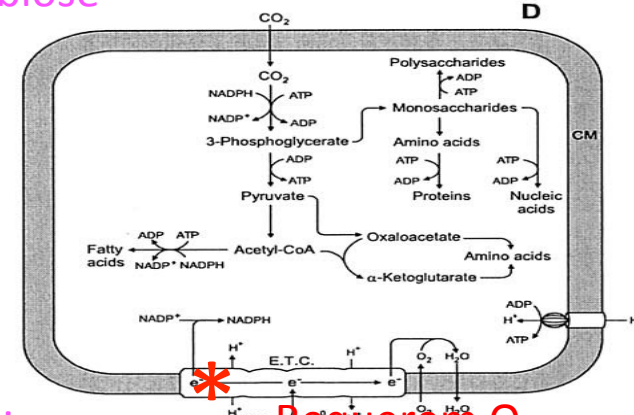
Anaerobiose

Mitocondria

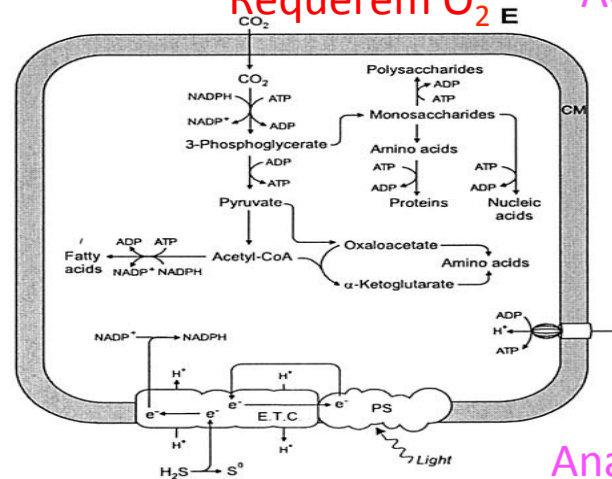


Requerem O<sub>2</sub>

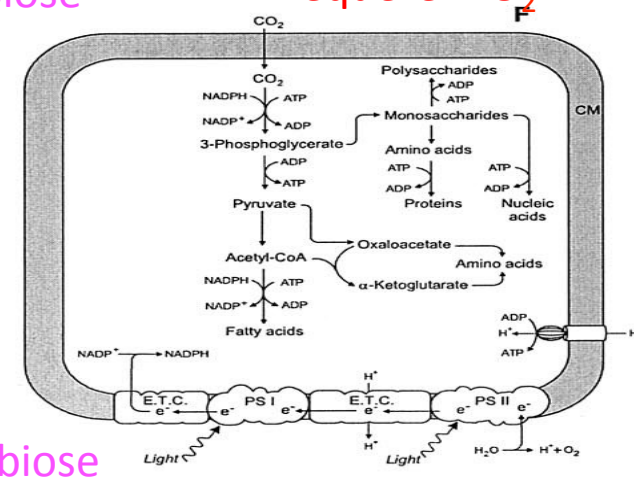
Aerobiose

