



# **EDITING OUR EVOLUTION**

Rewriting the Human Genome

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## Individual Packet

# Instructions

### **Step 1: Introductions and Instructions (2 minutes)**

1. Start by having each person introduce themselves including their name and what they found most interesting about the introductory presentation.

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### **Step 2: Scenarios (60 minutes)**

1. For each scenario, start by having one person read the prompt at the top of the page out loud.
2. Then, as a group, work through the questions below the prompt. Discuss each question as a group before you record your answer. Some questions ask you to record your personal answer in your individual packet, while others ask you to record your group's answer on the group answer sheets.
3. When time is up for each scenario, the moderator will introduce you to the next scenario.
4. Scenario 1 has two parts, so be sure to leave time to read the second prompt and answer the questions below it as well.

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### **Step 3: Share-Out (10 minutes)**

1. One person from each table will have 30 seconds to share the most interesting thing that came up in their group discussion. Don't worry about covering your entire conversation. Did anything surprise you? Was anything controversial?

# Scenarios

## Scenario 1: Therapy vs. Enhancement (25 minutes)

### Part 1:

Imagine you are the parent of a baby boy who has just been diagnosed with Duchenne (Du-SHEN) muscular dystrophy (DMD). DMD is a genetic disorder where a person's muscles get weaker and weaker over time. It affects about 1 in 3,600 boys, usually starting around age 4. It is much less common in girls, affecting about 1 in 50 million. The average life expectancy for a person with DMD is about 25 years. Your doctor told you about a treatment called gene therapy that repairs the mutation in the DNA. The treatment would be a single shot that would consist of deactivated viruses that have been engineered to carry the healthy form of the gene, which could restore most muscle function, or even prevent its loss if done early enough. The earlier you do this treatment, the more effective it will be. If you choose to use this treatment, the genetic change will **NOT** be passed down to your son's children, so your grandchildren could still have DMD.

**1** If money were not an issue, would you use this gene therapy on your son? Why or why not?

Things to consider:

- How would you make your decision? What information would you want to have?
- How would you explain your decision to your child when he is a teenager?
- How do you think your decision would affect your relationship with your child?
- How do you think people would act towards people whose parents chose or chose not to cure them?

Yes

Why or why not?

No

Not Sure

**2** What parts of this discussion were most important to your **group's** decision making process?

Have someone record your group's answer on the group answer sheet.

## Part 2:

In the first part of this scenario, we asked you to think about using gene therapy to cure a genetic disorder, but gene therapies could also be created to enhance certain genes in healthy people.

Now imagine there is a gene therapy that can be used to strengthen the muscles of healthy babies with average capabilities to be at the stronger end of the normal range, like Michael Phelps. They will have an easier time building strength and likely be better athletes. Their stronger muscles would last into adulthood and might slow age-related muscle deterioration. If you choose to use this treatment, the genetic change will **NOT** be passed down to your baby's children.

**1** If money were not an issue, would you use this technique on your healthy baby? Why or why not?

Things to consider:

- How would you make your decision? What information would you want to have?
- How would you explain your decision to your child when they are a teenager?
- How do you think your decision would affect your relationship with your child?
- Does your answer change based on the gender of the baby?
- Do you think this treatment should be illegal in the US?
- Do you think people who have enhanced muscles should be allowed to play professional sports?
- How would using this treatment affect what activities you would suggest for your child?

Yes

Why or why not?

No

Not Sure

**2** If you were going to pay the cost of this enhancement treatment, what factors would be important for your decision making process?

Have someone record your group's answer on the group answer sheet.

**3** Would you be more likely to use or support the use of this technique in the U.S. if it is being used in other places with different historical, cultural, and social contexts (like Europe, Japan, or China)?

Yes

Why or why not?

No

Not Sure

## Scenario 2: Equity and Access (20 minutes)

Roughly 100,000 people in the U.S. have sickle-cell disease, most of them Black/African Americans and Latinos. Low income Black/African Americans and Latinos are more likely to be uninsured and can have worse health care outcomes for the same conditions. Compared with the average American, people with sickle-cell disease can live much shorter lives—to about 40 to 60 years old.

