

LECTURE 4: INTRODUCTION TO ENZYMES

- Historical perspectives
- Nomenclature
- Classification
- Properties

Review of biological functional groups

Remember structures of functional groups
(remember your Organic Chem!)

Review of amino acids

Names of the 20 amino acids

Review of amino acids...

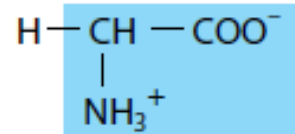
Draw the structures of any 5 amino acids

Review of amino acids and protein structure

Amino Acids with Aliphatic Side Chains (*non-polar*)

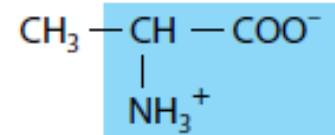
Glycine

Gly [G]



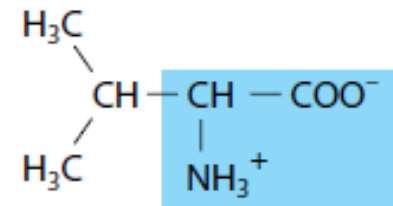
Alanine

Ala [A]



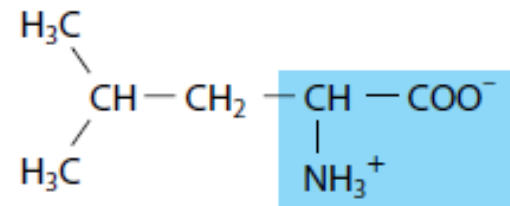
Valine

Val [V]



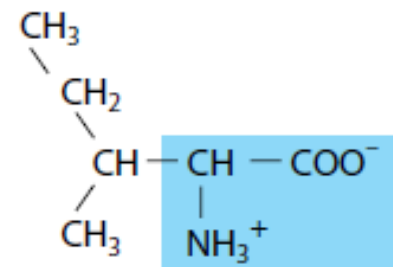
Leucine

Leu [L]



Isoleucine

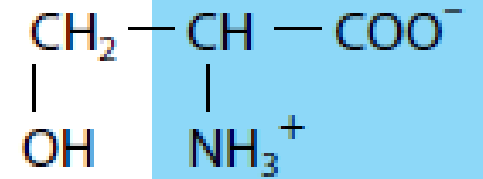
Ile [I]



Amino Acids with Hydroxyl-Containing Side Chains

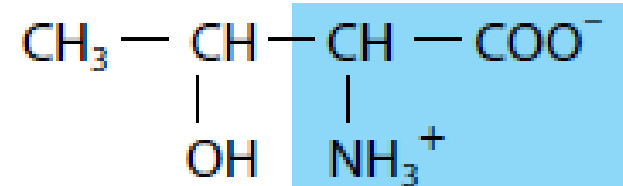
Serine

Ser [S]



Threonine

Thr [T]



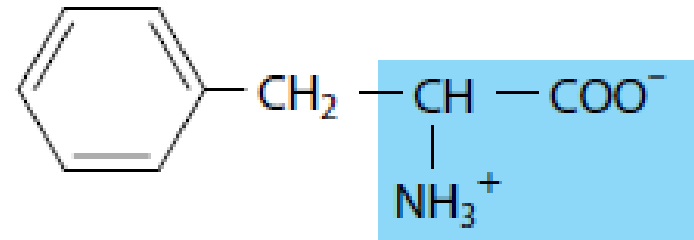
Tyrosine

Tyr [Y]

Amino Acids with Aromatic Side Chains

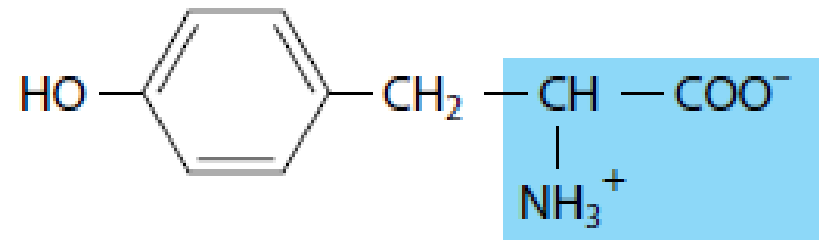
Phenylalanine

Phe [F]



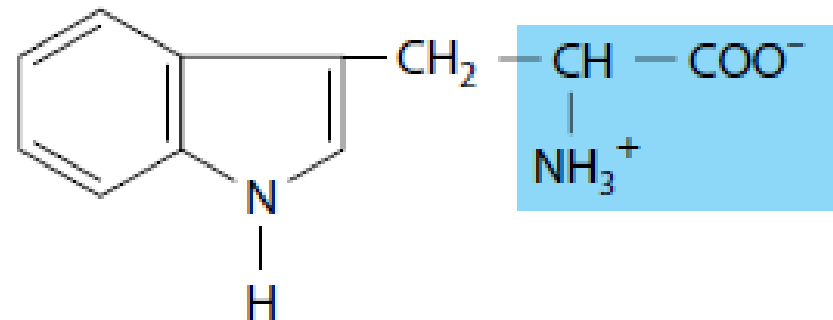
Tyrosine

Tyr [Y]



Tryptophan

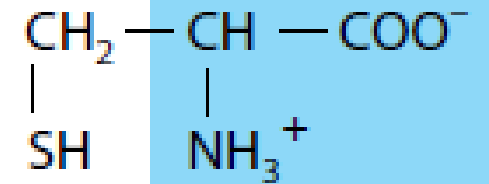
Trp [W]



