Enzymes

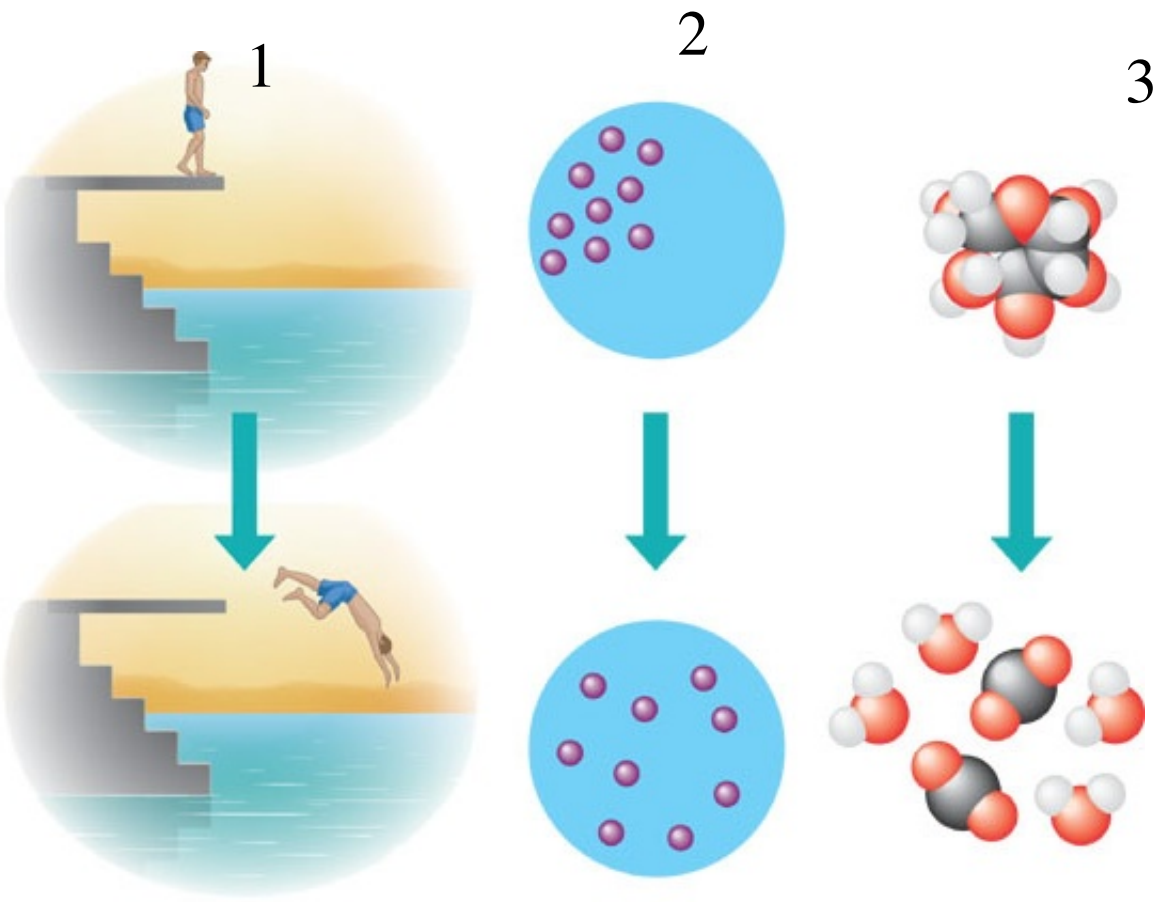
Part 1: Energy and Metabolism

Life is highly organized

Organisms need _free_ energy to survive, grow, and reproduce

In each system, the arrow is pointing in the direction of spontaneous change. Why?

- **More** free energy to **less** free energy.
- **Less** stable to **more** stable.
- **More** work capacity to **less** capacity.
- **More** organized to **less** organized (**less** entropy to **more** entropy)



Life requires free energy input from the sun

- PHOTOSYNTHESIS

positive ΔG

non-spontaneous

reduces entropy

ender gonic

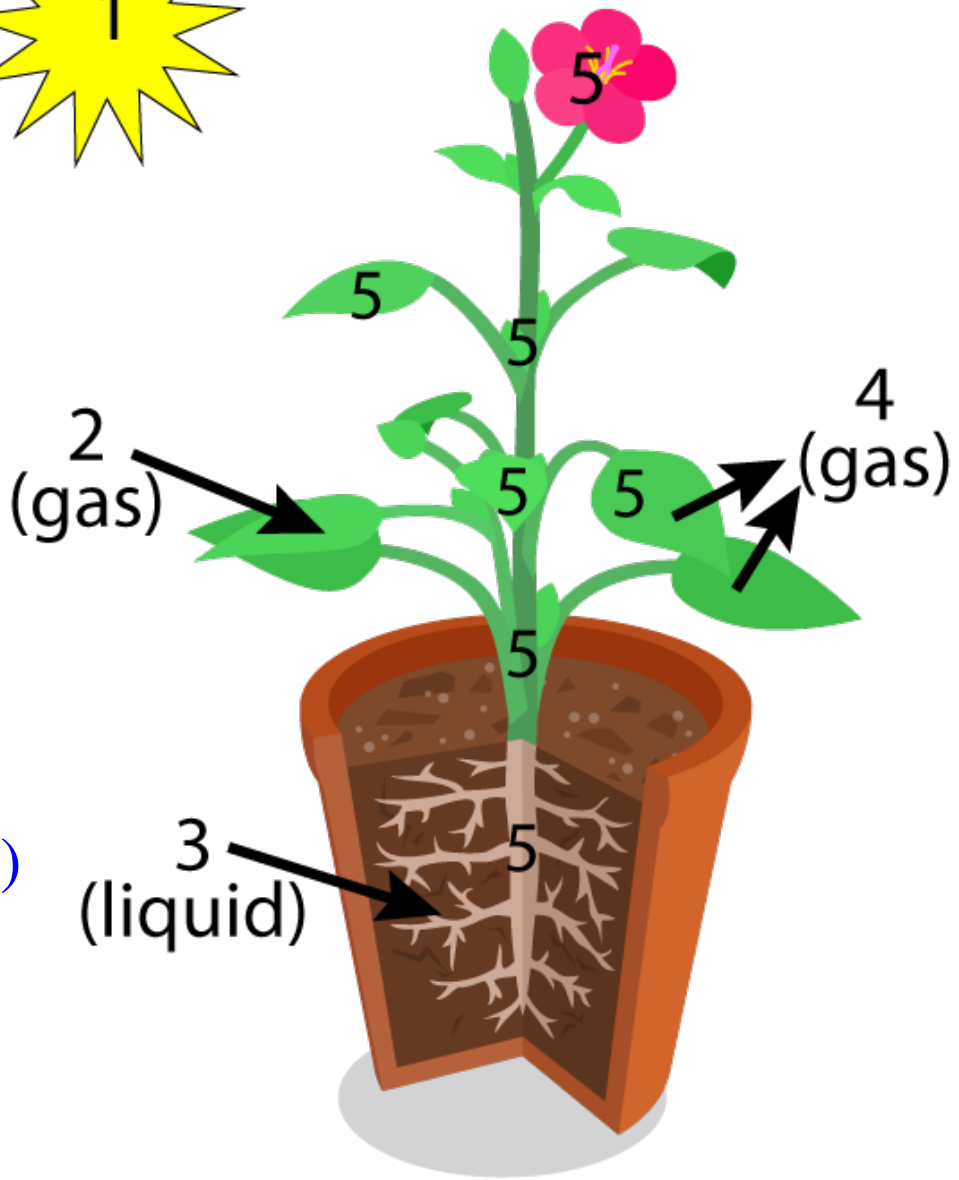
1: sunlight

2: Carbon dioxide (high entropy)

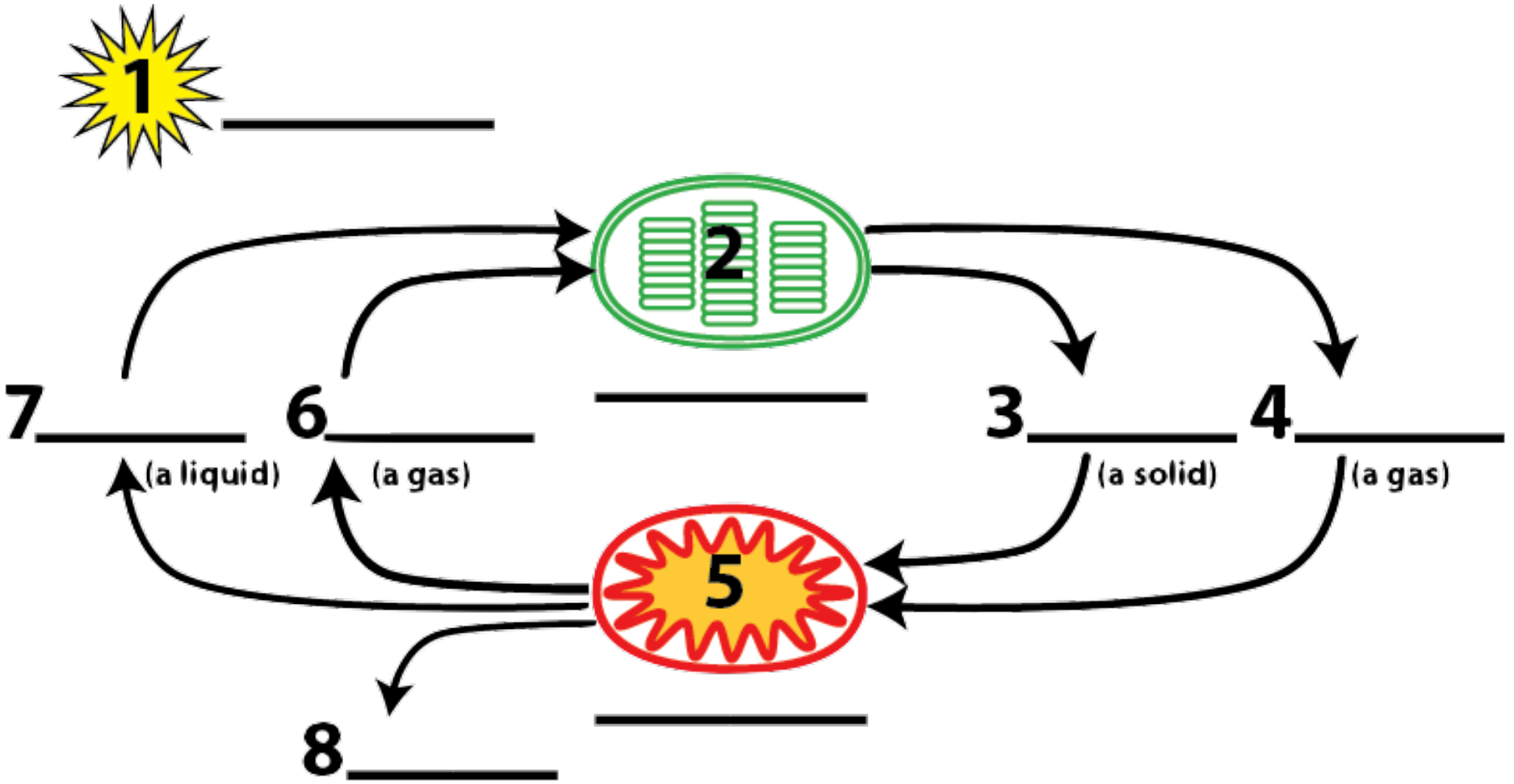
3: water

4: oxygen

5: Carbohydrate (lower entropy)



PSN makes respiration possible…



Cellular respiration

$C_6H_{12}O_6$ + ___ → 6____ + 6___ + ENERGY

Cellular respiration

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_20 + \text{ENERGY}$$

Respiration is like combustion

1. Both are _exergonic_ (energy releasing) reactions.
2. Both have a _negative_ ΔG
3. Both _oxidize_ fuels.

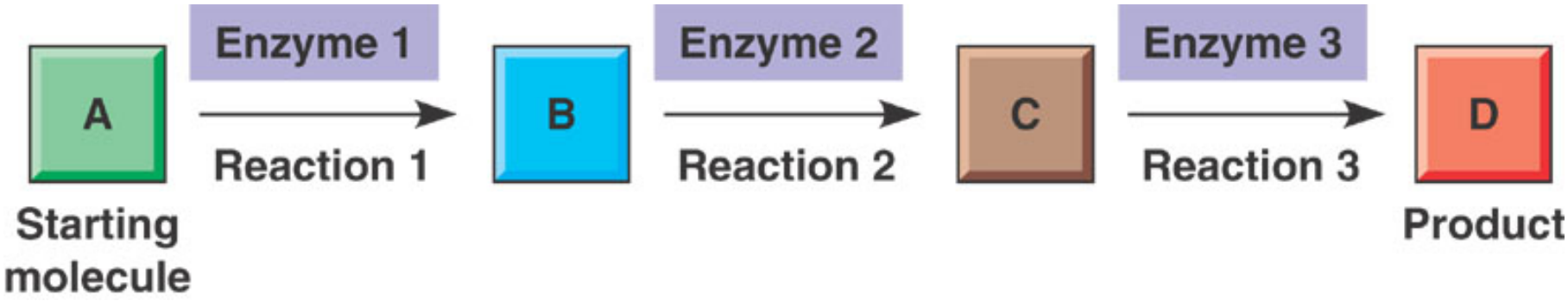
(burning wood)

Respiration is *not* like combustion

one step

Many small steps…

These steps are organized into *pathways*.

