AP BIOLOGY · UNIT 3 · TOPIC 3.1

# Enzymes · Lowering Activation Energy

*Learning objective 3.1.A Explain how enzymes catalyze reactions by lowering the activation energy, and what that does and does not change.*

Name: Date: Period:

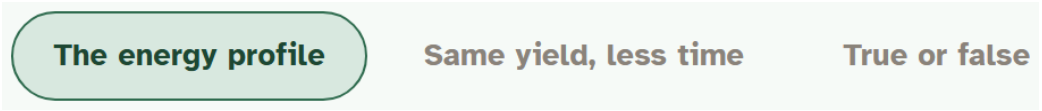
Use the tool **Lowering the Hill**. Work on **The energy profile** tab for Parts 1 to 3, **Same yield, less time** for Part 4, and **True or false** for Part 5. Many of the questions ask what an enzyme does **not** change, so record the readouts that stay the same as carefully as the one that changes.

*switch tab* *scroll down* *predict first*

*record from the tool* *score yourself*

*The purple bar in the margin names the AP science practice a question uses.*

## Part 1 · Add the enzyme and watch the readouts




Use **The energy profile** tab. It is the one showing when the tool opens.

Select an **exergonic** reaction, with no enzyme added. Record all four readouts, then press **Add the enzyme** and record them again.

| | Activation energy | Reactant level | Product level | ΔG |
|---|---|---|---|---|
| Without enzyme | | | | |
| With enzyme | | | | |
| Changed?<br>*circle one* | yes / no | yes / no | yes / no | yes / no |

SP 4 · REPRESENTING AND DESCRIBING DATA

**1. When the enzyme was added, one of the four readouts changed.**
**(a) Identify the readout that changed.**

**(b) Identify the three readouts that did not change.**

SP 1 · CONCEPT EXPLANATION

**2. (a) Describe what activation energy is.**

**(b) Describe where activation energy is measured on an energy profile.**

## Part 2 · Why a lower barrier is faster

Stay on **The energy profile** tab and scroll down to the **Why a lower barrier means a faster reaction** section.

Open **Why a lower barrier means a faster reaction** and record the rows of its table for activation energies of 70, 45 and 15.

| Activation energy | Share of collisions with enough energy | Relative rate |
|---|---|---|
| 70 | | |
| 45 | | |
| 15 | | |

**3. Explain how lowering the activation energy increases the rate of a reaction. In your answer, refer to collisions between molecules.**

**4. A student claims that an enzyme speeds up a reaction by giving the substrate molecules more energy. Explain why the student's claim is incorrect.**

SP 6 · ARGUMENTATION

## Part 3 · Both kinds of reaction

Stay on **The energy profile** tab.

Select an **endergonic** reaction. If the enzyme button reads Take the enzyme away, press it so that no enzyme is present. Record ΔG and the activation energy, then press Add the enzyme and record both again. In the last column, write Yes or No and the two activation energies, for example Yes, 45 → 15. Copy the Exergonic row from Part 1.

| Reaction | ΔG without enzyme | ΔG with enzyme | Activation energy falls? *circle one* |
|---|---|---|---|
| Exergonic | | | yes / no |
| Endergonic | | | yes / no |

**5. (a) Describe the effect of adding the enzyme on the ΔG of the endergonic reaction.**

**(b) Explain what this result shows about whether an enzyme can change a reaction from endergonic to exergonic.**

**6. An exergonic reaction is spontaneous. Explain why a spontaneous reaction does not necessarily happen quickly.**

## Part 4 · Same yield, less time

First, on **The energy profile** tab, select an exergonic reaction.




Click the **Same yield, less time** tab at the top of the tool.

Both flasks start with 100 units of substrate. Press Reset. **Write your predictions in the table before you press Run both.**

| | Final product (predict) | Final product (actual) | Steps to finish |
|---|---|---|---|
| No enzyme | | | |
| With enzyme | | | |

SP 4 · REPRESENTING AND DESCRIBING DATA

**7. (a) Describe how the curve for the flask with the enzyme differs from the curve for the flask without the enzyme.**

**(b) Describe how the two curves are the same.**

SP 6 · ARGUMENTATION

**8. The yield of a reaction is the final amount of product. Based on the Part 4 results, explain why the enzyme changed the rate of the reaction but not its yield.**

## Part 5 · Judge the claims




Click the **True or false** tab at the top of the tool.

Work all six claims, pressing Next claim after each one. Then answer questions 9 to 11 in complete sentences.

SP 1 · CONCEPT EXPLANATION

**9. Identify three things that do not change when an enzyme catalyzes a reaction.**

SP 6 · ARGUMENTATION

**10. A student claims that an enzyme can make an endergonic reaction release energy. Evaluate the student's claim.**

**11. A reaction is catalyzed by an enzyme. Researchers double the amount of enzyme and keep the amount of substrate the same.**
**(a) Predict the effect of doubling the amount of enzyme on the final amount of product. Justify your prediction.**

**(b) Predict the effect of doubling the amount of enzyme on the time the reaction takes to finish. Justify your prediction.**

## Part 6 · Learning check self-report

Scroll down to the **Learning check** at the bottom of the tool. Type an answer to each question, check it against the rubric, and check off the points you earned. Then record your score here and, for every point you did not earn, write what the rubric asked for that your answer left out.

| Question | Points possible | Points I earned | Missed opportunities (what the rubric wanted that I left out) |
|---|---|---|---|
| 1 | 2 | | |
| 2 | 2 | | |
| 3 | 3 | | |
| 4 | 3 | | |
| **Total** | **10** | | |

## What the model simplifies

Energy is in arbitrary units. Real activation energies and free energy changes are measured in kilojoules per mole, and the numbers here are chosen so the diagram reads clearly rather than to match any particular reaction.

The share of collisions with enough energy is calculated with a Boltzmann-style exponential. That gives the right shape (a small drop in the barrier producing a large rise in rate) without pretending to real temperatures or real units.

The energy profile is drawn as a single smooth hump. Real reactions often pass through several intermediates and have several humps.

Both flasks react at a rate proportional to how much substrate is left, so both curves flatten as they approach completion. Real enzyme kinetics also saturate as substrate concentration rises, which Topic 3.2 covers.