Enzyme

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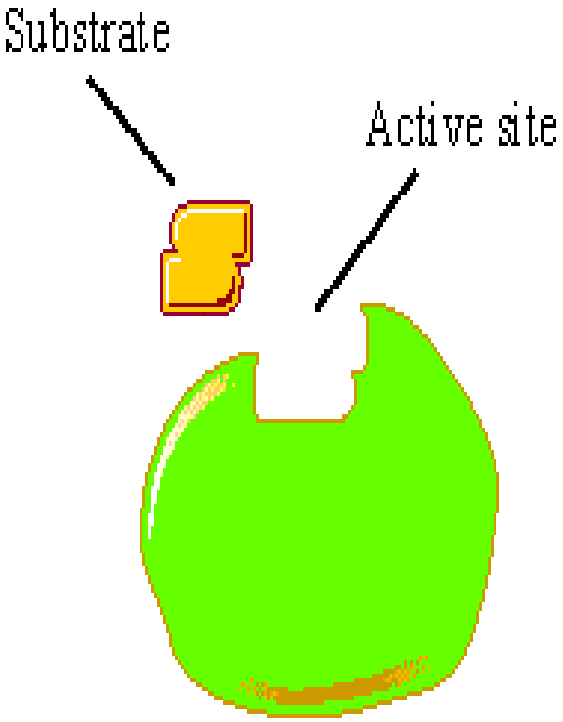
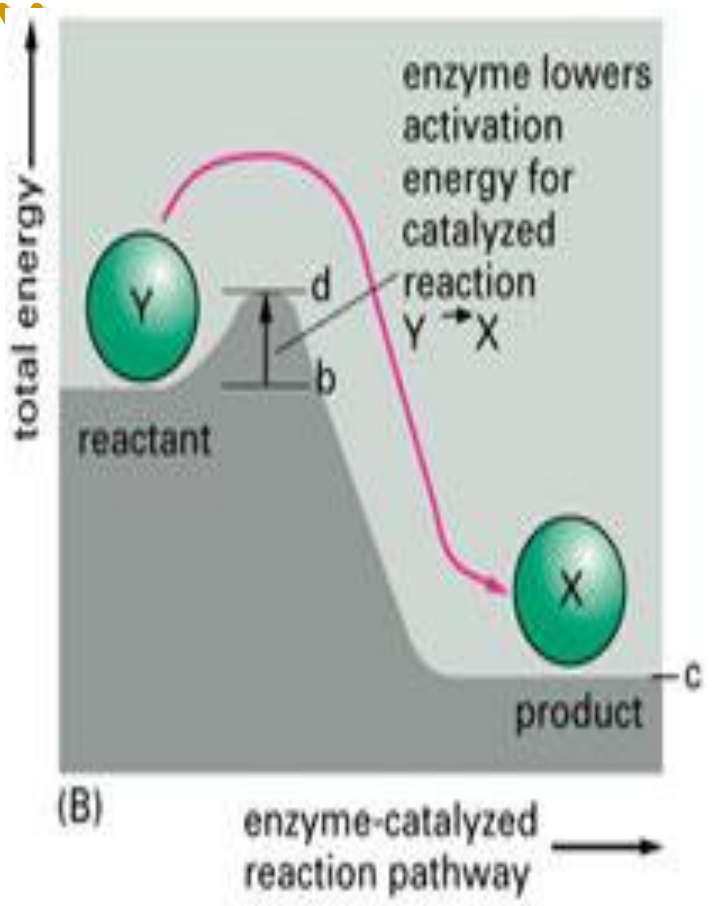
What Are Enzymes?

- Most enzymes are Proteins (tertiary and quaternary structures)
- Act as Catalyst to accelerates a reaction
- Not permanently changed in the process
- Are specific for what they will catalyze
- Are Reusable
- End in –ase
  - -Sucrase
  - -Lactase
  - -Maltase

How do enzymes Work?

