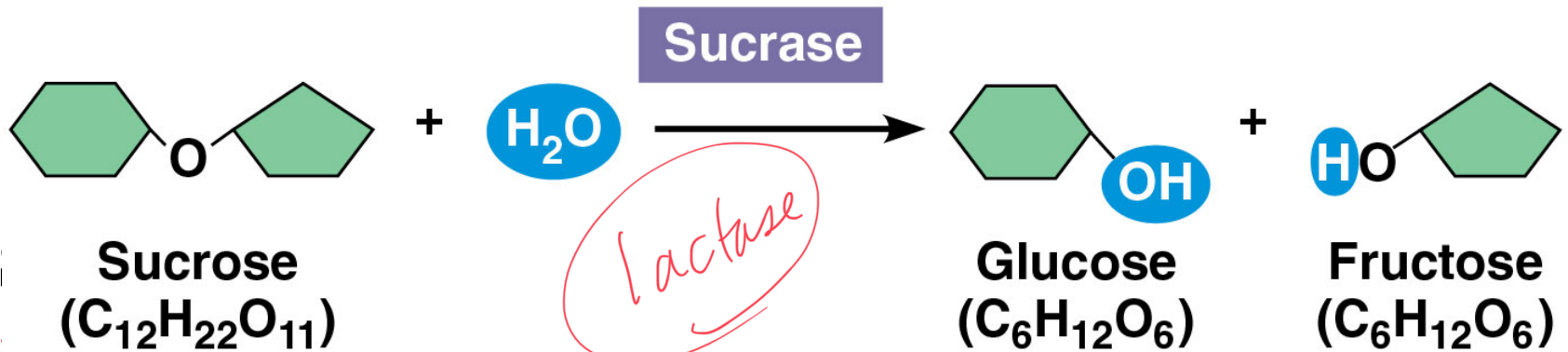


○ Catalyst: substance that can change the rate of a reaction without being altered in the process

○ Enzyme = biological catalyst

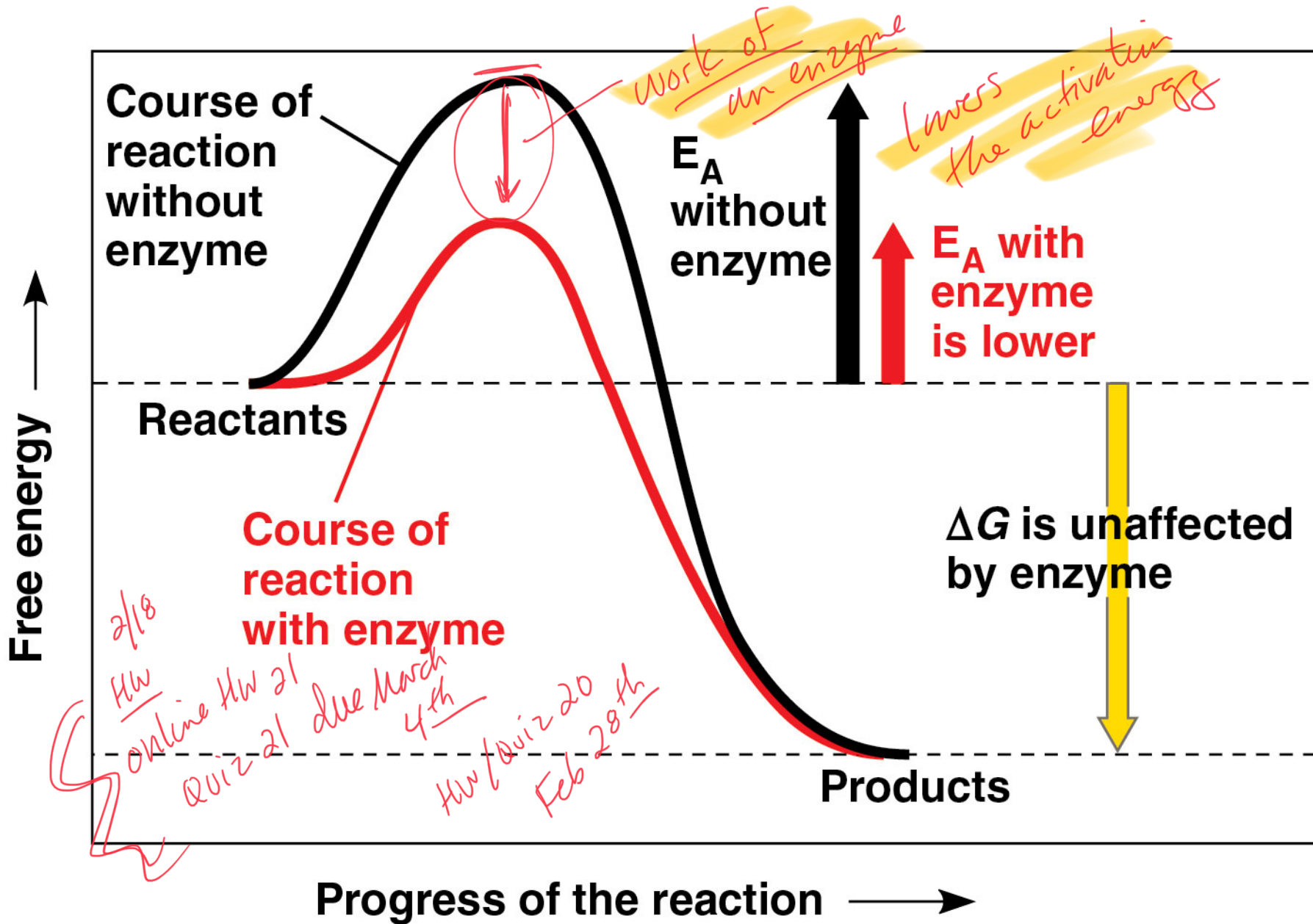
*by lowering activation energy*



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breaking bonds)

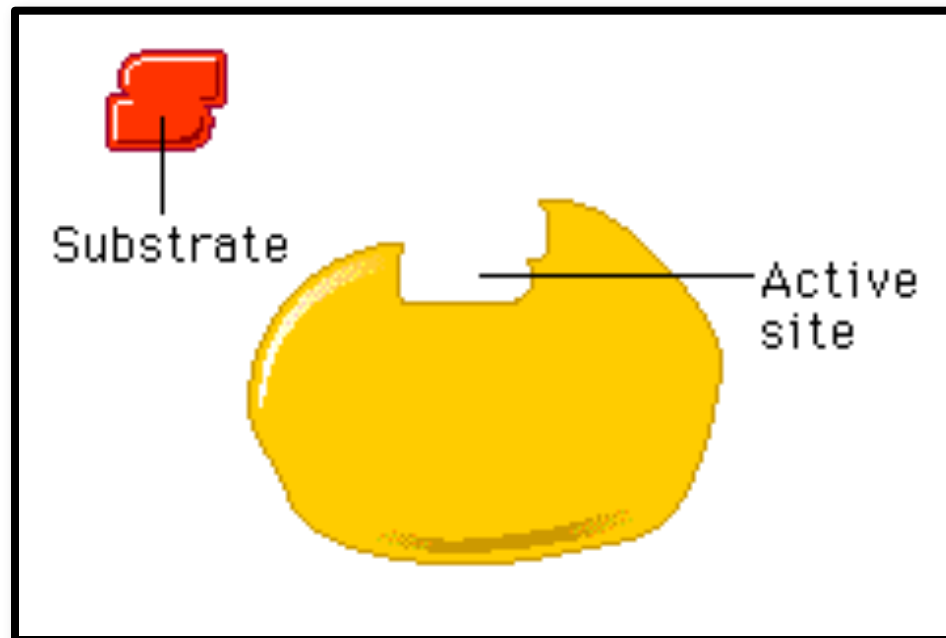




# SUBSTRATE SPECIFICITY OF ENZYMES

- The reactant that an enzyme acts on is called the enzyme's **substrate**
- The enzyme binds to its substrate, forming an **enzyme-substrate complex**
- The **active site** is the region on the enzyme where the substrate binds