Imagine you have sickle-cell disease, which you inherited from your parents, who were both carriers but didn't have the disease. Because of your disease, you have painful episodes, called crises (CRY-sees), which can last from hours to days and can be severe enough to require a hospital stay. You are 43 years old, and you have been hospitalized over 300 times.

There is a gene therapy that would cure your sickle-cell disease. It works by taking bone marrow stem cells out of your body, changing their DNA, and putting them back into your body. Currently the only way that sickle-cell disease can be cured is by a bone marrow transplant from another person. This treatment would have some of the same risks as that method, but there would be no risk of rejection between the donor cells and your cells. However, there might be new risks that are still unknown. The genetic change from this treatment would **NOT** be passed down to your children. Unfortunately, the treatment is very expensive and it is not widely available.

**1** If money were not an issue, would you want this treatment? Why or why not?

Yes

Why or why not?

No

Not Sure

★ Consider the following questions from your own perspective, not as the person described above.

**2** Who does your **group** think should be responsible for providing access to treatment for a person in the U.S. who needs and wants to use it but can't afford it?

Things to consider:

- Options could include:
  - State or national governments
  - The companies that make the treatments
  - Non-governmental organizations (NGOs) like the Red Cross
  - Hospitals
  - Communities
  - Families
  - Individuals themselves
- Should different groups be responsible for providing access to treatment for children and adults?

**Have someone record your group's answer on the group answer sheet.**

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3 How should whichever group(s) you chose in question 2 provide this access?

Things to consider:

- Options could include:
  - Government could grant companies longer-lasting patents on treatments if the companies charge less for those treatments
  - Government could provide tax incentives for companies producing the treatment to lower the costs for patients
  - Government could require insurance to cover the treatment
  - Government, companies, hospitals, or NGOs could pay some or all of the cost of the treatments for patients who can't afford it
  - Communities could hold fundraisers for members of their community
  - Individuals or families could pay the cost of the treatment over time

**Have someone record your group's answer on the group answer sheet.**

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4 Do you think that society should prioritize providing access to gene therapies that can cure sickle-cell disease over providing access to traditional treatments that may not be as effective? Why or why not?

Things to consider:

- Is your answer different for children and adults?
- What would happen to people who could not or chose not to use the gene therapy?

Yes

Why or why not?

No

Not Sure

## Scenario 3: Heritable Changes (15 minutes)

Imagine one of your family members died of breast cancer, so you were tested and found that you carry a BRCA (BRAK-uh) mutation that puts you at a much higher risk of getting the same disease. Now imagine you're getting ready to start a family. Both men and women can pass down a mutated BRCA gene. Recent advances in CRISPR technology allow doctors to create and implant an embryo using in vitro fertilization (IVF) that would not carry the mutated gene. The change would not eliminate the risk of breast cancer, but it makes their risk much lower. This heritable gene therapy would be a way of having genetically related children who are not affected by a harmful BRCA mutation. Because changing the DNA of an early embryo results in changes to cells that will eventually produce sperm or eggs, any children he or she has **WILL** inherit the healthy gene. This would mean that none of your child's descendants would need to use this gene therapy. However, even after this treatment has been used for years and seems to be safe, it will take decades before it is possible to see whether any unintended effects come up for future generations.

**1** If money were not an issue, would you create an embryo that doesn't have the mutated gene? Why or why not?

Things to consider:

- How would you decide?
- How do you think your decision would affect your relationship with your child?
- How would you explain your decision to your child? To your grandchildren?
- What are the health risks that concern you most?
- What other concerns do you have, besides any potential health risks?

Yes

Why or why not?

No

Not Sure

**2** There are over 6,000 genetic diseases that are determined by a single gene. How does your **group** think it would affect society, both positively and negatively, if we could cure all of them using gene therapies?

Things to consider:

- Who would be able to access these gene therapies?
- What would change a generation or more after people start using these gene therapies?
- How should we balance the potential benefits against the potential risks?
- Would parents who are carriers for a genetic disease have an obligation to use gene therapies to have children who are not affected? Who should get to decide?

