Science X-Change

Seminar III

Seminar III

- ATP-Generation via substrate level phosphorylation, electron transport phosphorylation
- CO_2 Fixation
- (Eukaryotic/prokaryotic cell)
- Bacterial cell wall
- Antibiotic resistance

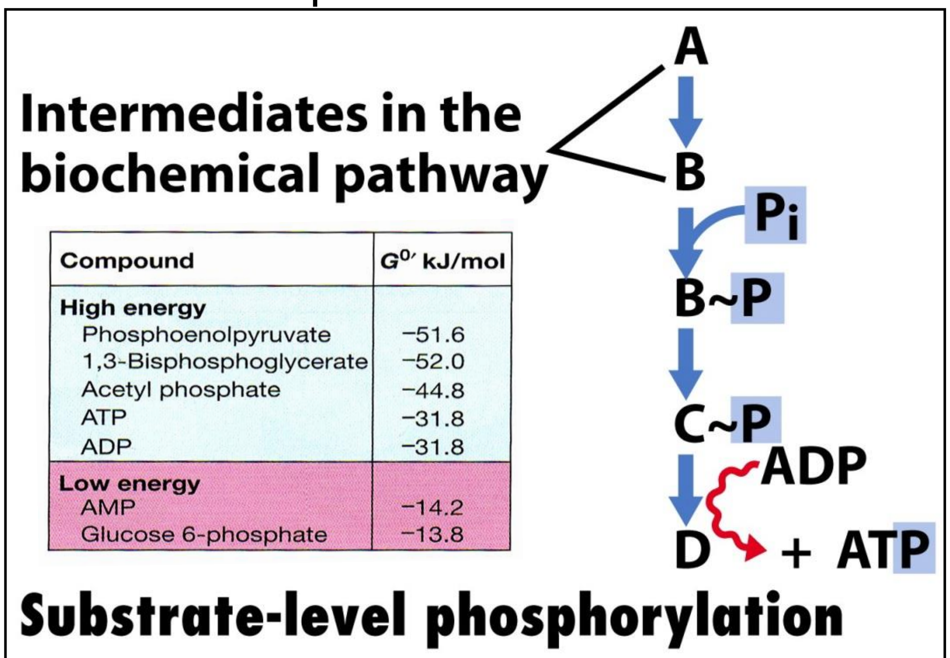
Basic Mechanisms of Energy Conservation

Substrate-level phosphorylation

Formation of energy-rich intermediates produces ATP

Elektron-transport phosphorylation

(Oxidative Phosphorylation)



Compound	$G^{0\prime}$ kJ/mol
High energy	
Phosphoenolpyruvate	−51.6
1,3-Bisphosphoglycerate	−52.0
Acetyl phosphate	−44.8
ATP	−31.8
ADP	−31.8
Low energy	
AMP	−14.2
Glucose 6-phosphate	−13.8

Figure 5-13a Brock Biology of Microorganisms 11/e

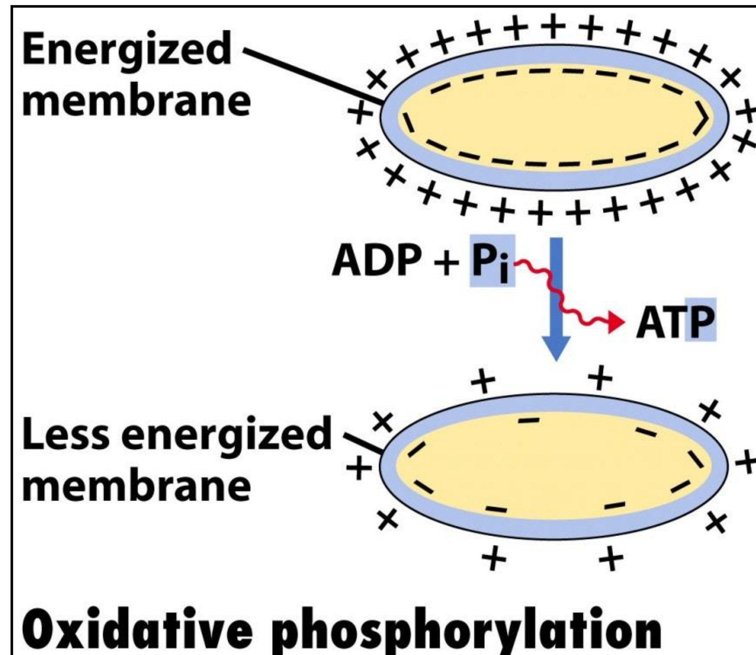
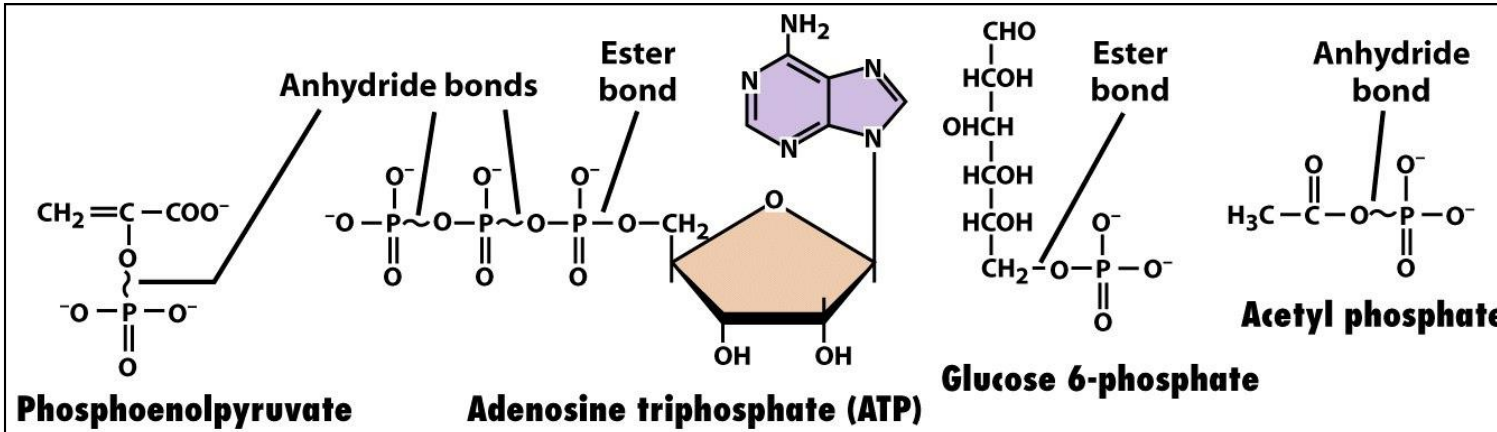
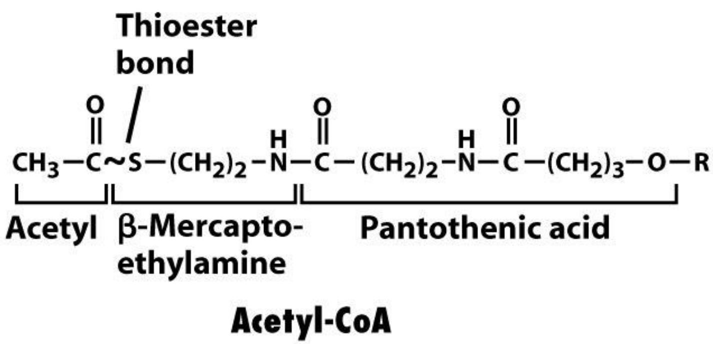


Figure 5-13b Brock Biology of Microorganisms 11/e

Fig. 5.13 Brock Biology of Microorganisms (11th edition) (Madigan et al.)

Energy-Rich Compounds





Compound	$G^{0\prime}$ kJ/mol
$\Delta G^{0\prime} > 30$kJ	
Phosphoenolpyruvate	−51.6
1,3-Bisphosphoglycerate	−52.0
Acetyl phosphate	−44.8
ATP	−31.8
ADP	−31.8
Acetyl CoA	−31
$\Delta G^{0\prime} < 30$kJ	
AMP	−14.2
Glucose 6-phosphate	−13.8

Figure 5-12 Brock Biology of Microorganisms 11/e

Chemiosmotic Model

- In this simple representation of the chemiosmotic theory applied to mitochondria, electrons from NADH and other oxidizable substrates pass through a chain of carriers arranged asymmetrically in the inner membrane.
- Electron flow is accompanied by proton transfer across the membrane, producing both a chemical gradient (ΔpH) and an electrical gradient (Δψ).
- The inner mitochondrial membrane is impermeable to protons; protons can reenter the matrix only through proton-specific channels (F_o). The **proton-motive force (PMF)** that drives protons back into the matrix provides the energy for ATP synthesis, catalyzed by the F_1 complex associated with F

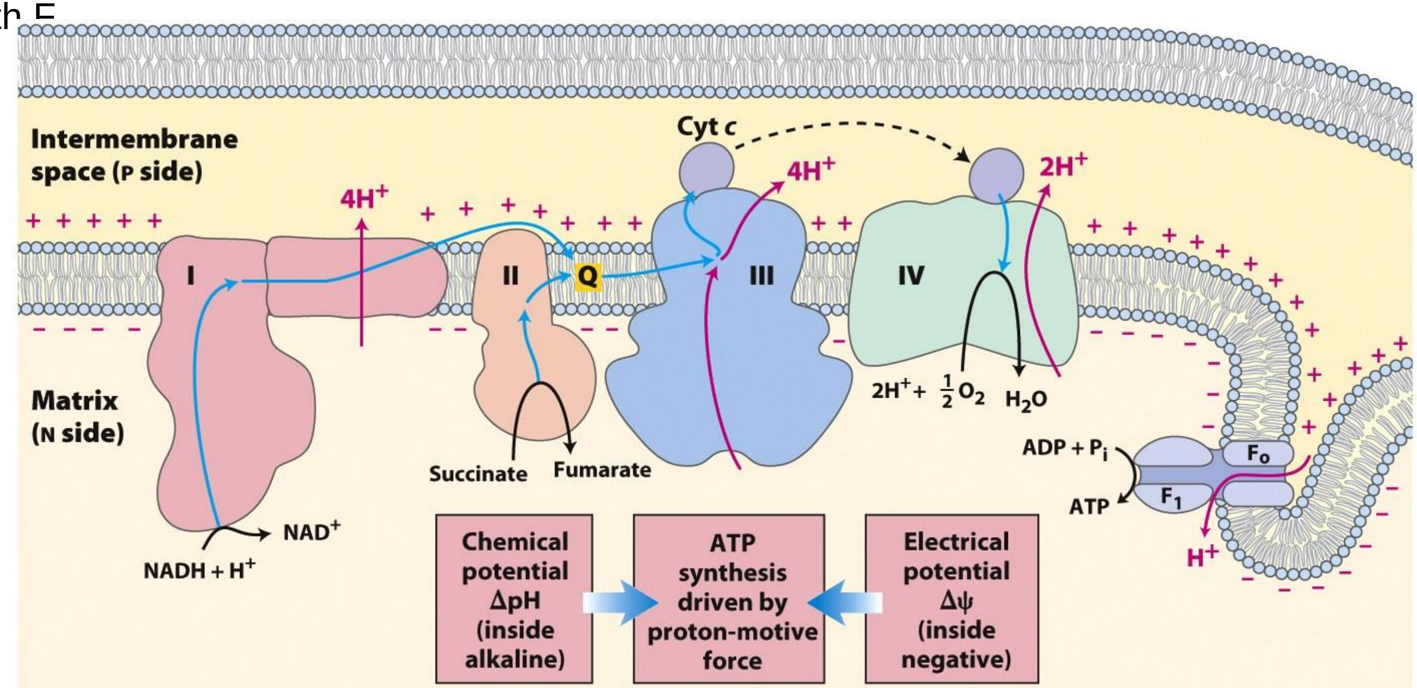


Figure 19-19
Lehninger Principles of Biochemistry, Fifth Edition

PMF Energized Membrane

Proton-motive force (PMF)

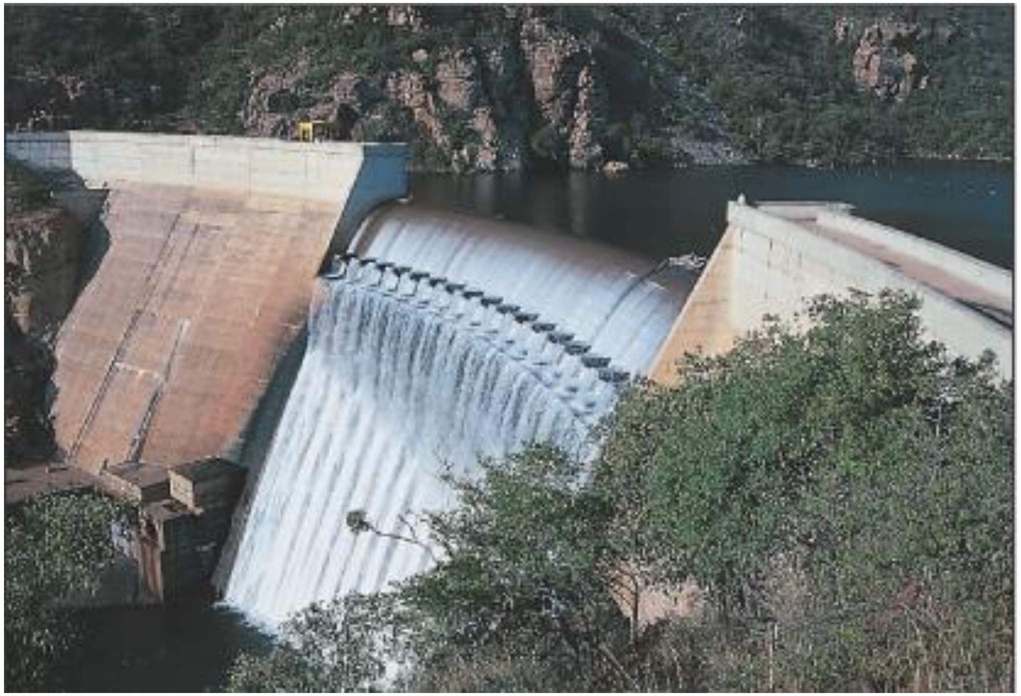


Figure 12-11 Essential Cell Biology, 2/e. (© 2004 Garland Science)