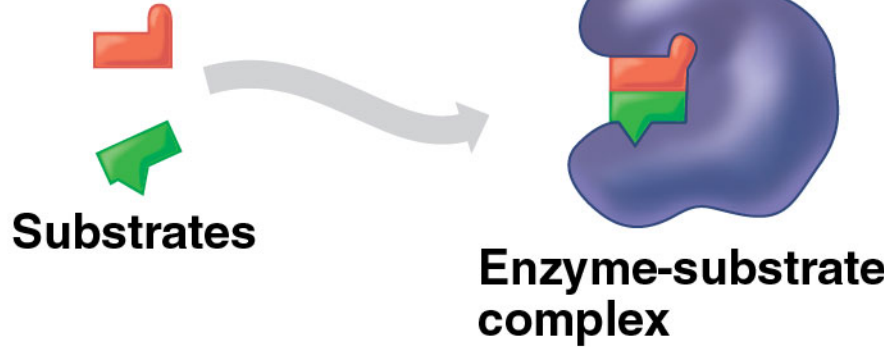
*enzymes are shape dependent.*



**1** Substrates enter active site.

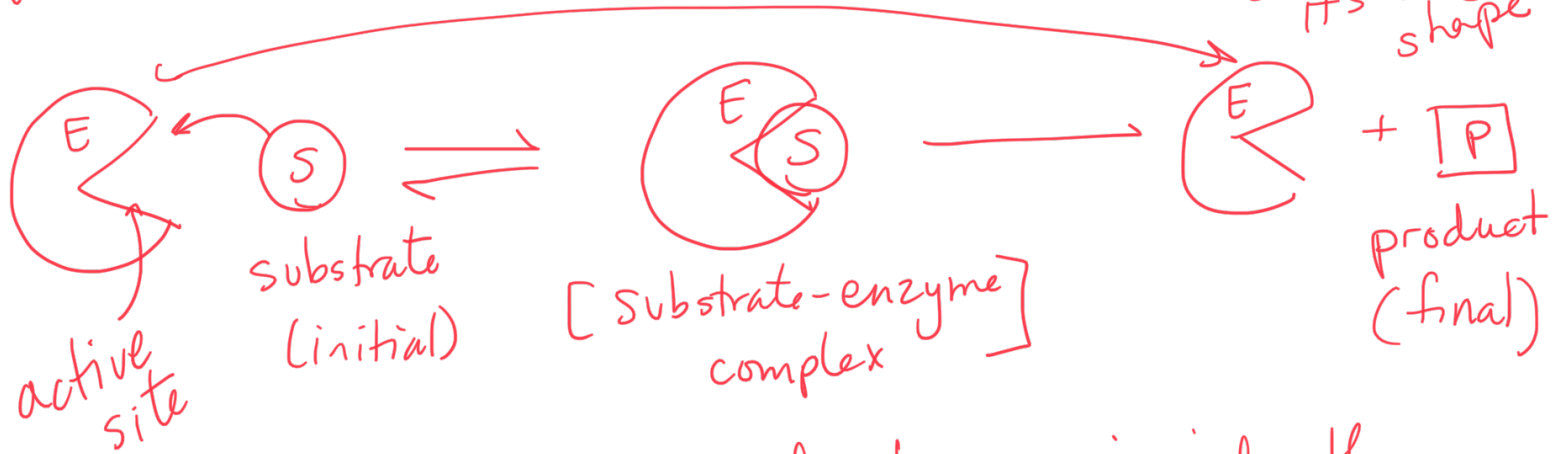
**2** Substrates are held in active site by **weak interactions.**

Nonpolar amino acids in the interior of protein - Expel water



made more powerful because it takes place in a nonpolar environment.

enzyme returns to its original shape



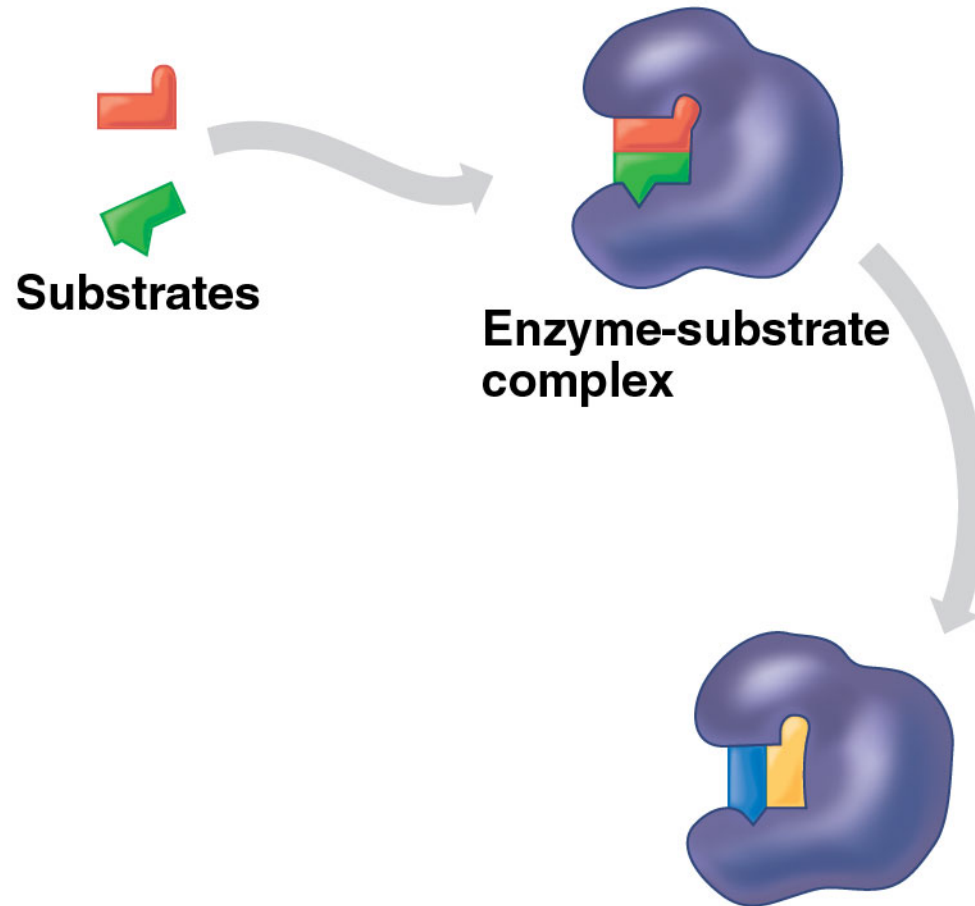
Active site - where substrate and enzyme interact - where the work is done on the substrate by the enzyme

