



Editing Our Evolution

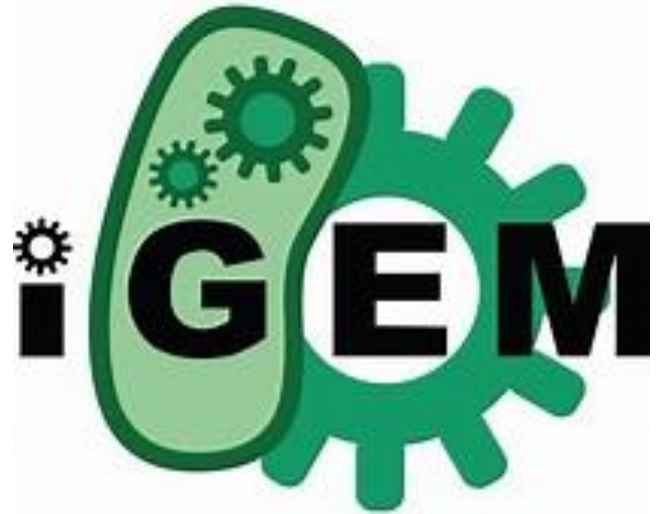
Rewriting the Human Genome





WILLIAM
& MARY

CHARTERED 1693



Bioengineering - Synthetic Biology

Bio - Having to do with life and living systems

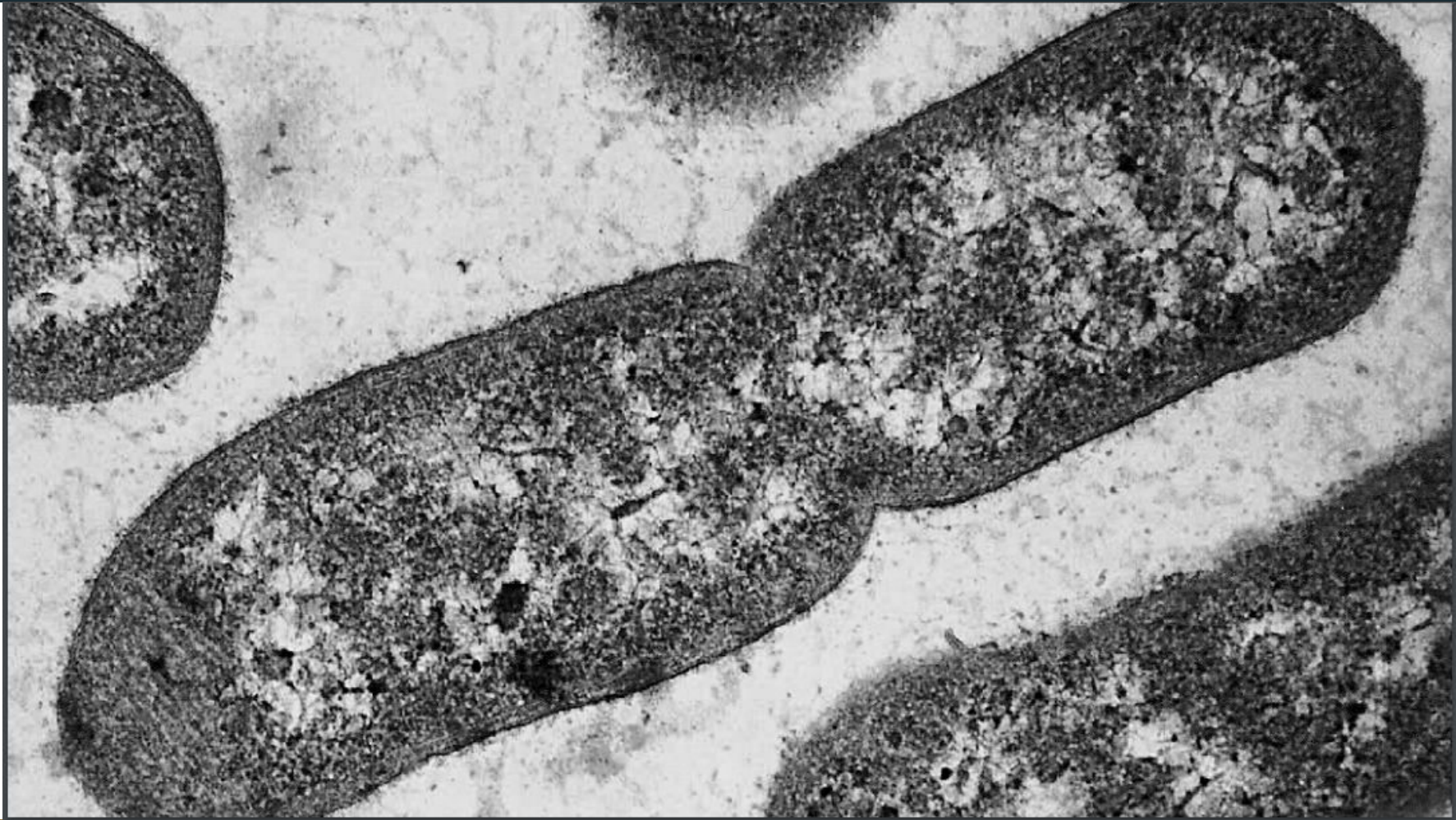
Engineering - To Design, Build or Create

