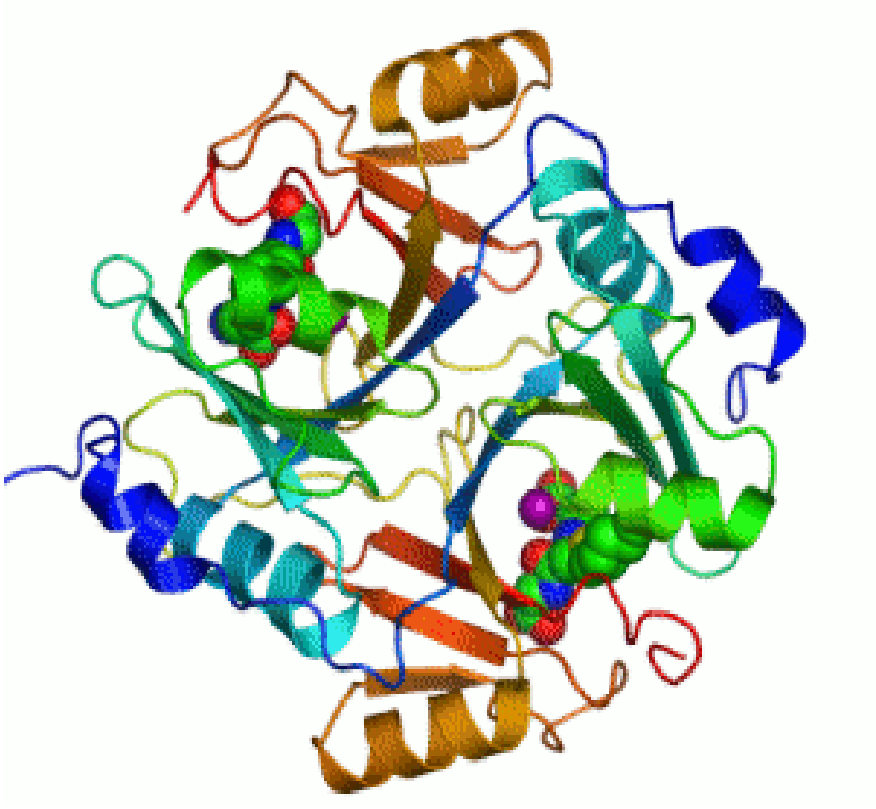
AL-RASHEED UNIVERSITY COLLEGE
DEPARTMENT OF MEDICAL LABORATORY TECHNIQUES



Enzymes

Lecture 1

Prepared By
Dr. Kutaiba I. Alzand & Dr. Rusul H. Hamza

حقيبة تعليمية

بعنوان: الكيمياء الحياتيه السريريه

Clinical Biochemistry

إعداد

أ.م.د. قتيبه ابراهيم خضر الزند

دكتوراه في الكيمياء الطبية

م.د. رسل هاشم حمزة الحسيني

دكتوراه في الكيمياء الحياتية

2023 - 2022

بسم الله الرحمن الرحيم

{يَرْفَعِ ٱللَّهُ ٱلَّذِينَ آمَنُواْ مِنكُمْ وَٱلَّذِينَ أُوتُواْ ٱلْعِلْمَ دَرَجَاتٍ وَٱللَّهُ بِمَا تَعْمَلُونَ خَبِيرٌ }[المجادلة: 11]

صدق الله العظيم

المقدمة

يتسم البرنامج التعليمي لمقرر الكيمياء الحياتية السريرية بتعليم الطلبة بالاساسيات النظرية لمادة الكيمياء الحياتية السريرية وتطبيقاتها العملية ضمن منهج متكامل حيث يتدرب الطالب خلال هذه الفترة على إكتساب المعلومات والتقنيات التطبيقية المهمة وعلى فهم دور الكيمياء الحياتية السريرية في الحالة الصحية والمرضية في أجهزة الجسم المختلفة وعلى تفسير نتائج تحاليل الكيمياء الحياتية ودمجها مع الممارسة السريرية الطبية.

