


# GATTACA is still pertinent 25 years later

Dov Greenbaum & Mark Gerstein

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It has been 25 years since the release of *GATTACA*, a film that tells the story of a credible near future in which society's inequalities, formerly associated with race and class, have been replaced with new prejudices based on genetic determinism. Here we compare *GATTACA*'s fictional technologies with reality's state of the art, assessing the legal protections afforded in today's society against *GATTACA*'s dystopian future in which personal freedom and privacy rights are substantially curtailed by genomic innovations. We further discuss how *GATTACA*'s prescient forewarnings are still relevant today in light of the current trajectory of genomic science and technology.

*GATTACA*, a film directed by Andrew Niccol, was released 25 years ago, only a couple of years before the June 2000 announcement of the first working draft sequence of the human genome at the White House Rose Garden. Similarly auspiciously, Stanley Kubrick's *2001: A Space Odyssey* was released a year shy of Apollo 11's landing in the Sea of Tranquility on the moon.

Notably, the world presented in Kubrick's films and books, with regular human space travel to and beyond Jupiter, is still completely removed from current technological capabilities. The notion of human travel to Jupiter now seems even further in the future than it did then, especially with the US national space program languishing in anachronistic technologies. Even the new Artemis Space Launch System, per US Congress dictate, is obliged to use space-shuttle-derived components dating back almost 40 years<sup>1</sup>. December 2022 marks half a century since humankind last stepped on the moon, and it will be perhaps decades more until astronauts are systematically traveling to Mars or orbiting Jupiter.

Compare that to the genetics-centric world *GATTACA* imagines. The film's technologies, pervasive notion of surveillance, and concomitant privacy issues seem prescient. Since the movie came out, science has produced rapid, accurate and cheap genome sequencing, genome-wide association studies, and precision genetic manipulation tools such as synthetic biology and CRISPR. Arguably, in the United States, much of this state of the art can be attributed to vast investments by the biotechnology industry, the profit margins that entice them, and extensive support by the government for both public genomic endeavors and private ones<sup>2</sup>. In contrast, although innovative, the privately funded billionaire space-exploration class is still in its nascent phase, conceivably driven more by vanity than by profits<sup>3</sup>.

Given that advancements in genetics continue to approximate and perhaps even supersede the innovations of the film, *GATTACA* remains a relevant touchstone – 25 years later – in discussions related to the ethical, legal and social implications of genomics and bioengineering for scientists, policymakers<sup>4,5</sup> and the lay public<sup>6</sup>. The film continues to be a valuable feature of genetics and bioethics syllabi in academia.

In brief, *GATTACA* tells of a dystopian future in which class divisions seem to be based merely on the degree of prenatal genetic manipulation, reminiscent of the caste system in Aldous Huxley's *Brave New World*. 'Valid's are virtually guaranteed the best opportunities, given their perceived genetic superiority, whereas genetically unmodified 'In-Valid's are second-class citizens, or worse. Ethan Hawke's character Vincent was conceived without any medical intervention. Although in another era he would have been considered a "perfectly healthy, normal baby," in Niccol's not-too-distant-future, to his detriment, his "destiny was mapped out...[all his] flaws, predispositions and susceptibilities [including] the date and cause of...death."

Not content to be constrained by these social norms and determined to be an astronaut at the eponymous GATTACA Aerospace Corporation, Vincent becomes a 'borrowed ladder', buying access to the DNA of Jerome (played by Jude Law), a disabled Valid who can no longer use his genetic enhancements to become a world-class athlete.

We watch as Vincent seemingly successfully conceals his true genetic identity through a daily purging of all his shed DNA and the planting of Jerome's DNA – that is, until a genetically identifiable wayward eyelash, which suggests that its In-Valid owner must be the murderer of a GATTACA director, threatens to upend his deception. Suspense follows as Vincent must evade exposure and capture by an inexplicably dogged and relentless police investigator. Ultimately, a Valid, Director Josef (played by Gore Vidal), is identified as the murderer, and the film closes with Vincent fulfilling his dream, blasting off toward the Saturnian moon Titan; granted, this part of Niccol's vision of the future, like Kubrick's, is not yet a reality.

*GATTACA* and pop culture stories like it are, for better or for worse, some of the main sources of society's conventional science wisdom<sup>7</sup>. Consider the paradigmatic fictional foundation of the public's apprehension of innovative science: *Frankenstein*. The story portrayed in books and film is so enmeshed in social consciousness that for many it symbolizes their visceral distrust of many advanced technologies, including genetics<sup>8</sup> – hence the continued abuse of the prefix 'Franken'-<sup>9</sup>.

