G11 Biology 2017-2018 Enzymes

CIE Biology Jones pp 111-122

Mrs Cooper Enzyme Structure (9 min)
https://www.youtube.com/watch?v=Vo_-agMhFxE&index=1&list=PLb-ivq7Cou6ZCSnW1IVImotQhmOe9jljh

Mrs Cooper Enzyme control and cofactors (9 min)
https://www.youtube.com/watch?v=RkkqhA0R2bc&list=PLb-ivq7Cou6ZCSnW1IVImotQhmOe9jljh&index=2

ONLINE NOTES
https://alevelnotes.com/Enzymes/144

Mrs Cooper Enzyme inhibitors (11 min)
https://www.youtube.com/watch?v=8woEVmLWTbk&list=PLb-ivq7Cou6ZCSnW1IVImotQhmOe9jljh&index=3

Mrs Cooper Enzyme Temp and pH (8 min)
https://www.youtube.com/watch?v=nHCyUCtfeVI&list=PLb-ivq7Cou6ZCSnW1IVImotQhmOe9jljh&index=4

Mrs Cooper Enzyme substrate concentration (8 min)
https://www.youtube.com/watch?v=zcsjXmJwyUU&list=PLb-ivq7Cou6ZCSnW1IVImotQhmOe9jljh&index=5

Learning Objective:

Investigate the influence of different conditions (temperature, pH, substrate concentration, inhibitor) on enzyme activity.

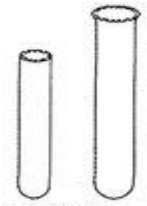
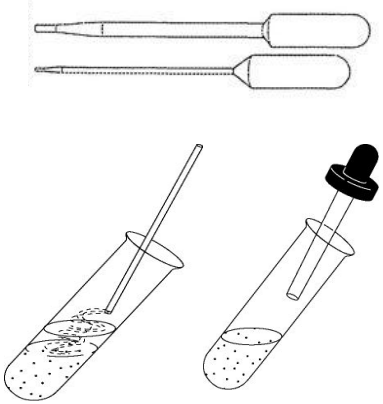
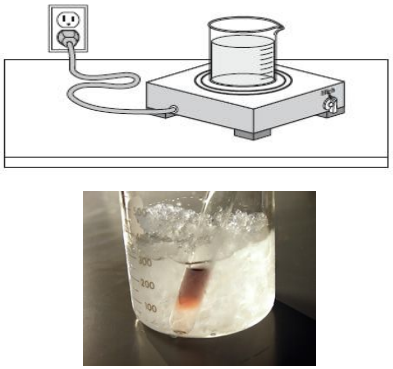
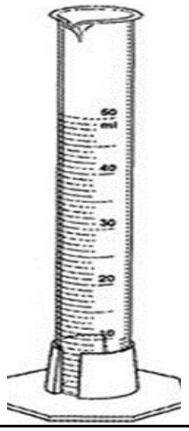
Success Criteria

1. Correctly identify the variables and describe the method used in the investigation.
2. Investigate temperature, pH, substrate, and inhibitor on enzyme activity.
3. Repeat X 3
4. Collect data, organize, table, and plot on graph.
5. Formulate conclusions.

Terminology

English	Google Russian ☺
Substrate	подложка
Active site	Активный сайт
Cofactor	кофактор
Coenzyme	Коэнзим
Prosthetic	протезный
Specificity, specific	Специфичность, специфичность
Optimum	оптимум
Induced fit, lock and key	Индуцированная посадка, замок и ключ
Active site	Активный сайт
Allosteric site	Аллостерический сайт
Denatured	денатурированный
Enzyme	энзим
Substrate	подложка
Enzyme – substrate complex	Комплекс фермент - субстрат
Condensation / hydrolysis	Конденсация / гидролиз
Inhibitors , inhibition	Ингибиторы, ингибирование
Competitive / non competitive	Конкурентные / неконкурентные
Reversible / non reversible	Реверсивный / необратимый
Feedback inhibition of enzymes	Обратная реакция ингибирования ферментов

Equipment

Funnel and test tube	Mortar and pestle	Digital scale
		
Micropipette, dropper	Water bath	Graduated cylinder – volume mL
		

- Revison

- Continue discussing variables and questions found on practical.

Substrate

Product

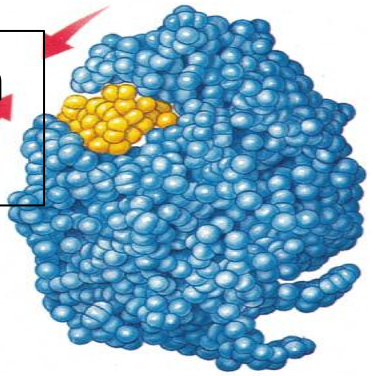
Active Site

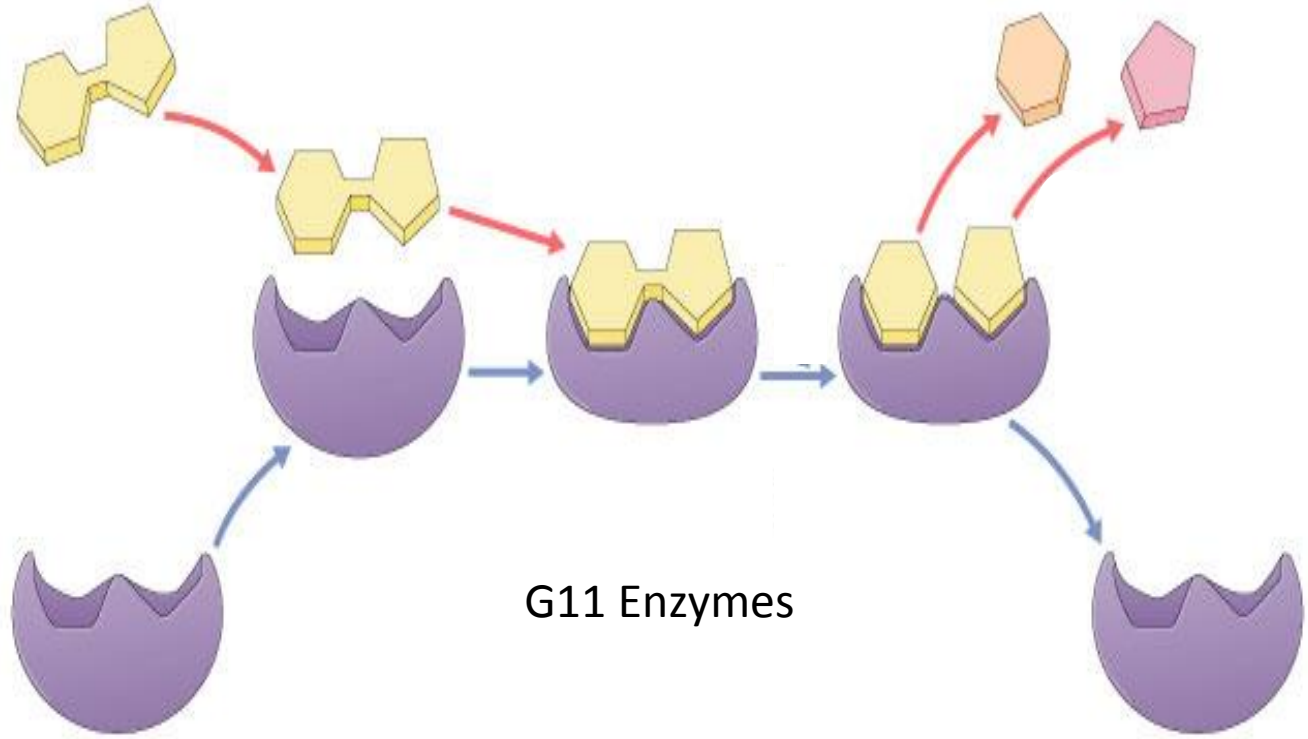
Enzyme

Reactant

Enzyme substrate complex

Hydrogen bonds





G11 Enzymes

Enzymes vocabulary

substrate

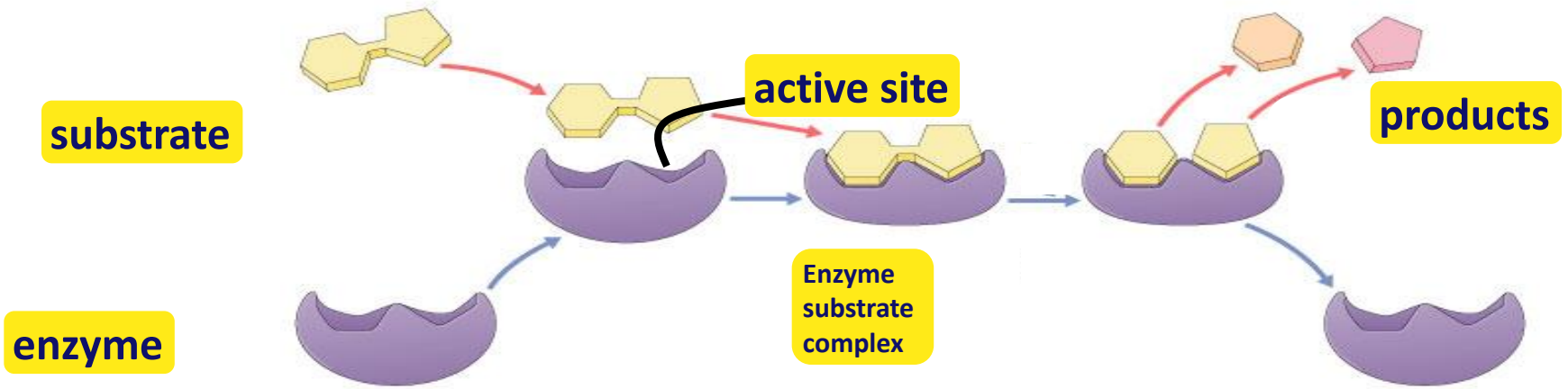
- reactant which binds to enzyme
- enzyme-substrate complex: temporary association

