We will look at:

- Function, Structure + Specificity
- Enzymes and energy
- Models of enzyme action
- Cofactors + coenzymes
- Factors affecting enzyme activity
- Enzyme inhibitors
- Experiments and enzyme immobilisation

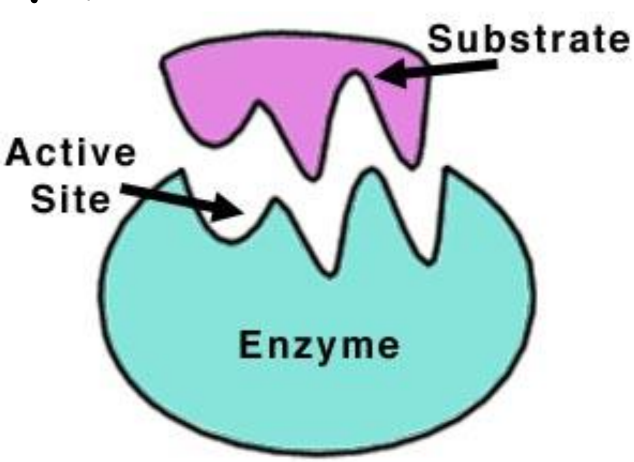
Enzyme function

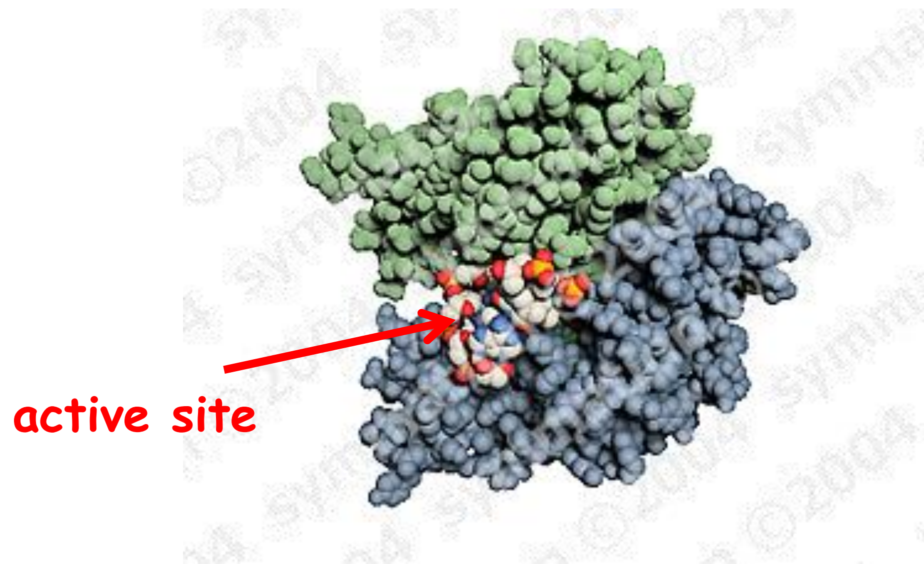
Enzymes control metabolic reactions in living cells. There is one type of enzyme for each reaction; they convert substrate to product. There are 2 types of enzyme controlled (catalysed) reaction:

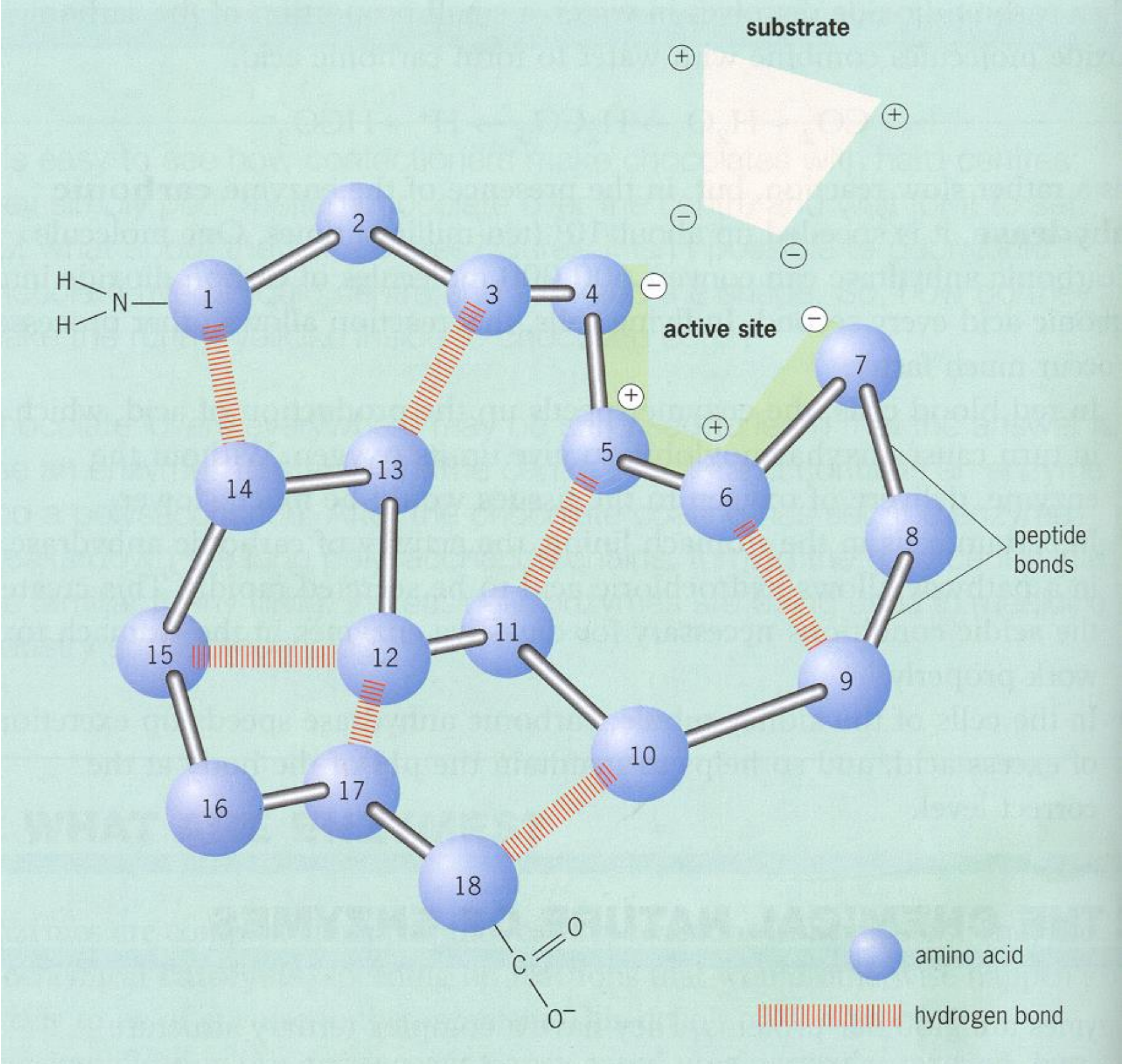
- **Catabolism** – "breaking down reactions" breakdown a substrate e.g. lipase breaks down lipids to fatty acids and glycerol
- **Anabolism** – synthesis ("building up") reactions join substrates e.g. DNA polymerase joins nucleotides to exposed DNA bases to form a new DNA strand

Structure

- They are globular protein molecules with complex 3D tertiary structure (folding and twisting of the polypeptide chain due to R group bonding e.g. H bonds)
- Each particular enzyme has an indent called the active site; this gives the enzyme its specificity
- Any factor that disrupts the tertiary structure of an enzyme will therefore affect its specificity and function






substrate
active site
peptide bonds
amino acid
hydrogen bond
H
N
H
C
O
O–
1
2
3
4
5
6
7
8
9
10
11
12
13
14
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16
17
18

Complete corrections for homework and begin definitions:

- Active site
- Specificity
- Substrate
- Prosthetic group
- Conjugated protein
- Co-factor
- Co-enzyme
- Lock and key hypothesis
- Induced fit theory
- Activation energy
- Optimum temperature
- Optimum pH
- Denature
- Globular
- Q10
- Rate of reaction
- Inhibitor
- Competitive inhibitor
- Non-competitive inhibitor
- Immobilisation
- Adsorption
- Entrapment
- Cross linkage
- Diagnostic test
- Clinistix
- Albustix

