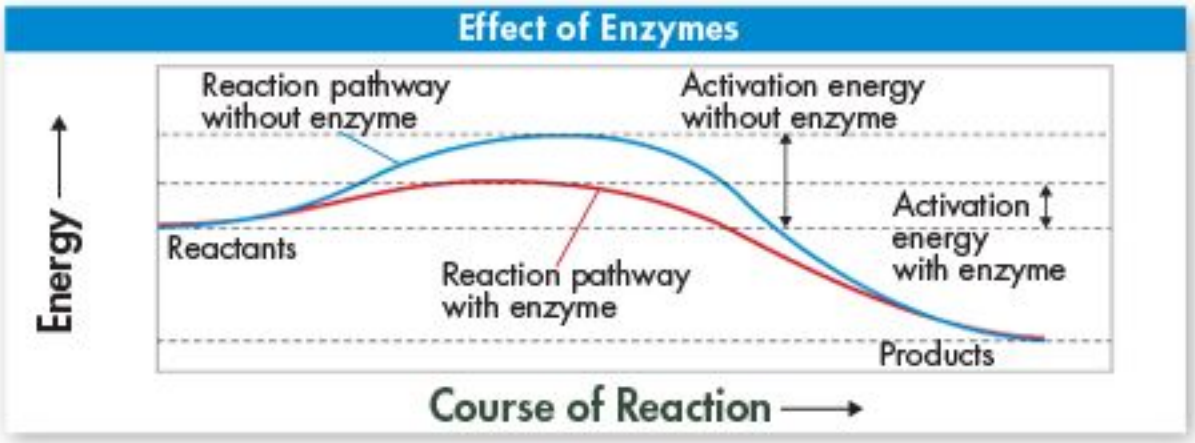
Catalysts

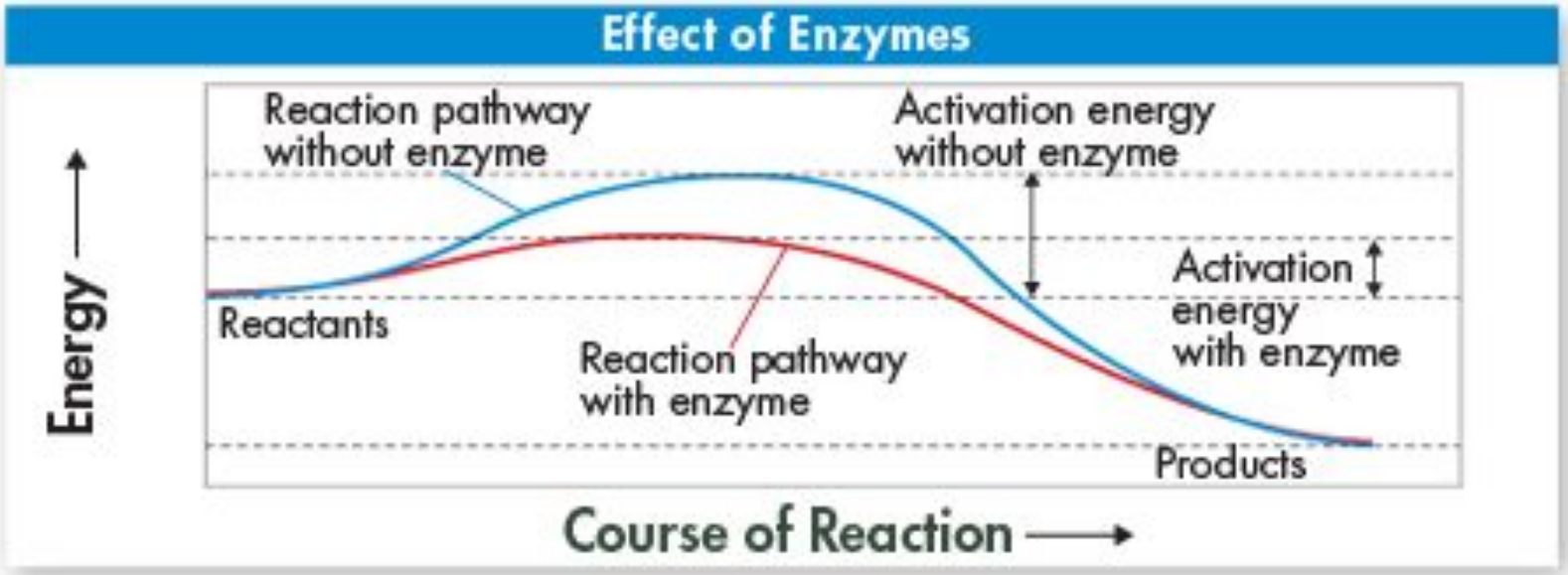
- Some chemical reactions are too slow or have activation energies that are too high to make them practical for living tissue.
- These chemical reactions are made possible by **catalysts**.
- A catalyst is a substance that **speeds up** the rate of a chemical reaction.
- Catalysts work by **lowering** a reaction's activation energy.

