Instructions

- Use the pages button at the left to display thumbnails of these slides. The F4 key can also be used to display thumbnails in most PDF readers.
- Viewing might be easier if you maximize the window (button on upper right).
- Click on the thumbnails at the left to advance the slides. It is best to view them in order.
- This slide presentation is intended to be a lecture. It might be helpful to take notes as you progress through the slides. It is important that you understand each slide before advancing to the next because concepts build upon previous concepts.

Forms of Energy

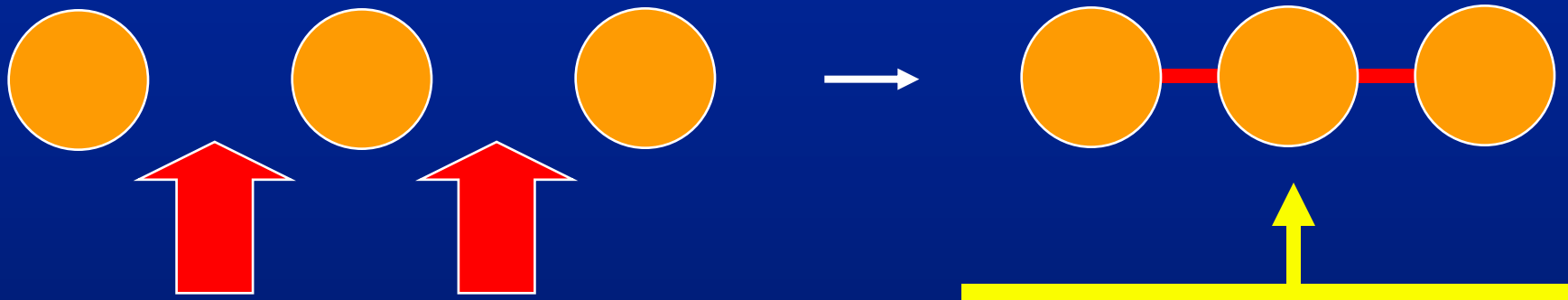
- These forms of energy are important to life:
  - chemical
  - radiant (examples: heat, light)
  - mechanical
  - electrical
- Energy can be transformed from one form to another.
- Chemical energy is the energy contained in the chemical bonds of molecules.
- Radiant energy travels in waves and is sometimes called electromagnetic energy. An example is visible light.
- Photosynthesis converts light energy to chemical energy.
- Energy that is stored is called ***potential energy***.

Laws of Thermodynamics

- 1st law: Energy cannot be created or destroyed.
  - Energy can be converted from one form to another. The sum of the energy before the conversion is equal to the sum of the energy after the conversion.
  - Example: A light bulb converts electrical energy to light energy and heat energy. Fluorescent bulbs produce more light energy than incandescent bulbs because they produce less heat.
- 2nd law: Some usable energy dissipates during transformations and is lost.
  - During changes from one form of energy to another, some usable energy dissipates, usually as heat. The amount of usable energy therefore decreases.

Energy is required to form bonds.

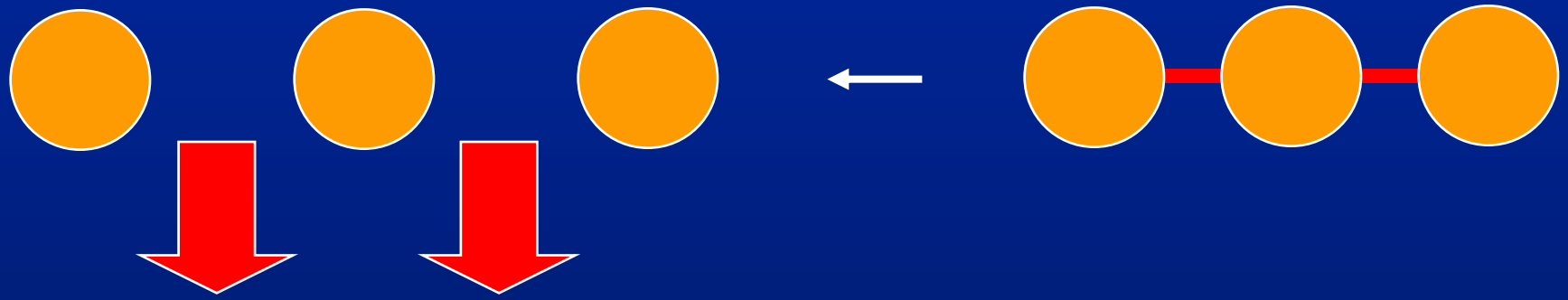
Atoms or molecules + Energy → Larger molecule



The energy that was used to form the bonds is now stored in this molecule.

Energy is released when bonds are broken.