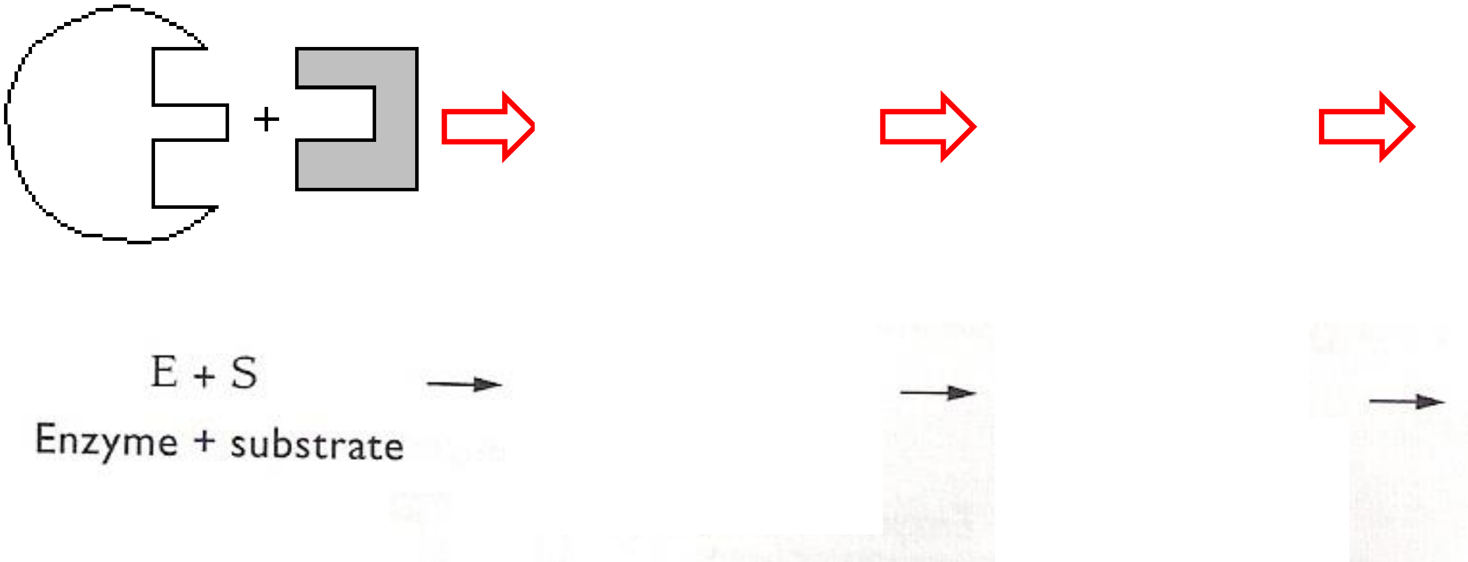
Specificity

- Each enzyme catalyses only one kind of reaction e.g. if 1000 different reactions occur in cell, then there will be 1000 different enzymes
- Only one substrate will fit the active site; enzymes are therefore specific
- Specific amino acids from different parts of the polypeptide chain are found within the active site and are responsible for binding to the substrate
- Most other amino acids are involved in maintaining the correct globular shape of the molecule

Read Froggy p63-65

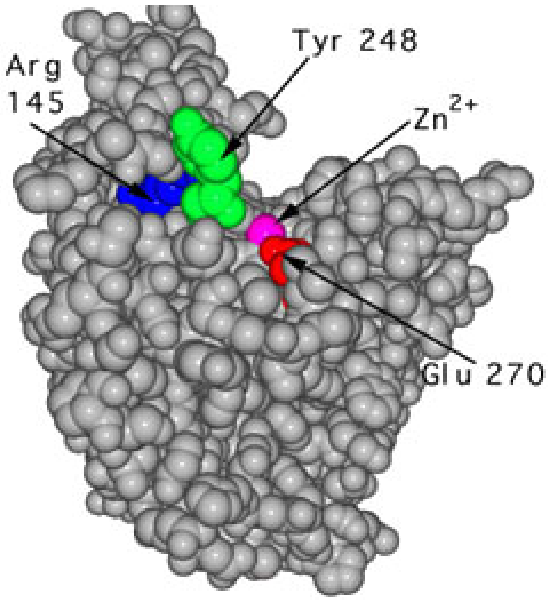
An enzyme catalysed reaction:

Work sheet



•In order to catalyse a reaction, the enzyme and substrate must collide to form an enzyme substrate complex
•Catalysis (speeding up of the reaction) takes place on the surface of the enzyme at the active site and this high-energy, unstable intermediate quickly changes into product
•The enzyme is unchanged at the end of the reaction

The active site...



