g a t t a c a

Essay #1:
Poker Face

Your unique DNA sequence can be found inside every cell in your body. That's a lot of DNA! Vincent taking on Jerome's identity required much careful thought and planning. Vincent had to deposit as much of Jerome's valid DNA *into* GATTACA to ensure his identity was never questioned, but at the same time had to find ways of keeping his own invalid DNA *out* of GATTACA.

Describe the daily preparations that Vincent must complete to pass as Jerome Morrow at GATTACA For each, describe how he did the preparation AND explain why each was necessary. Would you be willing to go to the same lengths as Ethan Hawke's character to fake your identity, so that you were not limited by your genetic makeup? In your answer, reference the terms "genoism", "de-generate", & "borrowed ladder".

Essay #2
Nature vs. Nurture

GATTACA is a glimpse into the not-so-distant future of a world with genetically engineered humans & technologically reinforced discrimination. An individual's career and place in society depends on his/her genes and is used exclusively to gauge one's potential. Individuals engineered with superior genetic profiles are hired into higher level jobs, while the others are considered for menial work only. Although individuals with "inferior genes" can still do well, they are never given the chance to prove themselves. How do the characters Vincent/Jerome, Anton, Jerome/Eugene, & Irene show the limits to which our genes ultimately determine our possibility of being successful in life? With hard work, determination, and access to opportunity can one exceed their genetic potential? Or is it a better system to use technology as a tool to "fix" our genetic imperfections at the source rather than through personal striving?

Essay #3
Designer Babies

During a scene in GATTACA, Vincent's parents visited a doctor who specialized in child conception to select for the best traits for his future brother. They hoped that his brother would have the best possible chances for a successful life. Some of the traits mentioned in GATTACA included intelligence, height and any possibility of inheritable diseases. Read the article "Are We Too Close to Making GATTACA a Reality" and argue your position on Human Genetic Engineering portrayed in the movie GATTACA.

a. If you decided to have a child one day and are given the opportunity to select for special traits, would you do so? Argue why or why not.
b. If you *would* select special traits, to what extent would you want to control the outcome? Would you simply eliminate the possibilities of certain diseases or birth defects, or would you want to choose the sex, physical traits, and possibly the academic, athletic, or artistic abilities of your child? What would be your top 3 picks of genetic traits of your child and why?
   If you *would NOT* choose to do so, would you be more open to the idea if you lived in a society where many other people were genetically engineering their children and you would risk putting your child at a disadvantage by conceiving naturally? What traits in your own family would you hope are naturally passed to your child (pick 3) and why.

Essay #4
THE INTERVIEW

In groups of 3, choose a pair of characters from the list below and write interview questions for each as though you are interviewing them for a documentary.

