



# Personal Genetics Education Project

## Ethical, Legal and Social Issues in Personal Genetics

**Title:** Genetics and Reproduction

**Aim:** How does genetic testing of embryos and fetuses offer hope to individuals wishing to have children, and what are the ethical implications of that testing?

**Time:** This lesson can be adjusted to fill 1 or 2 classes. It provides a selection of activities from which teachers can choose the most appropriate.

### Guiding Questions:

- Why have many people welcomed the option for reproductive genetic testing?
- What are the ethical issues of using reproductive genetic testing?
- What are the possibilities and limits of using reproductive technologies to choose characteristics?
- Does an individual's genetic makeup determine everything about that individual?
- Do we need rules for the use of reproductive technologies? If so, who should make the rules and how should they be enforced?

### Learning Objectives:

After completing this lesson, students will be able to:

- Discuss some of the new technologies for reproductive testing
- Define preimplantation genetic diagnosis (PGD)
- Discuss the benefits of PGD
- Analyze the ethical implications that PGD can raise
- Argue for or against the use of PGD and support their opinions with facts and examples
- Know that an individual's physical, mental and behavioral traits reflect environmental, lifestyle, as well as genetic influences

**Materials:** Projector or Smartboard, laptop, handouts.

### Common Core Standards:

RH.9-10.9. Compare and contrast treatments of the same topic in several primary and secondary sources.

RST.11-12.2. Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

RST.11-12.7. Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.

**Background information and note to teachers:**

This lesson addresses the genetic reproductive technologies that are being used by individuals who, for a variety of reasons, wish to know and/or have some choice about the genetic makeup of their children. It begins with a discussion of the technologies that can reveal the genetic makeup of fetuses and then moves on to a technology called preimplantation genetic diagnosis (PGD). First performed in 1990, PGD is a process in which one or more cells are removed from an embryo created by in vitro fertilization (IVF) and then tested for various genetic markers. Based on the results of the tests, one or more embryos can be selected for transfer into the woman's uterus.

Students are often curious about costs of and access to reproductive technology. This is a rapidly changing landscape. In 2014, a single IVF attempt costs, on average, roughly \$12,400 US. Additional testing for PGD can add \$3,000-\$9,000. Fifteen states require insurers to cover the cost of IVF if it is being used to address infertility, but laws and rates vary. PGD is occasionally also covered by insurance, but it varies by state and individual health plan. Many people pay for these treatments themselves without the help of insurance.

PGD is often used to assess whether an embryo has the genetic mutations that are associated with fatal childhood diseases, with the goal of avoiding those diseases. Thousands of healthy children have been born as a result of this technology, free of the genetic diseases that have, in many cases, devastated the older generations of their families. At the same time, PGD has raised ethical issues, as it gives individuals the capacity to select one embryo over another. The goal of this lesson is to give students an opportunity to discuss many aspects of PGD such that they become aware of the diversity of opinions surrounding PGD.

A crucial point to make in a lesson about genetic reproductive technologies is that many of the traits people might wish for in their children, such as freedom from all physical, mental and behavioral disorders, athletic prowess, and mental agility, are unlikely to be achieved via genetic selection alone. This is because our physical, mental and behavioral states are the result of

complex interactions between multiple genes in combination with our environment and our lifestyles. In addition, scientists are still far from having identified all the genes that contribute to our physical, mental and behavioral traits. It is also key to convey to students that PGD does not modify the genetic make-up of an embryo; that is, it does not alter, add or subtract genes. It is, instead, a tool for assessing the genes that already exist in an embryo.

This lesson contains a number of resources and a selection of activities from which teachers can choose the most appropriate.