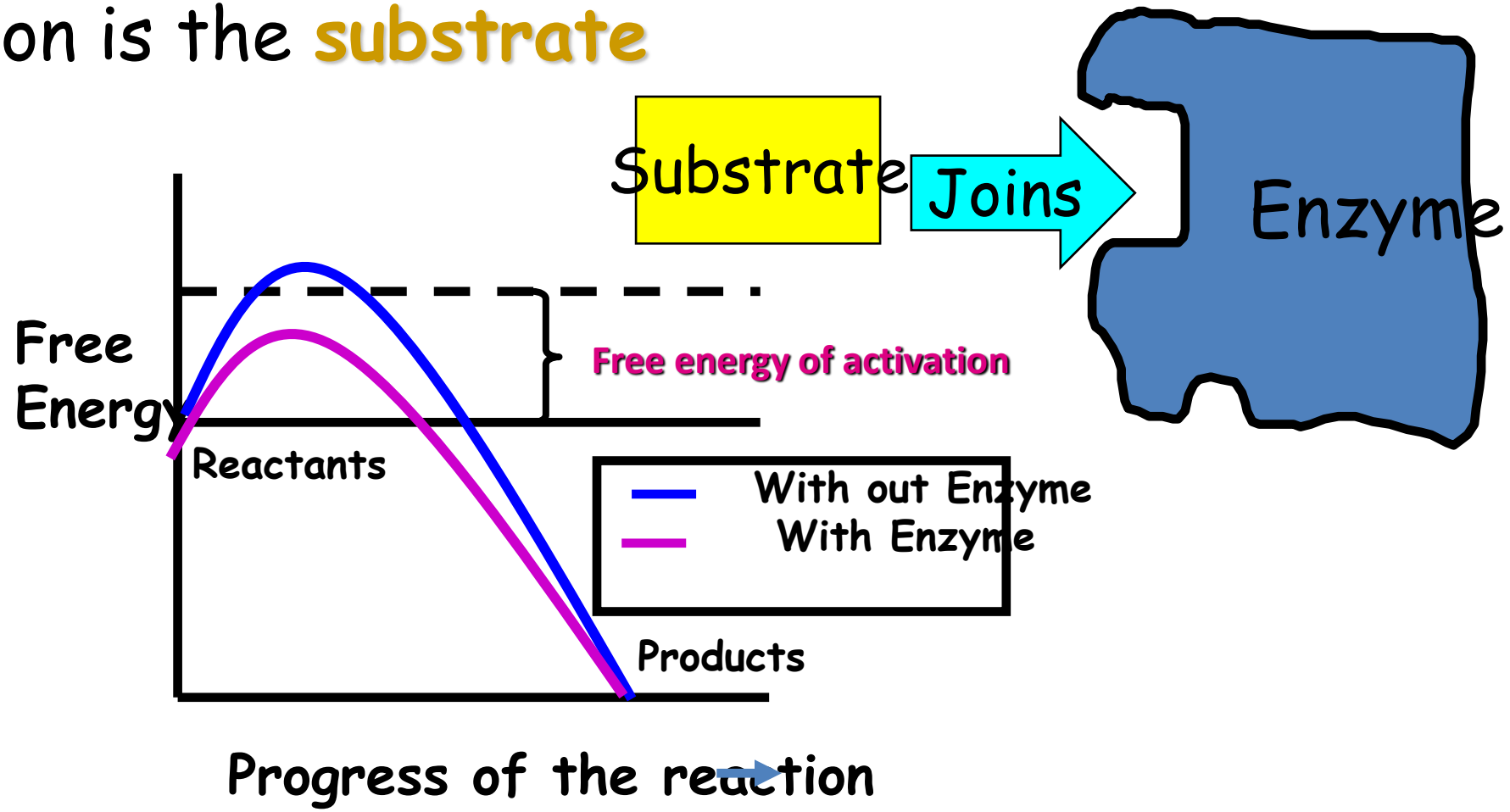
Enzymes work by weakening bonds which lowers activation energy