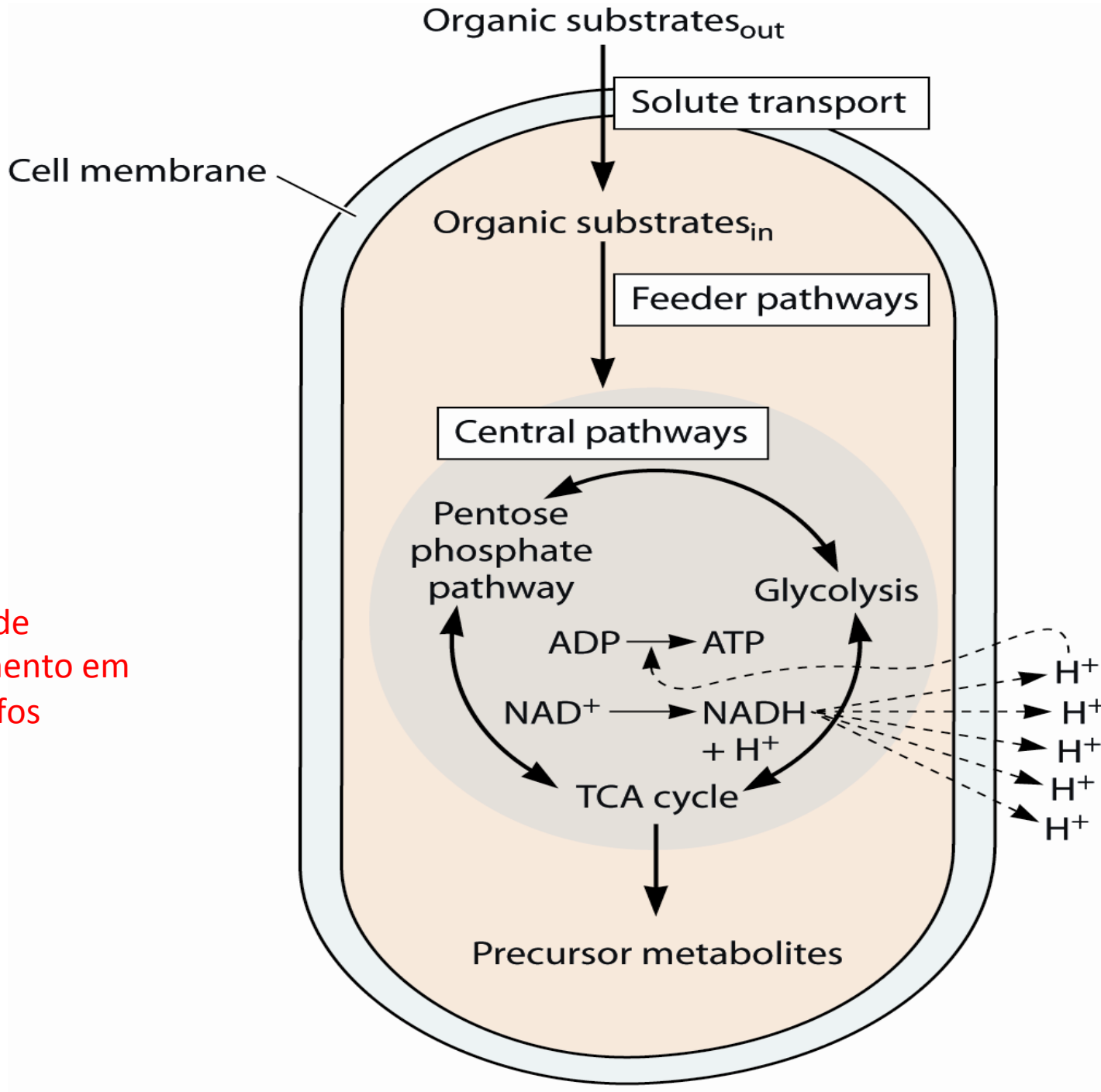


Requerem O<sub>2</sub>



Anaerobiose

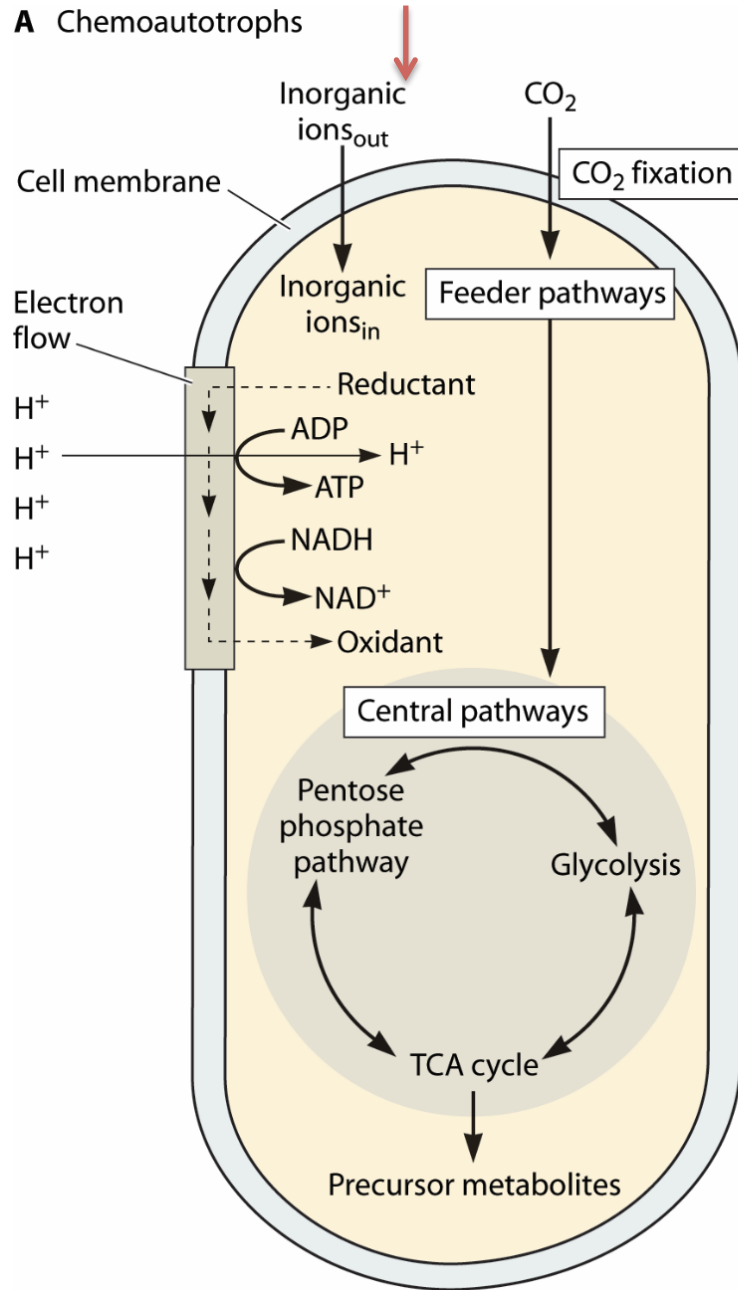




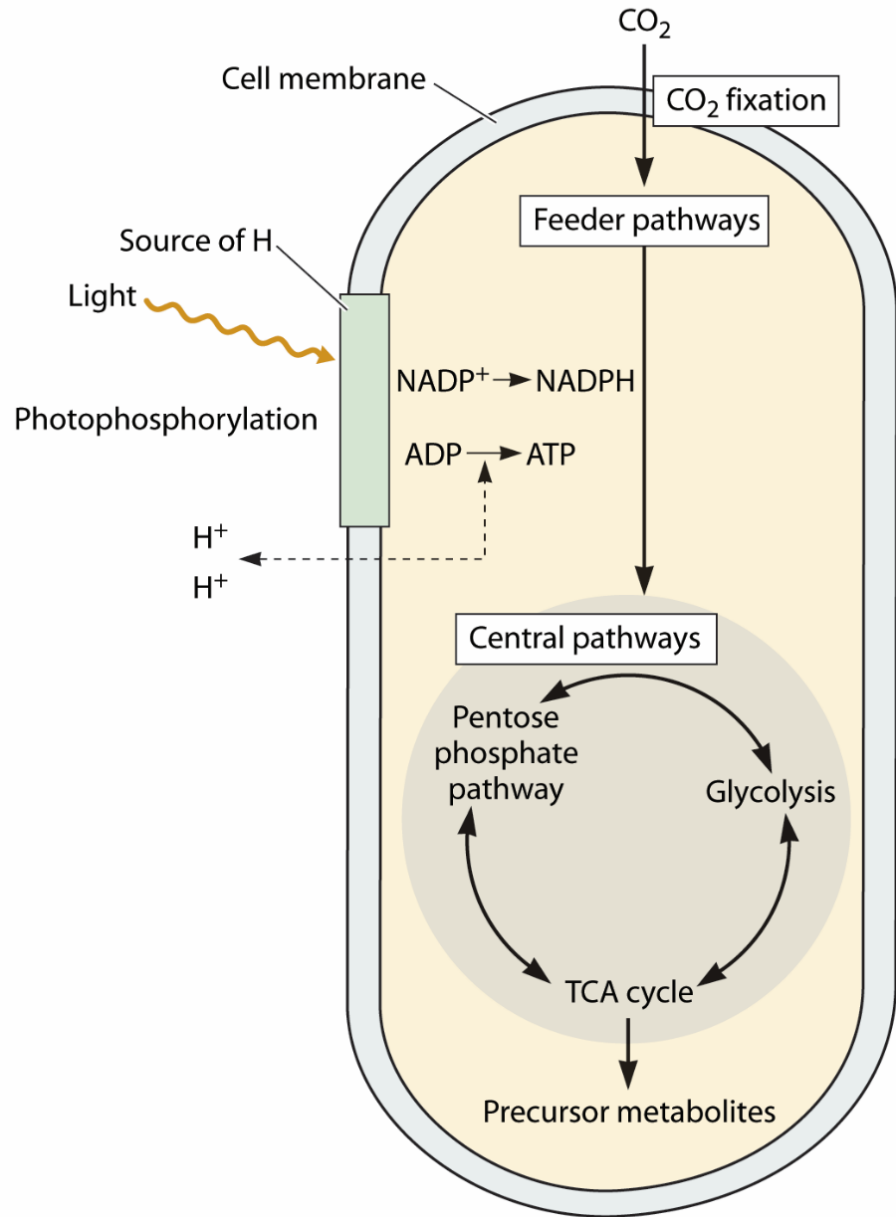
Processo de abastecimento em heterótrofos