فهرس المحتويات

دليل البرنامج

1	اسم البرنامج التعليمي	الكيمياء الحياتية السريرية
2	رمز البرنامج التعليمي	CB231
3	اسم التدريسي	أ.م.د. قتيبة ابراهيم خضر الزند
4	مدة البرنامج	(30) اسبوعا بواقع (2) ساعة اسبوعيا
5	عدد الساعات الكلية	(60) ساعة
6	الفئة المستهدفة من البرنامج	طلبة المرحلة الثانية / قسم تقنيات المختبرات الطبية
7	اسم الجهة المشرفة على التنفيذ	كلية الرشيد الجامعة
8	تاريخ اعداد البرنامج	22 / 8/ 2022
9	الهدف العام للبرنامج	تدريس الطالب كيفية التعرف على المركبات الكيميائية وتزويده بمعلومات كافية تمكنه من فهم ما يجري من فعاليات حيوية في جسم الانسان على المستوى الجزيئي، وتطبيقها بدروس عملية وتبيان الطرق المستخدمة في تشخيص بعض الامراض.

دليل البرنامج

10	اهداف البرنامج التفصيلية	يتوقع من الطالب في نهاية البرنامج أن يكون قادراً على: • فهم دور الكيمياء الحياتية السريرية في الحالة الصحية والمرضية في أجهزة الجسم المختلفة • مناقشة المسارات الطبيعية للكيمياء الحياتية ومسببات المرض وحدوث الأمراض بسبب الاضطرابات الكيميائية الحياتية التابعة لأمراض مختلفة. • تفسير نتائج تحاليل الكيمياء الحياتية ودمجها مع الممارسة السريرية للطب. • اكتساب المهارات العملية المتعلقة بالعمل في المختبرات الكيمياء السريرية • تعزيز مهارات التفكير النقدي • الامتثال لقواعد السلامة والاحتياطات العالمية • حل المشاكل المتعلقة بالتناقضات في نتائج الاختبار • تطبيق تكنولوجيا الحاسوب في معالجة البيانات المخبرية السريرية، والإبلاغ عن البيانات واسترجاع المعلومات. • الحفاظ على أخلاقيات مهنية عالية. • التأقلم الفعال ضمن عمل الفريق.

المنهج

الزمن	أهداف الوحدة	موضوعات الوحدة	الاسبوع
8 ساعات	**OBJECTIVES** • Define enzyme and describe how enzyme are classified based on their structures or their actions on substrate. • Define the following terms: (Active Site, Apoenzyme, Holoenzyme, Cofactor, Coenzyme, Cosubstrates) • State the Michaelis-Menten and Lineweaver-Burk equations and relate them to enzyme kinetics by defining reaction velocity, Vmax, and Km. • List the factors that affect the velocity of an enzymatic reaction and how these factors affect enzyme kinetics. • List the physiological factors that affect blood enzyme levels.	**ENZYMES** ➢ OVERVIEW ➢ NOMENCLATURE ➢ PROPERTIES OF ENZYMES ➢ HOW ENZYMES WORK ➢ FACTORS AFFECTING REACTION VELOCITY ➢ MICHAELIS-MENTEN EQUATION ➢ INHIBITION OF ENZYME ACTIVITY ➢ REGULATION OF ENZYME ACTIVITY ➢ ENZYMES IN CLINICAL DIAGNOSIS	4 - 1

المنهج

الزمن	أهداف الوحدة	موضوعات الوحدة	الاسبوع
16 ساعة	**OBJECTIVES** By the end of the lectures, the student should be able to: • Explain glucose metabolism • Know glycolysis pathways • Know glycolysis-related diseases. • Explain the reactions of the citrate cycle, • Know the importance of the citrate cycle and related diseases. • Commentary on the use of ATP from the glycolytic and citrate cyclic site • Explains gluconeogenesis metabolism • Know the importance of gluconeogenesis, its reactions and its regulation with glycolysis • Explains the importance of glycogen metabolism for metabolism. • Know the synthesis and degradation of glycogen metabolism • Know fructose and galactose metabolism • Explain the metabolic pathways involved • Know how to organize the whole carbohydrate metabolism	**CARBOHYDRATES METABOLISM** ➢ GLYCOLYSIS • Transport of Glucose into Cells • Reactions of Glycolysis • Hormonal Regulation of Glycolysis • Alternative Fates of Pyruvate ➢ TRICARBOXYLIC ACID CYCLE • Reactions of the TCA Cycle • Energy Produced by the TCA Cycle • Regulation of the TCA Cycle ➢ GLUCONEOGENESIS • GLYCOGEN METABOLISM • Structure and Function of Glycogen • Synthesis of Glycogen (Glycogenesis) • Degradation of Glycogen (Glycogenolysis) • Regulation and Degradation Synthesis and Degradation • Glycogen Storage Diseases ➢ METABOLISM OF MONOSACCHARIDES • Fructose & Galactose Metabolism • Blood Glucose Level and its Regulation • Diabetes Mellitus and Insulin Metabolism • Hypoglycemia	12-5