ATP-Synthase/ATPase

-reversibel

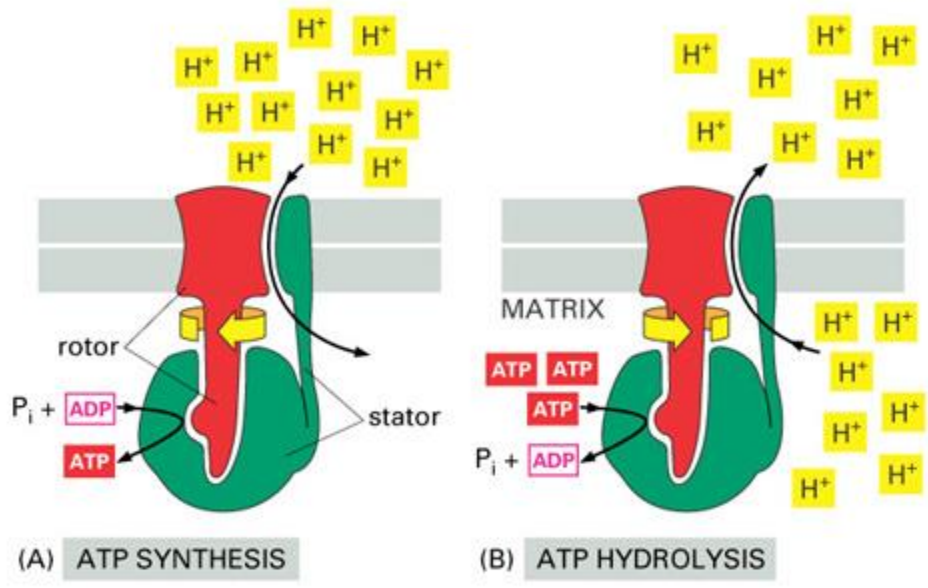
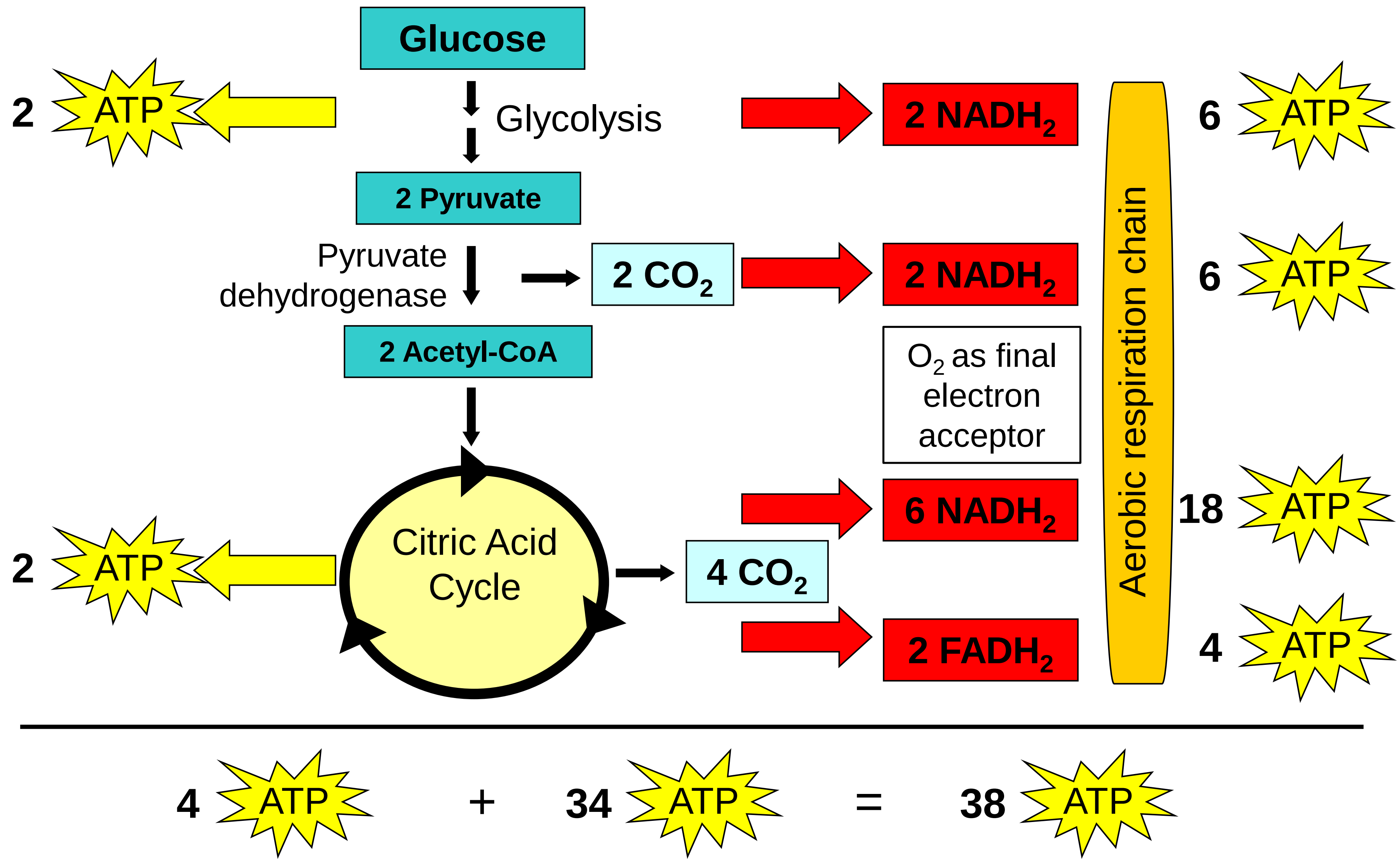


Figure 14-15 Essential Cell Biology, 2/e. (© 2004 Garland Science)

Fig. 14.15 Essential Cell Biology (2nd edition, Alberts, Bray et al.)

Energetics of Carbohydrate Metabolism (Aerobic Respiration)



Aerobic Respiration „Eucaryotes“

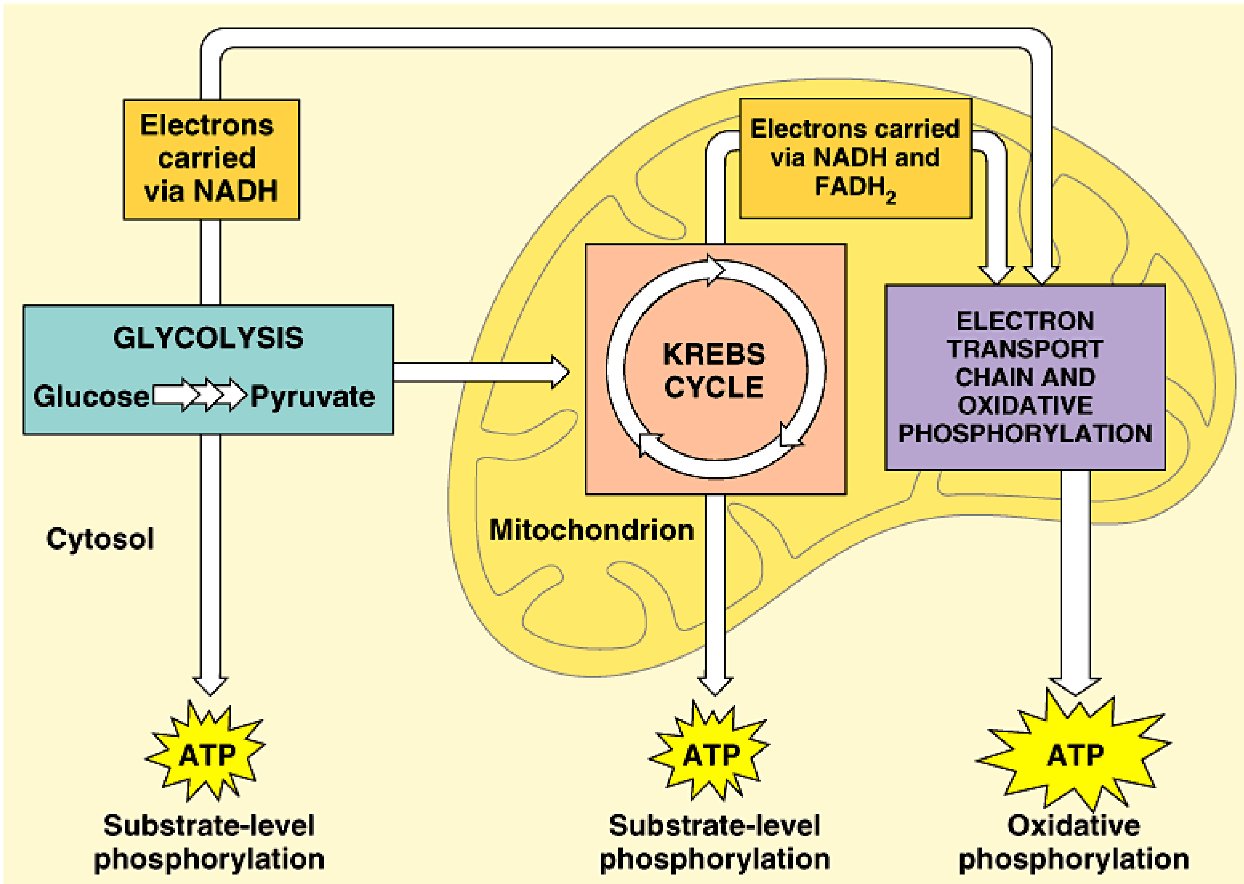


Abb. 9.6 **Die Zellatmung im Überblick.**
Biologie (Campbell)

Regulation

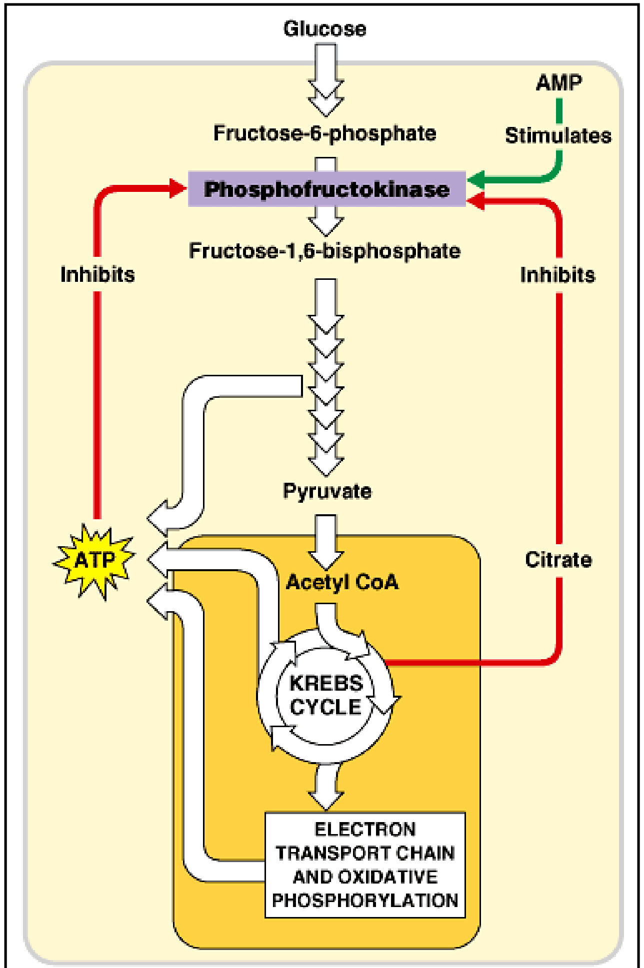


Fig. 9.20 **Die Kontrolle der Zellatmung.**
Biology (6th edition, Campbell & Reece)

Conversion of different Nutrients

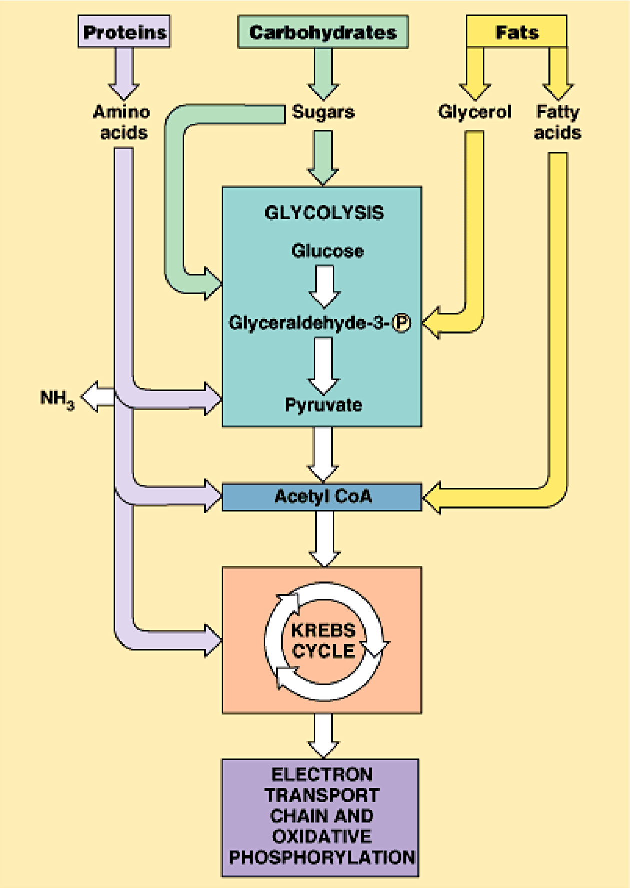


Fig. 9.19 **Catabolism of different nutrients.**
Biology (6th edition, Campbell & Reece)

