Bio-organic chemistry

Lecture #5

Enzymes. Classification, structure, physiological role.

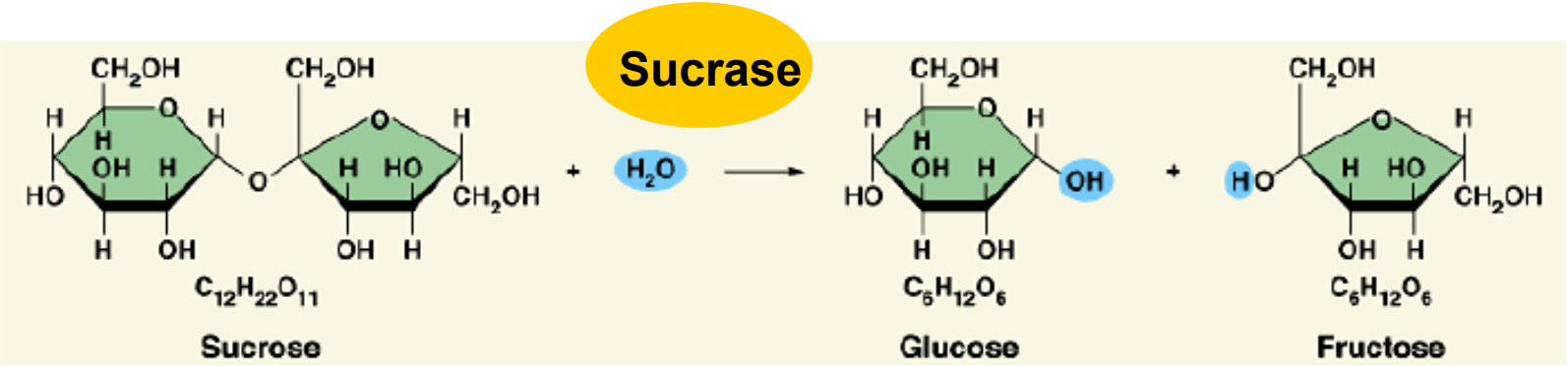
Lecturer:
Dr. Gulnaz Seitimova
Associate Professor

ENZYME

1. Enzymes are globular proteins that works as catalyst of chemical reactions.
2. They speed up chemical reactions without being altered themselves.
3. Conventionally we say the enzyme acts on the substrate (S) to yield a product (P)

ACTIVE SITE

1. Active site is the region on the surface of the enzyme to which substrate(s) bind and which catalyses the reaction (the conversion of the substrate to the product).



Substrate **Product**

Enzymes are named depending on the reaction they catalyse.
Examples of enzyme groups are:

- EC 1 - Oxidoreductases
- EC 2 - Transferases
- EC 3 - Hydrolases
- EC 4 - Lyases
- EC 5 - Isomerases
- EC 6 - Ligases

Enzymes are proteins

- In general, a protein is a chain of **amino acids** (aa) covalently linked (when the chain is short ~5-10 aa, the protein is often called oligopeptide/polypeptide or simply peptide)

- Thousands of different proteins are built with the same ubiquitous set of 20 amino acids (the protein "alphabet")

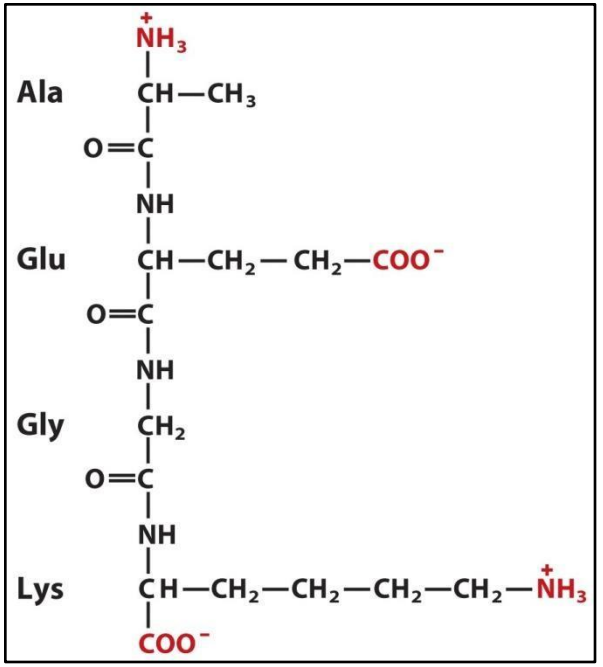
- Some proteins have structural roles (e.g. actin in the muscles), other have catalytic (chemical-reaction-making) activity and are called **enzymes**

- A polypeptide with 4 amino acids (Ala-Glu-Gly- Lys)