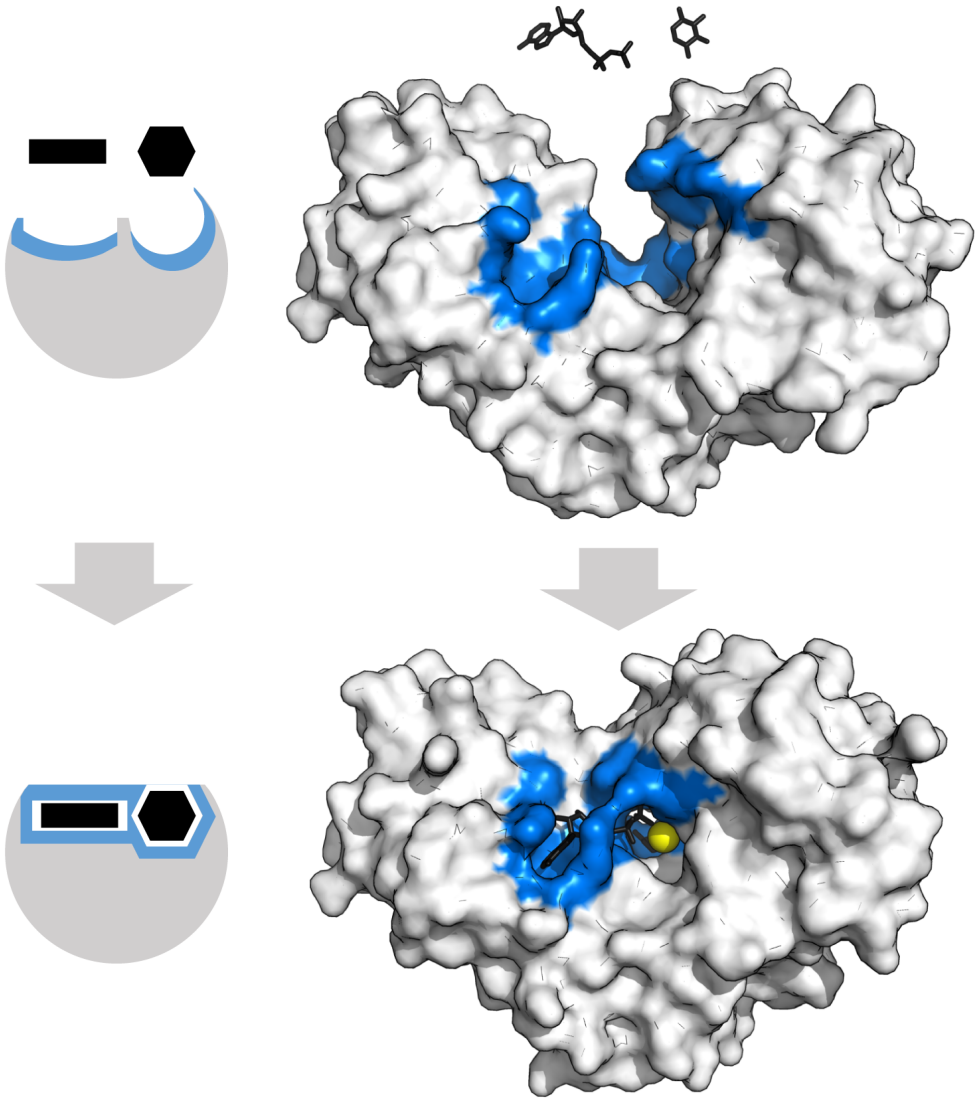


A: *reactant*

B and C: intermediates

D: *product*

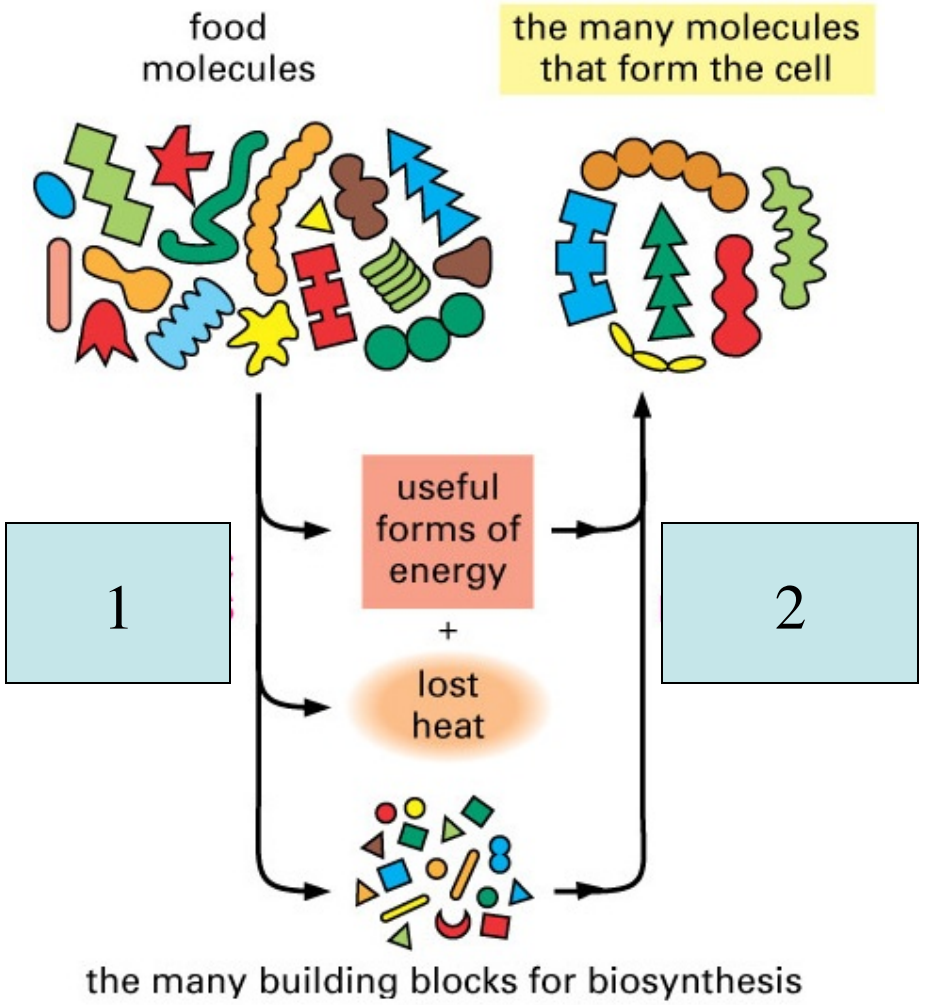
Each step is controlled by *enzymes*



- Protein catalysts
- Act on substrates
- Reduce activation energy

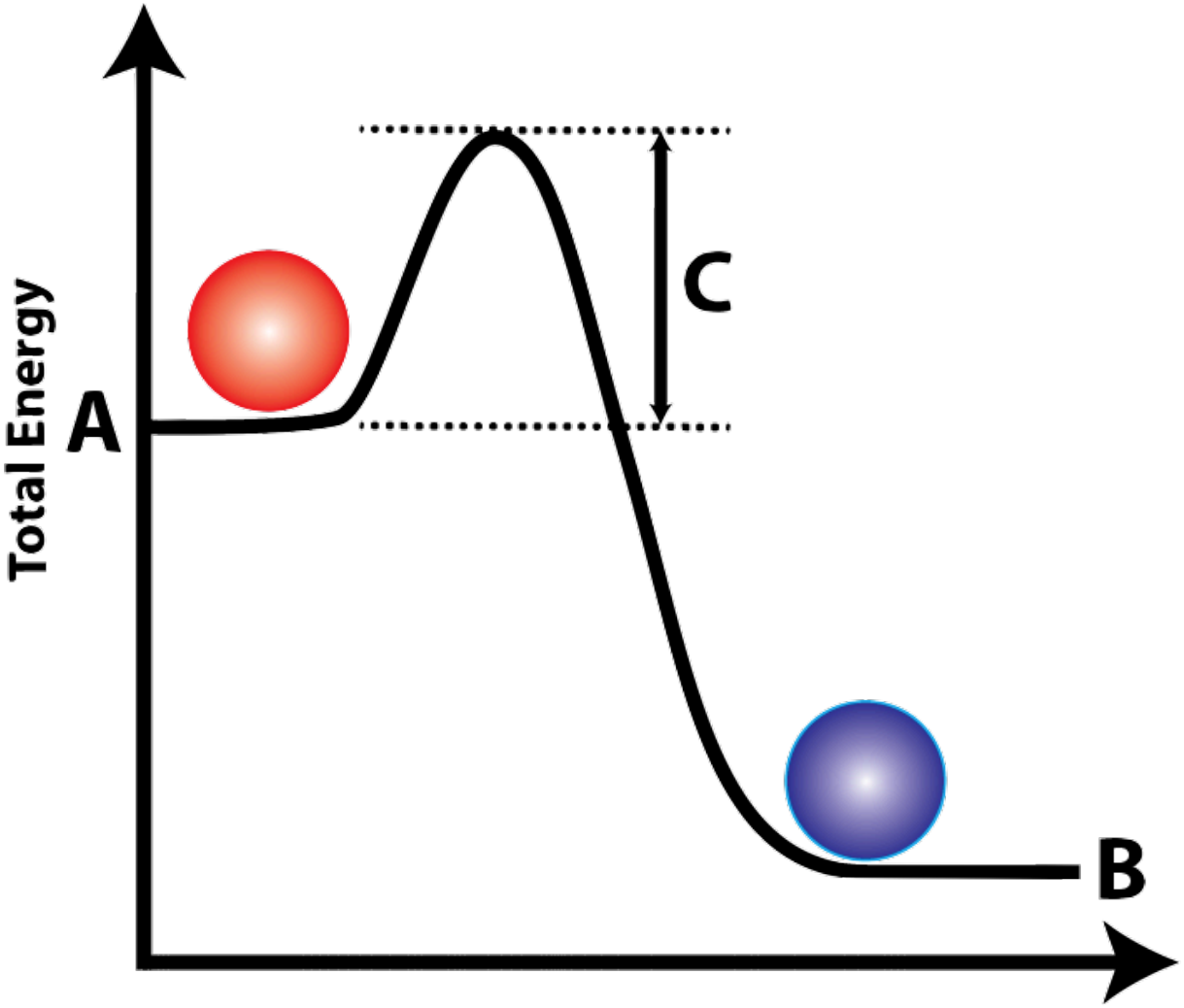
Metabolism: the reactions occurring in an organism

- *Catabolism*: breaks things down (exergonic)
- *Anabolism*: builds things up (endergonic)



Part 2: Understanding Enzymes

Activation Energy



- The energy needed to **start** a process or reaction.