Life Comes in Many Forms

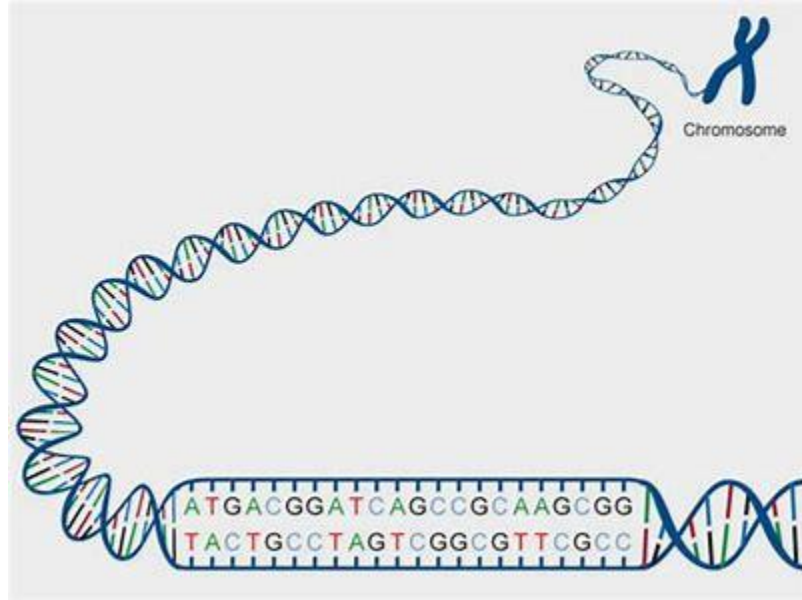
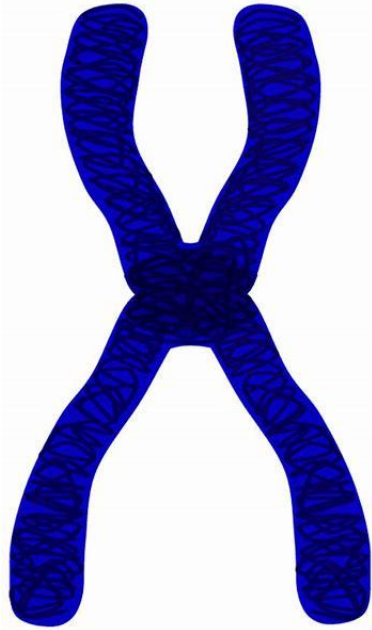






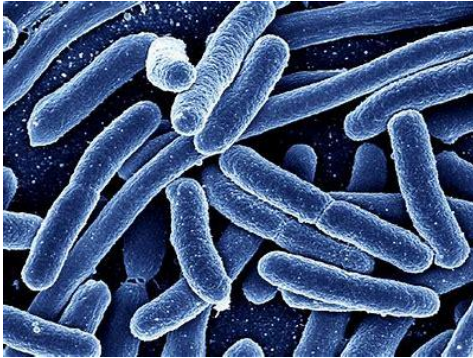


But all life has one thing in common...