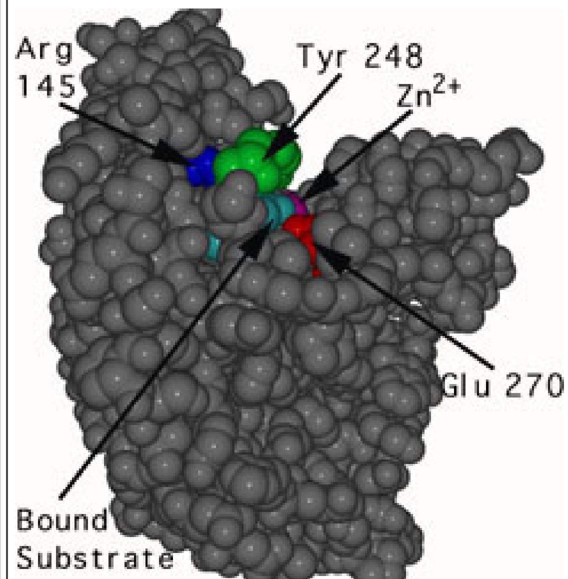


Figure 2:

This is a molecular model of the unbound carboxypeptidase A enzyme. The cpk, or space-filled, representation of atoms is used here to show the approximate volume and shape of the active site. Note the zinc ion (magenta) in the pocket of the active site. Three amino acids located near the active site (Arg 145, Tyr 248, and Glu 270) are labeled.

Figure 3:

This is a cpk representation of carboxypeptidase A with a substrate (turquoise) bound in the active site. The active site is in the induced conformation. The same three amino acids (Arg 145, Tyr 248, and Glu 270) are labeled to demonstrate the shape change.

Note: Coordinates for Figures 2 and 3 are from x-ray crystallographic data.

What happens at the active site?

In an anabolic reaction, substrate molecules are orientated on the active site so as to allow bonding between them

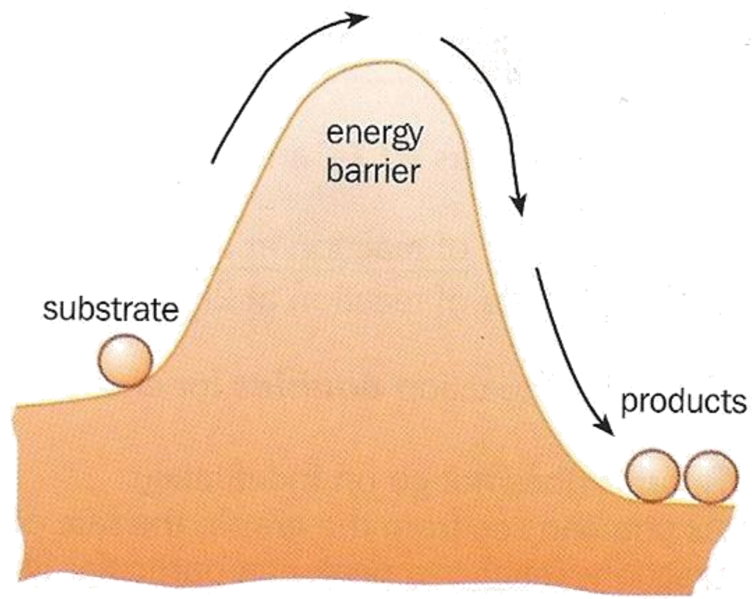
In a catabolic reaction, the way the active site forms around the substrate helps to break particular bonds

Enzymes and Energy

For chemical reactions to happen between particles that collide, there needs to be sufficient energy. This is called the activation energy and is needed to break existing bonds inside the molecules. Enzymes lower the activation energy by providing a different pathway for the reaction to follow