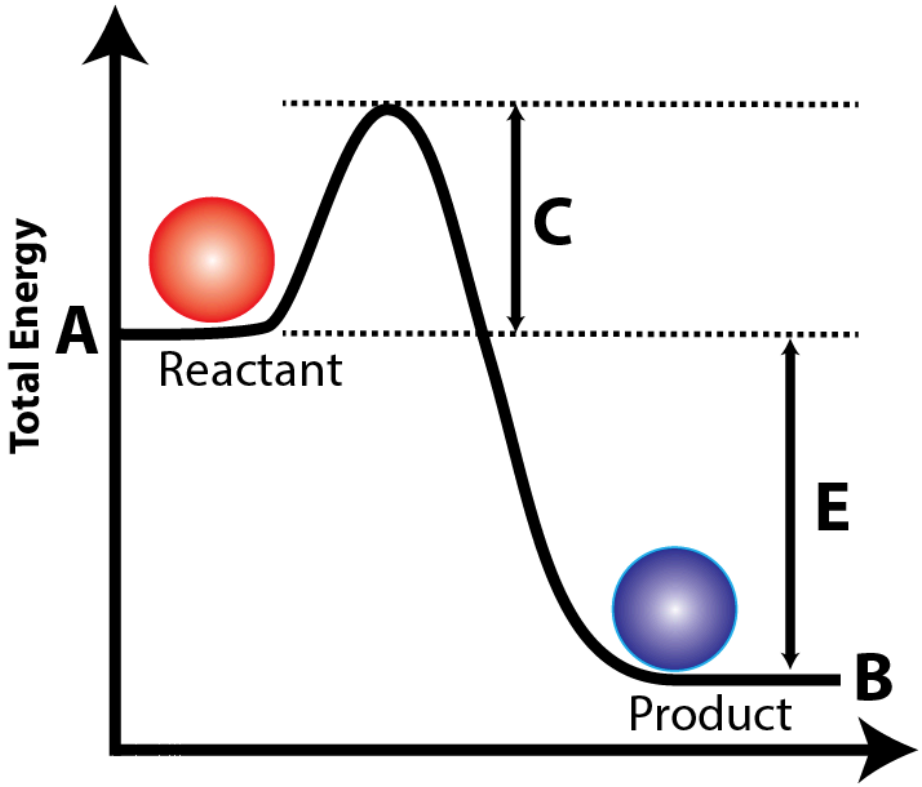
A: starting energy

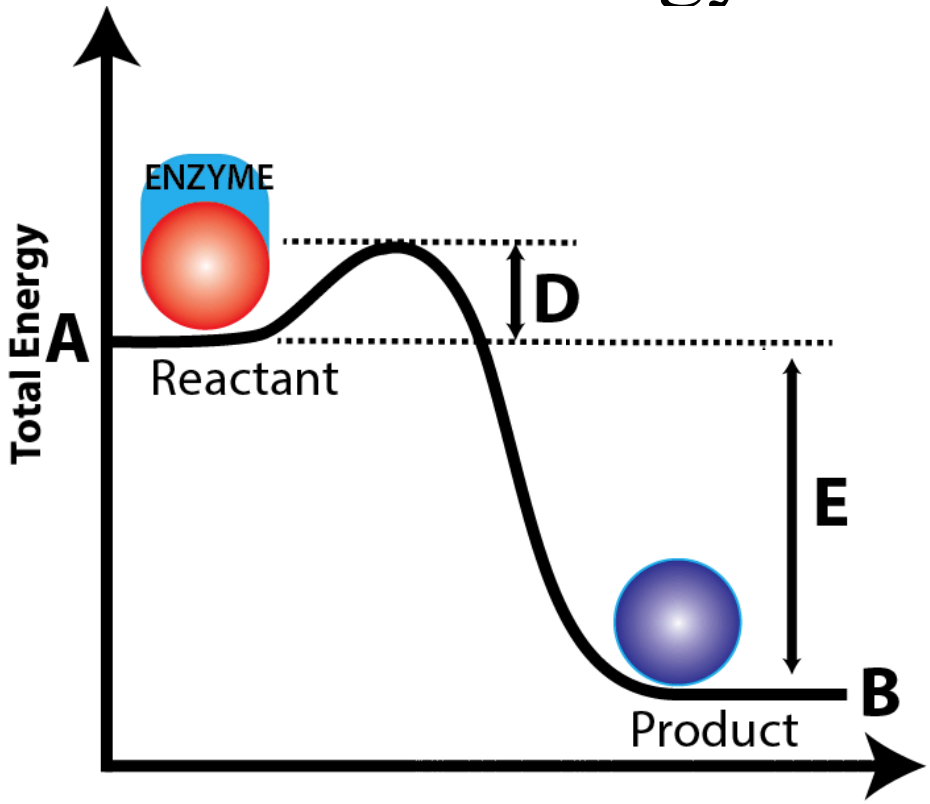
B: final energy

C: activation energy

Activation Energy

Enzymes lower activation energy





D. Activation energy w/ enzyme

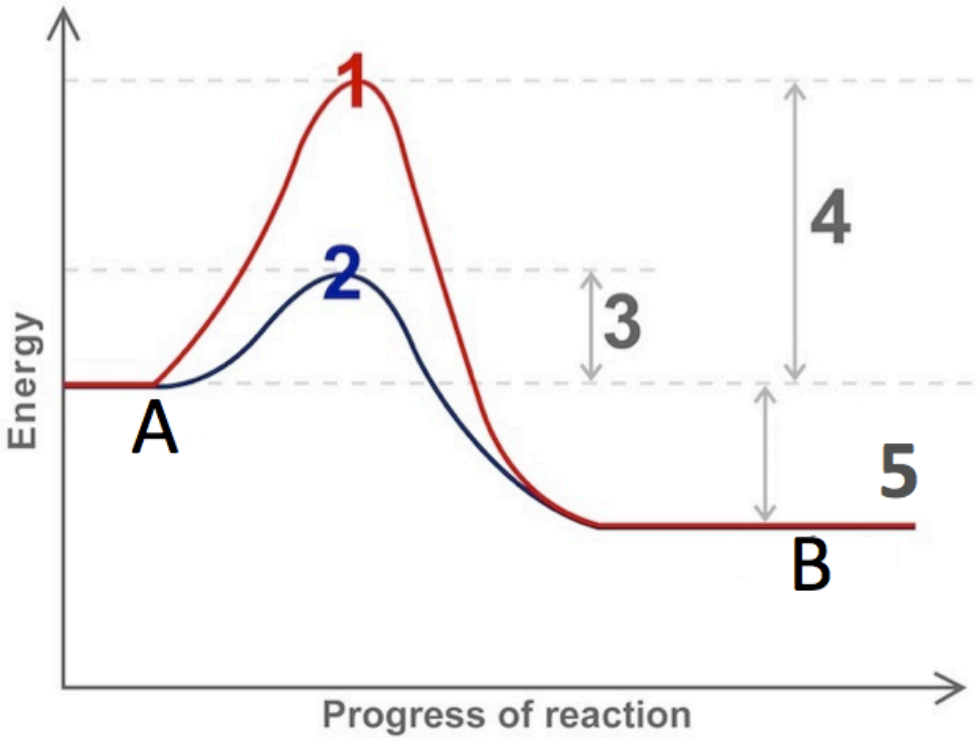
E. Energy released

Checking Understanding

1. Course of rxn without enzyme
2. Course with enzyme
3. Activation E w/ enzyme
4. Activation E w/out enzyme
5. Energy released by rxn

A: reactant

B: product



Enzymes are *substrate specific*

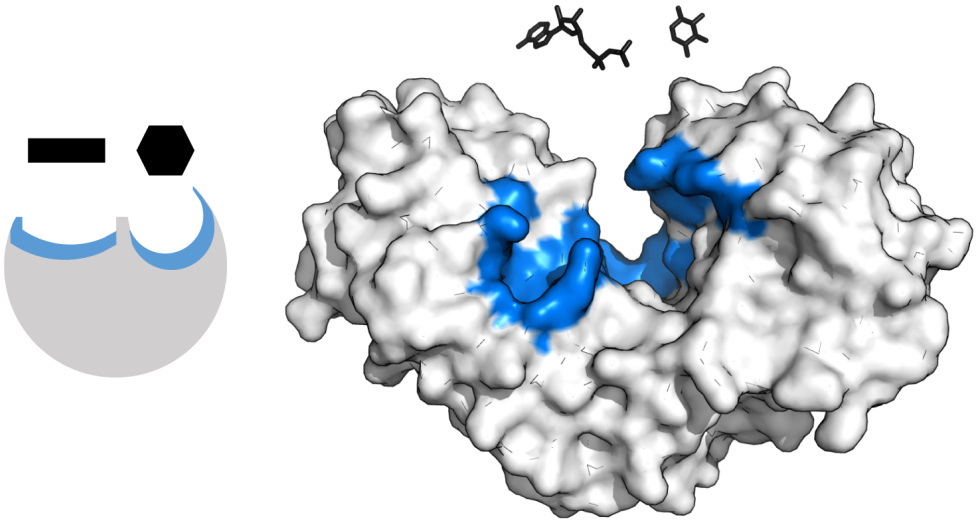
Examples:

AMYLOSE + water $\xrightarrow{\textit{amylase}}$ GLUCOSE

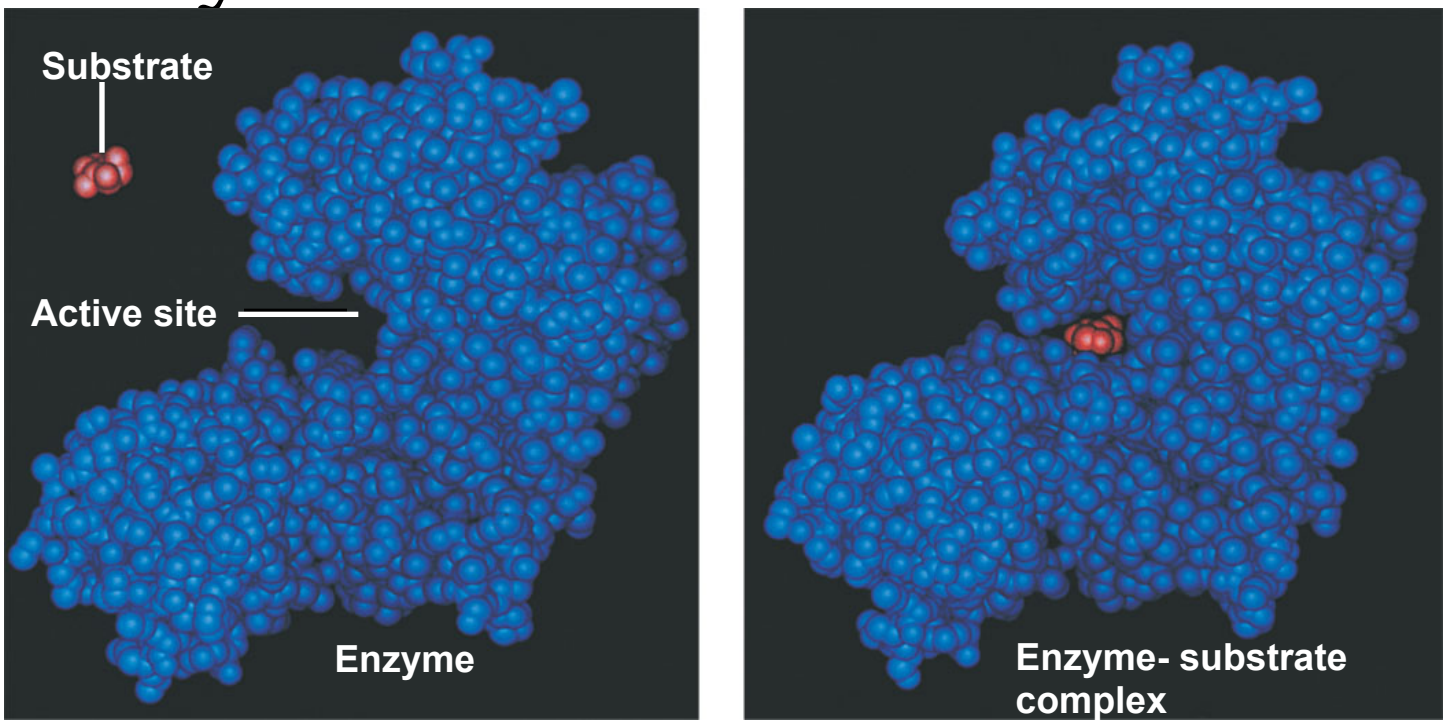
SUCROSE + water $\xrightarrow{\textit{sucrase}}$ GLUCOSE + FRUCTOSE

Substrate Enzyme Product(s)