1. Readings for students (page 3)
2. Do now (pages 3-4)
3. Slideshow (page 4, slide notes on pages 4-7)
4. PGD questionnaire exercise (page 6, handout on page 11)
5. Scenarios (page 7, handouts on pages 12-16)
6. Fishbowl discussion (pages 8-9)
7. Additional resources for teachers (page 9)
8. Short quiz (answer key on page 10, handout on page 17)

### **Readings for students:**

Before the lesson, have students read [About Genetic Selection](#), including the information from the link to [Frequently Asked Questions](#) and/or, for a more personal story, "[Couples Cull Embryos to Halt Heritage of Cancer](#)," by Amy Harmon in the *New York Times*. Although the *New York Times* article is long, it is very informative and offers a personal story to which students may relate. "[Chinese project probes the genetics of genius](#)" by Ed Yong in *Nature* will give students some background to tackle Scenario A while reinforcing key concepts about genetic complexity.

**Activities:** Do now (5-7 minutes), slideshow (15-20 minutes), scenarios (20-45 minutes), fishbowl discussion (20-30 minutes)

### **Part 1. Do Now** (5-7 minutes)

Have students individually answer the following questions and then share their answers in a brief classroom discussion. These questions are on the second slide in the slideshow.

If you could choose specific traits or qualities that you would want your child to have, what would you choose? Why?

Are there traits you would not want your child to have? What are they? Why?

Note: An important concept to raise is that many physical, mental and behavioral traits are very difficult to predict or ensure. This is because such traits are the result of an individual's environment and lifestyle as well as an individual's genetic make-up. In addition, the genetic basis of many traits is extremely complex and beyond our current understanding.

**Part 2. Slideshow** (15-20 minutes)

We provide a PowerPoint slideshow that introduces the major innovations in reproductive genetic testing and then focuses more on PGD. It gives students a more concrete understanding of PGD and offers an introduction to the social issues that are raised in the scenarios presented below. You should rearrange or delete slides to best fit your class and students' needs. The slideshow is located on the pgEd website along with this [lesson](#), and accompanying explanatory notes for the slideshow are provided below.

**Slideshow notes:**

**Slide 2:** The questions for this "Do Now" activity are a good way to start discussions. Allow students a few minutes to respond and discuss. Refer to the "Do Now" section on page 3.

**Slide 3:** This slide gives an overview of the applications of genetic reproductive technologies. (Note: Slide 4 will explain the difference between an embryo and a fetus.) The slides are broken into two sections; Slides 4-7 give an overview of several technologies in reproductive genetics, while the remaining slides focus on PGD.

**Slide 4:** Every individual begins from the fusion of an egg with a sperm, which results in an embryo that eventually develops into a fetus. Amniocentesis and chorionic villus sampling (CVS) are common prenatal tests that are carried out to reveal information about the developing fetus. Both are considered invasive procedures. An amniocentesis involves inserting a large needle through the pregnant woman's abdomen, uterus and then the amniotic sac to obtain fetal DNA. CVS is performed vaginally or via a needle through the abdomen to collect fetal tissue from the placenta. Both procedures carry a small risk (how small remains a matter of debate, but could be anywhere from a .005% to 1% chance) of miscarriage.

**Slide 5:** More recently, non-invasive methods are being developed, known as non-invasive prenatal testing (NIPT). Every individual begins from the fusion of an egg with a sperm, which results in an embryo that eventually develops into a fetus. Except for the very earliest stages of embryonic development, the embryo and the fetus are connected to the mother by an

organ called the placenta. The placenta facilitates nutrient uptake and waste disposal. Sometimes placental cells break open, releasing fragmented fetal DNA into the blood. This “cell-free” fetal DNA can then enter the mother's bloodstream. There, it mixes with cell-free DNA that has been released from cells in the mother's body. Cell-free fetal DNA makes up a small fraction of the cell-free DNA found in the mother's bloodstream. Since the mother's blood circulates throughout her body, a blood sample taken from the mother's arm will contain cell-free fetal DNA. Extracting cell-free DNA from the mother's blood will give a mix of maternal and fetal DNA. Physicians and researchers have now found a way to analyze this cell-free DNA to reveal information about the developing fetus. While sorting maternal from fetal DNA can still be challenging, the technology has developed to a point where it is being used for NIPT.