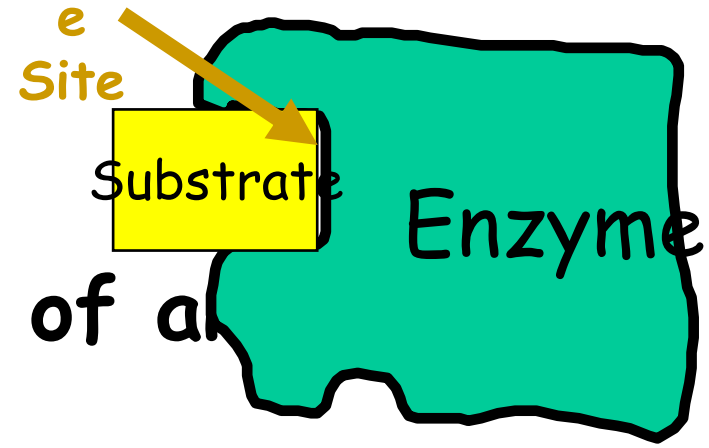
Enzyme-Substrate Complex

The **substance** (reactant) an **enzyme** acts on is the **substrate**



❖ Active Site

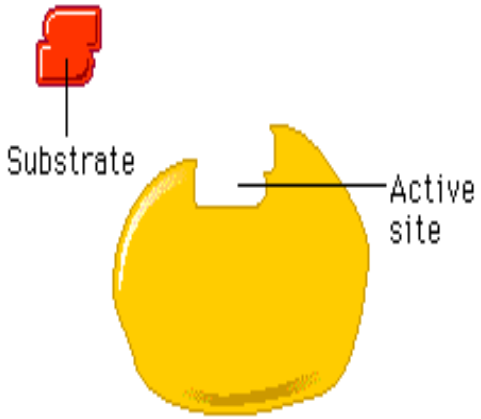
- A **restricted region** of an **enzyme** molecule which **binds** to the **substrate**.



❖**Induced Fit:**

- **A change in the shape of a**
  enzym

active s **by the substrate.**



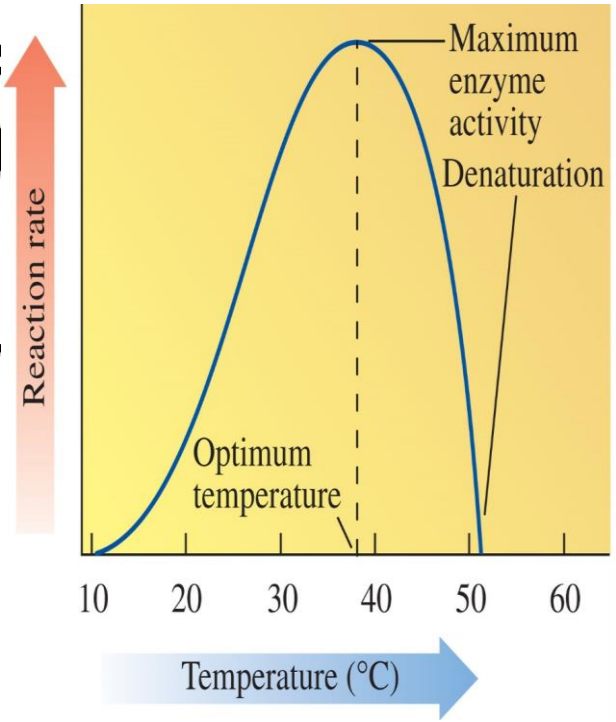
What Affects Enzyme Activity?

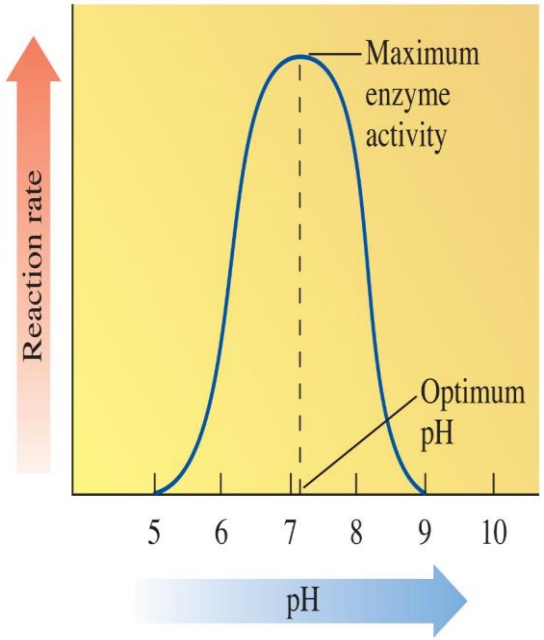
- Three factors:
  1. Environmental Conditions
  2. Cofactors and Coenzymes
  3. Enzyme Inhibitors