„Platform Metabolism“ Anabolism

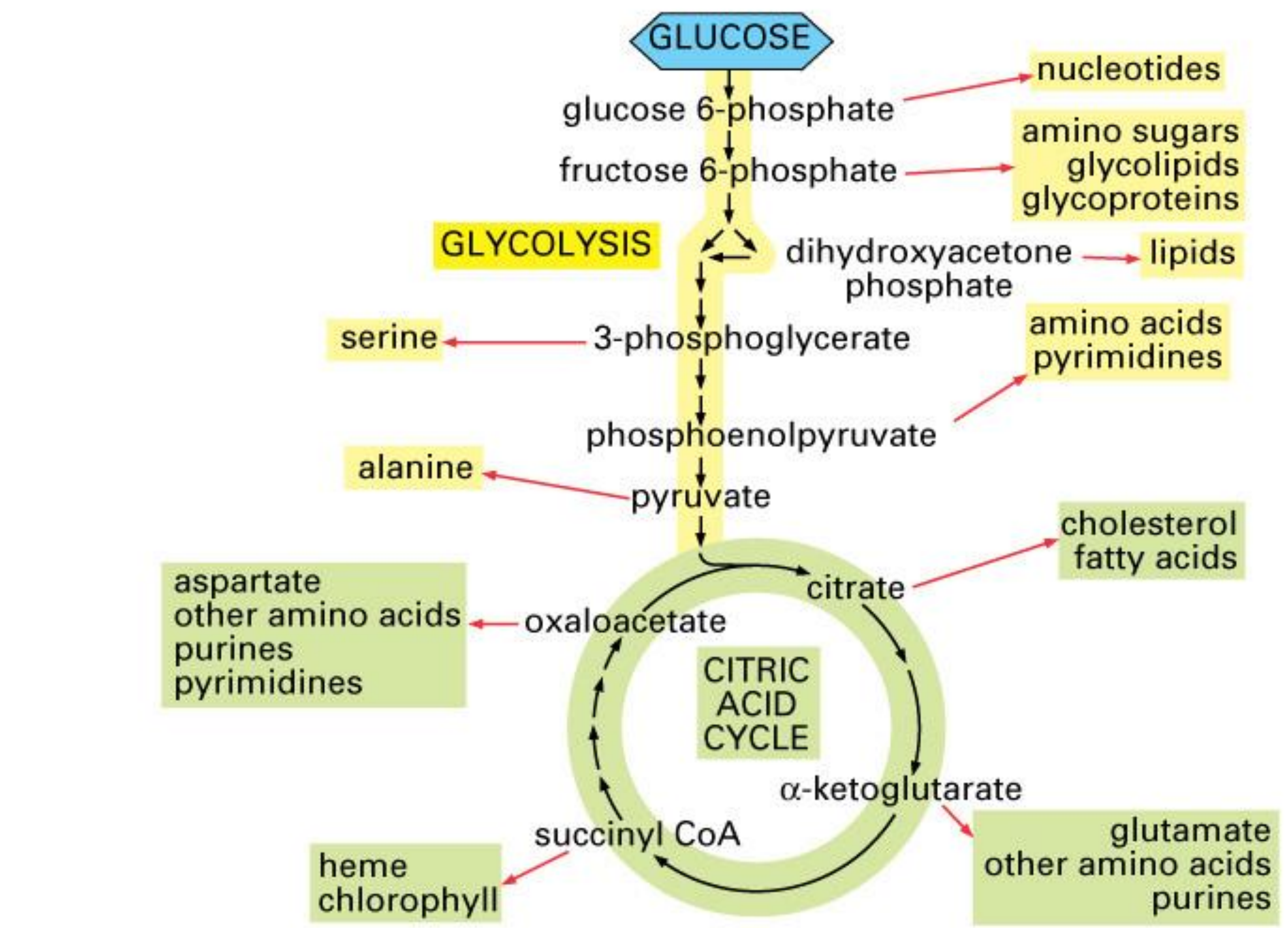


Figure 13-23 **Essential Cell Biology, 2/e. (© 2004 Garland Science)**

Fermentation

Atmung/Fermentation

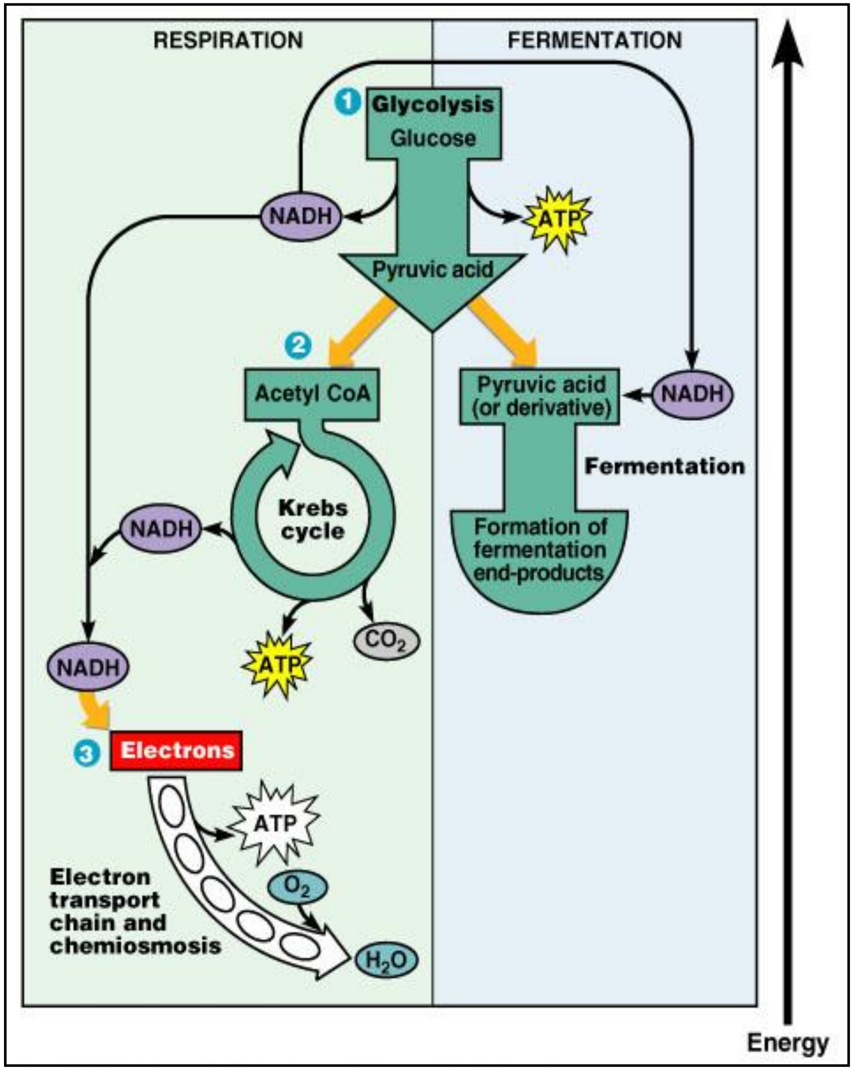
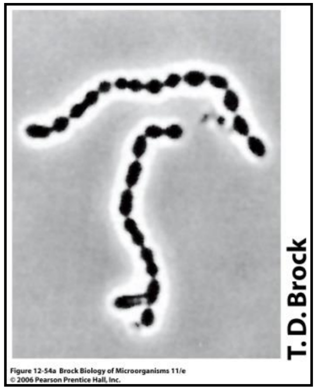
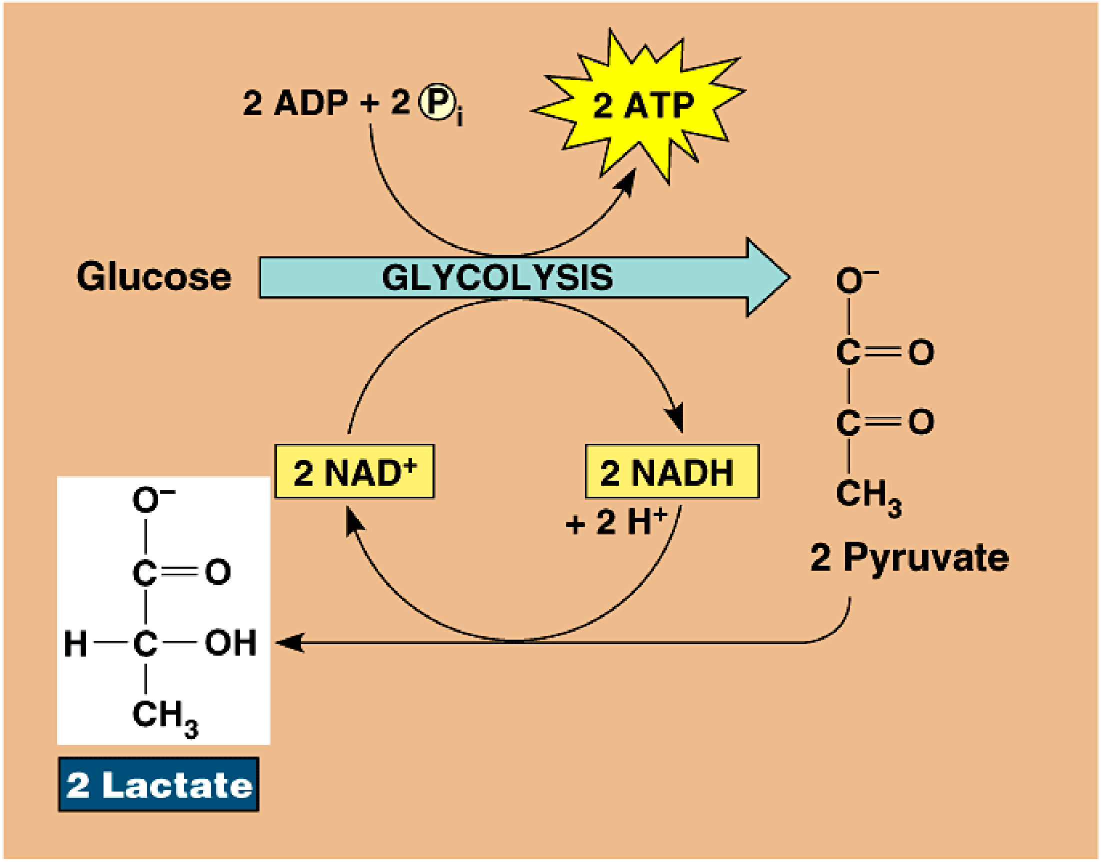


Fig. 5.14 Microbiology: An Introduction (Tortora, Funke, Case)

Lacitc Acid Fermentation



Lactococcus lactis



(b) Lactic acid fermentation

Anaerobic Respiration

- **Alternative electron acceptors in absence of oxygen**
- **Energy source**:

  mostly organic compounds (chemoorganotrophic org.); but also inorganic compounds (chemolithotrophic org.)
- **Electron acceptors**:

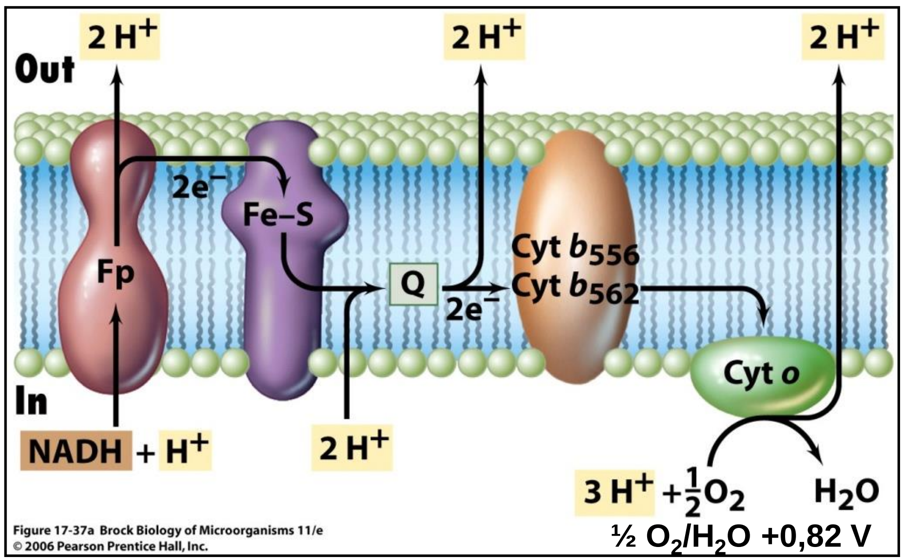
  Inorganic compounds, NO_3^-, SO_4^{2-}, Fe^{3+}, NO_2^-, S^0, CO_2
- **Electron transport chain**:

  analogue to the aerobic chain (Cytochrome, Quinone, Fe-S Proteine)
- **Facultative aerobes/anaerobes** with aerobic and anaerobic respiration;
- **Obligate anaerobes** only anaerobic respiration

Nitrate Reduction (*E. coli*)

- **Enterobacteriaceae** (e.g. *E. coli*)
- **Facultative anaerobic** Bacteria (anaerobic fermentation)
- Only **reduction of nitrate to nitrite** (nitrate reductase A)

aerob



anaerob (NO_3^-)

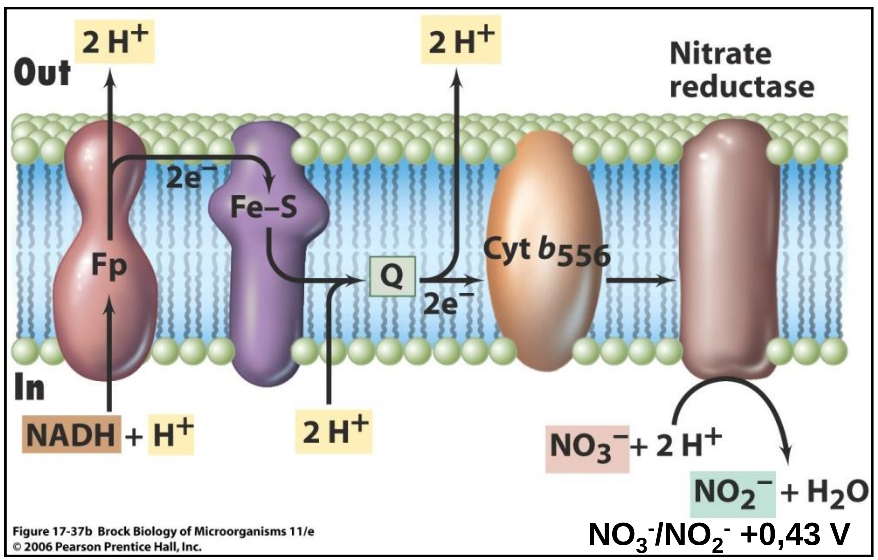


Fig. 17.37 **Vergleich aerobe und Nitrat Atmung.**
Brock Biology of Microorganisms (10th edition) (Madigan et al.)

Knallgas-Bacteria

- Biologic knallgas-reaktion „Oxidation of hydrogen“

$H_2 + ½ O_2 \rightarrow H_2O$ $\Delta G^{0‘}$=-237 kJ

„Hydrogenase“
- Different Bacteria:
  - G⁻: *Pseudomonas, Alcaligenes, Paracoccus,*
  - G⁺: *Nocardia, Mycobacterium, Bacillus*
- Hydrogenase (membrane-bound) „Electron transport“; some organisms in addition soluble hydrorgenase „direct reduction of NAD^+“
- Chemolithoautotrophe „CO_2 fixation via calvin cycle“
- Chemoorganotrophic growth (Calvin cycle and hydrogenase repressed)

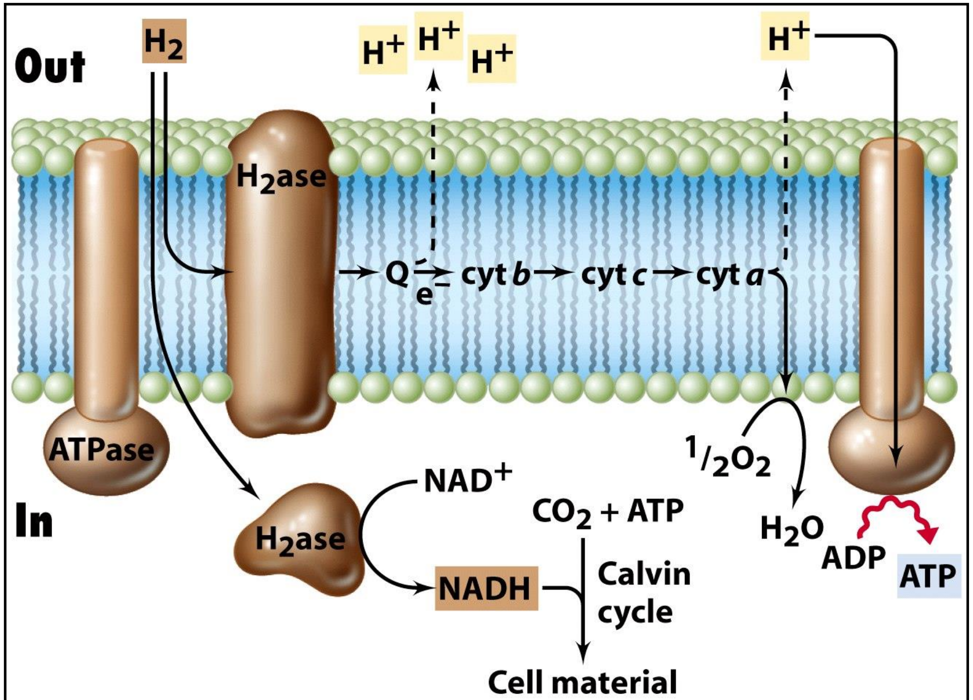


Figure 17-25 Brock Biology of Microorganisms 11/e

Photosynthesis
Light- and Dark- Reaction

Calvin cycle
Melvin Calvin (1940)

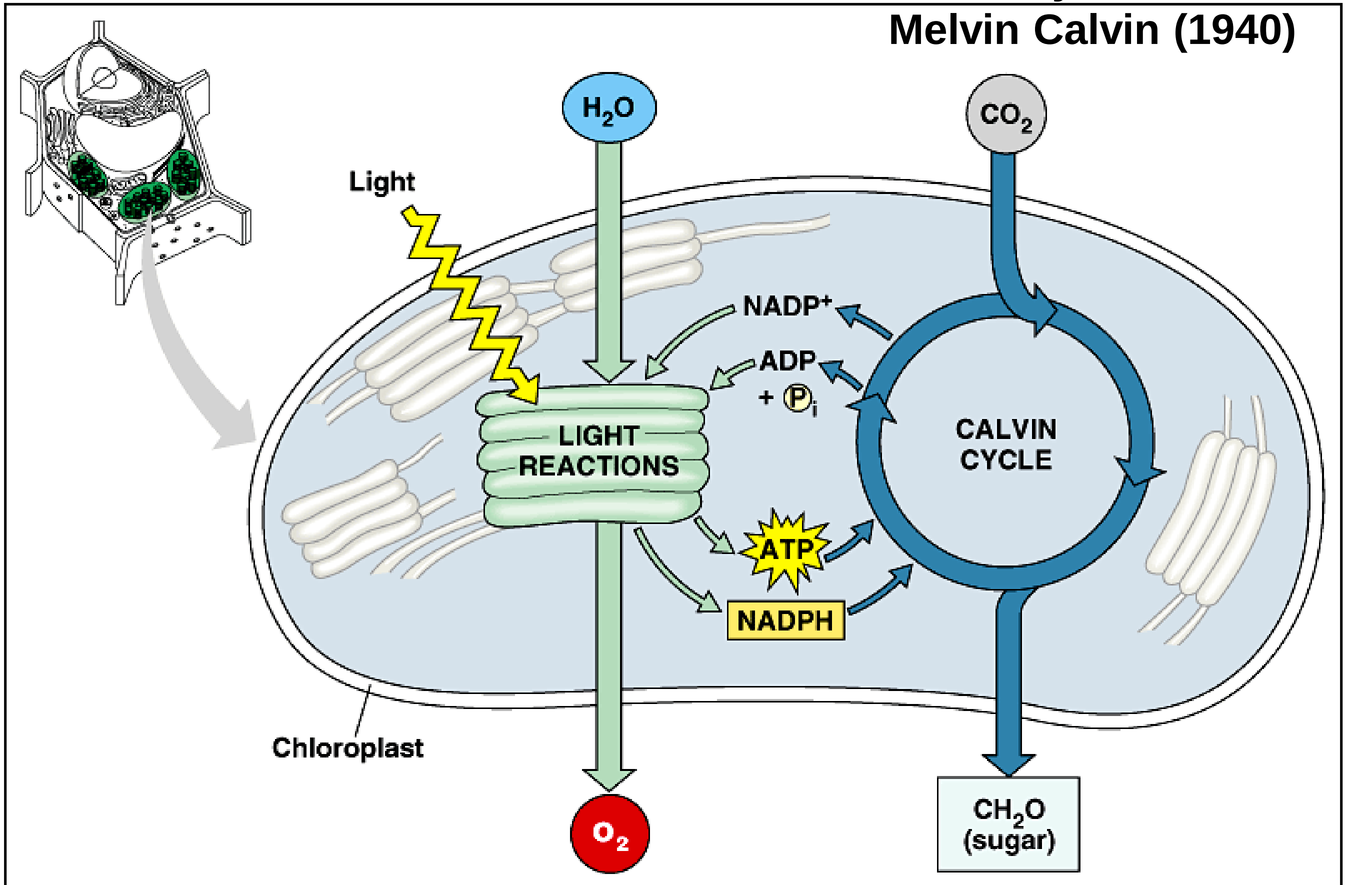


Fig. 10.4 Biology (6th edition, Campbell & Reece)