Enzyme-substrate fit is an adaptation that evolved through natural selection

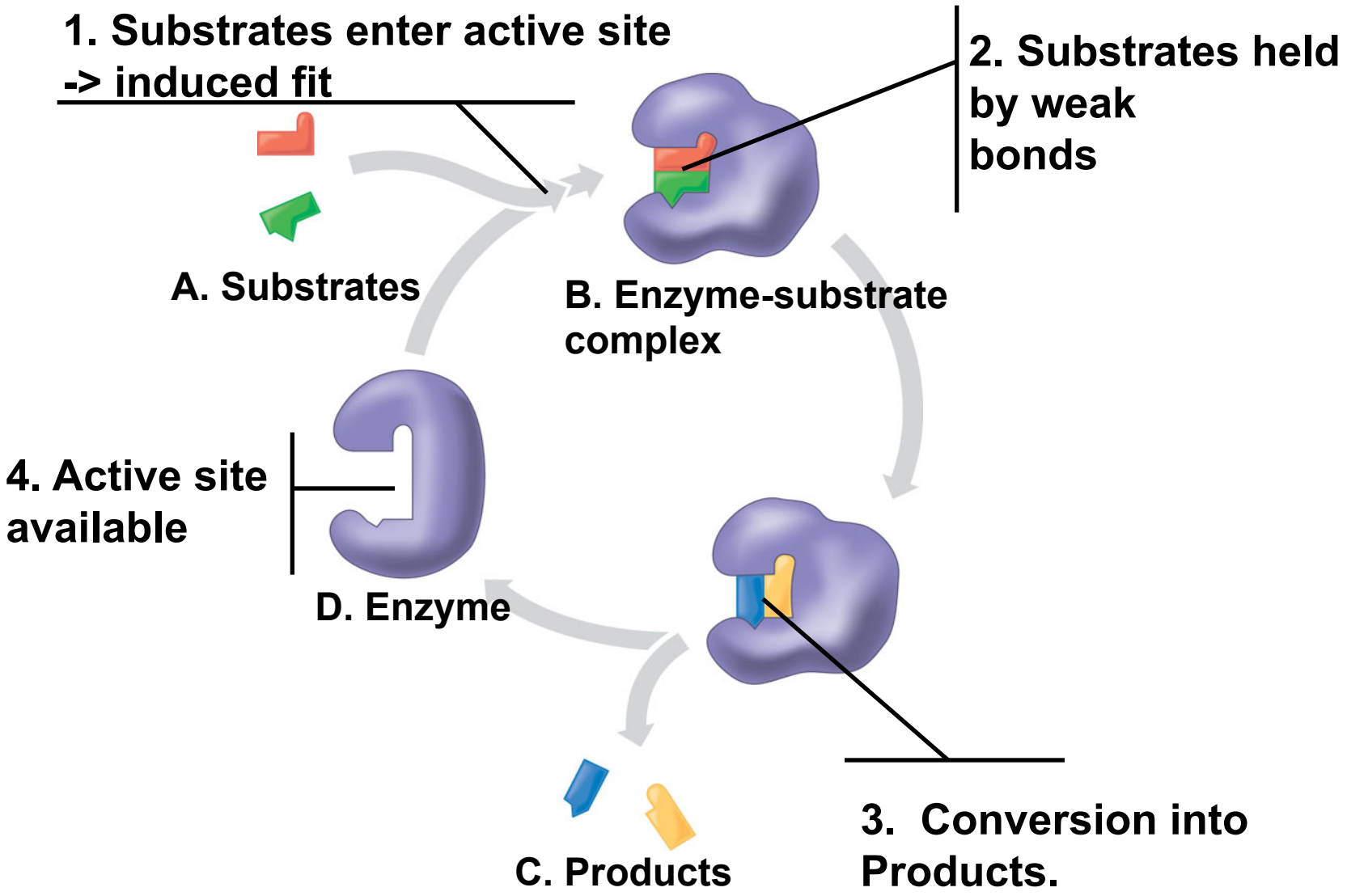


Enzyme/Substrate Interaction



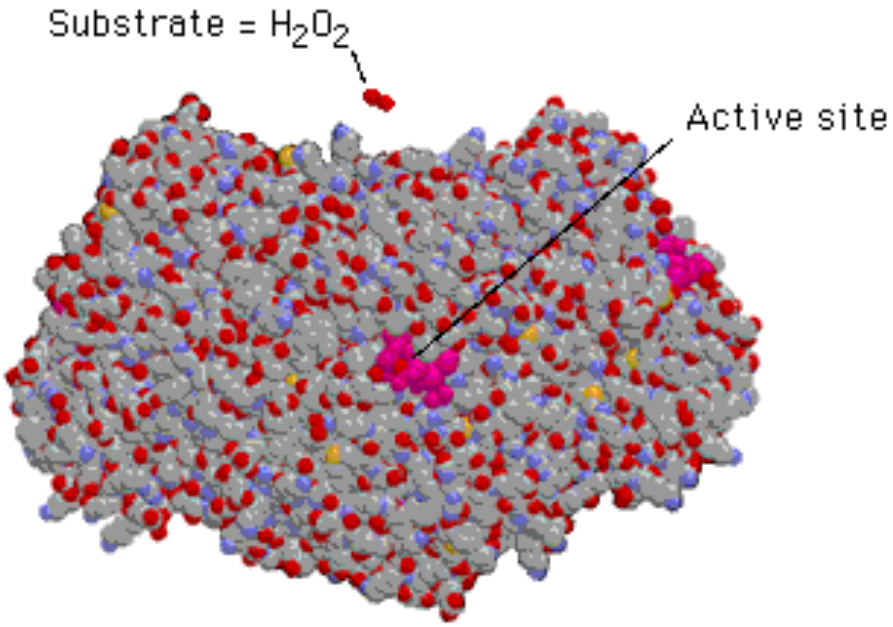
- Enzymes fit w/ substrates at an *active site*.
- Fit is like a *lock and key*.
- Enzyme changes shape after binding: *induced fit model*.