product

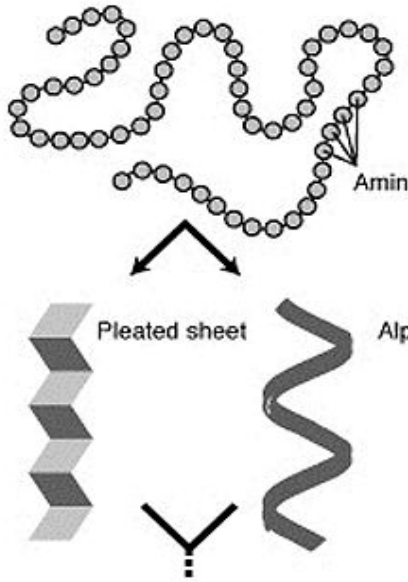
- end result of reaction

active site

- enzyme's catalytic site; substrate fits into active site

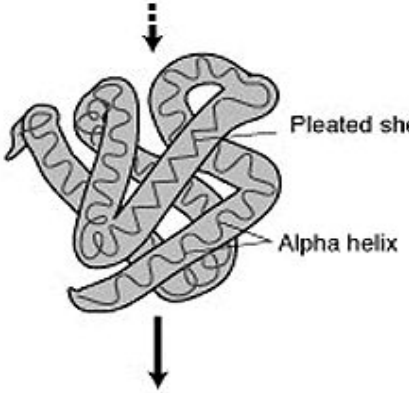


Protein **Structure** and **Bonds** Review



Primary Structure
-peptide bonds

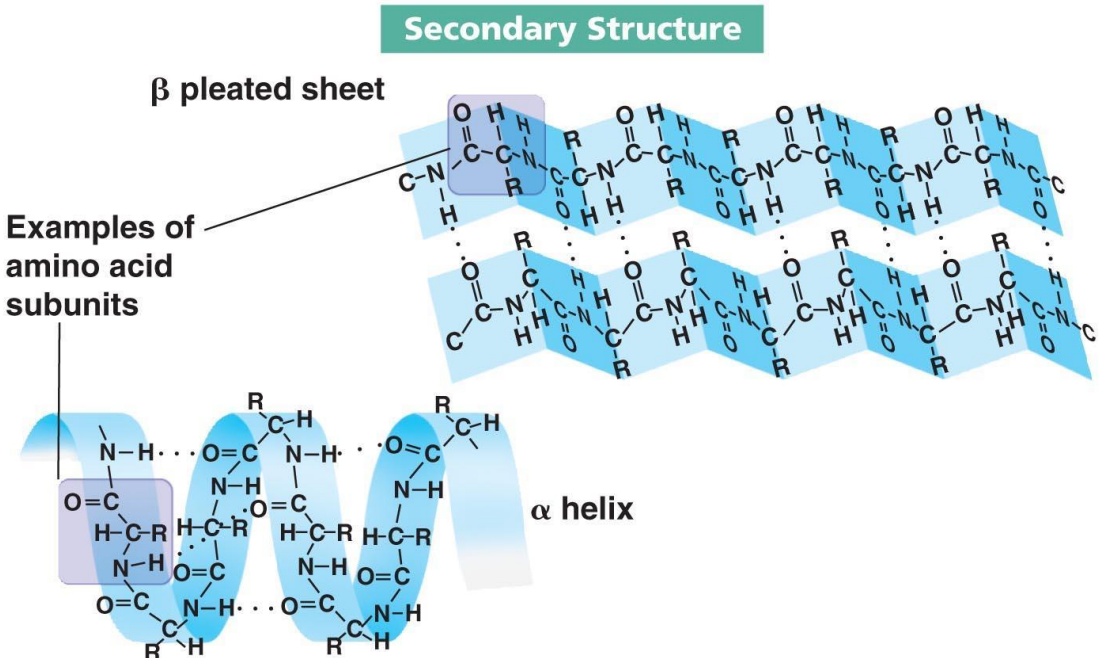
Secondary Structure
-hydrogen bonds

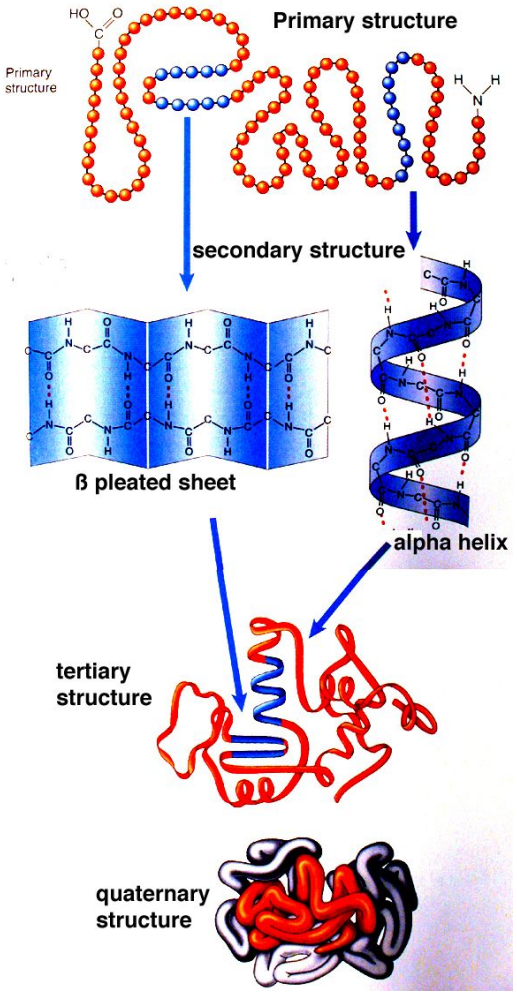


Tertiary Structure
-R-groups interact
-van der waals
-polar / non polar interactions

Quaternary Structure
-more than one amino acid chain combines

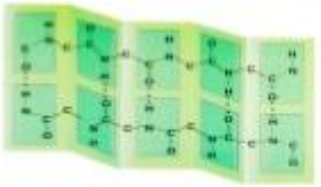
Which are globular structures that catalyse metabolic reactions.

