Enzymes and the EC nomenclature

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STRUCTURE OF ENZYMES AND PROTEINS

- Enzymes are Biological Catalysts that are Protein Molecules in Nature.
- Enzymes are Produced by Living Cells (Animal, Plant, and Microorganism)

Introduction

Absolutely essential as catalysts in biochemical reactions.

Almost every cell reaction requires the presence of a specific enzyme.

Substrates : reactants of enzyme catalyzed reactions

All enzymes are proteins; but w/o the presence of a non-protein component called co-factor, many enzyme proteins lack catalytic activity

Inactive protein component – apoenzyme

ENZYMES

All Enzymes are protein molecules

Enzyme has two parts of protein

i. Active protein ii. inactive protein with a non protein component (cofactor).

- Many enzymes lack catalytic activity in the absence of cofactor
- In above case, inactive protein part is referred as apoenzyme

Active protein including cofactor is holoenzyme

ENZYME

Cofactor-organic or metal ion
Prosthetic enzyme-cofactor is tightly bound ; can not be separated w/o damaging enzyme
Major function of enzyme : Catalyze the making and breaking of chemical bonds . Thus increasing the rate of reaction without themselves undergoing permanent chemical changes.

ENZYMES

The catalytic ability of enzymes is due to its particular protein structure.

A specific chemical reaction is catalyzed at a small portion of the surface of an enzyme, which is known as the active site.

Some physical and chemical interactions occur at this site to catalyze a certain chemical reaction for a certain enzyme.

ENZYME REACTIONS VS CHEMICAL REACTIONS

1. An enzyme catalyst is highly specific, and catalyzes only one or a small number of chemical reactions.

A great variety of enzymes exist, which can catalyze a very wide range of reactions.

2. The rate of an enzyme-catalyzed reaction is usually much faster than that of the same reaction when directed by non- biological catalysts.

Only a small amount of enzyme is required to produce a desired effect.

3. The reaction conditions (temperature, pressure, pH, and so on) for the enzyme reactions are very mild.

4. Enzymes are comparatively sensitive or unstable molecules and require care in their use.

NOMENCLATURE OF ENZYMES

Originally enzymes were given nondescriptive names example

Rennin- curding of milk to start cheese-making process

pepsin -hydrolyzes proteins at acidic pH

Trypsin- hydrolyzes proteins at mild alkaline pH

-called as Trival name

-no idea of source, function or reaction catalyzed by the enzyme name

The nomenclature was later improved by adding the suffix *-ase to the name* of the substrate with which the enzyme functions, or to the reaction that is catalyzed.

NOMENCLATURE OF ENZYMES

Nomenclature by "International Union Of Biochemistry "

Examples:

Name of substrate + *ase*

α-amylase: starch → glucose + maltose +oligosaccharides

Lactase :lactose → glucose + galactose

Lipase :lipid(fat) → fatty acids + glycerol

Maltase: maltose → glucose

Urease: urea + H2O → 2NH3 + CO2

Cellobiase: cellobiose → glucose

Note: *oligos(small)saccharides(2-10): small no. of component sugars*

NOMENCLATURE OF ENZYMES

Reaction which is catalyzed + *ase*

Alcohol dehydrogenase: ethanol+NAD ↔ acetaldehyde + NADH2

NADH-Nicotinamide Adenine Dinucleotide

Glucose isomerase: glucose↔ fructose

Glucose oxidase: D-glucose + O_2 *+* H_2O *→ gluconic acid*

Lactic acid dehydrogenase: lactic acid → pyruvic acid

As more enzymes were discovered, this system generated confusion.

ENZYME COMMISSION(EC) NUMBER

Enzymes are classified into six different groups according to the reaction being catalyzed.

The nomenclature was determined by the Enzyme Commission in 1961 (with the latest update having occurred in 1992), hence all enzymes are assigned an “EC” number.

EC was appointed by International Union of Biochemistry

EC has given all known enzymes a systematic name and a four figure classification

EC NUMBERS

- This classification does not take into account amino acid sequence (ie, homology), protein structure, or chemical mechanism
- EC numbers have four digits, for example a.b.c.d, where “a” is the class, “b” is the subclass, “c” is the sub-subclass, and “d” is the sub-sub-subclass.
- The “b” and “c” digits describe the reaction, while the “d” digit is used to distinguish between different enzymes of the same function based on the actual substrate in the reaction.
- Alcohol + NAD^+ → acetaldehyde + $NADH^+$ + H^+

EC number :1.1.1.1

Trival name:Alcohol dehydrogenase

Chitinase
(poly(1,4-(*N-acetyl-β-D-glucosaminide))*
glycanohydrolase,
Chitin to low-molecular-weight,
soluble multimers of *N-acetyl-β-D-glucosamine*
(GlcNAc) and the dimer *N,N'-diacetyl chitobiose*
E.C. 3.2.1.14

EXAMPLES

Chitosanase

chitosan *N-acetylglucosaminohydrolase*

Hydrolyzes β-1,4-linkages between GlcNAc and D-glucosamine

(GlcN) residues in chitosan by an endowise manner but not chitin

[E.C. 3.2.1.132])

SIX MAIN CLASSES OF EC

EC 1. Oxidoreductases

EC 2. Transferases

EC 3. Hydrolases

EC 4. Lyases

EC 5. Isomerases

EC 6. Ligases

A list of the subclasses for each class is given below. Additional information on the sub-subclasses and sub-sub-subclasses follows the subclasses.