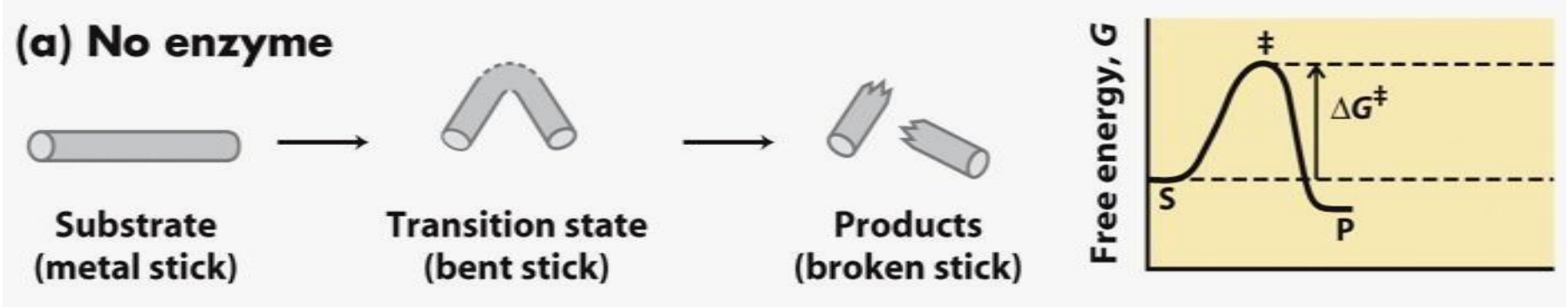
- The electrically charged groups are shown in red

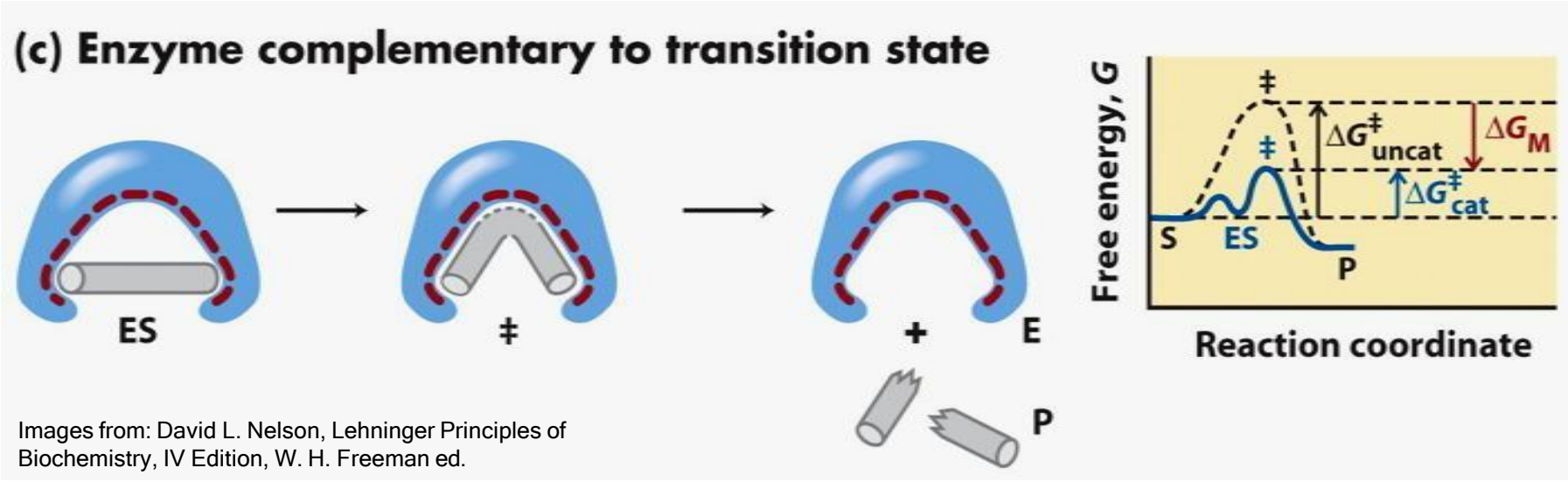
- In a longer protein the electrically charged lateral groups can line a pocket of the enzyme 3D structure to generate an active reaction site (see following slides)

- Enzymes are proteins and their activities depends on the 3D structure of the amino acids that compose them