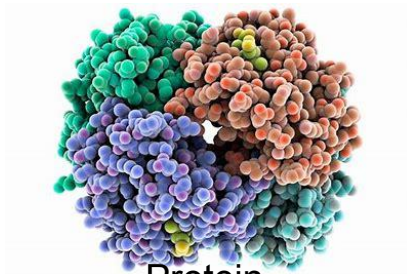
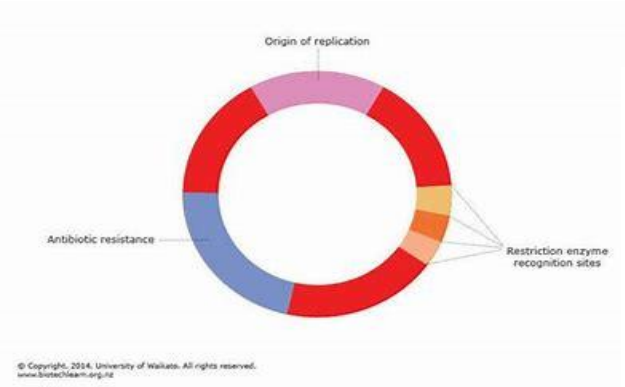


....so all life has the
potential to be affected by
bioengineering

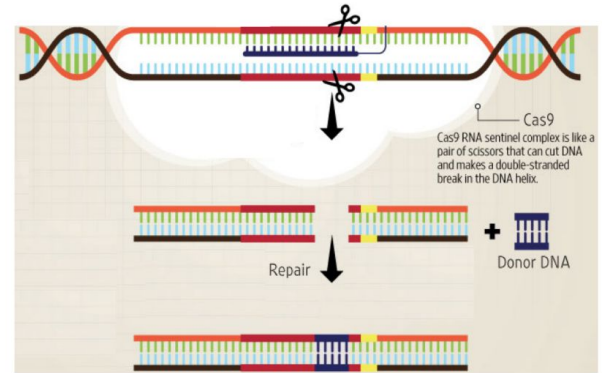
Players



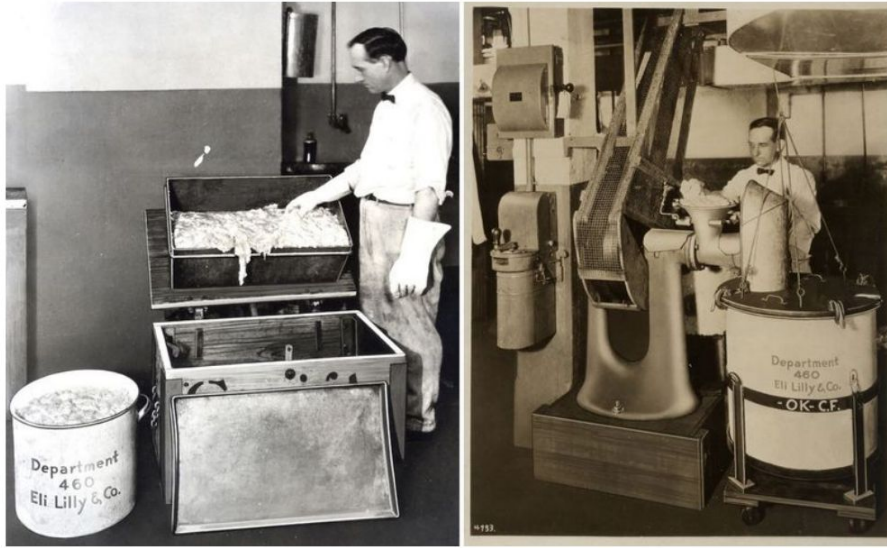
DNA



Protein



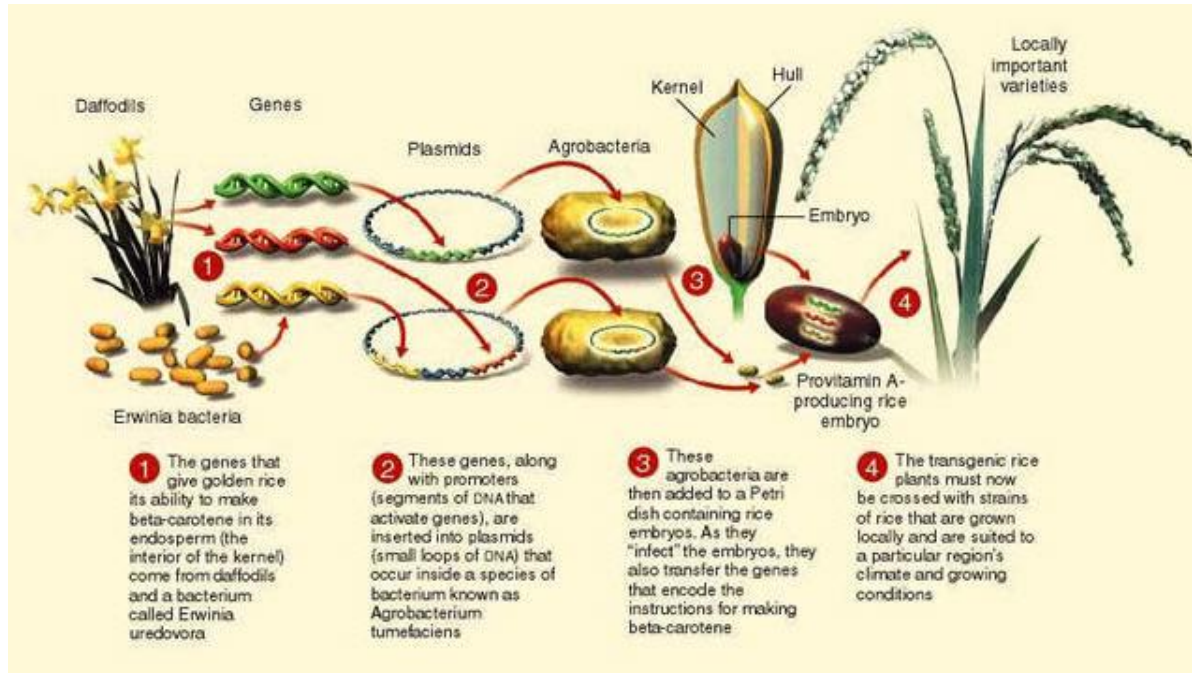
Bacteria At Work - Insulin



Insulin extraction from pig pancreas (1920)

- Type I diabetes
- Can be treated by insulin injections