Vincent & Eugene	Vincent & Irene	Vincent & Anton	Vincent & Caesar

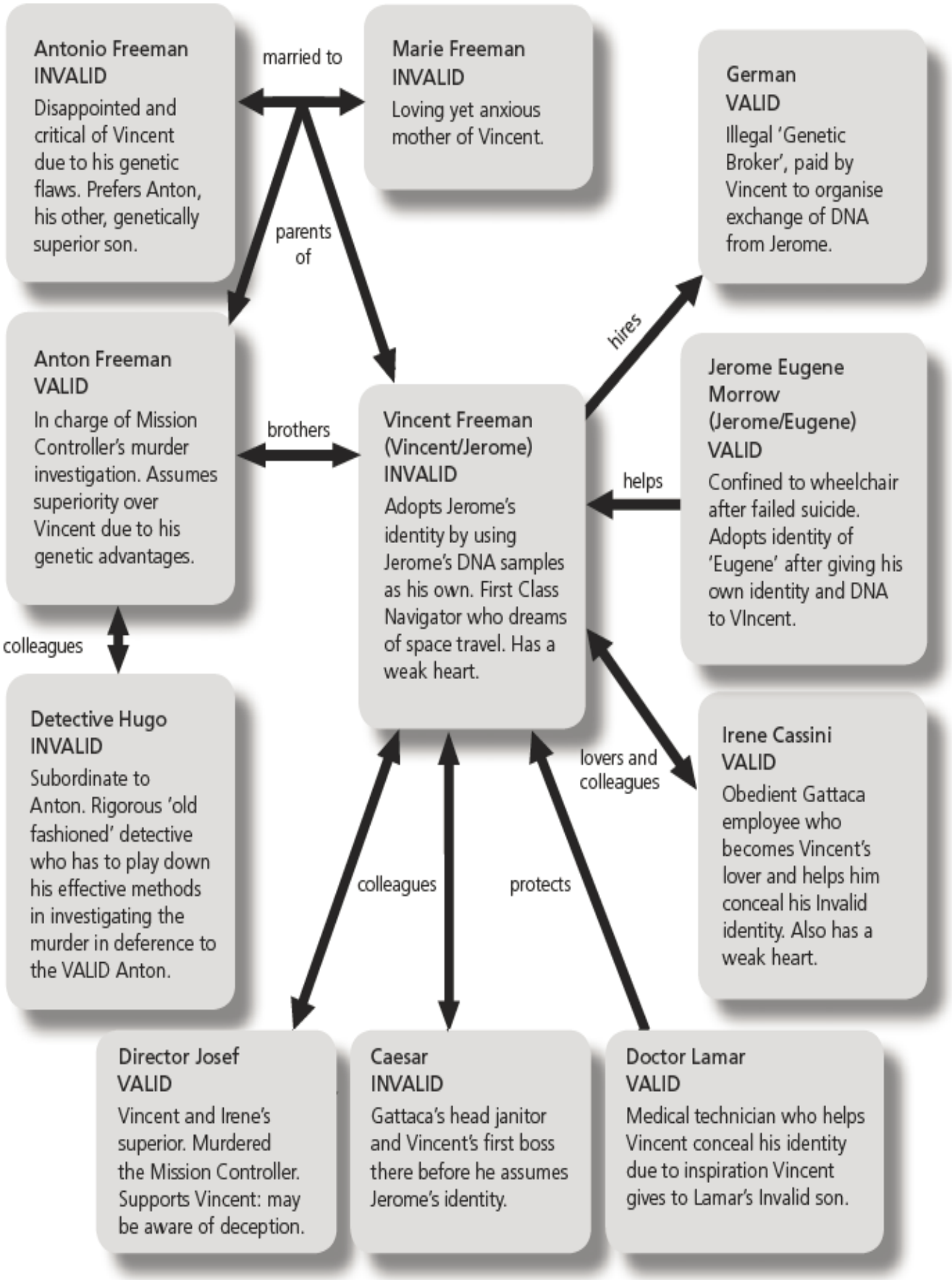
The aim of this documentary is to explore the characters' relationship as accurately as possible. The focus of your questions should illustrate the following:

- What their relationship was like at the beginning of the movie.
- How it changed over the course of the movie.
- How their different personalities affected the relationship.
- What their relationship was like at the end of the movie.

Once you've written the interview questions and character responses, be prepared to be "called on" to come up in front of the class to "act out" your interview. One person will act as the interviewer while the remaining members will act as the selected pair of characters.

NCSCS: 31: Explain how traits are determined by the structure and function of DNA
NCSCS: 33: Understand the application of DNA technology

Character Map



Are We Too Close to Making Gattaca a Reality?

Sometime in the not-too-distant future, Marie and Antonio Freeman step into a doctor's office to design their next child.

"Your extracted eggs, Marie, have been fertilized with Antonio's sperm," the doctor says. "After screening we're left with, as you see, two healthy boys and two very healthy girls."

A monitor displays what looks like soap bubbles that bumped into each other on a green background.

"Naturally, no critical predispositions to any of the major heritable diseases," the doctor says. "All that remains is to select the most compatible candidate. We might as well start with gender—have you given it any thought?"

"We would want Vincent to have a brother, you know, to play with," Marie says, referring to her first child.

Acknowledging this, the doctor continues: "You have specified hazel eyes, dark hair and fair skin. I have taken the liberty of eradicating any potentially prejudicial conditions: premature baldness, myopia, alcoholism and addictive susceptibility, propensity for violence and obesity—"

"We didn't want—I mean, diseases, yes," Marie interrupts.

"Right, we were wondering if it's good to leave a few things to chance," Antonio says.

"You want to give your child the best possible start," the doctor replies. "Believe me, we have enough imperfection built-in already. Your child doesn't need any additional burdens. And keep in mind, this child is still you, simply the best of you. You could conceive naturally a thousand times and never get such a result."