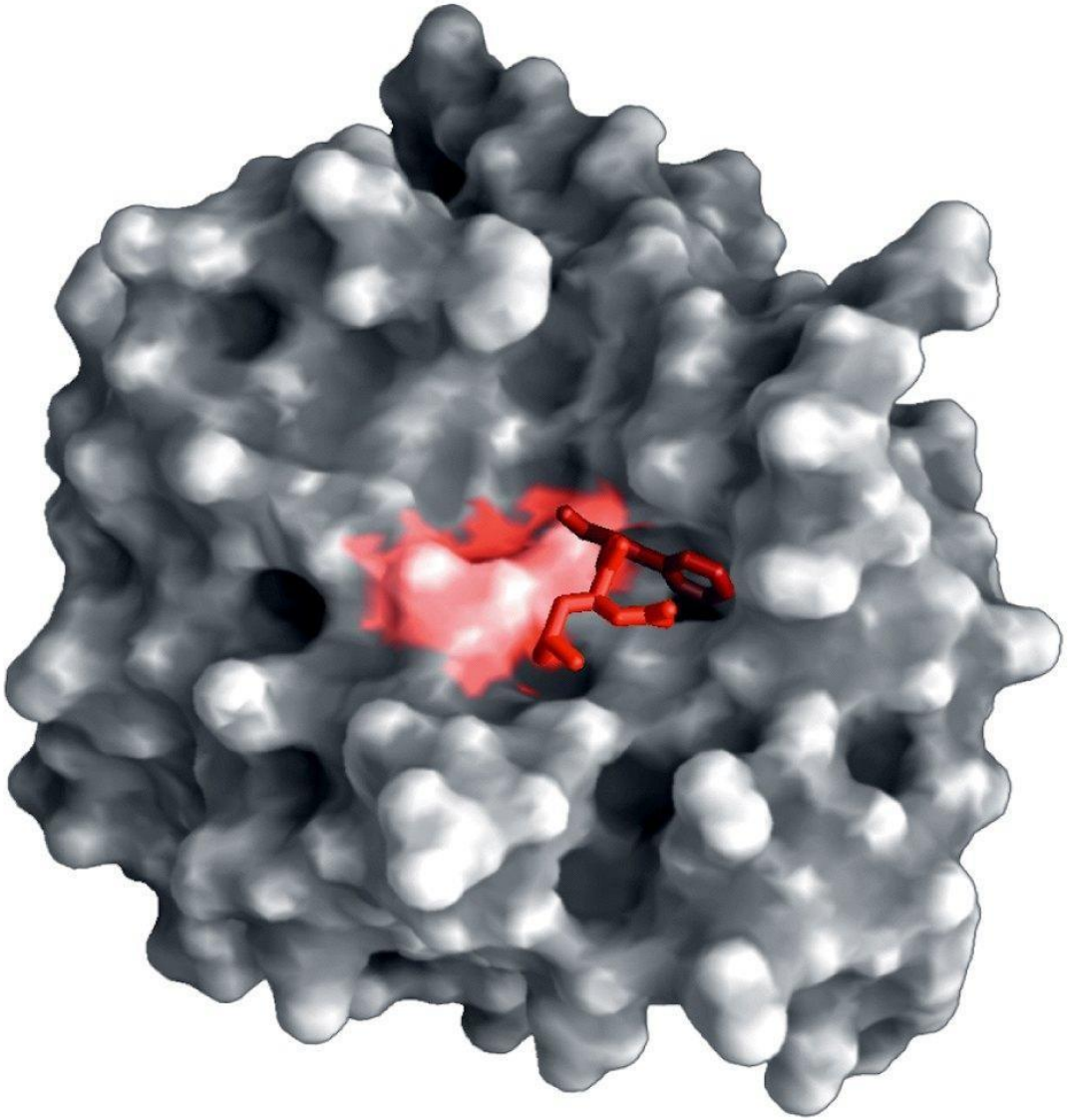
The enzyme action on the transition state