**Have someone record your group's answer on the group answer sheet.**

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- 3 In your **group's** opinion, where does making heritable changes to the human genome fall on the spectrum between just being the next step in medicine and being a fundamental change to what it means to be human?

**Have someone record your group's answer on the group answer sheet.**





# Demographic Survey

In order to help us understand how people are thinking about human genome editing technologies, we'd like to get a better sense of who is attending this forum. Please fill out the following demographic and background information. Participation is voluntary, and all responses are anonymous. This survey will take about 5 minutes of your time to complete. Thank you!

1 What is your age? \_\_\_\_\_

- 2 What is the highest level of education you have completed?
1. Some high school or less
  2. High school
  3. Some college but no degree
  4. 2-year college degree
  5. 4-year college degree
  6. Post-graduate degree (such as an MA, MBA, MD, JD, PhD, etc).
  7. Other: \_\_\_\_\_
  8. Prefer not to say

- 3 What gender do you identify as?
1. Male
  2. Female
  3. Another category  
Please specify: \_\_\_\_\_
  4. Prefer not to say

- 4 Please indicate which racial or ethnic group(s) you identify as. Please select all that apply.
- A. American Indian or Alaskan Native
  - B. Asian or Asian American
  - C. Black or African American
  - D. Hispanic or Latino
  - E. Native Hawaiian or Pacific Islander
  - F. White or Caucasian
  - G. Other: \_\_\_\_\_
  - H. Prefer not to say

- 5 Do you or does anyone close to you have a genetic disorder or condition, meaning conditions that are caused by characteristics in a person's genes? Some examples include Huntington's disease, Sickle cell anemia, or Muscular Dystrophy.
- A. Yes
  - B. No
  - C. Don't know
  - D. Prefer not to say

# Demographic Survey

- 6 The terms “liberal” and “conservative” may mean different things to people, depending on the kind of issue one is considering.

In terms of **economic issues**, would you say you are: (circle one)

Very Liberal	Liberal	Somewhat Liberal	Moderate	Somewhat Conservative	Conservative	Very Conservative
1	2	3	4	5	6	7

Now, thinking in terms of **social issues**, would you say you are: (circle one)

Very Liberal	Liberal	Somewhat Liberal	Moderate	Somewhat Conservative	Conservative	Very Conservative
1	2	3	4	5	6	7

- 7 How much guidance does religion provide in your everyday life? (circle one)

0	1	2	3	4	5	6	7	8	9	10
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No guidance ← → A great deal of guidance

- 8 How much do you agree with the following statements?

A. Science is the best way that society has for producing reliable knowledge. (circle one)

Strongly disagree	Disagree	Somewhat disagree	Neither disagree nor agree	Somewhat agree	Agree	Strongly agree
1	2	1	1	1	2	1

B. Science is the best way to understand the world. (circle one)

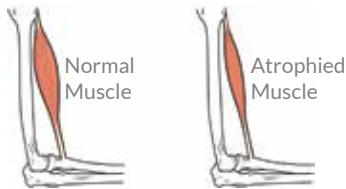
Strongly disagree	Disagree	Somewhat disagree	Neither disagree nor agree	Somewhat agree	Agree	Strongly agree
1	2	1	1	1	2	1

# Supplemental Information

## Duchenne Muscular Dystrophy (DMD)

DMD is an X-linked recessive disorder, which means that it almost entirely affects males. About 2/3 of DMD cases are inherited from a parent, while 1/3 come from new mutations.

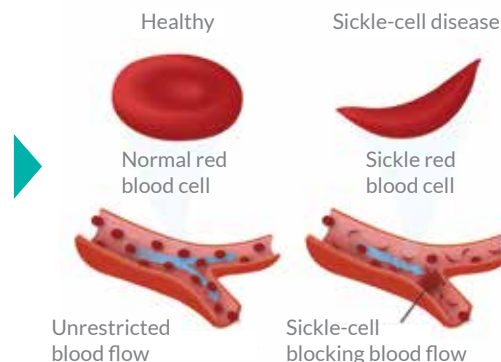
There is currently no cure for DMD, but medicine can slow muscle weakening and damage to important muscles like the heart. Eventually, people with DMD need physical aids like wheelchairs and assisted breathing devices. Insurance generally covers these treatments and devices.



