



ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

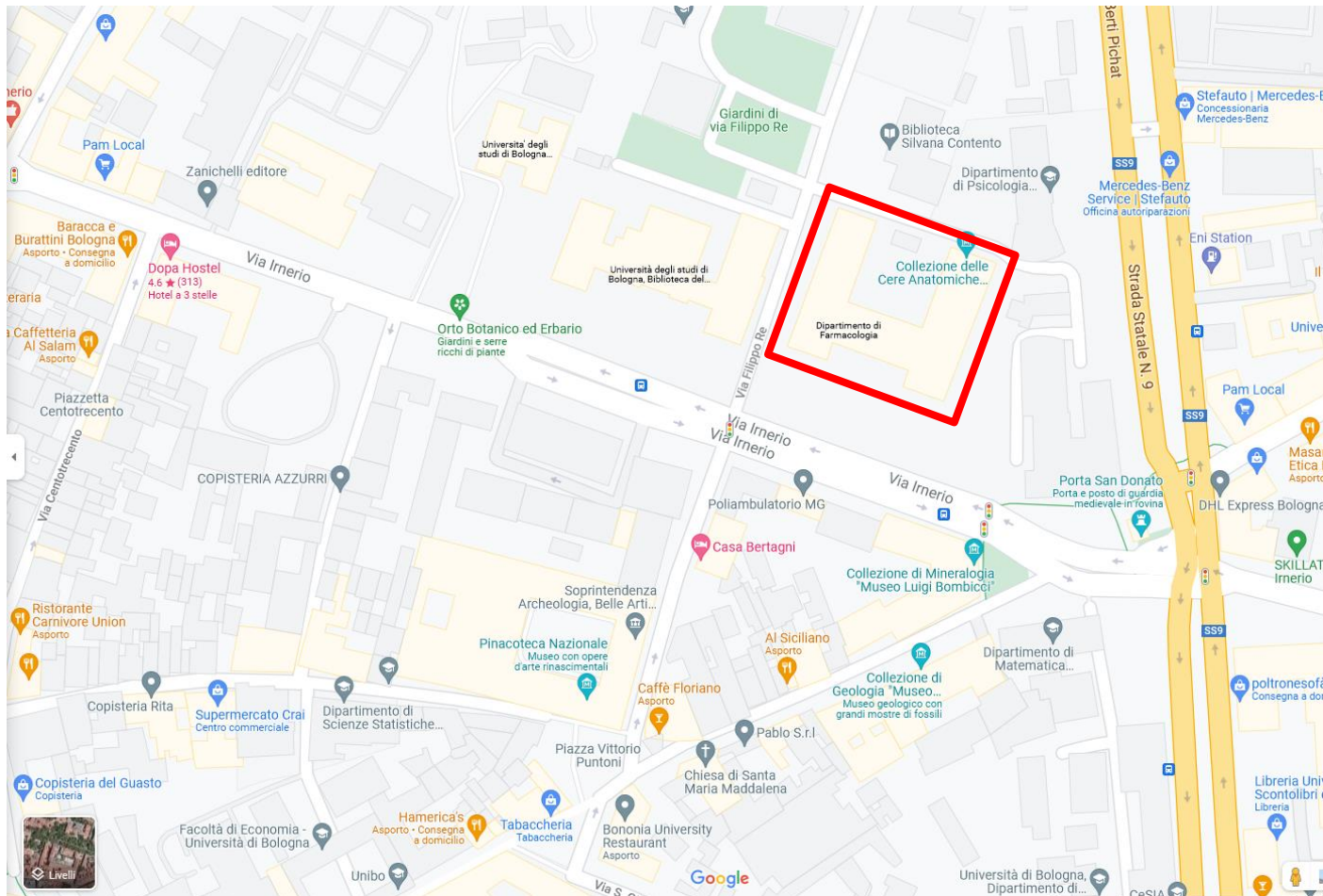
METABOLIC BIOCHEMISTRY (MODULE B1)

Prof. Michele Di Foggia

Dipartimento di Scienze Biomediche e
Neuromotorie – DIBINEM – via Irnerio 48, Bologna