# Processo de abastecimento em autótrofos

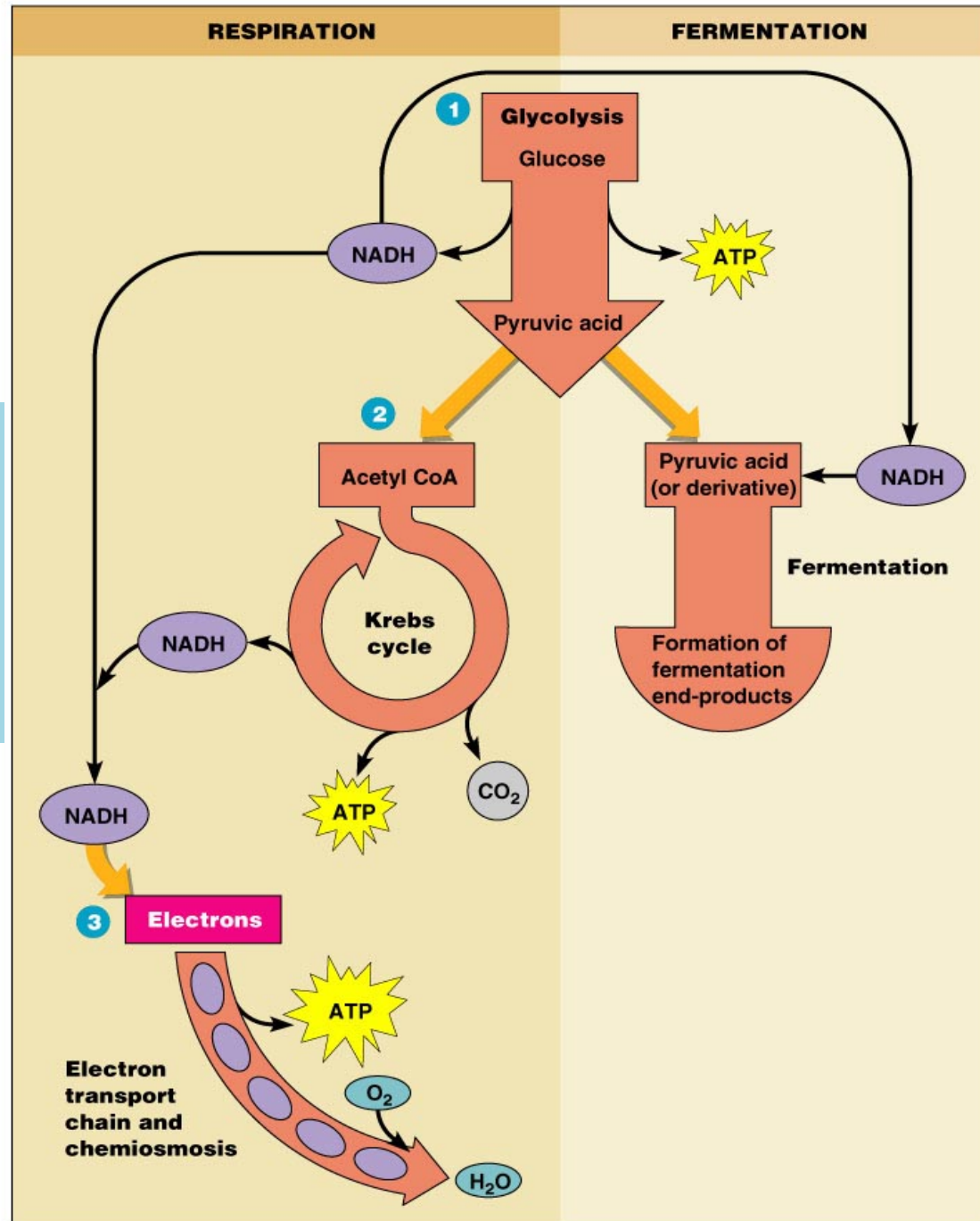
**A** Chemoautotrophs



**B** Photoautotrophs



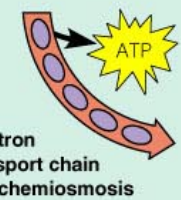
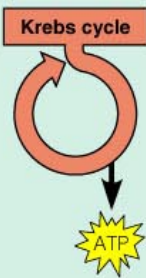
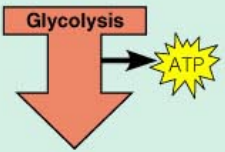
An overview of respiration and fermentation