Like *Frankenstein*, *GATTACA* universalizes the fears and potential dangers of science run amok, although not necessarily of the science of genetics per se, but rather of its unregulated exploitation. More than *Frankenstein* and its fictional 'reanimation technology', *GATTACA* makes its feasible science and the concerns it raises approachable, contextualizable and, ultimately, understandable. *GATTACA* not only allows the public to comprehend the context of genetic technologies within society but also provides the tools with which to appreciate the actual legal, ethical and social importance of the issues raised. And like *Frankenstein*, the film portrays how the public sees scientists in the

genetics field, an invaluable understanding for researchers aiming to be ethical and socially conscious.

*GATTACA* can also be appreciated as a retelling of the *Frankenstein* story, wherein man's efforts to use science to rise above nature's limitations always disappoint. To wit, throughout the film, it is the genetically optimized Valid who is shown to be physically and mentally flawed, despite the best medical efforts. In contrast, Vincent, the unaltered In-Valid, succeeds despite his perceived genetic limitations. Perhaps this best represents the filmmakers' rejection of genetic determinism, still a critical concern a quarter of a century later, as research continues to reveal how the complex synthesis of nature and nurture coalesce to make humans who we are.

Through the lens of genetic exceptionalism, society often envisions genetic predictions as infallibly deterministic. Consider the demand for direct-to-consumer genomic technologies and the foresight consumers believe it will bring. In reality, much of genetics is inherently messy owing to, among other things, the complexity of polygenic risk profiles, especially in light of unknowable environmental considerations.

The movie's warnings against allowing these statistical likelihoods to become self-fulfilling prophecies remain apropos. This is especially true for the increasingly pervasive 'walking sick' – those who underestimate their disease probabilities – and the 'worried well' (or, as the film refers to them, the 'healthy ill') – those who overestimate their statistical predispositions to future genetic conditions. Arguably, geneticists in their professional capacities can also sometimes seem to view genetic information as too deterministic. Even scientists can fail to fully appreciate the inexactness of many genetic predispositions, given penetrance, expressivity and external environmental factors that modulate the genetic information.

The film also portrays a more ominous aspect of genetic determinism. Offscreen, we learn of Jerome's attempted suicide after he fails to live up to his parents' predetermined genetic aspirations of gold medals. In the final scenes, he ultimately commits suicide; as a paraplegic, he can no longer achieve his preprogrammed genetic objectives, and his life now lacks its presumed purpose.

Sequencing services that promise to ascertain a young child's future abilities could potentially wreak similar mental havoc on children and their parents. Vulnerable people may even feel compelled to live up to the predictions of the often scientifically suspect genetic predispositions imposed on them by recreational direct-to-consumer genetic services<sup>10</sup>.

Even more nefarious than foisting a forecasted future on a young child through still-inaccurate genetic predictions is the possibility of parents choosing an embryo through preimplantation genetic diagnoses not because that embryo lacks a detrimental genetic condition, but instead to select a particular condition, whether that condition is an enhancement or, unfortunately, even a disease condition<sup>11</sup>.

Consider the example in *GATTACA*: In a musical sound bridge, Niccol takes us through scenes of various instances of egregious police abuse of In-Valid, contrasted with a piano recital by an enhanced musician playing Schubert's *Impromptu* (with added chords for additional complexity). We are left to assume that the pianist's parents prenatally picked an embryo to produce a polydactyl prodigy. Although their progeny lives up to their aspirations, he hides his face with his 12 fingers in his promotional posters, perhaps presaging the anguish he is likely to feel later in life.

These instances of police-based genetic discrimination in the film are one of at least two dystopian societal abuses of genetic information

in *GATTACA*'s envisioned future. Viewers watch as the police use knowledge about a person's genetic predispositions to justify discrimination, whether surreptitiously or overtly. Although current genomic technology allows science to determine much about a person, debatably even anti-social and aggressive behaviors<sup>12</sup>, from genome sequencing, the state of the art does not carry the same evidential weight as it does in the film<sup>13</sup>. However, as more understanding of the science is gained, this fundamentally unjust use of genetic knowledge remains a concern. And like in the film, in which "it's illegal to discriminate on the basis of genetics... but no one takes the laws seriously," in the real world, many laws against genetic discrimination often contain too many loopholes to be effective.

The American 2008 Genetic Information Nondiscrimination Act (GINA), a product of years of legislative negotiations, attempted to create a federal minimum level of protection of genetic information despite the reported lack of finding of widespread and ongoing genetic discrimination in the workforce so endemic in the film<sup>14,15</sup>. According to GINA, actionable discrimination is limited to some instances within employment and health insurance contexts. Many states have subsequently expanded the protections granted by GINA to include broader safeguards against other discrimination in the workforce or during the procurement of various types of insurance<sup>16</sup>.

