Future in Our Genes: Exploring CRISPR

Submitted by: Ashley Waycaster, Science
Cedar Bluff Middle School, Knoxville, TN

Target Grade: 7th Grade Science

Time Required: Three 50-minute class periods

Standards

MS-LS3-1: Develop and use a model to describe why structural changes to genes (mutations) may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism.

Clarification: This lesson does not directly address the structure or function of proteins. Instead, it focuses on how mutations in genes can lead to changes that may have varying effects, harmful, beneficial, or neutral, on an organism.

Lesson Objectives

Students will:

1. Model a DNA sequence and simulate gene editing using CRISPR.
2. Explain how gene editing can be used to address genetic disorders.
3. Evaluate and debate ethical considerations of using gene editing in humans.
4. Design and present a PSA with a clear stance on gene editing using scientific and ethical reasoning.

Central Focus

In this three-day lesson sequence, students will explore the scientific and societal implications of CRISPR, a gene-editing technology. The unit begins with a foundational understanding of DNA structure and how CRISPR functions at the molecular level through a hands-on simulation. Students then engage in ethical role-playing scenarios to examine real-world dilemmas involving gene editing, encouraging them to consider multiple perspectives and develop critical thinking skills. The unit culminates in a collaborative Public Service Announcement (PSA) project, where students synthesize their scientific knowledge and ethical reasoning to take a stance on CRISPR's use in society.

Key words: bioethics, genetic technology, ethics, project-based learning

Background Information

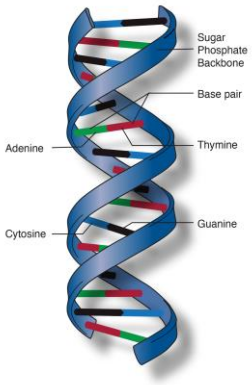
Teacher background information

Before teaching this lesson, it's important to have a solid grasp of the following:

1. DNA Structure & Function

- DNA (deoxyribonucleic acid) is the molecule that carries genetic instructions.

- It's composed of four bases: A (adenine), T (thymine), C (cytosine), G (guanine).
- Base pairing rules: A pairs with T, and C pairs with G.
- Genes are segments of DNA that code for proteins, which determine traits.



2. Mutations
   - Mutations are changes in the DNA sequence.
   - They can be harmless, beneficial, or harmful depending on where they occur and how they affect protein function.
3. CRISPR-Cas9 Technology
   - CRISPR (Clustered Regularly Interspaced Short Palindromic Repeats) is a gene-editing tool adapted from a bacterial immune system.
   - Cas9 is an enzyme that acts like molecular scissors to cut DNA at a specific location.
   - Scientists can use CRISPR-Cas9 to remove, add, or alter sections of DNA with high precision.
4. Ethical Considerations
   - Gene editing raises ethical questions about equity, unintended consequences, and the definition of "normal" or "desirable" traits.

Resources for further exploration:

- https://www.broadinstitute.org/what-broad/areas-focus/project-spotlight/crispr-timeline
- TED-Ed Video – *How CRISPR lets us edit our DNA*: https://youtu.be/2pp17E4E-O8

Common Areas of Confusion & How to Address Them

Potential Confusion	**Clarification Strategy**
Students think CRISPR is like "cut and paste" in Word.	Emphasize that while the concept is similar, gene editing is far more complex and involves biological systems. Use the paper model to simulate the process.
Students may confuse gene editing with cloning or genetic engineering in general.	Clarify that CRISPR is a specific tool for editing genes, not for creating entire organisms or inserting foreign DNA (like GMOs).
Ethical scenarios may feel abstract.	Encourage students to connect scenarios to real-world examples (e.g., sickle cell treatment). Use role-play to make it personal and relatable.
Students may assume CRISPR is widely used already.	Explain that while CRISPR is promising, it's still being tested and regulated, especially for human use.

What to Prepare Before Teaching

Prep Tasks:

- Watch the TED-Ed video yourself to anticipate student questions.
- Print or prepare:
  - DNA model materials (colored paper strips, glue, scissors)
  - Ethical scenario cards (1 per group)

  - Sticky notes or slips of paper
  - PSA planning templates (optional)
- Set up:
  - A board or wall space for sticky note activities
  - A T-chart on the board for Day 1 discussion
  - Devices or art supplies for PSA creation

Student background information

1. Basic Understanding of DNA

Students should know:

- DNA is the molecule that carries genetic information in living things.
- It's made up of four bases: A (adenine), T (thymine), C (cytosine), G (guanine).
- These bases pair up in a specific way: A with T, and C with G.
- DNA is organized into genes, which give instructions for traits like eye color or height.