Amino Acids with Sulfur-Containing Side Chains

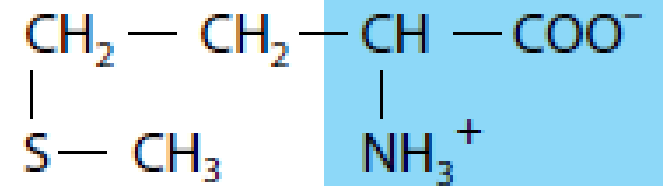
Cysteine

Cys [C]



Methionine

Met [M]

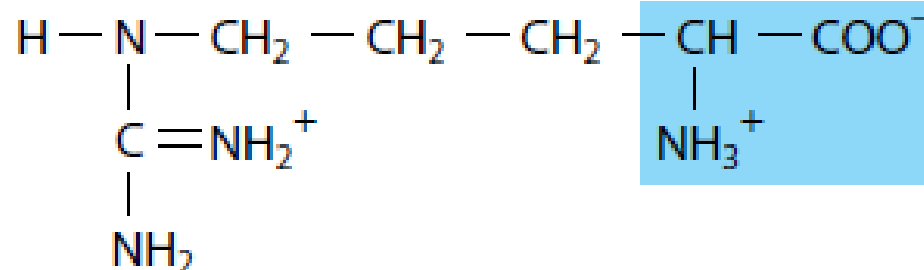


Amino Acids with "Basic" Side Chains

(Structures are those that predominate at pH 7)

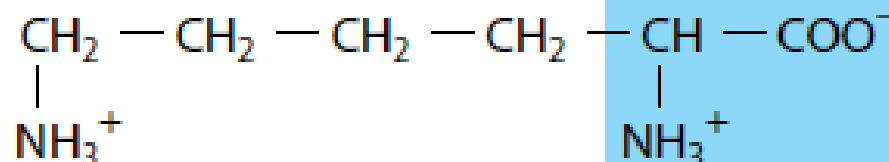
Arginine

Arg [R]



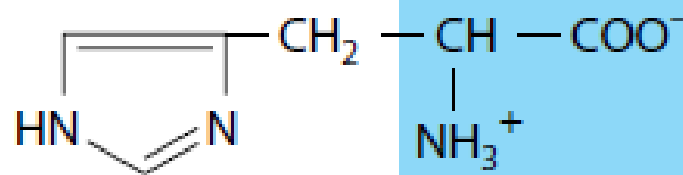
Lysine

Lys [K]



Histidine

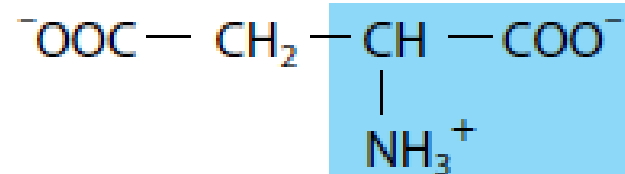
His [H]



Amino Acids with Acidic Side Chains and their Amides (Structures are those that predominate at pH 7)

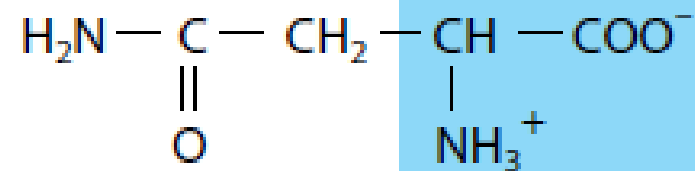
Aspartic acid

Asp [D]



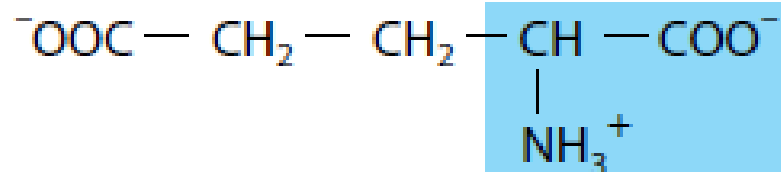
Asparagine

Asn [N]



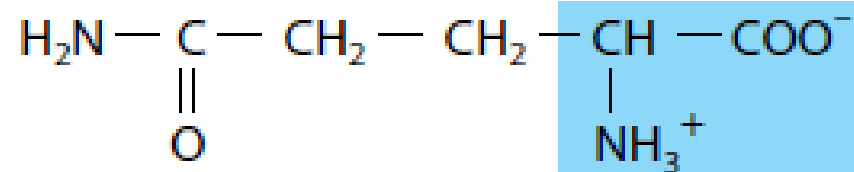
Glutamic acid

Glu [E]



Glutamine

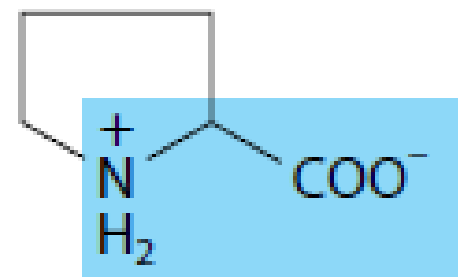
Gln [Q]