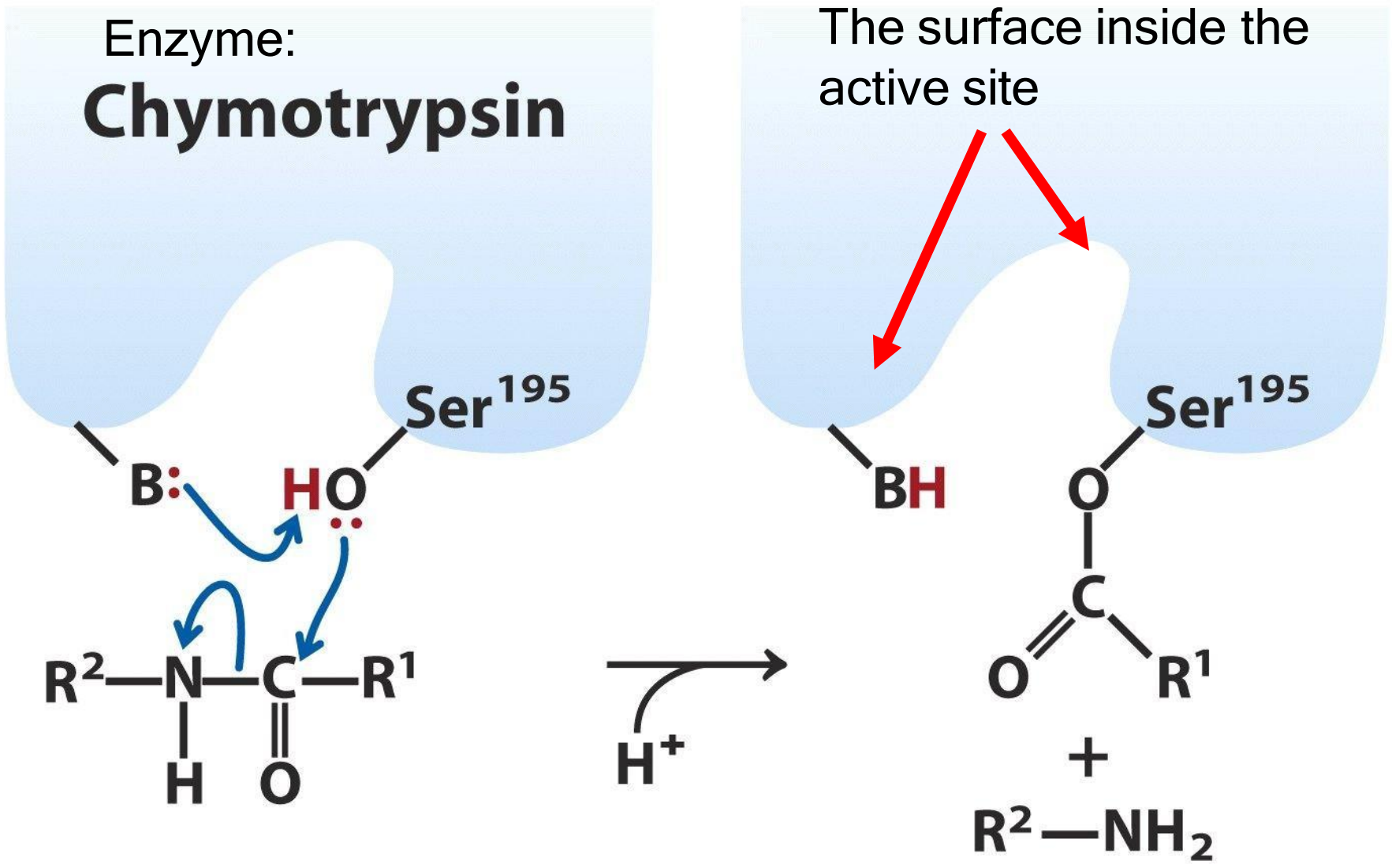
Images from: David L. Nelson, Lehninger Principles of Biochemistry, IV Edition, W. H. Freeman ed.