1. Environmental Conditions

1. Extreme Temperature are the mo
   - high temps may denature (unfold)

2. pH (most like 6 - 8 pH near neu
3. Ionic concentration (salt ions)





Optimum pH Values

Enzymes in

- the body have an **optimum pH** of about 7.4.
- certain organs operate at lower and higher

TABLE 16.11 Optimum pH for Selected Enzymes

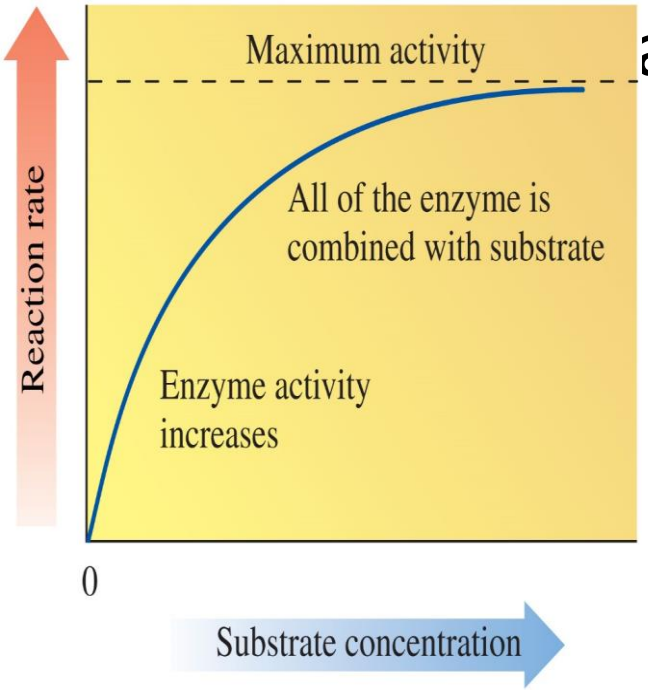
Enzyme	Location	Substrate	Optimum pH
Pepsin	Stomach	Peptide bonds	2
Urease	Liver	Urea	5
Sucrase	Small intestine	Sucrose	6.2
Pancreatic amylase	Pancreas	Amylose	7
Trypsin	Small intestine	Peptide bonds	8
Arginase	Liver	Arginine	9.7

Substrate Concentration

As **substrate concentration** increases,

- the **rate of reaction** increases (at constant enzyme concentration).

- the enzyme eventu ated, giving maximum act



Quiz

Sucrase has an optimum temperature of 37 °C and an optimum pH of 6.2. Determine the effect of the following on its rate of reaction.

1) no change 2) increase 3) decrease

A. Increasing the concentration of sucrose
B. Changing the pH to 4
C. Running the reaction at 70 °C

2. Cofactors and Coenzymes

- Inorganic substances (zinc, iron) and vitamins (respectively) are sometimes need for proper enzymatic activity.

- Example:

  Iron must be present in the quaternary structure - hemoglobin in order for it to pick up oxygen.

Enzyme Inhibition

Inhibitors

- are molecules that cause a loss of catalytic activity.
- prevent substrates from fitting into the active sites.