HOW TO REACH ME

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BOOK

LEHNINGER PRINCIPLES OF BIOCHEMISTRY

Authors: David L. Nelson; Michael M. Cox

Eighth Edition ©2021

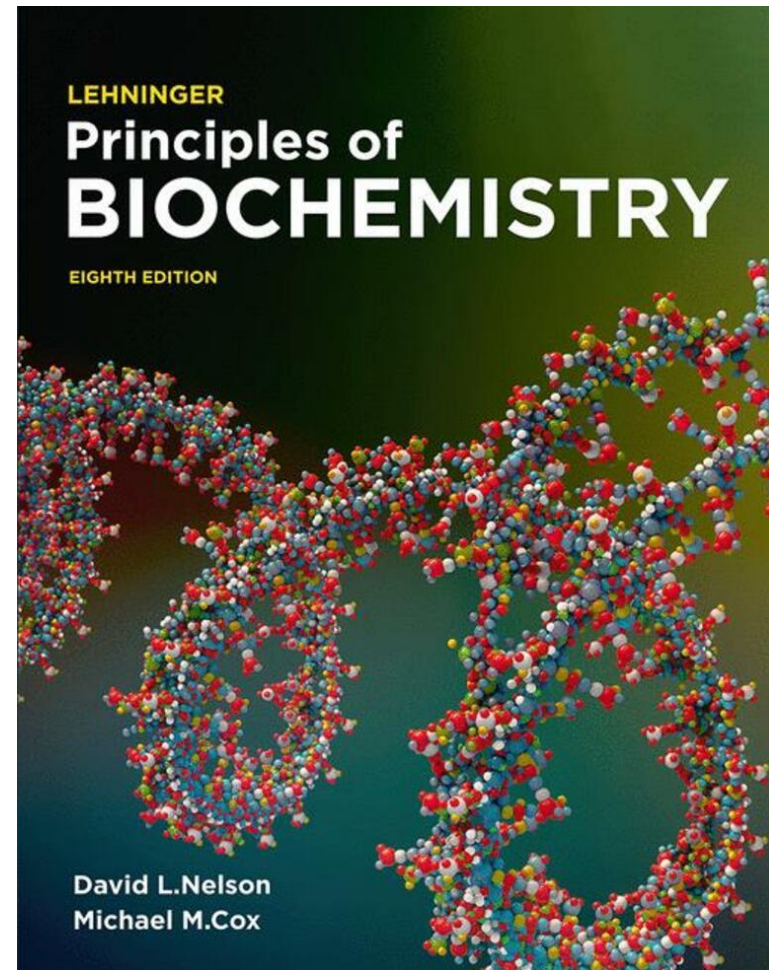
Paperback ISBN: 9781319381493

PRINCIPLES OF BIOCHEMISTRY

E-book ISBN: 9781319322397

Copies of the book are available in UNIBO libraries:

- **B. Clinica 'F. B. Bianchi' – Bologna**
- **B. Biomedica centrale – Bologna**
- B. Veterinaria 'Ercolani' – Bologna
- B. Centrale – Campus di Rimini



BOOK

CHAPTERS OF STUDY:

Chapter 14: Glycolysis, Gluconeogenesis, and the Pentose Phosphate Pathway

Chapter 15: The Metabolism of Glycogen in Animals

Chapter 16: The Citric Acid Cycle

Chapter 17: Fatty Acid Catabolism

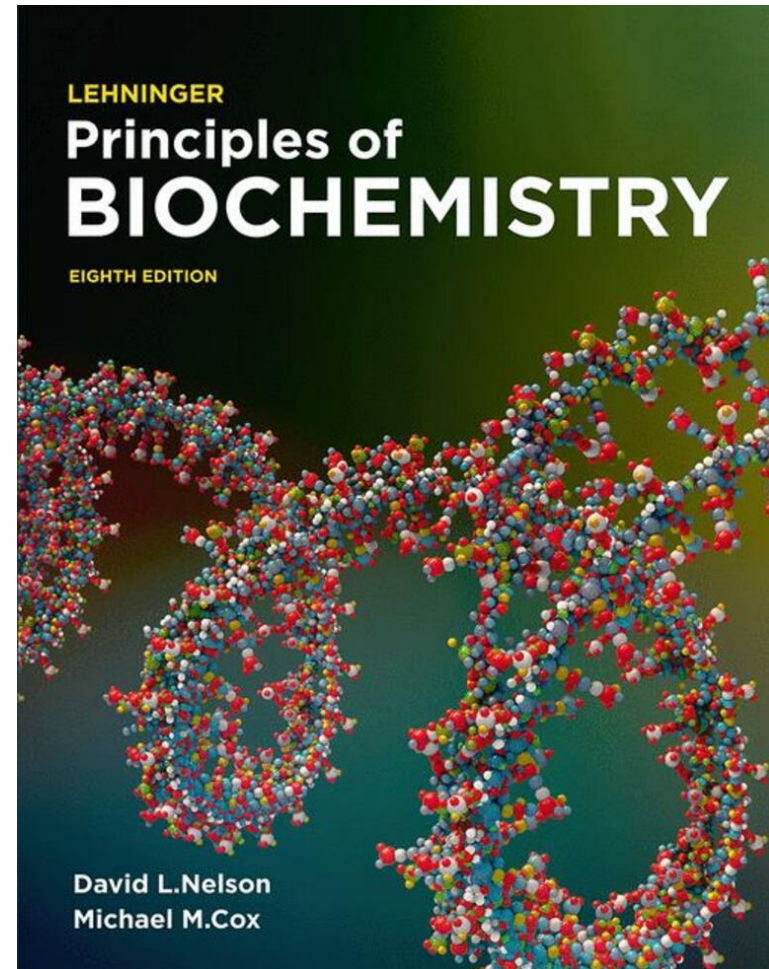
Chapter 18: Amino Acid Oxidation and the Production of Urea

Chapter 19: Oxidative Phosphorylation

Chapter 21: Lipid Biosynthesis

Chapter 22: Biosynthesis of Amino Acids, Nucleotides, and Related Molecules

Chapter 23: Hormonal Regulation and Integration of Mammalian Metabolism



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Syllabus 2025-2026 Signalling pathways in health and disease Module B1 – Metabolic Biochemistry – Prof. M. Di Foggia - 3 CFU (25.5 hours)

DATE	TIME	TITLE
12 Mar	11-13	Introduction to metabolism. ATP synthesis and utilization.
13 Mar	11-13	Oxidative phosphorylation – part 1
16 Mar	9-11	Oxidative phosphorylation – part 2
17 Mar	9-11	Overview of carbohydrate metabolism
19 Mar	11-13	Glycogen metabolism
24 Mar	11-13	Glycolysis – part 1
26 Mar	11-13	Glycolysis – part 2
16 Apr	9-11	Pyruvate oxidation and TCA cycle
20 Apr	11-13	Gluconeogenesis
21 Apr	9-11	Pentose phosphate pathway
05 Jun	11-12:30	<i>Metabolic integration</i>
09 Jun	11-13	<i>Specific metabolism of some organs and tissues, part 1</i>
10 Jun	9 – 11	<i>Specific metabolism of some organs and tissues, part 2</i>



EXAM

WRITTEN EXAM (JUNE, 26TH; JULY, 27TH; SEPTEMBER, 11TH; SEPTEMBER, 25TH)

2 HOURS

14 POINTS (9 CELL SIGNALLING + 9 PHYSIOLOGY)

1 DAY – 3 EXAMS:

- 1) PHYSIOLOGY
- 2) METABOLIC BIOCHEMISTRY
- 3) CELL SIGNALLING

MORE DETAILS WERE GIVEN BY PROF. GENOVA (COORDINATOR OF THE INTEGRATED COURSE)



EXAM (only Metabolic Biochemistry section) – part 1

9 MULTIPLE-CHOICE QUESTIONS IN WHICH YOU HAVE TO JUSTIFY EVERY SINGLE ANSWER (0.5 POINTS FOR THE CORRECT ANSWER + UP TO 0.5 POINTS FOR THE EXPLANATION)

In uncontrolled Type 1 diabetes, we observe metabolic acidosis (decrease of plasma pH) because:

- a. free fatty acids increase in plasma
- b. bicarbonate is consumed for carboxylation reactions
- c. there are high levels of plasma β -hydroxybutyrate
- d. enhanced glycolysis produces excess lactate
- e. glucose-6-P is hydrolysed to glucose plus phosphate

c. In the absence of sufficient insulin, the body increases lipolysis. The liver converts fatty acids into ketone bodies, including β -hydroxybutyrate, which are acidic.