Tip: A quick review or mini-lesson on DNA structure can help refresh this knowledge before the model activity.

2. What Genes Do

Students should understand:

- Genes are like instructions that tell our bodies how to grow and function.
- Everyone has slightly different versions of genes, which is why we all look and function a little differently.
- Sometimes, genes can have mutations (changes) that cause diseases or disorders.

3. What CRISPR Is (at a Basic Level)

Students don't need to know the full science behind CRISPR, but they should understand:

- CRISPR is a tool scientists use to change DNA.
- It can be used to remove harmful mutations or even add new traits.
- It's still being researched and tested, especially in humans.

The TED-Ed video at the start of the lesson will help introduce this concept in a student-friendly way.

4. Ethical Thinking Skills

Students should be ready to:

- Think about what's right or wrong when it comes to using science to change people's genes.
- Consider different points of view (e.g., a doctor vs. a parent).
- Respectfully discuss complex issues where there may not be one "right" answer.

Materials

- Computer with internet access
- Projector or screen for video and presentations
- TED-Ed video: How CRISPR Lets Us Edit Our DNA
- Sticky notes (at least 3–5 per student)

- Science notebooks or loose-leaf paper
- Slips of paper (for reflections or voting)
- Colored paper strips:
    - 4 distinct colors for DNA bases: A (adenine), T (thymine), C (cytosine), G (guanine)
    - 1 additional color for the DNA backbone
- Scissors
- Glue sticks or tape
- Markers or colored pencils
- Whiteboard or large chart paper
- Printed ethical scenario cards (1 per group), each including:
    - A brief scenario
    - A guiding question
    - Four role prompts: Doctor, Scientist, Lawmaker, Parent
- Optional: Role name tags or labels
- Student devices (laptops/tablets) for digital PSA creation (Google Slides, Canva, video tools)
- Art supplies for physical PSAs:
    - Poster paper
    - Markers, pens, pencils
    - Glue, scissors, rulers
- Optional: PSA planning templates or checklists

Instruction

Day 1 – What Is CRISPR?

Hook (10 min)

- Show the TED-Ed video How CRISPR Lets Us Edit Our DNA.
    - The 4-minute video explains how the CRISPR-Cas9 system, originally a bacterial defense mechanism, has been adapted by scientists as a powerful and precise tool for editing genes in living cells, with wide-ranging applications in research, medicine, and agriculture.
- Ask students: "If science could change one thing about humans, what would you pick?"
- Have students write their ideas on sticky notes and post them on the board.

DNA Model & Simulation (30 min)

- Distribute colored paper strips to each student: A, T, C, G for the bases, and a different color for the DNA backbone.
- Model the DNA structure by showing how to match base pairs (A–T, C–G) and glue them between the backbone strips.
- Illustrate gene editing by identifying a specific "mutated" section in the model (either pre-selected by the teacher or clearly marked on a reference example). Then, show how to cut out that section and replace it with a

"corrected" piece. Emphasize that while real gene editing is more complex, this models how CRISPR targets and edits specific DNA sequences.

- Instruct students to do the same cutting process with their models and then sketch the before-and-after versions in their science notebooks or on paper.

Class Discussion (5 min)

- Draw a T-chart on the board with the headings: "CRISPR Can Help…" and "CRISPR Could Be Risky If…"
- Conduct a think-pair-share by having students think alone about their response, then discuss with a partner, then share with the class.
- Use these guiding questions to support deeper thinking:
    - "CRISPR Can Help…" column:
        - "What diseases do you think scientists might want to cure with CRISPR?"
        - "How could gene editing improve someone's quality of life?"
        - "Could CRISPR help people who are already sick? How?"
        - "What are some ways CRISPR might be used to help animals, plants, or ecosystems?"
    - "CRISPR Could Be Risky If…" column:
        - "What are some possible unintended consequences of editing genes using CRISPR?"
        - "How might CRISPR affect ecosystems if used in wild populations?"
        - "In what way could CRISPR be misused?"
        - "Should we use CRISPR for non-medical reasons? What might those be?"
        - "Could changing our genes change what it means to be human? Why or why not?"