The catalytic cycle of an enzyme

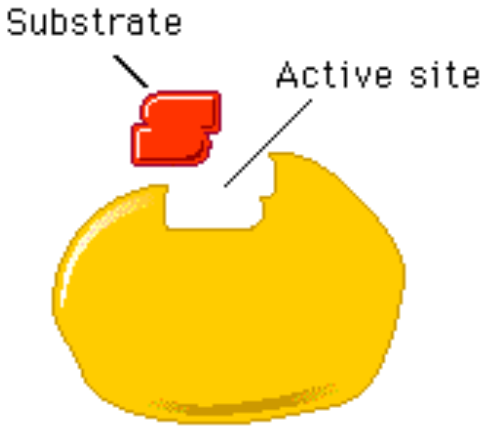


Possible enzyme mechanisms

1. Stressing bonds in the substrate(s)
2. Amino acid side chains create microenvironments to catalyze rxn (eg: low pH)

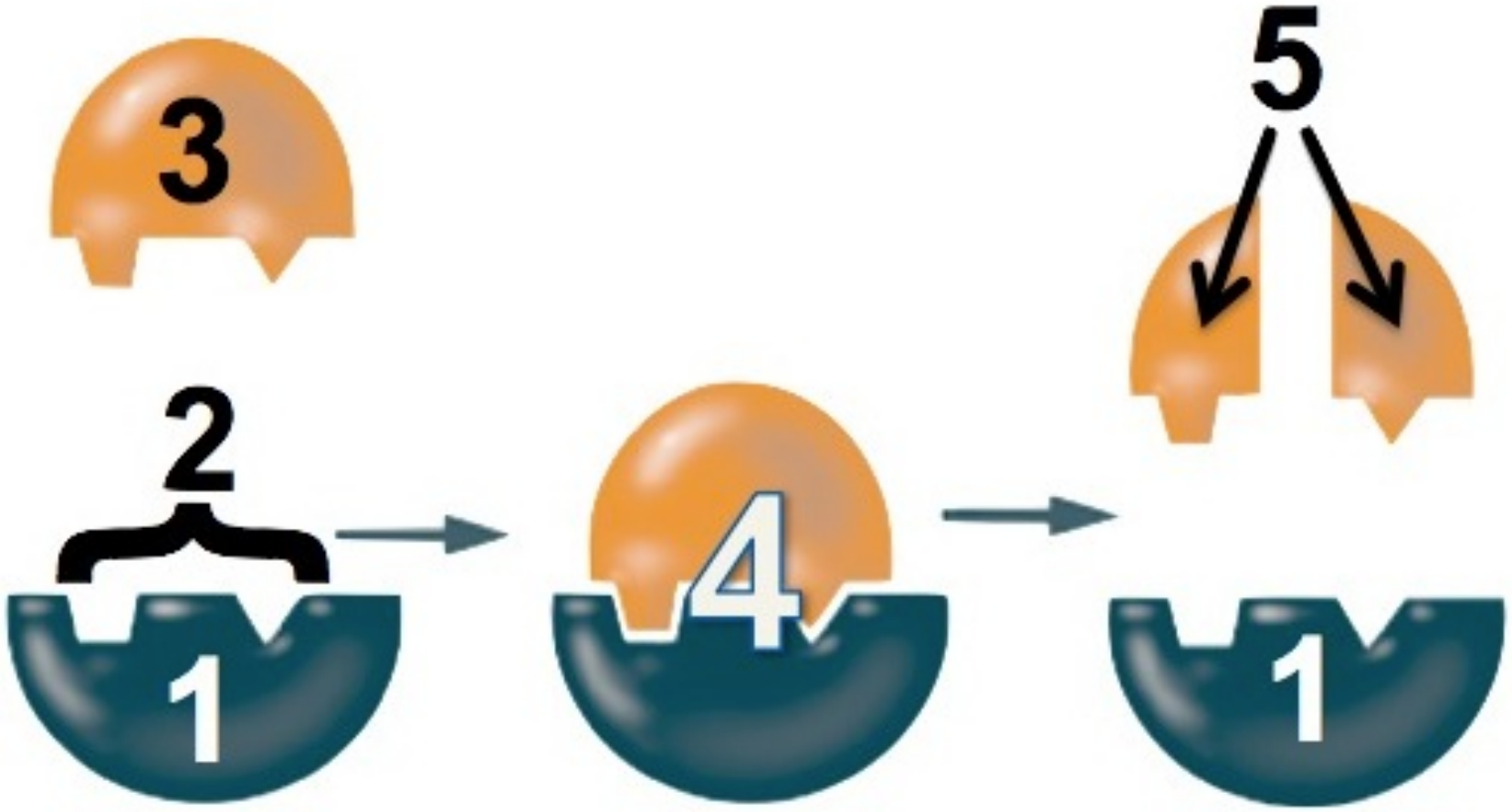


Molecular model of catalase

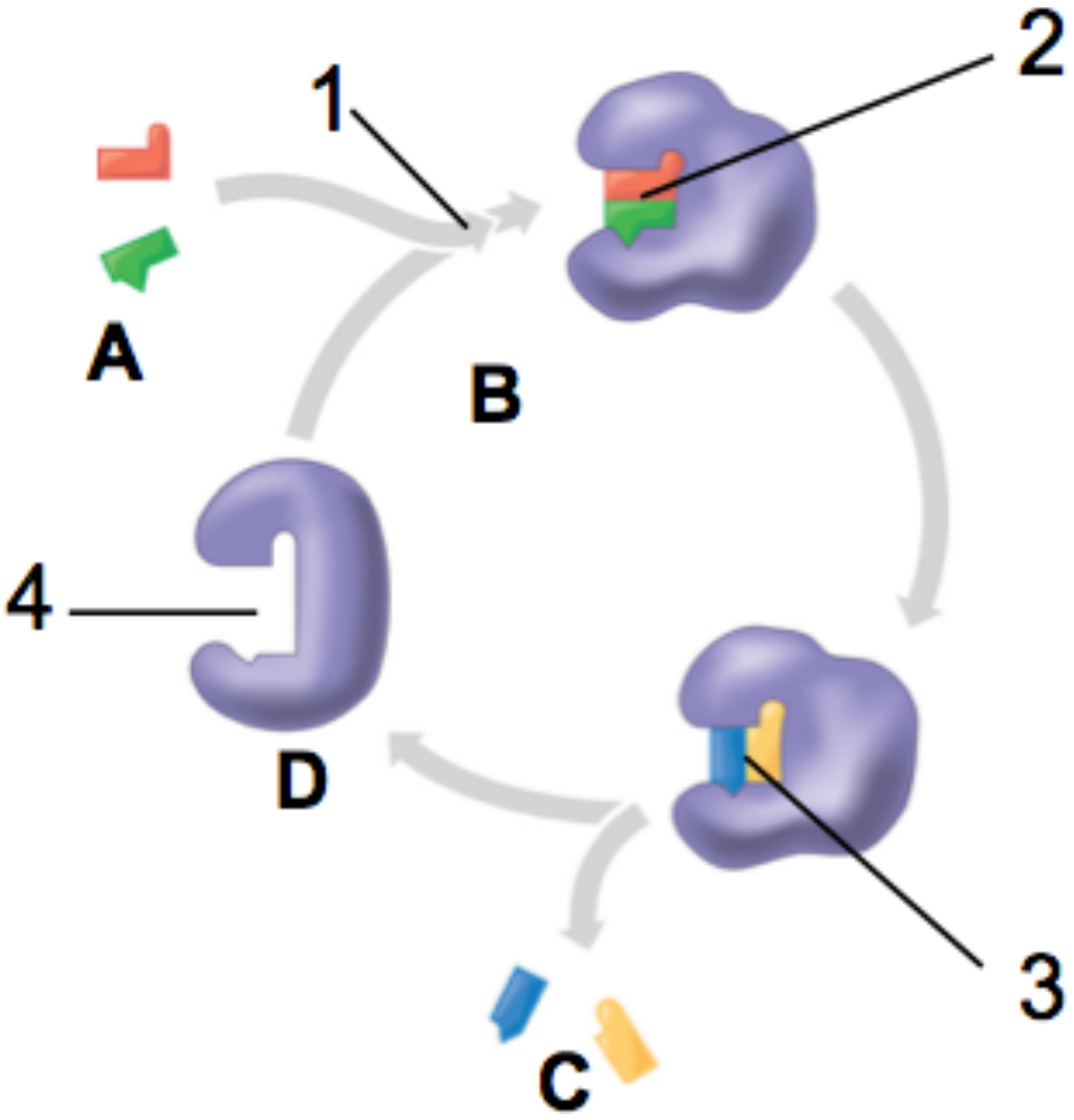


Schematic model of an enzyme

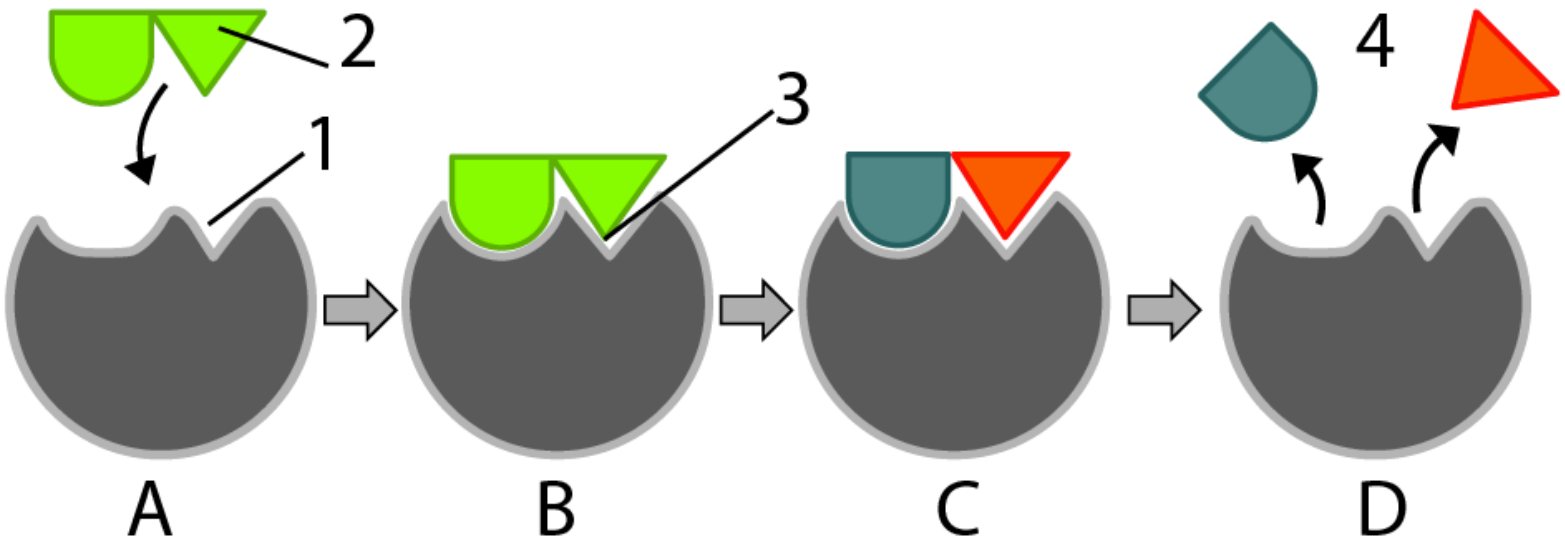
Checking Understanding



Checking Understanding



Checking Understanding



A: Enzyme

1. Active site
2. Substrate
3. Induced fit

B. E-S complex

C: conversion to product

4. Product

D. Enzyme

Part 3: Demonstration (salivary amylase)

Enzyme Demonstration

- Starch solution in Benedict's indicator: _____
- Glucose solution in Benedict's indicator: _____
- Starch + amylase enzyme in benedict's indicator: _____
- Boiled amylase + starch in benedict's indicator: _____
- Explain what happened:

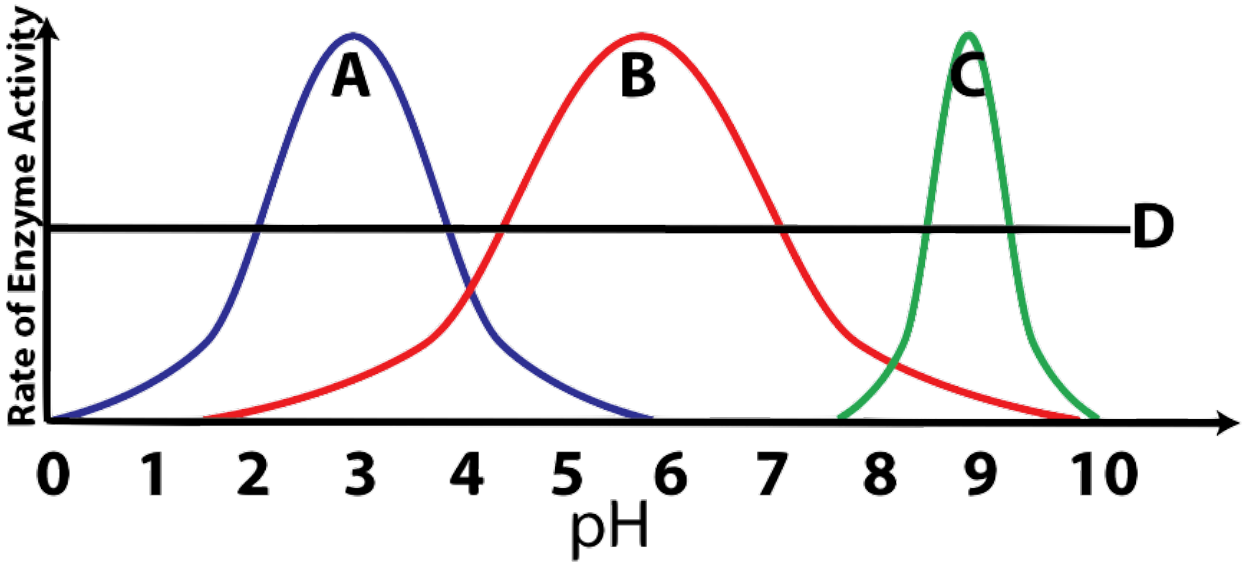
Enzyme Demonstration (results)

- Starch solution in Benedict's indicator: negative (no glucose)
- Glucose solution in Benedict's indicator: positive (glucose)
- Starch + amylase enzyme in benedict's indicator: positive (glucose)
- Boiled amylase + starch in benedict's indicator: negative (no glucose)
- Explain what happened:

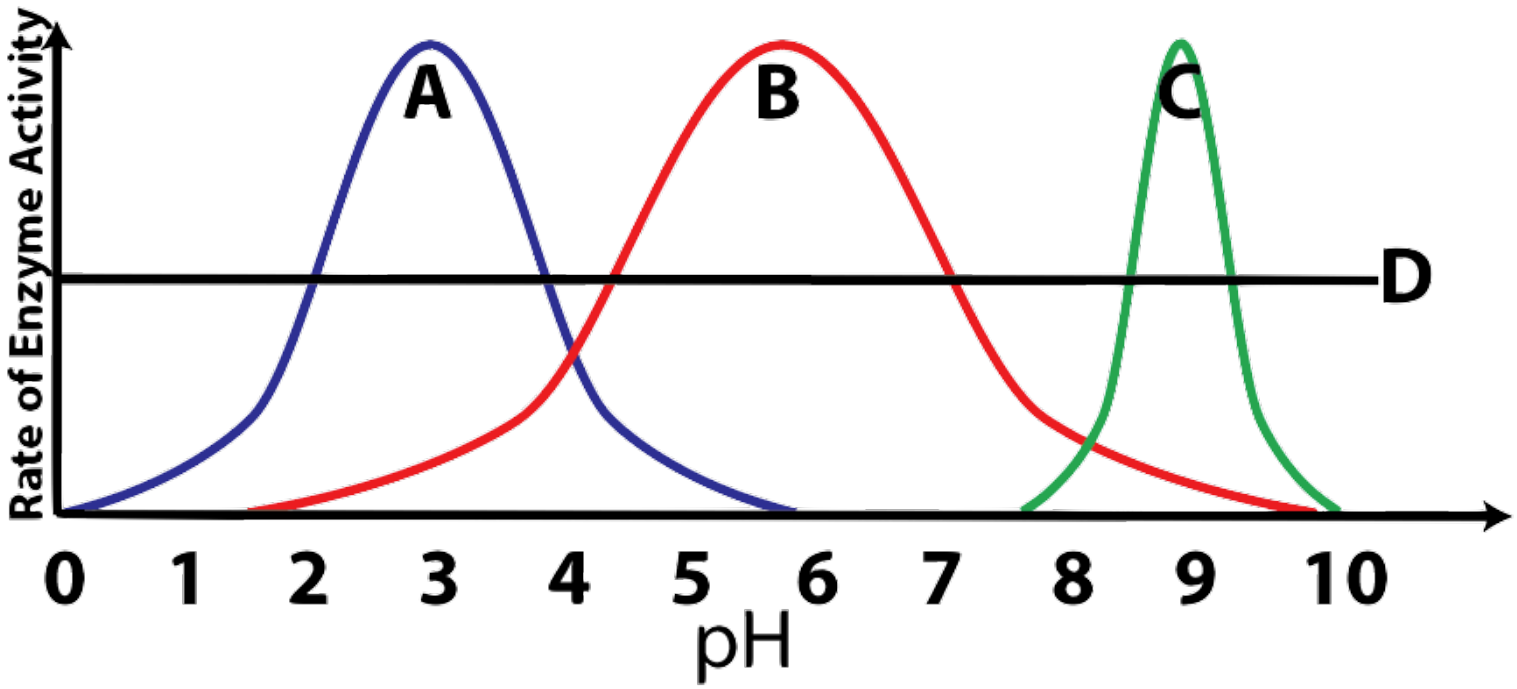
Part 4: Enzymes and their environment

Environmental effects on enzymes (1)

- A, B, and C are enzymes. D is an inorganic catalyst.
- Based on this graph, a) make a claim about the effect of pH on enzymes, b) provide some evidence for the claim, and c) explain why based on what you know about enzymes, this would this make sense?