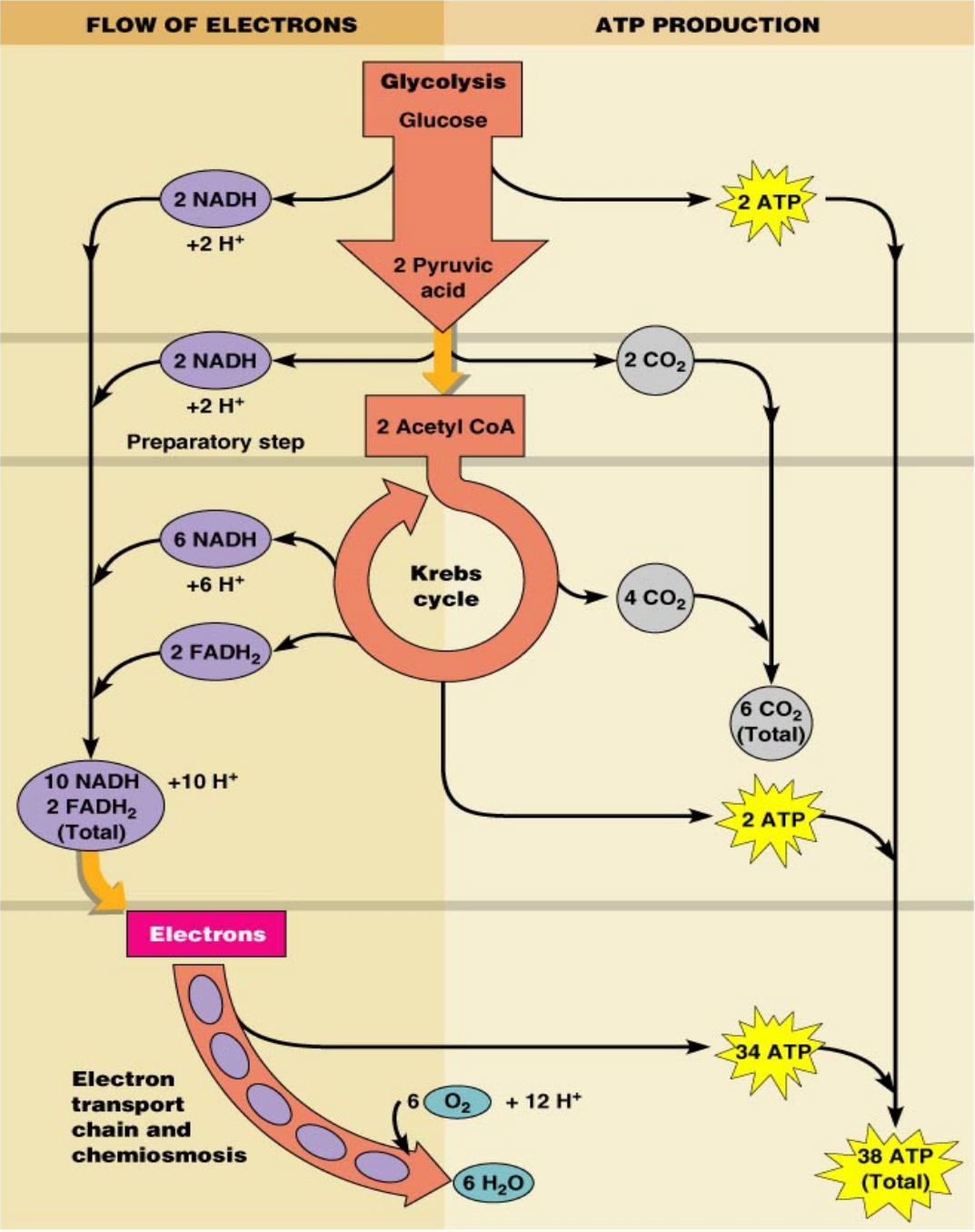


**TABLE 5.3**

**ATP Yield During Prokaryotic Aerobic Respiration of One Glucose Molecule**

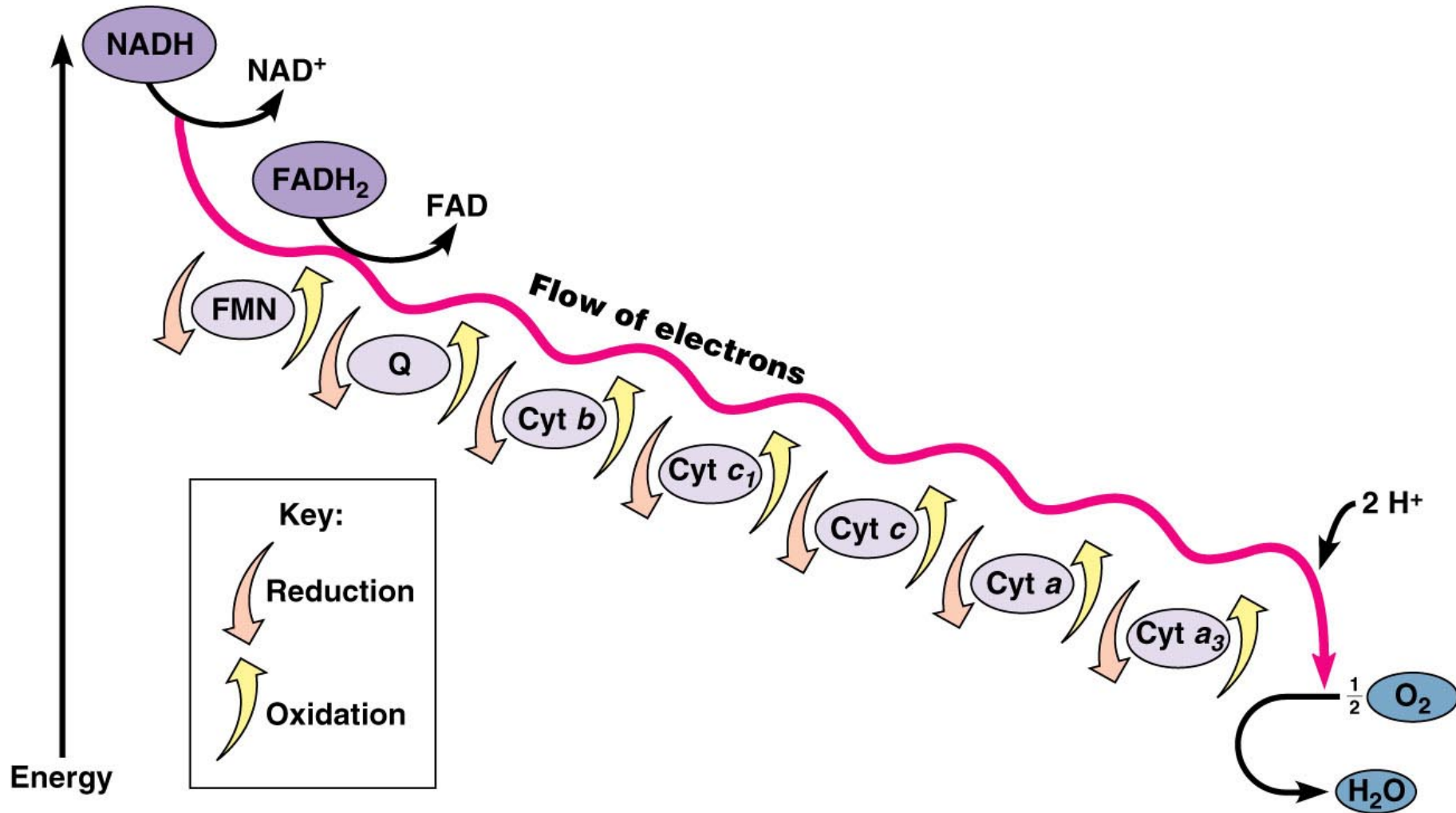
Source	ATP Yield (Method)
<p><b>Glycolysis</b></p> <ol style="list-style-type: none"> <li>1. Oxidation of glucose to pyruvic acid</li> <li>2. Production of 2 NADH</li> </ol>	<p>2 ATP (substrate-level phosphorylation)</p> <p>6 ATP (oxidative phosphorylation in electron transport chain)</p>
<p><b>Preparatory Step</b></p> <ol style="list-style-type: none"> <li>1. Formation of acetyl CoA produces 2 NADH</li> </ol>	<p>6 ATP (oxidative phosphorylation in electron transport chain)</p>
<p><b>Krebs Cycle</b></p> <ol style="list-style-type: none"> <li>1. Oxidation of succinyl CoA to succinic acid</li> <li>2. Production of 6 NADH</li> <li>3. Production of 2 FADH</li> </ol>	<p>2 GTP (equivalent of ATP; substrate-level phosphorylation)</p> <p>18 ATP (oxidative phosphorylation in electron transport chain)</p> <p><u>4 ATP</u> (oxidative phosphorylation in electron transport chain)</p>
<p>Total: 38 ATP</p>	