Enzymes

- Enzymes are **proteins** that act as **biological catalysts**.
- Enzymes **speed up** chemical reactions that take place in cells.
- Enzymes act by **lowering the activation energies**, which has a dramatic effect on how quickly reactions are completed.



How is the reaction without an enzyme different than with an enzyme?



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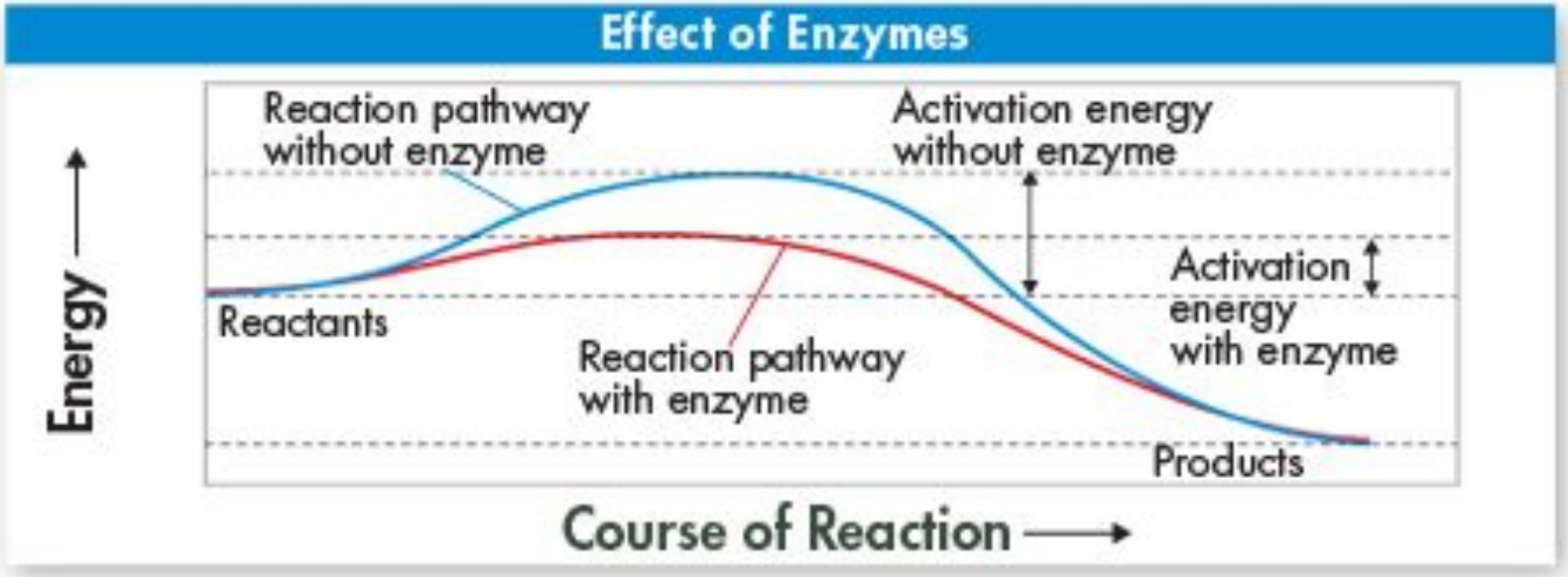
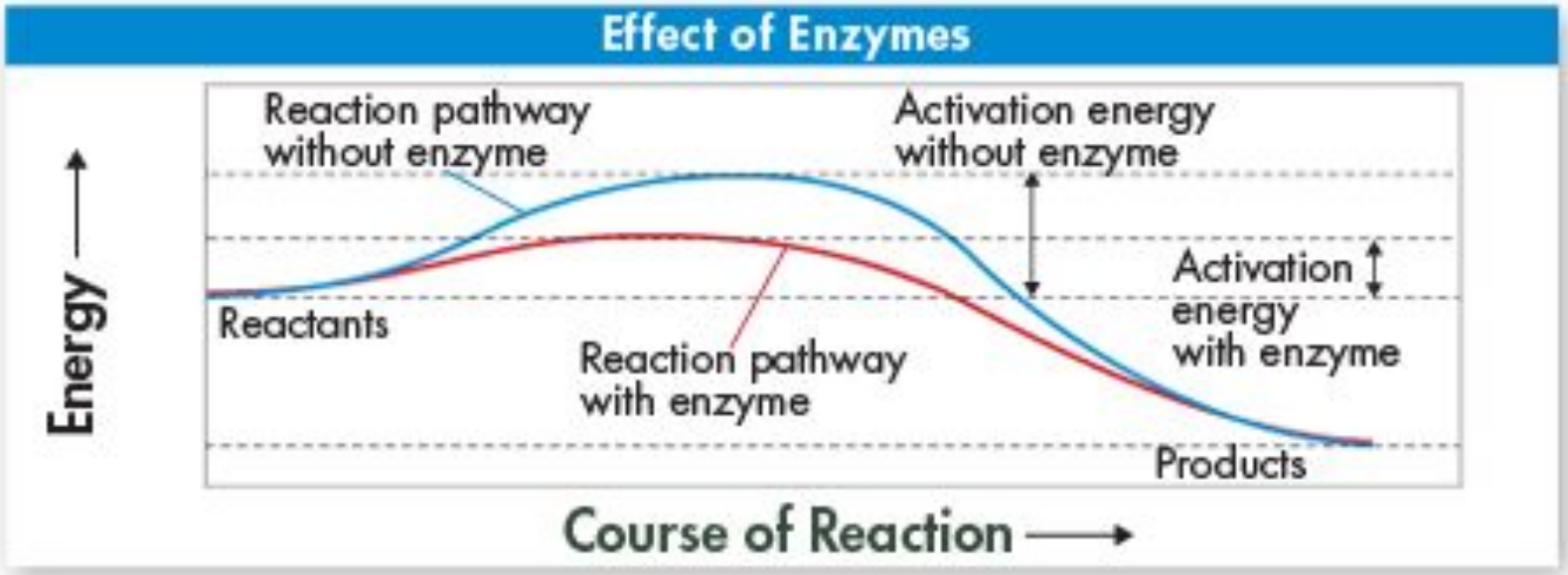


The activation energy is lower with the enzyme.

What effect does lowering the activation energy have on the rate of reaction?