المنهج

الزمن	اهداف الوحدة	موضوعات الوحدة	الاسبوع
8 ساعات	**LEARNING OBJECTIVES** By the end of the lectures, the student should be able to: • Explain the metabolic fate of ammonia • Know the normal values of urea • Explain amino acids as buffers • Know insulin structure • Explains amino acid biosynthesis and biomolecules with amino acid structure	**PROTEIN METABOLISM** ➢ Metabolic Fate of Ammonia ➢ Urea: (Normal Values, Uremia) ➢ Amino Acids as Buffers ➢ Serum Protein Components ➢ Insulin Structure ➢ Selected Inborn Errors of Amino Acid Metabolism	16 – 13
8 ساعات	**LEARNING OBJECTIVES** By the end of the lectures, the student should be able to: • Explain the Oxidation of Fatty acids • Know the Metabolism of Ketone Bodies • Explain the Lipoprotein Metabolism • Explain the Cholesterol Metabolism	**LIPID METABOLISM** • Oxidation of Fatty acids • Metabolism of Ketone Bodies • Lipoprotein Metabolism • Cholesterol Metabolism • Atherosclerosis	20 - 17

المنهج

الزمن	أهداف الوحدة	موضوعات الوحدة	الاسبوع
8 ساعات	**LEARNING OBJECTIVES** By the end of the lectures, the student should be able to: • Explain the Disorders of Purines & Pyramidines metabolism • Explain the Uric acid synthesis & hyperuricemia	**NUCLEIC ACID METABOLISM** • Disorders of Purines & Pyramidines metabolism • Uric acid synthesis & hyperuricemia	14-12
6 ساعات	**LEARNING OBJECTIVES** By the end of the lectures, the student should be able to: • Explain the Synthesis of Heme • Know the Disorder of Heme Biosynthesis • Explain the Breakdown of Hemoglobin	**HEMOGLOBIN METABOLISM** • Synthesis of Heme • Disorder of Heme Biosynthesis • Breakdown of Hemoglobin	27 - 25
6 ساعات	**LEARNING OBJECTIVES** By the end of the lectures, the student should be able to: • Explain the Metabolism of Sodium, Potassium, Chloride, Calcium, Phosphorus and Magnesium • Know the Metabolism of Sulfur • Explain the Metabolism of Trace Elements	**Mineral Metabolism** • Introduction • Metabolism of Sodium, Potassium and Chloride • Metabolism of Calcium, Phosphorus and Magnesium • Metabolism of Sulfur • Metabolism of Trace Elements	30 - 28

إرشادات للطلبة

- الرغبة والحماس للتعليم
- كن مشاركاً في جميع الأنشطة
- احترم أفكار المدرس والزملاء
- أنقد أفكار المدرس والزملاء بأدب إن كانت هناك حاجة.
- احرص على استثمار الوقت
- تقبل الدور الذي يسند إليك في المجموعة
- حفز أفراد مجموعتك في المشاركة في النشاطات
- احرص على بناء علاقات طيبة مع المدرس والزملاء أثناء البرنامج التدريبي
- احرص على ما تعلمته في البرنامج وطبقه في الميدان .
- ركز ذهنك بالتعليم واحرص على التطبيق المباشر
- تغلق الموبايل قبل الشروع بالتدريب

الوحدة الأولى (الانزيمات)
اليوم الأول - الزمن: 360 دقيقة

أهداف الوحدة (OBJECTIVES):

1. Define enzyme and describe how enzyme are classified based on their structures or their actions on substrate.
2. Define the following terms: (Active Site, Apoenzyme, Holoenzyme, Cofactor, Coenzyme, Cosubstrates, First-order and zero-order kinetics, K_m, V_{max}, Enzyme inhibition (competitive, noncompetitive, uncompetitive).
3. State the Michaelis-Menten and Lineweaver-Burk equations and relate them to enzyme kinetics by defining reaction velocity, V_{max}, and K_m.
4. Draw and label a Michaelis-Menten curve and a Lineweaver-Burk plot.
5. List the factors that affect the velocity of an enzymatic reaction and how these factors affect enzyme kinetics.
6. State the way in which each type of inhibition affects enzyme kinetics and illustrate how each of the three types affects the enzymatic reaction rate using a Lineweaver-Burk plot.
7. List the physiological factors that affect blood enzyme levels.