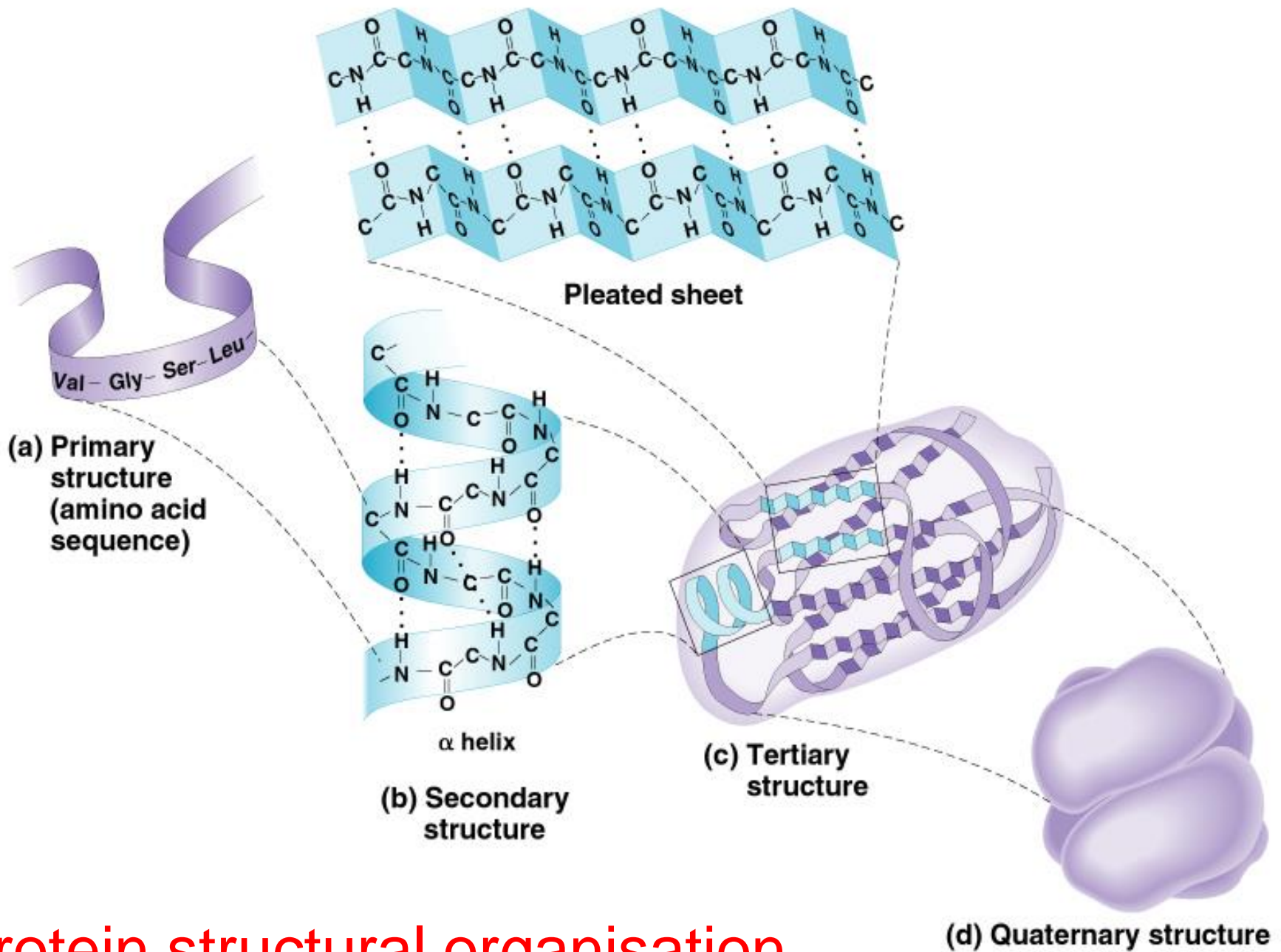


Imino acid

Proline

Pro [P]





Protein structural organisation

Introduction to enzymes

- (1). Much of the early history of biochemistry is the history of enzyme research
- (2). Biological catalysts were first recognized in studying animal **food digestion** and **sugar fermentation** with yeast (brewing and wine making)
- (3). **Ferments (i.e., enzymes, meaning “in yeast”)** were thought (wrongly) to be inseparable from living yeast cells for quite some time (Louis Pasteur)

(4). Yeast extracts were found to be able to ferment sugar to alcohol (Eduard Buchner, 1897, who won the Nobel Prize in Chemistry in 1907 for this discovery)

(5). Enzymes were found to be proteins (1920s to 1930s, James Sumner on urease and catalase ,“all enzymes are proteins”, John Northrop on pepsin and trypsin, both shared the 1946 Nobel Prize in Chemistry)

(6). Catalytic RNA (also called ribozyme ---from ribonucleic acid enzyme, or RNA enzyme) were found in the 1980s (Thomas Cech, Nobel Prize in Chemistry in 1989)

Characteristics of Enzymes

- i. Almost all enzymes are proteins. Enzymes follow the physical and chemical reactions of proteins.
- ii. They are heat labile.
- iii. They are water-soluble.
- iv. They can be precipitated by protein precipitating reagents (ammonium sulfate or trichloroacetic acid).
- v. They contain 16% weight as nitrogen.