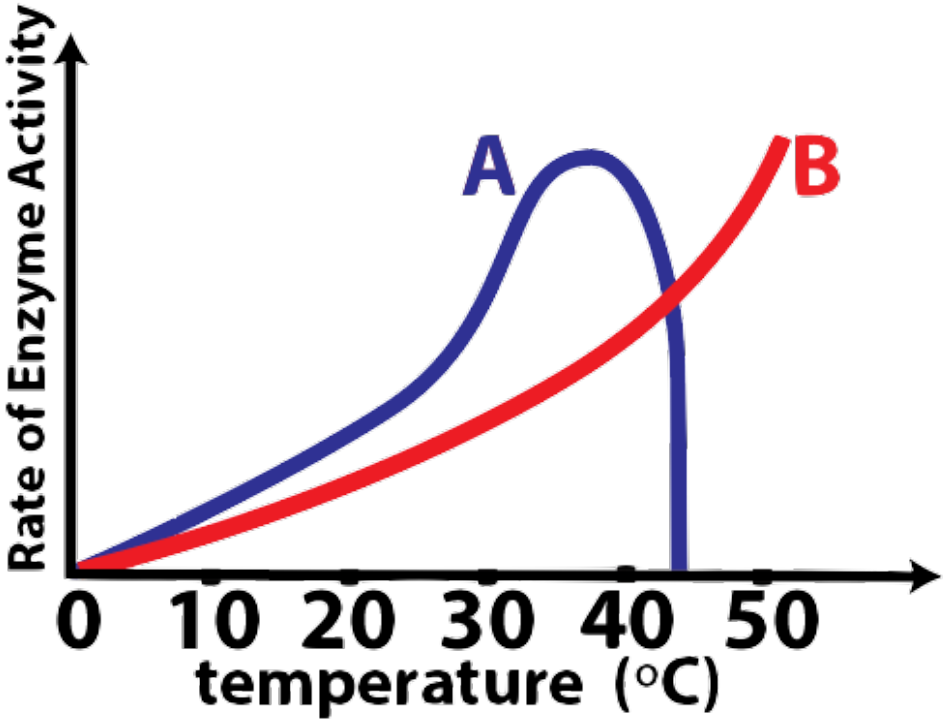
Enzymes and pH



- Enzymes have a pH ___optimum___
- Below and above optimum, activity ___decreases___ because…
- Active site becomes ___denatured___

Environmental effects on enzymes (2)

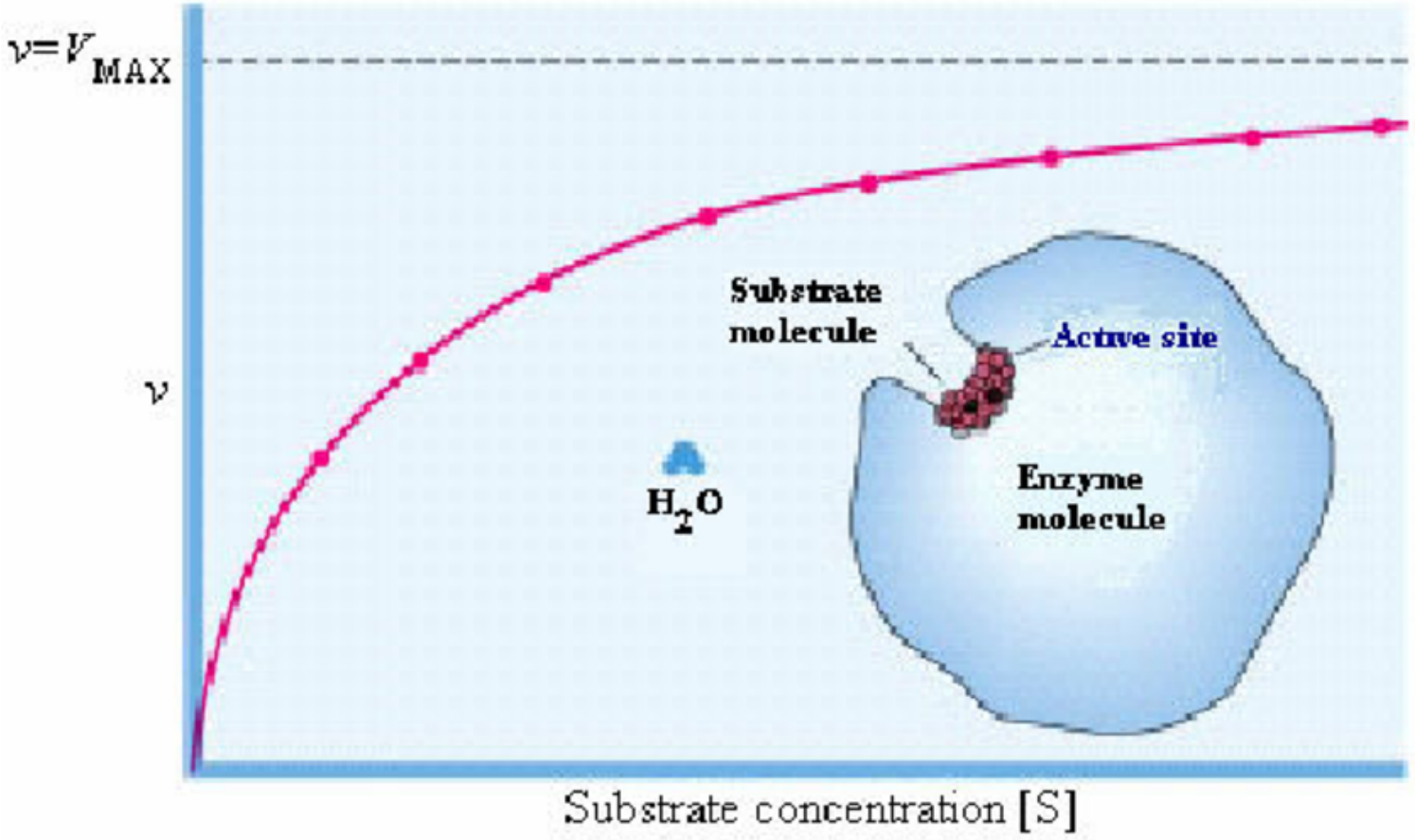
- A is an enzyme. B is an inorganic catalyst. What does this graph say about the effect of temperature on enzymes?
- Why, based on what you know about enzymes, would this make sense?



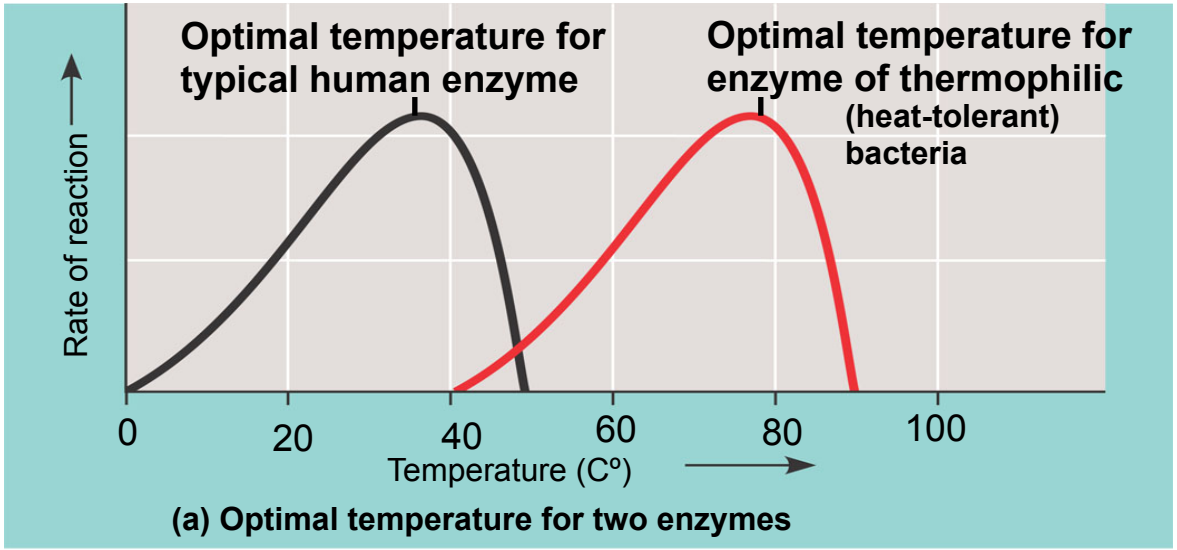
Beano: it's an enzyme supplement that prevents flatulence. You can't cook it into your food. Why?

Environmental effects on enzymes (3)

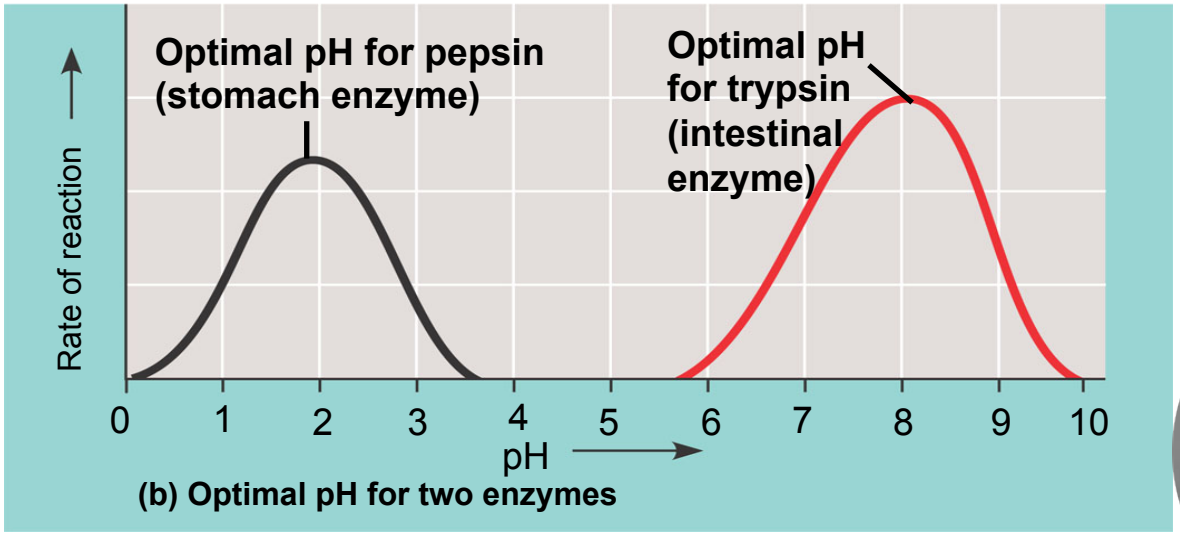
- Amount of enzyme is constant.
- X axis is substrate concentration.
- Y axis is *the rate of the reaction*.
- What's happening?



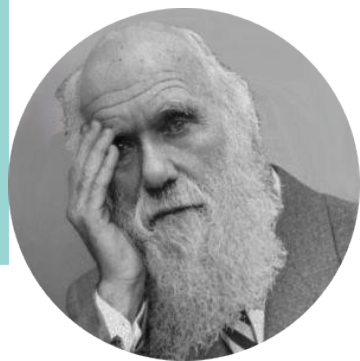
These optima are also ___adaptations___.



(a) Optimal temperature for two enzymes

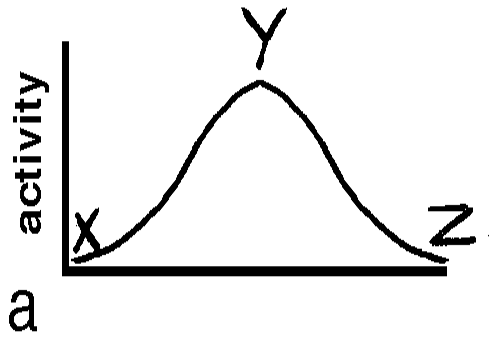


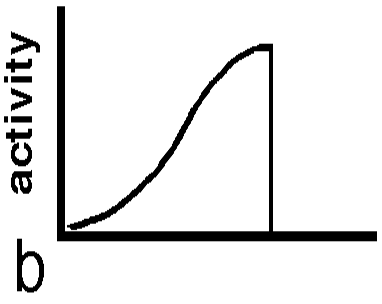
(b) Optimal pH for two enzymes

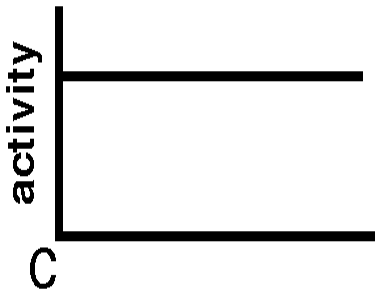


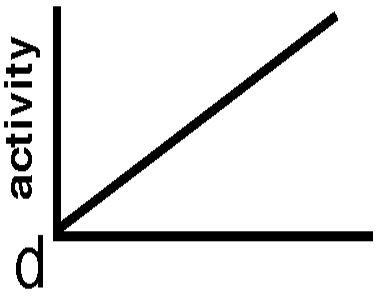
Checking Understanding

1. Which graph shows the effect of pH on an inorganic catalyst?
2. Which shows the effect of temperature on an enzyme?
3. Which shows the effect of pH on an enzyme?
4. Which shows the effect of temperature on an inorganic catalyst?
5. Which letter shows the pH optimum of an enzyme?