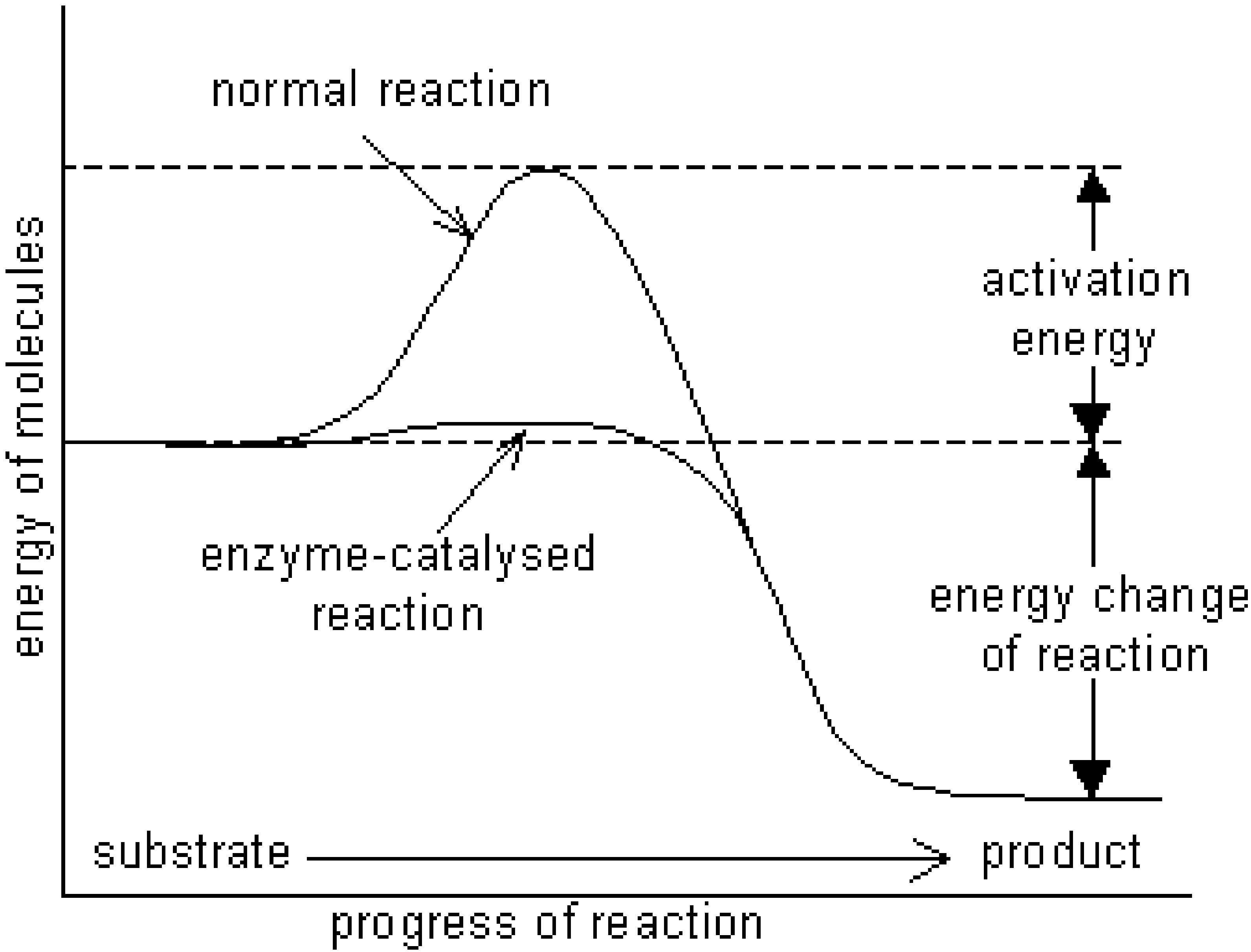
The activation energy is defined as:

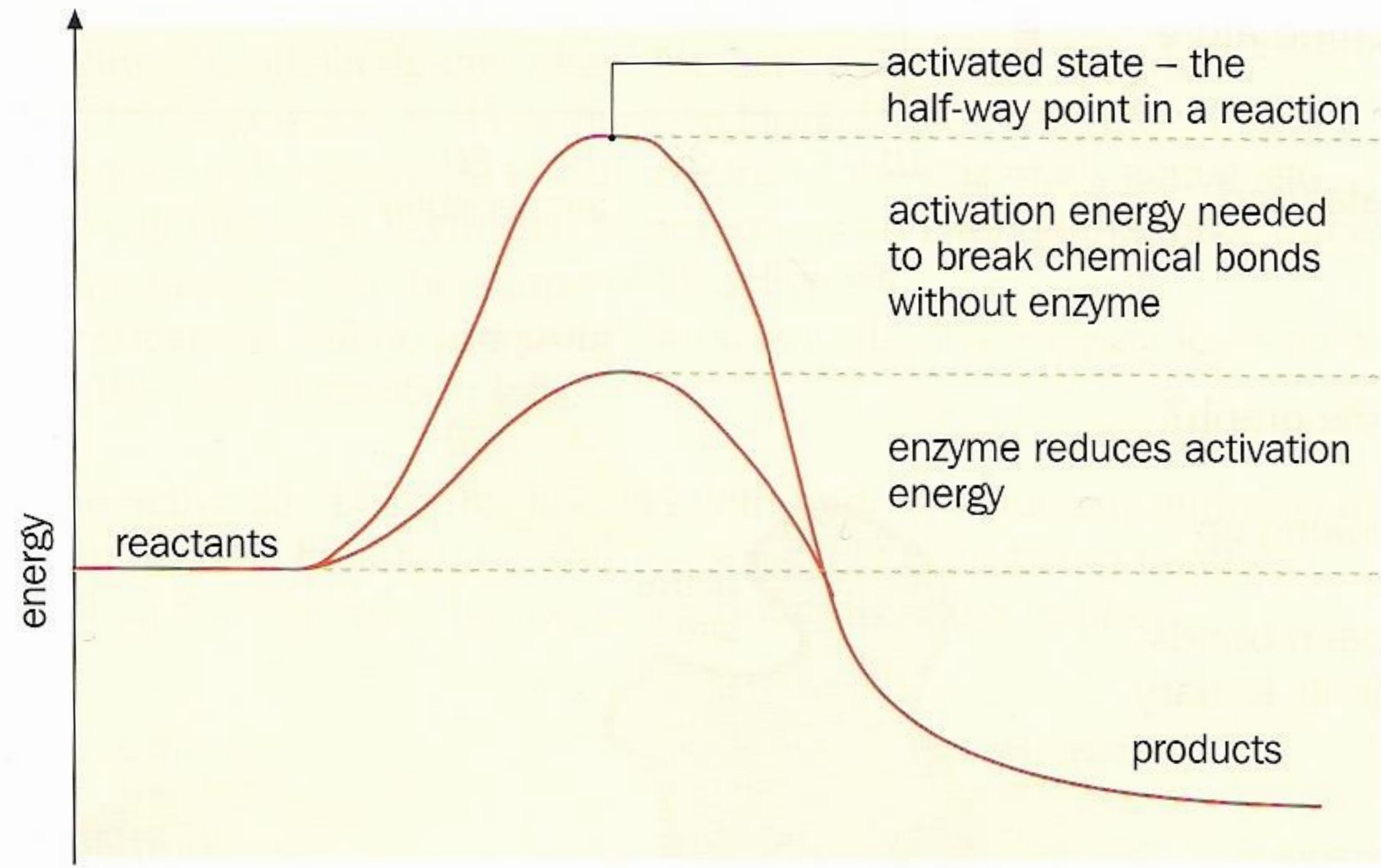
"The amount of energy necessary for a chemical reaction to occur"



Activation energy could be lowered by heating the particles and providing more energy that way. Why would this not be good for metabolic reactions?

The heat would damage (and denature) body cells and molecules e.g. proteins. By lowering the activation energy, enzymes allow reactions to take place at the lower temperatures found in cells


normal reaction
activation energy
energy change of reaction
enzyme-catalysed reaction
energy of molecules
substrate
product
progress of reaction


activated state – the
half-way point in a reaction
activation energy needed
to break chemical bonds
without enzyme
enzyme reduces activation
energy
energy
reactants
products

How do enzymes Work?

