The Genetic Remix: Understanding CRISPR and the Future of Gene Editing

Materials Needed

- Printed DNA sequence strips (provided in the lesson body)
- Scissors (representing the Cas9 enzyme)
- Tape (representing Ligase/repair mechanisms)
- Highlighters (two different colors)
- Access to a computer/tablet for a short video and research
- "Ethical Dilemma Cards" (outlined in the activity)

Learning Objectives

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

- Explain the biological origin and mechanism of the CRISPR-Cas9 system.
- Simulate the process of identifying, cutting, and replacing a specific gene sequence.
- Critically evaluate the ethical implications of gene editing in humans, agriculture, and the environment.

I. Introduction: The Hook (10 Minutes)

The Scenario: Imagine you could "Search and Replace" a genetic disease just like you do with a typo in a Word document. If you could delete the gene for hereditary blindness, would you? What if you could add a gene that allows humans to see in infrared? Where do we draw the line between "healing" and "hacking"?

The Concept: CRISPR (Clustered Regularly Interspaced Short Palindromic Repeats) is essentially a molecular "GPS and Scissors" system. It was originally a bacterial immune system used to fight off viruses, but scientists have hijacked it to edit the code of life itself.

II. Body: Content and Practice (45 Minutes)

1. "I Do": How CRISPR Works (Direct Instruction)

Think of CRISPR as a two-part tool:

- **The Guide RNA (The GPS):** A custom-built piece of RNA that matches the exact DNA sequence we want to change. It "scouts" the genome until it finds the perfect match.
- **Cas9 (The Scissors):** An enzyme that follows the Guide RNA. Once the GPS finds the destination, the scissors snip the DNA double helix at that exact spot.

Once the DNA is cut, the cell tries to repair it. Scientists can "trick" the cell by providing a new piece of DNA to be stitched into the gap, effectively rewriting the genetic code.

2. "We Do": The Gene-Editing Simulation (Guided Practice)

Let's simulate editing a sequence that causes a (fictional) "Zombification Virus" susceptibility in a strand of DNA.

> **The Target DNA Sequence:**
> `A-T-G-C-C-G-`**`[T-A-G-C-C-T-A]`**`-G-G-A-T-T-A`
>
> **Step 1:** Identify the "Target Mutation" (the sequence in brackets). This is what we want to remove.
> **Step 2:** Create your "Guide RNA." On a separate strip of paper, write the complementary sequence to the target (Remember: in RNA, A pairs with U, and C pairs with G).
> **Step 3:** Use your "Cas9 Scissors" to cut the DNA strip at the beginning and end of the target sequence.
> **Step 4:** Discard the "mutation" and tape in the "Healthy Gene" strip: `[A-T-C-G-G-A-T]`.

3. "You Do": The Bioethics Board (Independent Application)

Choose **one** of the following real-world CRISPR applications to research for 10 minutes. Prepare a 2-minute "pitch" or a short paragraph defending whether this project should be funded or banned.

- **The De-Extinction Project:** Using CRISPR to bring back the Woolly Mammoth by editing elephant DNA.
- **The Malaria Mosquito:** Using a "Gene Drive" to make an entire species of mosquito infertile to wipe out Malaria.
- **The Designer Athlete:** Using gene editing to increase muscle density or oxygen-carrying capacity in human embryos.

III. Conclusion: Closure and Recap (10 Minutes)

Summary: We've learned that CRISPR isn't just science fiction; it's a tool borrowed from bacteria that allows us to precisely edit DNA. We've seen how the Guide RNA directs the Cas9 enzyme to cut DNA, allowing for the deletion or insertion of traits.

Self-Reflection Question: If you were the head of a global ethics board, what is the #1 rule you would create for gene editing? (e.g., "Only for life-threatening diseases," or "No editing traits that affect personality.")

Assessment

Formative (During the lesson): Successful completion of the DNA paper simulation and the ability to explain why the "Guide RNA" must match the target DNA.

Summative (End of lesson): Write a "Social Media Thread" (3-5 posts) explaining CRISPR to a friend who knows nothing about biology. You must use the terms *Guide RNA*, *Cas9*, and *Bioethics* correctly.

Success Criteria

- I can identify the two main components of the CRISPR-Cas9 system.
- I can demonstrate how a DNA strand is cut and repaired using a simulation.
- I can articulate at least two pros and two cons of gene editing technology.

Adaptability & Differentiation

- **For Struggling Learners:** Focus on the "Scissors" analogy. Use color-coded DNA strips where the Guide RNA and the Target Sequence are the same color for easier identification.
- **For Advanced Learners:** Research the *PAM Sequence* (Protospacer Adjacent Motif) and explain why Cas9 won't cut DNA without this specific "security code" nearby.
- **Digital Adaptation:** Use an online tool like the "CRISPR Virtual Lab" (HHMI BioInteractive) instead of the paper simulation.