Biotechnology: CRISPR & Gene Editing

AP Biology · Unit 6: Gene Expression and Regulation

The Teaching Analogy

"Bacteria have been fighting viruses for billions of years — every time a virus attacked, bacteria saved a copy of its DNA as a mugshot file. Then Cas9 uses that file like GPS coordinates to find and cut the exact same sequence in any genome. CRISPR is a stolen bacterial immune system."

Key Concept

CRISPR-Cas9 is a bacterial immune defense system adapted for gene editing. Guide RNA (gRNA) acts as GPS coordinates, directing the Cas9 enzyme to a precise DNA sequence where it makes a targeted cut. Scientists Jennifer Doudna and Emmanuelle Charpentier won the 2020 Nobel Prize for reprogramming these coordinates to edit any gene in any organism.

Guided Practice

1. In the mugshot file analogy, what does the "mugshot file" represent in actual CRISPR biology? What molecule holds that information and how does it match the target DNA?
2. If Cas9 is the "scissors," what is the "GPS system" that directs it to the right location? How does changing the GPS coordinates let scientists target a different gene?
3. A student asks: "Why do bacteria keep viral DNA if viruses are dangerous?" Using the mugshot analogy, explain why storing this information is adaptive — and how it prevents future infections.

Extension Activity

Have students design a hypothetical CRISPR guide RNA to correct a single-nucleotide mutation causing sickle cell disease. Students must (1) identify the target sequence in the normal beta-globin gene, (2) design a 20-nucleotide gRNA complementary to it, and (3) predict the cell's repair outcome — NHEJ (deletion/insertion) vs. HDR (precise correction). Discuss why HDR requires a DNA template and when each repair pathway is preferable for therapeutic use.