Lab 9: Enzymes & Metabolism

BIOL-8

Name: _____ **Date:** _____

Name: _____ **Date:** _____

Objectives

By the end of this lab, you will be able to:

- **Define enzymes** and explain their role as biological catalysts.
- **Investigate** how environmental factors (temperature, pH, substrate concentration) affect enzyme activity.
- **Calculate** Basal Metabolic Rate (BMR) and understand daily energy needs.
- **Compare** aerobic and anaerobic cellular respiration.
- **Trace** the flow of energy from food to ATP.

Introduction

Enzymes are proteins that act as biological catalysts—they speed up chemical reactions in the body without being consumed. Without enzymes, the reactions that sustain life would occur too slowly to keep us alive.

Each enzyme is specific to a particular **substrate** (the molecule it acts on). The enzyme's shape, specifically its **active site**, fits the substrate like a key fits a lock.

In this lab, you will explore **catalase**, an enzyme found in liver cells (and many other tissues). Catalase protects cells by breaking down hydrogen peroxide (H_2O_2), a toxic byproduct of metabolism, into harmless water (H_2O) and oxygen gas (O_2).

$$ 2H_2O_2 \xrightarrow{Catalase} 2H_2O + O_2 (gas) $$

The bubbles you see when you pour peroxide on a cut are the oxygen gas being released!

Part 1: Catalase Enzyme Activity

> ***Dashboard Tool:*** *Use the* ***Catalase Enzyme Lab*** *section.*

In this simulation, you will add hydrogen peroxide to liver tissue and measure the rate of oxygen bubble production.

Experiment A: Effect of Temperature

1. Set **pH** to 7.0 and **Substrate** to 50%.
2. Run the experiment at the following temperatures and record the reaction rate (Bubbles/min).
3. Alternatively, use the "Run Temperature Sweep" button to generate a graph.

Temperature Data

#	Temperature (°C)	Reaction Rate (Bubbles/min)	Enzyme Status (Active/Denatured)
1			
2			
3			
4			
5			
6			

> **1. What was the optimal temperature for catalase activity? Why does this make sense for a human enzyme?**

2. What happened to the reaction rate at 80°C? Explain what happened to the enzyme molecule using the term "denatured".

Experiment B: Effect of pH

1. Set **Temperature** to 37°C and **Substrate** to 50%.
2. Run the experiment at pH 3, 7, and 10, or use the "Run pH Sweep" button.

3. At which pH was the enzyme most active?

4. How does the activity at pH 3 compare to pH 7? Why might stomach enzymes (like pepsin) function differently than liver enzymes?

Experiment C: Substrate Concentration

1. Set **Temperature** to 37°C and **pH** to 7.0.
2. Run the experiment with **Substrate** at 10%, 50%, and 100%.

5. Describe the relationship between substrate concentration and reaction rate. Does it keep increasing forever, or does it level off? Explain why.

Part 2: Basal Metabolic Rate (BMR)

> ***Dashboard Tool:*** *Use the* ***BMR Calculator*** *section.*

Your **Basal Metabolic Rate (BMR)** is the amount of energy (calories) your body needs just to stay alive at rest—pumping blood, breathing, and maintaining body temperature.

1. Enter your (or a hypothetical) age, sex, height, and weight.
2. Select an activity level.

BMR Results

#	Metric	Value
1		
2		

6. If you consume more calories than your TDEE, what happens to the excess energy?

7. How does activity level affect your daily calorie needs compared to your BMR?

Part 3: Cellular Respiration (Aerobic vs. Anaerobic)

> ***Dashboard Tool:*** *Use the* ***Aerobic vs Anaerobic*** *section.*

Cells produce ATP (energy) through two main pathways:

1. **Aerobic Respiration**: Requires oxygen, produces lots of ATP with CO_2 and H_2O as waste.
2. **Anaerobic Respiration (Fermentation)**: No oxygen, produces little ATP with **Lactic Acid** as waste.

Run the simulation at different intensities to see when your muscle cells switch pathways.

Respiration Data

#	Activity Intensity	Primary Pathway	ATP Production Rate	Waste Product Accumulation?
1				
2				
3				
4				

8. Why can't you sprint at maximum speed forever? (Hint: Look at the "Lactic Acid" buildup and ATP levels).

9. Which pathway is more efficient at producing ATP from glucose?

Part 4: Metabolic Pathways map

> ***Dashboard Tool:*** *Use the* ***Metabolic Pathway Map****.*

Explore how carbohydrates, fats, and proteins all feed into the same energy-generating pathways.

10. Can proteins be used for energy? If so, where do they enter the pathway?

11. If you eat a zero-fat diet but excess carbohydrates, can your body still store body fat? Use the map to explain how (Hint: Look for connections between Acetyl-CoA and lipids).

Review Questions

12. Why is high fever (above 105°F / 40°C) dangerous to your body's enzymes?

13. Summarize the flow of energy in the body: From Food -> _____ -> ATP -> Work.

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