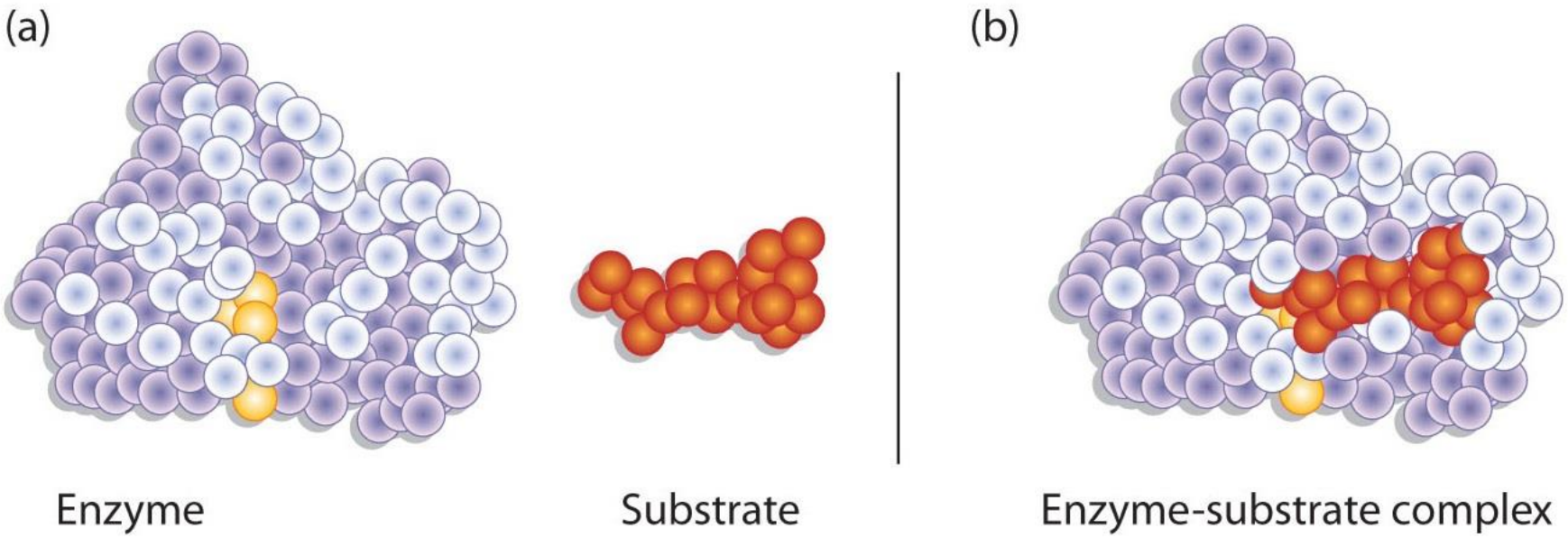
The enzyme active site



The red molecule is the substrate, the active site appears painted in red

From: David L. Nelson, Lehninger Principles of Biochemistry, IV Edition, W. H. Freeman ed.

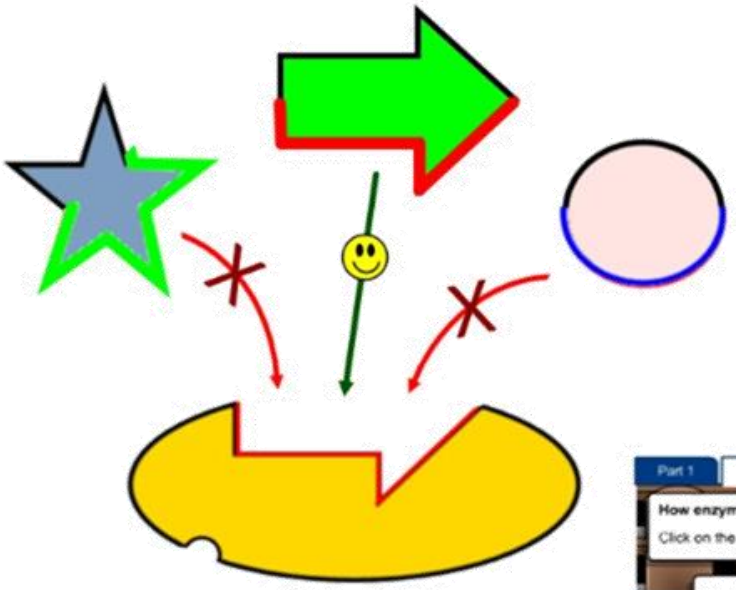

Enzyme:
Chymotrypsin
The surface inside the active site
Ser195
B:
HO
R2—N—C—R1
H
O
H+
BH
Ser195
O
C
O
R1
+
R2—NH2



Substrate Binding to the Active Site of an Enzyme. The enzyme dihydrofolate reductase is shown with one of its substrates: $NADP^+$ (a) unbound and (b) bound. The $NADP^+$ (shown in red) binds to a pocket that is complementary to it in shape and ionic properties.

Explain enzyme-substrate specificity

Enzymes are specific to their substrates



enzyme substrate

The Lock-and-Key hypothesis:

The substrate and the active site match each other in two ways:

Structurally

The 3D structured of the active site is specific to the substrate. Substrates that don't fit, won't react.

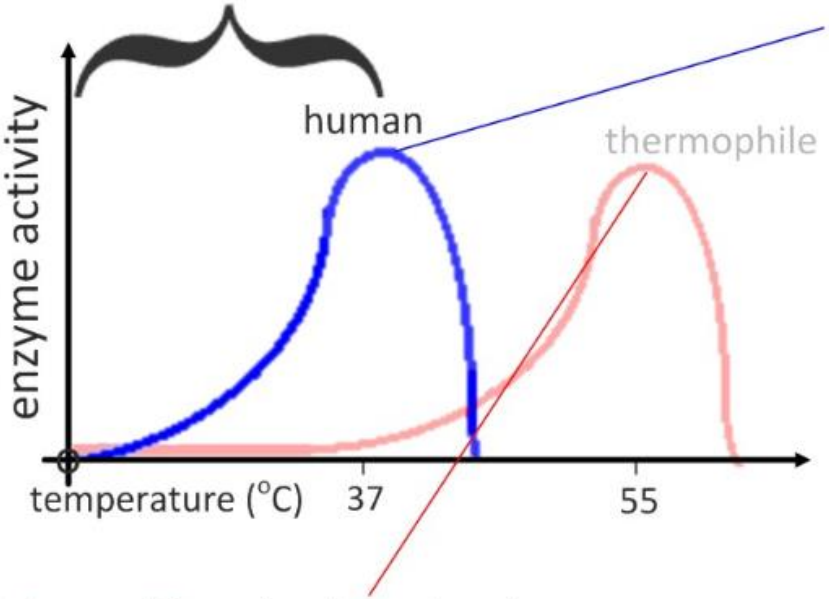
Chemically

Substrates that are not chemically attracted to the active site won't be able to react.