Non-cyclic Photophosphorylation

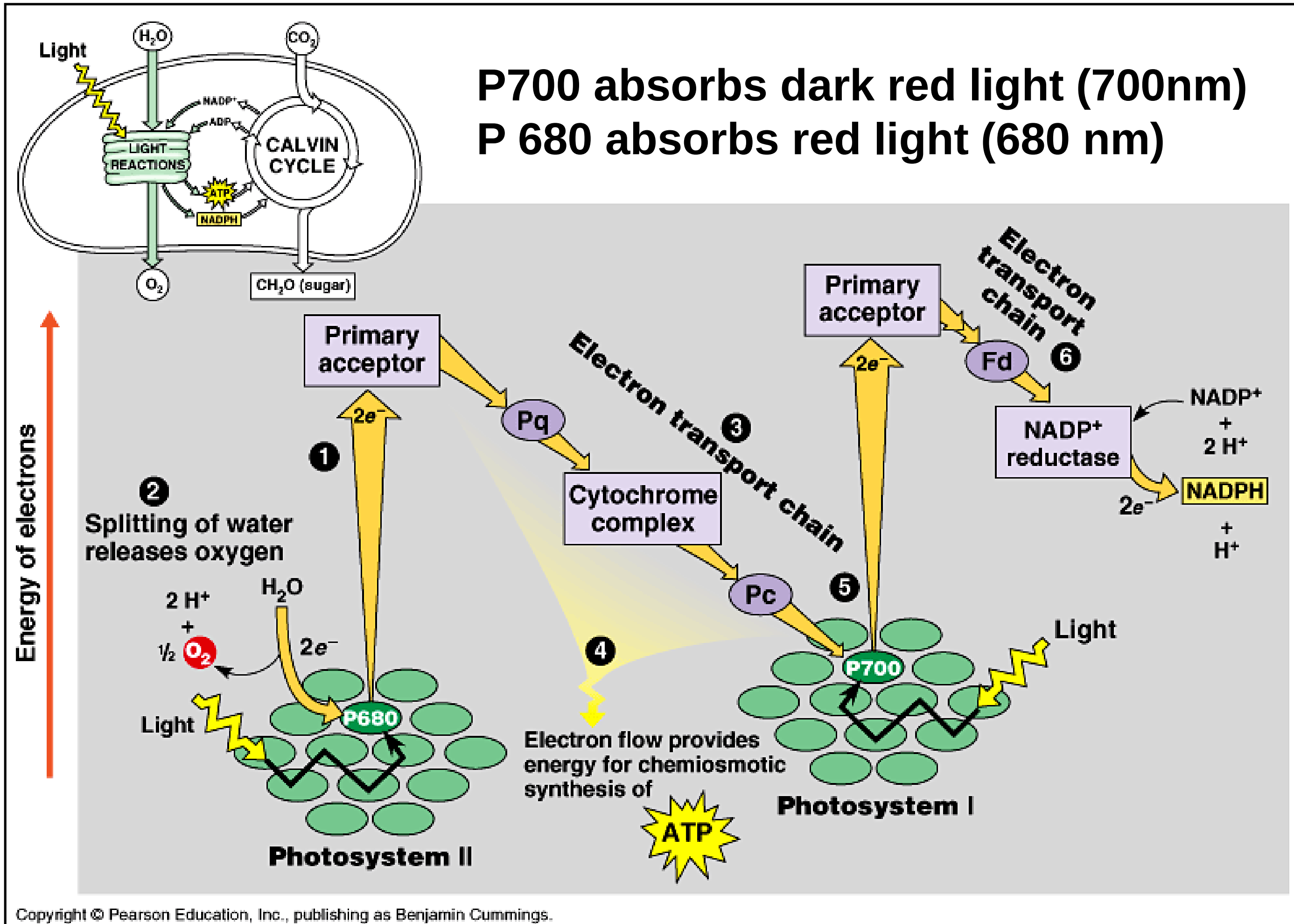


Fig. 10.12 Biology (6th edition, Campbell & Reece)

Plastoquinone (Pq), Cytochrome b_6-f-complex (proton pump), Plastocyanin (Pc, Cu^{2+}-Protein)

The Light Reaction and Chemiosmosis

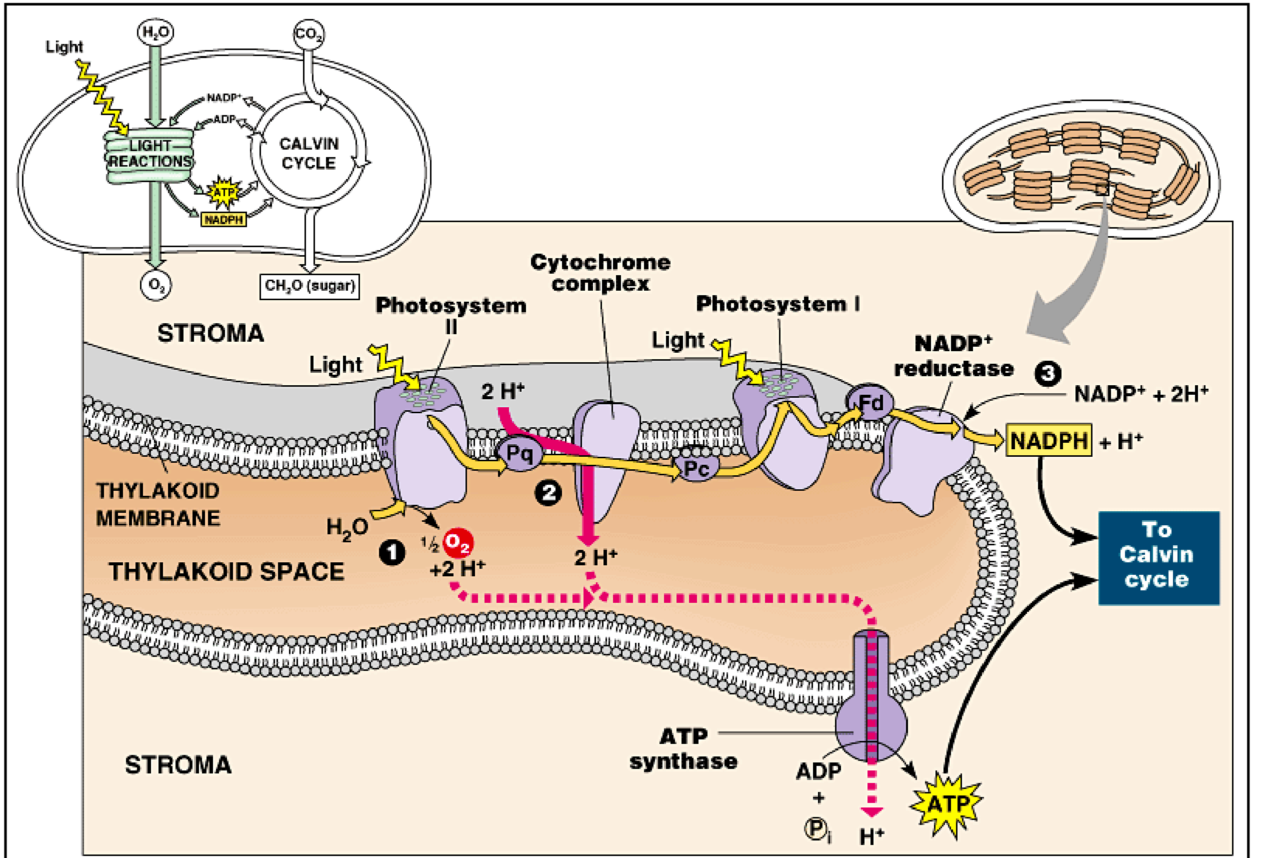


Fig. 10.16 Biology (6th edition, Campbell & Reece)

Comparison of Chemioosmosis in Mitochondrion and Chloroplast

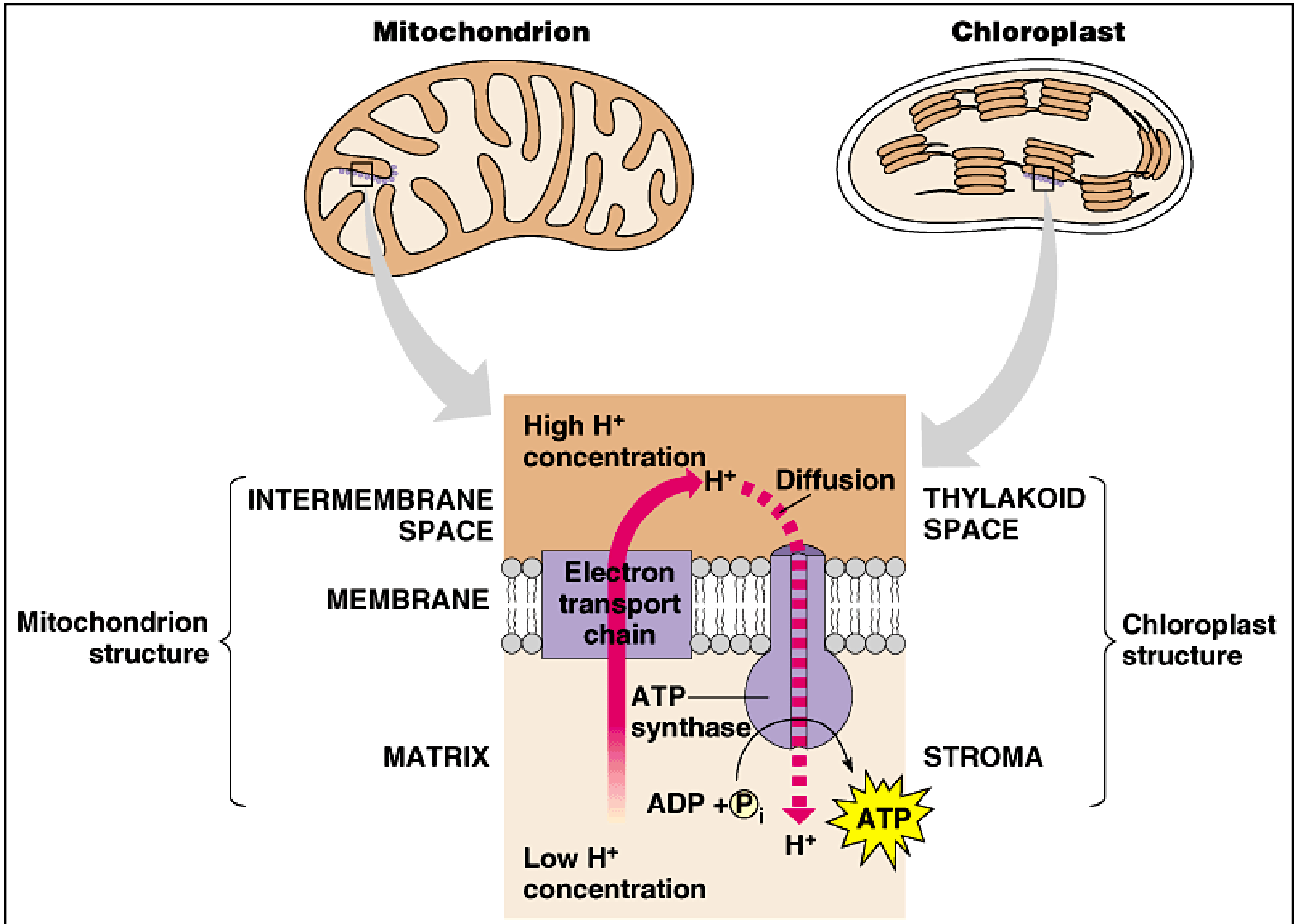


Fig. 10.8 Biology (6th edition, Campbell & Reece)

CO_2 Fixation

CO_2 fixation pathway	ATP requirement/ pyruvate	Relation to O_2	Advantages
Calvin cyle	7 ATP	aerobes	Products = sugars, seperated from other metabolic pathways
Reductive citric acid cycle	2(-3) ATP	anaerobes, microaerobes	Suited for microaerobic conditions, revers: Oxidation of acetyl-CoA
Reductive acetyl-CoA pathway	1 ATP	strict anaerobes	Suited for the assimilation of C1 units
3-hydroxypropionate pathway	7 ATP	aerobe	Suited for mixotrophic assimilation of fermentation products

The Calvin Cycle „Dark-Reaction“

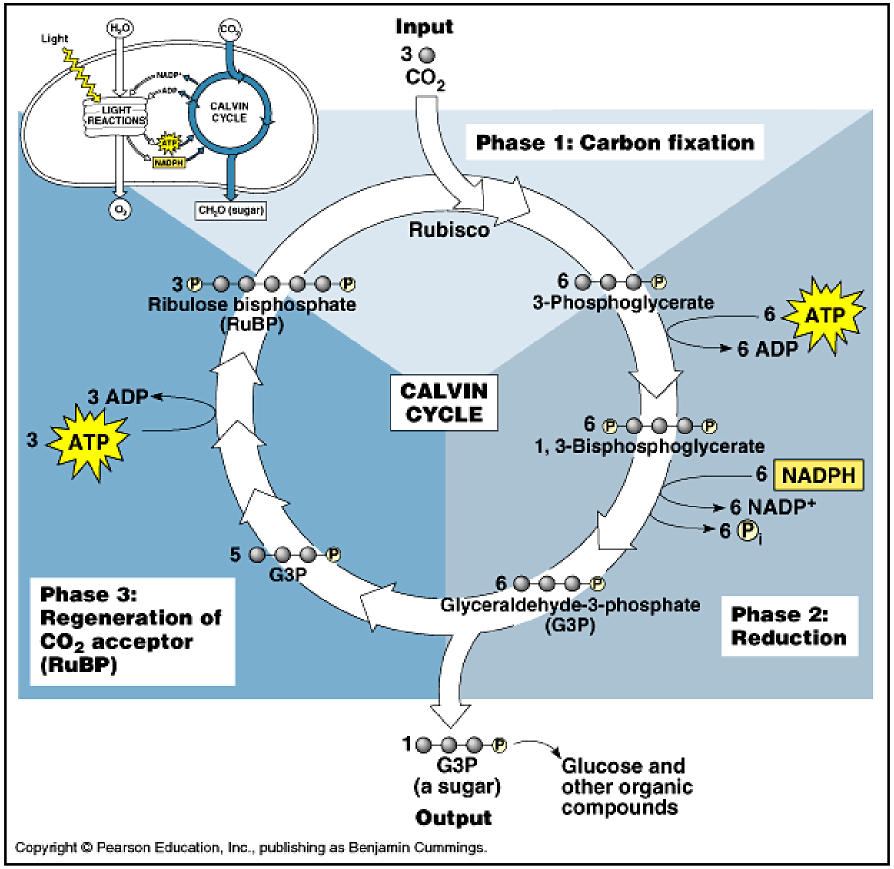


Fig. 10.17 Biology (6th edition, Campbell & Reece)

Key Reactions of the Calvin Cycle
(Reductive Pentose Phosphate Cycle)