- a. Doesn't directly lead to metabolic acidosis.
- b. Bicarbonate consumption is not a significant factor in this context.
- d. Lactate can contribute to acidosis, but less than the accumulation of ketone bodies.
- e. This reaction primarily involves glucose metabolism rather than acid-base balance.



EXAM (only Metabolic Biochemistry section) – part 2

3 EXERCISES:

A) COMPLETE THE FOLLOWING REACTIONS (TOTAL 1.5 POINTS – 9 REACTIONS):

a. **Glycogen (n) + → Glycogen (n-1) +**

Glycogen (n) + inorganic phosphate (Pi) → Glycogen (n-1) + Glucose-1-phosphate (G1P)

B) WRITE ALL COENZYMES AND PROSTHETIC GROUPS, IF ANY, INVOLVED IN THE ACTION OF THE FOLLOWING ENZYMES. IF THEY DERIVE FROM A VITAMIN, WRITE WHICH VITAMIN IS. ALSO WRITE THE COMPLETE REACTIONS (TOTAL 1.5 POINTS – 9 ENZYMES).

a. **Alpha-ketoglutarate dehydrogenase complex**

- Thiamine pyrophosphate (TPP) - derived from Vitamin B1
- Lipoic acid
- Coenzyme A (CoA) - derived from Vitamin B5 (pantothenic acid)
- Flavin adenine dinucleotide (FAD) - derived from Vitamin B2 (riboflavin)
- Nicotinamide adenine dinucleotide (NAD⁺) - derived from Vitamin B3 (niacin)

α -Ketoglutarate + NAD⁺ + CoA → Succinyl-CoA + NADH + CO₂



WHAT TO REMEMBER FROM CHEMISTRY

- Number of bonds made by atoms (C, H, N, O, S, P)
- Ions' charges
- Electronegativity and its changes across the periodic table
- Forecast polarity and type of bonds
- Recognise H and C atoms even if they're not indicated, as well as lone pairs of electrons
- Draw resonance structures
- Recognise stereoisomers
- Recognise electrophiles and nucleophiles
- Identify redox reactions
- Calculate oxidation numbers



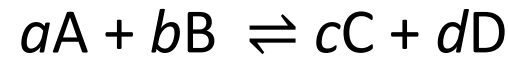
WHAT TO REMEMBER FROM CHEMISTRY

- Difference between thermodynamics and kinetics of reactions
- Chemical equilibrium
- ΔG (spontaneous reactions)
- High-energy bonds
- Phosphate groups chemistry
- Intermolecular interactions (H-bonds, dipoles.....)
- pH and pK_a of weak acids
 - Carboxylic acids (4-5)
 - Protonated amines (9-10)
 - Thiols (10)
 - Alcohols (16-18)



WHAT TO REMEMBER FROM CHEMISTRY

- Henderson-Hasselbach's equation
 - $\text{pH} = \text{pK}_a - \log \left(\frac{[\text{HA}]}{[\text{A}^-]} \right)$
- Physiologic buffers' systems (bicarbonate and phosphate)
- Equilibrium constants
- Gibbs' free energy
 - $\Delta G = \Delta H - T\Delta S$
 - $\Delta G^\circ, \Delta G'^\circ, \Delta G$
 - $\Delta G^\circ = -RT \ln K_{\text{eq}}$
 - $\Delta G = \Delta G^\circ + RT \ln Q$



$$K_{\text{eq}} = \frac{[\text{C}]^c [\text{D}]^d}{[\text{A}]^a [\text{B}]^b}$$



WHAT TO REMEMBER FROM CHEMISTRY

Form **Organic chemistry**

- Same principles:
 - nucleophilicity
 - electronegativity
 - acidity/basicity
- Similar reaction mechanisms:
 - chemical reactions on carbonyl groups (nucleophilic acyl substitution, aldolic condensation, Claisen's condensation)
 - redox reactions
 - elimination reactions
 - addition reactions on conjugate systems