Atoms or molecules + Energy ⟵ Larger molecule

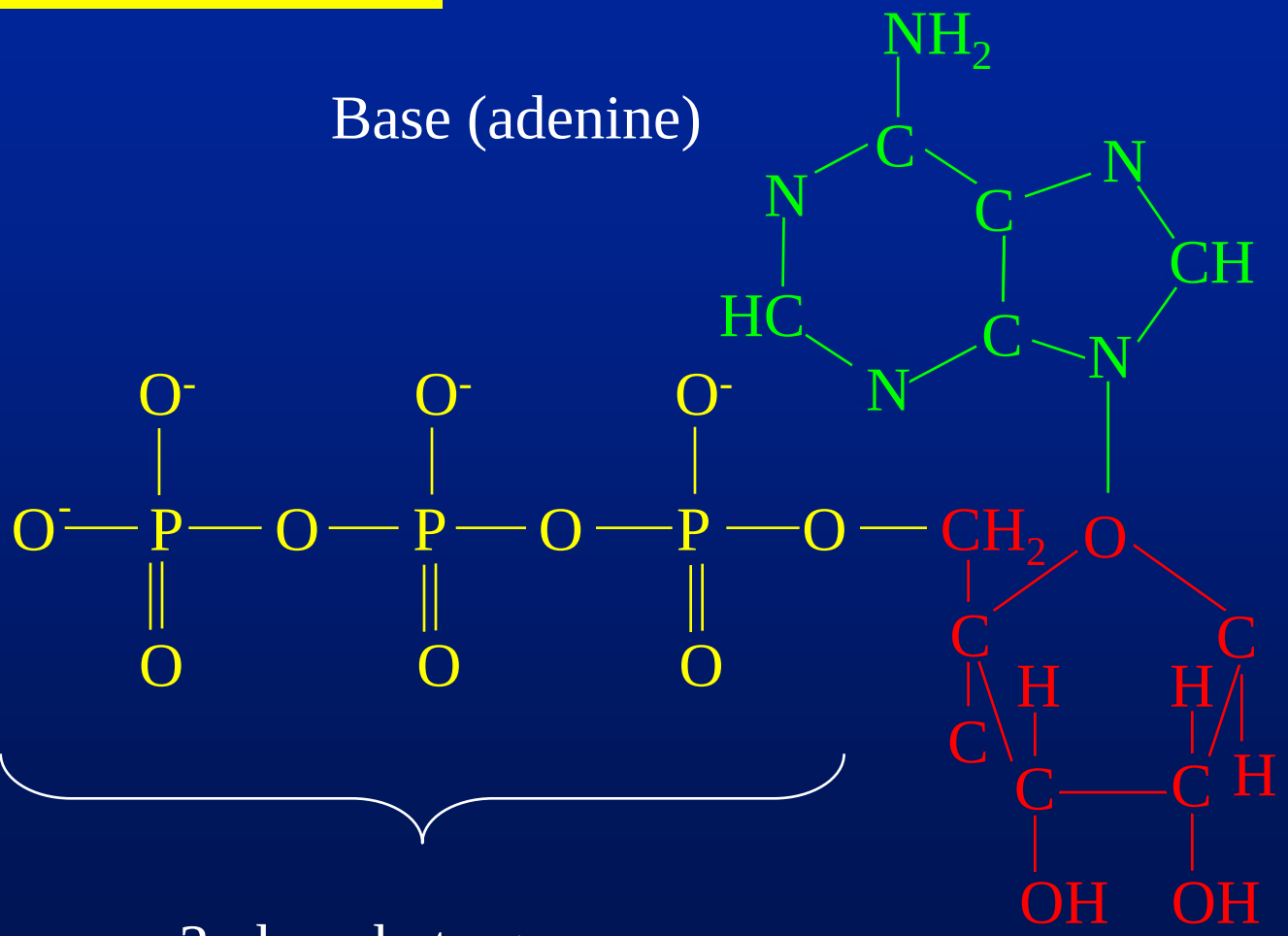


Energy Energy

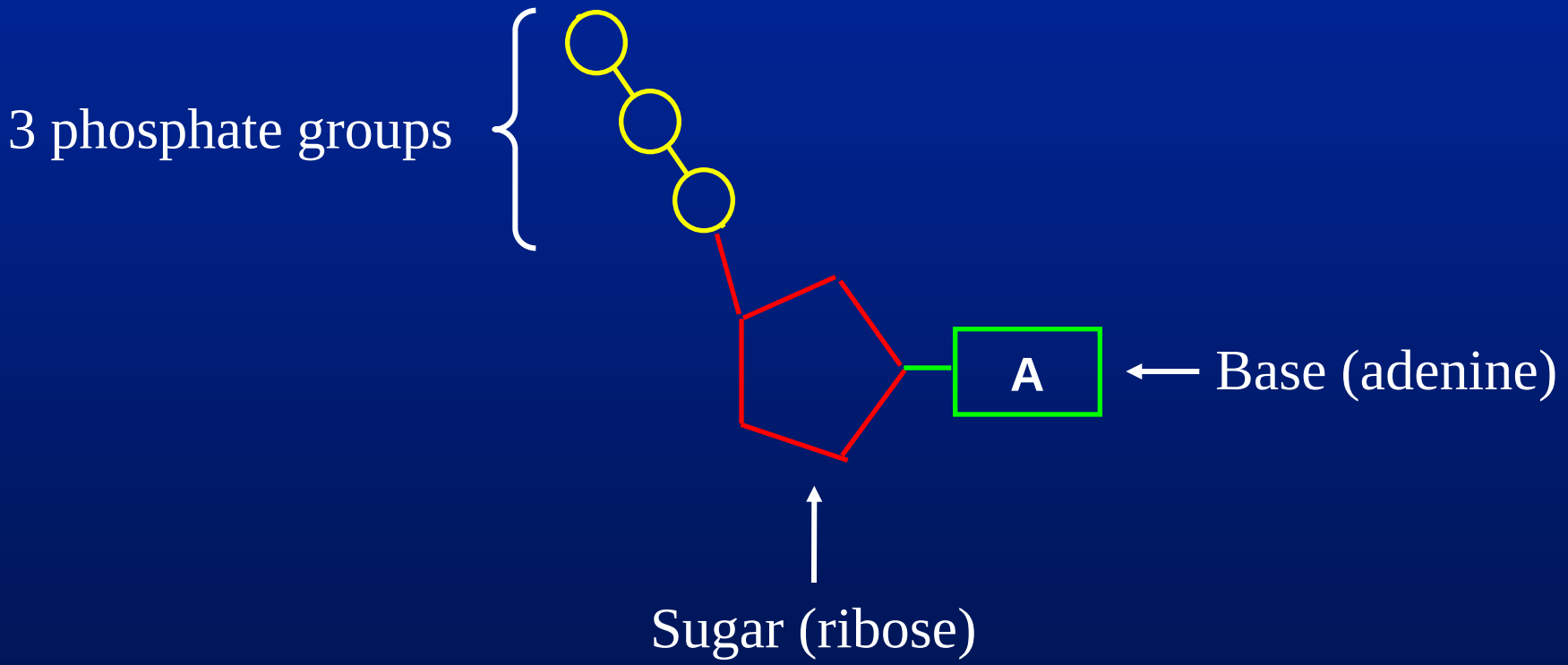
The energy is now released. It may be in a form such as heat or light or it may be transferred to another molecule.

ATP (Adenosine Triphosphate)

Most cellular activities that require energy use ATP as an energy source. The energy in ATP is stored in chemical bonds.



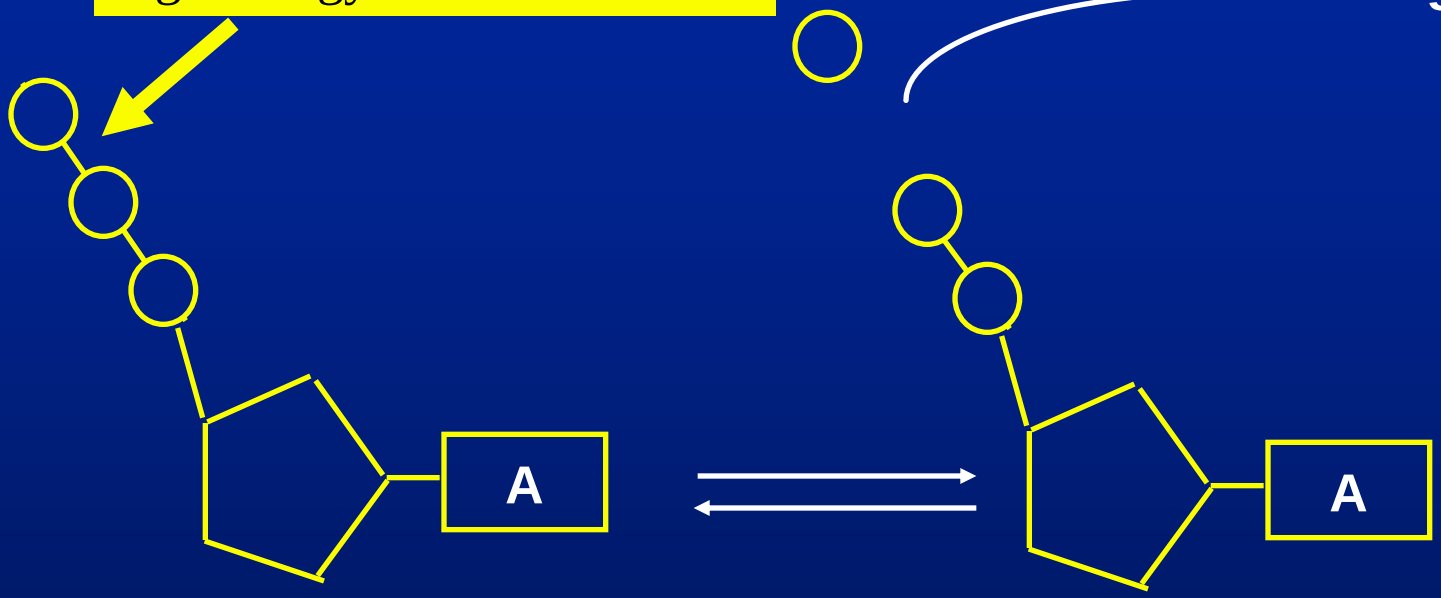
ATP (Simplified Drawing)



ATP Stores Energy

Breaking the bonds releases the energy.

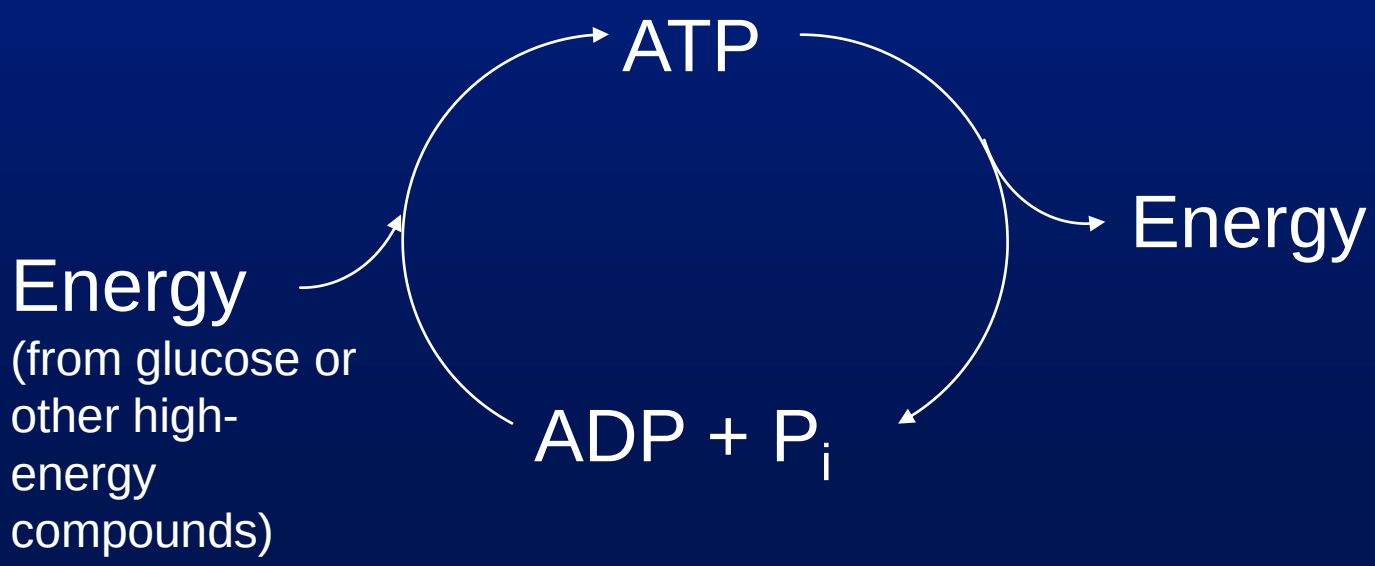
The phosphate bonds are high-energy bonds.



