DNA TECHNOLOGIES & ETHICS

How should faith inform our acceptance of new technologies?

MEET
Geneticist Francis Collins

GROW
Wisdom
Evaluating GMOs
Genetic Testing
The Human Enhancement Continuum
Genome Editing
Ignorance as Inequity, Ignorance as Bliss
Making Hard Choices

EXPERIENCE

ENGAGE

INTEGRATE

Above: Geneticist Francis Collins
# Unit 6: DNA Technologies and Ethics

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Unit Overview

Unit 6: DNA Technologies and Ethics introduces students to the science behind genetic technologies and asks them to consider the potential good and the potential harm of what is becoming possible.

This unit features:

• A video introduction to geneticist and BioLogos founder Francis Collins, who discovered the genetic basis for several diseases and led the Human Genome Project.

• A devotional Bible study on the virtue of wisdom.

• An activity introducing the kinds of genetic testing available and the potential controversy they introduce.

• A chance to investigate others’ opinions about genetically modified organisms (GMOs) and study the impact of three specific GMOs.

• Discussion of the ethical issues surrounding different kinds of treatments that enhance or modify the human body.

• A closer look at how CRISPR-Cas9 works and the distinction between genetically modifying germline cells versus somatic cells.

• A challenge to consider the potential burden on individuals and the disparities in society that can arise from DNA technologies.

• An opportunity to apply ethical reasoning to two case studies that involve DNA technologies.
Learning Outcomes

What will students know or be able to do after this unit?

- Describe how to proceed wisely when faced with decisions about how to use a new technology.
- Assign, evaluate, and reflect on the level of controversy involved in various types of genetic testing.
- Discern potential benefits and costs for specific examples of genetically modified organisms (GMOs).
- Formulate questions to consider when evaluating a particular GMO.
- Assess personal comfort level with the acceptability of different types of human enhancements.
- Describe three applications of CRISPR-Cas9 technology.
- Identify ethical differences between genome editing in germ cells versus somatic cells.
- Develop a written argument for or against a particular CRISPR therapy.
- Give examples of the moral and ethical issues involved in genetic testing and genetic therapies.

How to Use This Unit

Please see the User Introduction and Overview (biologos.link/user-intro) for important information and links, such as the difference between the five module types (Meet, Grow, Experience, Engage, and Integrate); our terms of use (how documents may be modified and distributed); and advice for communicating with parents or others in your community about potentially controversial topics.

This document contains lesson plans for the entire unit. Other files, such as student handouts, images for the Grow module, teacher instructions for specific activities, answer keys, and slide presentations, are accessible via links within this document.

Teacher’s Notes and sample answers are formatted with italics.

Scope and Sequence

This unit introduces students to various DNA technologies and the promise and ethical concerns that surround their use. After completing Unit 6: DNA Technologies and Ethics, you can continue with other units (biologos.link/units-list) that pair well with your science or Bible course (biologos.link/course-pairing). The modular design gives you flexibility to pick and choose the activities that best suit your goals, time constraints, and students’ interests.

To explore other ethical and theological questions that surround the complexity and value of life, see Unit 4: Cells and Design, Unit 5: Genetic Diversity and Human Dignity, and Unit 7: Fearfully and Wonderfully Made.
For an introduction to approaching questions at the intersection of faith and science, see Unit 1: Faith and Science Foundations. For more on how science and theology can complement each other as we think about ethical choices, see Unit 2: Ways of Knowing. To help students consider whether God may be leading them to work in a scientific career, see Unit 3: Science as a Christian Vocation.

Other open questions and debated issues about how to reconcile theological and scientific knowledge are explored in Unit 8: Bible Interpretation and Science, Unit 9: Evolution and God’s Creation, Unit 10: The Fossil Record and Faith, and Unit 11: Humans and the Rest of Creation. God’s provision for creation is explored in Unit 12: Seeing God in Creation, and God’s calling for humans to participate in creation care is presented in Unit 13: Caring for People and the Planet, Unit 14: Climate Change and Our Commission, and Unit 15: Biodiversity and Conservation.