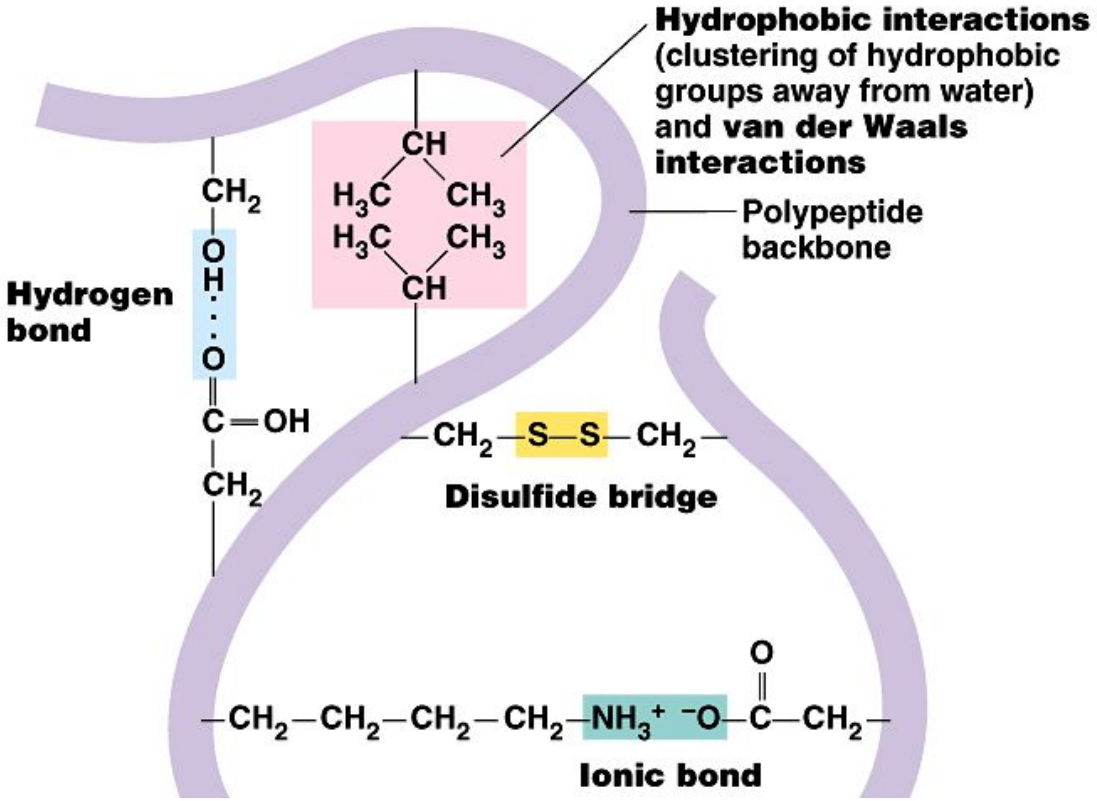


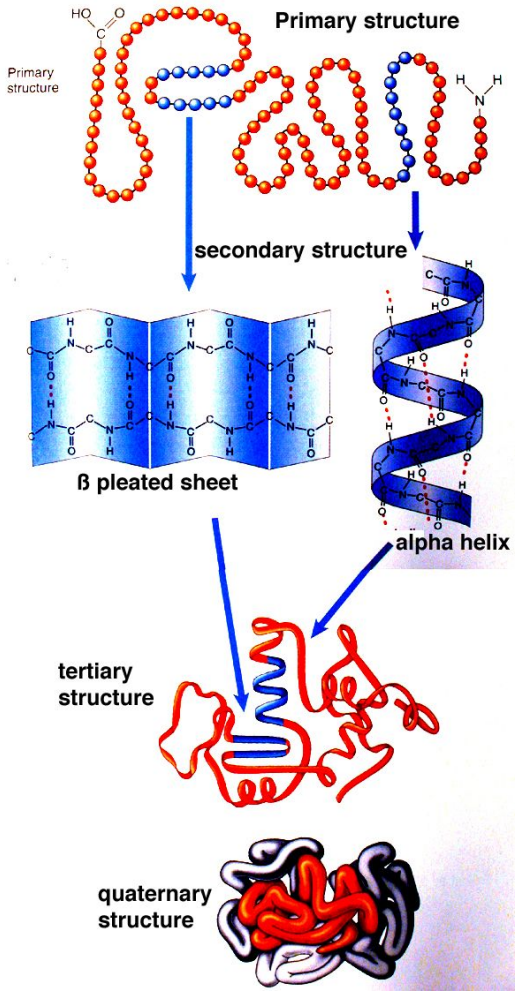


Secondary Structure Hydrogen bonds <u>between the polypeptide / protein backbone</u> form the alpha and beta shapes

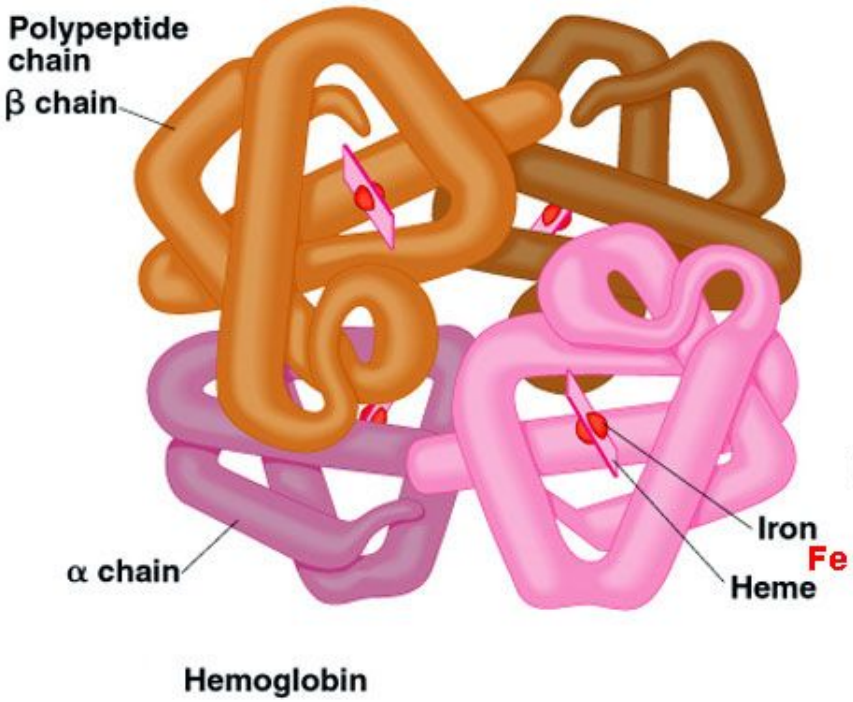
Comparison of ∝-helix and β-sheet

	∝-helix 	β-sheet 
Structure	1 polypeptide chain	1 or more polypeptide chains
polypeptide	Coiled	Almost fully extended
Hydrogen bonds	- Formed between 2 peptide bonds of 4 amino acids apart in the primary structure. - Parallel to the axis of polypeptide chain.	- Formed between amino acids which has no relation in primary structure. - Perpendicular to the axis of polypeptide chain.
R groups	- Protrude outside the helix	- Project above and below the plane of the sheet

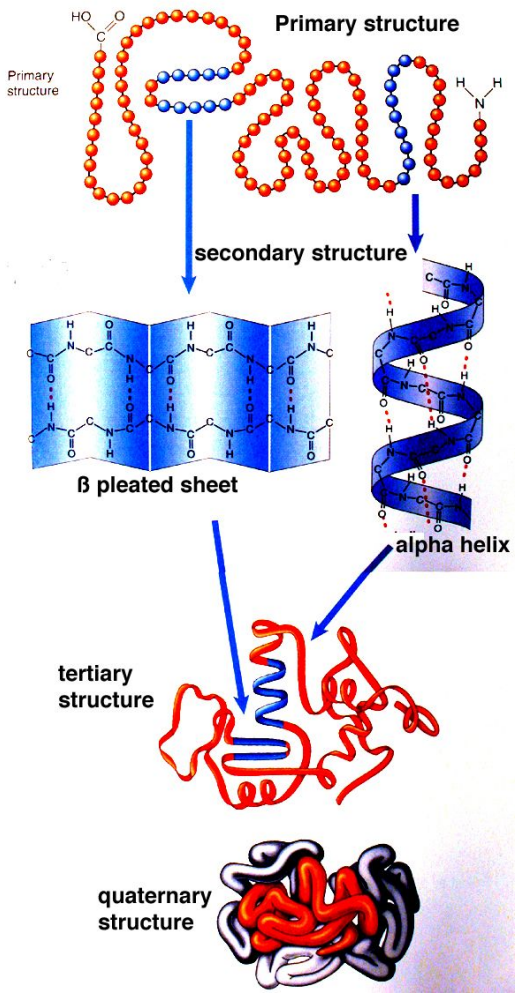




<u>Tertiary structures</u> bonds come from interactions between R-groups

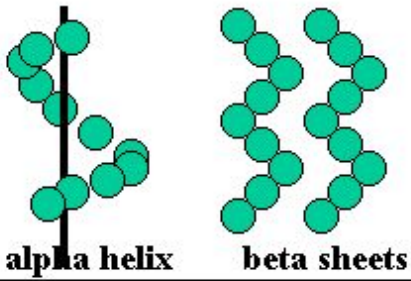
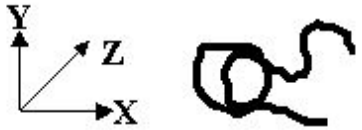
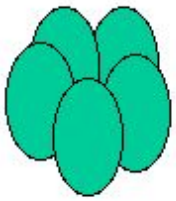


Hemoglobin



<u>Quaternary Structure</u> – 2 or more tertiary structure bound together -**globular**

Protein Structure(Summary)

•Primary	The amino acid sequence	Glu-Arg-Phe-Gly
•Secondary	Characteristic structures that occur in many proteins (E.g. alpha helix , beta sheets)	
•Tertiary	Three dimensional structure of proteins	
•Quaternary	Three dimensional structure of proteins composed of multiple subunits	

Fibrous vs Globular Proteins

Fibrous

Little or no tertiary structure.

Long parallel polypeptide chains.

Cross linkages at intervals.

Long fibres and sheets formed.

Mostly insoluble.

Most have a structural role.

Keratin

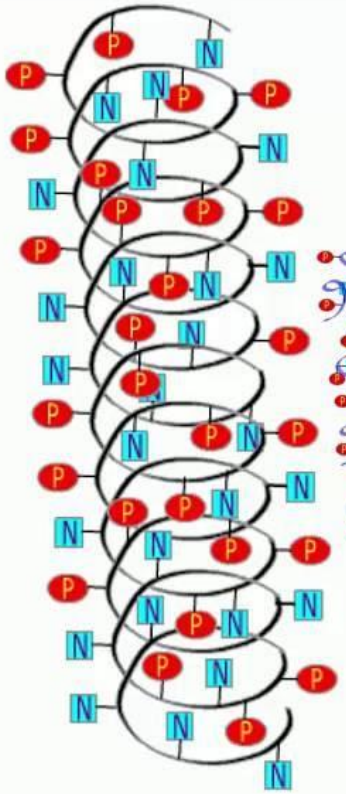
In hair and outer layer of skin.