جدول الجلسات:

الجلسة	مواضيعها	زمنها
الجلسة الاولى	ENZYMES ➢ OVERVIEW ➢ NOMENCLATURE ➢ PROPERTIES OF ENZYMES	90 دقيقة
الجلسة الثانية	➢ HOW ENZYMES WORK ➢ FACTORS AFFECTING REACTION VELOCITY	90 دقيقة
الجلسة الثالثة	➢ MICHAELIS-MENTEN EQUATION ➢ INHIBITION OF ENZYME ACTIVITY	90 دقيقة
الجلسة الرابعة	➢ REGULATION OF ENZYME ACTIVITY ➢ ENZYMES IN CLINICAL DIAGNOSIS	90 دقيقة

الوحدة الأولى

الجلسة الأول - الزمن: 90 دقيقة

أهداف الجلسة الاولى (OBJECTIVES)

- Define enzyme and describe how enzyme are classified based on their structures or their actions on substrate.
- Define the following terms: (Active Site, Apoenzyme, Holoenzyme, Cofactor, Coenzyme, Cosubstrates).
- Describe the following properties of enzymes: (Catalytic Efficiency of Enzymes, Specificity of Enzymes, Regulation of Enzymes Activity and Location of Enzymes

موضوعات الجلسة الاولى

ENZYMES

- OVERVIEW
- NOMENCLATURE
- PROPERTIES OF ENZYMES

النشاط (1/1/1)

نشاط تدريبي التعارف وكسر الجمود من خلال تعبئة المطلوب

اسم النشاط	نشاط التعارف
ادوات تنفيذ النشاط	بطاقة تعريف – أقلام ملونة
آلية التنفيذ	توزع بطاقة تعريف على الطلبة والمطلوب تعبئة البيانات ومن ثم تبادل البطاقات وكل طالب يقرأ بطاقة زميله وهكذا يتم التعرف على الجميع.
مدة النشاط	10 دقائق

نشاط التعارف يطبع ويوزع على الطلبة

م	المطلوب	الإجابة
1	الاسم الثلاثي	
2	الهوايات والمواهب	
3	أمنية تتمنى تحققها	
4	الاسباب التي دعتك للمشاركة في هذا البرنامج	

الوحدة الأولى

الجلسة الأول - الزمن: 90 دقيقة

Enzymes

I. OVERVIEW

- Virtually all reactions in the body are mediated by enzymes, which are protein catalysts that increase the rate of reactions without being changed in the overall process.
- Among the many biologic reactions that are energetically possible, enzymes selectively channel reactants (called substrates) into useful pathways.
- Enzymes thus direct all metabolic events.

II. NOMENCLATURE

Each enzyme is assigned two names.

- The first is its short, recommended name, convenient for everyday use.
- The second is the more complete systematic name, which is used when an enzyme must be identified without ambiguity.

A. Recommended name

- Most commonly used enzyme names have the suffix "-*ase*" attached to the substrate of the reaction (for example, *glucosidase* and *urease*), or to a description of the action performed (for example, *lactate dehydrogenase* and *adenylyl cyclase*).

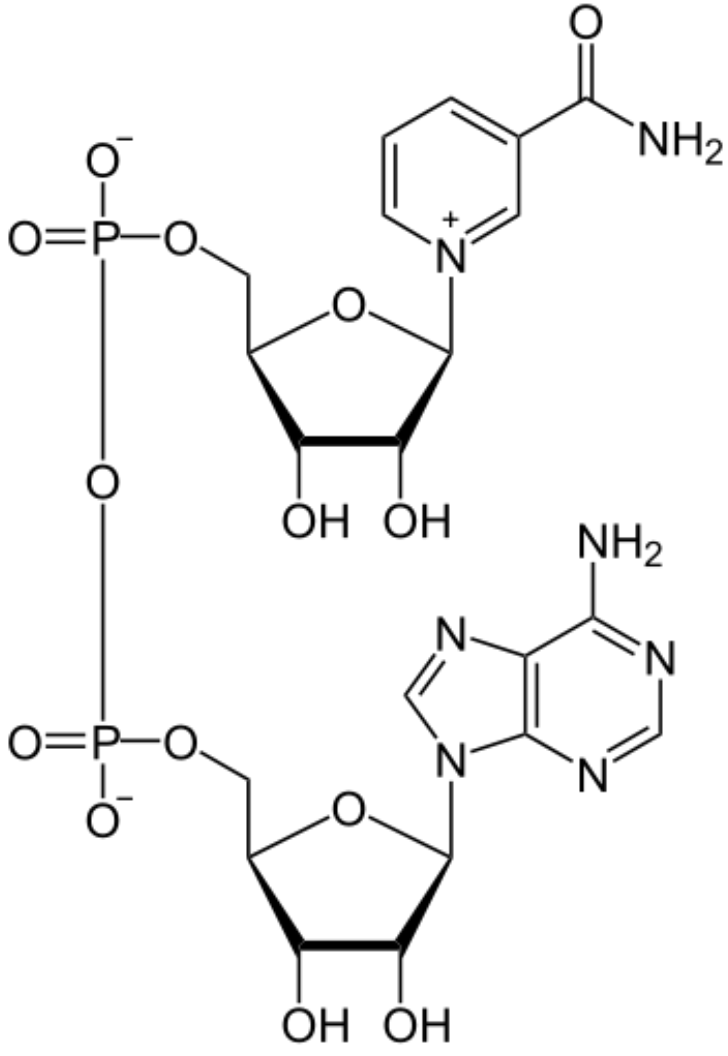
- [Note: Some enzymes retain their original trivial names, which give no hint of the associated enzymic reaction, for example, *trypsin* and *pepsin*.]