**Pedagogy of Hospitality**

Integrate presumes acceptance of, or directly teaches, the scientific consensus on some matters of controversy within the Christian community: namely, modern cosmology, the age of the earth, evolution, and anthropogenic climate change. At the same time, we as authors recognize that in any community of Christians, there is likely a diversity of viewpoints. Our goal is education, not indoctrination. As such, we include opportunities to explore various Christian perspectives within Integrate. Reflection assignments and discussion questions are intentionally open-ended, without an expectation that students adopt any one “correct” perspective. We also believe practicing gracious dialogue is more important than winning an argument. For this reason the curriculum includes opportunities for respectful engagement with others who think differently. For tips on how to create a welcoming environment in your community, see biology professor Kerry Fulcher’s article *A Pedagogy of Hospitality* (biologos.link/hospitality).

**Corequisite Science**

While Integrate is flexible and may be used as a standalone resource for enrichment, it is designed to supplement, not replace, science instruction. Students will be prepared to engage with the material in this unit assuming concurrent or previous study of genetics and the human body.

**NGSS Alignment**

The Next Generation Science Standards (NGSS; biologos.link/ngss) are research-based, cutting-edge K-12 science standards. They set expectations for what students should know and be able to do. While not an NGSS curriculum, Integrate has many points of alignment with NGSS. If you refer to NGSS in your lesson planning, please see the NGSS Alignment for Integrate (biologos.link/ngss-alignment).
Vocabulary

The following terms and concepts are used in this unit or in the additional resources. Definitions and explanations are found in the Unit Glossary at the end of the unit. Many additional terms are included in the main Integrate Glossary (biologos.link/glossary).

- allele
- bioethics
- biotech
- CRISPR-Cas9
- designer babies
- embryo
- empirical evidence
- eugenics
- fine-tuning
- gene
- general revelation
- genetic counseling
- genetic testing
- genetically modified organism (GMO)
- genome
- genotype
- germ cells
- germline modification
- Human Genome Project
- image of God
- in vitro fertilization (IVF)
- informed consent
- mutation
- phenotype
- prenatal screening
- reproductive technology
- scientific method
- somatic cells
- special revelation
- trait
- two books metaphor
Making Hard Choices

What ethical questions do DNA technologies raise?

Activity Overview

Students apply wisdom as they weigh the ethical and moral implications of a genetic technology.

Activity

Give students the following handout in which they choose one of two scenarios to analyze: selecting for a disability such as hearing impairment, or pediatric whole genome sequencing.

Teacher’s Note: The first scenario presumes basic familiarity with reproductive technology, specifically, in vitro fertilization (IVF). Review the glossary entries for these terms if students are not familiar with them.

Hard Choices (biologos.link/hard-choices)

[student handout: 3 pages]

[beginning of content from student handout]

Instructions:

1. Read the two scenarios and choose one.
2. List all the potentially affected people in the scenario.
3. Identify and describe the different choices the couple could make in the scenario.
4. List the implications of each choice for the people affected. (Think of how it might affect health, mental health, finances, relationships, planning, etc.)
5. Make a case for what you think is the most ethical course of action for the people involved and provide reasons from science or Christian ethics to back up your argument.

Scenario 1: Selecting for a disability

In some countries, people born with genetic modifications that cause hearing impairments have formed communities with their own subculture, shared histories, customs, and sign languages. Members of these Deaf communities have been active politically in some spheres, pushing against the idea that they are “disabled,” and communicating that their differences contribute to a rich human experience that is not deficient or inferior and should instead be celebrated.

In Britain, a Deaf couple had a child who was born with the same genetic difference as her parents, causing her to be hearing-impaired like them. The couple is grateful that their daughter is hearing-impaired like they are and can fully share the same language, culture, and life experience with them. The couple would like to have
another child, and since the mother is older, they may need to seek in vitro fertilization (IVF) treatment. They decided they would like another hearing-impaired child, and inquired whether they could screen out embryos without the genetic modification who would be born with no hearing impairment.

The British government told the couple it would be illegal for them to intentionally select an embryo with the genetic modification that leads to hearing impairment for implantation. From the government’s perspective, this would be cruelly setting up a child to live his or her whole life with a disability, even though the parents had the option of bringing a child not deprived of one of his or her senses into the world. The only way they say the couple should be allowed to select an embryo with the genetic modification is if all the embryos produced via IVF have it. However, this would be statistically unlikely. Or they could choose not to screen the embryos at all, and take their chances that a randomly selected embryo would have the genetic modification and develop the hearing impairment.