The Freemans are characters in the science fiction film *Gattaca*, which explores liberal eugenics as an unintended consequence of certain technologies meant to assist human reproduction. Although Antonio and Marie do not exist outside the movie's imaginary universe, their real-life counterparts could be walking among us sooner than we think—and, in a sense, they already are.

When *Gattaca* premiered in 1997, doctors had been using laboratory techniques to help women and men overcome infertility for more than a decade. In 1978, Louise Brown of the U.K. became the world's first "test tube baby"—the first person conceived through in vitro fertilization (IVF), a procedure in which sperm and eggs are combined in the lab to create several viable embryos that are subsequently implanted in a woman's womb. The first IVF clinic opened in the U.S. in 1980. Today, hundreds of fertility clinics in the country offer IVF and more than one percent of children born in the U.S. are conceived this way.

In the years surrounding *Gattaca*'s release, doctors were also talking about how to responsibly use another, more controversial technique to help people have children: preimplantation genetic diagnosis (PGD). In this procedure, clinicians vacuum up one of eight cells in a three-day-old embryo created through IVF and analyze the DNA within to find genes associated with debilitating and potentially fatal diseases. Sometimes, doctors wait two more days, when the embryo has become what is known as a blastocyst—a mostly hollow ball of around 100 cells—and collect between 5 and 20 cells for DNA analysis. In most cases, this extraction does not significantly disturb the embryo's development. PGD can identify embryos that will almost certainly develop disorders caused by a mutation in a single gene, such as cystic fibrosis, sickle cell disease, Tay-Sachs and Huntington's, as well as disorders that result from an extra chromosome, such as Down syndrome. From its earliest days, PGD has been principally intended for people who have a high risk of conceiving a child with a particular disorder, because it runs in the family or because they happen to harbor a certain genetic mutation.

Couples have also created one child through IVF-PGD in order to save another. At least 30 fertility clinics in the U.S. will help parents conceive a “savior sibling”—a child whose umblical cord blood can be harvested as a source of stem cells to treat leukemia, Fanconi anemia or another terrible illness in his or her older sibling. An infusion of stem cells donated by a relative whose immune cells are genetically similar to those of the sick child has a much better chance of succeeding than cells from a stranger. Siblings inherit their immune system genes from the same parents, so they are sometimes an almost exact immunological match—something doctors at fertility clinics can determine by looking at an embryo's DNA.

Nominally, clinics agree to help parents in this way only if the couple had always intended to have several children. But some parents in this situation undoubtedly alter their original family plan out of desperation. So what happens if the treatment fails? How will the inevitable disappointment change the way parents feel about their second child? And how does learning that one’s entire existence hinges on saving someone else’s life warp the psychological development of a child or young adult? In Jodi Picoult’s 2004 novel *My Sister’s Keeper*, thirteen-year-old savior sibling Anna sues her parents for medical emancipation when they ask her to donate a kidney to her older sister Kate, who has leukemia. Preventing and treating diseases are not the only reasons people have turned to pre-implantation genetic diagnosis. PGD also makes it possible for parents to predetermine characteristics of a child to suit their personal preferences. In a few cases, people have used PGD to guarantee that a child will have what many others would consider a disability, such as dwarfism or deafness. In the early 2000s, lesbian couple Sharon Duchesneau and Candy McCullough—both deaf from birth—visited one sperm bank after another searching for a donor who was also congenitally deaf. All the banks declined their request or said they did not take sperm from deaf men, but the couple got what they were looking for from a family friend. Their son, Gauvin McCullough, was born in November 2001; he is mostly deaf but has some hearing in one ear. Deafness, the couple argued, is not a medical condition or defect—it is an identity, a culture. Many doctors and ethicists disagreed, berating Duchesneau and McCullough for deliberately depriving a child of one of his primary senses. Much more commonly, hopeful parents in the past decade have been paying upwards of $18,000 to choose the sex of their child. Sometimes the purpose of such sex selection is avoiding a disease caused by a mutation on the X chromosome: girls are much less likely to have these illnesses because they have two X chromosomes, so one typical copy of the relevant gene can compensate for its mutated counterpart. Like Marie and Antonio Freeman in *Gattaca*, however, many couples simply want a boy or a girl. Perhaps they have had three boys in a row and long for a girl. Or maybe their culture values sons far more than daughters. Although the U.K., Canada and many other countries have prohibited non-medical sex selection through PGD, the practice is legal in the U.S. The official policy of the American Society of Reproductive Medicine is as follows: “Whereas preimplantation sex selection is appropriate to avoid the birth of children with genetic disorders, it is not acceptable when used solely for nonmedical reasons.” Yet in a 2006 survey of 186 U.S. fertility clinics, 58 allowed parents to choose sex as a matter of preference. And that was seven years ago. More recent statistics are scarce, but fertility experts confirm that sex selection is more prevalent now than ever.