Naming Enzymes

- The name of an enzyme in many cases end in –ase
- For example, **sucrase** catalyzes the hydrolysis of sucrose
- The name describes the function of the enzyme
For example, **oxidases** catalyze **oxidation reactions**
- Sometimes common names are used, particularly for the digestion enzymes such as *pepsin* and *trypsin*
- Some names describe both the substrate and the function. For example, **alcohol dehydrogenase** oxidizes ethanol

Enzymes Are Classified into six functional Classes (EC number Classification) by the International Union of Biochemists (I.U.B.) on the Basis of the Types of Reactions That They Catalyze

EC 1. Oxidoreductases

EC 2. Transferases

EC 3. Hydrolases

EC 4. Lyases

EC 5. Isomerases

EC 6. Ligases

Principle of the international classification

Each enzyme has **classification number** consisting of four digits:

Example, **EC:** (2.7.1.1) HEXOKINASE

EC: (2.7.1.1) these components indicate the following groups of enzymes:

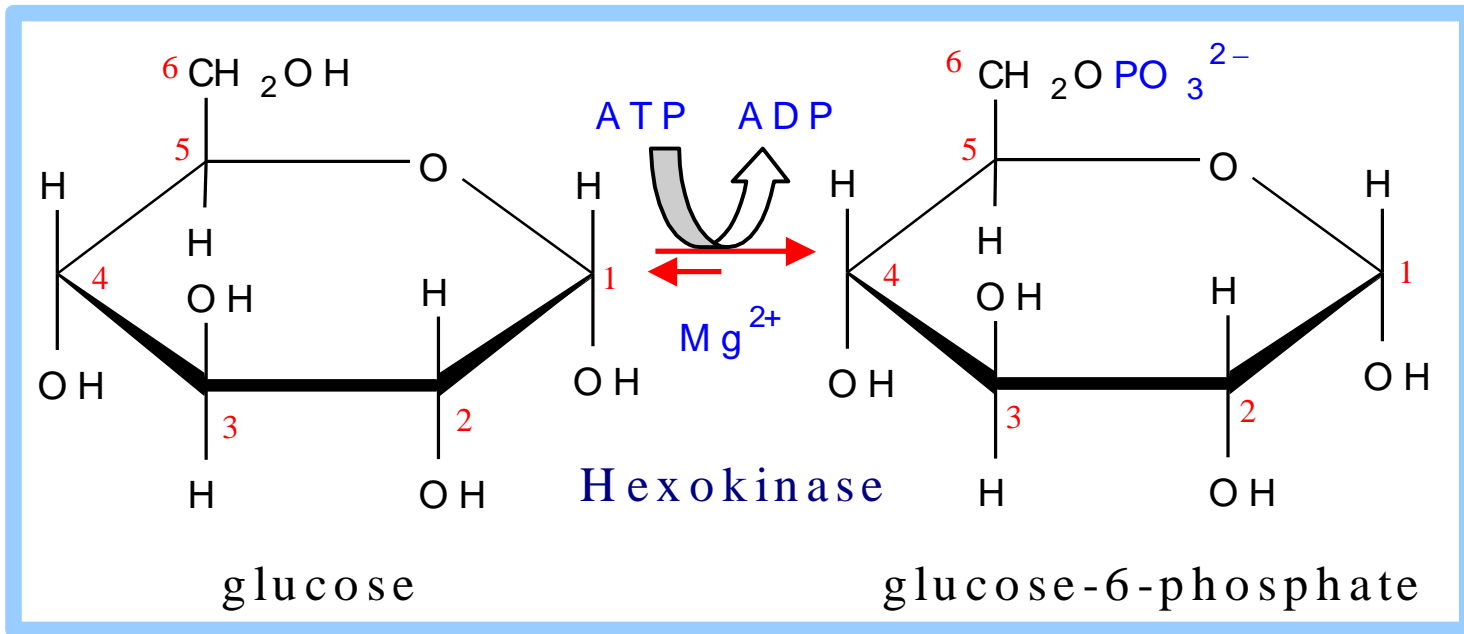
2. IS CLASS (TRANSFERASE)

7. IS SUBCLASS (TRANSFER OF PHOSPHATE)

1. IS SUB-SUB CLASS (ALCOHOL IS PHOSPHATE ACCEPTOR)

1. SPECIFIC NAME

**ATP,D-HEXOSE-6-PHOSPHOTRANSFERASE
(Hexokinase)**



Hexokinase catalyzes:

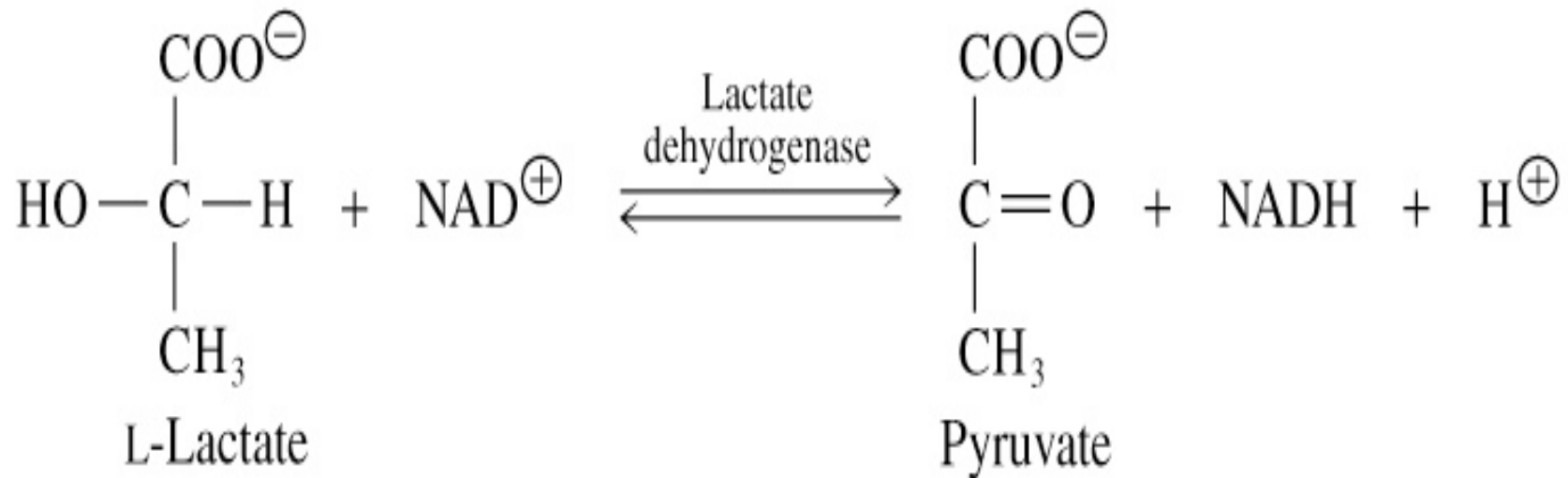


EC 1. Oxidoreductases

- **Biochemical Activity:**
 - **Catalyse Oxidation/Reduction**
 - Reactions Act on many chemical groupings to add or remove hydrogen atoms**
- **Examples:**
 - **Lactate dehydrogenase**
 - **Glucose Oxidase**
 - **Peroxidase**
 - **Catalase**
 - **Phenylalanine hydroxylase**

1. Oxidoreductases

- Catalyze oxidation-reduction reactions



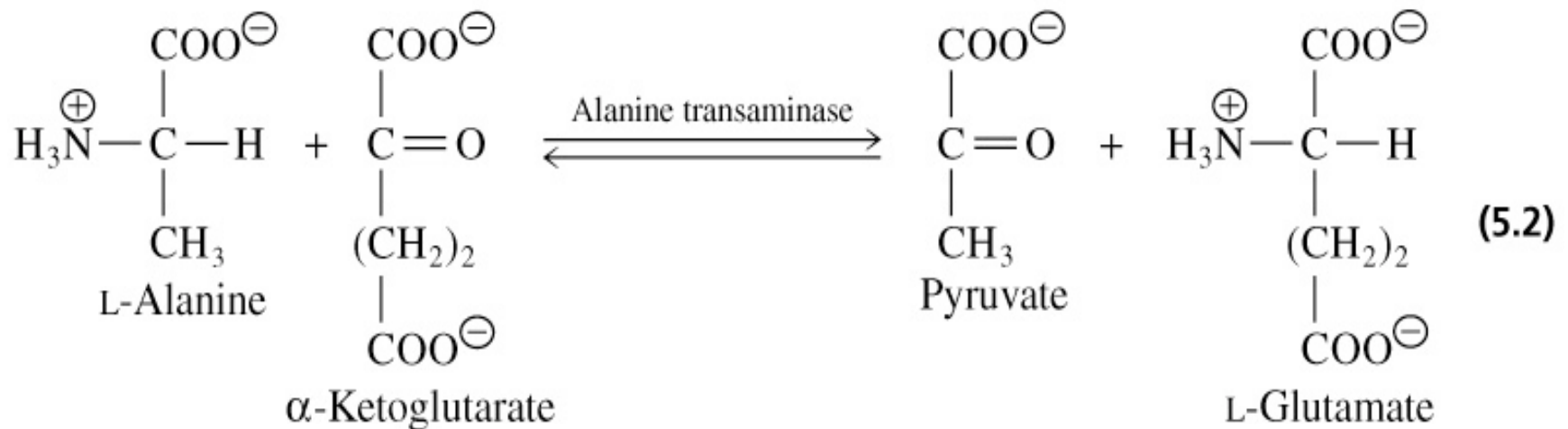
- oxidases
- peroxidases
- dehydrogenases

EC 2. Transferases

- **Biochemical Activity:**
 - Transfer a functional groups (e.g. methyl or phosphate) between donor and acceptor molecules
- **Examples:**
 - **Transaminases (ALT & AST)**
 - **Phosphotransferases (Kinases)**
 - **Transmethylases**
 - **Transpeptidases**
 - **Transacylases**