Deep inside the enzyme (proteins) "Quiet" nonpolar



**1** Substrates enter active site.

**2** Substrates are held in active site by weak interactions.

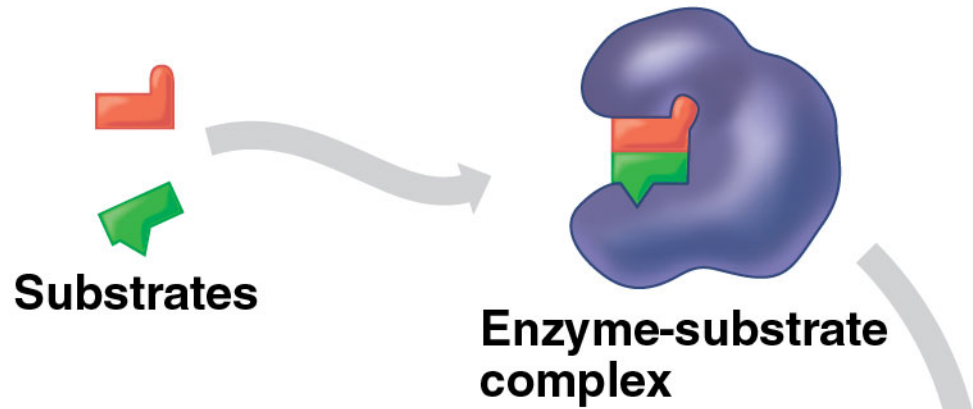


**3** Substrates are converted to products.



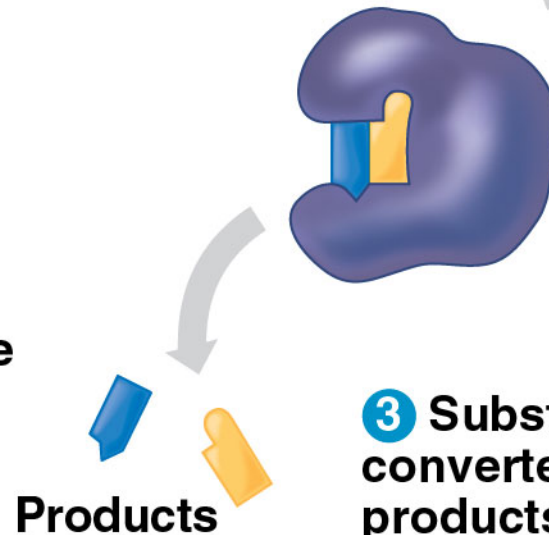
**1** Substrates enter active site.

**2** Substrates are held in active site by weak interactions.



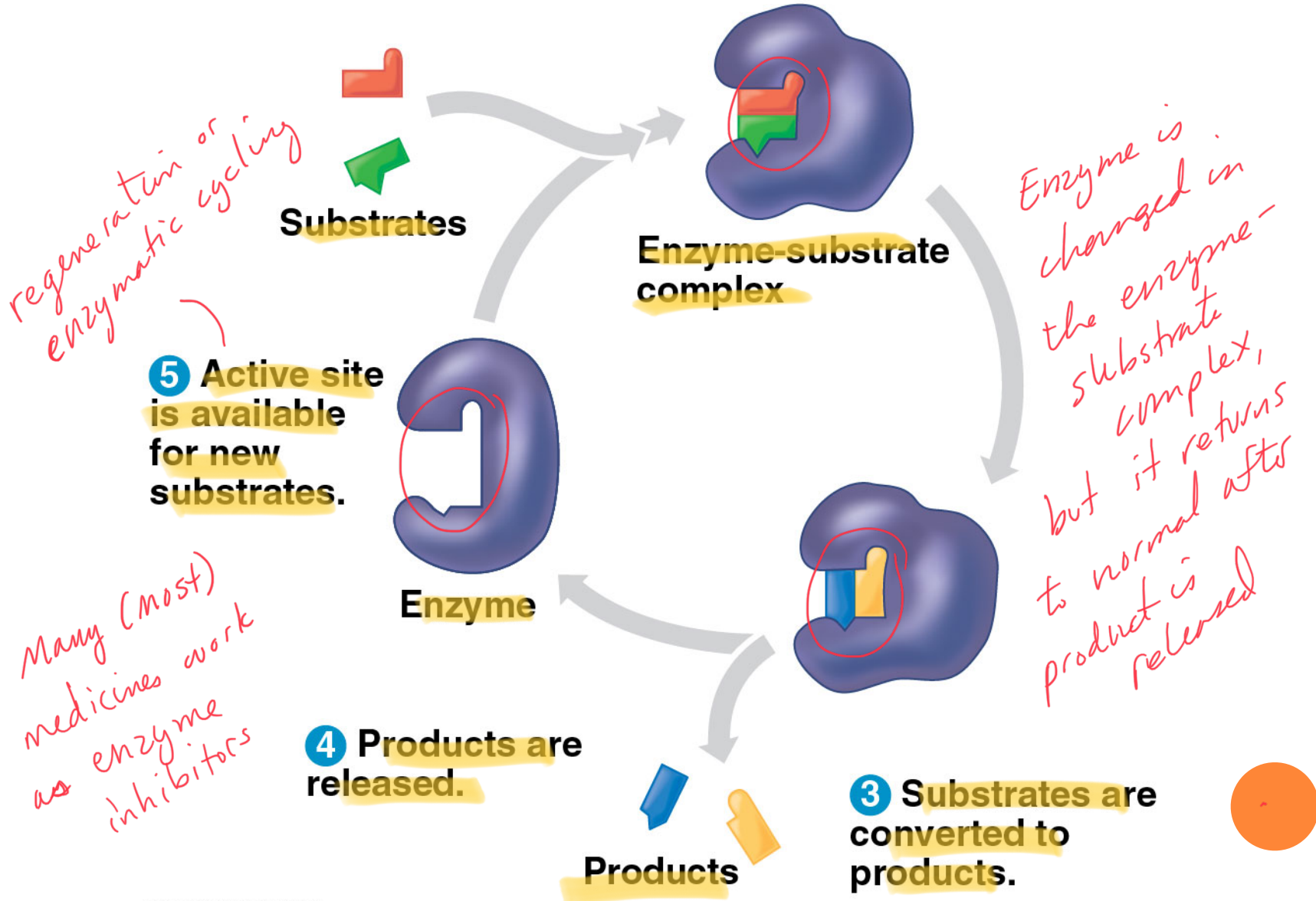
**4** Products are released.