“A lot of U.S. clinics offer non-medical sex selection,” says Jeffrey Steinberg, director of The Fertility Institutes, which has branches in Los Angeles, New York and Guadalajara, Mexico. “We do it every single day. We did three this morning.”

In 2009 Steinberg announced that he would soon give parents the option to choose their child’s skin color, hair color and eye color in addition to sex. He based this claim on studies in which scientists at deCode Genetics in Iceland suggested they could identify the skin, hair and eye color of a Scandinavian by looking at his or her DNA. "It's time for everyone to pull their heads out of the sand,” Steinberg proclaimed to the BBC at the time. Many fertility specialists were outraged. Mark Hughes, a pioneer of pre-implantation genetic diagnosis, told the *San Diego Union-Tribune* that the whole idea was absurd and *the Wall Street Journal* quoted him as saying that “no legitimate lab would get into it and, if they did, they'd be ostracized." Likewise, Kari Stefansson, chief executive of deCode, did not mince words with the WSJ: “I vehemently oppose the use of these discoveries for tailor-making children,” he said. Fertility Institutes even received a call from the Vatican urging its staff to think more carefully. Seifert withdrew his proposal.

But that does not mean he and other likeminded clinicians and entrepreneurs have forgotten about the possibility of parents molding their children before birth. “I’m still very much in favor of using genetics for all it can offer us,” Steinberg says, “but I learned a lesson: you really have to take things very, very slowly, because science is scary to a lot of people.” Most recently, a minor furor erupted over a patent awarded to the personal genomics company 23andMe. The patent in question, issued on September 24th, describes a method of “gamete donor selection based on genetic calculations." 23andMe would first sequence the DNA of a man or woman who wants a baby as well as the DNA of several potential sperm or egg donors. Then, the company would calculate which pairing of hopeful parent and donor would most likely result in a child with various traits.

Illustrations in the patent depict drop down menus with choices like: “I prefer a child with Low Risk of Colorectal Cancer; “High Probability of Green Eyes;” "100% Likely Sprinter;" and “Longest Expected Life Span” or “Least Expected Life Cost of Health Care." All the choices are presented as probabilities because, in most cases, the technique 23andMe describes could not guarantee that a child will or will not have a certain trait. Their calculations would be based on an analysis of two adults’ genomes using DNA derived from blood or saliva, which does reflect the genes inside those adults’ sperm and eggs. Every adult cell in the human body has two copies of every gene in that person’s genome; in contrast, sperm and eggs have only one copy of each gene and which copy is assigned to which gamete is randomly determined. Consequently, every gamete ends up with a unique set of genes. Scientists have no way of sequencing the DNA inside an individual sperm or egg without destroying it.

“When we originally introduced the tool and filed the patent there was some thinking the feature could have applications for fertility clinics. But we’ve never pursued the idea, and have no plans to do so,” 23andMe spokeswoman Catherine Afarian said in a prepared statement. Nevertheless, doctors using PGD can already—or will soon be able to—accomplish at least some of what 23andMe proposes and give parents a few of the choices the Freemans made about their second son.

Since Steinberg’s contentious proposal in 2009, researchers have developed a much clearer understanding of the various genes responsible for the pigments in our bodies. Forensic geneticist Manfred Kayser of Erasmus MC and his colleagues have published many studies in which they have accurately identified people’s eye and hair color by looking at their DNA. Their tests cannot recognize every possible shade, but they are specific enough to distinguish between brown, blue and mottled brown-blue eyes, as well as brown, black, blonde and red hair. Such studies are intended to help solve crimes, but clinicians at fertility clinics could easily adapt the strategies for PGD. Based on ongoing research, Manfred thinks he and other scientists will soon be able to confidently identify skin color by looking at someone’s genes as well. In the more distant future, he adds, researchers will probably learn enough to deduce the texture of a person's hair, the shape of his or her face, and the person's height.