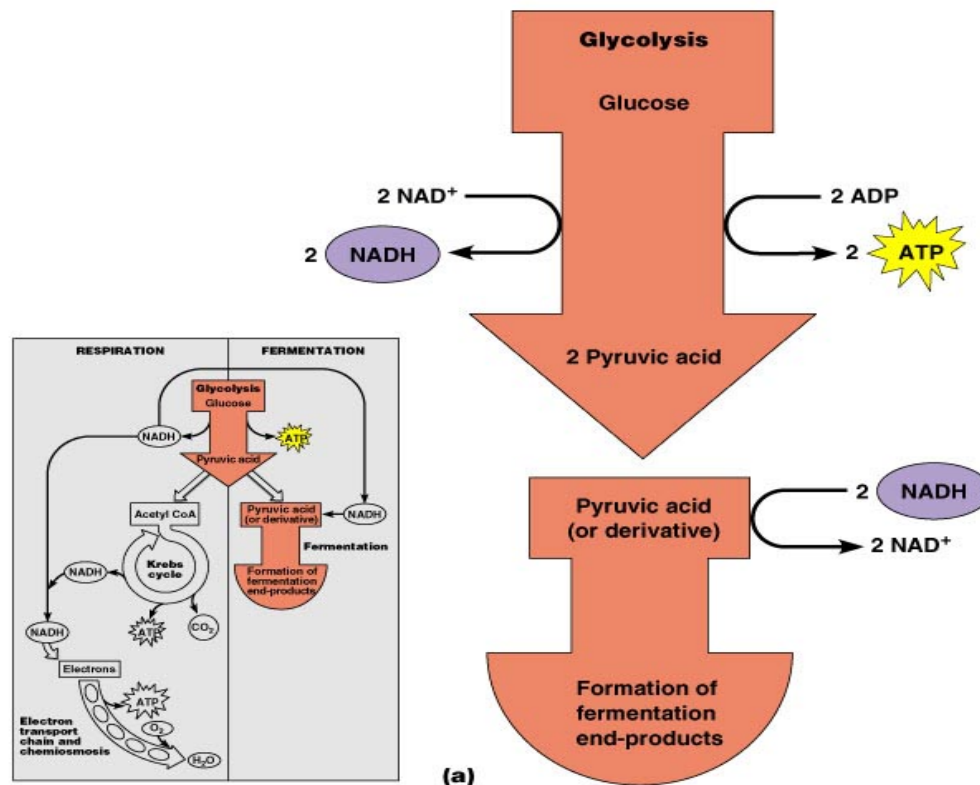






# Electron transport chain



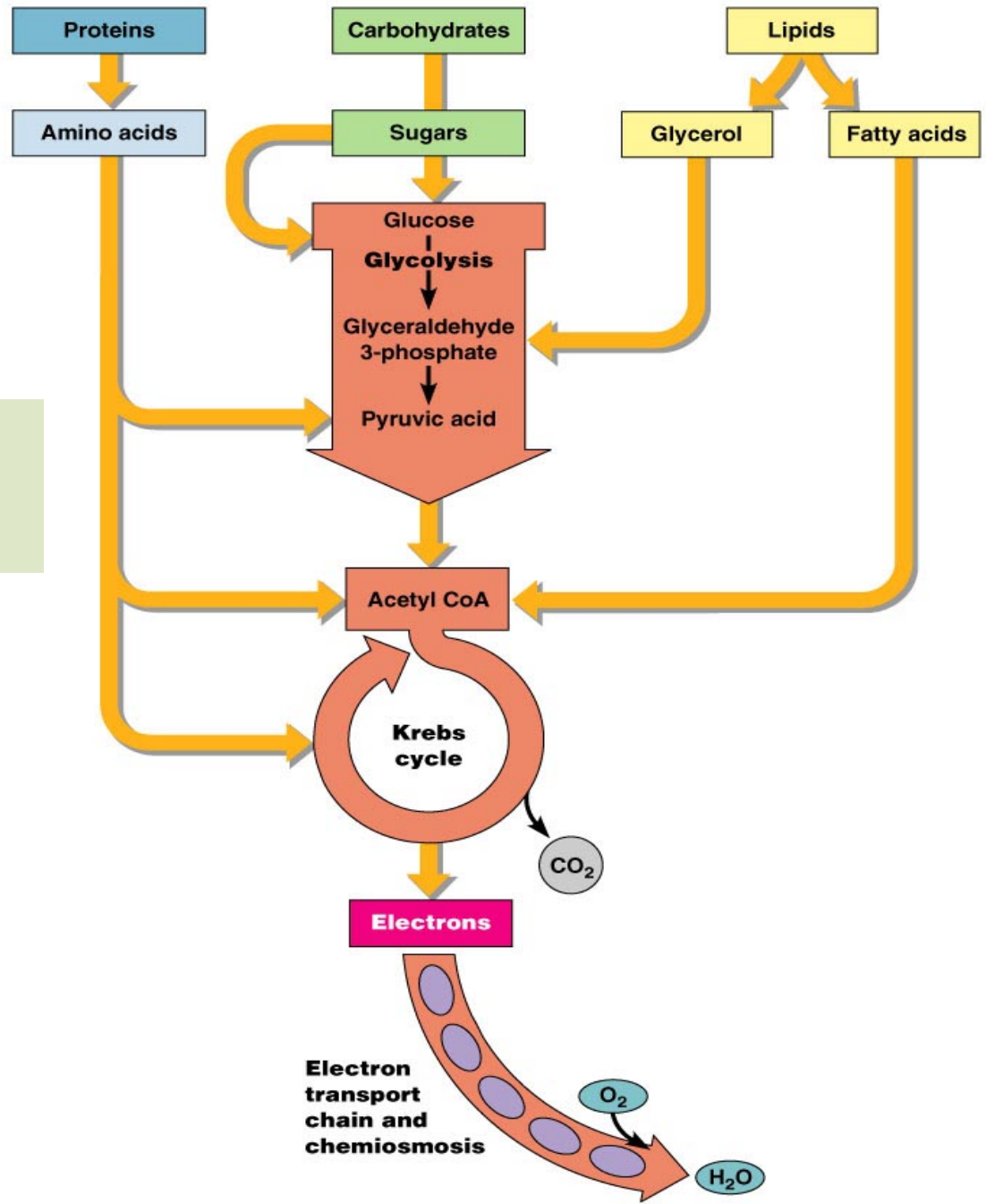


(a)