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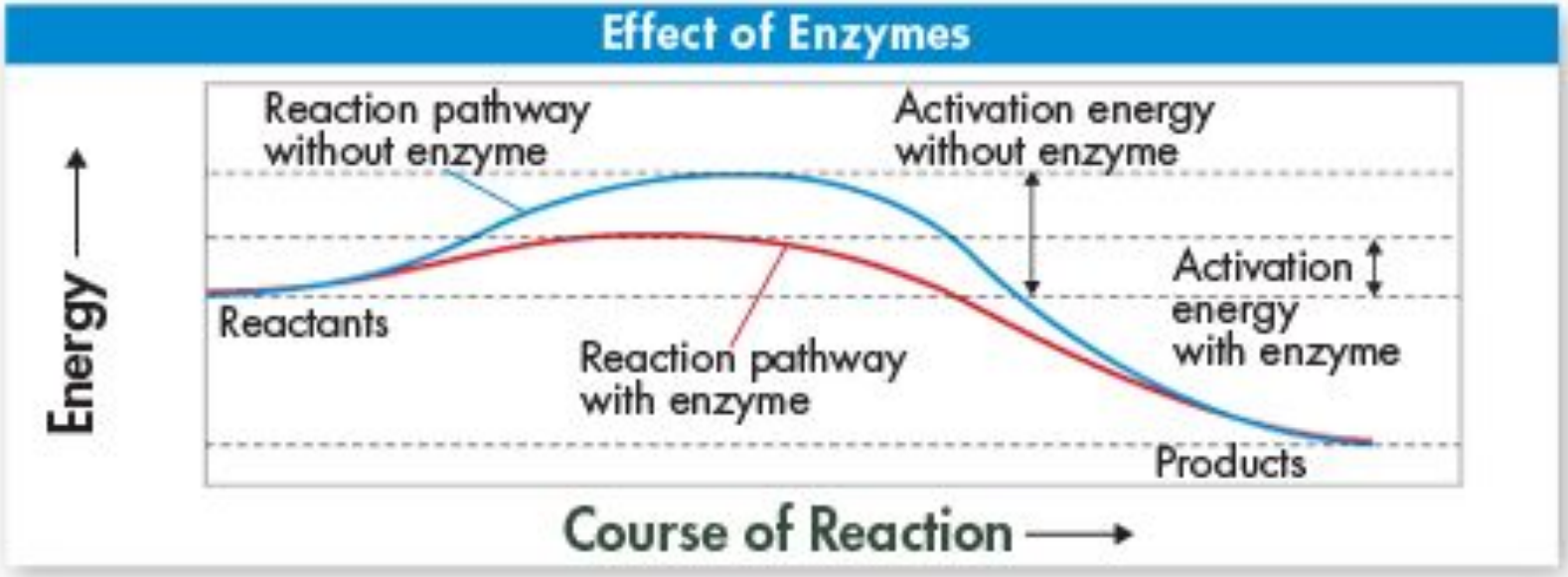


Enzymes speed up chemical reactions that take place in cells by lowering the activation energy.

Nature's Catalysts

For example, the reaction in which carbon dioxide combines with water to produce carbonic acid is so slow that carbon dioxide might build up in the body faster than the bloodstream could remove it.

$$CO_2 + H_2O \longrightarrow H_2CO_3$$

Your bloodstream contains an enzyme called carbonic anhydrase that speeds up the reaction by a factor of 10 million, so that the reaction takes place immediately and carbon dioxide is removed from the blood quickly.

Enzymes

- Enzymes only catalyze a **single** reaction, a property called **specificity**.

- Part of an enzyme's name is usually derived from the reaction it catalyzes ending with ***–ase***.

- Example - Carbonic anhydrase gets its name because it also catalyzes the reverse reaction that removes water from carbonic acid.

Enzymes

- For a chemical reaction to take place, the **reactants** must collide with enough energy so that existing bonds will be broken and new bonds will be formed.