**Slide 6:** Another aspect of genetics research is to develop therapies. Recent scientific breakthroughs have brought the possibility of “modifying” or “editing” the genome to repair a disease-causing genetic mutation within reach. This field is still in its early days, yet the hope is that, in the future, gene-editing technologies may one day provide a cure for genetic diseases (e.g. hemophilia, cystic fibrosis, Huntington’s disease) and enable people to better fight off viral infections (e.g. HIV). The idea behind this so-called “genomic surgery” is to alter a specific DNA sequence at its natural location within the genome. This is considered to be a significant advance over conventional approaches for gene therapy, which seek to add one or more working copies of a gene when a person’s existing copies of the gene do not work.

**Slide 7:** In vitro fertilization (IVF) is a process used to help people with fertility issues. Usually, women are given hormone injections to produce multiple eggs, which are then placed in a petri dish with sperm. One or more embryos are then transferred to the woman’s uterus.

**Slide 8:** Preimplantation genetic diagnosis (PGD) can be used during IVF when parents have a high likelihood of passing on a serious or deadly genetic condition to a child. Such genetic disorders include deadly childhood diseases, such as Tay-Sachs and cystic fibrosis, as well as adult-onset diseases, such as Huntington’s disease and breast cancer. Typically, a single cell is removed from an 8-cell embryo and tested. Any embryos that are free of the genetic mutation for which they are being tested are then considered for transfer into the woman’s uterus.

**Slide 9:** This slide shows an image of a cell being removed from an 8-cell embryo (3 days after fertilization).

**Slide 10:** The picture is of siblings Molly and Adam Nash. Molly was born in 1994 with a deadly disorder called Fanconi Anemia, which disrupts the ability of cells to repair their DNA. Molly needed a stem cell transplant to save her life. Molly's parents wanted another baby and decided to conceive a child using IVF and PGD so that they could increase their chances of having a child without Fanconi Anemia who also would be a perfect donor match for Molly. (For more details about the process, check here: <http://www.seattlecca.org/diseases/BMT-hla.cfm>.) This is how Molly's brother, Adam, was conceived. When Adam was born, he donated umbilical cord blood stem cells to his sister. The Nash family was the first in the United States to go public with their use of PGD and donor matching. Molly was able to receive this treatment without government approval. Since the transplant, Molly has recovered and both children are doing well.

We recommend that you pause after slide 10 and conduct the following exercise, which encourages students to form their own opinions about PGD. Afterwards, students will see the results of studies that were designed to reveal what citizens of the United States think about PGD in Slides 11-13.

- 1) Hand out the questionnaire on page 11 of this document.
- 2) Tell the students NOT to put their name or any identifying mark on the page.
- 3) Have them answer the questions on their own.
- 4) Collect all the sheets, scramble and then redistribute them among the students at random.
- 5) Tell the students not to let anyone know if they happen to have received their own answer sheet back.
- 6) Ask the students to go through the sheet in front of them and think about how these answers may differ or overlap with their own answers. Discuss with the group if time allows, and then complete the slideshow.

**Slide 11:** Most IVF clinics that provide PGD use this technology to address serious genetic disorders. In a study that was published in 2006, 42% of clinics surveyed will also assess the sex of the embryo for "non-medical reasons." For example, parents want a boy or girl based on preference and not because they wish to avoid a genetic condition that is typically associated with one sex or the other. The study also shows that 3% of clinics allow families to select embryos with traits that others might see as a disability, such as deafness or dwarfism. The topic of PGD and deafness is

explored in Scenario D of this lesson. Note: some of the percentages mentioned above have likely changed since their publication in 2006. The authors of this publication sampled 137 clinics, all based in the United States.