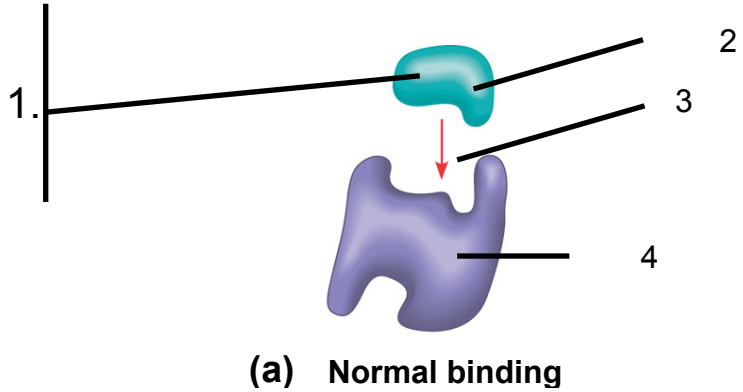






Part 4: Inhibition and Regulation of Enzymes

Enzyme Inhibition (1)



(a) Normal binding

1 & 2: Substrate

3. Active site

4. Enzyme

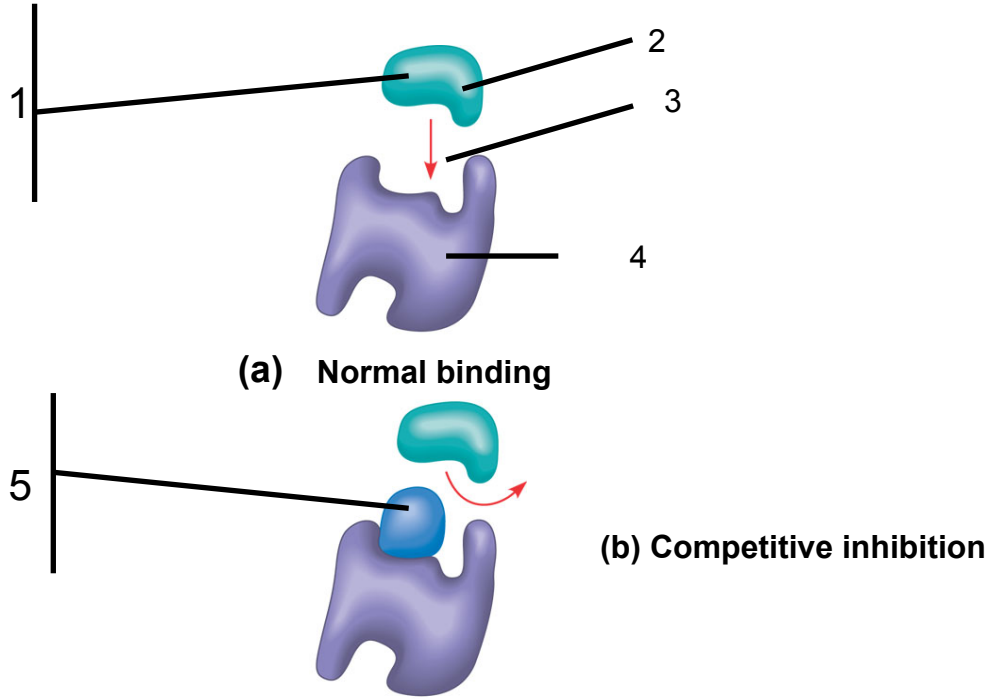
Enzyme Inhibition (2)

1 & 2: Substrate

3. Active site

4. Enzyme

5. Competitive inhibitor



Enzyme Inhibition (3)