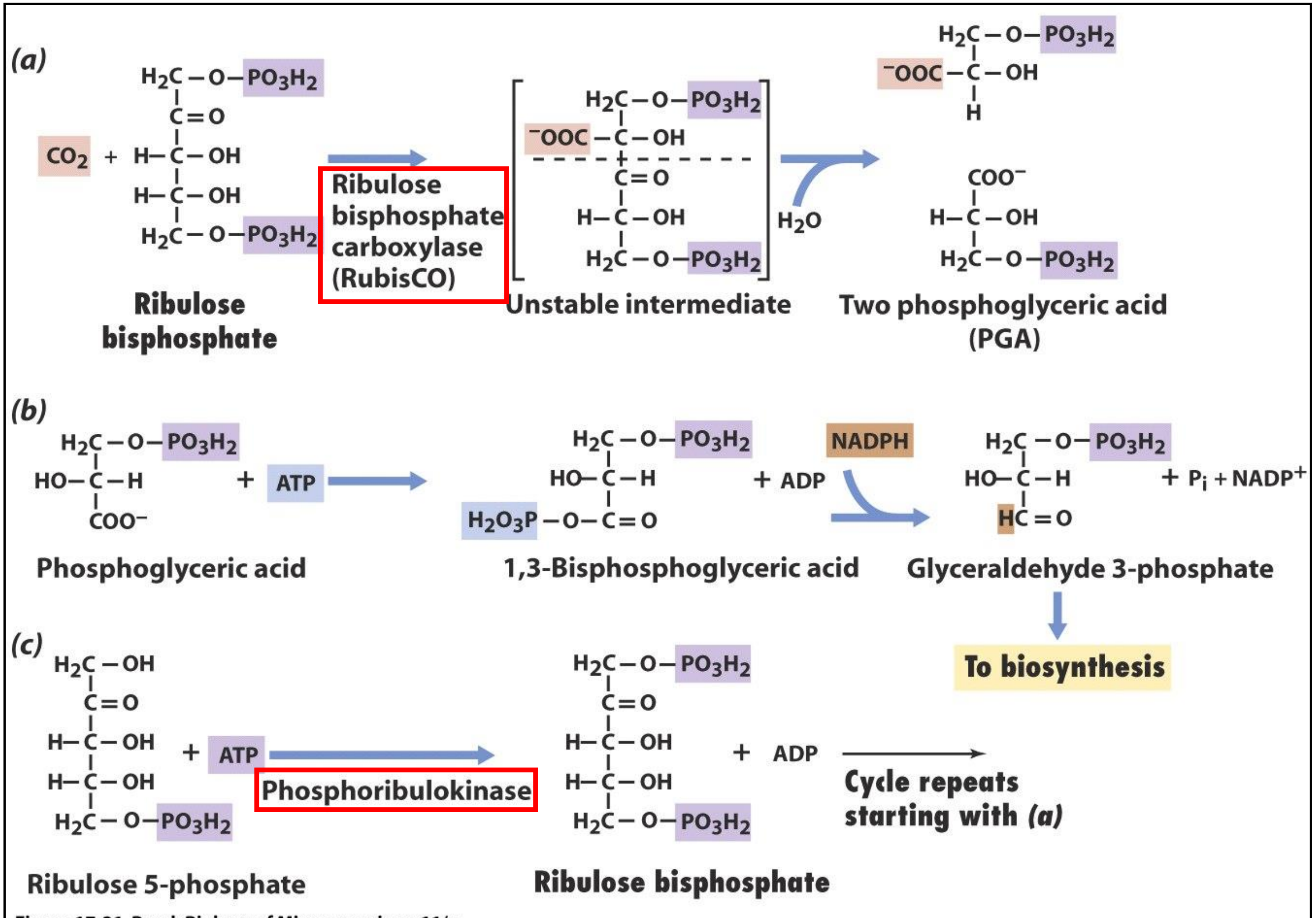
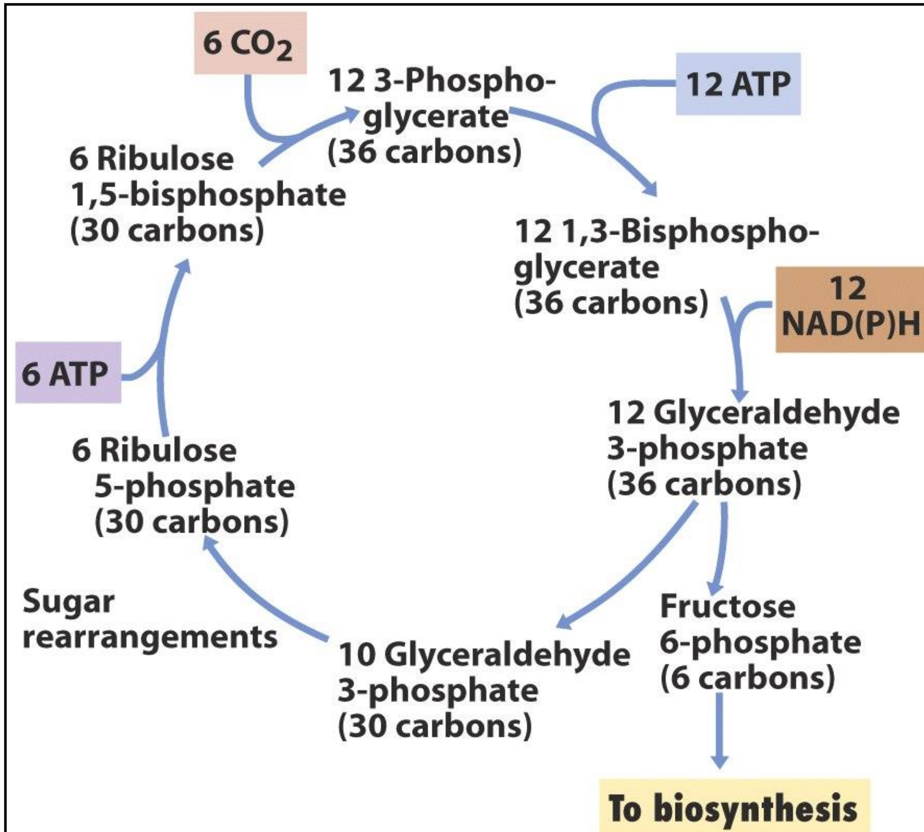


Figure 17-21 Brock Biology of Microorganisms 11/e

Balance of the Calvin Cycle



Overall stoichiometry:

$$6\ CO_2 + 12\ NADPH + 18\ ATP \longrightarrow C_6H_{12}O_6(PO_3H_2) + 12\ NADP^+ + 18\ ADP + 17\ P_i$$

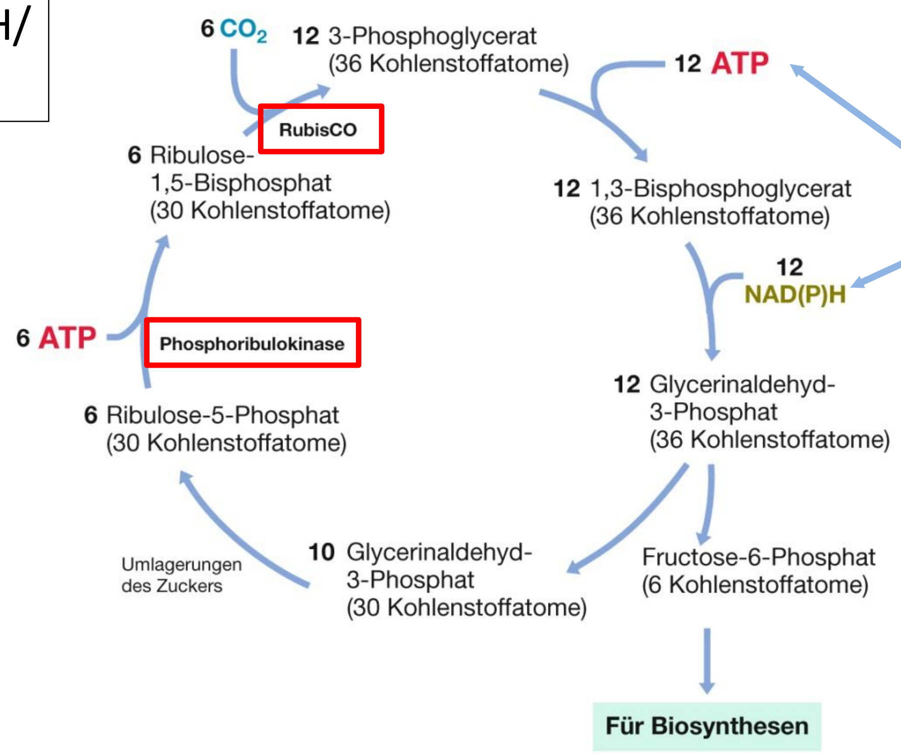
Figure 17-22 Brock Biology of Microorganisms 11/e

Reductive pentose phosphate cycle

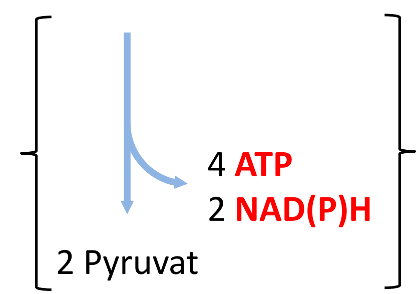
(Calvin-Benson cycle)

RubisCO = Ribulose-bisphosphate carboxylase/oxygenase

∑ 7ATP +5 NAD(P)H/ pyruvate



From light dependent reactions of photosynthesis
(ETP reactions in chemosynthesis)



- Plants, algae, cyanobacteria, most aerobic and facultativ aerobic Bacteria
- Triosephosphates, 3-phosphoglycerate, sugar phosphates as intermediates

Photosynthesis
Light- and Dark- Reaction

Calvin cycle
Melvin Calvin (1940)

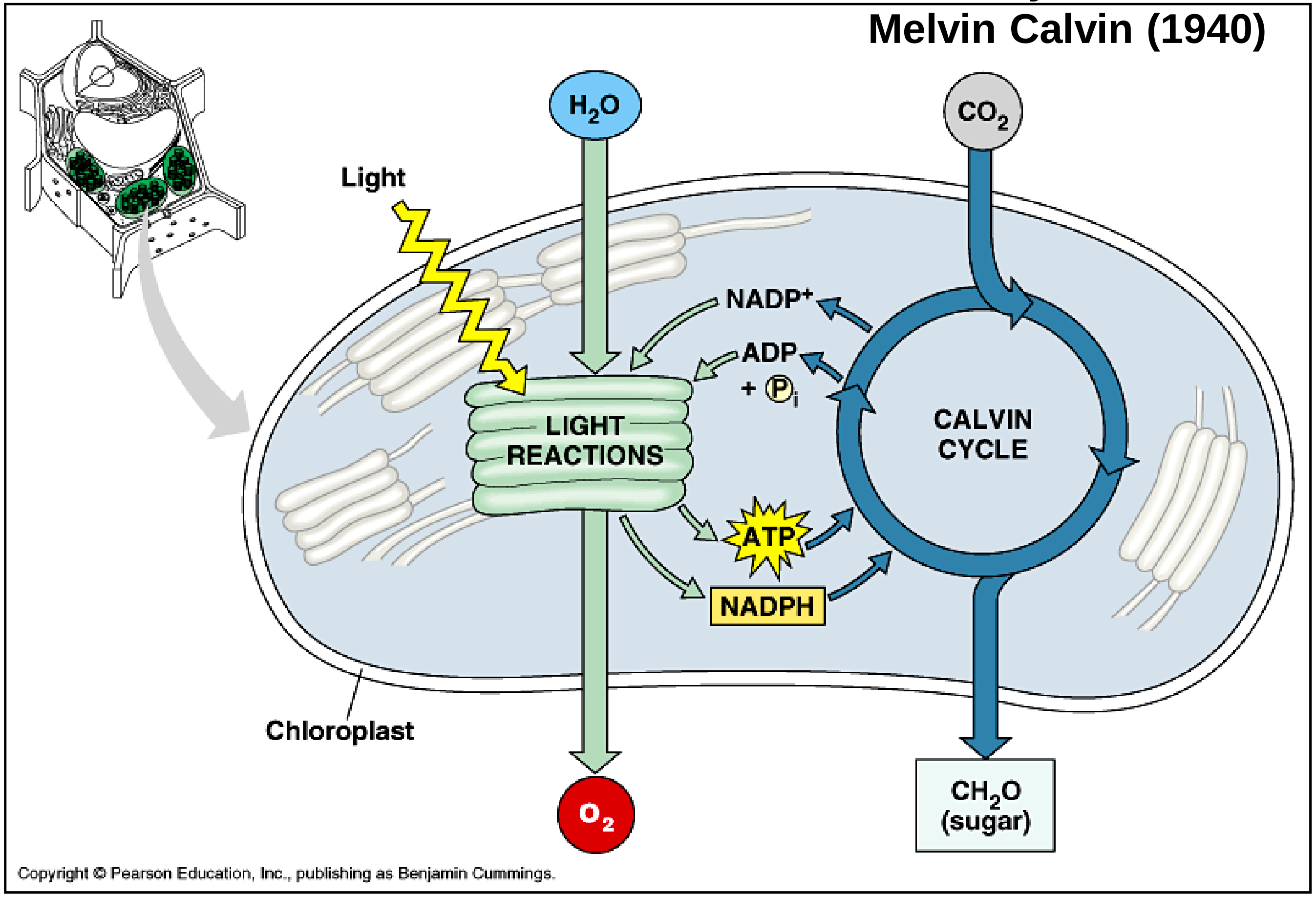


Fig. 10.4 Biology (6th edition, Campbell & Reece)

Pyruvate Dehydrogenase and Oxidative Citric Acid Cycle

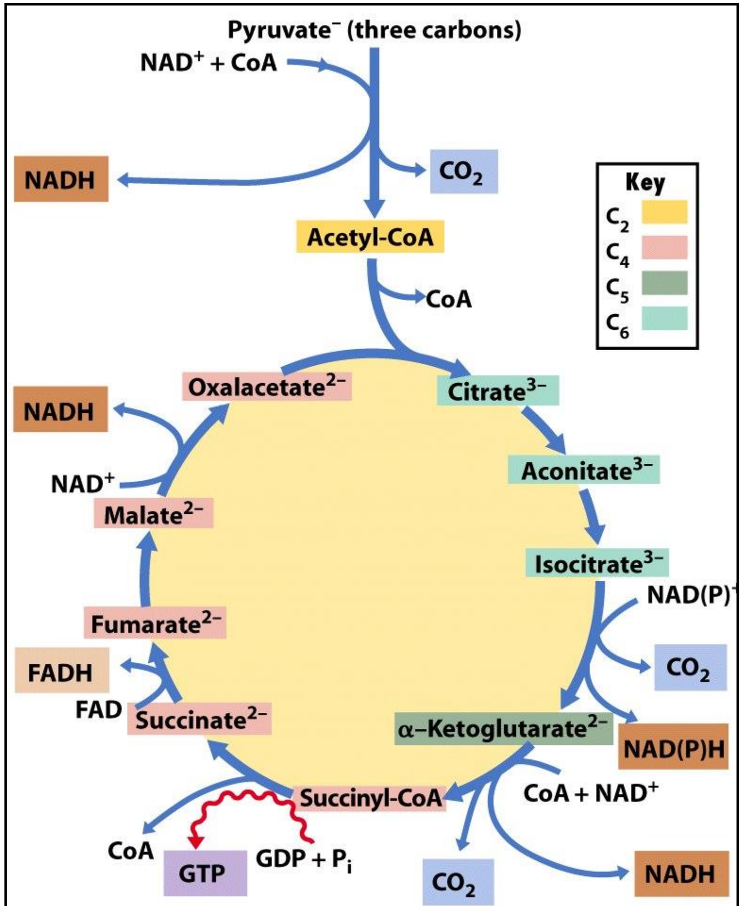


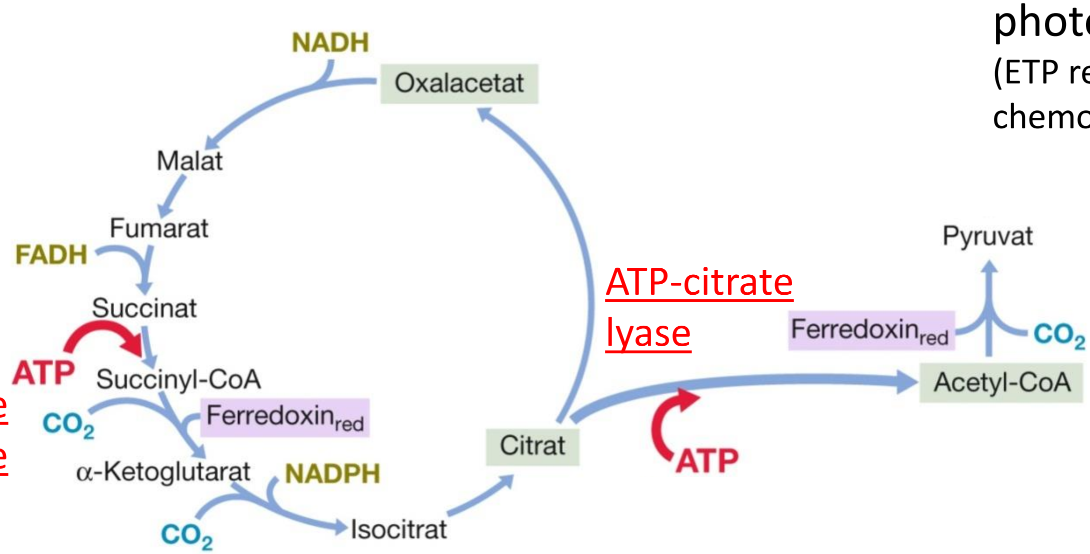
Figure 5-22a Brock Biology of Microorganisms 11/e