2. Transferases

- Catalyze group transfer reactions

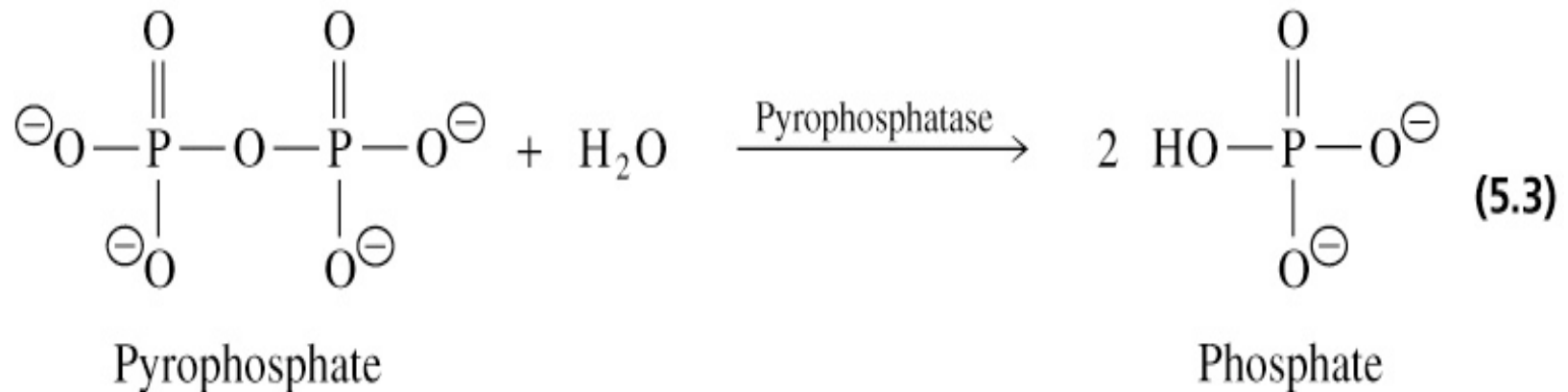


EC 3. Hydrolases

- **Biochemical Activity:**
 - **Catalyse the hydrolysis of various bonds**
Add water across a bond
- **Examples:**
 - **Protein hydrolyzing enzymes (Peptidases)**
 - **Carbohydases (Amylase, Maltase, Lactase)**
 - **Lipid hydrolyzing enzymes (Lipase)**
 - **Deaminases**
 - **Phosphatases**

3. Hydrolases

- Catalyze **hydrolysis reactions** where water is the acceptor of the transferred group

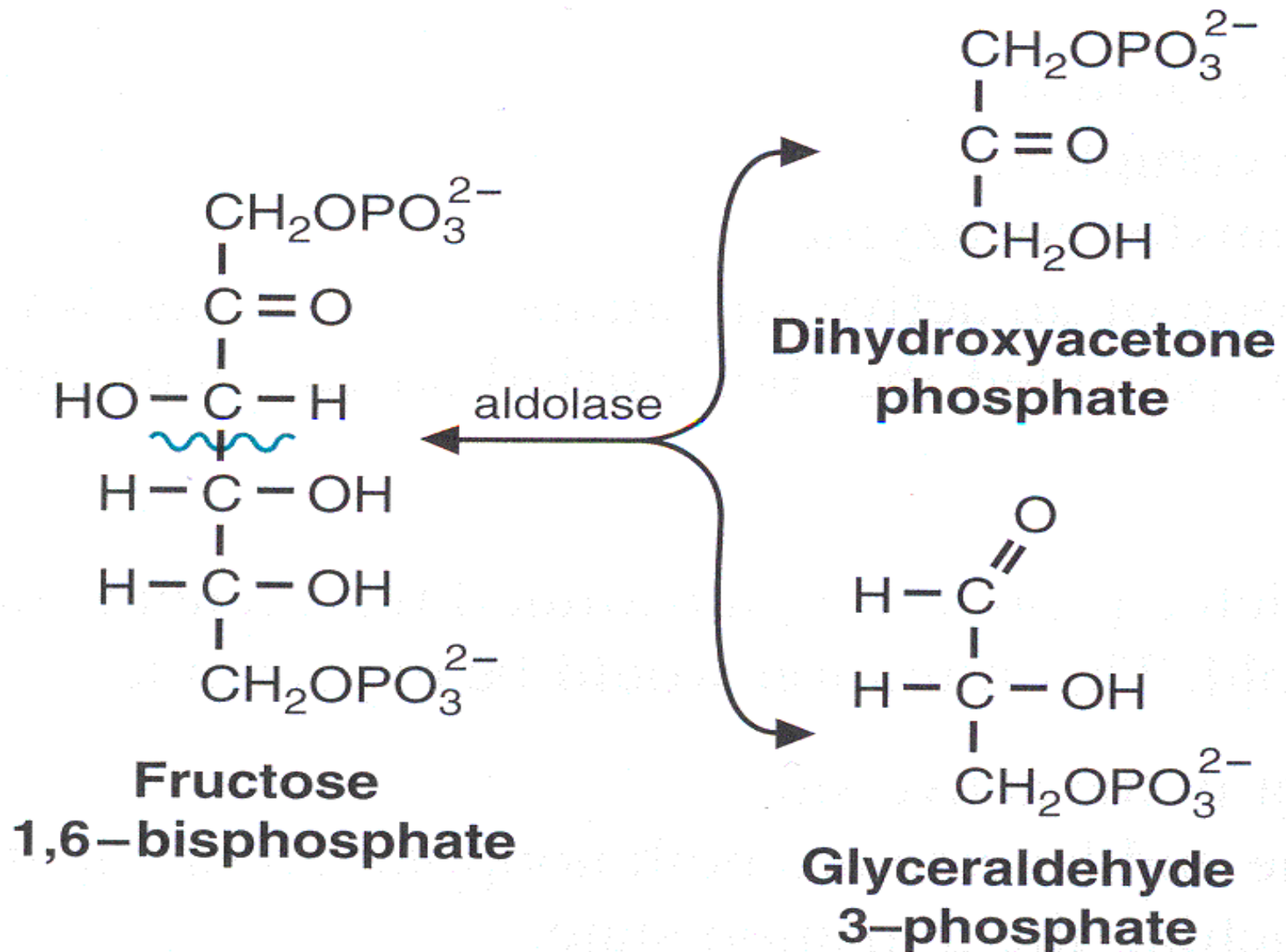


- **esterases**
- **peptidases**
- **glycosidases**

EC 4. Lyases

- **Biochemical Activity:**
 - **Cleave various bonds by means other than hydrolysis and oxidation**
 - **Add Water, Ammonia or Carbon dioxide across double bonds, or remove these elements to produce double bonds**
- **Examples:**
 - **Fumarase**
 - **Carbonic anhydrase**