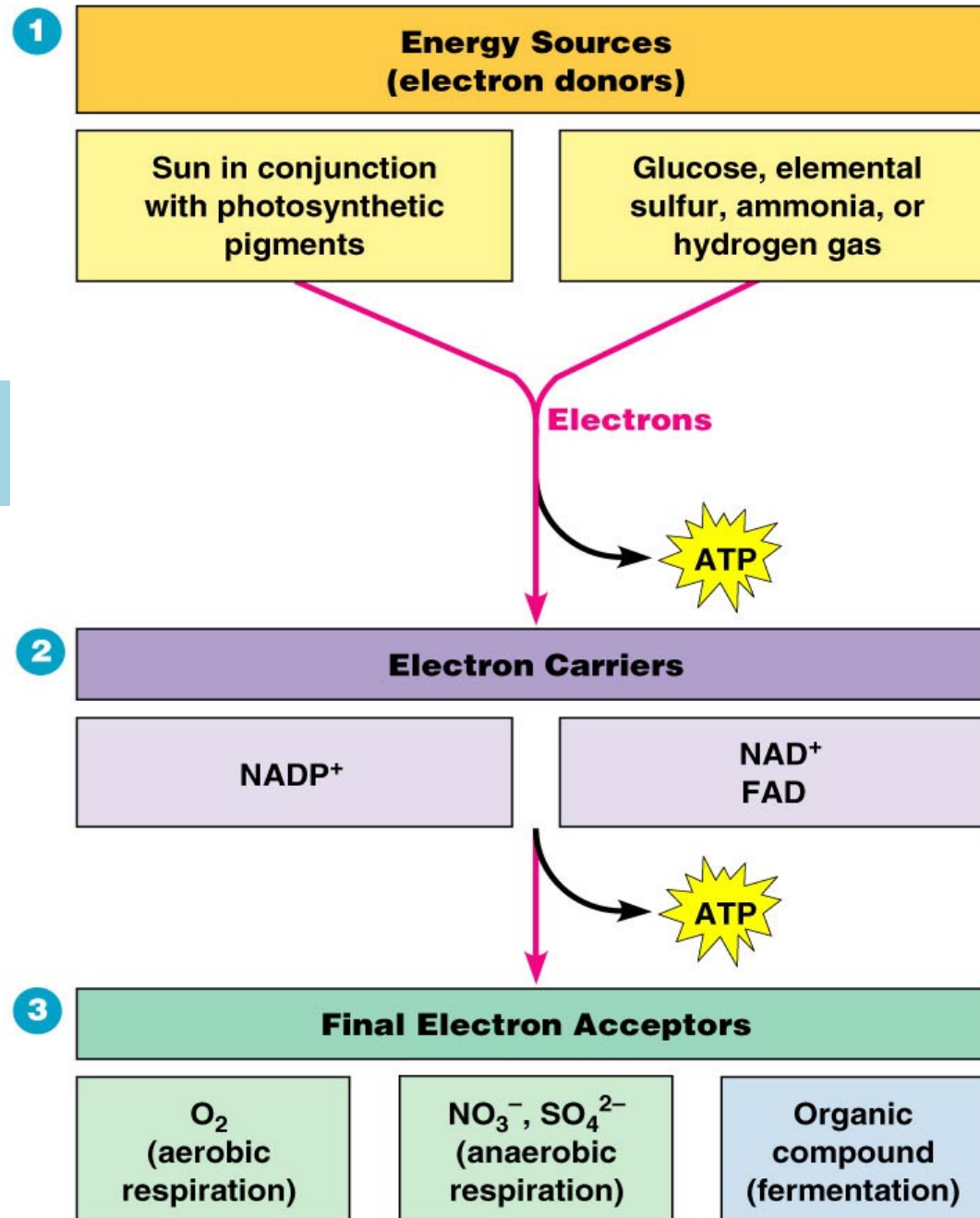
	Pyruvic Acid					
<b>Organism</b>	<i>Streptococcus, Lactobacillus, Bacillus</i>	<i>Saccharomyces</i> (yeast)	<i>Propionibacterium</i>	<i>Clostridium</i>	<i>Escherichia, Salmonella</i>	<i>Enterobacter</i>
<b>Fermentation end-product(s)</b>	Lactic acid	Ethanol and CO <sub>2</sub>	Propionic acid, acetic acid, CO <sub>2</sub> , and H <sub>2</sub>	Butyric acid, butanol, acetone, isopropyl alcohol, and CO <sub>2</sub>	Ethanol, lactic acid, succinic acid, acetic acid, CO <sub>2</sub> , and H <sub>2</sub>	Ethanol, lactic acid, formic acid, butanediol, acetoin, CO <sub>2</sub> , and H <sub>2</sub>

(b)