Reductive Citric Acid Cycle

(Arnon-Buchanan cycle)

∑ 2 (-3) ATP + 3 NAD(P)H + 2 ferredoxin/ pyruvate

ATP and ferredoxin from light dependent reactions of photosynthesis
(ETP reactions in chemosynthesis)



Fumarate reductase

2-Oxoglutarate synthase

Isocitrate dehydrogenase

Pyruvate synthase

- Anaerobic Green sulfur bacteria (Chlorobiales) and other Proteobacteria, Aquificales (microaerophilic)
- Acetyl-CoA, pyruvate, oxaloacetate, succinyl-CoA, 2-oxoglutarate, (PEP)
- Advantages under anaerobic, microaerophilic conditions

Seminar III

- ATP-Generation via substrate level phosphorylation, electron transport phosphorylation
- (Eukaryotic/prokaryotic cell)
- Bacterial cell wall
- Antibiotic resistance

Prokaryotes & Eukaryotes

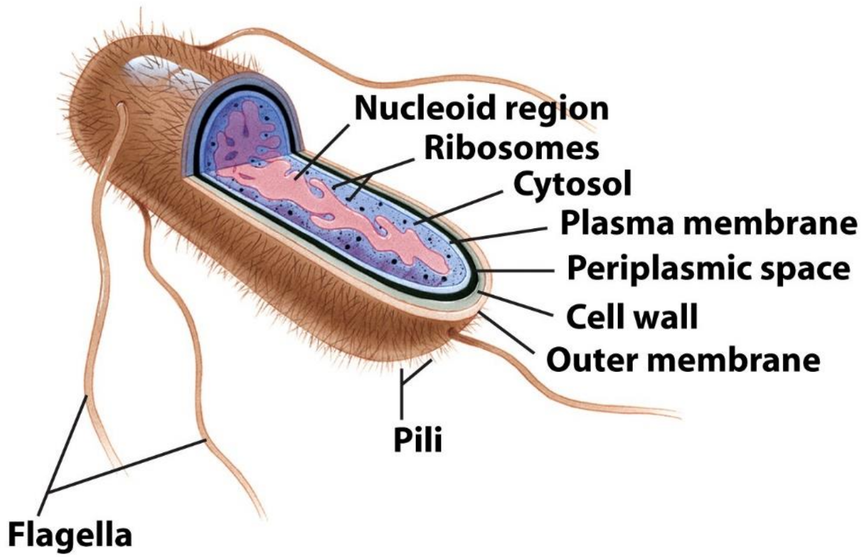


Figure 1-14 Principles of Biochemistry, 4/e

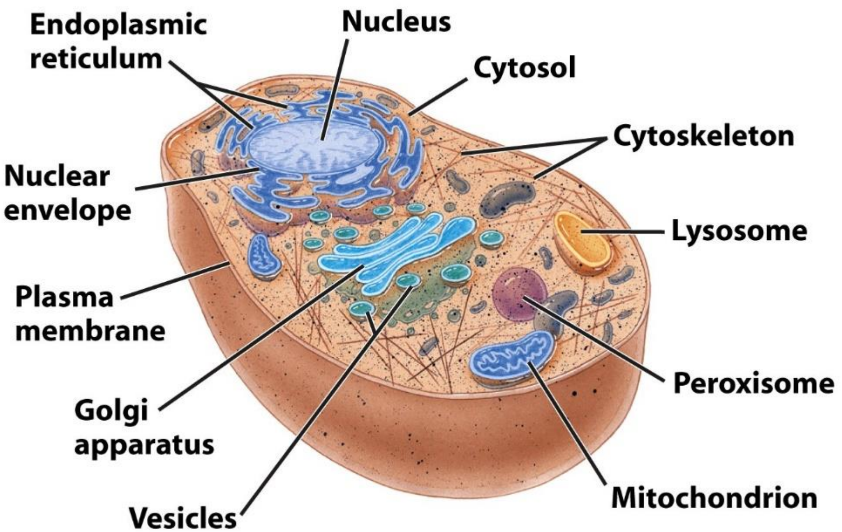


Figure 1-15a Principles of Biochemistry, 4/e

Murein: Cell wall (Bacteria)

- Gram positive cell wall

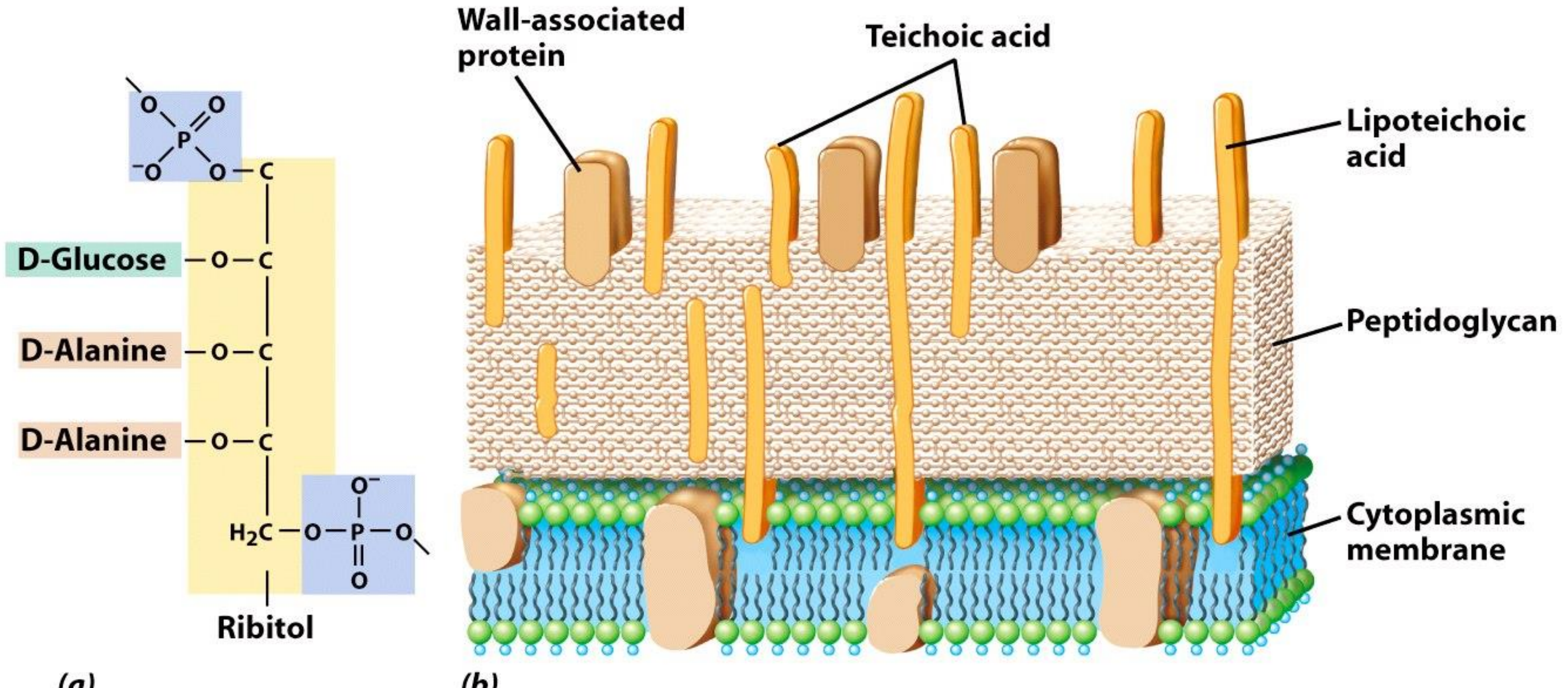


Figure 4-31 Brock Biology of Microorganisms 11/e

Murein: Cell wall (Bacteria)

- Gram negative cell wall

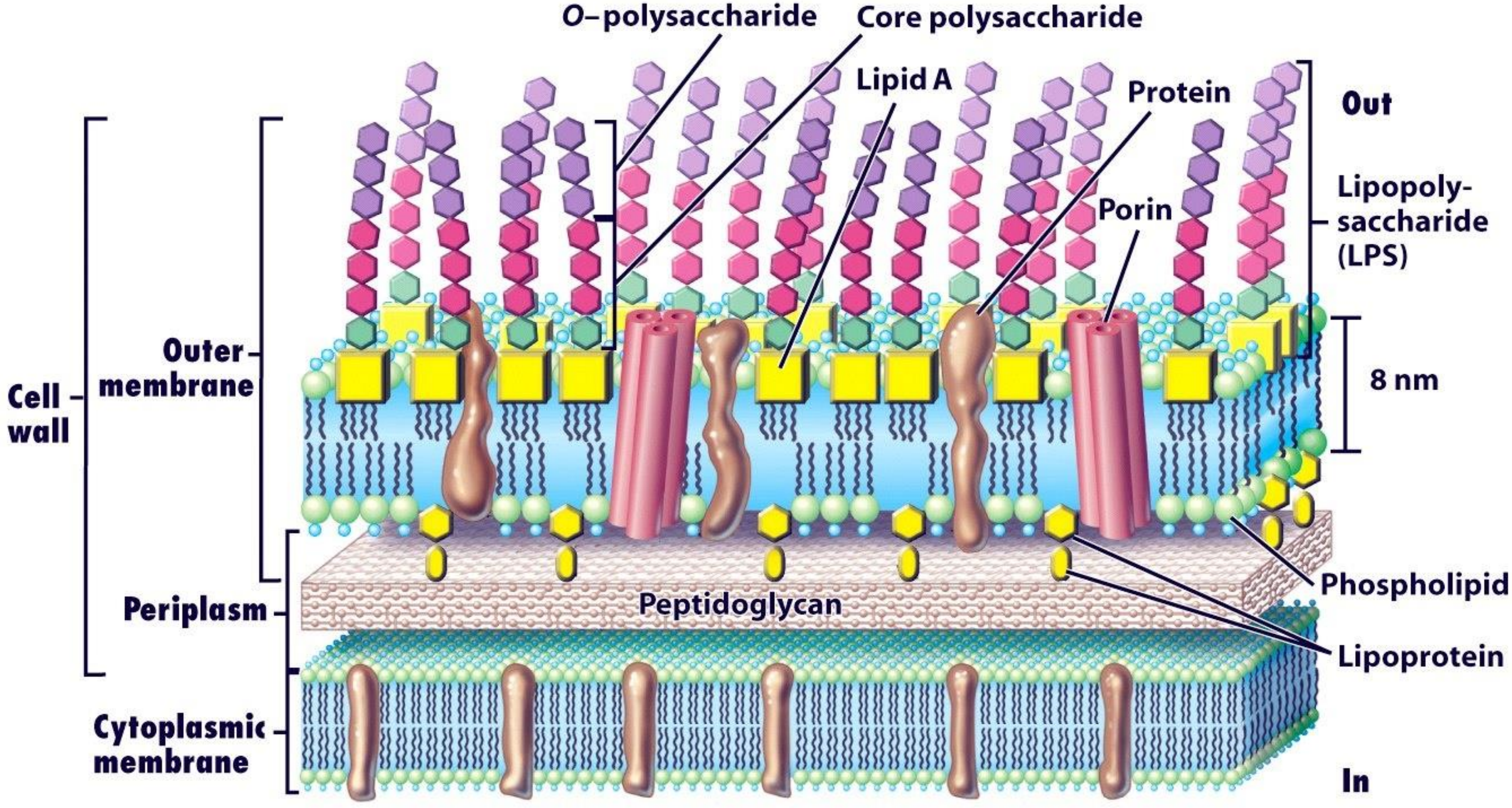


Figure 4-35a Brock Biology of Microorganisms 11/e

N-acetylglucosamine

- N-acetylglucosamine, a sugar derivative, basic building block for **chitin** and **murein**.

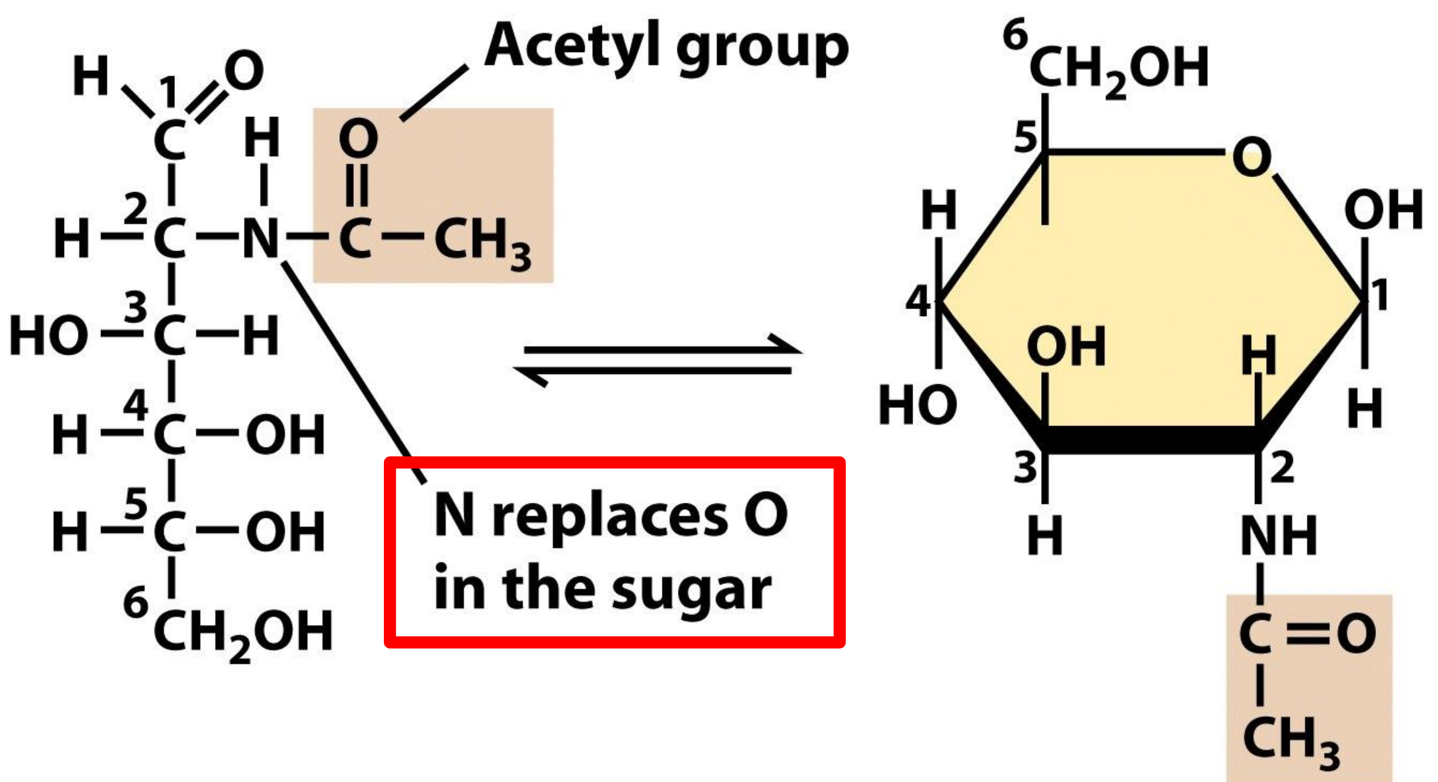


Figure 3-5 Brock Biology of Microorganisms 11/e

Murein: Cell wall (Bacteria)

- Structure of the polysaccharide in bacterial cell wall **peptidoglycan**.
- The glycan is a polymer of alternating **GlcNAc** and ***N*-acetylmuramic acid** (MurNAc, Lactic acid linked to C-4 atom) residues.
- Alternating **peptide chains of D- und L-amino acids**
- Linkage of the L-alanine amino group (amide linkage) with the lactylcarboxylgroup of a MurNac residue