**3** Substrates are converted to products.



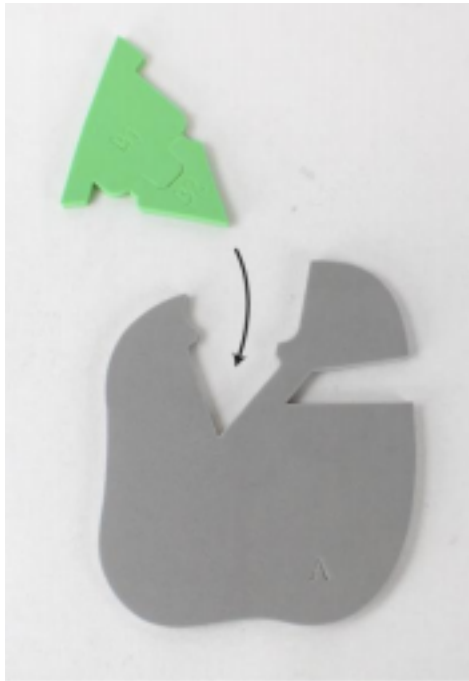
**1 Substrates enter active site.**

**2 Substrates are held in active site by weak interactions.**



# ENZYME ACTION: CATABOLISM

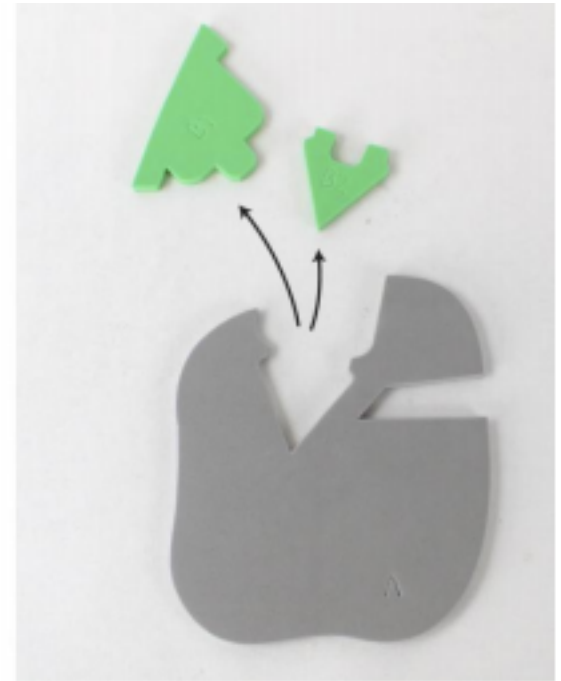
*break down*



**Step 1**



**Step 2**



**Step 3**



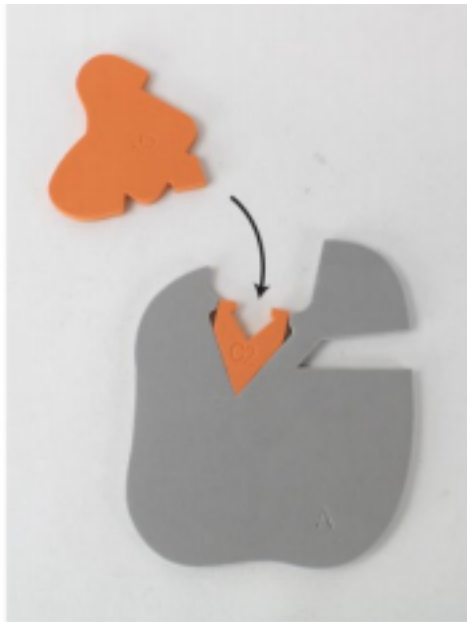


# ENZYLE ACTION: ANABOLISM

*Build up compounds*



**Step 1**



**Step 2**



**Step 3**

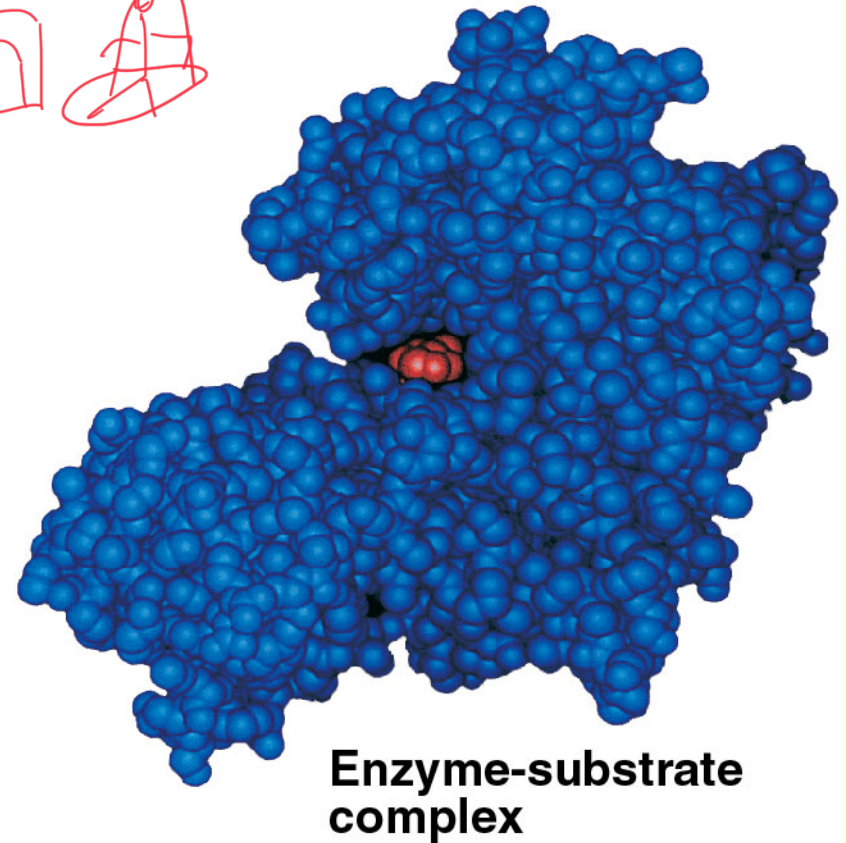
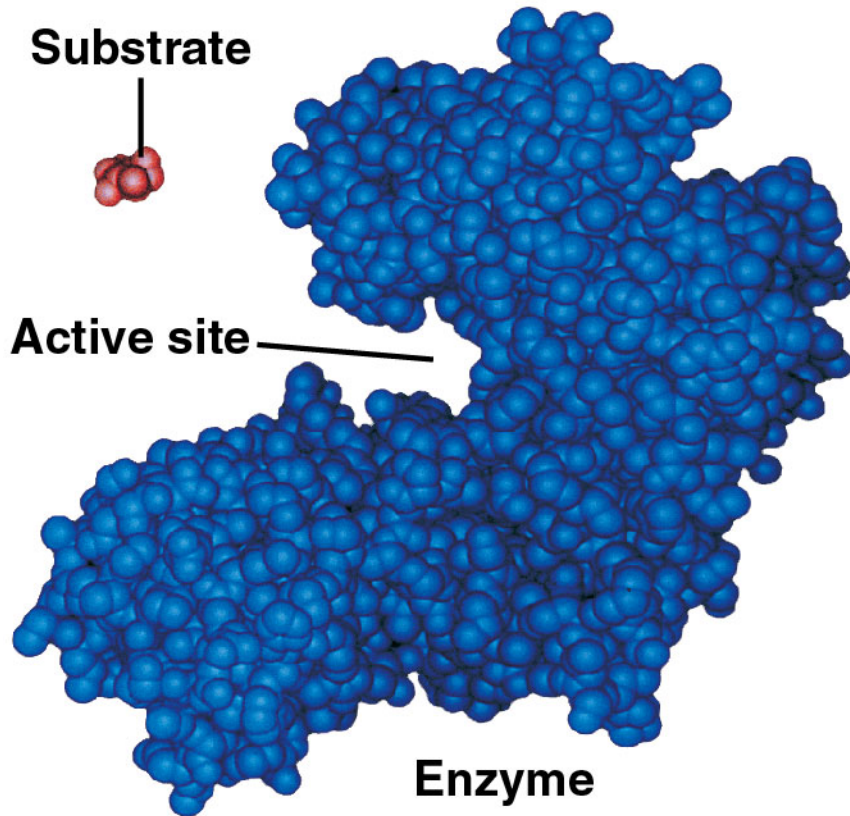


**Step 4**



**INDUCED FIT: ENZYME FITS SNUGLY AROUND SUBSTRATE -- "CLASPING HANDSHAKE"**

*Sometimes an enzyme is not shaped correctly until the substrate comes along*



Enzymes work based on their shape (shaped-dependent)

Denaturants change the shape of an enzyme  
An enzyme's activity can be affected by:

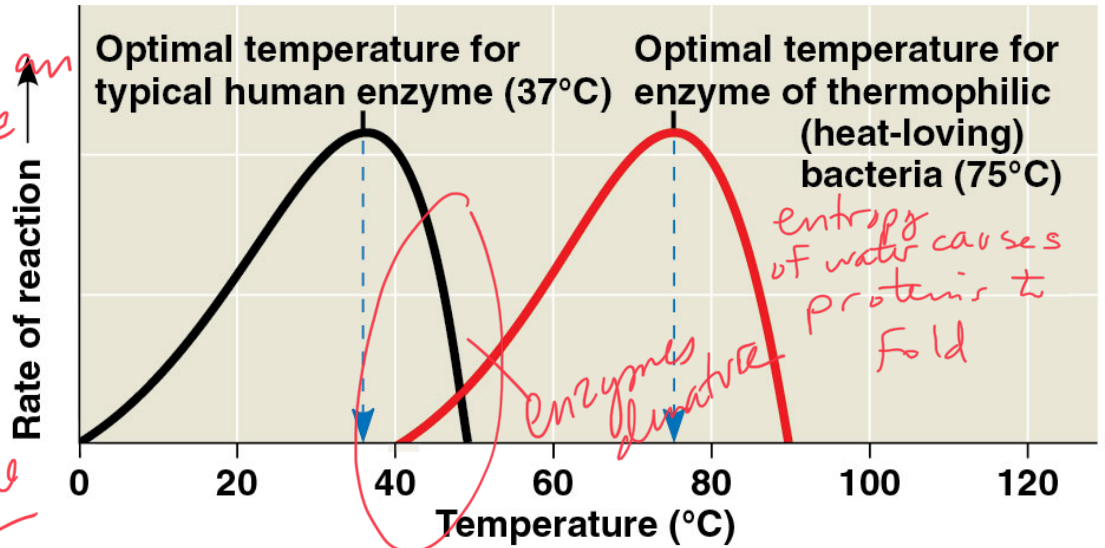
- **Temperature**
- **pH**
- **Chemicals**