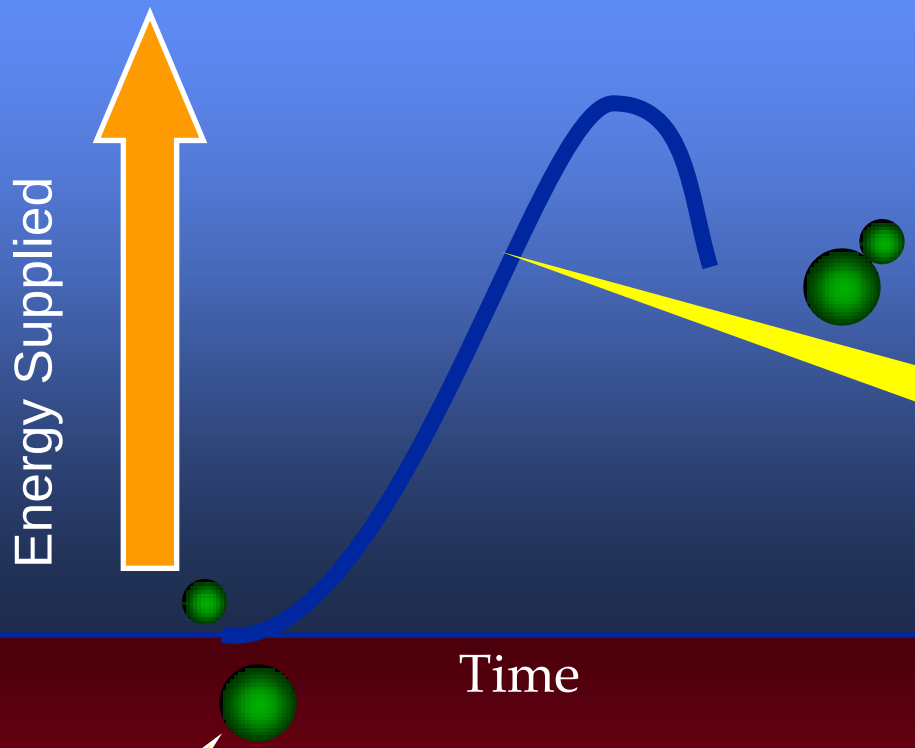
ATP ⇌ **ADP + P_i + Energy**

ATP is Recycled

- ATP (Adenosine Triphosphate) is an energy-containing molecule used to supply the cell with energy. The energy used to produce ATP comes from glucose or other high-energy compounds.
- ATP is continuously produced and consumed as illustrated below.
- ADP + P_i + Energy → ATP + H_2O
  (Note: P_i = phosphate group)
- Most ATP are produced in the mitochondrion by a series of chemical reactions. This group of reactions are called to as *cellular respiration*.



Anabolic Reactions

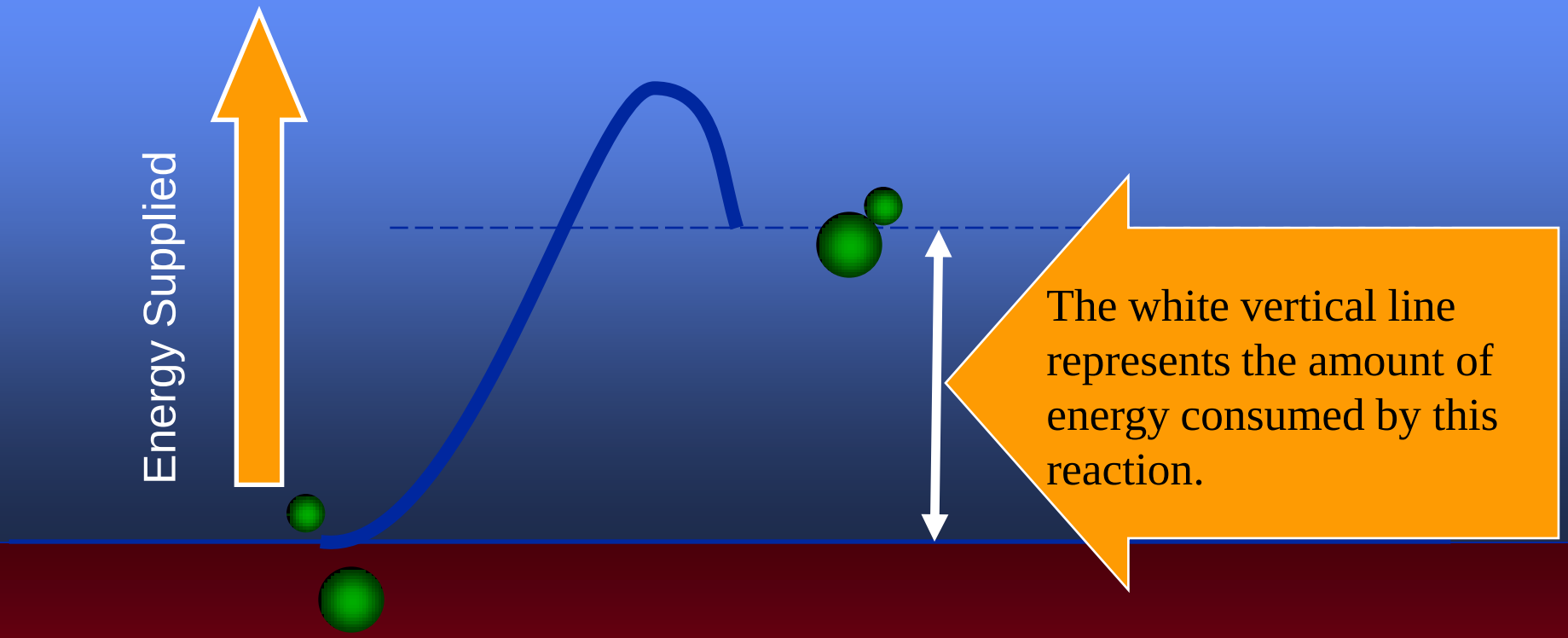


Products

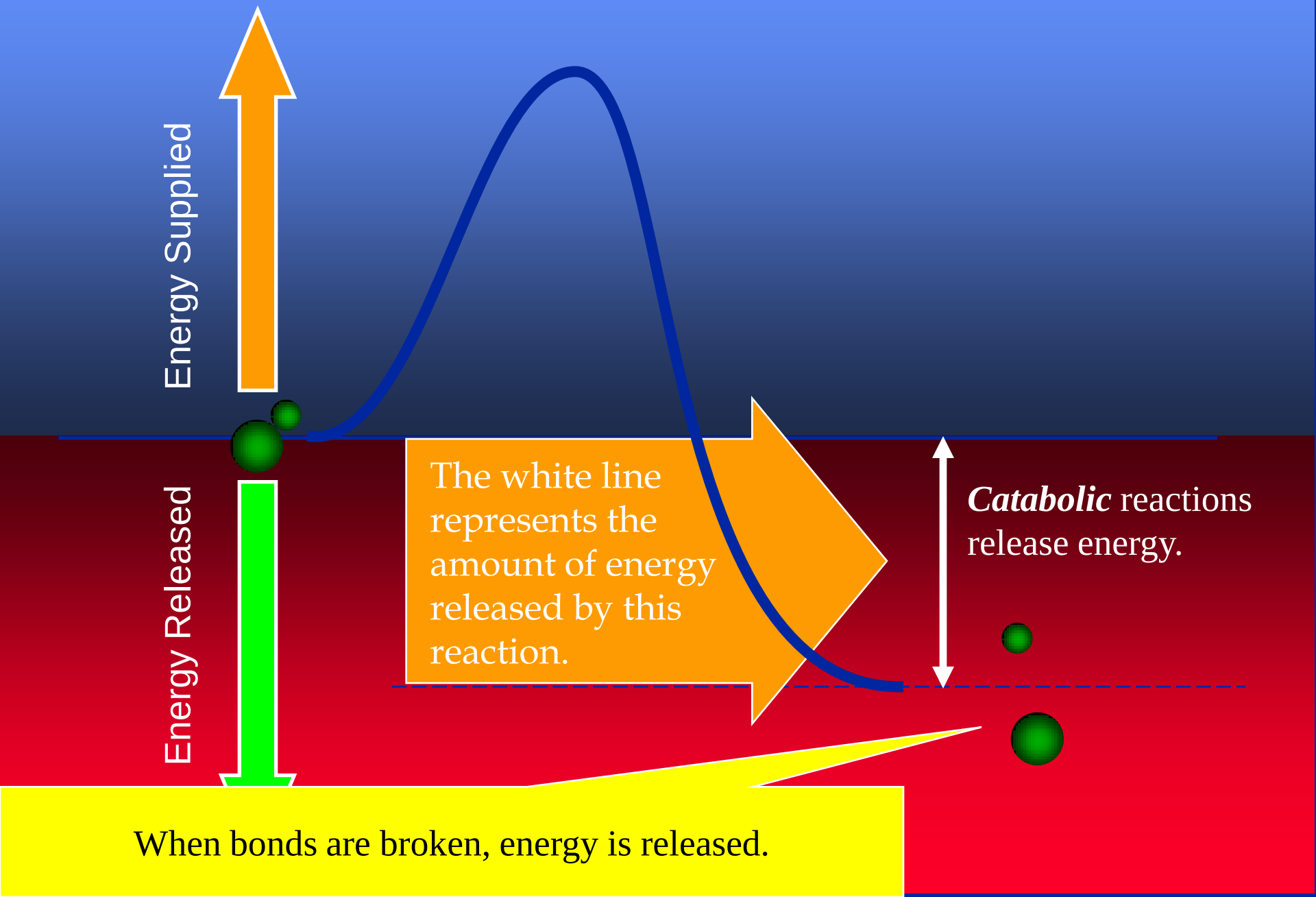
During anabolic reactions, substrate molecules are bonded together to produce products. This graph shows that energy is supplied.