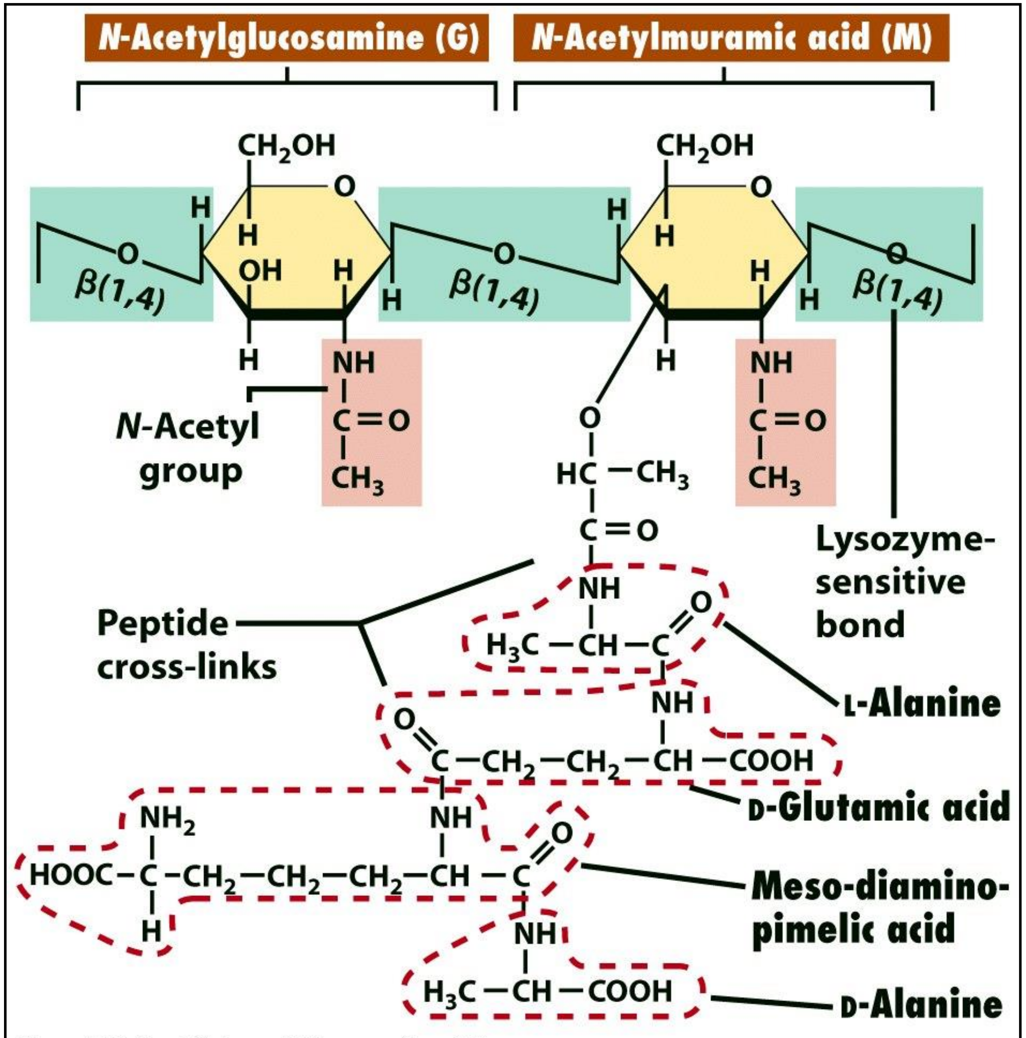


Figure 4-29 Brock Biology of Microorganisms 11/e

Murein: Cell wall (Bacteria)

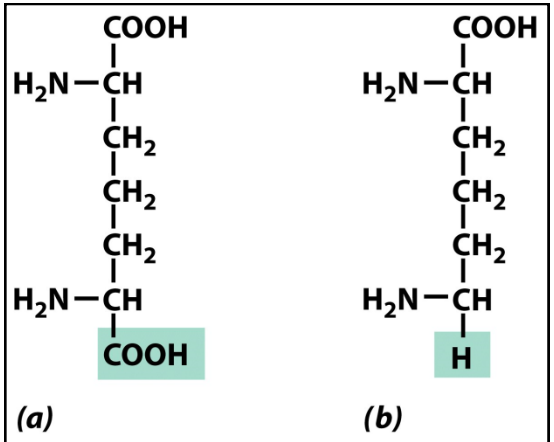


Figure 4-28 Brock Biology of Microorganisms 11/e
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(a) Diaminopimelinsäure
(b) Lysin

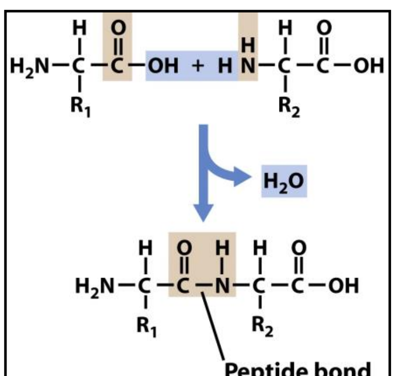

Figure 3-13 Brock Biology of Microorganisms 11/e
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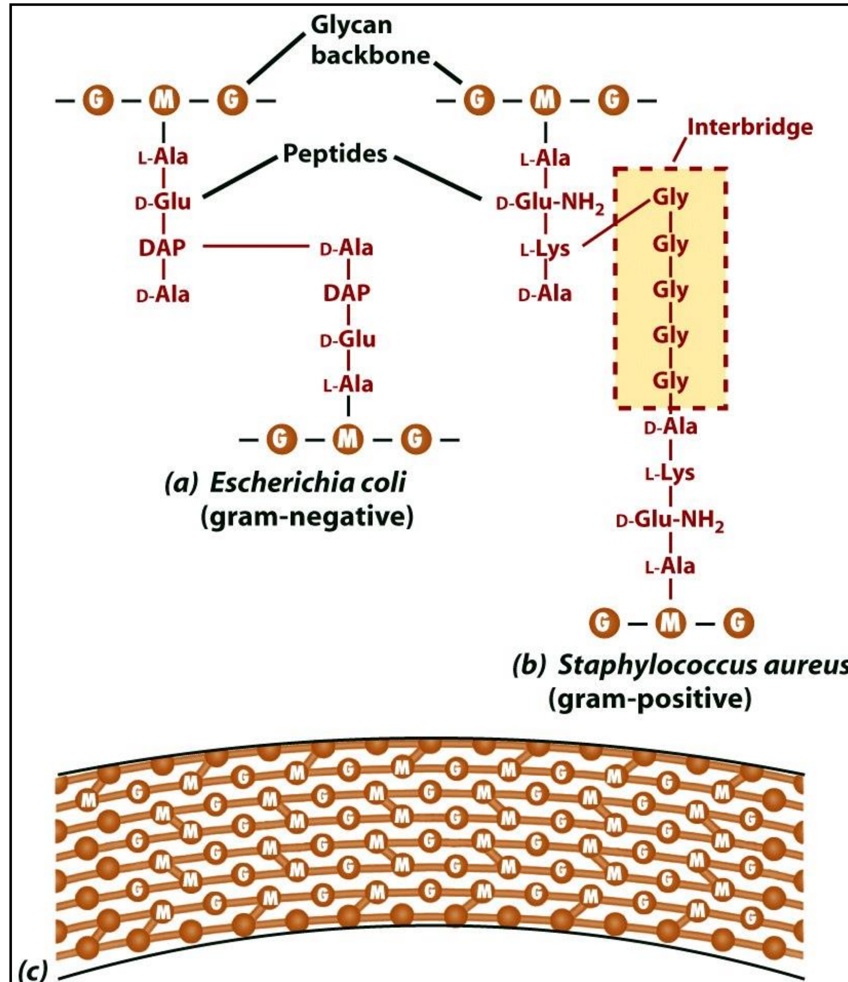

Figure 4-30 Brock Biology of Microorganisms 11/e
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Murein: Cell wall (Bacteria)

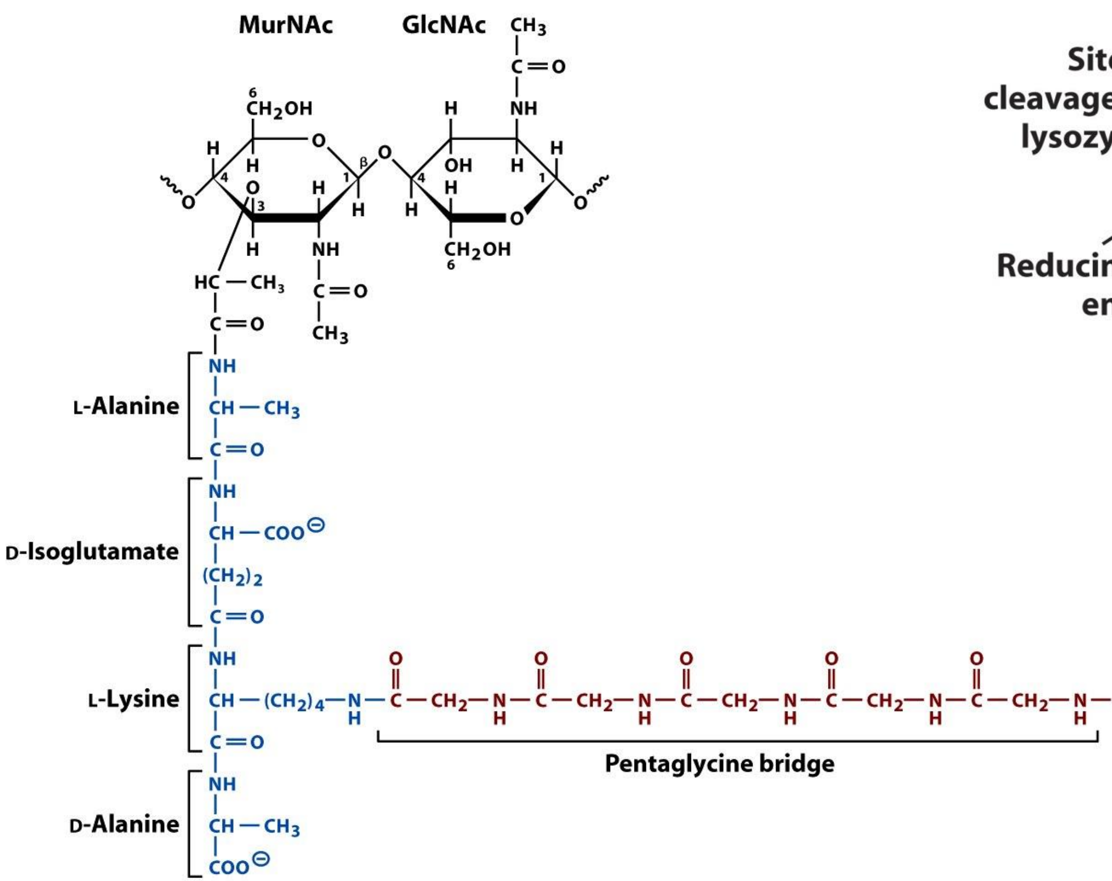
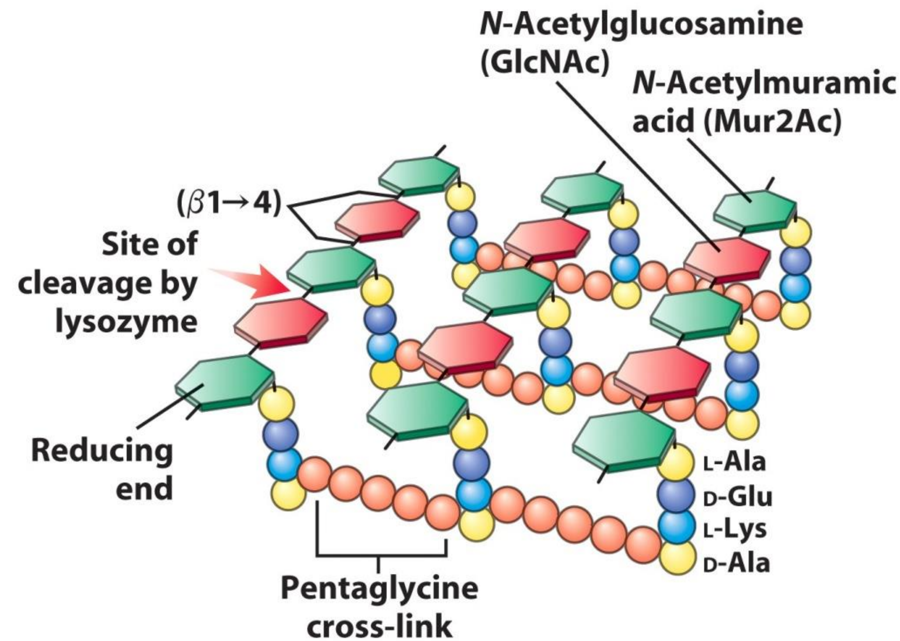


Figure 8-31a Principles of Biochemistry, 4/e



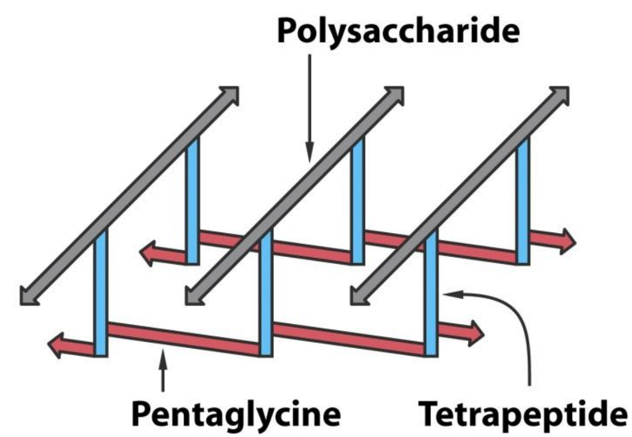


Figure 8-31b Principles of Biochemistry, 4/e

Glycoconjugate

- Glycolipids
  - Lipopolysaccharide (Gram negative Bacteria, outer membrane)