CLASSIFICATION OF ENZYMES

Class	Reactions catalyzed
Oxidoreductoases	**oxidation-reduction**
Transferases	**transfer group of atoms**
Hydrolases	**hydrolysis**
Lyases	**add/remove atoms to/from a double bond**
Isomerases	**rearrange atoms**
Ligases	**combine molecules using ATP**

MAIN CLASS 1: EC 1. OXIDOREDUCTASES

Oxidoreductases - catalyzing oxidation reduction reactions

EC 1. Oxidoreductases : Catalyze the transfer of hydrogen or oxygen atoms or electrons from one substrate to another.

The second digit in the code number of EC1 indicates the donar of the reducing equivalents(hydrogen or electrons) involved in the reaction.

Ex for second digit

Second digit	Hydrogen or electron acceptor
1	Alcohol(>CHOH)
2	aldehyde or ketone(>C=O)

Hydrogen or electr ***dehydrogenases, or reductases. Note that since these are ‘redox’ reactions, an electron donor/acceptor is also required to complete the reaction.***

Second digit	Hydrogen or electron donar
3	-CH.CH-
4	Primary amine(-CHNH2 or –CHN+H3)
5	secondary amine (>CHNH-)
6	NADH or NADPH(only where some other redox catalyst is the acceptor)

Third digit of EC1 refers to

Third digit	Hydrogen or electron acceptor
1	NAD+ or NADP+
2	Fe3+(e. g. cytochromes)
3	Oxygen
99	An otherwise an unclassified acceptor

EX: E.C. 1.1.1.27

Trivial name:lactate dehydrogenase

First number is 1 for oxidoreductases- donor of hydrogen

Second number is 1 for alcohol-the donor

Third number is 1 for NAD+ - the acceptor

EC 2. TRANSFERASES

Transferases - catalyzing transfer of functional groups

EC 2. Transferases – Catalyze group transfer reactions, excluding oxidoreductases (which transfer hydrogen or oxygen and are EC 1). These are of the general form:

A-X + B ↔ BX + A

Names end with X-transferases where X is the group transferred

Second digit describes the type of group transferred

Second digit of class 2	Group transferred
1	1-carbon group
2	Aldehyde or ketone group(>C=O)
3	Acyl group(-C-R) ‖ O
4	Glycosyl(carbohydrate group)
7	Phosphate group

Third digit of class 3	Transferred group	name
1	-CH3	Methyl transferases
2	-CH2OH	Hydroxymethyl transferases
3	(-C-OH) ‖ O	carboxyl

EC 2. TRANSFERASES

2.1 Transferring one-carbon groups

- 2.1.1. Methyltransferases
- 2.1.2. Hydroxymethyl-, Formyl- and Related Transferases
- 2.1.3. Carboxyl- and Carbamoyltransferases
- 2.1.4. Amidinotransferases

2.2 Transferring aldehyde or ketonic groups

2.3 Acyltransferases

2.4 Glycosyltransferase

EC 3. HYDROLASES

Hydrolases - catalyzing hydrolysis reactions.

EC 3. Hydrolases – catalyze hydrolytic reactions. Includes *lipases, esterases, nitrilases, peptidases/proteases. These are of the general form:*

A-X + $_{H2O}$ ↔ X-OH + HA

3.1 Acting on ester bonds

- **3.1.1 Carboxylic Ester Hydrolases**
- **3.1.2 Thiolester Hydrolases**
- **3.1.3 Phosphoric Monoester Hydrolases**
- **3.1.4 Phosphoric Diester Hydrolases**
- **3.1.5 Triphosphoric Monoester Hydrolases**

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3.2 Glycosylases

3.3 Acting on ether bonds

3.4 Acting on peptide bonds (peptidases)

EC 4. LYASES

Lyases - catalyzing group elimination reactions to form double bonds.

EC 4. Lyases – catalyze non-hydrolytic (covered in EC 3) removal of functional groups from substrates, often creating a double bond in the product; *or*

the reverse reaction, ie, addition of functional groups across a double bond.

XA-B Y → A=B + X-Y

Includes decarboxylases and aldolases in the removal direction, and synthases in the addition direction.

EC 4. LYASES

- 4.1 Carbon-carbon lyases
    - 4.1.1 Carboxy-lyases
    - 4.1.2 Aldehyde-lyases
    - 4.1.3 Oxo-acid-lyases
    - 4.1.99 Other Carbon-carbon lyases
- 4.2 Carbon-oxygen lyases
- 4.3 Carbon-nitrogen lyases
- 4.4 Carbon-sulfur lyases
- 4.5 Carbon-halide lyases

EC 5. ISOMERASES

- EC 5. Isomerases – catalyzes isomerization reactions, including racemizations and cis-tran isomerizations.

EC 5. ISOMERASES

5.1 Racemases and epimerases

- 5.1.1. Acting on Amino Acids and Derivatives
- 5.1.2. Acting on Hydroxy Acids and Derivatives
- 5.1.3. Acting on Carbohydrates and Derivatives
- 5.1.99. Acting on Other Compounds

5.2 *cis-trans*-Isomerases

5.3 Intramolecular isomerases

5.4 Intramolecular transferases (mutases)

5.5 Intramolecular lyases

5.99 Other isomerases

EC 6. LIGASES

Ligases - catalyzing bond formation reactions couples with ATP hydrolysis

EC 6. Ligases -- catalyzes the synthesis of various (mostly C-X) bonds, coupled with the breakdown of energy-containing substrates, *usually ATP*