Substrates

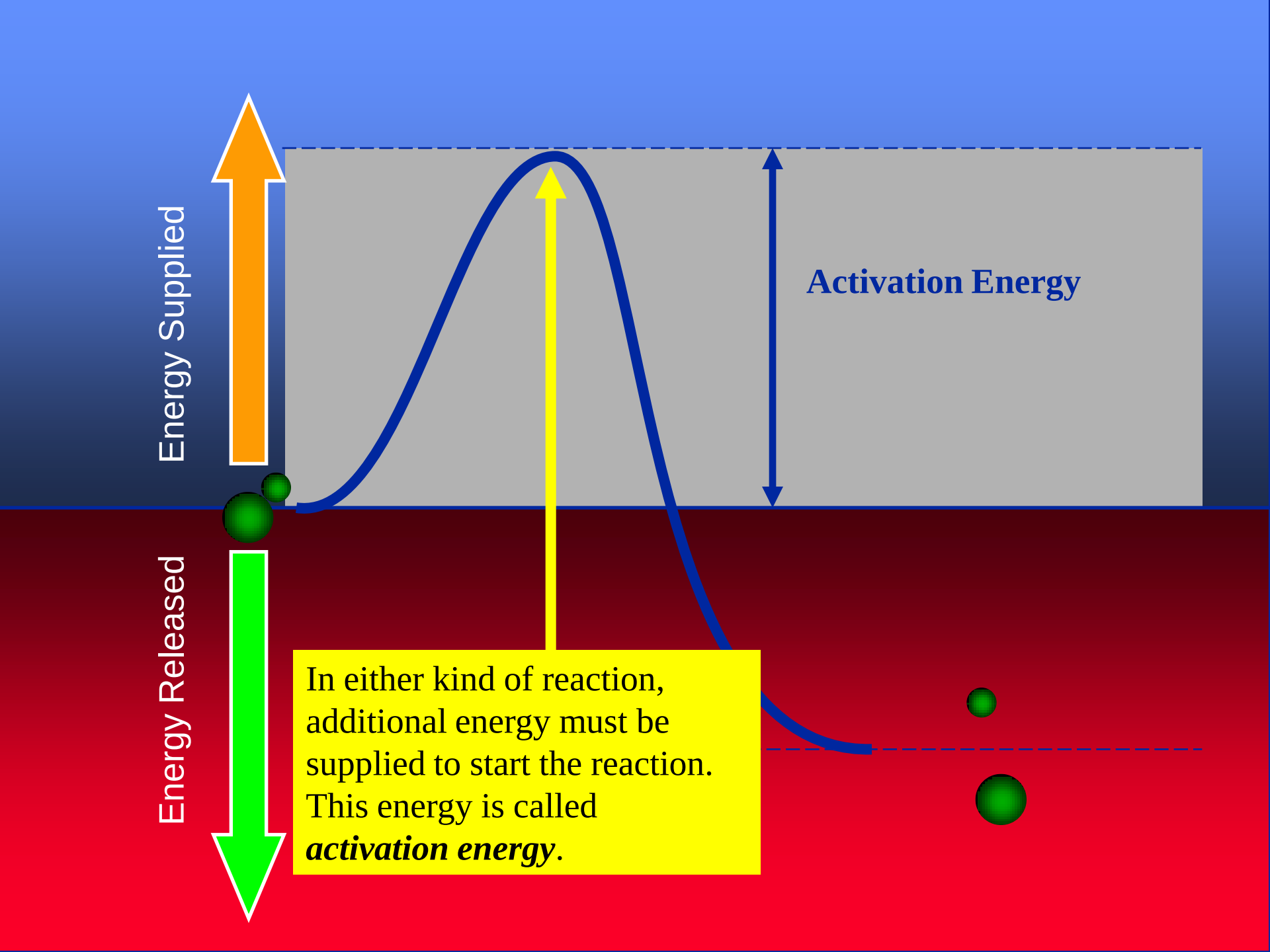
Anabolic Reactions Consume Energy

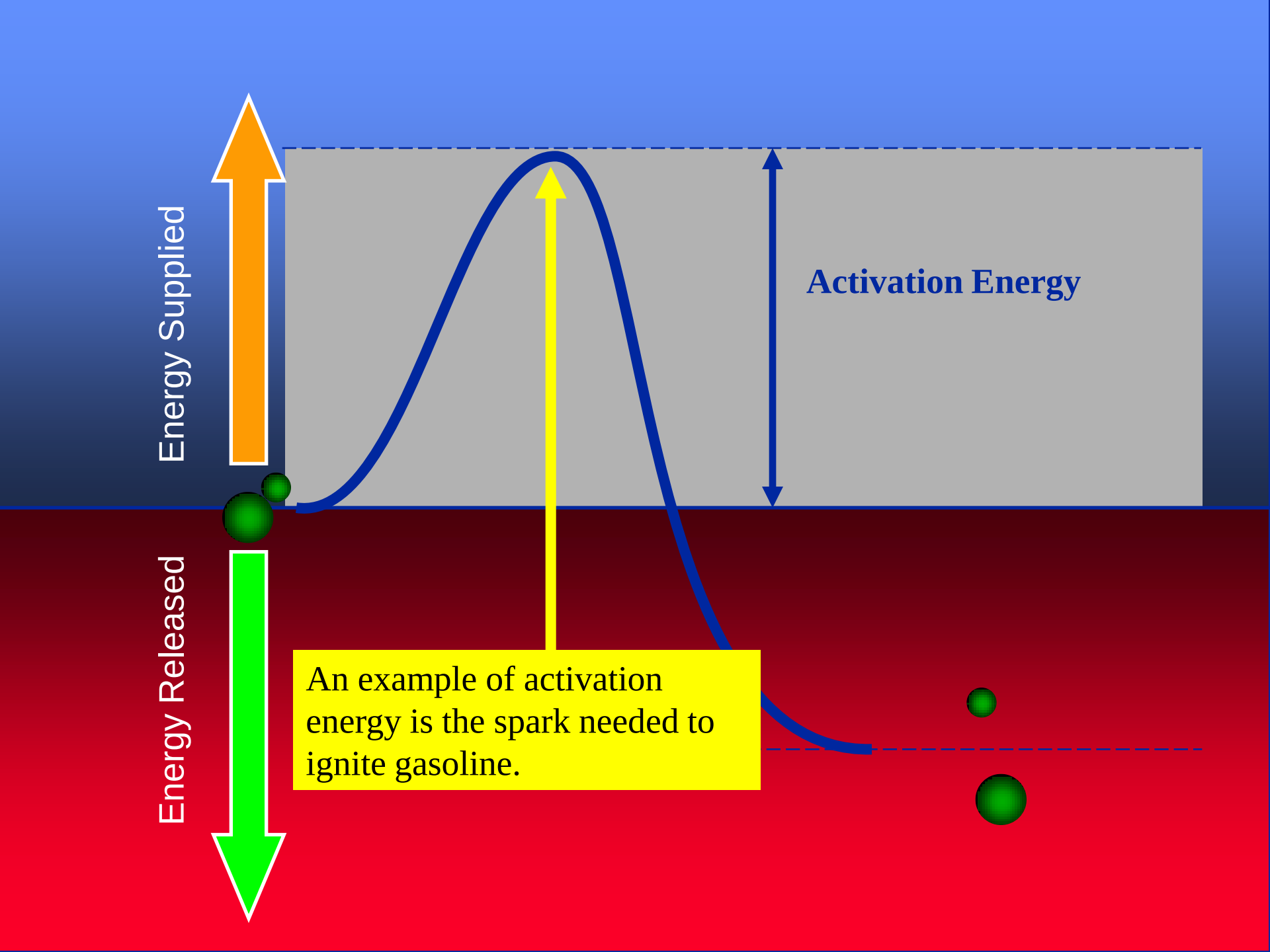


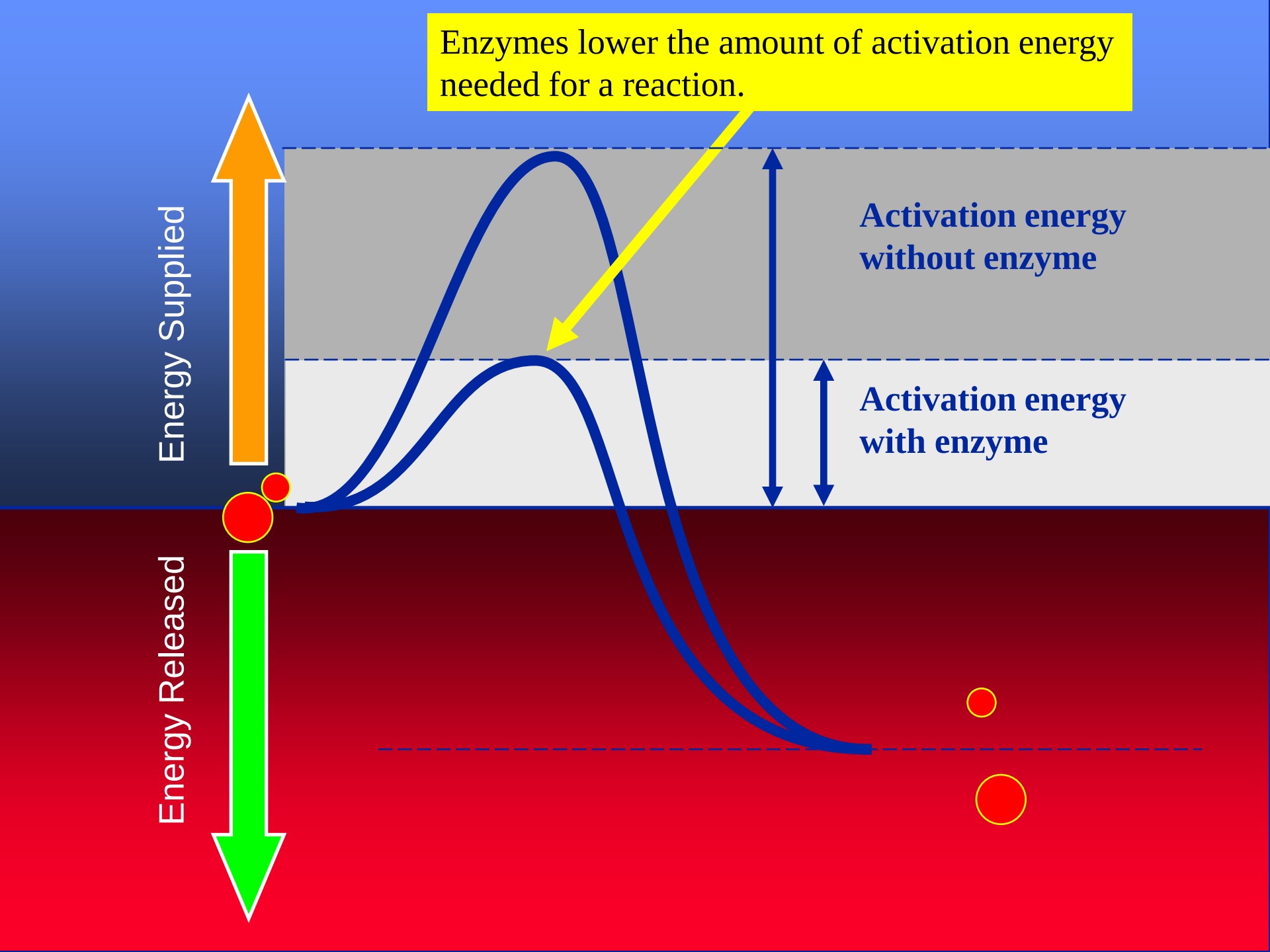
Catabolic Reactions Release Energy



When bonds are broken, energy is released.


Energy Supplied
Activation Energy
Energy Released
In either kind of reaction, additional energy must be supplied to start the reaction. This energy is called *activation energy*.

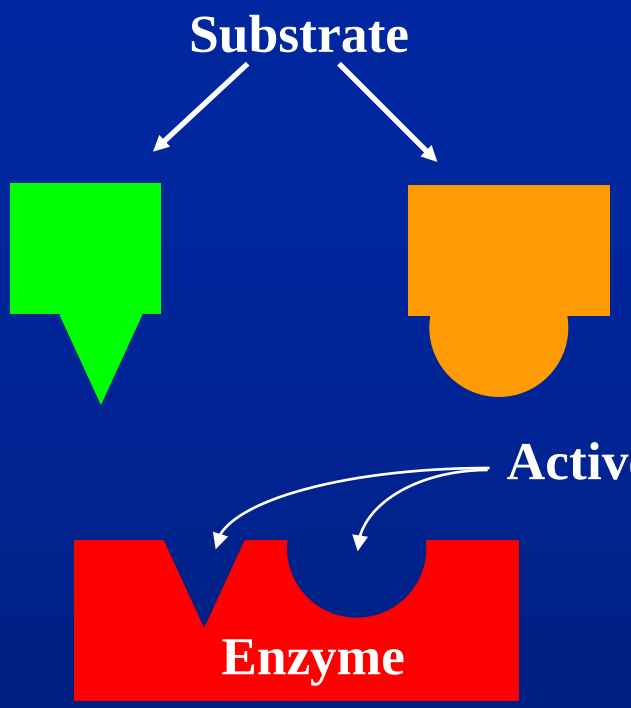

Energy Supplied
Activation Energy
Energy Released
An example of activation energy is the spark needed to ignite gasoline.


Enzymes lower the amount of activation energy needed for a reaction.
Energy Supplied
Energy Released
Activation energy without enzyme
Activation energy with enzyme

Enzymes

- Catalysts are substances that speed up chemical reactions. Organic catalysts (contain carbon) are called ***enzymes***.
- Enzymes are specific for one particular reaction or group of related reactions.
- Many reactions cannot occur without the correct enzyme present.
- They are often named by adding "ase" to the name of the substrate. Example: Dehydrogenases are enzymes that remove hydrogen.

Enzymes



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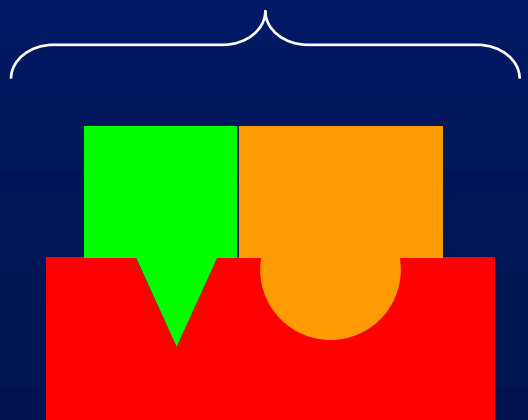
- Enzymes are organic catalysts.
- The shape of the active site matches the substrate.