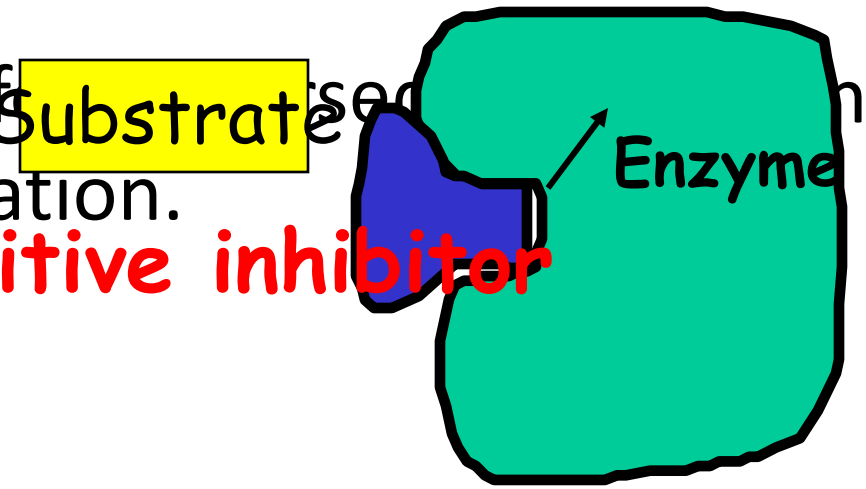
E + S ES E + P

E + I EI no P

Two examples of Enzyme Inhibitors

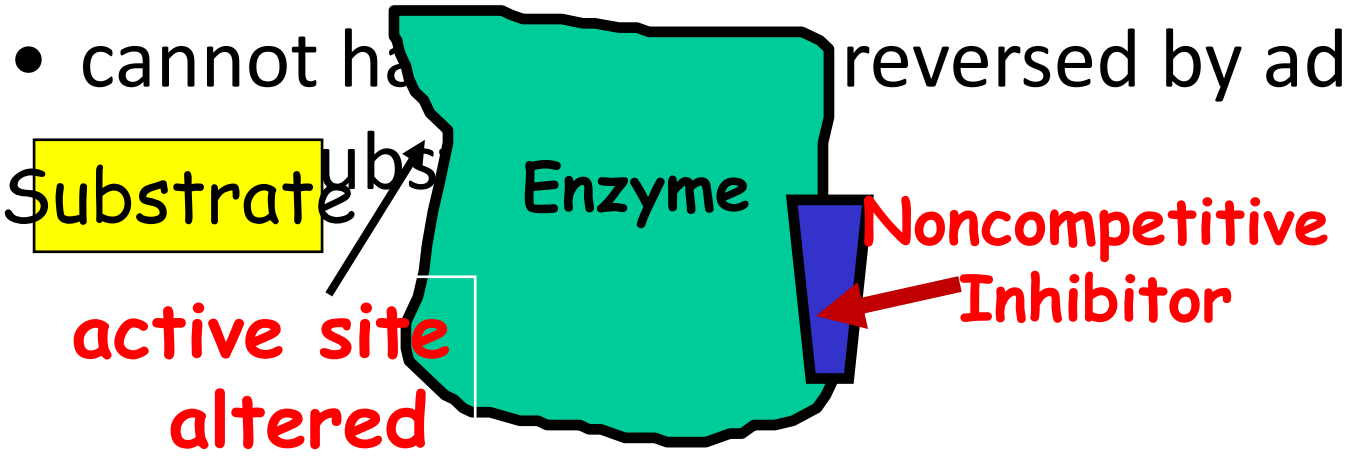
A- **competitive inhibitor**

- has a structure that is similar to that of the substrate.
- competes with the substrate for the active site.
- has its effect reversed by increasing substrate concentration.



B- **noncompetitive inhibitor**

- has a structure that is much different than the substrate.
- distorts the shape of the enzyme, which alters the shape of the active site.
- prevents the binding of the substrate.
- cannot ha reversed by adding
  ubs