- For decades the only source was from pigs and other animals
- In 1978 researchers used “restriction enzymes” to enable bacterial production of insulin

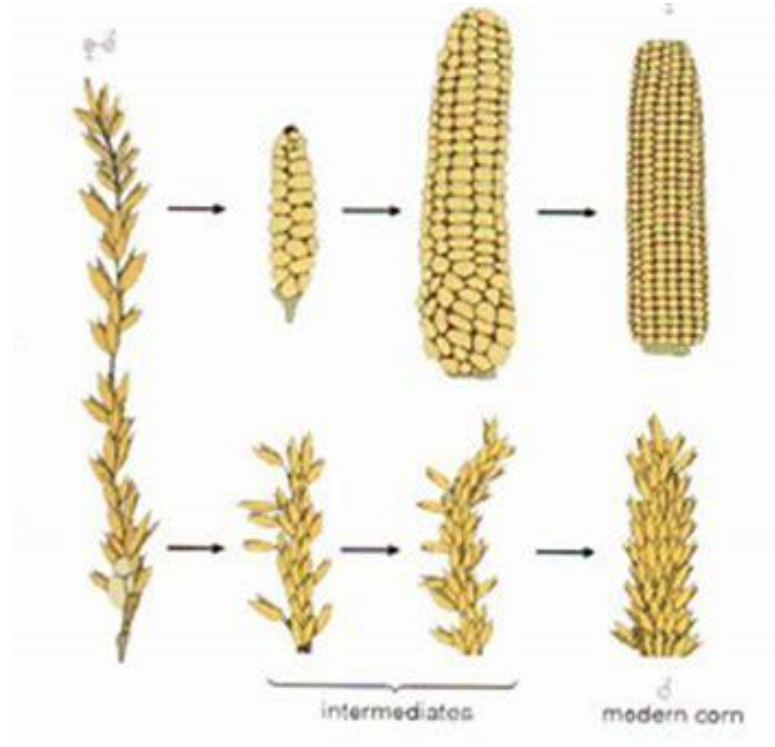
Golden Rice



Advancements in Progress

Food

- Pest resistance
- Drought Resistance
- Faster Growing Times
- Increased Yields
- Increased Nutrient Content
- Specific vitamin production
 - NASA
- Nitrogen fixation - April 2018