*denature an enzyme*

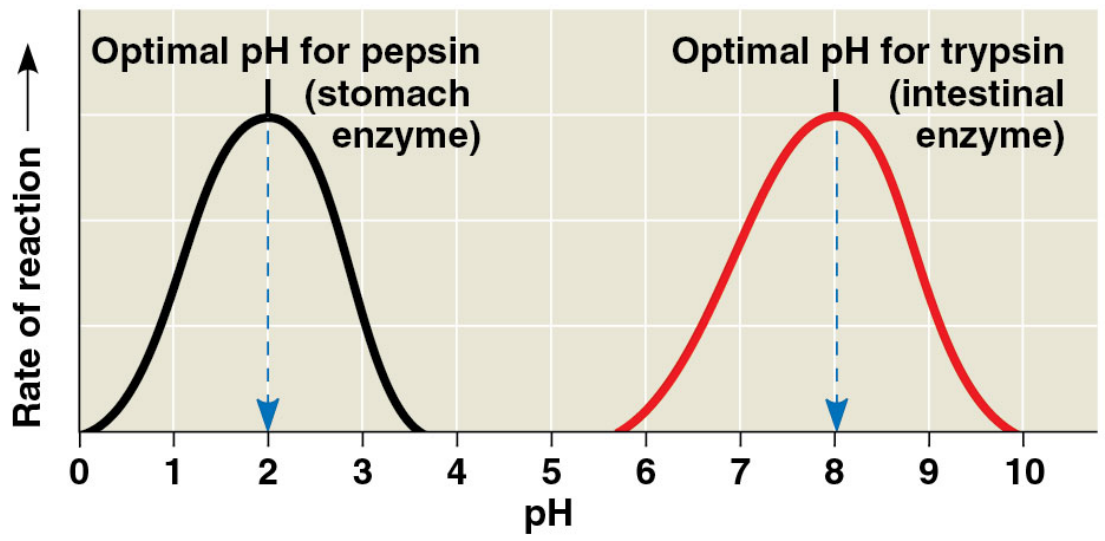
*(Chaotropes)*

*Entropy drives most reactions*

*chaotropes disrupt more entropy - ordered*



(a) Optimal temperature for two enzymes



(b) Optimal pH for two enzymes

# ENZYME STRUCTURE & FUNCTION

- Change to the **molecular structure** of a component in an enzymatic system may result in a change of **function** or **efficiency** of the system
- **Denaturation**: disrupt protein structure → reduce enzymatic activity
- **Environmental pH**: alter efficiency of enzyme activity; disruption of H-bonds
- In some cases, enzyme denaturation is *reversible* → enzyme regains activity

*change in  
SHAPE*

*changes  
SHAPE*



# COFACTORS

- Cofactors: nonprotein enzyme helpers such as minerals (eg. Zn, Fe, Cu)

- Coenzymes: organic cofactors (eg. vitamins)

prosthetic limb

Hemoglobin (iron) containing

protein in your blood that binds to O<sub>2</sub> oxygen)

## Enzyme Inhibitors

- Competitive inhibitor: binds to the active site of an enzyme, competes with substrate

- Noncompetitive inhibitor: binds to another part of an enzyme → enzyme changes shape → active site is nonfunctional

medicines  
competitive

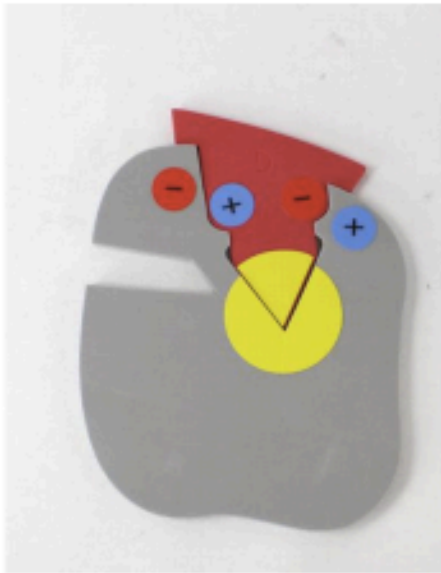
inhibitor → has the same shape as the substrate - competes at the active site



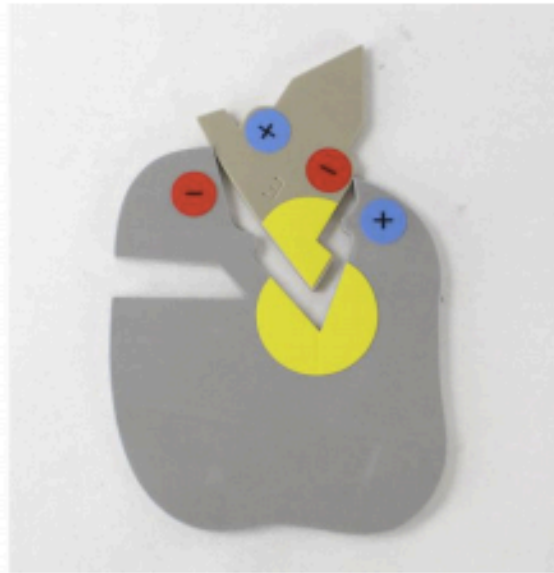
2/25 HW Online HW 22  
Quiz 22

HW/Quiz 20 due Feb 28<sup>th</sup>  
HW/Quiz 21 March 4<sup>th</sup>

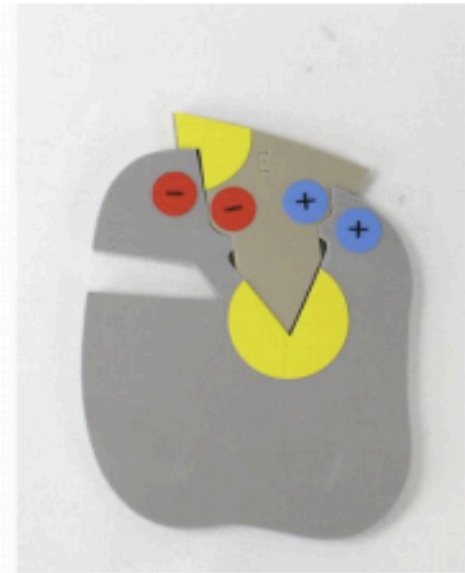
# ENZYME SPECIFICITY



**Figure 1:** Enzyme-substrate complex



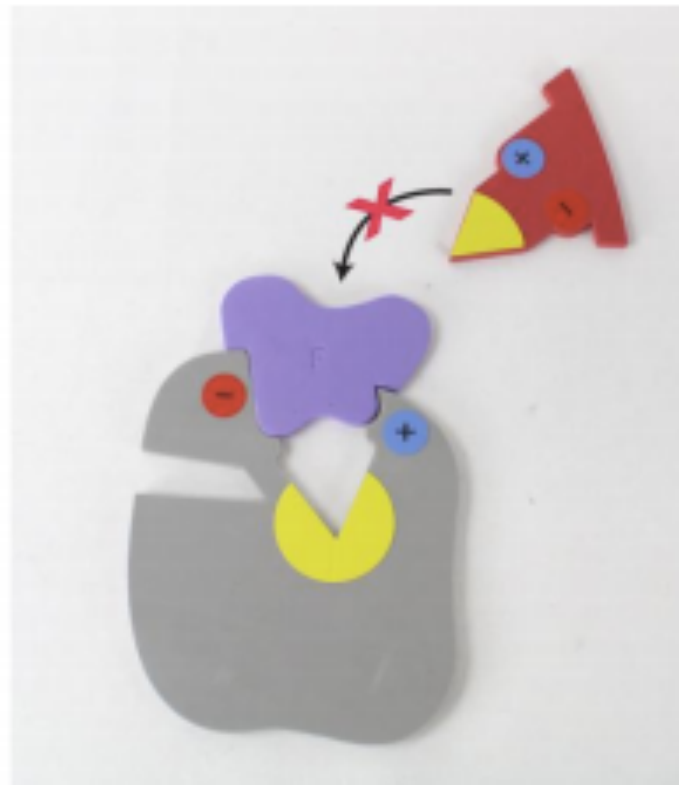
**Figure 2:** The charges align between the enzyme and the substrate; however, the enzyme's shape will not "fit".