Enzyme-Substrate Complex



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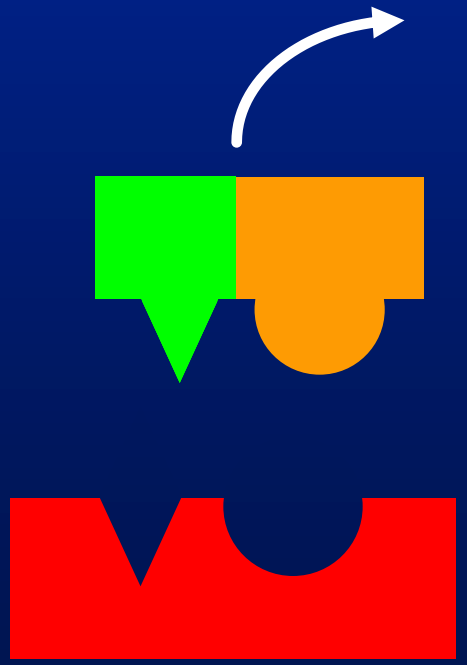
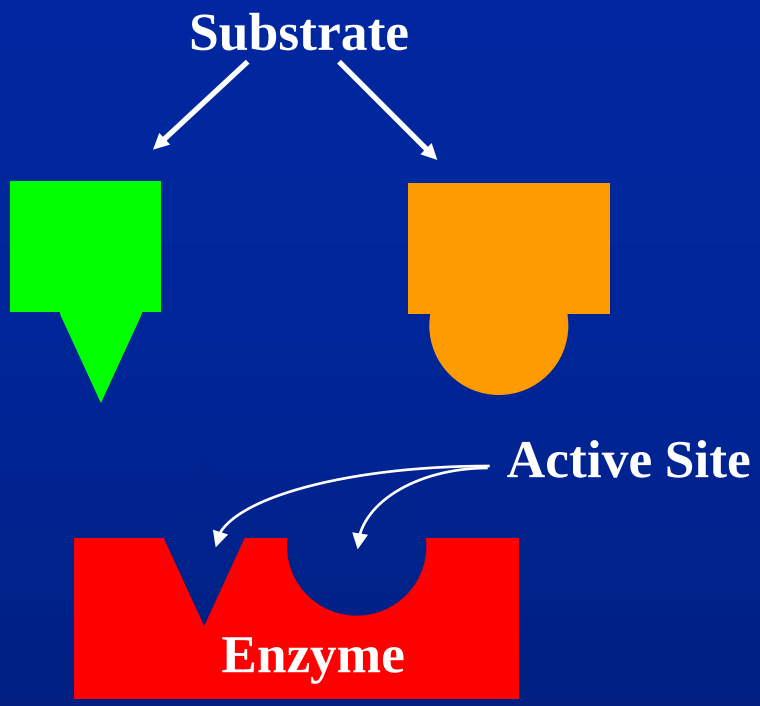


Enzymes



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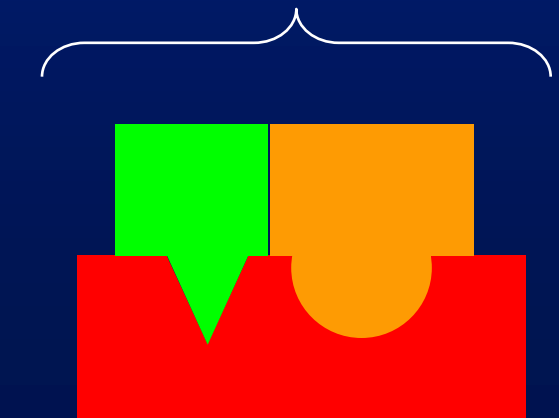
The enzyme is not changed during the reaction. As a result, the enzyme can be reused. Only a small amount of enzyme is needed because the enzyme can be used repatedly.



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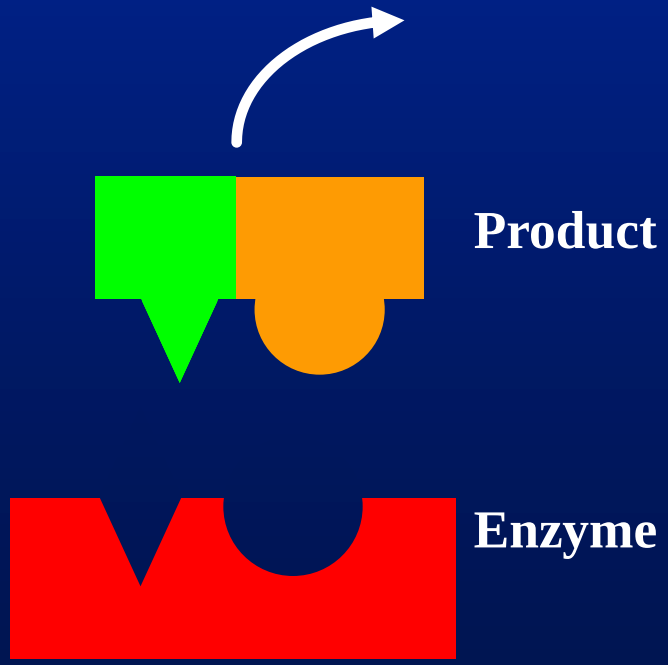
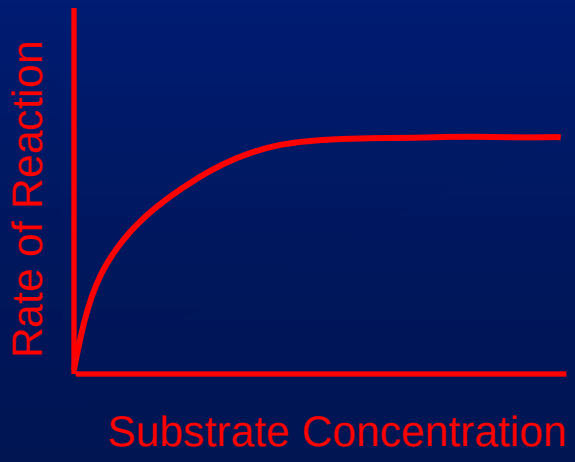


Rate of Reaction

- Reactions with enzymes are up to 10 billion times faster than those without enzymes.
- Enzymes typically react with between 1 and 10,000 molecules per second. Fast enzymes catalyze up to 500,000 molecules per second.
- Substrate concentration, enzyme concentration, Temperature, and pH affect the rate of enzyme reactions.

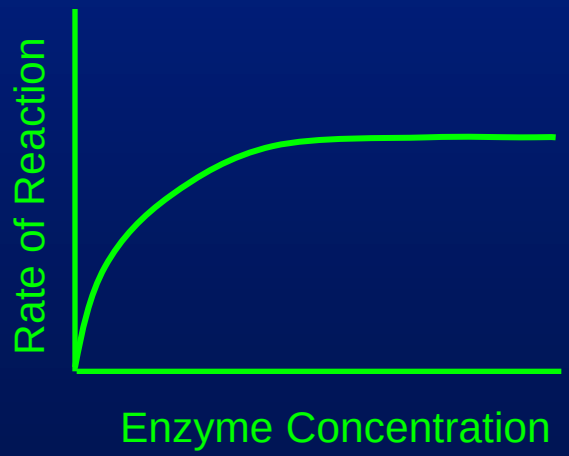
Substrate Concentration

- At low substrate concentration, the active sites on most of the enzyme molecules are not filled because there is not much substrate. Higher concentrations of substrate molecules result in faster reactions.
- The maximum velocity of a reaction is reached when the active sites are continuously filled. Increased substrate concentration beyond this point will not increase the rate of reaction.