B. Systematic name

- In the systematic naming system, enzymes are divided into six major classes (Figure 1), each with numerous subgroups.
- For a given enzyme, the suffix *-ase* is attached to a fairly complete description of the chemical reaction catalyzed, including the names of all the substrates; For example, *lactate:NAD^+ oxidoreductase*.
- [Note: Each enzyme is also assigned a classification number.]
- The systematic names are unambiguous and informative, but are frequently too cumbersome to be of general use.

Nicotinamide adenine dinucleotide

- Nicotinamide adenine dinucleotide (NAD) is a coenzyme found in all living cells.
- The compound is a dinucleotide, because it consists of two nucleotides joined through their phosphate groups.
- One nucleotide contains an adenine base and the other nicotinamide.
- Nicotinamide adenine dinucleotide exists in two forms: an oxidized and reduced form abbreviated as NAD+ and NADH respectively.



- In metabolism, nicotinamide adenine dinucleotide is involved in redox reactions, carrying electrons from one reaction to another.
- The coenzyme is, therefore, found in two forms in cells:
  - NAD+ is an oxidizing agent – it accepts electrons from other molecules and becomes reduced.
  - This reaction forms NADH, which can then be used as a reducing agent to donate electrons.
  - These electron transferreactions are the main function of NAD.

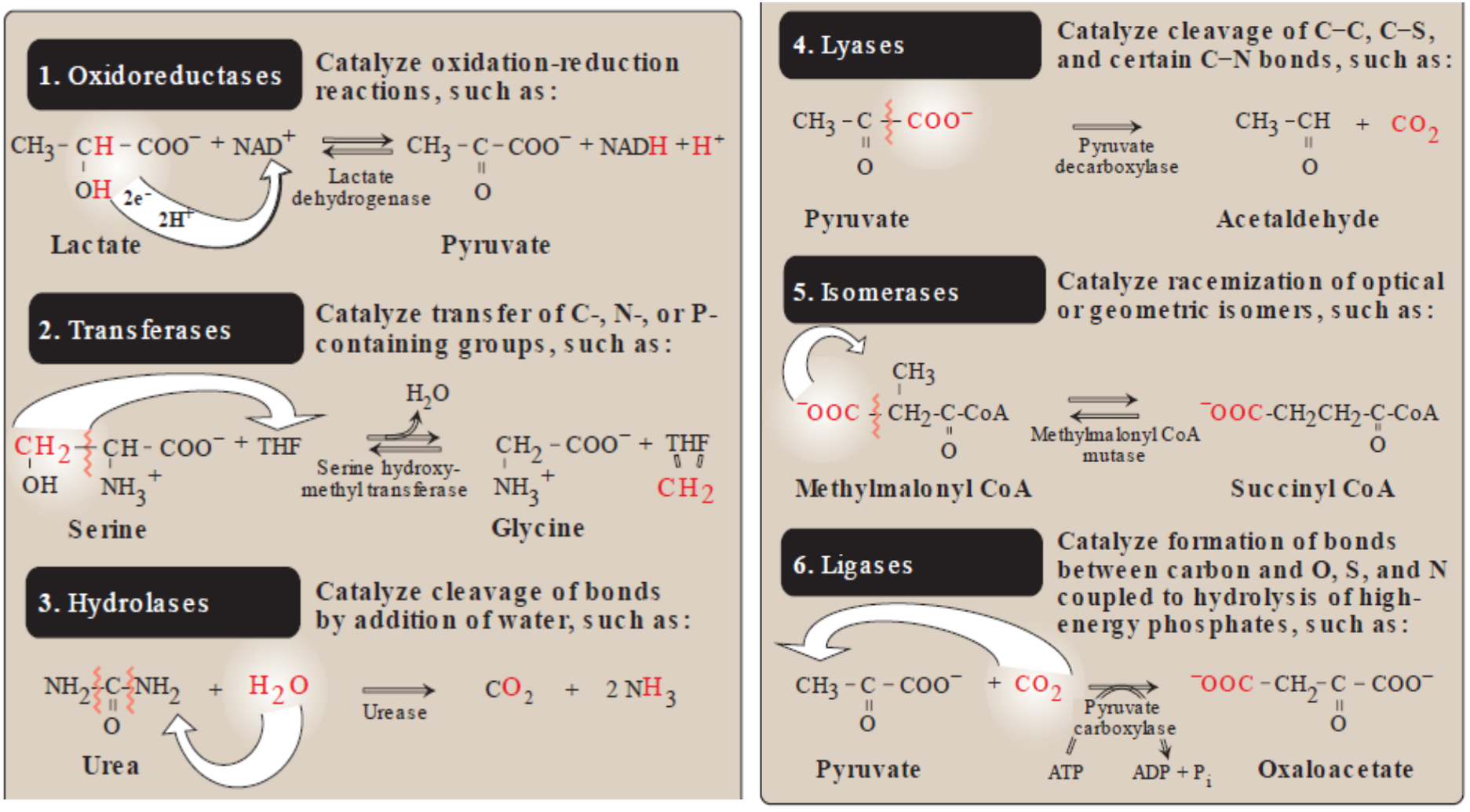


Figure 1.1 The six major classes of enzymes with examples.
THF = tetrahydrofolate.

III. PROPERTIES OF ENZYMES

- **Enzymes** are protein catalysts that increase the velocity of a chemical reaction, and are not consumed during the reaction.
- Some RNAs can act like enzymes, usually catalyzing the cleavage and synthesis of phosphodiester bonds.
- RNAs with catalytic activity are called **ribozymes**, and are much less commonly encountered than protein catalysts.

A. Active sites

- Enzyme molecules contain a special pocket or cleft called the **active site**. The active site contains amino acid side chains that participate in substrate binding and catalysis.
- The substrate binds the enzyme, forming an enzyme–substrate (ES) complex.
- Binding is thought to cause a conformational change in the enzyme (induced fit) that allows catalysis.
- ES is converted to an enzyme–product (EP) complex that subsequently dissociates to enzyme and product.

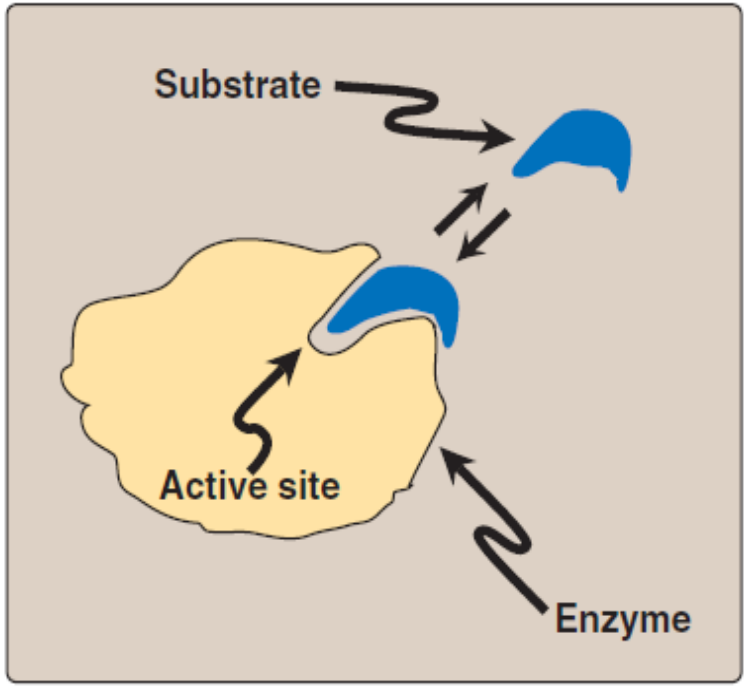


Figure 1.2 Schematic representation of an enzyme with one active site binding a substrate molecule.