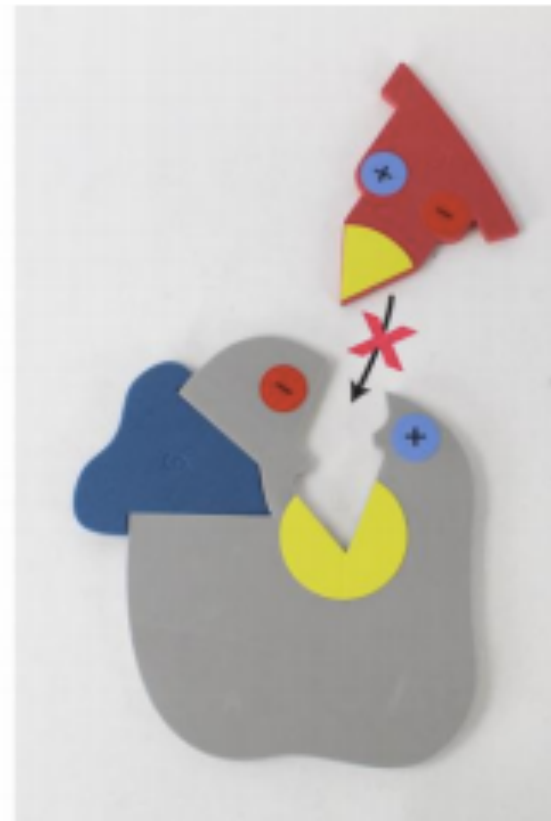
**Figure 3:** The shape of the substrate appears to fit but the charges do not align in the active site of the enzyme.