The couple argued that their hearing impairment is not a disability, but the key to their culture, which they want to share with their offspring. They say preferring hearing children over hearing-impaired children is discrimination and that selecting an embryo because it would not develop a hearing impairment would send a message to their Deaf daughter that she is inferior. They also say that a hearing child would be disadvantaged in their home, where hearing impairment is central to the other family members’ identity and communication.

Q: Should the couple be allowed to screen out embryos without the genetic modification that leads to hearing impairment if they opt to use IVF?

This scenario is based on Clare Murphy’s BBC News article Is it Wrong to Select a Deaf Embryo? (biologos.link/deaf-embryo).

Scenario 2: Pediatric Whole Genome Sequencing

There is a difference between screening newborns for specific genetic diseases that occur during childhood and sequencing an infant or child’s whole genome. Screening of newborns is now routine and relatively uncontroversial. Currently in the U.S., states run their own newborn screening programs, testing infants for 30-50 serious but treatable conditions that occur during childhood. The tests use a dried blood sample collected after birth to check for the presence of disease biomarkers. The tests are a low-cost, accurate way to identify diseases before symptoms occur. This can help families and medical professionals prepare for the best care, interventions, or treatments.

However, some doctors think that whole genome sequencing should replace current newborn screening tests. The cost of whole genome sequencing is now as affordable as many other complex medical tests and is currently used in the diagnosis and treatment of sick infants. Sequencing a healthy newborn’s genome would provide more health information than the current screening tests, which only test for a few dozen specific childhood diseases. An infant’s whole genome sequence would provide information not just about treatable childhood diseases and conditions, but also untreatable ones that occur in adulthood, such as Huntington’s disease or Alzheimer’s disease. Their genome sequence could also be referenced throughout their lives as new genetic discoveries are made.

A couple was given a chance to participate in the National Human Genome Research Institute’s investigation into whether introducing newborn whole genome sequencing as a standard procedure would be advisable. If they decided to participate in the study, it would give them access to their newborn’s whole genome sequencing data.
The woman was concerned that if they learned their child had genetic markers for untreatable adult diseases, this might negatively affect how they raised the child or negatively affect their marriage by introducing grief and stress. She worried that if a genetic predisposition was known, it could lead to discrimination against their child, or potential problems with their health insurance coverage. She thought the normal newborn screening provided all the information they needed to make good decisions about their child’s health in the short term. She also did not think it was fair to put the burden of knowing the details of their genetic makeup on a child before they were old enough to understand the implications or be able to give informed consent for the testing.

The man thought they should participate in the study. He argued that knowledge is power, and the more they knew about what the future might hold, the better equipped they would be to make decisions in the present. He pointed to some other families he knew of who had benefited from better healthcare because they could provide doctors with detailed genetic information.

They asked their pediatrician what she thought. She said sometimes doctors can feel conflicted when detailed genetic information is disclosed. She felt that a child should be able to give informed consent before decisions about the direction of medical care that could be delayed are discussed. But she admitted she wasn’t very educated on the topic, since whole genome sequencing was a relatively new option. She added that pediatricians are only beginning to develop protocols for what to advise when parents disagree with one another, or when the parents have older children, since they may also be affected by the new genetic information.

Q: Should the couple get their newborn’s genome sequenced?

This scenario is inspired by the National Human Genome Research Institute’s articles Newborn Screening Fact Sheet (biologos.link/newborn-screening-facts) and Who Should Decide? The Complex Ethics of Pediatric Genome Sequencing (biologos.link/complex-ethics-seq).

Assessment Rubric:

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Thorough and thoughtful</th>
<th>Adequate</th>
<th>Missing key elements</th>
<th>Incomplete or inaccurate</th>
<th>Missing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Answer demonstrates understanding of the scope of effects on everyone involved.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Answer identifies and describes multiple choices that could be made.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Answer argues for one course of action based on sound scientific or ethical considerations.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
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