**Slide 12:** In a 2004 study, a majority of the Americans surveyed thought it was acceptable to use PGD to select embryos in order to avoid serious illness or identify a match for stem cell donation. Note that over 20% of women and 30% of men thought it would be acceptable to test for intelligence or strength. These results provide the basis for a discussion to ensure students understand that it is difficult to discover the genetic basis of traits as complicated as intelligence or strength. Students should further understand that traits also reflect a person's environment and lifestyle.

**Slide 13:** Currently, there is little government oversight or regulation of reproductive technologies in the United States. In this study published in 2006, 62% of people surveyed think there should be some government regulation. Another 17% believe the government should have no role in regulating PGD and that the patient or doctor can make any decision related to the embryos.

**Slide 14:** This slide provides some additional questions to promote discussion. Most importantly, students should come away knowing that there are many differing opinions about the use of reproductive technologies.

### **Part 3. Scenarios (20-45 minutes)**

Students will read and discuss various scenarios related to PGD, provided on pages 12-16 of this document, in order to better understand the issues surrounding this technology. These are typically used after the slideshow.

1. Break students into groups and give each group one of the five scenarios. Although not essential, we recommend giving each group its own scenario. One of the primary goals of this activity is to give students the experience of forming an opinion about reproductive technologies and then defending that opinion. This activity also will help students become aware of the diversity of opinions and how to respect that diversity.
2. Within each group, have students read the assigned scenario and consider the accompanying questions.
3. Have students in each group present their scenario and the main ideas raised. Students may find it useful to refer to the articles they have read or their personal experience.

### **Part 4. Fishbowl Discussion (20-30 minutes)**

If time allows, students will participate in a fishbowl discussion about the use of PGD. They will be encouraged to dig deeper into the questions and discuss the ethics of this technology. Students should read the articles at the beginning of the lesson (page 3) and all of the scenarios (pages 12-16) to inform their opinions.

**Process:** A fishbowl discussion allows for multiple perspectives and opinions in a structured environment and encourages (or requires) all students to participate. A description of the fishbowl technique is at Facing History and Ourselves: <http://www.facinghistory.org/resources/strategies/fishbowl>. The “fishbowl” is a teaching strategy that helps students practice being contributors and listeners in a discussion. Students ask questions, present opinions and share information when they sit in the “fishbowl” circle, while students on the outside of the circle listen carefully to the ideas presented and pay attention to process. The roles then reverse. This strategy is especially useful when you want all students to participate in the discussion, to help students reflect on what a “good discussion” looks like and when you need a structure for discussing controversial topics.

A fishbowl requires a circle of chairs (“the fishbowl”) and enough room around the circle for the remaining students to observe what is happening in the fishbowl. Sometimes teachers place enough chairs for half of the students in the class to sit in the fishbowl, while other times teachers limit the number of chairs in the fishbowl. Typically, six to twelve chairs allows for a range of perspectives while still allowing each student an opportunity to speak. The observing students often stand around the fishbowl.

There are many ways to structure a fishbowl discussion. Sometimes teachers have half the class sit in the fishbowl for 10-15 minutes and then say “switch,” at which point the listeners enter the fishbowl and the speakers become the audience. Another common fishbowl format is the “tap” system, in which students on the outside of the fishbowl gently tap a student on the inside, indicating that they should switch roles.

Regardless of the particular rules you establish, you should make sure they are explained to students beforehand. You also need to provide instructions for the students in the audience. What should they be listening for? Should they be taking notes? Before beginning the fishbowl, you may wish to review guidelines for having a respectful conversation. Sometimes teachers ask audience members to pay attention to how these norms are followed by recording specific aspects of the discussion process such as the number of interruptions, respectful or disrespectful language used or speaking times (i.e. who is speaking the most? the least?)



After the discussion, you can ask students to reflect on how they think the discussion went, what they learned from it and how they evaluate their participation as listeners and as participants. These reflections can be in writing or can be structured as a small or large group conversation.