Collagen

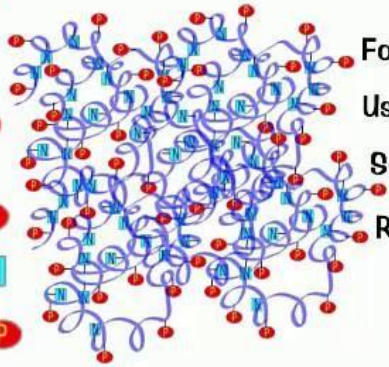
In connective tissue.

Bones, Teeth, Tendons & Walls of Blood Vessels

Silk



Globular



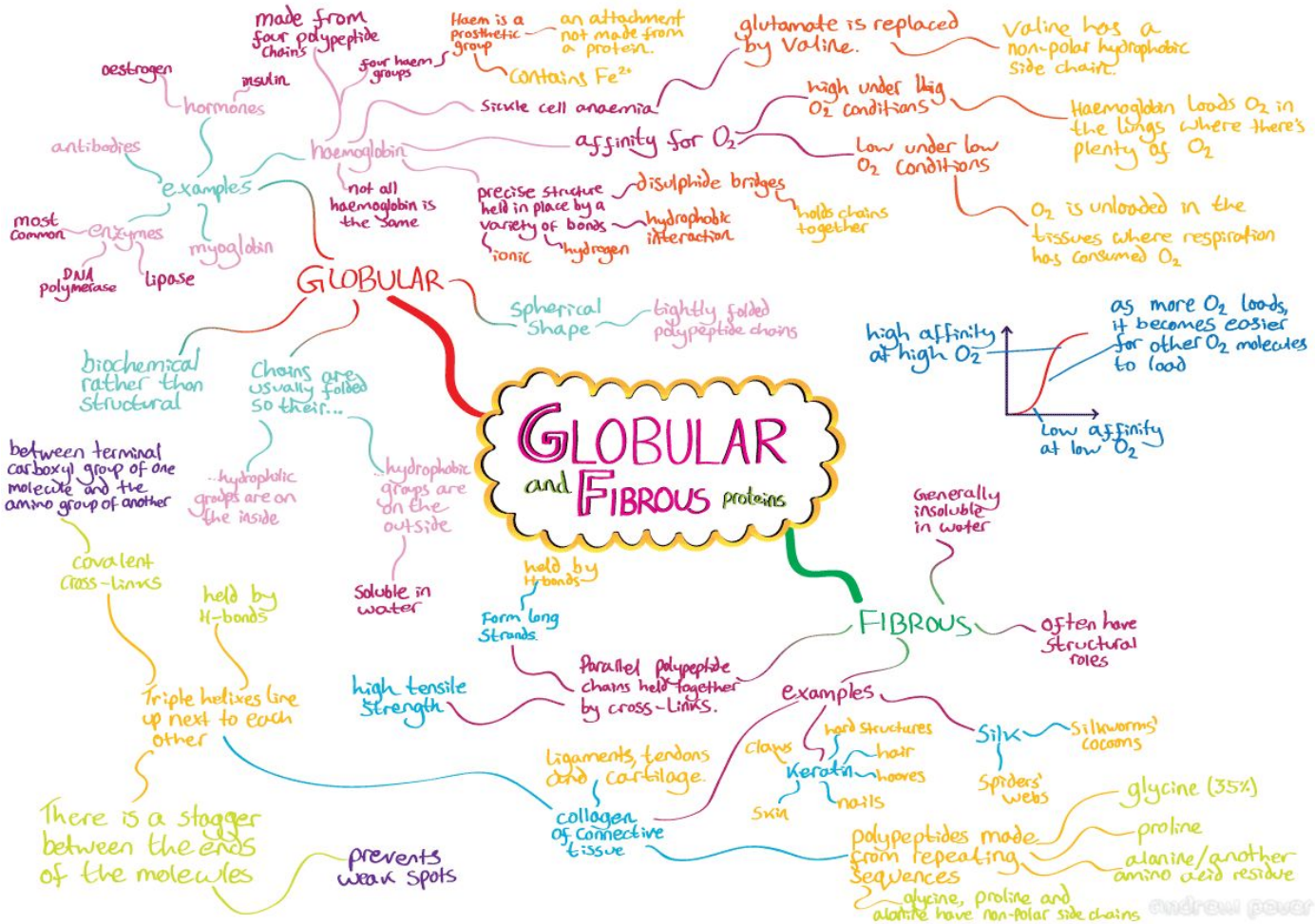
A complex tertiary structure.

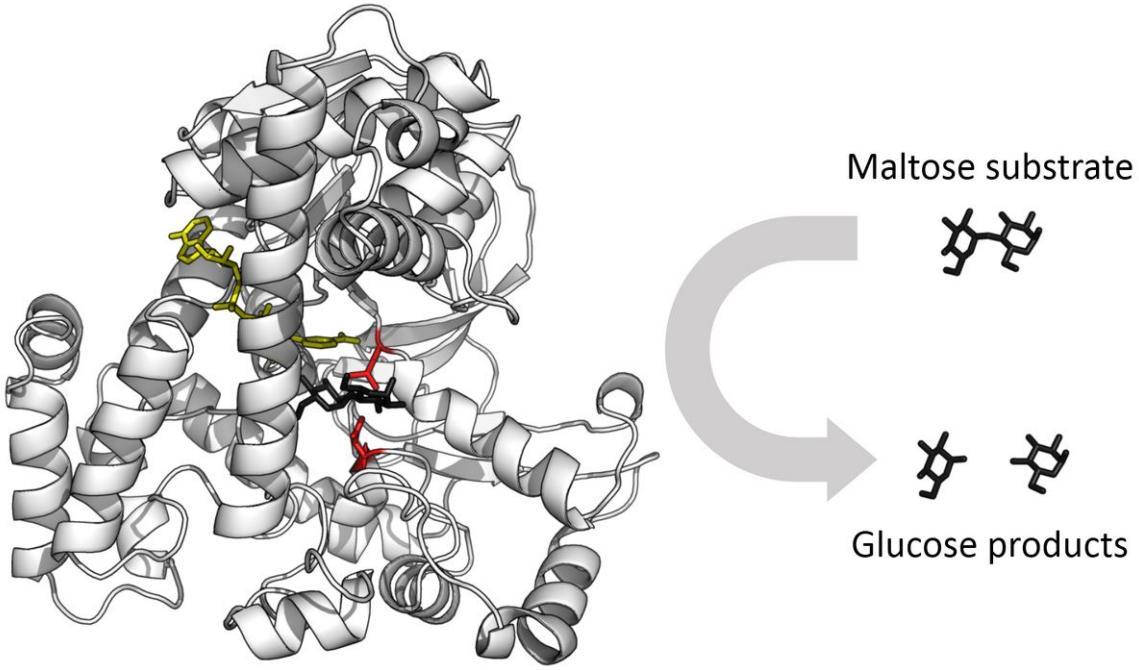
Folded into a spherical/globular shape.

Usually soluble in water.

Some have a quarternary structure.

Roles in metabolic reactions.


GLOBULAR and FIBROUS proteins
GLOBULAR
spherical shape
tightly folded polypeptide chains
biochemical rather than structural
Chains are usually folded so their...
hydrophilic groups are on the inside
hydrophobic groups are on the outside
Soluble in water
between terminal carboxyl group of one molecule and the amino group of another
covalent cross-links
held by H-bonds
Triple helixes line up next to each other
There is a stagger between the ends of the molecules
prevents weak spots
examples
hormones
oestrogen
insulin
antibodies
enzymes
most common
DNA polymerase
lipase
myoglobin
haemoglobin
made from four polypeptide chains
four haem groups
Haem is a prosthetic group
an attachment not made from a protein.
contains Fe^{2+}
not all haemoglobin is the same
precise structure held in place by a variety of bonds
ionic
hydrogen
hydrophobic interaction
disulphide bridges
holds chains together
Sickle cell anaemia
glutamate is replaced by Valine.
Valine has a non-polar hydrophobic side chain.
affinity for O_2
high under high O_2 conditions
Haemoglobin loads O_2 in the lungs where there's plenty of O_2
Low under low O_2 conditions
O_2 is unloaded in the tissues where respiration has consumed O_2
high affinity at high O_2
as more O_2 loads, it becomes easier for other O_2 molecules to load
low affinity at low O_2
FIBROUS
Generally insoluble in water
often have structural roles
held by H-bonds
Form long strands.
Parallel polypeptide chains held together by cross-links.
high tensile strength
examples
Ligaments, tendons and cartilage.
collagen of connective tissue
polypeptides made from repeating sequences
glycine (35%)
proline
alanine/another amino acid residue
glycine, proline and alanine have non-polar side chains
Keratin
skin
hair
hooves
nails
claws
hard structures
Silk
Silkworms' cocoons
Spiders' webs