There are 2 main theories to describe the action of an enzyme on a substrate:

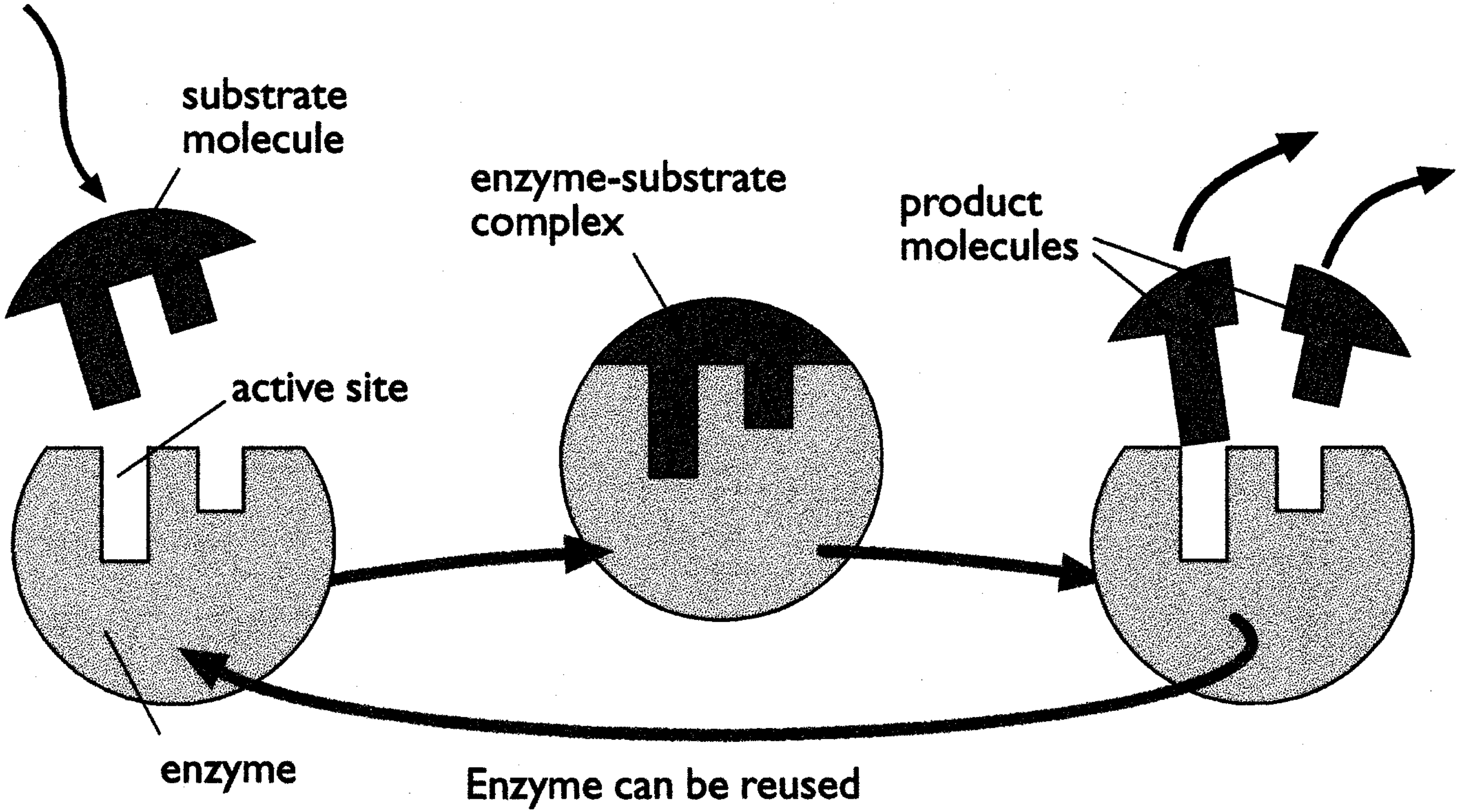
- The Lock and Key Hypothesis
- The Induced Fit Theory

Both theories are substrate specific

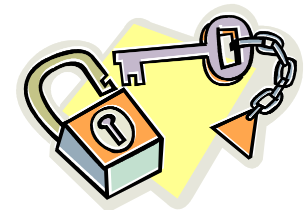
Add the following notes – take a title of

"Models of enzyme action on substrate"