**Assessment:**

In addition to participation, assess students through a 1-2 paragraph response to each set of questions posed at the end of each scenario (pages 12-16 of this document).

**Additional resources for teachers:**

Penn Medicine on PGD, with videos of the PGD procedure:

<http://www.pennmedicine.org/fertility/patient/clinical-services/pgd-preimplantation-genetic-diagnosis/>

Center for Genetics and Society, [Assisted Reproduction](#) section

"[New prenatal tests hold promise, worries](#)," March 2013, by Carolyn Johnson, *Boston Globe*.

"[Sequencing of fetal genomes using only maternal blood sample](#)," July 2012, by Krista Conger, *Science Daily*.

"[Is it wrong to select a deaf embryo?](#)" March 2008, by Clare Murphy, *BBC*.

The Nash family story is discussed in "[Son conceived to provide blood cells for daughter](#)" in October 2000 by Denise Grady in the *New York Times* and "[Embryo genetic screening controversial - and successful](#)" in January 2010 by Dan Vergano in *USA Today*. For a longer and more detailed article about Molly Nash, read "[The Miracle of Molly](#)" in August 2005 by Amanda Faison in *5280: The Denver Magazine*.

[Genetic Dilemmas: Reproductive Technology, Parental Choices and Children's Futures](#) - Dena Davis (non-fiction)

[My Sister's Keeper](#) – Jodi Picoult (fiction)

[GATTACA](#) – written and directed by Andrew Niccol (movie)

**“Genetics and Reproduction” quiz answer key (see page 17 for quiz)**

1. Gain information about an unborn fetus, help individuals conceive, allow individuals to select embryos based on the genetic makeup of the embryos.
2. F
3. T
4. F
5. A
6. F

## Questionnaire

**Do *not* give your name or make identifying marks.  
Answer the following questions by circling Yes or No  
Note: I will not be saving these after the exercise.**

Should people be allowed to test embryos:

1. for painful, deadly diseases that develop within the first three years of life?  
Yes or No
2. for painful, deadly diseases that develop in young adulthood? Yes or No
3. for painful, deadly diseases that develop at age 75 or beyond? Yes or No
4. for diseases that are not usually deadly, but can have a major impact on the family? Yes or No
5. to choose the sex of the child? Yes or No
6. to choose eye color? Yes or No

Name\_\_\_\_\_

Date\_\_\_\_\_

Directions: Read the following scenario and discuss the issues before answering the questions.

**Scenario A: A family decides about genetic testing.**

**Note:** *The genetics of intelligence is a very controversial topic. Not only is intelligence likely to reflect much more than just genetics, the mere definition of 'intelligence' is controversial. Perhaps for these very reasons, this is a useful example for illustrating the complexities of using genetic information.*

Imagine that, in the next 10-15 years, scientists discover a series of genes linked to intelligence. A test is developed that can be performed on embryos before they are implanted in a woman, and a company begins to sell the test to doctors. The company that sells the test claims children who are selected for intelligence could go on to better colleges, better jobs, etc.

You want to give your children every advantage possible. You moved to be closer to the best school in your neighborhood and you spend as much time as possible helping with homework. Your child knows how important it is to work hard at school.

You used IVF for your first child because of fertility issues and expect you will use it again. You are now debating whether to use this new PGD test to select an embryo.

1. Should parents be allowed to test embryos for intelligence? Why or why not? Is it acceptable for a company to sell a test that says it can help parents choose a smart child? Explain.
2. If you were the parent, how would you define intelligence? Is there only one way to be intelligent? Is it better to be good at math rather than writing, for example? Does having certain abilities make you smarter than having others? Think about a famous artist, such as Pablo Picasso or Frida Kahlo; if you gave them a chemistry test, do you think they would still appear to be brilliant? Explain.
3. Are you being fair to the oldest child? How would you feel if you were the older child, and your parent thinks you are not as smart as your younger sibling? How would you feel if your parent had lower expectations for you? Is this fair to the second child?

