AP BIOLOGY · UNIT 2 · TOPIC 2.9

# Cell Compartmentalization

*Learning objectives 2.9.A Describe the membrane-bound structures of the eukaryotic cell. 2.9.B Explain how internal membranes and membrane-bound organelles contribute to compartmentalization of eukaryotic cell functions.*

Name: Date: Period:

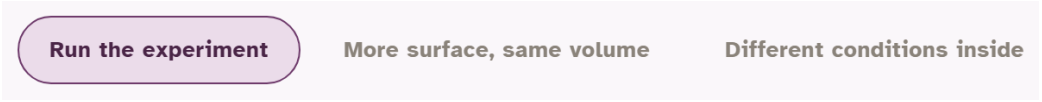
Use the tool **Why Cells Have Rooms**. Work on the **Run the experiment** tab for Parts 1 and 2, **More surface, same volume** for Part 3, and **Different conditions inside** for Part 4. Record every number in the tables, because the questions use them as evidence. Where a Part asks for a prediction, write the prediction before you use the tool to check it.

*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 · The experiment




Use the **Run the experiment** tab. It is the one showing when the tool opens.

The model has one substrate and two enzymes that work at the same rate. One enzyme converts the substrate to the product the cell needs; the other converts it to waste. The only variable is the percentage of the substrate enclosed in a compartment with the first enzyme. Predict the product for the 100% row before you move the slider, and leave the other cells of the predict column blank.

| Enclosed | Product (predict) | Product (actual) | Waste | Substrate left |
|---|---|---|---|---|
| 0% | | | | |
| 25% | | | | |
| 50% | | | | |
| 75% | | | | |
| 100% | | | | |

SP 1 · CONCEPT EXPLANATION

**1. At 0% enclosed, the amounts of product and waste were equal. Explain why, given that the two enzymes work at the same rate.**

## Part 2 · Argue from the result

Stay on the **Run the experiment** tab.

SP 4 · REPRESENTING AND DESCRIBING DATA

**2. (a) Calculate the sum of the actual product, the waste and the substrate left for two rows of the Part 1 table.**

**(b) Explain why the sum is the same in every row.**

**3. Enclosing all of the substrate nearly doubled the product, with the same substrate, the same enzymes and the same time. Explain the source of the extra product.**

**4. At 0% enclosed, the compartment model gives the same result as a cell with no compartments. Justify the use of the 0% enclosed condition as a control.**

**5. Based on the results in the Part 1 table, explain how compartmentalization allows a cell to carry out incompatible reactions at the same time.**

## Part 3 · Surface without size

Run the experiment | **More surface, same volume** | Different conditions inside

Click the **More surface, same volume** tab at the top of the tool.

Click through all four configurations.

| Configuration | Total membrane area | Volume | Area per unit volume |
|---|---|---|---|
| No internal membranes | | | |
| A few internal membranes | | | |
| Extensive internal membranes | | | |
| Mitochondrial cristae | | | |

SP 1 · CONCEPT EXPLANATION

**6. (a) Describe the effect of increasing the membrane area on the volume in the Part 3 table.**

**(b) Explain why adding membrane area without adding volume is important to a cell.**

**7. (a) Explain how internal membranes increase the surface area available for reactions.**

**(b) Identify one organelle in which internal membranes increase the surface area for a reaction, and identify that reaction.**

**8. Topic 2.2 used the same surface area-to-volume argument. Describe how the use of the argument in this topic differs from its use in Topic 2.2.**

## Part 4 · Conditions unlike the cytosol




Click the **Different conditions inside** tab at the top of the tool.

Click through every compartment. The cytosol is at pH **7.2**.

| Compartment | Internal pH | Difference from cytosol | What it holds |
|---|---|---|---|
| Lysosome | | | |
| Mitochondrion (matrix) | | | |
| Chloroplast (stroma) | | | |
| Nucleus | | | |
| Cytosol | | | |

**9. (a) Describe one reason that a lysosome must be enclosed by a membrane.**

**(b) Describe a second, different reason that a lysosome must be enclosed by a membrane.**

**10. Explain how a membrane makes it possible for a compartment to hold a concentration of a substance that is different from the cytosol's.**

SP 6 · ARGUMENTATION

Scroll down to **The three advantages** on the same tab. For each claim, pick the result that is evidence for it and click **Check my evidence**. Then answer question 11.

**11. A cell's internal membranes are damaged, so its compartments leak.**
**(a) Predict one consequence of the damage for reactions that compete for the same substrate.**

**(b) Predict one consequence of the damage for reactions that take place on internal membranes.**

**(c) Predict one consequence of the damage for compartments that keep conditions different from the cytosol.**

## Part 5 · 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 | 2 | | |
| 4 | 2 | | |
| **Total** | **8** | | |

## What the model simplifies

The competing-reaction model uses two enzymes with equal rate constants acting on one substrate. Real competing pathways differ in rate, and a real cell has many more than two.

Enclosure is modeled as a clean fraction: substrate is either shut in with the wanted enzyme or out in the cytosol with both. Real compartments leak, and substrates are imported and exported continuously.

Membrane area is expressed as a multiple of the plasma membrane area. The figures for internal membrane are illustrative, though the direction and order of magnitude are right: a liver cell really does have many times more internal membrane than plasma membrane.

pH values are representative resting figures. They vary between cell types, between organisms, and with what the compartment is doing at the time.