WHAT TO REMEMBER FROM CHEMISTRY

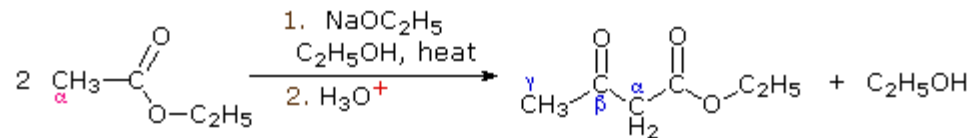
Functional Class	Formula	Characteristic Reactions
Alkanes	C-C, C-H	Substitution (of H, commonly by Cl or Br) Combustion (conversion to CO ₂ & H ₂ O)
Alkenes	C=C-C-H	Addition Substitution (of H)
Alkynes	C≡C-H	Addition Substitution (of H)
Alkyl Halides	H-C-C-X	Substitution (of X) Elimination (of HX)
Alcohols	H-C-C-O-H	Substitution (of H); Substitution (of OH) Elimination (of HOH); Oxidation (elimination of 2H)
Ethers	(α)C-O-R	Substitution (of OR); Substitution (of α-H)
Amines	C-NRH	Substitution (of H); Addition (to N); Oxidation (of N)
Benzene Ring	C ₆ H ₆	Substitution (of H)
Aldehydes	(α)C-CH=O	Addition Substitution (of H or α-H)
Ketones	(α)C-CR=O	Addition Substitution (of α-H)
Carboxylic Acids	(α)C-CO ₂ H	Substitution (of H); Substitution (of OH) Substitution (of α-H); Addition (to C=O)
Carboxylic Derivatives	(α)C-CZ=O (Z = OR, Cl, NHR, etc.)	Substitution (of Z); Substitution (of α-H) Addition (to C=O)



WHAT TO REMEMBER FROM CHEMISTRY

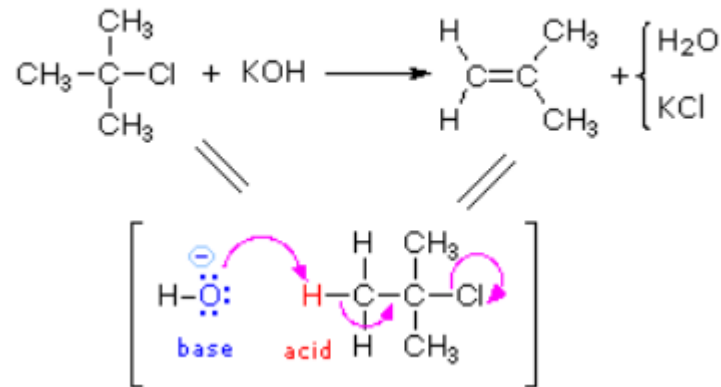


Aldolic condensation

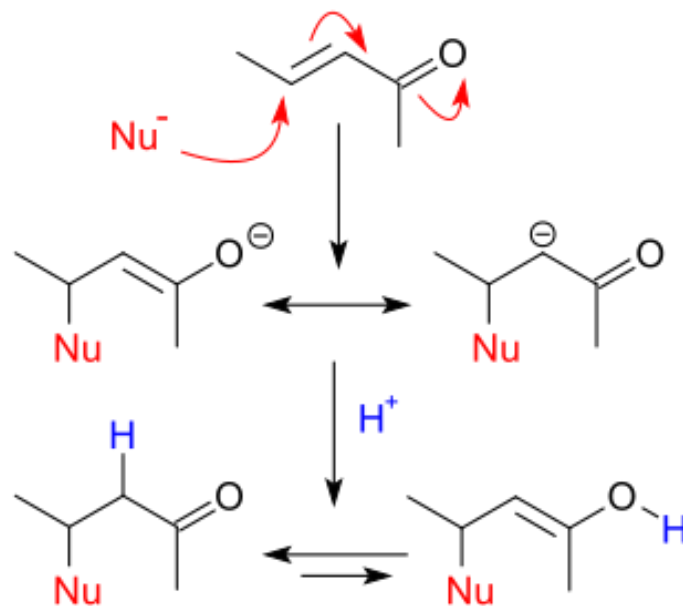


Claisen's condensation

elimination



WHAT TO REMEMBER FROM CHEMISTRY



Addition reaction in conjugate systems

WHAT TO REMEMBER FROM CHEMISTRY

From **Organic Chemistry**

- Functional groups:
 - derivatives of carboxylic acids (amides, esters, anhydrides),
 - alcohol
 - amines
 - thioesters and thiols
- Leaving groups:
 - phosphates
 - sulfur-containing groups (thioesters and thiolates)





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