Closure (5 min)

- Prompt students with: "Has your thinking about CRISPR or gene editing changed after today's lesson? What's one new idea or question you have now?"
- Have students respond to the prompt using one of the following options:
    - Revise their original sticky note to reflect any new thoughts.
    - Write a 2–3 sentence reflection in their notebook or on a slip of paper.
- (Optional) Invite a few students to share their updated ideas or questions with the class.

<u>Day 2 – Ethics in Action</u>

Hook (5–10 min)

- Begin by asking students: "Should parents be allowed to choose their child's traits (eye color, height, intelligence)?"
- Have students turn and talk with a partner, then invite volunteers to share.
- Follow up by asking: "What if instead of choosing a trait, the gene editing is to fix a disease?"
- Allow students to share their answers.

Ethical Scenario Role-Play (25–30 min)

- Divide students into groups of four and give each group a printed scenario card.
    - Each card presents a different CRISPR-related ethical dilemma: preventing a genetic disease, selecting traits like eye color or intelligence, enhancing soldiers, preventing disabilities, editing animals, or extending human life.
    - Every card includes:
        - A brief scenario describing the situation.
        - A big question to guide discussion.
        - And role prompts for four perspectives: Doctor, Scientist, Lawmaker, and Parent.
- Assign each student a role: Scientist, Parent, Lawmaker, or Doctor.
- Have them discuss their scenario from their assigned perspective and list pros/cons.
    - If needed, provide sentence starters such as:
        - "As a doctor, I believe…"
        - "From a parent's view…"
- Have groups create a stance poster or digital slide summarizing their perspective.

Share-Out (10 min)

- Choose a presentation format for the class:
    - Option 1: Have each group briefly present their scenario and discussion to the class. After each presentation, allow 2–3 minutes for class discussion, where classmates can ask questions, share reactions, or offer different perspectives.
    - Option 2: Set up a gallery walk, allowing students to rotate and spend about 2 minutes per poster. At each station, ask students to leave one comment or question on a sticky note to encourage peer feedback and deeper thinking.

Closure (5 min)

- Have students respond to the following prompts on a sticky note:
    - What is one potential benefit and one possible risk of gene editing?
    - Was it challenging to decide your group's opinion? Why or why not?
- Collect the sticky notes or have students post them on a designated board or wall to wrap up the activity and highlight different perspectives.

<u>Day 3 – Design a PSA</u>

Warm-Up (5–10 min)

- Conduct a class discussion by asking students to recall the biggest pros and cons of gene editing discussed so far and list them on the board.

PSA Project (30–35 min)

- Tell students they will create a Public Service Announcement (PSA) to inform and persuade others about the use of CRISPR for editing human genes.

- Explain that their PSA must take a clear stance: either for, against, or a balanced perspective.
    - Let students choose their format: Google Slides, Canva, poster, short video, or skit.
- Review the PSA requirements with the class:
    - Take a clear stance on the issue
    - Include at least one scientific reason and one ethical reason
    - Add a catchy slogan or title to grab attention
- Encourage advanced students to include a real-world case study, data, or an expert quote to strengthen their message.
- Have students form small groups and begin brainstorming their PSA.
    - Remind students to divide responsibilities within their group (e.g., researcher, writer, designer, presenter).
- Circulate the room to support groups, ask guiding questions, and help them stay focused.

Share-Out (10–15 min)

- Choose a share-out format to showcase student PSAs:
    - Option 1: Gallery Walk
        - Set up all PSAs around the room and have students rotate through each station. Provide each student with two sticky notes or voting slips to cast their votes for: "Most Creative" or "Most Convincing." Tally and announce the results at the end for a fun wrap-up.
    - Option 2: Class Presentations
        - Invite groups to present their PSA to the class. After each presentation, allow time for peer questions or comments to encourage discussion and reflection.

Closure

- Ask students to reflect on their learning and creative process by responding to the following prompt in their notebooks or on a sticky note: **"**What did you learn about CRISPR and gene editing while creating your PSA, and how did your group decide on your stance?"
- Invite a few volunteers to share their reflections aloud.

Differentiation

Day 1 – What Is CRISPR?

Emerging Learners / Students Needing Support:

- Provide a visual vocabulary sheet with terms like DNA, gene, mutation, CRISPR, and base pairs.
- Use color-coded base pair examples during the DNA model activity to reinforce A–T and C–G matching.
- Offer a step-by-step visual guide for building the DNA model.
- Allow students to dictate their reflection to a peer or teacher if writing is a barrier.

Advanced Learners:

- Challenge students to research a real-world application of CRISPR and share a quick summary with the class.
- Ask them to compare CRISPR to other gene-editing technologies (e.g., TALENs or ZFNs).