source unknown

The Effect of Temperature on Enzyme Activity

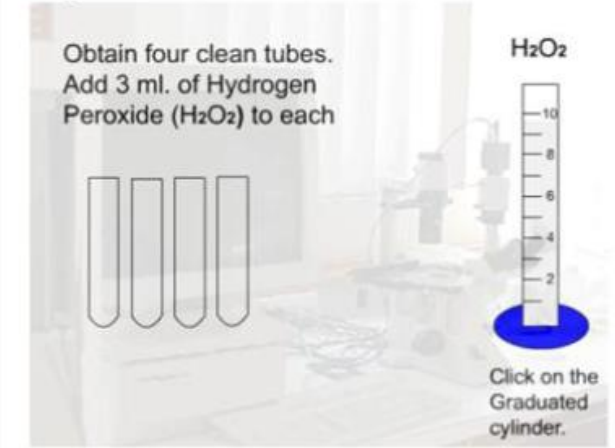
As temperature increases, rate of reaction increases as molecules have more energy, move faster and therefore collide and react more frequently.



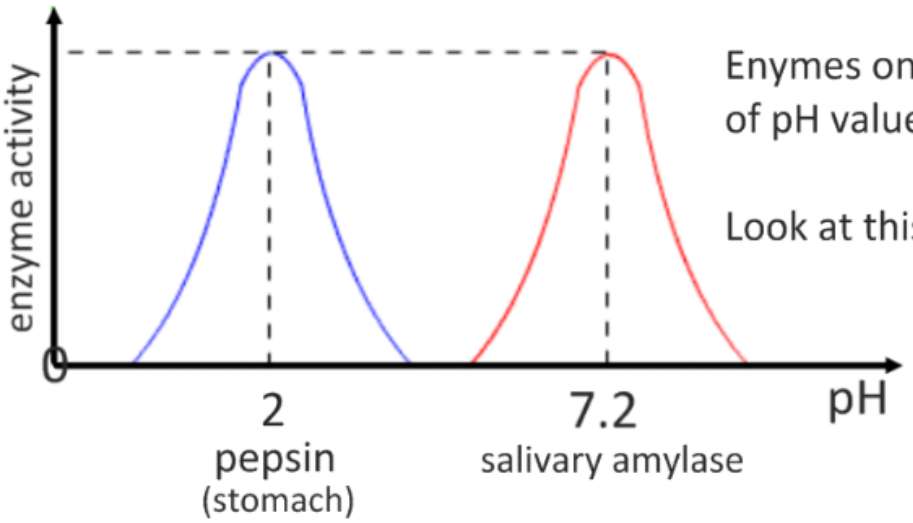
Above the optimum temperature, further increase in temperature leads to denaturation of the enzyme. The active site is changed and so loses function.

A thermophile, such as bacteria at deep-sea vents, is an organism that is able to withstand much higher temperatures before its enzymes denature.

Try this virtual lab:



The Effect of pH on Enzyme Activity.



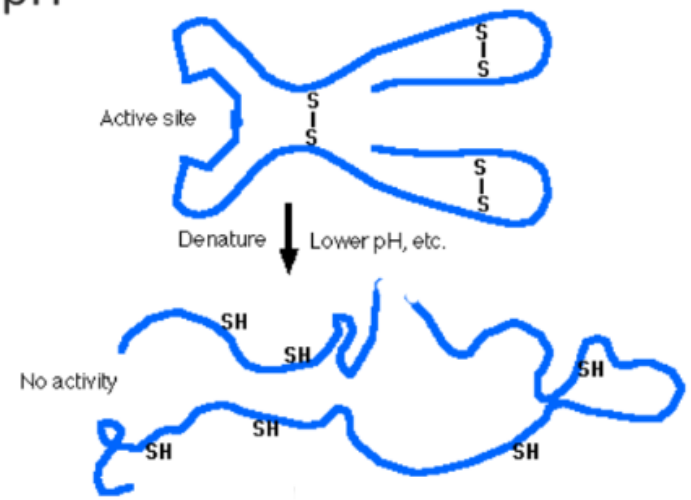
Enymes only operate within a narrow range of pH values. This is called an optimum pH.

Look at this example of two digestive enzymes.

If there is a deviation from the optimum pH, the hydrogen bonds between amino acids in the structure of the enzyme are broken.