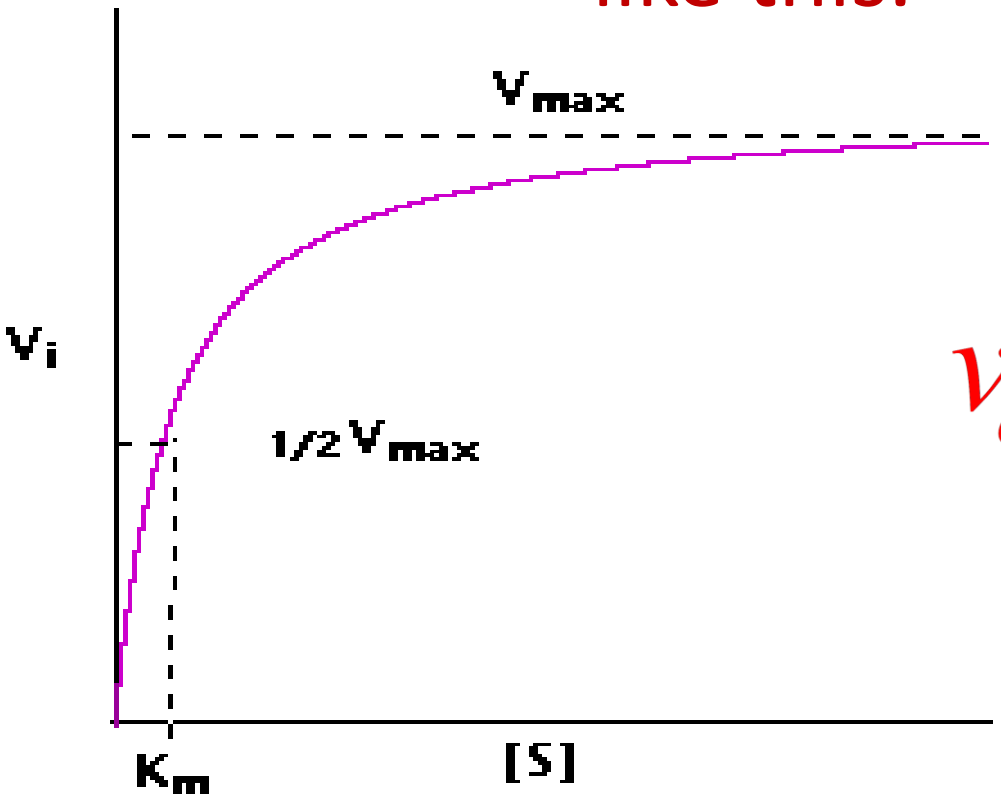


Mechaelis Menton kinetics

Plotting Vi as a function of [S], we find that

- At low values of [S], the initial velocity,Vi, rises almost linearly with increasing [S].
- But as [S] increases, the gains in Vi level off (forming a rectangular hyperbola).
- The asymptote represents the maximum velocity of the reaction, designated Vmax
- The substrate concentration that produces a Vi that is one-half of Vmax is designated the Michaelis-Menten constant, Km(named after the scientists who developed the study of enzyme kinetics)

Plotting out our data it might look like this.



$$v_o = \frac{V_{max}[S]}{K_M + [S]}$$

V_i = initial velocity (moles/time)

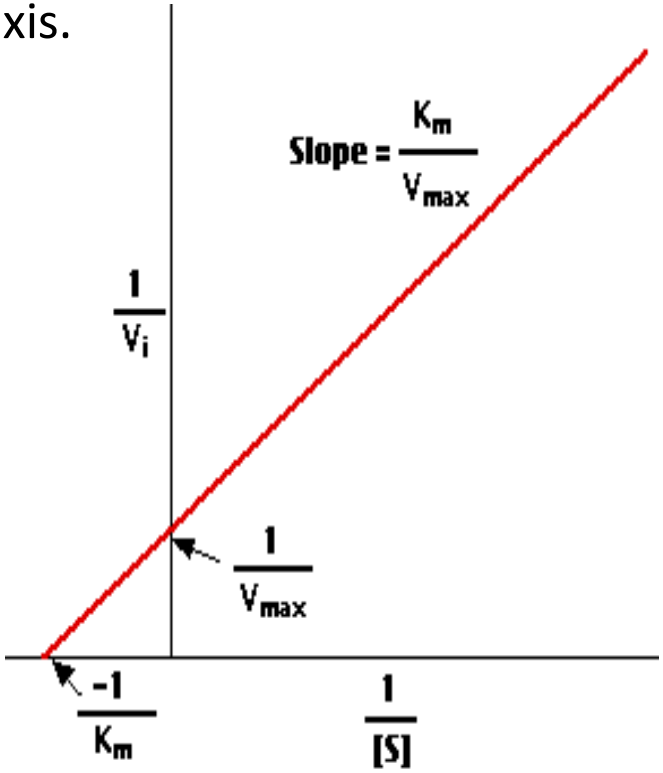
[S] = substrate concentration (molar)