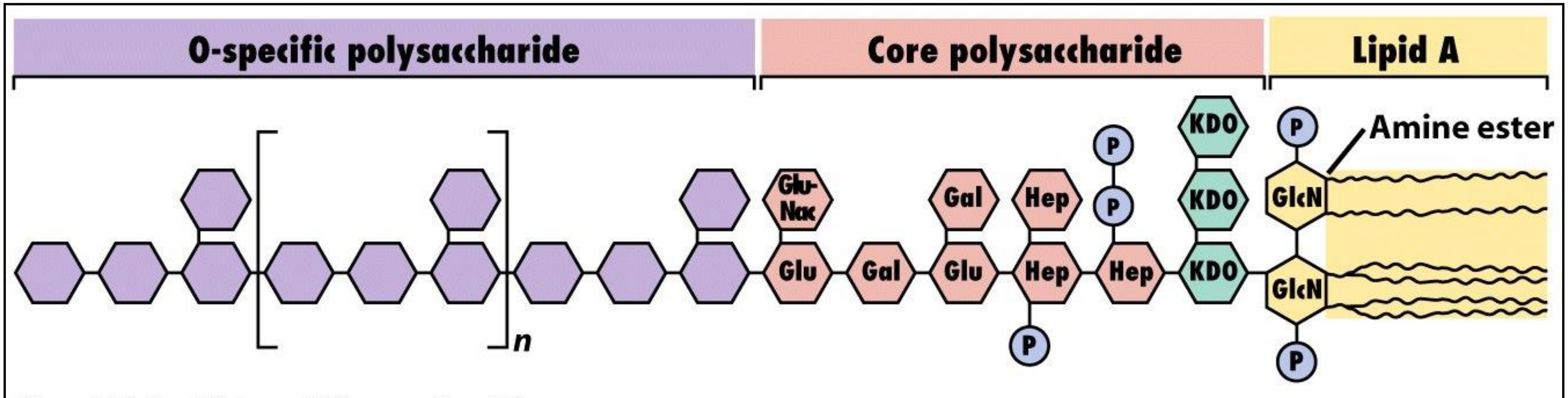


Figure 4-34 Brock Biology of Microorganisms 11/e

Mode of Action of Some Major Antimicrobial Agents

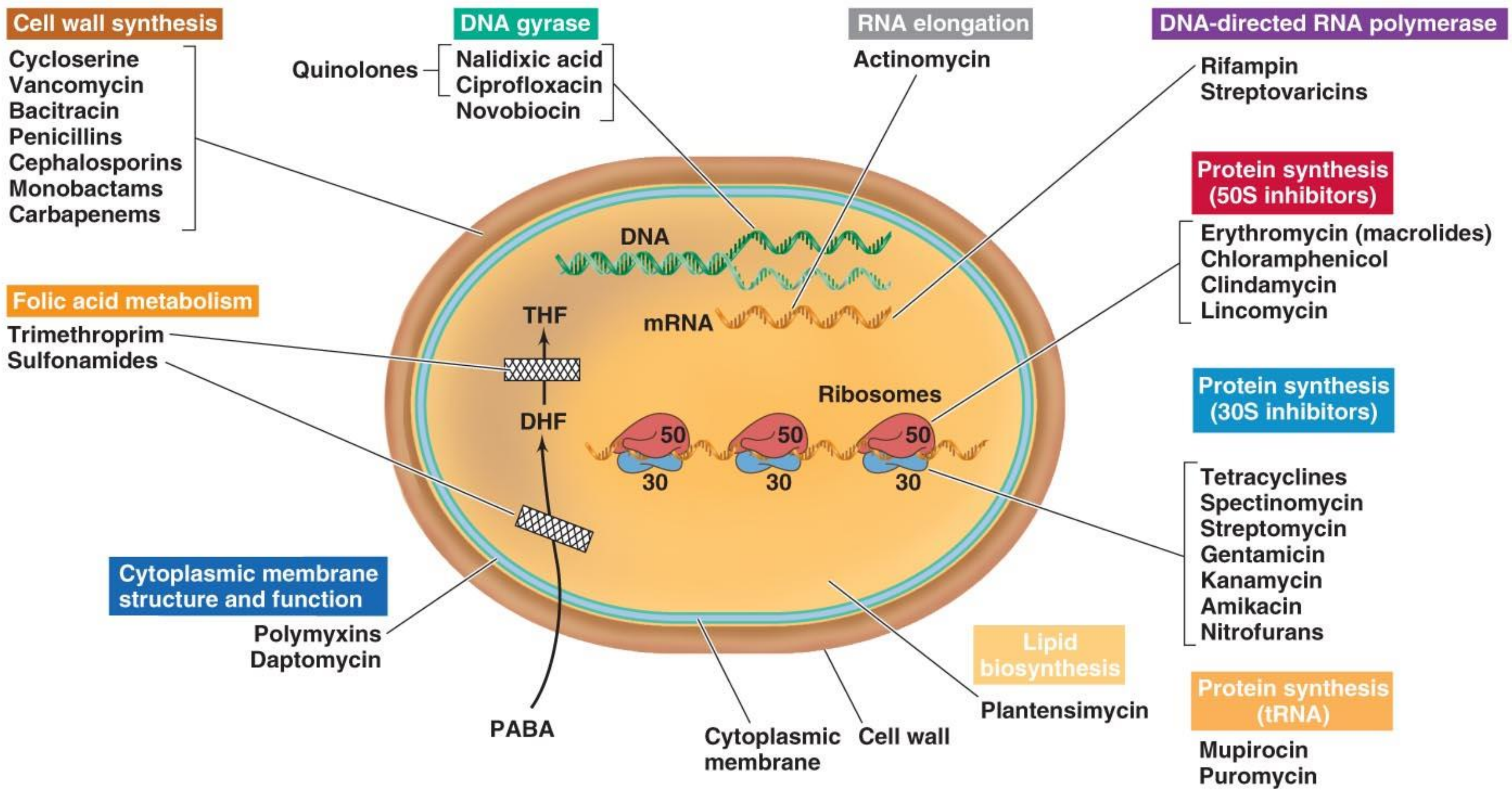


Figure 27.12

Antimicrobial Spectrum of Activity

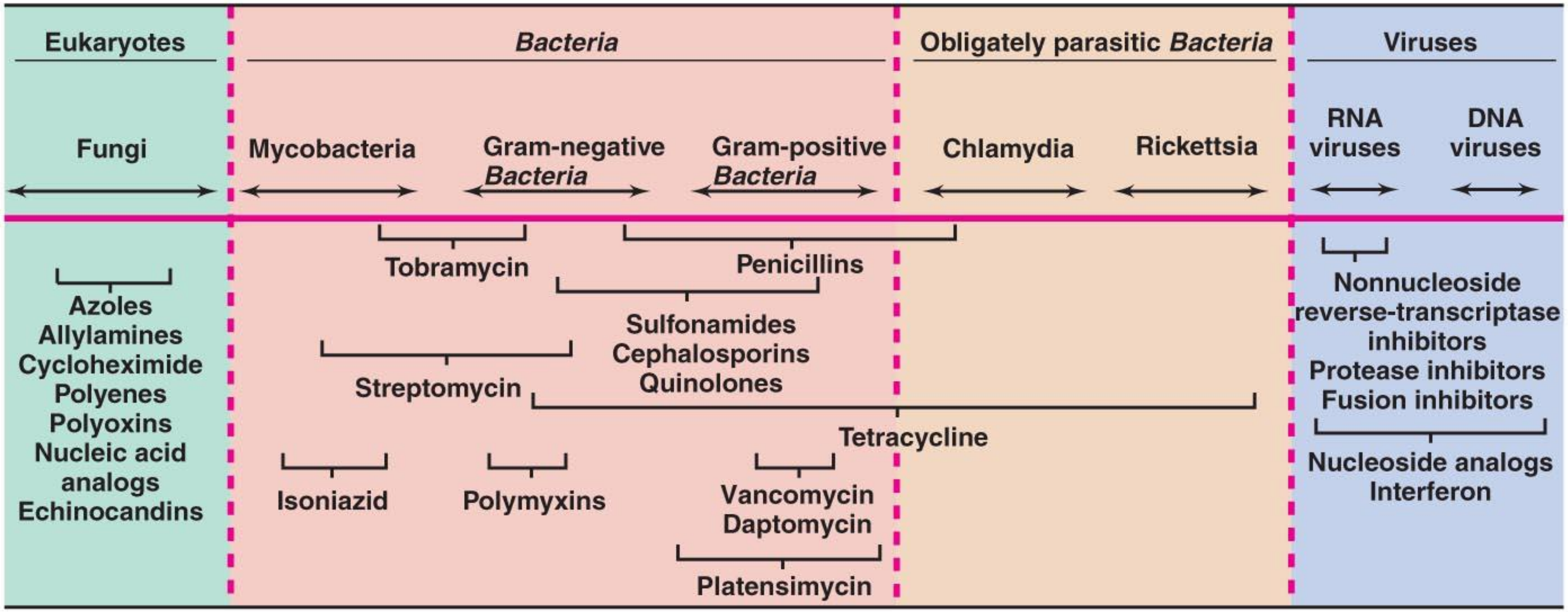
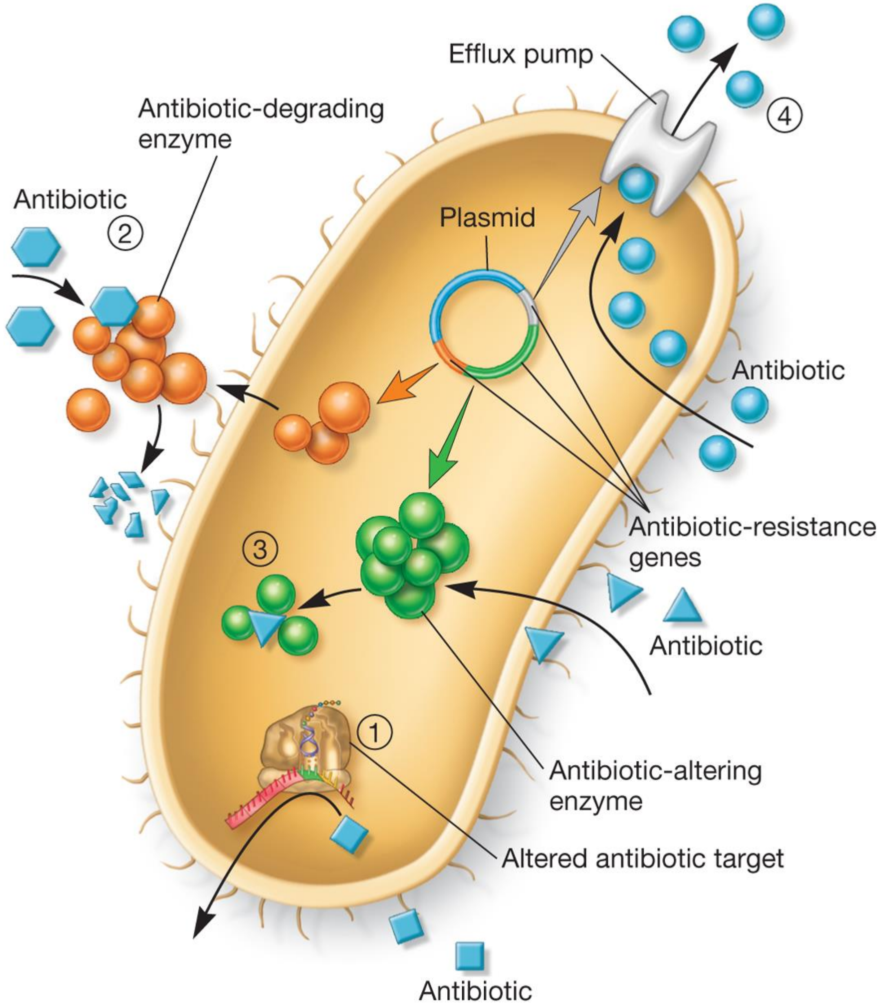


Figure 27.13

Antimicrobial Drug Resistance

- *Antimicrobial drug resistance*
  - The acquired ability of a microbe to resist the effects of a chemotherapeutic agent to which it is normally sensitive

Mechanisms of Drug Resistance



- Prevent entrance of drug
- Drug efflux (pump drug out of cell)
- Inactivation of drug
  - chemical modification of drug by pathogen
- Modification of target enzyme or organelle
- Use of alternative pathways or increased production of target metabolite

Sites at Which Antibiotics are Attacked by Enzymes

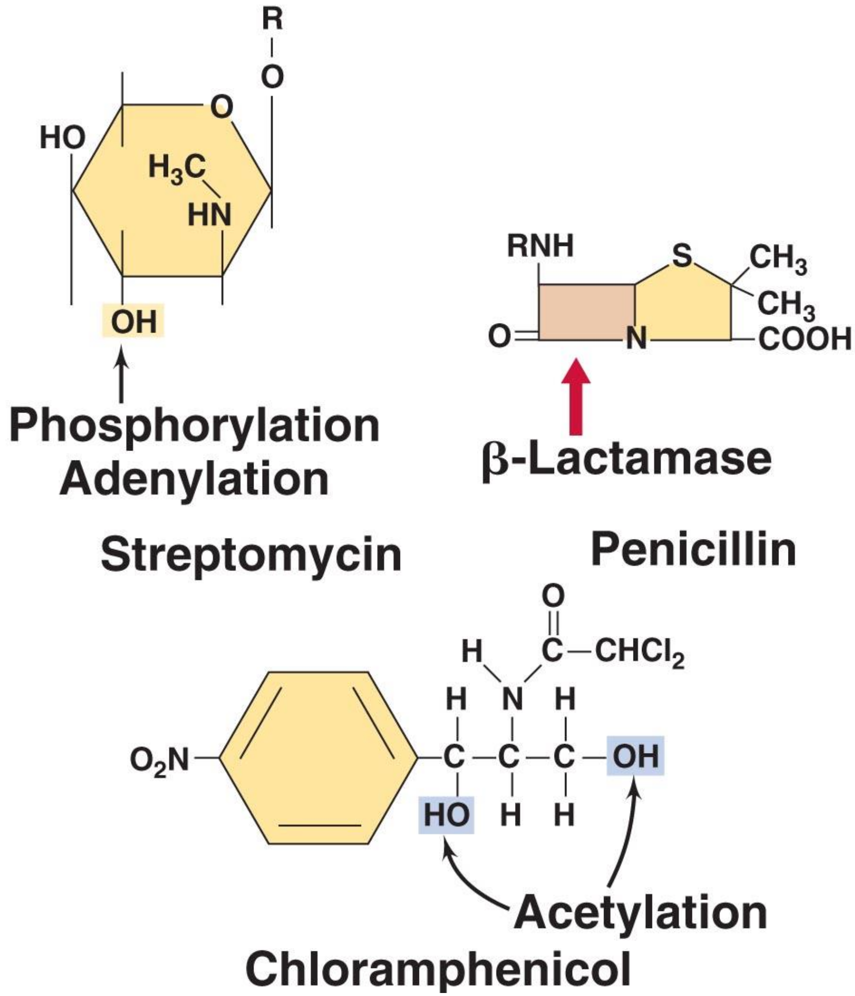
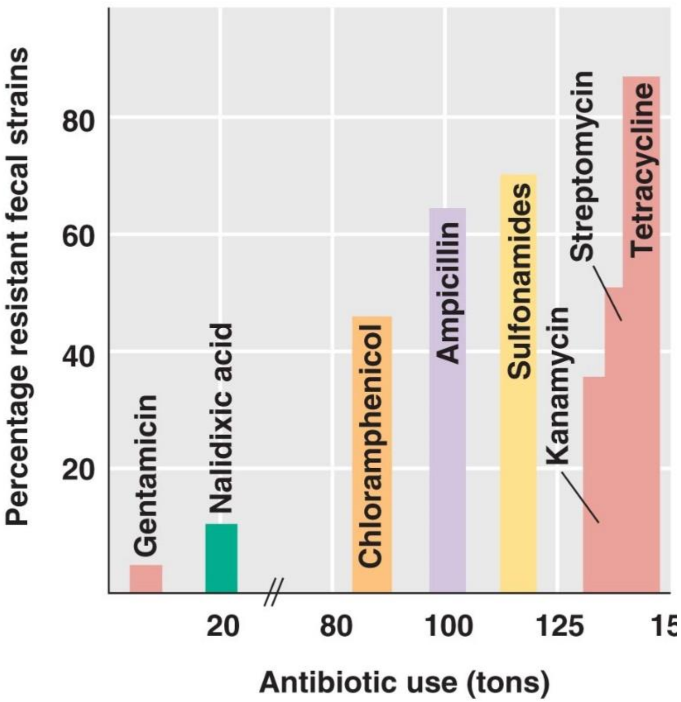


Figure 27.27

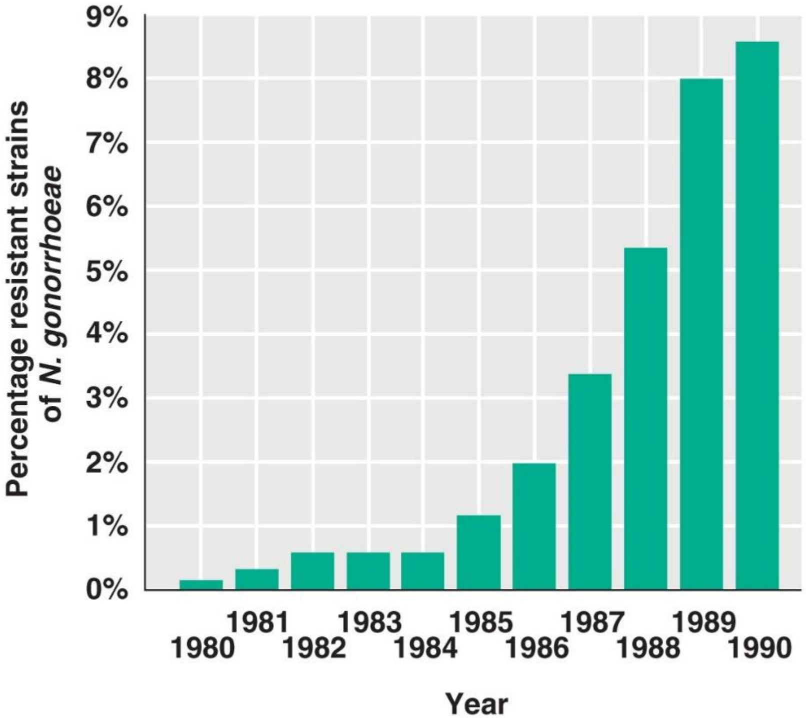
Antimicrobial Drug Resistance

- Most drug-resistant bacteria isolated from patients contain drug-resistance genes located on **R plasmids**
- The use of antibiotics in **medicine, veterinary,** and **agriculture** select for the **spread of R plasmids**
  - Many examples of **overuse** of antibiotics
  - Used far more often than necessary (i.e., antibiotics used in agriculture as supplements to animal feed)

Patterns of Drug Resistance in Pathogens



(a)



(b)

Figure 27.28

Figure 27.28