Name\_\_\_\_\_

Date\_\_\_\_\_

Directions: Read the following scenario and discuss the issues before answering the questions.

**Scenario B: A family weighs its options to help a sick child.**

PGD can be used when a parent has a high likelihood of passing on a genetic mutation that can lead to a severe genetic disease. It allows doctors to implant embryos that do not carry the mutation. Supporters of this technique argue that the resulting child benefits because he or she is born without the mutation that causes this disease.

PGD also can be used to select an embryo that will grow to become a perfectly matched donor for a sick older sibling. The idea is that this child would be a match to donate cells, tissues or even an organ to his or her sibling.

Your first child is very sick and needs a bone marrow transplant. You are planning to have a second child, and, if that child were a match, it would be possible to transplant cells taken from the umbilical cord blood at birth. Blood is collected after the cord is cut and no longer attached to the baby. There is no guarantee that a transplant will permanently cure your sick older child, but, from a medical perspective, it is a good approach.

You are considering doing PGD both to avoid the illness your first child has and to make sure a future child could also be a donor. The hope is that this child will only need to donate stem cells from the umbilical cord, which would be painless for the baby. However, it is possible that, sometime in the future, this child may be called on to donate other tissues, such as bone marrow.

1. What would you do as a parent if you were in this situation? Why?
2. How would you explain to both children the role that the younger sibling played in the life of the first child? How could this impact how each child sees his or her role in the family?
3. Discuss the ethical implications of choosing an embryo that will become a child who is a perfect match for an older sibling? Do you think it is ethical to let a child die without doing everything possible to save him or her? Explain.

Name\_\_\_\_\_

Date\_\_\_\_\_

Directions: Read the following scenario and discuss the issues before answering the questions.

**Scenario C: Congress is asked to vote on genetic testing of embryos.**

PGD can assess embryos for a specific genetic mutation that may lead to a disease. It can also test the embryo's potential to be a perfect match to donate stem cells to a sick sibling. If a second child is born a match, blood cells from his or her umbilical cord would be removed via a painless procedure after the baby's umbilical cord is cut and transplanted into the sick child.

You are a member of the United States House of Representatives. Imagine that a bill has been proposed to ban some uses of PGD. The bill argues that it is not in the best interest of a child to have been selected as a perfectly matched donor for an older sibling.

Supporters of the ban argue that children who are a perfect match to an older sibling may be pressured to donate additional tissues or organs to that sibling. As children, they may not be able to fully understand the medical and emotional risks of becoming a donor, and they have a right to be born without this sort of burden. Supporters of the ban also are concerned that parents, when faced with the possible or likely death of a child, may have difficulty evaluating what is best for each child.

However, some patient groups want the use of PGD to be unregulated. They argue that it is unethical to restrict a technology that can lead to healthier children and save the lives of children who are suffering.

1. Do you think it is ethical to test embryos to find a match for a sick sibling? Why or why not?
2. How would you vote if you were in Congress: allow this use of PGD to continue or ban it? Why?
3. Currently, there are no federal laws in the United States governing how this technology should be used. Do you think there should be? Are there other options besides banning PGD or leaving PGD unregulated? What might be a compromise solution?

Name\_\_\_\_\_

Date\_\_\_\_\_

Directions: Read the following scenario and discuss the issues before answering the questions.

**Scenario D: A family decides whether to have a baby with what is traditionally thought of as a genetic disorder or disability.**

You and your partner are both deaf and proud members of the Deaf culture, with its own language and values. You have one child who is deaf. You hope your second baby will also be deaf, so he or she will more readily be a part of your culture and community; you don't feel like deafness is a disability.

You and your partner are hoping to have a baby using in vitro fertilization (IVF). You know some deaf people who have used IVF and PGD to determine which embryos have a genetic makeup associated with deafness and which have a genetic makeup associated with hearing. You have the potential to choose which embryos to transfer to the uterus.