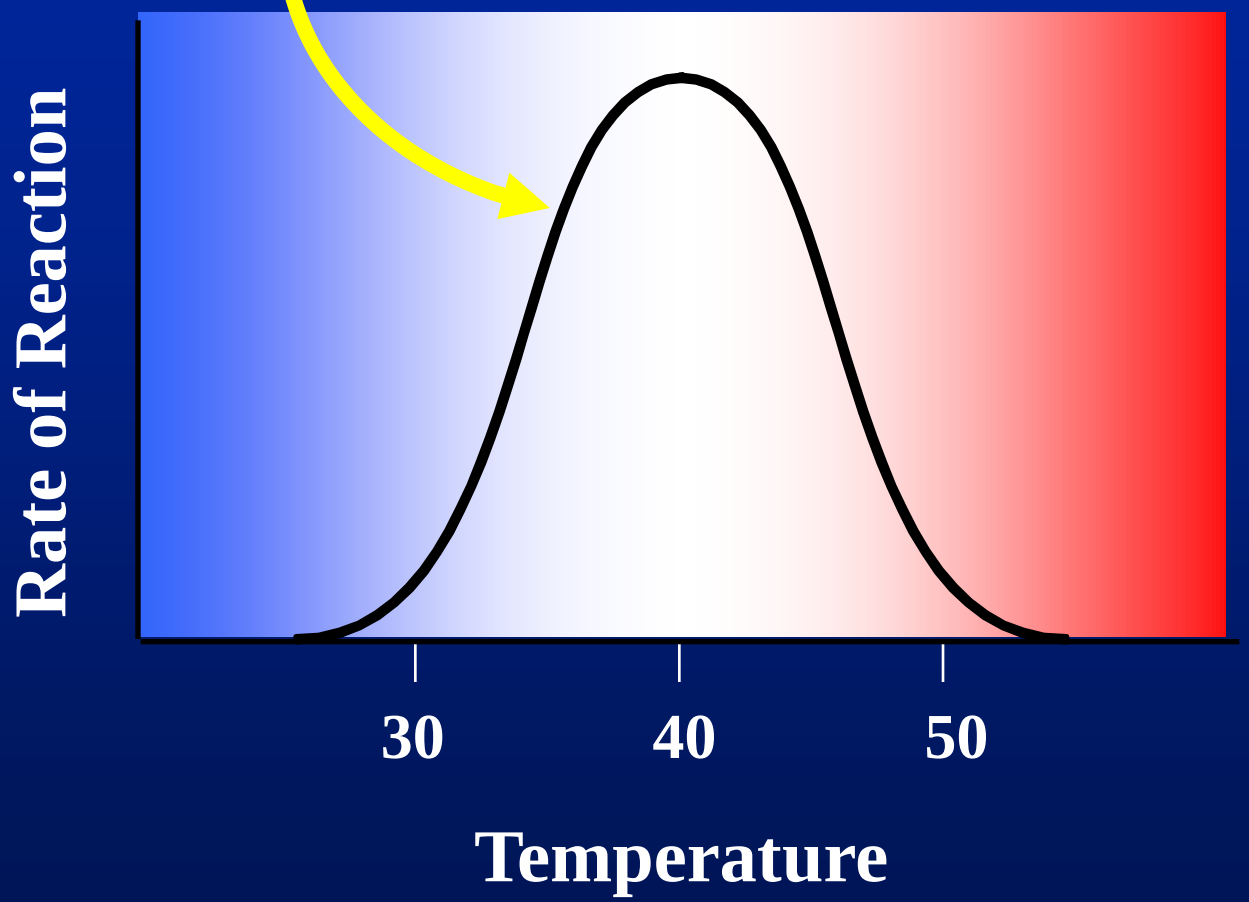
Enzyme Concentration

- If there is insufficient enzyme present, the reaction will not proceed as fast as it otherwise would because there is not enough enzyme for all of the reactant molecules.
- As the amount of enzyme is increased, the rate of reaction increases. If there are more enzyme molecules than are needed, adding additional enzyme will not increase the rate.



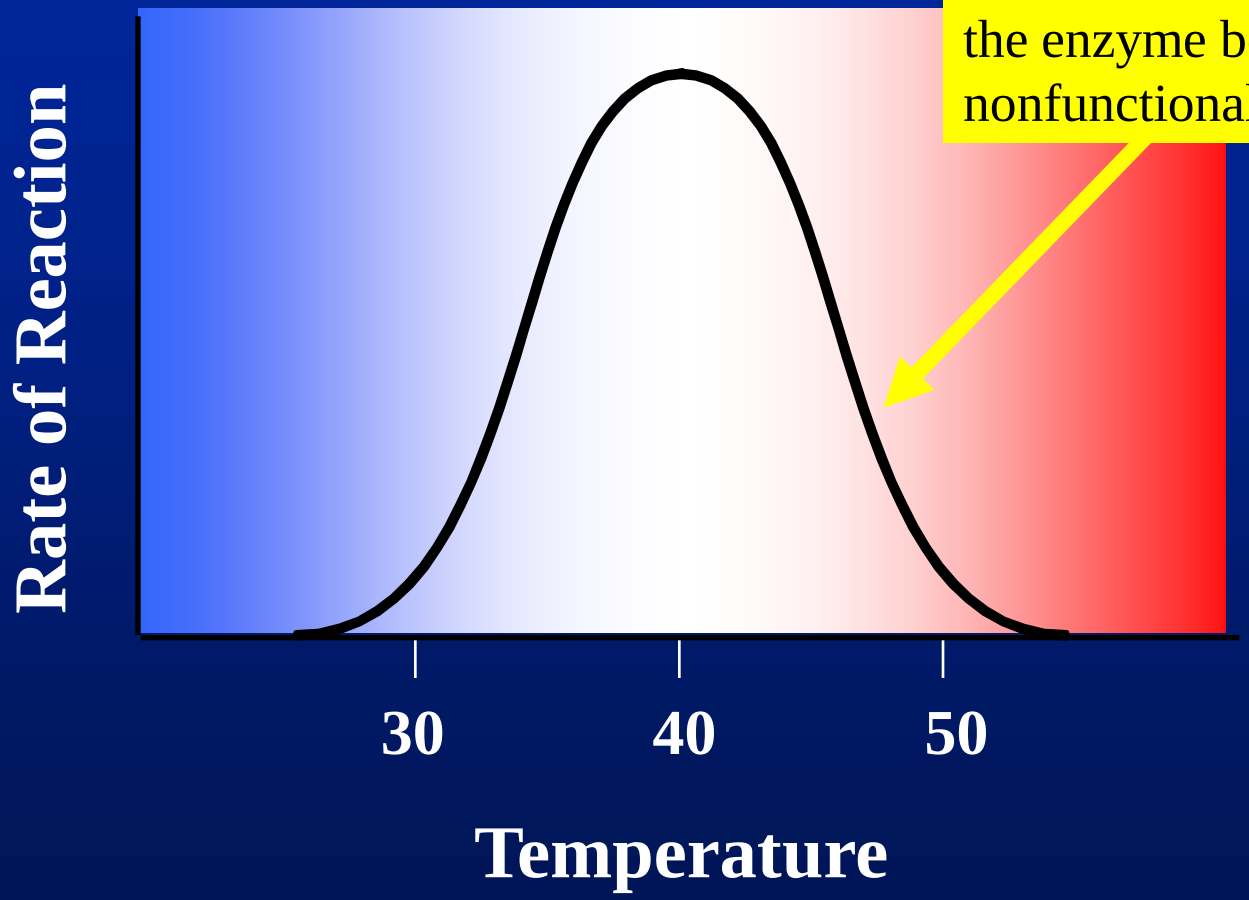
nzyme Activity

Increasing the temperature causes more collisions between substrate and enzyme molecules. The rate of reaction therefore increases as temperature increases.



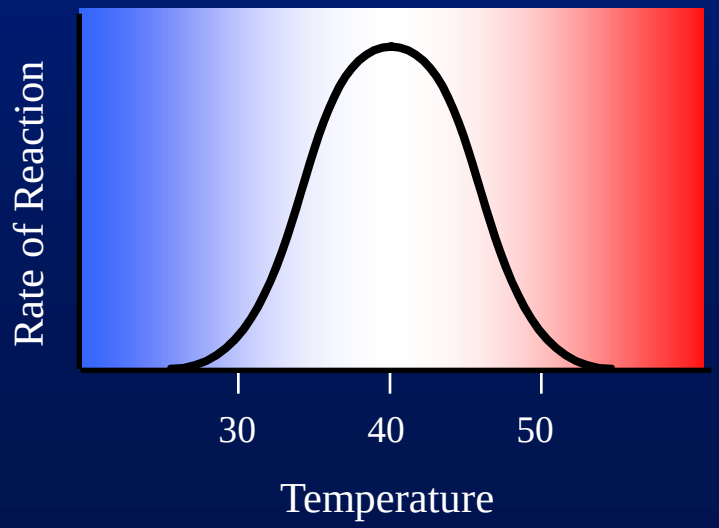
Effect of Temperature on Enzyme Activity

Enzymes denature when the temperature gets too high. The rate of reaction decreases as the enzyme becomes nonfunctional.



Temperature

- Higher temperature causes more collisions between the atoms, ions, molecules, etc. It therefore increases the rate of a reaction. More collisions increase the likelihood that substrate will collide with the active site of the enzyme.
- Above a certain temperature, activity begins to decline because the enzyme begins to denature (unfold).
- The rate of chemical reactions therefore increases with temperature but then decreases.