V_{max} = maximum velocity

K_m = substrate concentration when V_i is one-half V_{max} (Michaelis-Menton constant)

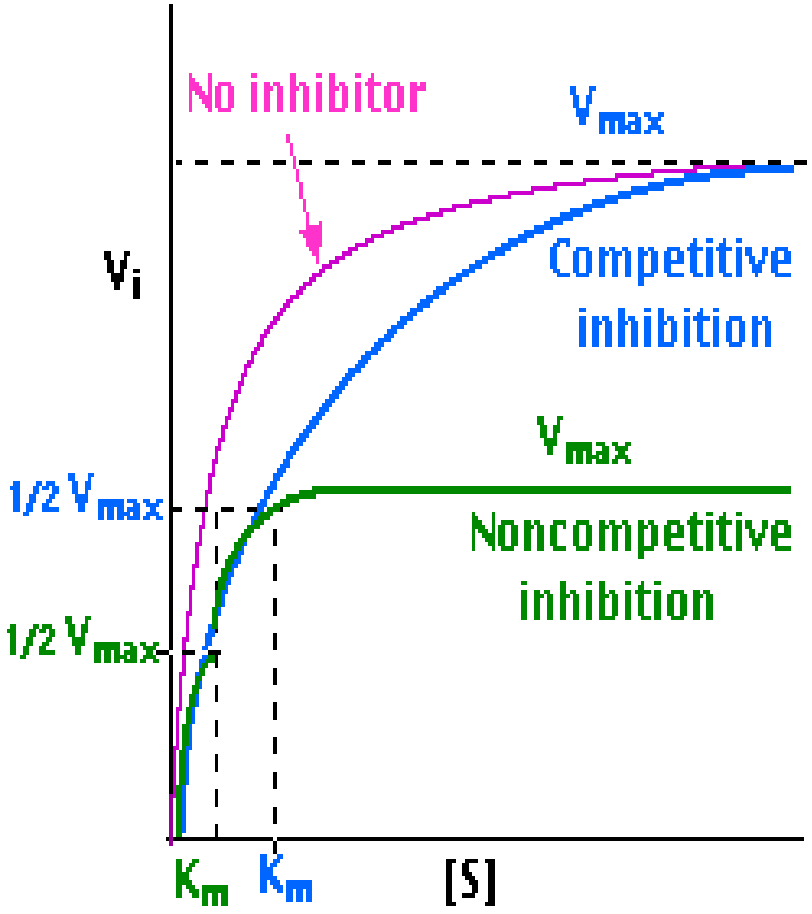
Lineweaver-Burke plot

Plotting the reciprocals of the same data points yields a "double-reciprocal" or Lineweaver-Burk plot. This provides a more precise way to determine Vmax and Km. Vmax is determined by the point where the line crosses the 1/Vi = 0 axis (so the [S] is infinite). Note that the magnitude represented by the data points in this plot decrease from lower left to upper right. Km equals Vmax times the slope of line. This is easily determined from the intercept on the X axis.