If you have a child who can hear, he or she might be alienated from your family, though the child would be less isolated in the larger world. If you have a deaf child, he or she may more easily integrate into your family's culture, have your support in how to navigate the world as a deaf person and be part of a close-knit deaf community. However, deaf people often have a difficult time in school and in finding a job, and can face social isolation.

Note: First, the details of this scenario are not as important as the issues raised, which extend beyond this example and shed light on different perspectives on disability. Second, when choosing the embryos to transfer to a woman's uterus, the choice is not between *making* a child deaf or permitting it to hear; **nobody is changing or manipulating the embryo**. The choice is between an embryo that, from a genetic standpoint, is already likely to develop into a child who is deaf or an embryo that is already likely to develop into a child who can hear.

1. If you were the parent, would you choose the embryo(s) that would develop into a child who would likely be deaf? Why? What factors would you consider as you make your decision?

2. There are debates about whether PGD should be used to select for traits traditionally considered a disability. Who do you think should decide how PGD is used: parents, doctors, lawmakers, religious leaders or others?

Name\_\_\_\_\_

Date\_\_\_\_\_

Directions: Read the following scenario and discuss the issues before answering the questions.

### **Scenario E: Using PGD when Huntington's Disease runs in the family**

Huntington's disease (HD) is a genetic disorder in which nerve cells in certain parts of the brain waste away. It is caused by a mutation in the Huntingtin gene. Most people affected by this disease develop symptoms in their 30s or 40s and die about 15-20 years later. As the disease is passed down from one generation to the next, symptoms develop at younger and younger ages. There is currently no cure for HD.

HD is a devastating disease. Symptoms include behavioral disturbances, hallucinations, irritability, paranoia, psychosis and loss of motor control. Abnormal and unusual movements include grimaces and wild jerking of the arms, legs, face as well as other body parts. Affected individuals also suffer from personality changes and dementia, including disorientation, confusion and loss of judgment and memory.

If one of your parents has HD, you have a 50% chance of inheriting the mutation in the Huntingtin gene. If you inherit this mutation, you will develop the disease at some point in your life, and each of your children will have a 50% chance of inheriting it from you. If you do not inherit this mutation, you will not develop HD and will not pass it on to your children.

It is possible for people who know they carry a mutation in the Huntingtin gene to avoid passing it to their children. By using [in vitro fertilization](#) (IVF), in which eggs are fertilized with sperm outside the womb, it is possible to test embryos for genetic mutations prior to transfer to the uterus. This strategy enables parents to select only embryos that are free from the mutation in the Huntingtin gene.

1. If you knew that you carried a mutation in the Huntingtin gene but wanted to have children, what are your options? What do you think you would do in this situation?
2. What do you see as the biggest benefits and risks in using this technology?



Name\_\_\_\_\_

Date\_\_\_\_\_

### **"Genetics and Reproduction" quiz**

1. Short answer: What are some purposes of "reproductive technology"?
  
2. The United States population agrees how and why reproductive technology should be used for all people. T/F
  
3. It is possible to use genetic testing to find out if a fetus is likely to develop into a child who has a condition such as Down Syndrome or has a higher risk than average for hereditary breast cancer. T/F
  
4. It is possible to use genetic testing to conclusively find out if a fetus will develop into a child who will be tall, good at math or a talented artist. T/F
  
5. Preimplantation genetic diagnosis (PGD) is a type of genetic testing that allows:
  - a) potential parents to screen embryos for certain traits, usually to avoid serious medical conditions.
  - b) potential parents to choose traits like intelligence and height in their children.
  - c) children to learn about their own DNA when they turn 18.
  - d) allows potential parents to add desirable genes or delete undesirable ones from an embryo.
  
6. The United States highly regulates and monitors how reproductive technologies are used. T/F