# COMPETITIVE INHIBITION



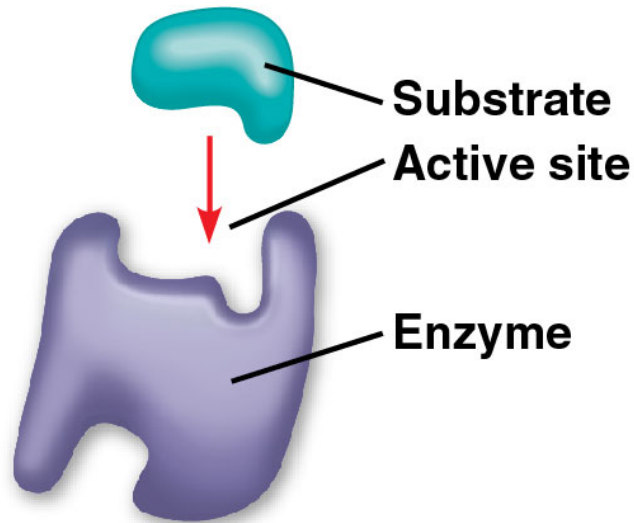
# NONCOMPETITIVE INHIBITION



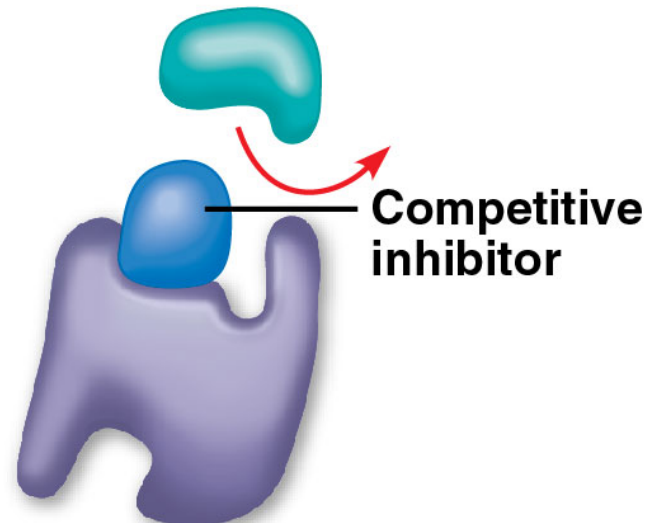


# INHIBITION OF ENZYME ACTIVITY

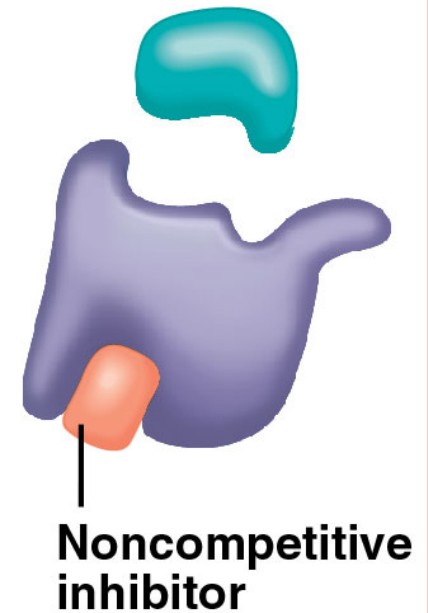
(a) Normal binding



(b) Competitive inhibition



(c) Noncompetitive inhibition

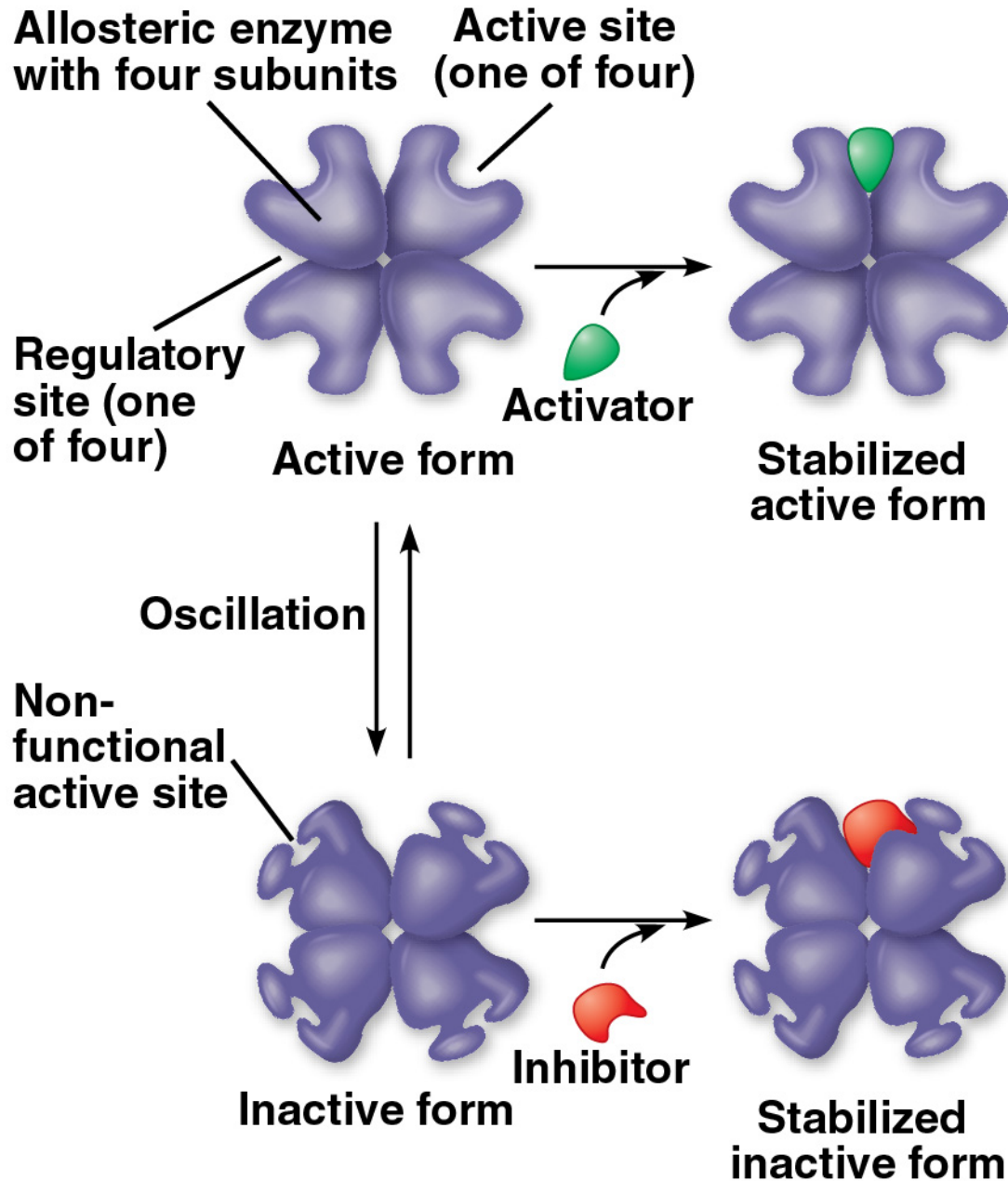


# REGULATION OF ENZYME ACTIVITY

- To regulate metabolic pathways, the cell switches on/off the genes that encode specific enzymes
- **Allosteric regulation**: protein's function at one site is affected by binding of a **regulatory molecule** to a separate site (allosteric site)
  - **Activator** – stabilizes active site
  - **Inhibitor** – stabilizes inactive form
  - **Cooperativity** – one substrate triggers shape change in other active sites → increase catalytic activity