B. Catalytic Efficiency

- Enzyme-catalyzed reactions are highly efficient, proceeding from 10^3–10^8 times faster than uncatalyzed reactions.
- The number of molecules of substrate converted to product per enzyme molecule per second is called the turnover number, or k_{cat} and typically is 10^2–$10^4 s^{-1}$.

C. Specificity

- Enzymes are highly specific, interacting with one or a few substrates and catalyzing only one type of chemical reaction.
- [Note: The set of enzymes made in a cell determines which metabolic pathways occur in that cell.]

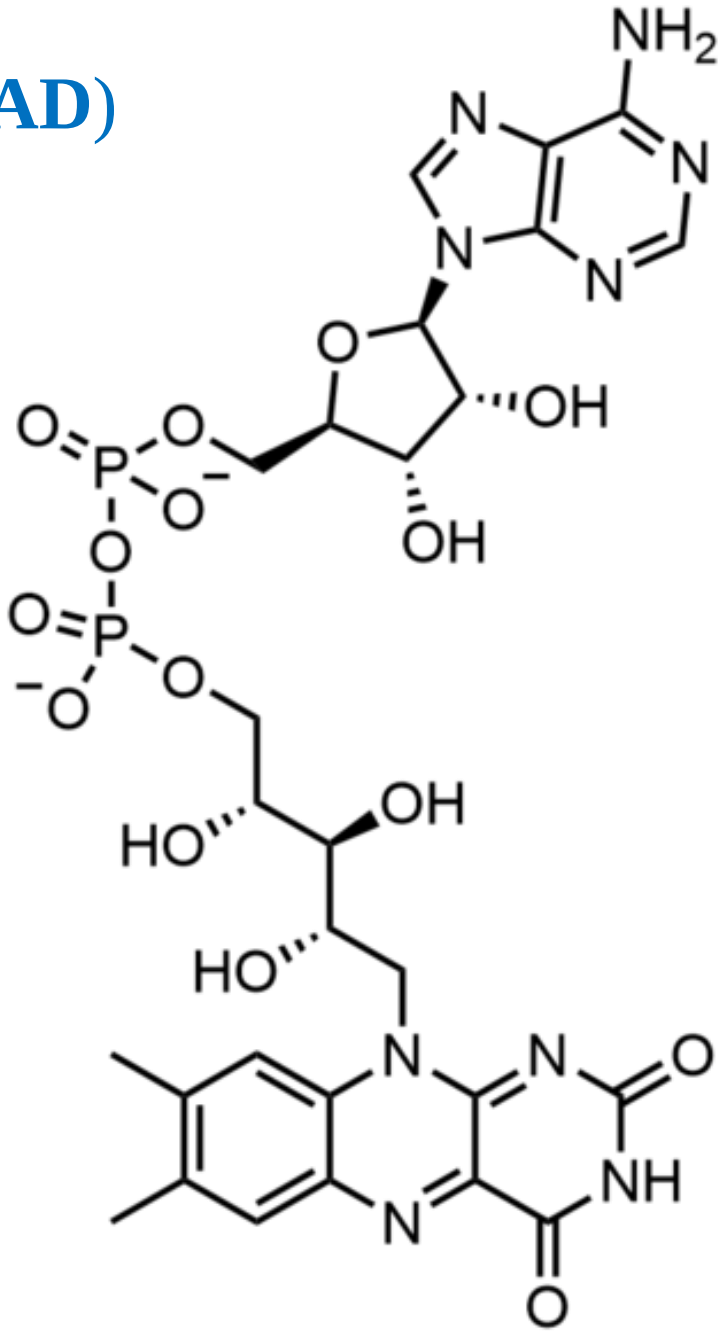
D. Holoenzymes

- Some enzymes require molecules other than proteins for enzymic activity.
- The term **holoenzyme** refers to the active enzyme with its nonprotein component, whereas the enzyme without its nonprotein moiety is termed an **apoenzyme** and is inactive.
- If the nonprotein moiety is a metal ion such as Zn^{2+} or Fe^{2+}, it is called a **cofactor**. If it is a small organic molecule, it is termed a **coenzyme**.