4. Lyases

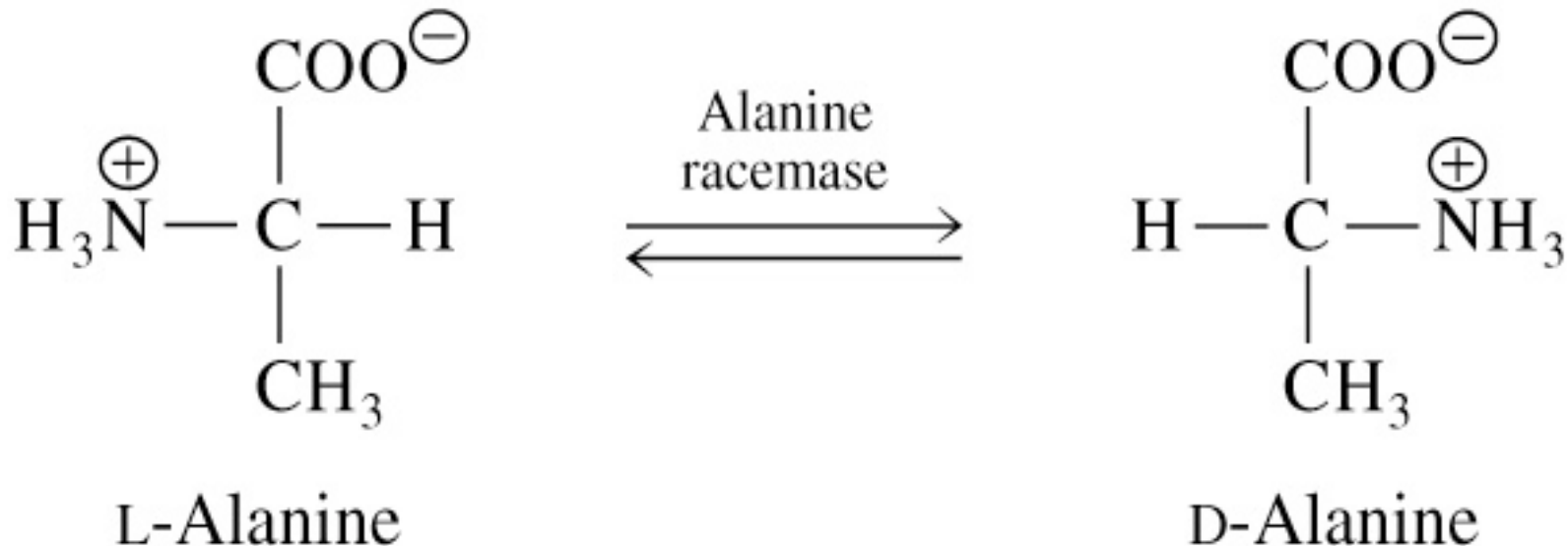


EC 5. Isomerases

- **Biochemical Activity:**
 - **Catalyse isomerization changes within a single molecule**
 - **Carry out many kinds of isomerization:**
 - **L to D isomerizations**
 - **Mutase reactions (Shifts of chemical groups)**
- **Examples:**
 - **Isomerase**
 - **Mutase**

5. Isomerases

- Catalyze isomerization reactions



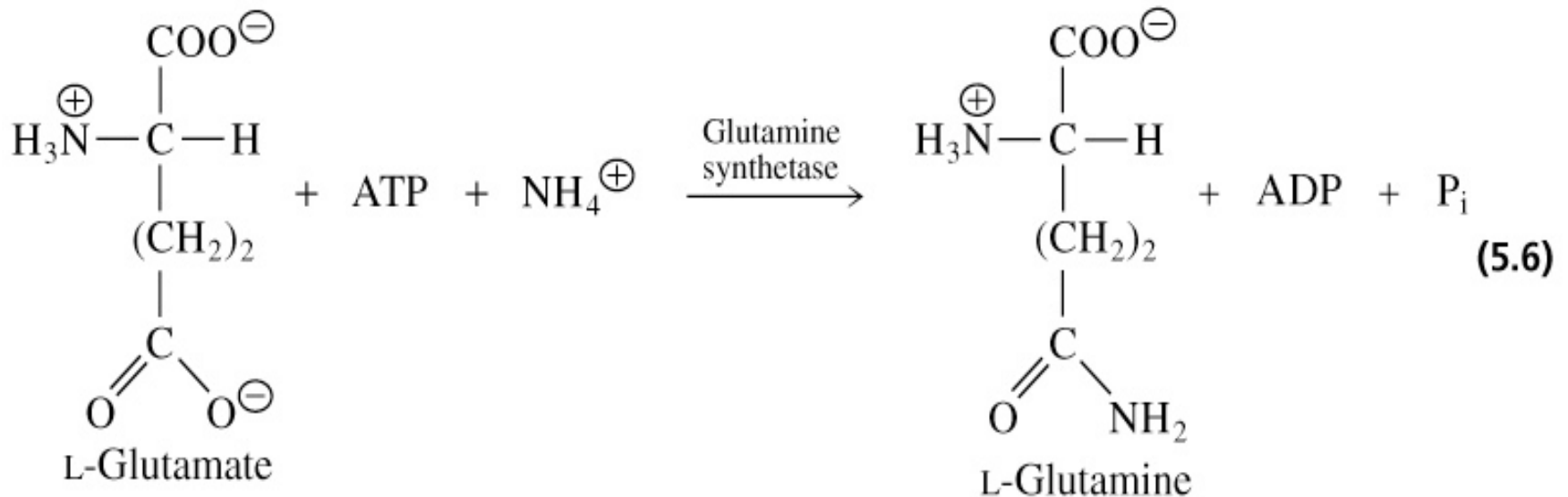
EC 6. Ligases

- **Biochemical Activity:**
 - Join two molecules with covalent bonds
 - Catalyse reactions in which two chemical groups are joined (or ligated) with the use of energy from ATP
- **Subclasses and the bonds formed by ligases**