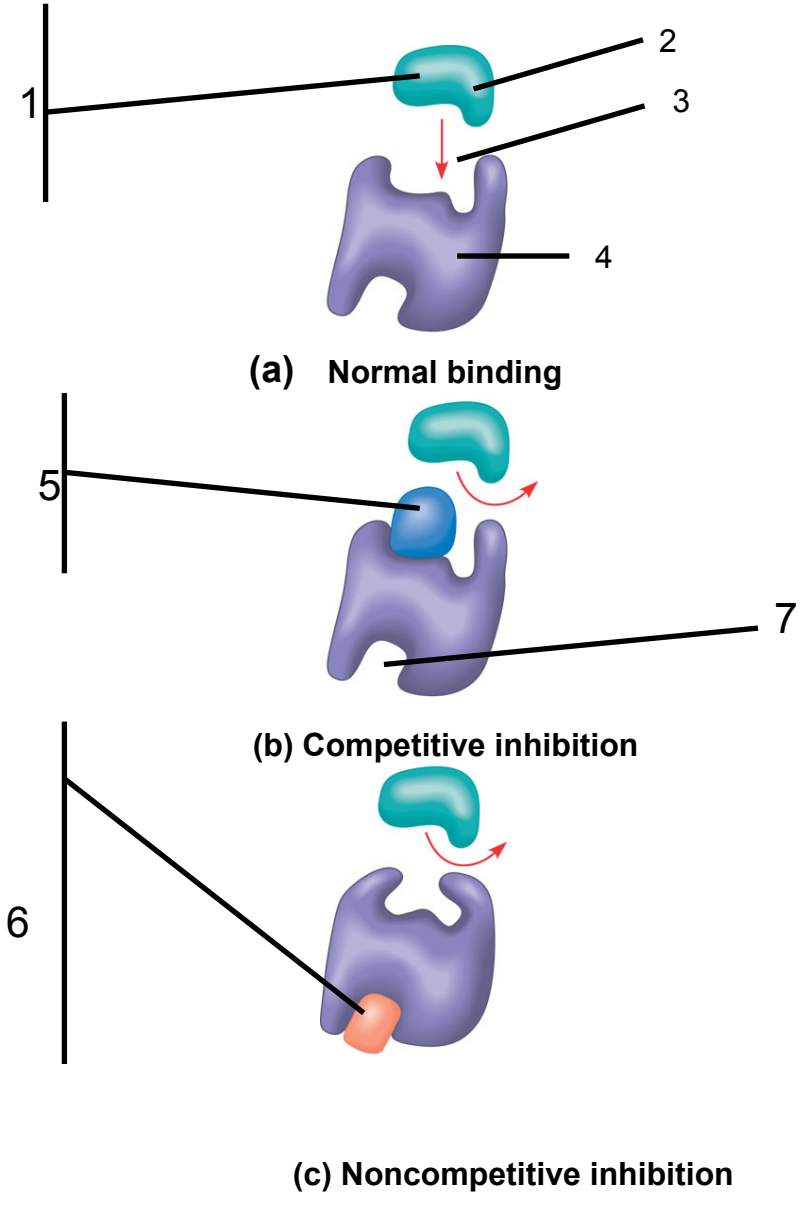
1 & 2: Substrate

3. Active site

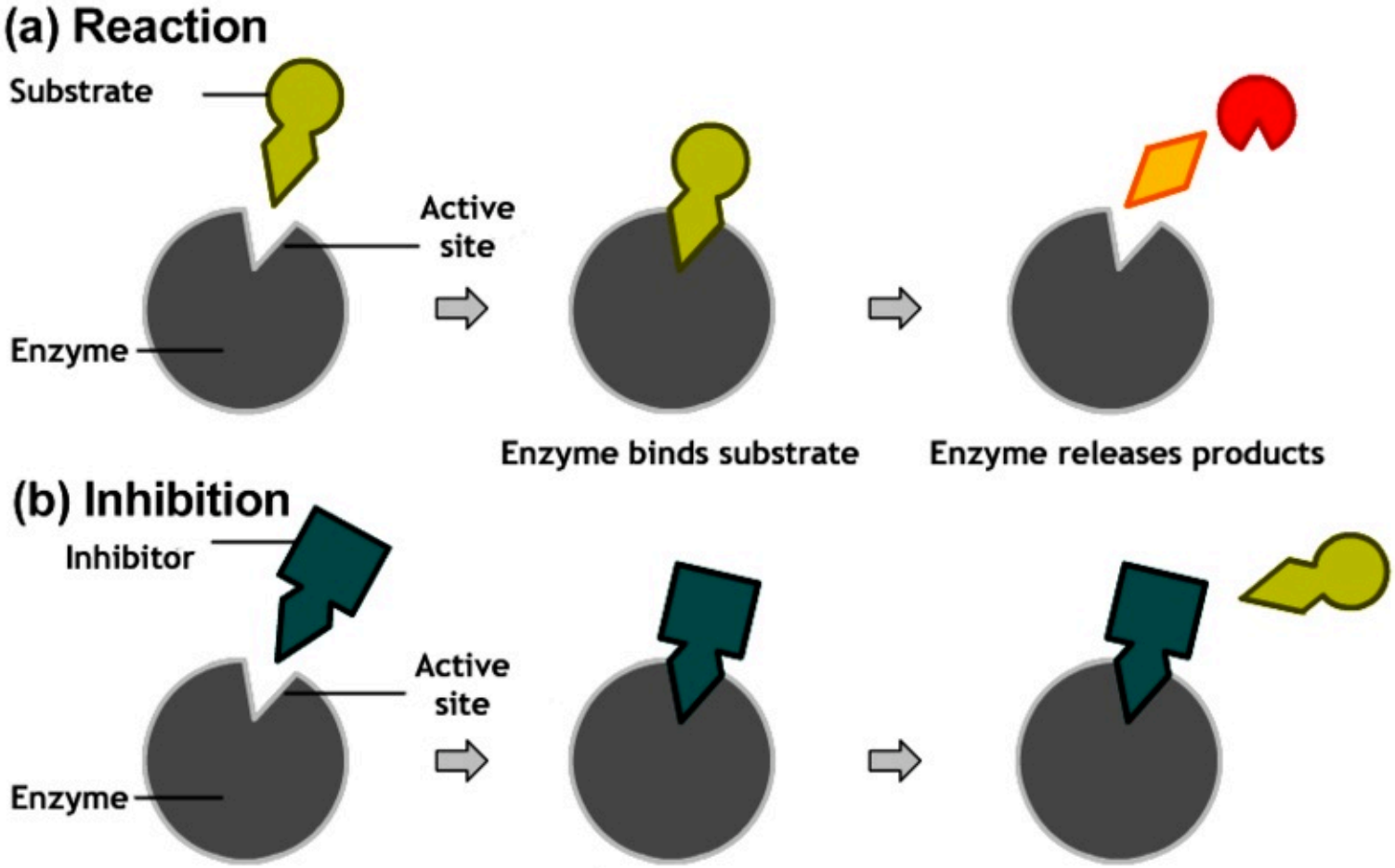
4. Enzyme

5. Competitive inhibitor

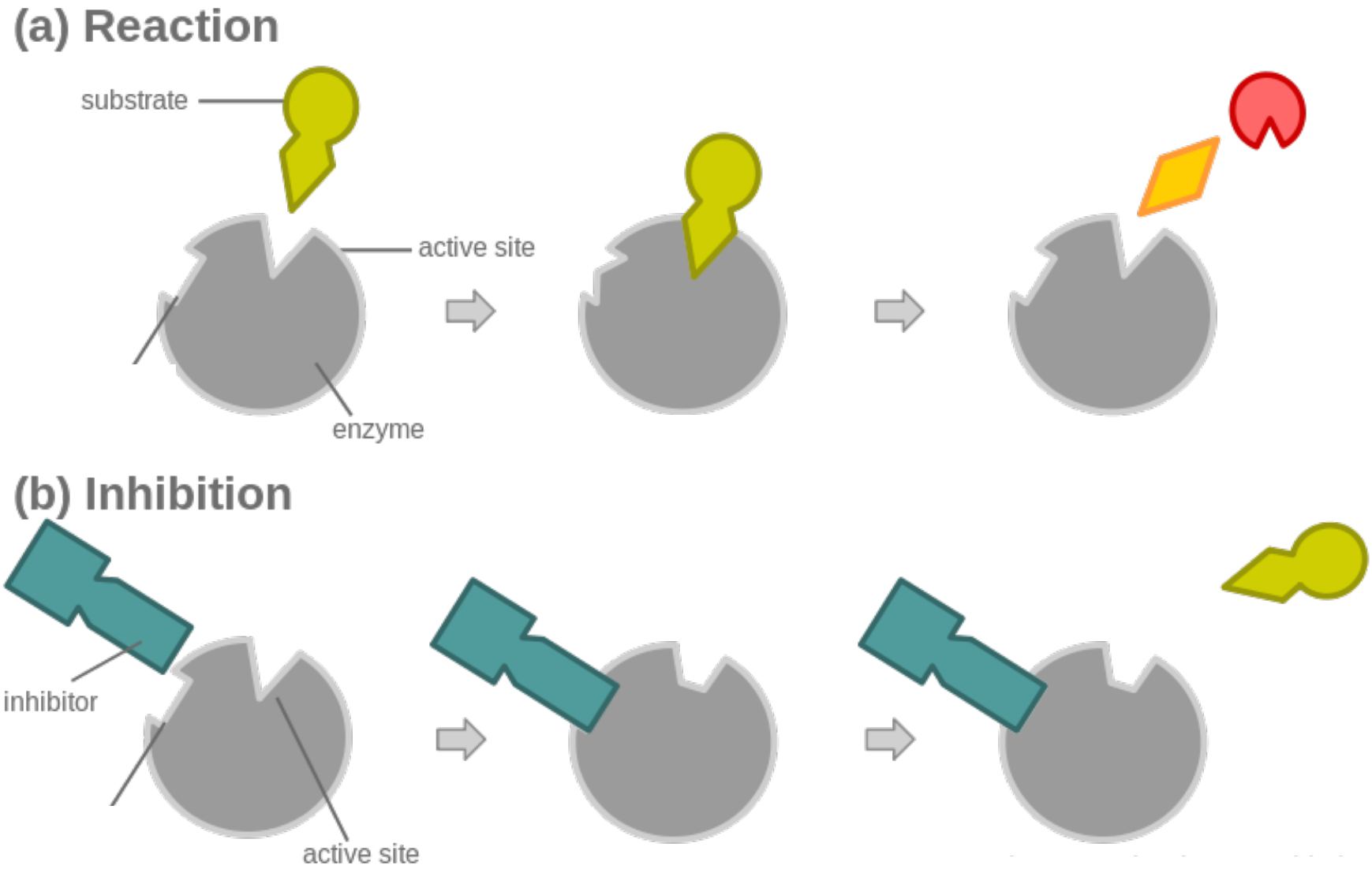
6. Non-competitive inhibitor



_____ inhibition because…

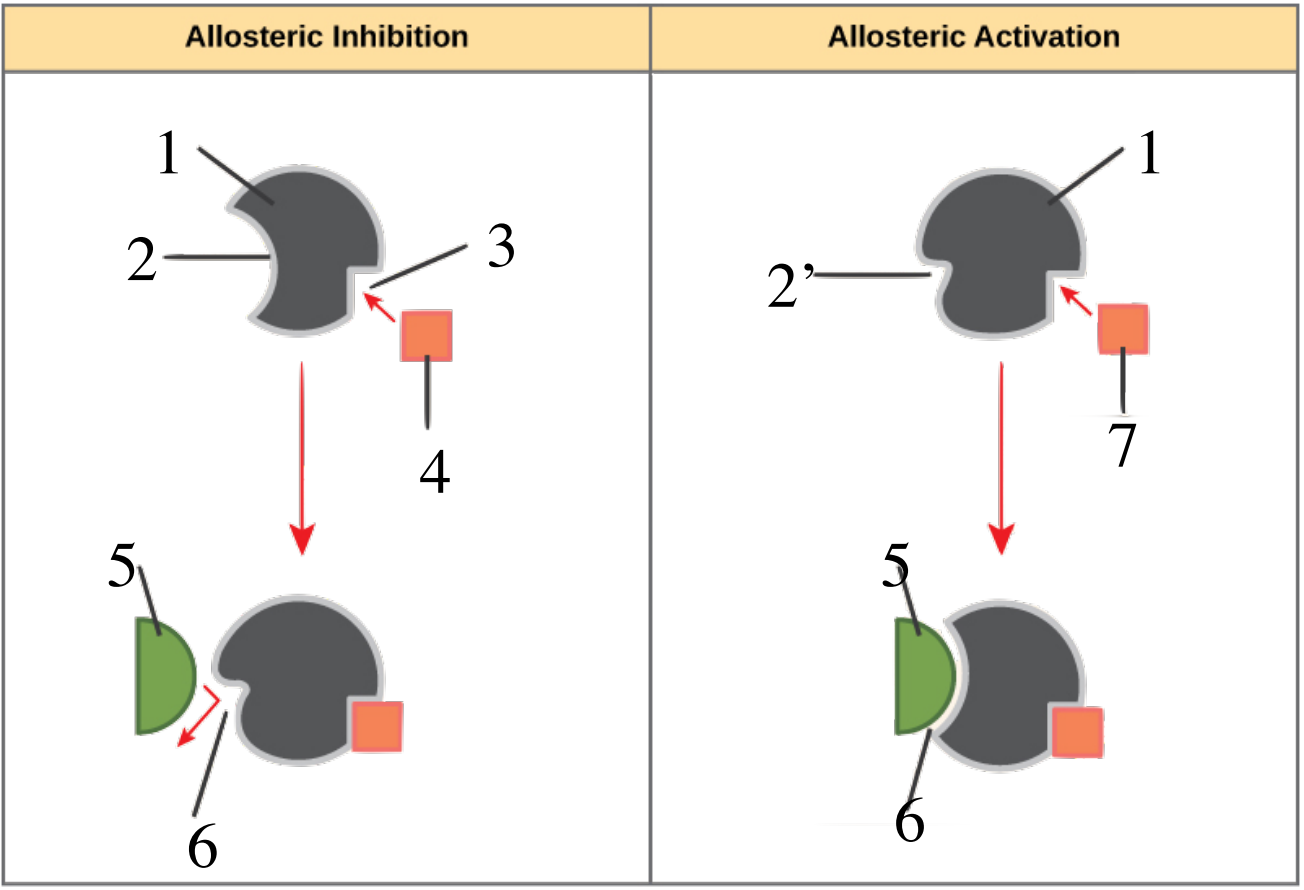


_____ inhibition because…



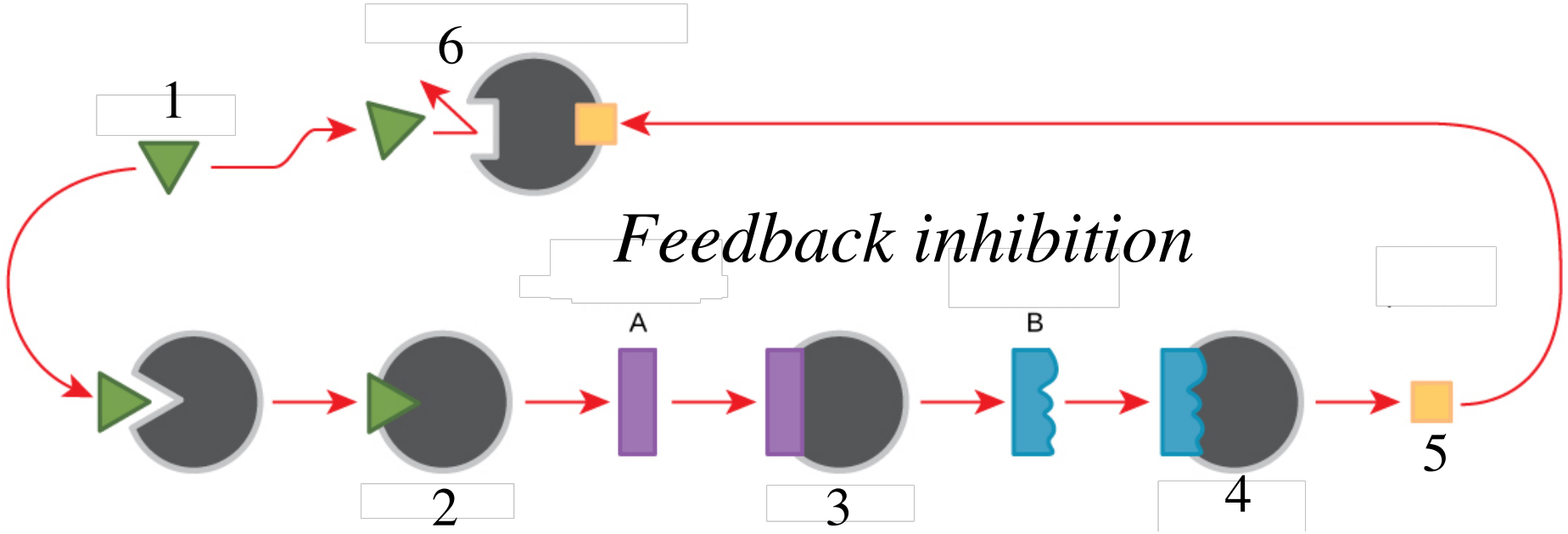
Allosteric *regulation*

Same mechanism as noncompetitive inhibition but used to control enzyme action.



1. Enzyme
2. Active site
3. Allosteric site
4. Inhibitor
5. Substrate
6. Modified active site
7. Activator

2'. Inactive active site



- Product of a pathway inhibits an enzyme earlier in the pathway.
- Allows a cell to turn off a pathway when it has produced enough product.

1. Substrate
2. First enzyme

A. First intermediate product

3. Second enzyme

B. Second intermediate product

4. Third enzyme
5. Product
6. Feedback inhibition

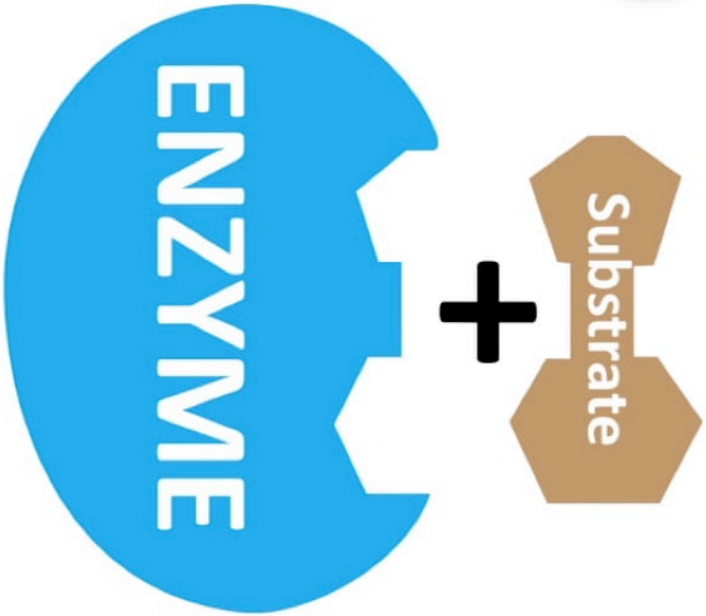
Checking Understanding

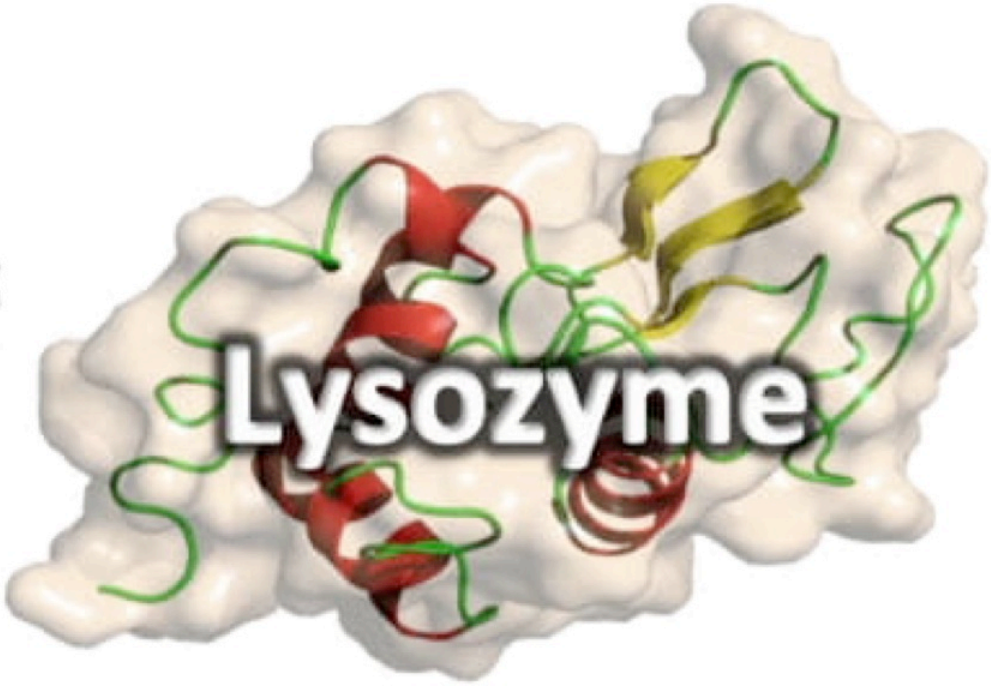
1. Enzyme
2. Substrate
3. Product
4. Activation energy
5. Induced fit
6. Lock and key
7. pH effects
8. Temperature effects
9. Inhibition (competitive & non-competitive)
10. Allosteric regulation (positive and negative)
11. Feedback inhibition

Enzyme Deficiency Diseases

- PKU disease
- Tay sachs
- Galactosemia

Enzymes!





https://www.sciencemusicvideos.com/enzymes/