Today, genetic analysis can also reveal the likelihood of various quirks of human biology that some people find fascinating and others might consider trivial. Take, for example, the probability that someone will experience “Asian glow." The ALDH2 gene codes for an enzyme named aldehyde dehydrogenase that converts a toxic byproduct of alcohol metabolism into a benign acid. People with only one or no working copies of the gene feel nauseated and flush red when they drink alcohol. Around 50 percent of East Asians have underactive aldehyde dehydrogenases. Earwax consistency is also relatively easy to predict with a genetic test because it is controlled by a single gene: one version of the gene produces sticky amber ear wax; the other makes dry, gray, flaky earwax. A single gene also largely determines one’s ability to taste certain bitter compounds commonly found in Brussels sprouts, coffee, cabbage and other foods.
These examples of relatively straightforward relationships between genes and traits are exceptions to the daunting complexity of human genetics. Most characteristics of the human body—even seemingly simple ones like earlobe attachment, dimples and hair whorls—have stumped researchers with far more convoluted genetics than they anticipated. That's why confidently reporting eye and hair color based on DNA is a relatively recent accomplishment. In high school, you may have learned that eye color is a simple Mendelian trait in which one or two dominant copies of a gene produces brown eyes whereas two recessive versions result in blue eyes. In fact, more than a dozen genes likely interact to determine the hue of your iris. So, when it comes to something as multi-faceted as intelligence or personality, we may never have a particularly useful predictive genetic test. For the foreseeable future, then, any possibility of designer babies may be limited to rather basic—though, to many parents, important—human features: essentially, the shape and color of a child's face and body.

IVF presents another set of barriers to tailor-making children through PGD. After all, PGD does not entail actively engineering DNA inside an embryo to fit parents' specifications; rather, parents select what they consider the most desirable genetic package from a group of successfully fertilized embryos. And clinicians can only fertilize as many eggs as they collect from a woman's ovaries Currently, IVF retrieves between 8 and 15 eggs on average—enough to provide parents with quite a few options, but not a large enough number to ensure that any one embryo will have more than a handful of desired traits.

As scientists continue to examine the human genome from every angle, however, they will undoubtedly uncover new genetic associations that—if they cannot promise a particular feature—will at least divulge a probability. 23andMe claims that, by sequencing your DNA, it can tell you something interesting about 60 "traits," many of which are physical

characteristics or talents of some kind. As that type of knowledge continues to surface, some people will not be able to resist it, even when it rests only on a few preliminary studies. A clinic could take advantage of these insights to discreetly

give couples the option of choosing more than just the sex of their child through PGD, framing it as a way to tip the scales, to—as the doctor in *Gattaca* says—give one's child "the best possible start." One couple would tell another. Some parents—especially the wealthy—may begin to believe they have a choice between leaving their child's future completely to chance and helping that child in at least some small way. When *Gattaca* appeared in theaters in 1997, much of what the film depicted was not yet possible. Now, some of it is. What separates our society from a proto-*Gattaca*today is not so much scientific understanding or technology as people's attitudes towards that technology—a much more delicate membrane.

"Unfettered development of PGD applications is providing parents and fertility specialists an increasing and unprecedented level of control over the genetic make-up of their children," wrote Tania Simoncelli, Assistant Director for Forensic Sciences within the White House Office of Science and Technology Policy, in 2003. "Indeed, if ever there was a case for a 'slippery slope,' this is it. Advances in PGD, together with cloning and genetic engineering, are tending towards a new era of eugenics. Unlike the state-sponsored eugenics of the Nazi era, this new eugenics is an individual, market-based eugenics, where children are increasingly regarded as made-to order consumer products."
An era of market-based eugenics would exterminate any lingering notions of meritocracy. Perseverance, adaptability, and self-improvement would become subordinate to what people would see as innate talent and near certain prosperity preordained by one's genes. Despite laws meant to prevent genetic discrimination, the world of *Gattaca* is a highly stratified one with two distinct classes: the valids—who have the right genes, the most prestigious jobs and the highest quality of life—and the in-valids, who were conceived in the typical fashion and are relegated to menial work and relative poverty. Eugenics also risks creating a genetically homogenous population that is far more vulnerable to disease and freak deleterious mutations than a diverse one.

But that could never happen this side of the silver screen, right?

"The demand is up," Steinberg says. "People are liberalizing. You will see PGD done on almost every embryo in the future."