ELLs:

- Pair with a language buddy for the DNA model activity.
- Provide sentence frames for the T-chart discussion.
- Use bilingual labels on materials and visuals when possible.

Day 2 – Ethics in Action

Emerging Learners / Students Needing Support:

- Assign roles based on student strengths
- Provide role-specific sentence starters and a graphic organizer to track pros/cons.

Advanced Learners:

- Encourage students to debate multiple roles or switch roles mid-discussion to explore different perspectives.
- Ask them to research a real ethical case involving CRISPR and compare it to their scenario.

ELLs:

- Pre-teach key ethical terms (e.g., consent, fairness, enhancement, disability).
- Provide translated versions of the scenario cards if available.

Day 3 – Design a PSA

Emerging Learners / Students Needing Support:

- Offer a PSA planning template with sections for stance, scientific reason, ethical reason, and slogan.
- Allow students to create a visual-only PSA (e.g., poster with images and minimal text).
- Provide examples of strong slogans and sentence starters for persuasive writing.

Advanced Learners:

- Challenge students to include data, expert quotes, or real-world case studies in their PSA.
- Encourage them to create a multimedia PSA (e.g., video or skit with sound effects or music).

ELLs:

- Provide visual examples of PSAs and model one as a class.
- Allow students to work in bilingual pairs and use translation tools.
- Offer sentence frames for persuasive language (e.g., “We believe CRISPR should/should not be used because…”).

Assessment

Formative Assessments

- Sticky Note Reflections (Day 1 & Day 2 Closures): Students reflect on their evolving thoughts about gene editing, providing insight into their comprehension and ethical reasoning.
- Think-Pair-Share Discussions (Day 1 & Day 2): Informal observation of student responses during class discussions helps assess their grasp of CRISPR concepts and ability to articulate pros and cons.
- DNA Model Activity (Day 1): Student participation and accuracy in building and editing the DNA model demonstrate understanding of base pairing and the basic mechanism of CRISPR.
- Ethical Scenario Role-Play (Day 2): Group discussions and role-based arguments allow you to assess students’ ability to consider multiple perspectives and apply ethical reasoning.

- Teacher Circulation & Questioning (All Days): As students work in groups, use questioning and observation to assess their collaboration, critical thinking, and content understanding in real time.

Summative Assessments

- Ethical Scenario Poster or Slide (Day 2): Assesses students' ability to summarize a complex ethical issue, articulate a group stance, and represent multiple viewpoints clearly and accurately.
- Public Service Announcement (Day 3): The final PSA project serves as the primary summative assessment. It evaluates understanding of CRISPR and its applications, ability to take and support a clear stance, use of scientific and ethical reasoning, creativity and communication skills
- Exit Reflection (Day 3 Closure): Provides a final opportunity for students to synthesize their learning and explain how their thinking evolved through the unit.

✂️ Ethical Role-Playing Scenario Cards

(Cut along the lines and give one card to each group)

Card 1: Preventing a Genetic Disease

Scenario: A couple finds out their baby will be born with a life-threatening genetic disease. Doctors say CRISPR could prevent the disease by changing the gene before birth.
Big Question: Should they use CRISPR to remove the gene that causes the disease?
Role Prompts:

- **Doctor:** "What are the health risks and benefits?"
- **Scientist:** "Do we know enough about how this will work long-term?"
- **Lawmaker:** "Should there be rules about using CRISPR on unborn babies?"
- **Parent:** "What should we think about when making this choice for our child?"

Card 2: Picking Eye Color

Scenario: A family wants to use CRISPR to choose their baby's eye color. There are no medical reasons, just preference.
Big Question: Is it okay to change a baby's appearance using science?
Role Prompts:

- **Doctor:** "Is this something doctors should be involved in?"
- **Scientist:** "What could happen if people start changing looks with CRISPR?"
- **Lawmaker:** "Should there be limits on using CRISPR for appearance?"
- **Parent:** "Should parents be able to choose how their baby looks?"

Card 3: Changing Intelligence

Scenario: A tech company is working on CRISPR methods to increase intelligence in babies.
Big Question: Should science be used to make kids smarter?
Role Prompts:

- **Doctor:** "Do we know if this is safe or even possible?"
- **Scientist:** "What are the risks of changing how the brain works?"
- **Lawmaker:** "Could this create unfair advantages for some people?"
- **Parent:** "What would this mean for our child's future?"