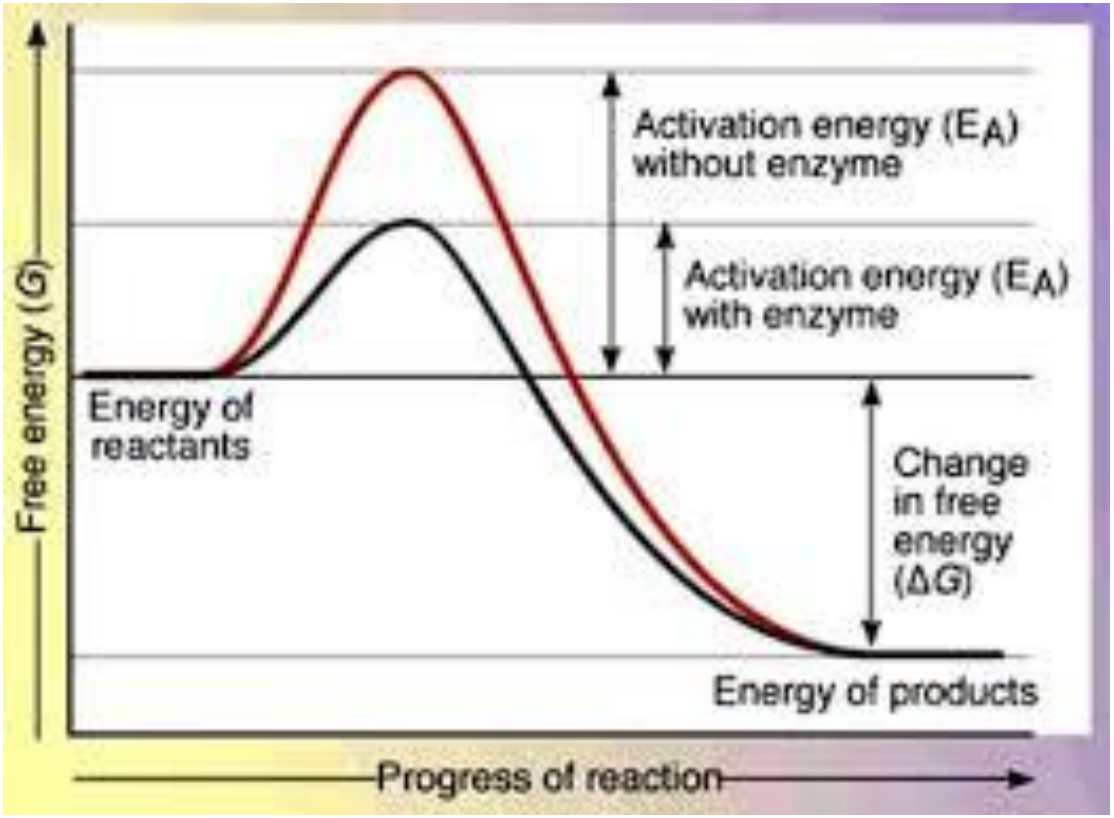

Maltose substrate
Glucose products

Functions of Enzymes

1. Enzymes are Catalysts
   - reducing the amount of energy to start a reaction

2. Activation Energy

- The amount of energy it takes for a reaction to begin.



Naming conventions

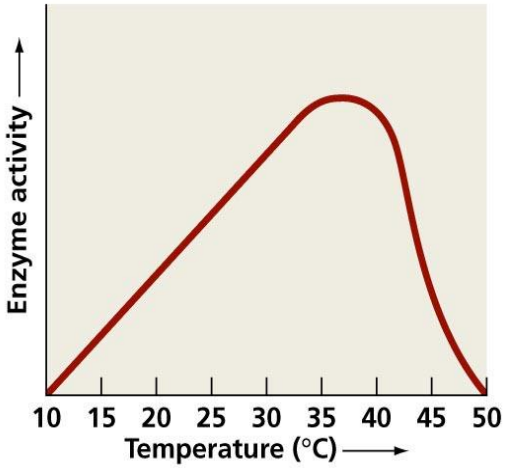
3. Enzymes named for reaction they catalyze

- sucrase breaks down sucrose
- proteases break down proteins
- lipases break down lipids
- DNA polymerase builds DNA
  - adds nucleotides to DNA strand
- pepsin breaks down proteins (polypeptides)

Many enzyme end in -ase

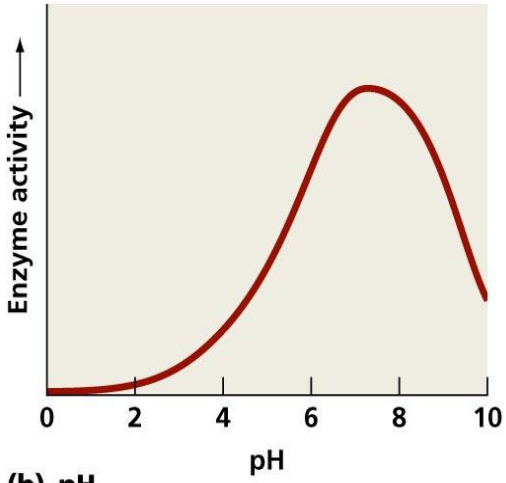
Properties of enzymes

4. Specific
   - each enzyme works with a specific substrate
     - H bonds & ionic bonds
5. Not consumed in reaction
   - 1 enzyme 600,000 reactions / second.
   - enzymes unaffected by the reaction
6. Factors that effect the reaction rate of enzymes
   - **Enzyme concentration**
   - **Substrate concentration**
   - **Temperature**
   - **pH**



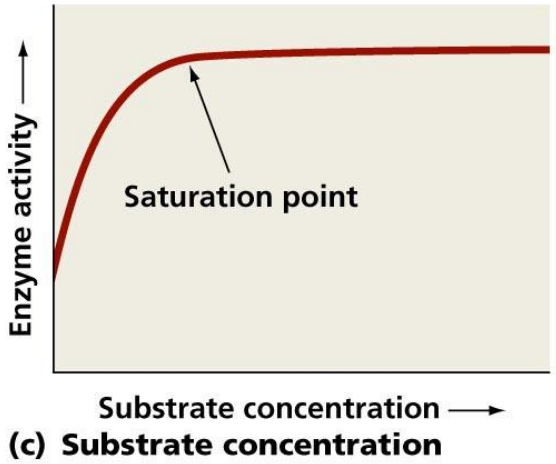
(a) Temperature

Each enzyme has an optimum temperature at which it works fastest. As temperature increased abour the **optimum** temperature above the optimum temperature, the enzyme gradually **denatures** (loses it precise tertiary structure). When denatured it stops functioning. Denaturing may be reversable.



(b) pH

Each enzyme has an optimum pH. Some enzymes operate only within a narrow pH, some have a broader pH range.



(c) Substrate concentration

The greater the concentration of the enzyme, the faster the rate of the reaction, provided there are enough substrate molecules present. Similarly, the greater the concentration of the substrate, the faster the rate of the reaction. The rate will slow down as the substate is used up.

7. Compounds which regulate enzymes

- Inhibitors
  - molecules that reduce enzyme activity
  - competitive inhibition
  - noncompetitive inhibition
  - feedback inhibition

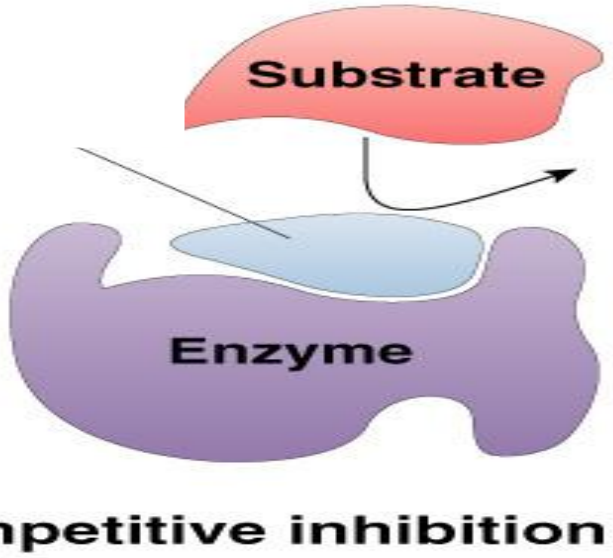
Comptetitive and NonCompetitive Inhibition Video – 2min

https://www.youtube.com/watch?v=p2xf1hYvvpg

Competitive Inhibitor

- Inhibitor & substrate “compete” for active site

Competitive Inhibitor



Examples:

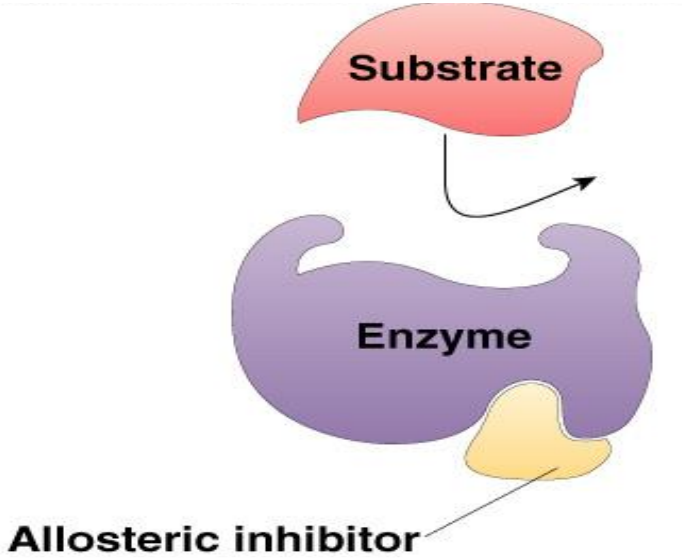
- penicillin
  blocks enzyme bacteria used to build cell walls

Non-Competitive Inhibitor

- Ihibitor that binds to site other than active site
  - allosteric inhibitor binds to allosteric site
  - causes enzyme to change shape

Examples:

- some anti-cancer drugs
  inhibit enzymes involved in DNA synthesis
  - stop DNA production
  - stop division of more cancer cells
- cyanide poisoning
  irreversible inhibitor of Cytochrome C,
  an enzyme in cellular respiration
  - stops production of ATP



(b) Noncompetitive inhibition

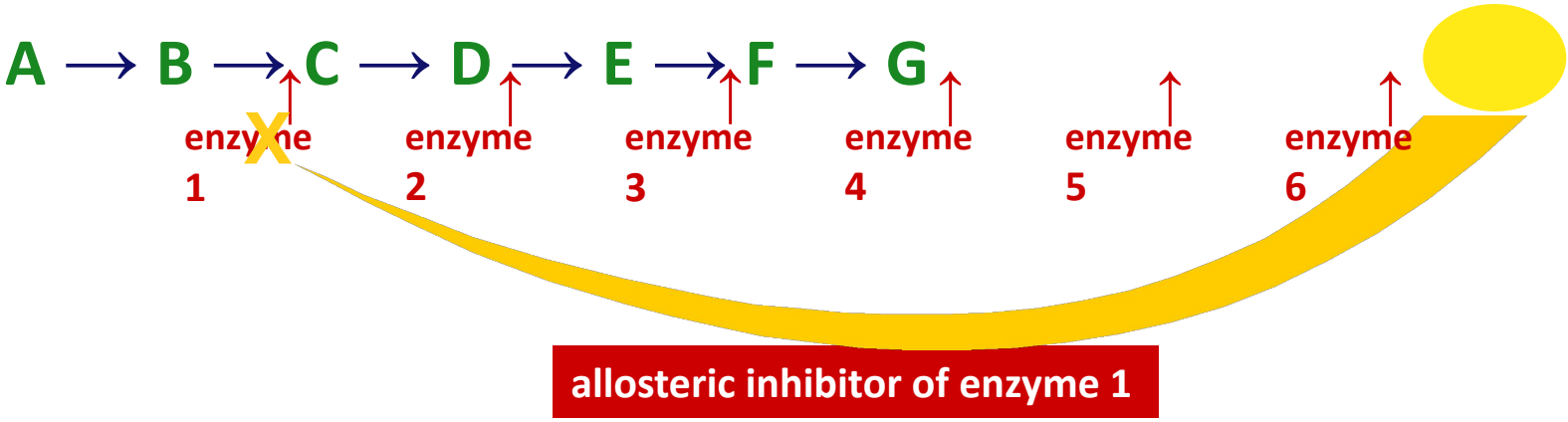
Irreversible inhibition

- Inhibitor permanently binds to enzyme
  - competitor
    - permanently binds to active site
  - allosteric
    - permanently binds to allosteric site
    - permanently changes shape of enzyme
    - nerve gas, sarin, many insecticides (malathion, parathion…)

Negative Feedback Inhibition

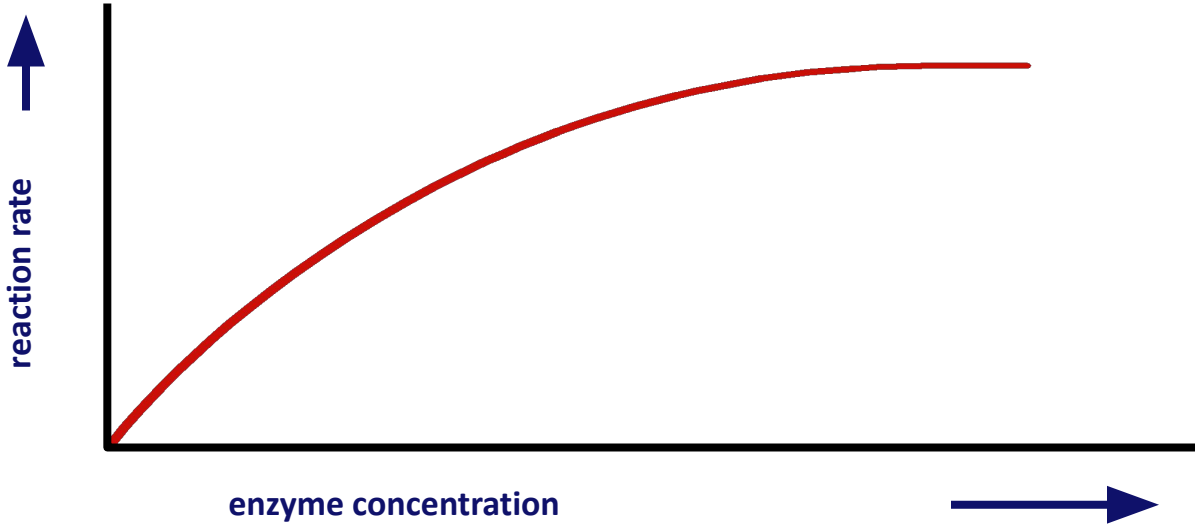
Feedback inhibition video- 2min https://www.youtube.com/watch?v=DHZtOKyMPRY

- Regulation & coordination of production
  - product is used by next step in pathway
  - final product is inhibitor of earlier step
    - allosteric inhibitor of earlier enzyme
    - feedback inhibition
  - no unnecessary accumulation of product



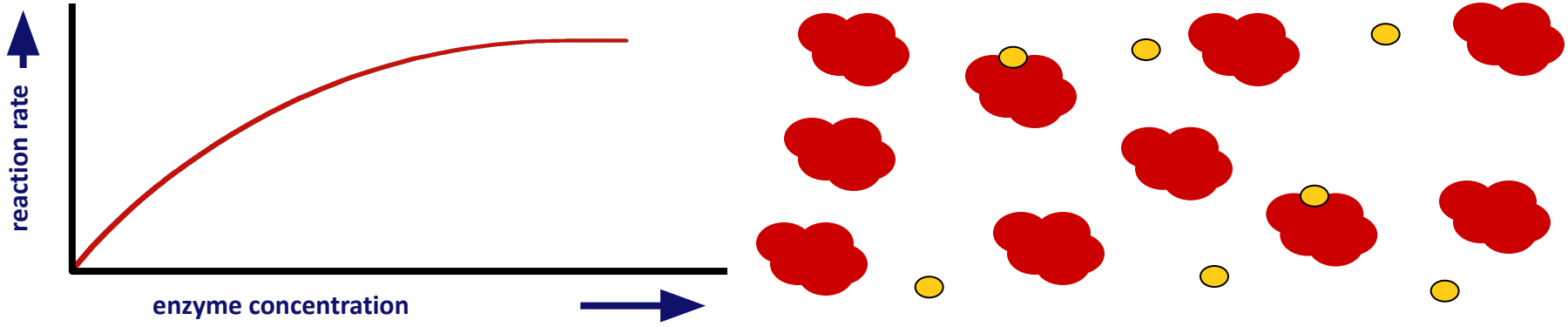
Graphs

Enzyme concentration

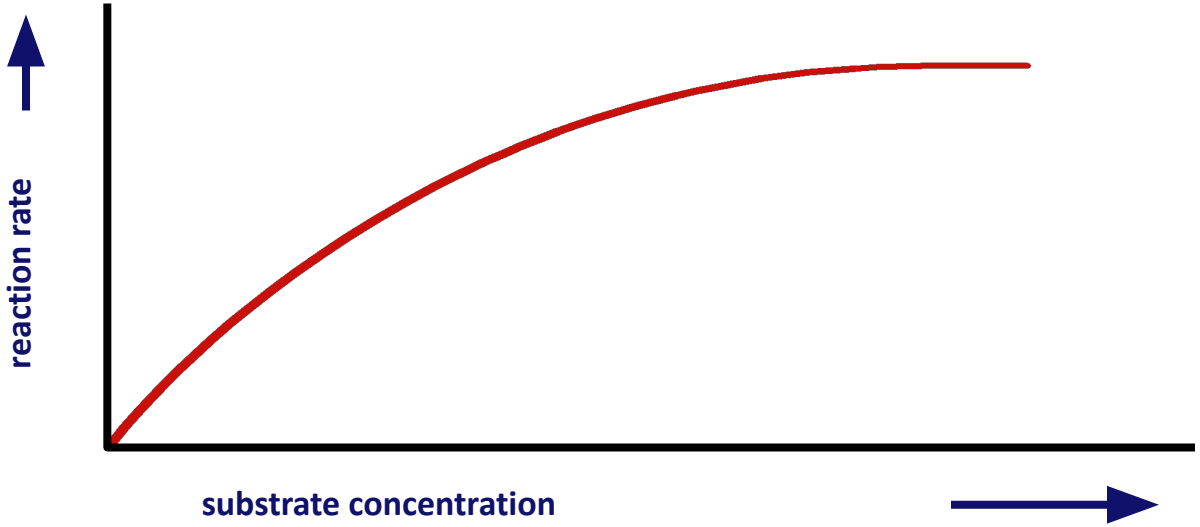


Factors affecting enzyme function

- Enzyme concentration
  - as ↑ enzyme = ↑ reaction rate
    - more enzymes = more frequently collide with substrate
  - reaction rate levels off
    - substrate becomes limiting factor
    - not all enzyme molecules can find substrate