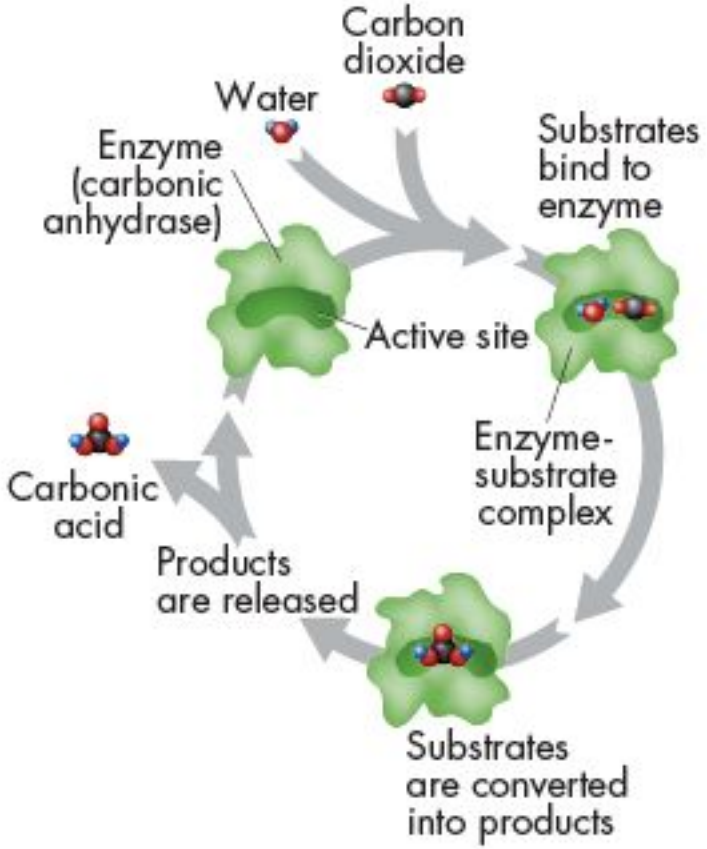
- If the **reactants** do not have enough energy, they will be unchanged after the collision.

- Enzymes provide a site where **reactants** can be brought together to react. Such a site reduces the **reaction's activation energy**.

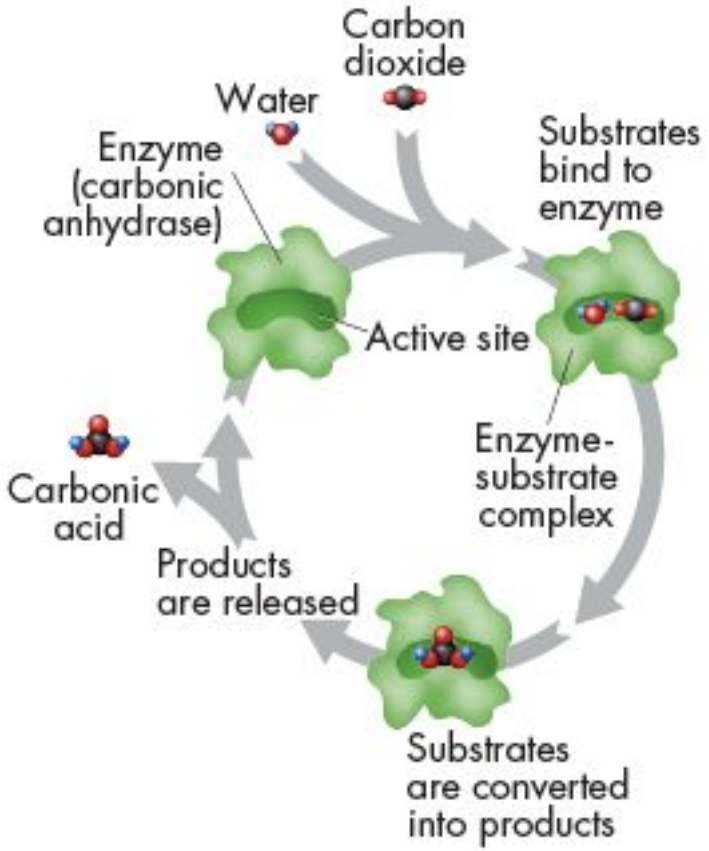
The Enzyme-Substrate Complex

- The reactants of enzyme-catalyzed reactions are known as **substrates.**

- For example, the enzyme carbonic anhydr**ase** converts the substrates carbon dioxide and water into the product carbonic acid (H_2CO_3).



Why is a cycle diagram appropriate to show how an enzyme works?