- Coenzymes that only transiently associate with the enzyme are called **cosubstrates**. Cosubstrates dissociate from the enzyme in an altered state (NAD^+ is an example).
- If the coenzyme is permanently associated with the enzyme and returned to its original form, it is called a **prosthetic group** (FAD is an example).
- Coenzymes frequently are derived from vitamins. For example, NAD^+ contains niacin and FAD contains riboflavin.

Flavin adenine dinucleotide (FAD)

In biochemistry, **flavin adenine dinucleotide (FAD)** is a redox coenzyme, more specifically a prosthetic group of a protein, involved in several important enzymatic reactions in metabolism.



E. Regulation

- Enzyme activity can be regulated, that is, increased or decreased, so that the rate of product formation responds to cellular need.

F. Location within the cell

- Many enzymes are localized in specific organelles within the cell (Figure 1.3).
- Such compartmentalization serves to isolate the reaction substrate or product from other competing reactions.
- This provides a favorable environment for the reaction, and organizes the thousands of enzymes present in the cell into purposeful pathways.

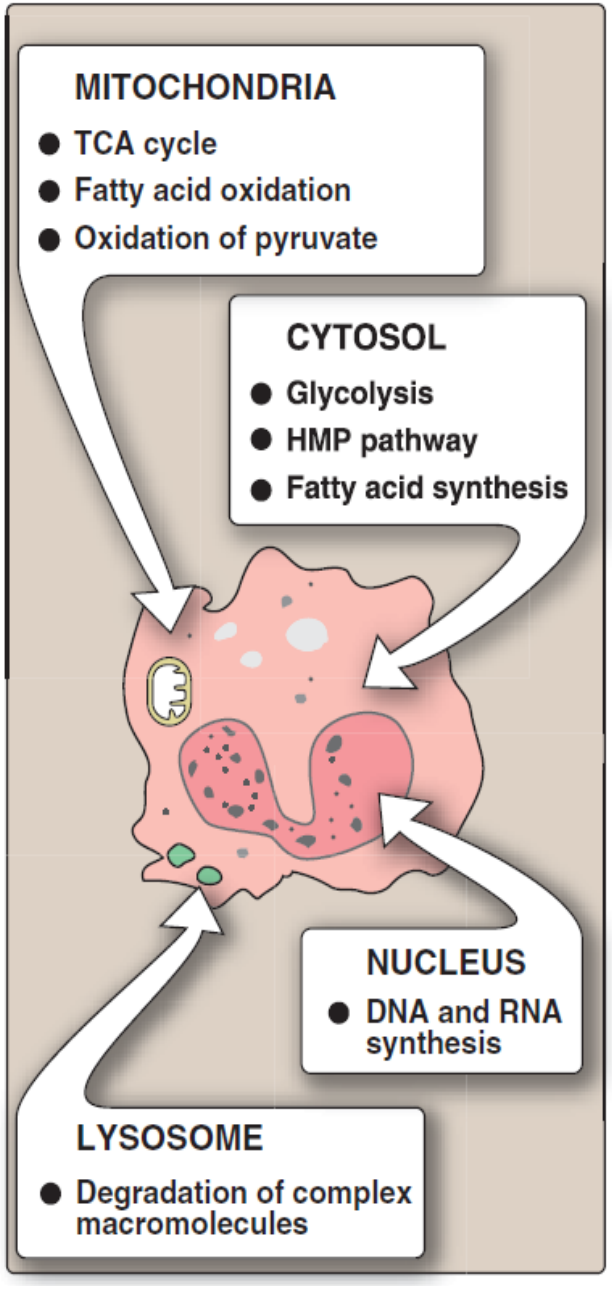


Figure 1.3 The intracellular location of some important biochemical pathways.

النشاط (2/1/1)
تمرين متعدد الخيارات

Choose the ONE correct answer.

1. One of the enzymes involved in glycolysis, aldolase, requires Zn^{2+} for catalysis. Under conditions of zinc deficiency, when the enzyme may lack zinc, it would be referred to as the:

   A. apoenzyme.

   B. coenzyme.

   C. holoenzyme.

   D. prosthetic group.

   E. substrate.

2. What is an apoenzyme?

   A. It is a protein portion of an enzyme

   B. It is a non-protein group

   C. It is a complete, biologically active conjugated enzyme

   D. It is a prosthetic group

3. Which one of the following is not among the six internationally accepted classes of enzymes?

   A. Hydrolases

   B. Ligases

   C. Oxidoreductases

   D. Polymerases

   E. Transferases