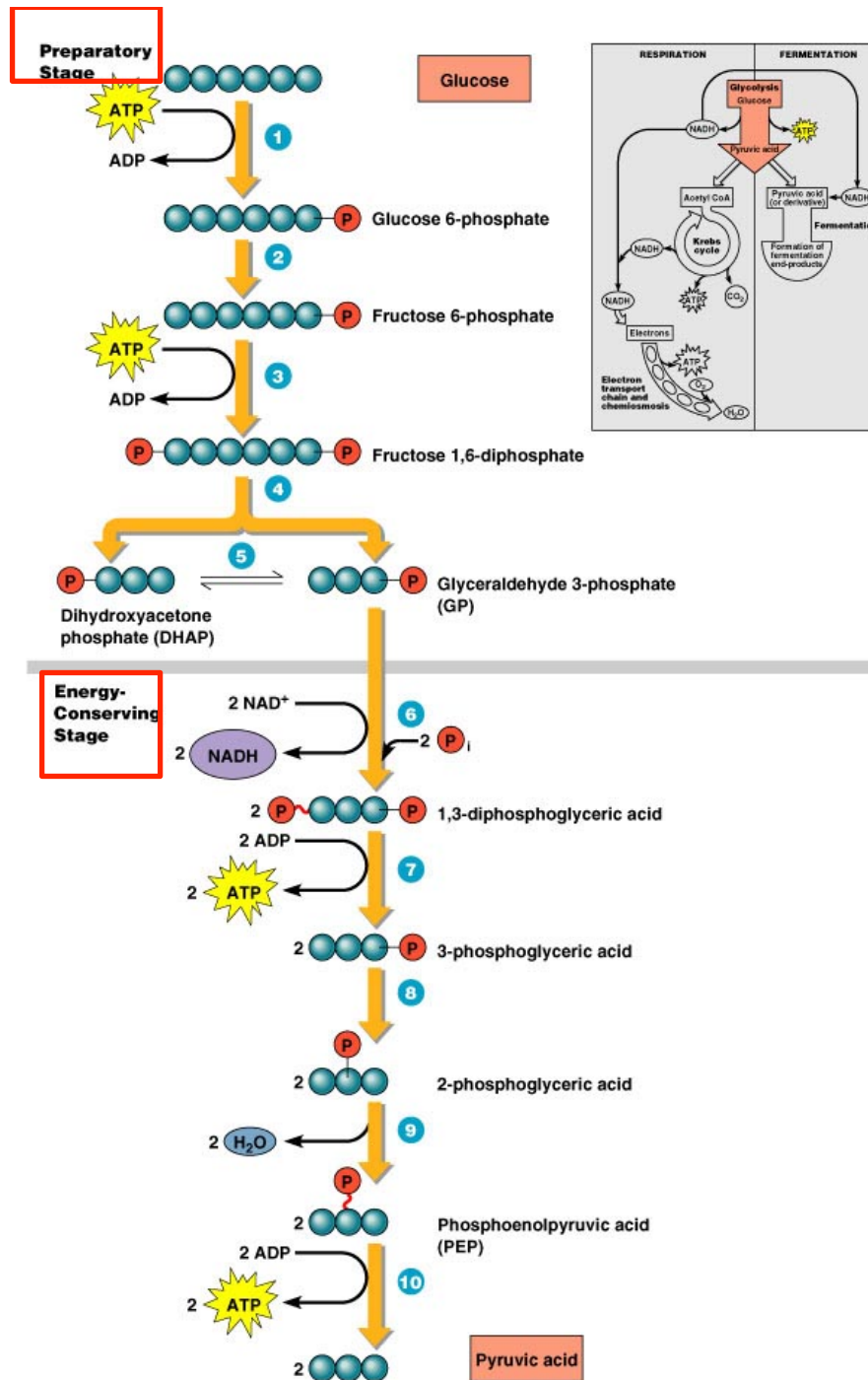
Catabolism of organic food molecules

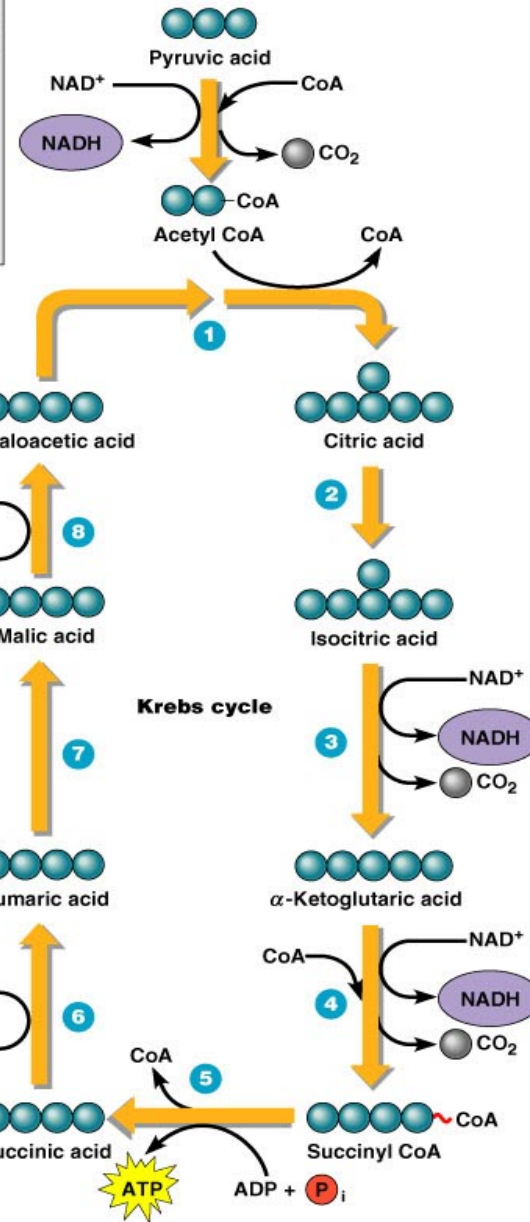
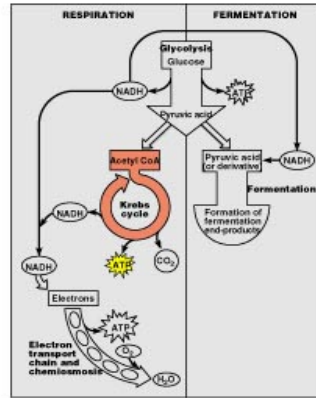


Requirements of ATP production



Reactions of glycolysis  
Embden-Meyerhof  
pathway





# The Krebs cycle