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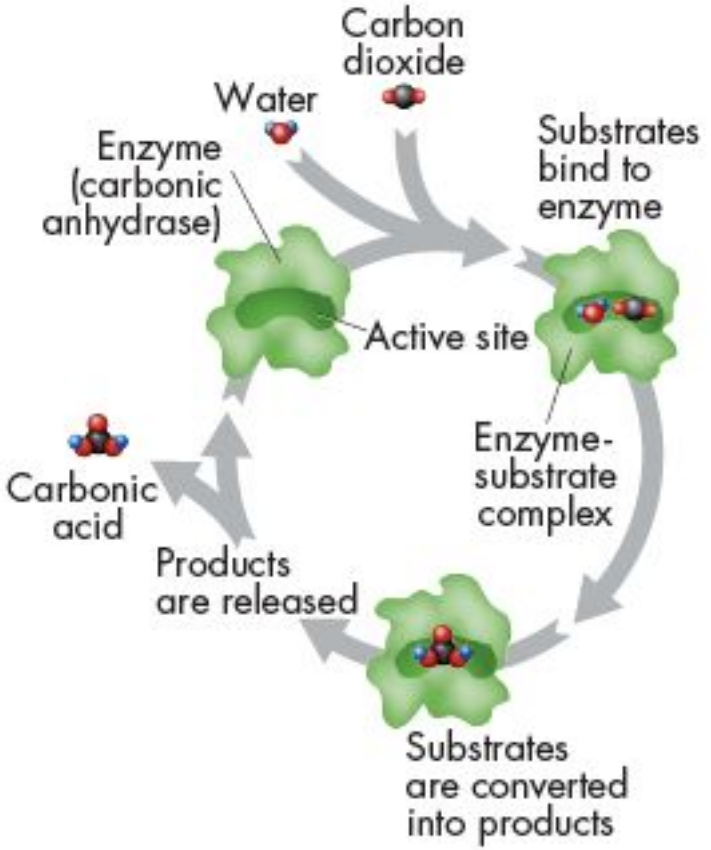
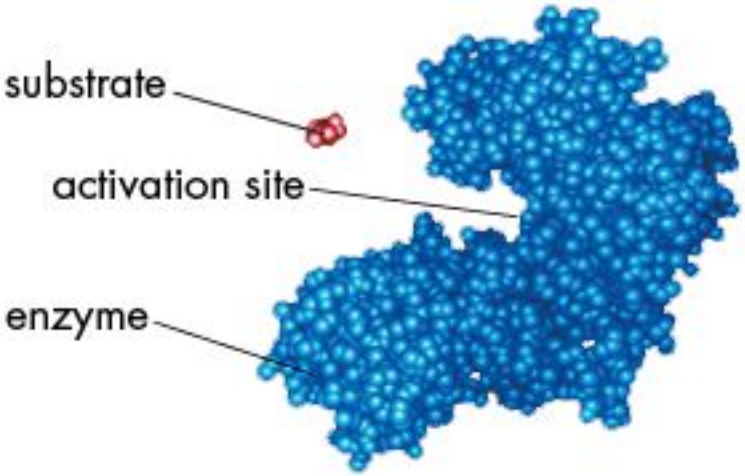
- Enzymes remain **unchanged** and are **not** used up in the reaction.

- The enzyme is free **catalyze** more reactions, which allows the process to keep repeating.



The Enzyme-Substrate Complex

- The substrates bind to a site on the enzyme called the **active site**.
- The active site and the substrates have **complementary** shapes.
- The fit is so precise that the active site and substrates are often compared to a lock and key.



Regulation of Enzyme Activity

- **Temperature**, **pH**, and **regulatory molecules** are all factors that can affect the activity of enzymes.

✓ Enzymes work best at certain temperature ranges.

✓ Enzymes work best at certain pH values.

✓ The activities of most enzymes are regulated by molecules that carry chemical signals within cells, switching enzymes “on” or “off” as needed.

A change in pH can change the shape of a protein. How might a change in pH affect the function of an enzyme such as carbonic anhydrase?

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If a change in pH changes the shape of an enzyme, it might result in the enzyme and substrates no longer fitting together properly. As a result, the enzyme would no longer be able to speed up the chemical reaction.