However, it is not only the areas of employment and insurance in which there is the potential for abuse of genetic information. In the film, the police seem to test the DNA of citizens with impunity. Even a civilian such as Irene (played by Uma Thurman), Vincent's love interest, easily obtains and sequences Vincent's DNA to assess his genomic information. Although the US Supreme Court has allowed the collection of genetic information in the course of police work, such as arrests<sup>17</sup>, society remains unsettled by the potential genetic panopticon that could follow from unfettered access of the police, and others, to genomic information.

This relates to a second dystopian characteristic of the film: genetic privacy. The notion of tracking people through their DNA has long been a reality – the use of DNA fingerprinting for pursuing criminals has been commonplace for decades. The exposé and conviction of the Golden State Killer showed how even recreational genetic genealogy has become entangled in genetic surveillance<sup>18</sup>. However, real-life privacy concerns are potentially even bleaker than those sketched out in the film. Consider the potential for sequencing genomes as an offensive tactic: recently, heads of state visiting President Putin refused coronavirus testing, as sequenced non-viral genomic material would 'de-protect' their genomes<sup>19</sup>. There are even worries that after the COVID-19 pandemic, border-based PCR testing centers could easily be repurposed to seek out other genetic information from incoming travelers, including targeting of people with potentially undesirable genetic conditions or predispositions. Genetic data can also be integrated with other revealing big data, such as web searches, facial recognition or phone geo-location, creating privacy leaks not evident when each data type is considered separately, which would create a future even more problematic than *GATTACA*'s.

In light of the continual encroachment of genetic surveillance on privacy, there is a growing dissatisfaction with the government's use of genetic information. In particular, this past spring, a class action lawsuit was filed against the New York City Police Department for hosting a genetic database comprising samples from thousands of people who live in New York<sup>20</sup>. According to the lawsuit, DNA was surreptitiously collected, without consent, from gum, drinks and cigarettes offered to those in police custody, including minors, regardless of their eventual guilt, and principally from minority communities<sup>21</sup>. Problematically,

the New York City Police Department's database lacks the regulatory oversight of state and federal DNA databases. A similar lawsuit was filed in Orange County, California, the year before, about an even larger DNA database of the County District Attorney's Office<sup>22</sup>.

In addition to the fears of potential discrimination and abuse by the justice system, genetic privacy remains an important component in the oversight of research involving human participants. And with science vastly outpacing legal controls, it is best to rely on self-regulation and technological tools to protect the privacy of millions worldwide who have been included in research databases. These protections relate both to privacy-enhancing technical tools for recording and aggregating data, and to the use of blockchain technology<sup>23</sup> and cyberbiosecurity methods for hardening the databases themselves<sup>24</sup>.

There are many positive uses for genetic information, such as when genetic information is medically actionable. Although the film never preaches against the overall validity of genetic information, or its many legitimate uses, it makes viewers think about the extent to which society should employ the technology in healthcare and even within the criminal justice system. *GATTACA*, however, warns of the very slippery slope: "What began as a means to rid society of inheritable diseases has become a way to design your offspring – the line between health and enhancement blurred forever."

Consider the description of the genetic engineering of Vincent's younger brother, Anton (played by Loren Dean). He is designed and born a Valid lacking "prejudicial conditions [such as] premature baldness, myopia, alcoholism and addictive susceptibility, propensity for violence and obesity." Here *GATTACA* cautions against eugenic attempts to wipe out various non-lethal and/or cosmetic genetic conditions that are part of our diverse society.

In an early version of the script, the film closes with "a succession of portraits and photographs of renowned and historic figures...list[ing] their [genetic] affliction rather than their accomplishments."<sup>25</sup> Today, communities representing genetic conditions, such as Down syndrome, argue that prenatal genetic tests designed to identify affected fetuses with the intent of abortion are an insidious form of eugenics that prevents the birth of potentially prized members of society. Whether one agrees or disagrees, *GATTACA* suggests that if these newfound genetic information and tools are not used wisely, humanity could end up discarding some of the most valued among us in the drive toward genetic perfection.

Dov Greenbaum <sup>1,2,3</sup> & Mark Gerstein <sup>3,4,5</sup>

<sup>1</sup>Zvi Meitar Institute for Legal Implications of Emerging Technologies, Reichman University, Herzliya, Israel. <sup>2</sup>Harry Radzyner Law School,

Reichman University, Herzliya, Israel. <sup>3</sup>Molecular Biophysics and Biochemistry Department, Yale University, New Haven, CT, USA.

<sup>4</sup>Computational Biology and Bioinformatics Program, Yale University, New Haven, CT, USA. <sup>5</sup>Department of Computer Science, Yale University, New Haven, CT, USA.

✉ e-mail: [dov.greenbaum@yale.edu](mailto:dov.greenbaum@yale.edu)

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## Competing interests

The authors declare no competing interests.