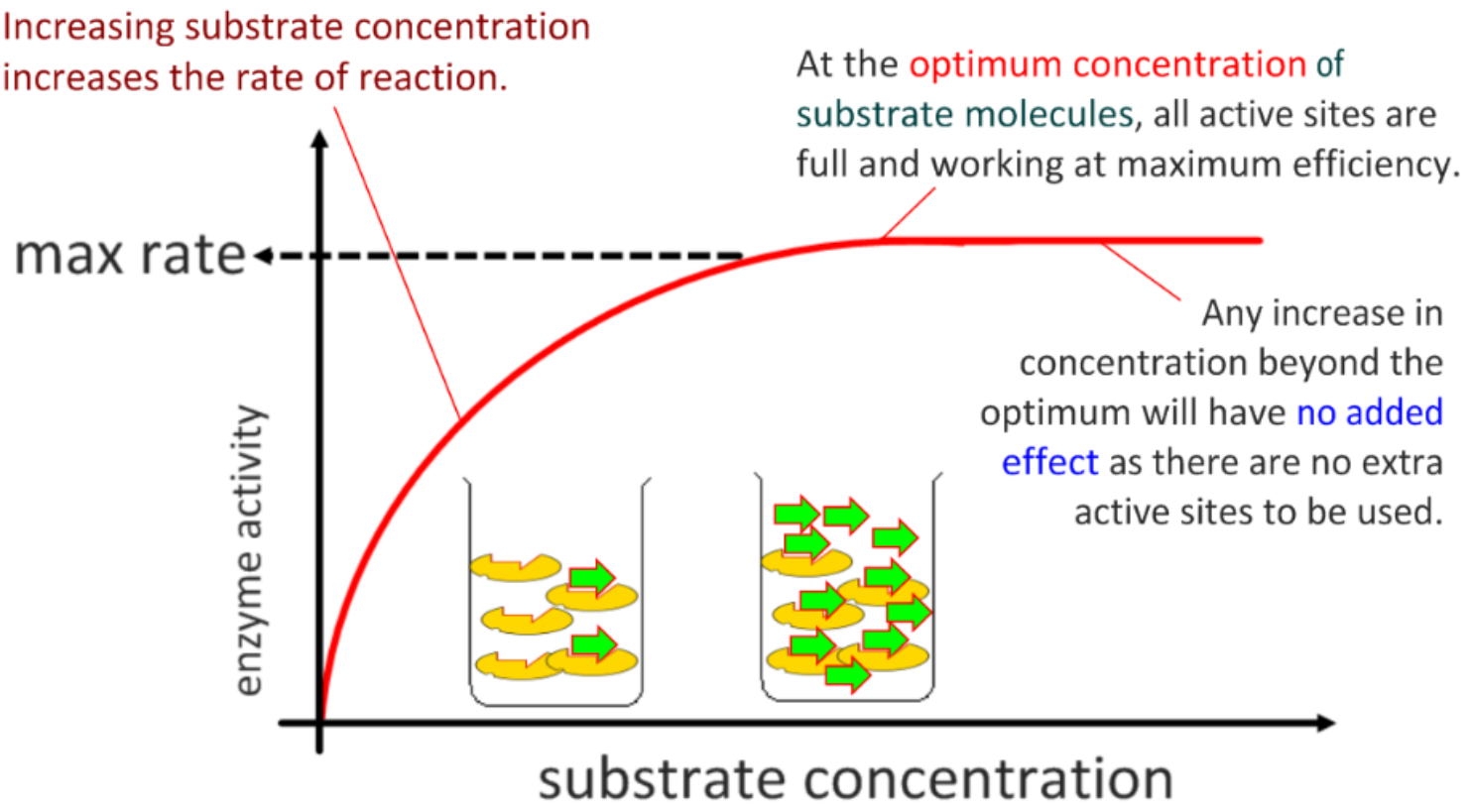
This results in the loss of the shape of the active site of the enzyme, so it does not function.

This is usually a permanent change.