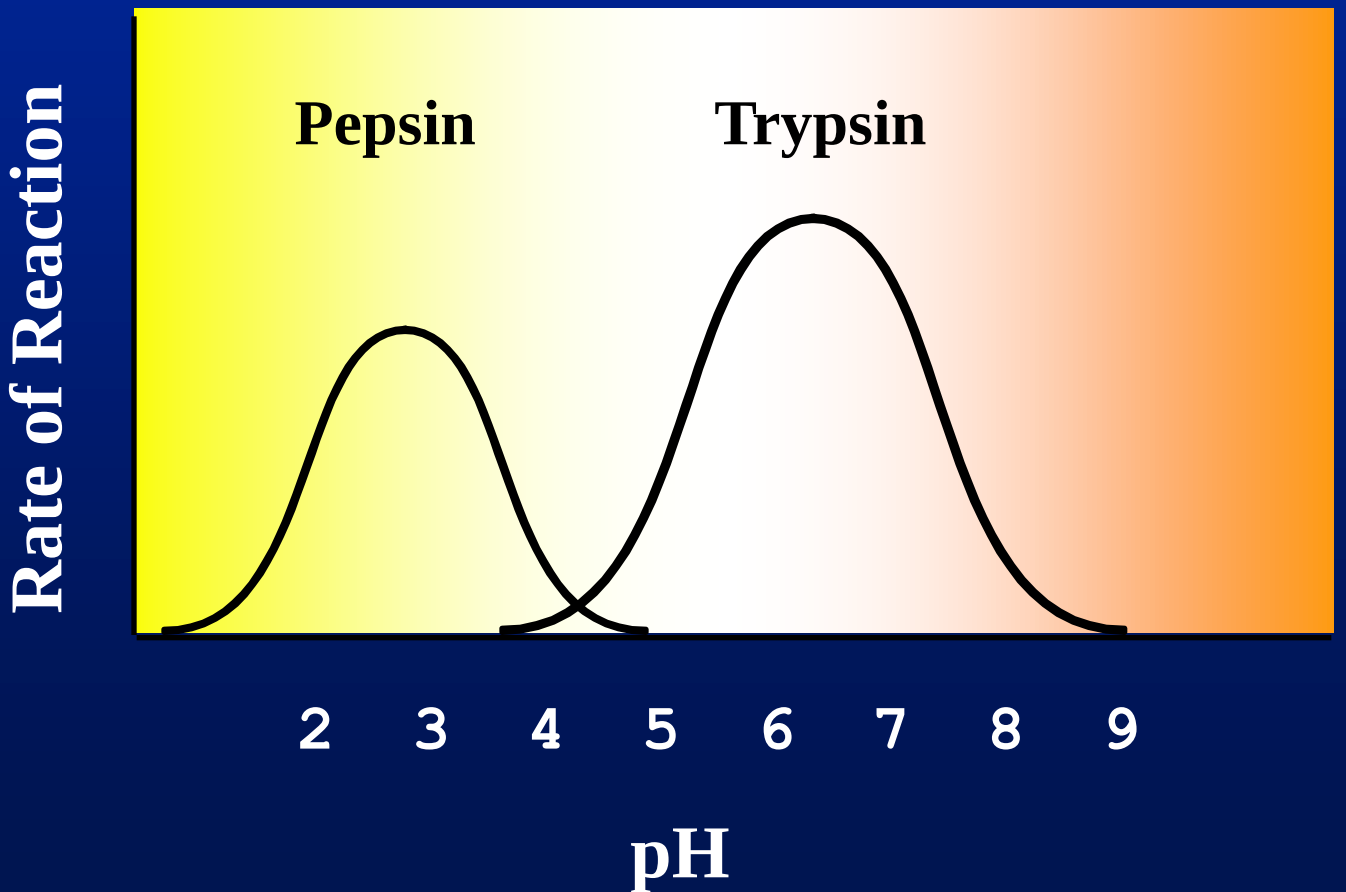


Denaturation

- If the hydrogen bonds within an enzyme are broken, the enzyme may unfold or take on a different shape. The enzyme is ***denatured***.
- A denatured enzyme will not function properly because the shape of the active site has changed.
- If the denaturation is not severe, the enzyme may regain its original shape and become functional.
- The following will cause denaturation:
  - Heat
  - Changes in pH
  - Heavy-metal ions (lead, arsenic, mercury)
  - Alcohol
  - UV radiation

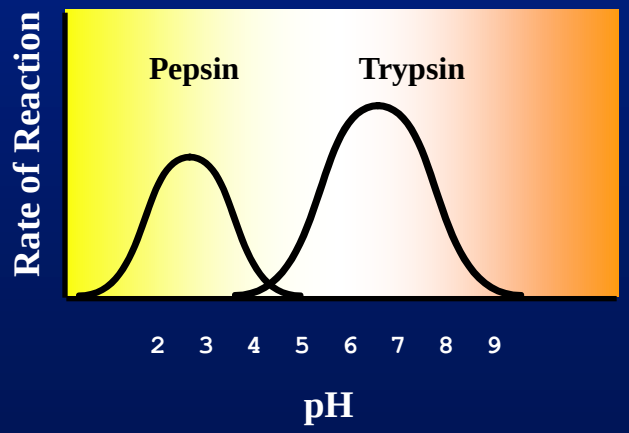
Effect of pH on Enzyme Activity

- Each enzyme has its own optimum pH.



pH

- Each enzyme has an optimal pH. Pepsin, an enzyme found in the stomach, functions best at a low pH. Trypsin, found in the intestine, functions best at a neutral pH.
- A change in pH can alter the ionization of the R groups of the amino acids. When the charges on the amino acids change, hydrogen bonding within the protein molecule change and the molecule changes shape. The new shape may not be effective.



Optimum pH of Some Enzymes

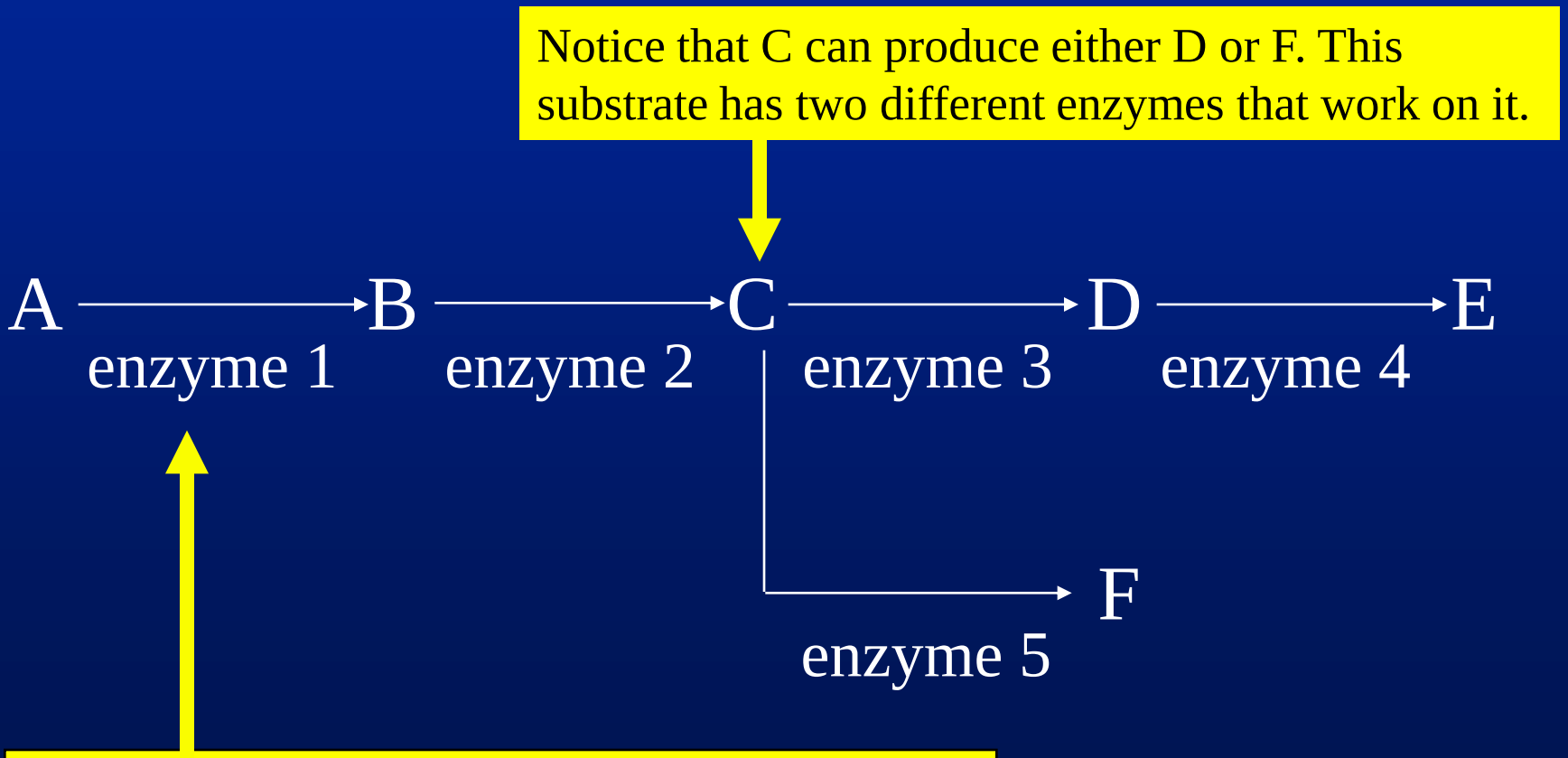
This table shows the pH that is best for several different enzymes. Notice that different enzymes have different optimum pHs.

• Pepsin	1.5 - 1.6
• Invertase	4.5
• Maltase	6.1 - 6.8
• Amylase (pancreas)	6.7 - 7.0
• Catalase	7.0
• Urease	7.0
• Trypsin	7.8 - 8.7
• Lipase (pancreas)	8.0

from http://www.worthingtonweb.com/introbiochem/effectspH.html

Metabolic Pathways

- ***Metabolism*** refers to the chemical reactions that occur within cells.
- Reactions occur in a sequence and a specific enzyme catalyzes each step.



The End