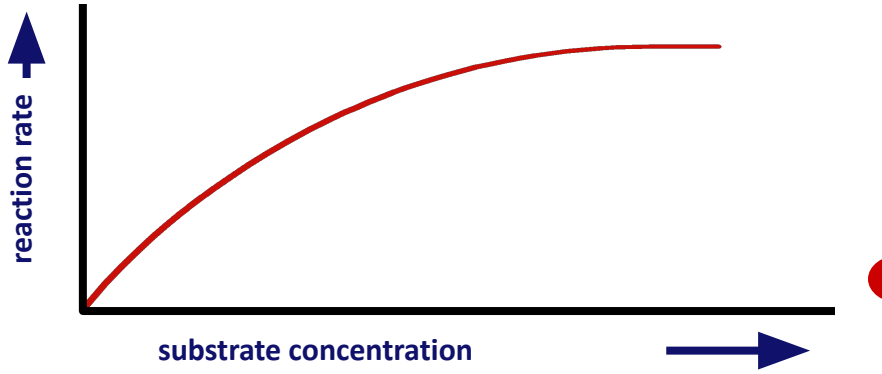


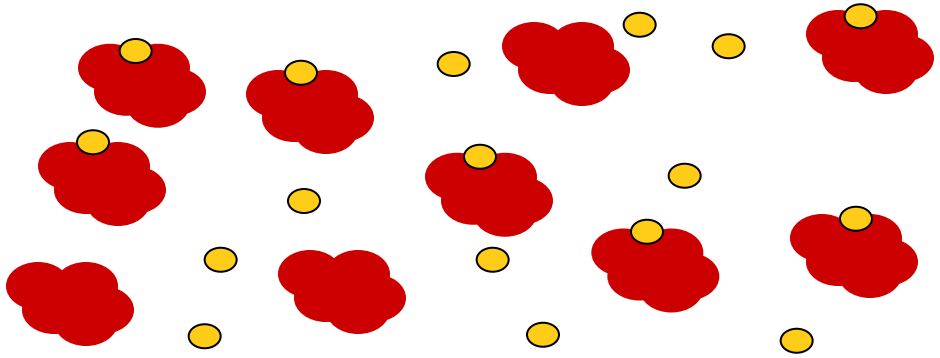
Substrate concentration



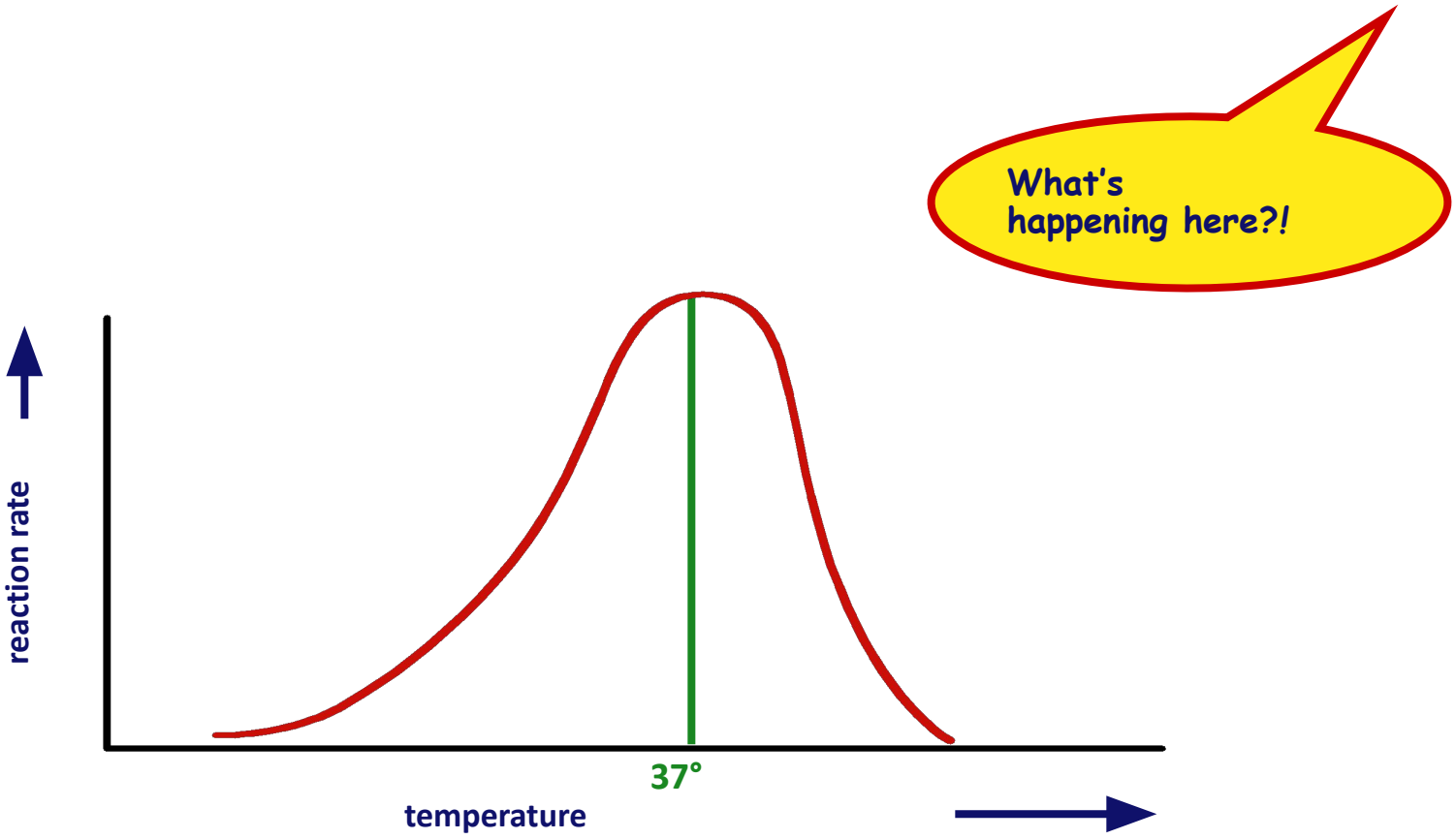
Factors affecting enzyme function

- Substrate concentration
  - as ↑ substrate = ↑ reaction rate
    - more substrate = more frequently collide with enzyme
  - reaction rate levels off
    - all enzymes have active site engaged
    - enzyme is saturated
    - maximum rate of reaction