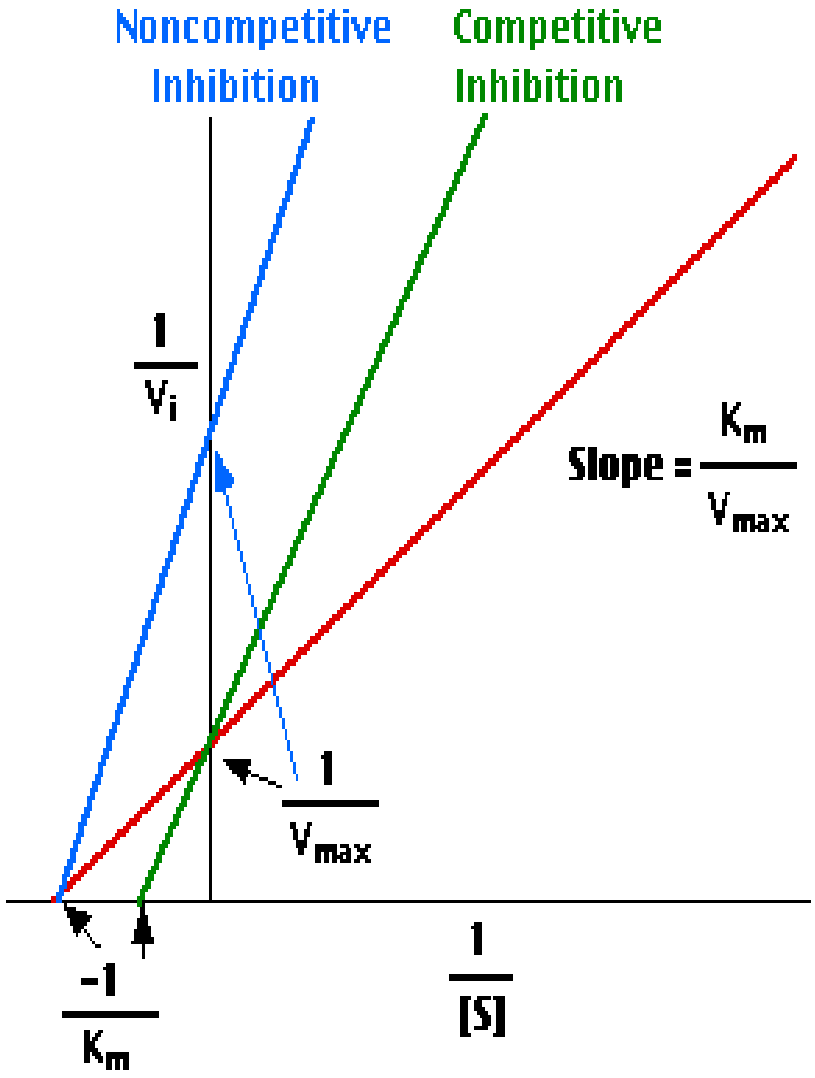


$$\frac{1}{v_o} = \left(\frac{K_M}{V_{max}}\right)\frac{1}{[S]} + \frac{1}{V_{max}}$$

Competitive/noncompetitive inhibitor



Effect of inhibitors



The K_M widely varies among different enzymes

The K_M

can be expressed as:

$$K_M = \frac{k_{-1}}{k_1} + \frac{k_2}{k_1} = K_s + \frac{k_2}{k_1}$$

As Ks decreases, the affinity for the substrate increases. The K_M can be a measure for substrate affinity if $\mathbf{k_2 < k_{-1}}$

- Michaelis constants: have been determined for many of the commonly used enzymes. The size of Km tells us several things about a particular enzyme.

1. A small Km indicates that the enzyme requires only a small amount of substrate to become saturated. Hence, the maximum velocity is reached at relatively low substrate concentrations.

2. A large Km indicates the need for high substrate concentrations to achieve maximum reaction

Lineweaver-Burk plot: slope = $K_M/Vmax$,

$1/v_o$ intercept is equal to 1/Vmax

the extrapolated x intercept is equal to $-1/K_M$

For small errors in at low [S] leads to large errors in $1/v_o$

★

$$k_{cat} = \frac{V_{max}}{[E]_T}$$

k_{cat} is how many reactions an enzyme can catalyze per second

The turnover number

For Michaelis -Menton kinetics $k_2 = k_{cat}$

When [S] << K_M very little ES is formed and [E] = $[E]_T$

and $$v_o \approx \frac{k_2}{K_M}[E]_T[S] \approx \frac{k_{cat}}{K_M}[E][S]$$

K_{cat}/K_M is a measure of catalytic efficiency

What is catalytic perfection?

When $k_2 >> k_{-1}$ or the ratio $\frac{k_1 k_2}{k_{-1} + k_2}$ is maximum

Then $\frac{k_{cat}}{K_M} = k_1$

Or when every substrate that hits the enzyme causes a reaction to

Diffusion-controlled limit- diffusion rate of a substrate is in the range of 10^8 to 10^9 $M^{-1}s^{-1}$. An enzyme lowers the transition state so there is no activation energy and the catalyzed rate is as fast as molecules collide