Card 4: Super Strong Soldiers

Scenario: The military is exploring CRISPR to create stronger, faster soldiers who don't get tired easily.
Big Question: Should gene editing be used for military purposes?
Role Prompts:

- **Doctor:** "Could this hurt the soldiers in the long run?"
- **Scientist:** "Just because we can do it, should we?"
- **Lawmaker:** "Should there be rules about using CRISPR in the military?"
- **Parent:** "How would this affect people who join the military?"

Card 5: Helping with Disability

Scenario: A couple wants to use CRISPR to prevent their child from being born blind.
Big Question: Should we try to remove all disabilities using CRISPR?
Role Prompts:

- **Doctor:** "Can we safely prevent blindness with CRISPR?"
- **Scientist:** "How do we respect people with disabilities while using this science?"
- **Lawmaker:** "Should there be rules about what counts as a disability?"
- **Parent:** "What kind of life do we want for our child?"

Card 6: Editing for Fun

Scenario: A celebrity wants to use CRISPR to give their child cool hair, long legs, and a great singing voice.
Big Question: Is it okay to edit traits for fun?
Role Prompts:

- **Doctor:** "Is this something doctors should be doing?"
- **Scientist:** "What could happen if people start editing for fun?"
- **Lawmaker:** "Should only some people be allowed to do this?"
- **Parent:** "Is it okay to want special traits for our child?"

Card 7: Editing in Secret

Scenario: A private clinic offers illegal CRISPR editing for "designer babies" in secret, without government approval.
Big Question: Should people be allowed to go around the law to edit their children?
Role Prompts:

- **Doctor:** "Is it safe to do this without approval?"
- **Scientist:** "What could go wrong if it's done in secret?"
- **Lawmaker:** "How can we protect families and children?"
- **Parent:** "With gene editing, should we be allowed to choose what's best for our child?"

Card 8: Extending Human Life

Scenario: Scientists think CRISPR might help people live much longer, maybe even 150 years.
Big Question: Should we use CRISPR to live longer lives?
Role Prompts:

- **Doctor:** "Will people stay healthy for that long?"
- **Scientist:** "How would this affect the planet and resources?"
- **Lawmaker:** "Would we need new laws for longer lives?"
- **Parent:** "How would this change life for our kids and grandkids?"

Card 9: Gene Editing in Animals

Scenario: Farmers want to use CRISPR to create cows that produce more milk and pigs that grow faster.
Big Question: Is it ethical to edit animal DNA for food production?
Role Prompts:

- **Doctor:** "Is this food safe for people to eat?"
- **Scientist:** "Can this help solve hunger problems?"
- **Lawmaker:** "Should there be rules to protect animals?"
- **Parent:** "What do we want to know about the food we eat?"

CRISPR PSA Planning Template

(Use this guide to plan and organize your Public Service Announcement)

1. Title or Slogan

Create a catchy title or slogan that grabs attention.
Example: *"CRISPR: The Future of Science"*

2. Your Group's Stance

Clearly state your position on CRISPR and gene editing:

☐ For
☐ Against
☐ Mixed/Neutral

Explain your reasoning in 1–2 sentences.

3. Scientific Reason

Find a **scientific fact or example** that supports your stance.

- What does research say?
- How does CRISPR work in this context?

4. Ethical Reason

Explain your **ethical perspective**:

- Why do you believe CRISPR is right or wrong in this situation?
- Consider fairness, safety, access, or long-term effects.

5. Group Member Contributions

List what each group member is responsible for:

Name	Role/Task

PSA Rubric

	0 points	1 point	2 points	3 points
Clear Position	No position stated.	Position is vague or unclear.	Position is stated but lacks support.	Position is clear and well-supported throughout.
Scientific Reason	No scientific reason stated.	Reason is off-topic or incorrect.	Reason is mostly correct but underdeveloped.	Strong, accurate science explanation supports position.
Ethical Reason	No ethical reason stated.	Ethical idea is confusing or weak.	Ethical concern is present but lacks depth.	Clear, thoughtful ethical perspective supports stance.
Creativity /Visuals	No effort to be creative or visually engaging.	Some visuals or creative elements included.	Presentation is creative or visually interesting.	Extremely creative, engaging, and visually well-designed.
Presentation /Clarity	Unclear or disorganized presentation.	Mostly understandable but some confusion.	Mostly clear with minor issues.	Easy to follow, well-organized, and clearly presented.

Total Score: _____/ 15 = _____%