Environment



- Current uses - Soil clean up
- Attempted uses - Oil Spills
- Synthetic Potential

Medicine

- PKU is a genetic disorder
- Phenylalanine cannot be broken down by the body
- Current treatment is a heavily restricted diet
- September 4th, The New York Times

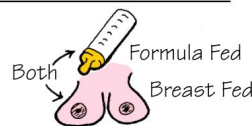
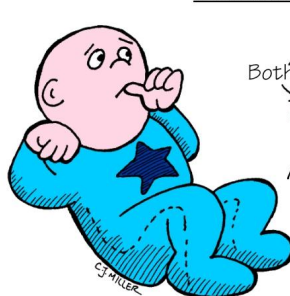
PHENYLKETONURIA (PKU) - Inherited Error In Metabolism

[Toxic levels of Phenylalanine (common protein amino acid) due to inability of body to convert]

Can Cause...

- Mental Retardation
 - Convulsions
- Behavior Problems
 - Skin Rash
- Musty Body Odor

Babies Are Tested...



A minimum of 24 hrs after beginning milk.

Retest in 7-10 days to catch earlier false negatives.

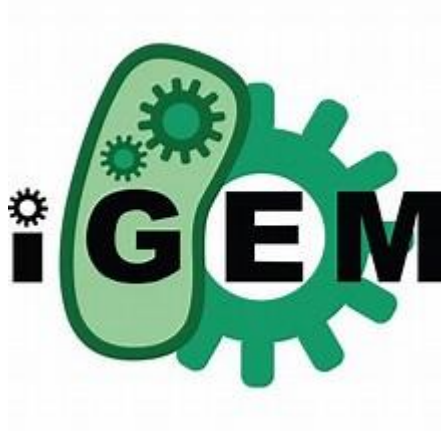
NO

- Meat 
- Dairy Products 
- Dry Beans 
- Nuts 
- Eggs 

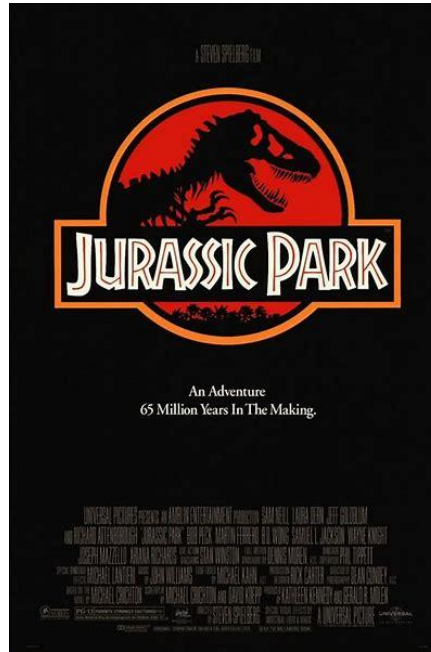
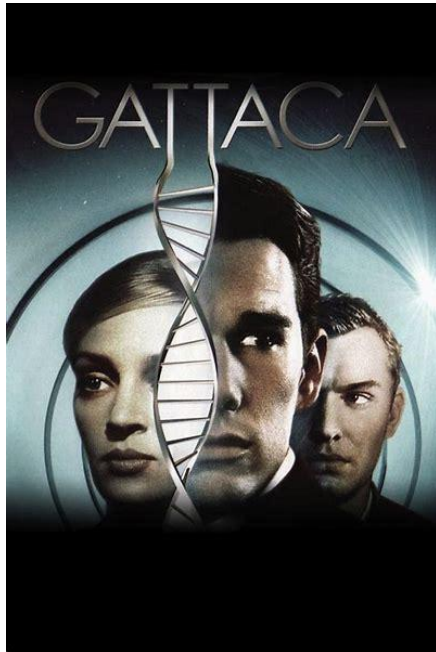
* Cereals, Fruits & Vegetables in Moderation *

Great Possibilities & Responsibility

Regulations Rather Limited



Past “Conversations”



- Is there a clear benefit to this kind of work?
- Is there a risk if it were to be put in the wrong hands?
- Does the gene edit affect one generation or every subsequent generation?
- Is the organism/edit containable?

Scenario 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.

Questions to Spark Discussion

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?

Scenario 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.

Questions to Spark Discussion

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?

Scenario 3

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.

Questions to Spark Discussion

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?

Final Questions

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?