## Sickle-Cell Disease

Sickle-cell disease is an inherited genetic disorder which causes red blood cells to form sickle shapes. These abnormal blood cells clump together in blood vessels leading to crises that can range from swelling to severe pain to organ failure and death.

Currently, the only cure for sickle-cell disease is a bone marrow transplant, where the bone marrow of the person with sickle-cell disease is replaced with bone marrow from a person who produces healthy red blood cells. This method is expensive, requires a donor who is a genetic match, and has a high risk of complications, such as low blood counts, bleeding, infection, and rejection between the donor cells and the recipient's cells, so it is rarely used. Insurance generally only covers bone marrow transplants for young patients with particularly severe sickle-cell disease.

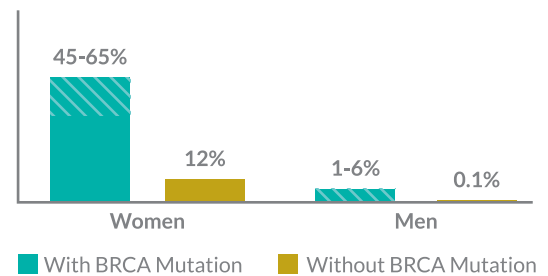


## BRCA Mutation

About 1 in 400 people have a BRCA mutation. BRCA1 and BRCA2 are genes that help repair mutations in breast cells. When a person has a mutated version of a BRCA gene, it can't repair other mutations. While a mutation in one of the BRCA genes cannot cause cancer, it makes it more likely that other mutations will be able to cause cancer. 45-65% of women with a BRCA mutation develop breast cancer before age 70, compared to 12% of women without the mutation. Men have a much lower risk of developing breast cancer than women. Only 1-6% of men with a BRCA mutation develop breast cancer in their lifetime compared to 0.1% of men without a mutation.

Currently, the most effective ways of reducing the cancer risk from a BRCA mutation are removing most or all of the breast tissue, or the ovaries and fallopian tubes. Either procedure can significantly lower the chances of developing breast cancer. Many insurance companies cover these preventative surgeries, especially for people with a BRCA mutation.

Lifetime Risk of Breast Cancer



# Supplemental Information

## Genome Editing Methods

There are two ways of doing genome editing. One method involves removing cells from the body, modifying the genome of those cells, and then putting the modified cells back into the patient's body.

The other method involves putting something into the patient's body to modify the genomes of the target cells. For example, modified viruses can be injected to find specific types of cells and deliver the treatment.

Patients would hopefully only need to go through a gene therapy once to be cured.

## Risks of Gene Therapy

The biggest concern about human genome editing is the risk of off-target effects. Off-target effects happen when the wrong part of the DNA is accidentally changed. This change may have no effect, or it could have severe negative effects, especially when it occurs in vital organs or affects the immune system. Scientists are working to make off-target effects extremely rare. However, there is still a lot that is unknown about the risks of genome editing, especially in the longer term.

## In Vitro Fertilization (IVF)

IVF is a process where a doctor combines sperm and eggs in a laboratory to create embryos. The embryos are implanted in a person's uterus and grow as in a normal pregnancy. In a recent study, scientists changed the genome of the cells in an embryo while ensuring that the embryo could still develop into a child (but the study stopped before that).

IVF can cost \$10,000-\$20,000 or more for one round, making it inaccessible for many people.

## Costs

Research for gene therapies can cost up to a billion dollars. When only a single treatment is needed to cure a rare disease, it's hard to charge enough to cover these research costs. For current gene therapies, the treatment cost can be hundreds of thousands of dollars or more and is often priced similarly to the cost of traditional treatments over a person's lifetime. However, it is too early to say how much new therapies will cost.

## Gene Therapy Timeline

It's hard to predict whether or when new gene therapies will become available, but there are over 2400 gene therapies in clinical trials around the world as of December 2017. Some will be available in the near future, while others are more distant or not being developed.

Sooner	Later	Someday
Sickle Cell	BRCA	Muscle Enhancement
DMD		