6.1 C-O	6.2 C-S	6.3 C-C
6.4 C-N	6.5 phosphate ester	
- **Examples:**
 - Acetyl~CoA Carboxylase
 - **Glutamine synthetase**

6. Ligases (synthetases)

- Catalyze **ligation**, or joining of two substrates
- Require chemical energy (e.g. ATP)



Synthetases are ATP-dependent enzymes catalysing biosynthetic reactions; they belong to Ligases (class 6). Examples are Carbamoyl phosphate synthetase; Argininosuccinate synthetase; PRPP synthetase and Glutamine synthetase

Synthases are enzymes catalysing biosynthetic reactions; but they do not require ATP directly; they belong to classes other than Ligases. Examples are Glycogen synthase and ALA synthase

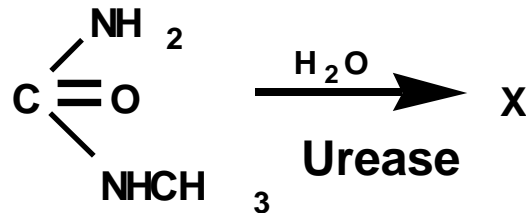
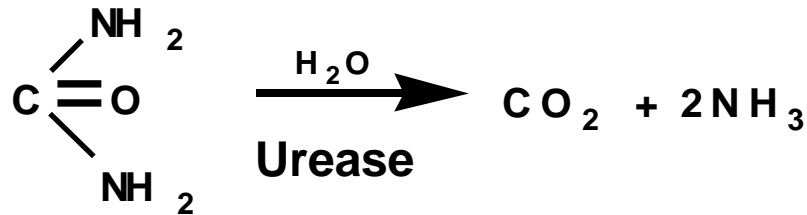
Properties of enzymes

- **Catalytic efficiency** – high efficiency, 10^3 to 10^{17} faster than the corresponding uncatalyzed reactions
- **Specificity** - high specificity, interacting with one or a few specific substrates and catalyzing only one type of chemical reaction
-
- **Mild reaction conditions**- 37 °C, physiological pH, ambient atmospheric pressure

High specificity

1). **Absolute specificity:** the enzyme will catalyze **only one reaction**.

e.g

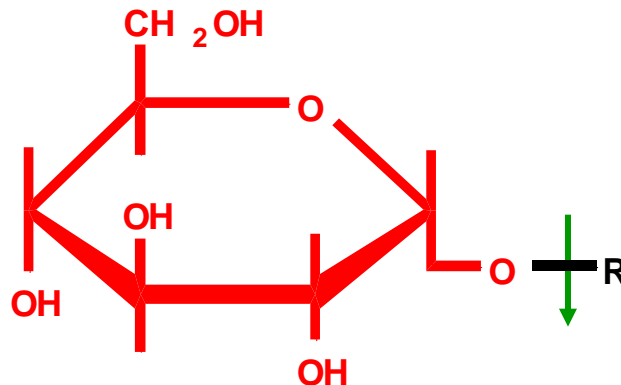


2). Relative specificity

(i) **Group specificity:** the enzyme will act only on molecules that **have specific functional groups**, such as amino, phosphate and methyl groups.

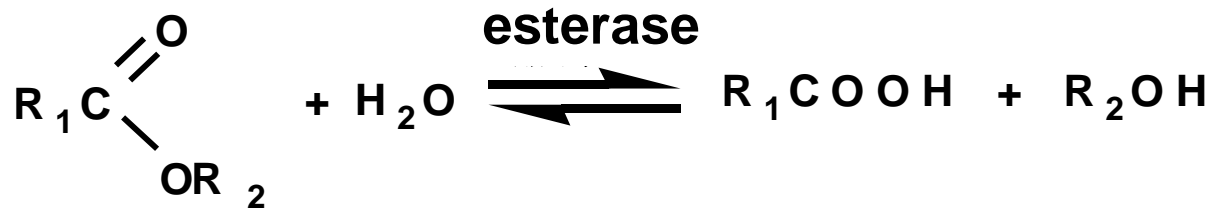


e.g α -D-glucosidase



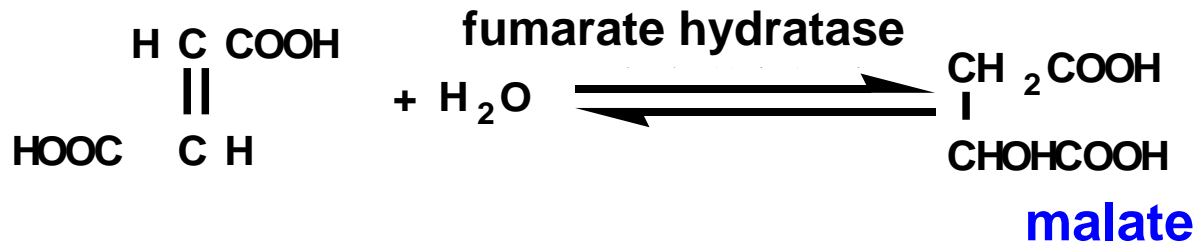
2). Relative specificity...

ii). **Bond specificity:** the enzyme will act on a particular type of chemical bond regardless of the rest of the molecular structure.



3). Stereospecificity:

The enzyme will act on a particular steric or optical isomer



Next lecture

Enzyme purification