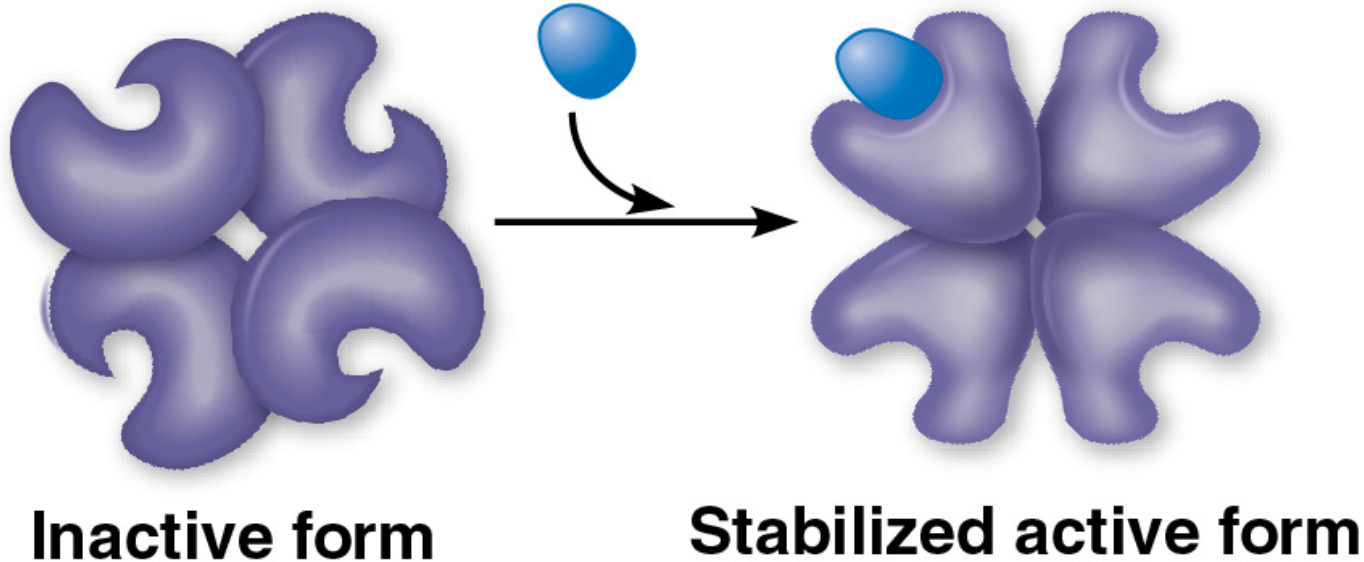


# (a) Allosteric activators and inhibitors



**(b) Cooperativity: another type of allosteric activation**

**Substrate**

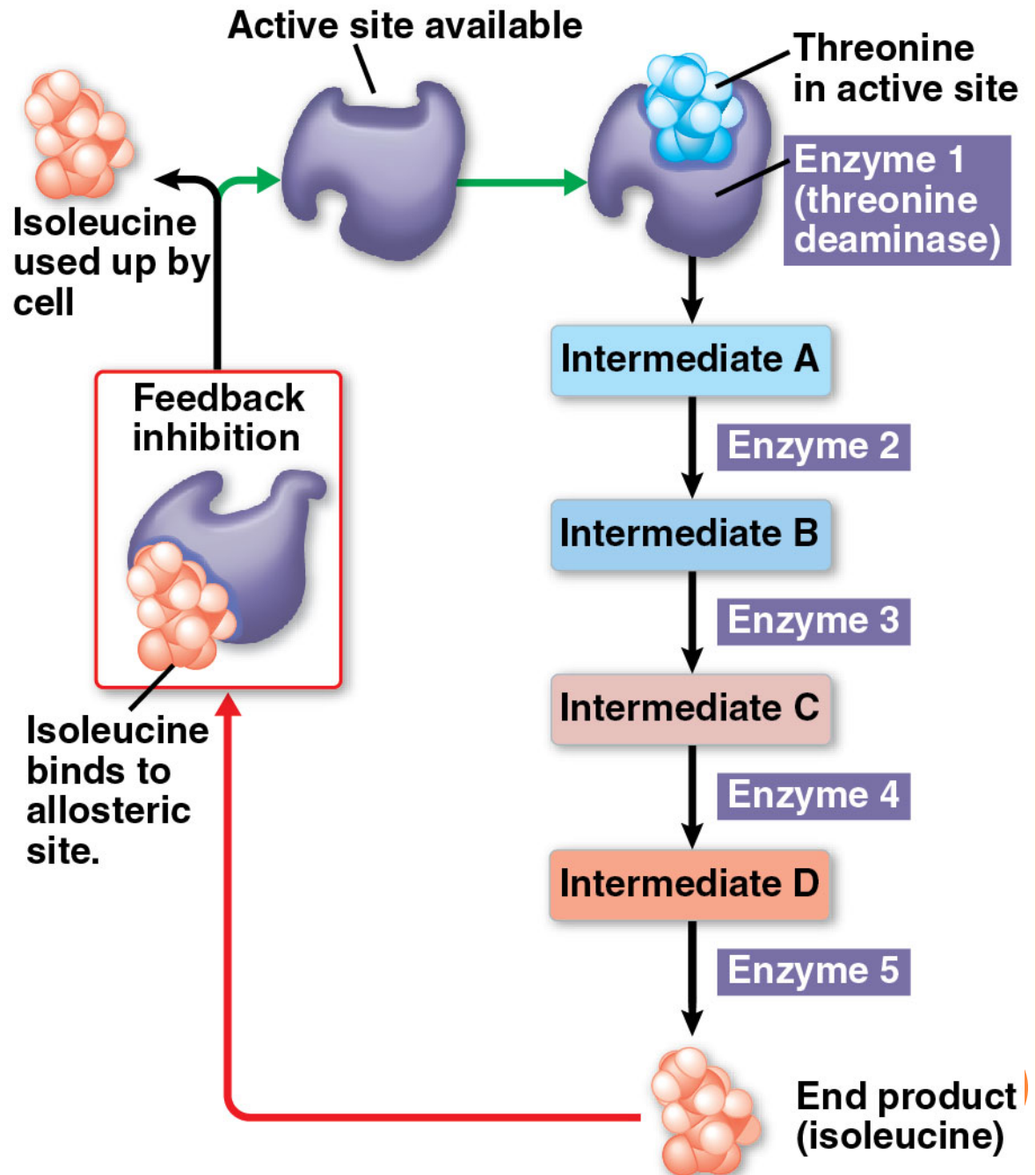


# *FEEDBACK INHIBITION*

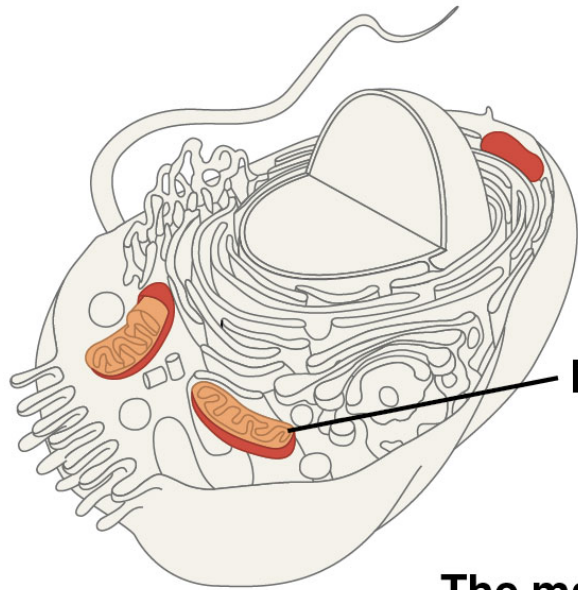
- End product of a metabolic pathway shuts down pathway by binding to the allosteric site of an enzyme
- Prevent wasting chemical resources, increase efficiency of cell



# FEEDBACK INHIBITION



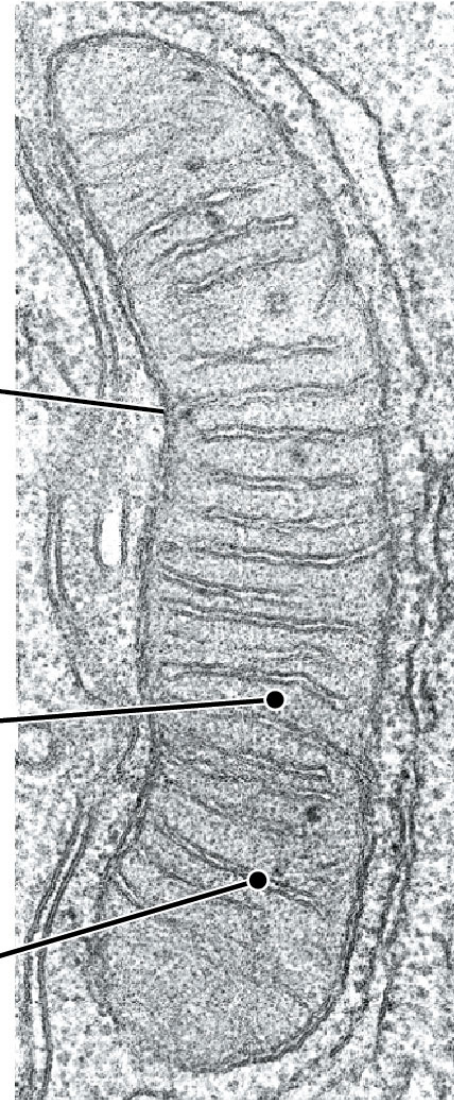
# ORGANIZATION OF ENZYMES WITHIN A CELL



Mitochondrion

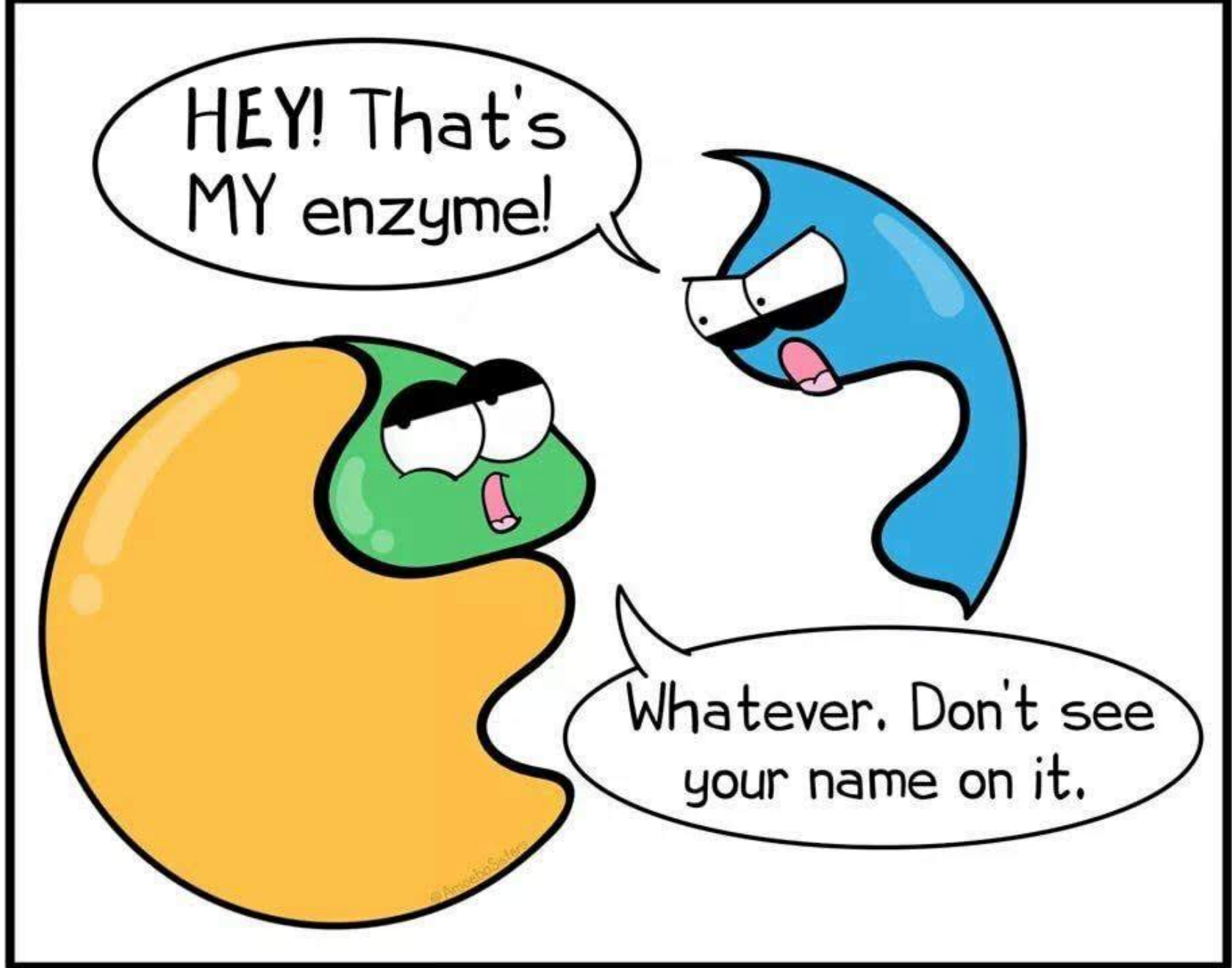
The matrix contains enzymes in solution that are involved in one stage of cellular respiration.

Enzymes for another stage of cellular respiration are embedded in the inner membrane.



1 μm





**Competitive Inhibitors:** If it fits, it sits.