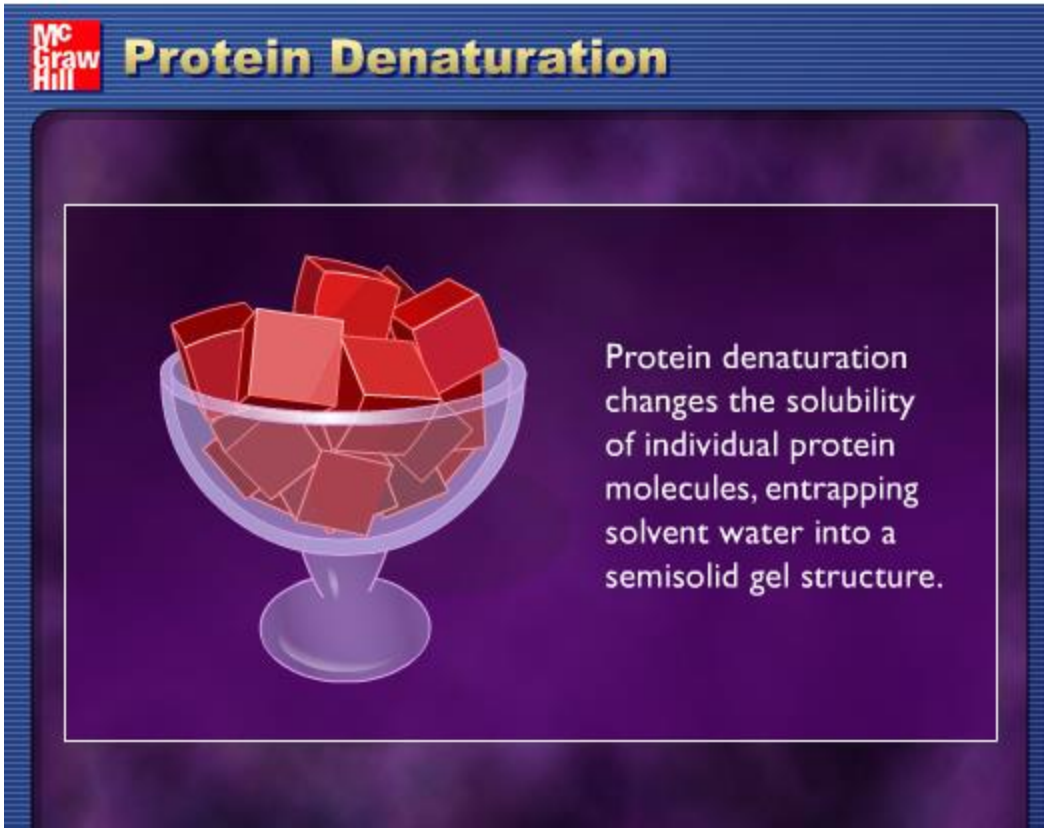


http://users.rcn.com/jkimball.ma.ultranet/BiologyPages/D/Denaturing.gif

The Effect of Substrate Concentration on Enzyme Activity



Denaturation is a structural change in a protein that results in the loss (usually permanent) of its biological properties. Enzymes can be denatured by pH and Temperature.

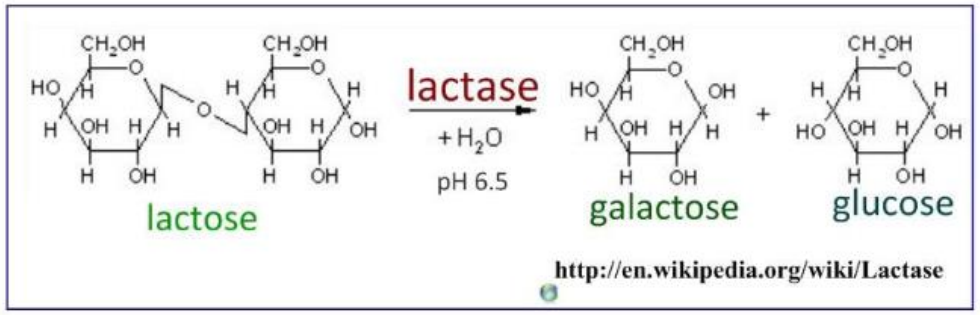


Explain the use of lactase in the production of lactose free milk

Lactose Intolerance

Lactose (milk sugar) can cause allergies in some people.

This is often because they are unable to produce the enzyme lactase in sufficient quantities.



http://en.wikipedia.org/wiki/Lactase

http://www.superlaugh.com/dan/lactose.htm

Most people produce less lactase as they get older - after all, we don't live off milk once we have been weaned. In some regions, such as Europe, a mutation has allowed lactase production to continue into adulthood. This mutation is not present in people who are lactose intolerant.

Global estimates of lactose intolerance:

http://en.wikipedia.org/wiki/Lactose_intolerance

How can we cope with lactose intolerance?

1. Take a lactase supplement

   These are produced industrially using the *Aspergillus niger* fungus (also used to make other enzymes).

2. Drink lactose-free milk

   Milk is treated with lactase (produced by *A. niger*) and essentially 'pre-digested' before being packaged.

   Lactose-free milk is made by different methods:

   a. Add lactase to milk

      (lower quality and wasteful of lactase)

   b. Run milk through apparatus with immobilised lactase

      (uses alginate beads, no enzyme in final product)

Aspergillus niger

http://129.215.156.68/Images/asexual.htm