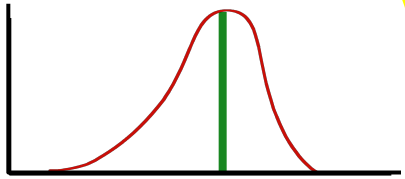




Temperature



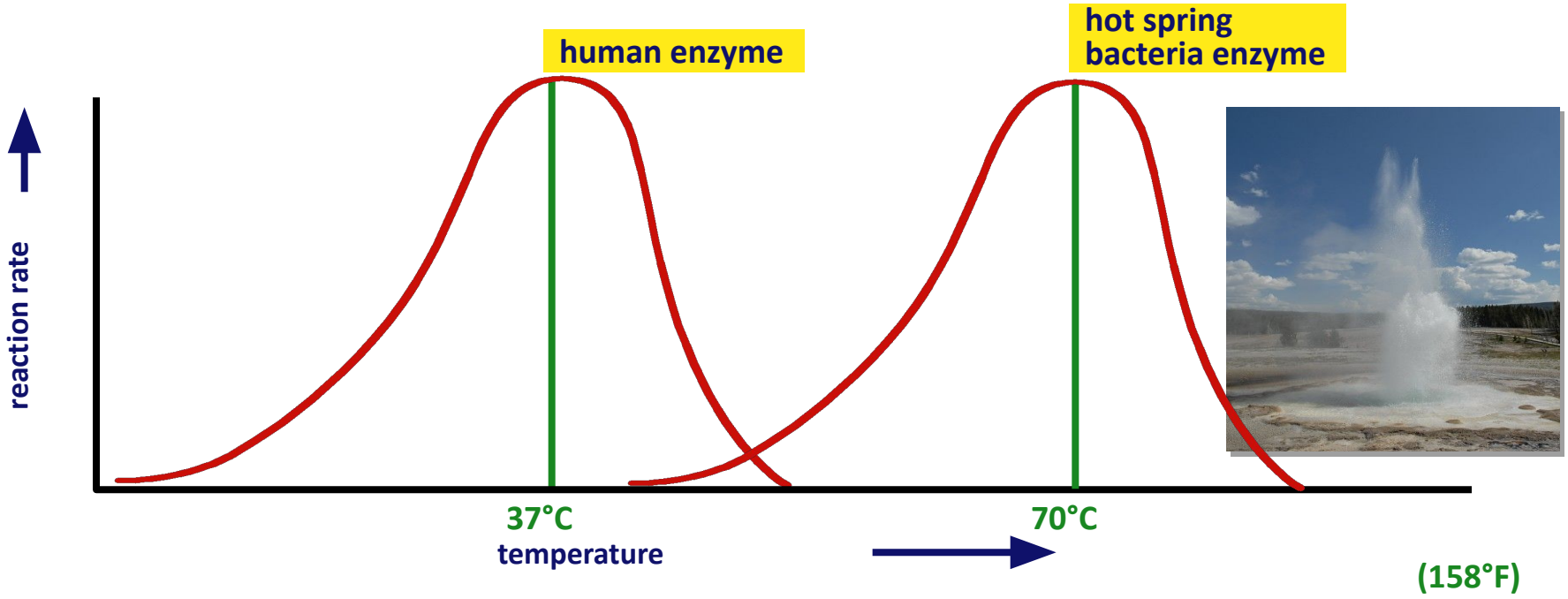
Factors affecting enzyme function



- Temperature
  - Optimum T°
    - greatest number of molecular collisions
    - human enzymes = 35°- 40°C
      - body temp = 37°C
  - Heat: increase beyond optimum T°
    - increased energy level of molecules disrupts bonds in enzyme & between enzyme & substrate
      - H, ionic = weak bonds
    - denaturation = lose 3D shape (3° structure)
  - Cold: decrease T°
    - molecules move slower
    - decrease collisions between enzyme & substrate

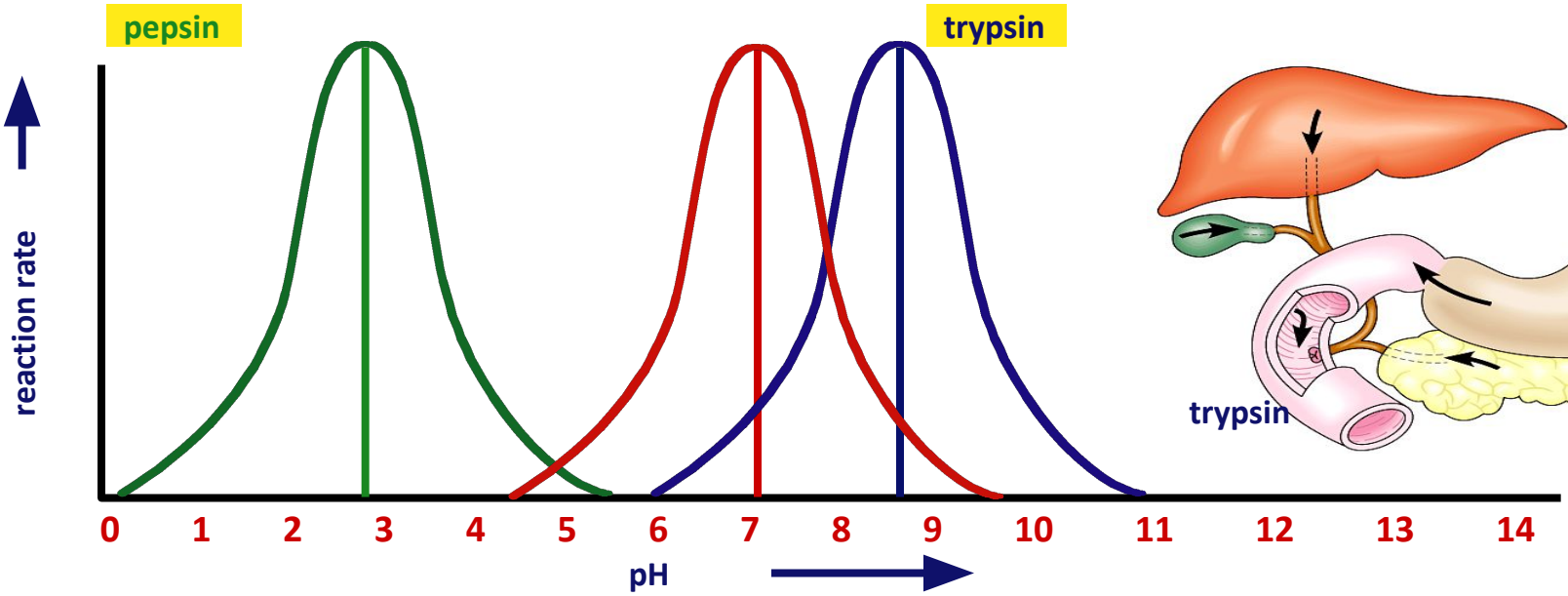
Enzymes and temperature

- Different enzymes function in different organisms in different environments



pH

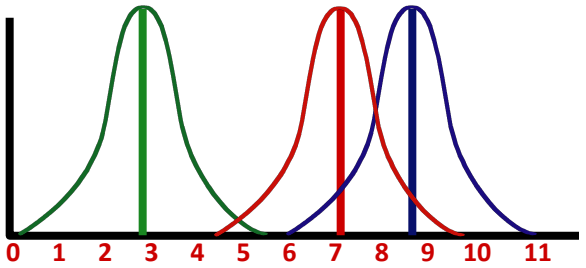

What's
happening here?!


pepsin
trypsin
reaction rate
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
pH

pepsin
trypsin

Factors affecting enzyme function

- pH
  - changes in pH
    - adds or remove H^+
    - disrupts bonds, disrupts 3D shape
      - disrupts attractions between charged amino acids
      - affect 2° & 3° structure
      - denatures protein
  - optimal pH?
    - most human enzymes = pH 6-8
      - depends on localized conditions
      - pepsin (stomach) = pH 2-3
      - trypsin (small intestines) = pH 8



1. Enzymes

What is an Enzyme? Enzymes are proteins

What is the structure of an enzyme? Enzymes have four main structures

What is the function of enzymes? Enzymes are catalysts

What can factors can effect enzymes rates? Factors the Affect Enzymes

How are enzymes regulated? Enzyme Regulation

Designing an experiment using enzymes

What is the structure of enzymes?

-1, 2, 3, 4

-amino acids

-peptide bonds

-specific

-globular

-denatured

-enzyme, substrate, product, active site

What is anEnzyme? https://www.youtube.com/watch?v=a_Bxtb-svh8

1. Enzymes are proteins – comprised of amino acids
2. Enzymes are catalysts – they speed up reactions
3. Enzymes are essential for the metabolism- hydrolysis and condensation of food to body parts or energy!.
4. Enzymes are specific – one enzyme, one bond
5. Enzymes are fast! - 1 enzyme every 600,000 seconds

proteins are chains of amino acids held together by peptide bonds.

there are 20 amino acids

What is the function of enzymes?

To help catalyze-speed up---chemical reactions

To make or break specific bonds

What are some factors that can effect enzyme function?

- temperature
- pH
- substrate
- concentration of substrate

How are enzymes regulated?

Competitive inhibition

Non competitive inhibition

Experiemental Variables

Enzyme Revision

Enzymes

Practical potato hydrogen peroxide 54 sec
https://www.youtube.com/watch?v=a_Bxtb-svh8

Lock and key

Induced fit

Fixed Variables in effect of pH practical

Fixed - Temperature

-Use thermostatically-controlled water bath

-If no controlled bath available, at least measure the temperature to check that it remains constant.

-Temperature must be fixed as if affects the number of enzyme-substrate collisions which can lead to product.

Fixed - Enzyme concentration

- Fixed mass of source to provide fixed number of enzyme molecule.

-Fixed surface area of source – fixed number of fixed size potato disks.

-Enzyme concentration must be fixed as if affects the frequency of enzyme-substrate collisions.

Fixed - Substrate concentration

-Fixed volume

-Fixed concentration of hydrogen peroxide solution

-Must be fixed as H_2O_2 concentration affects frequency/ number of enzyme – substrate collisions.

Not fixed – pH is the independent variable.

pH ins the input variable

-Varied by the use of a range of buffer solutions.

-Affect attraction between enzyme confirmation

-Use wide range pH of 4-8 increments of 0.5 to obtain more accurate value.

pH

temperature

Substrate concentration

Enzyme inhibitor

temperature

Substrate concentration

Enzyme inhibitor