The Lock and Key Hypothesis

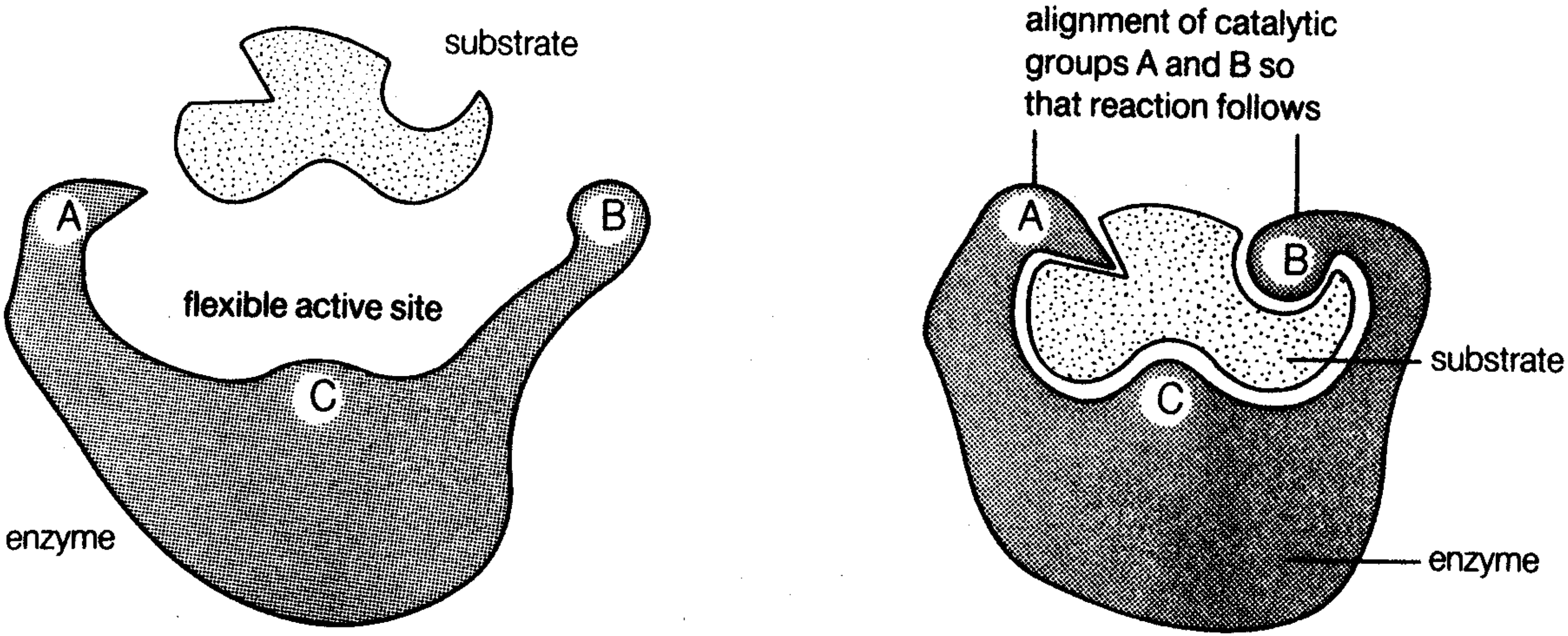


The Lock and Key Hypothesis



- The shape of the active site is complementary to part of the substrate
- The substrate molecule is like the key that fits into the enzymes lock, active site
- The 2 molecules form temporary structures called the enzyme-substrate complex and enzyme-product complex
- The reaction takes place at the active site where products are formed
- Products have a different shape to the substrate so no longer fit the active site and are repelled
- The active site is free to react with more substrate

The Induced Fit Theory



The induced fit theory

- The active site is not exactly complementary to the substrate
- The active site is flexible
- As the substrate binds it causes the active site to mould itself into a tighter fit around the substrate
- The enzyme puts strain on the bonds in the substrate
- The shape of the substrate in the enzyme-substrate complex distorts, causing the reaction to occur rapidly
- As the product is a different shape to the substrate it diffuses out of the active site, which returns to its original shape, ready to bind with the next substrate molecule

The induced fit model is preferred as it explains how activation energy is reduced in catabolic reactions