cold case

MARCH 2020 | ISSUE NO 1

DNA IN THE COURTROOM

From OJ "the Juice" Simpson to the Golden State Killer, how much does DNA *really* matter in criminal cases?

CONTENTS

DNA FOR DUMMIES®

Forensics can be interesting to read about and watch on crime TV shows, but if you've ever wondered how DNA really works as an investigative tool, this is the article for you! We're going to break down the basics of DNA, and after reading it you will be off solving crimes in no time.

Let's dive right in: our human bodies are made up of cells, individual structural units that comprise all of our organs, blood, and even hair! Your cells don't live forever, some last a few days and some last a few months. So how come humans can live up to a hundred years? Your cells keep replenishing by dividing and creating new cells (Watson, 2003). The molecule that allows them to divide and create new copies is deoxyribonucleic acid, or DNA.

DNA carries our genetic information by coding for different genes, or genetic units of inheritance. DNA is what is responsible for the way we look, the way we talk, and even the way we behave to a certain extent. We have about 25,000 different genes in the human genome (Watson, 2003). There are genes that code for our hair color, eye color, and how tall we're going to be. DNA can also replicate, or copy itself, so we carry on our genetic information in all of our new cells. The cells in your body all have different functions (for example, your skin cells serve a different function than your liver cells), but they all carry the same DNA molecule.

The difference between these cells is what genes are active in each of those cells. Going back to our eye color example, the gene that is responsible for giving someone brown eyes will be active in our eye cells, but it has no need to be active in our liver cells. So that's what it breaks down to: different genes are active in different cells, but they all have our entire DNA genome with every single gene.

In terms of forensics, you can think of DNA like your ID card, just without your name attached to it. Every person has their own unique DNA, and no two people's DNA is the same (except for identical twins!). While you might share certain traits with another person, you can't share every single trait in common. This is called genetic variability, or the differences we see from person to person (Watson, 2003). I mean, let's think about it: what are the odds that two people could share 25,000 genes in common? Very astronomically small, which is why no two people (again, other than identical twins) look exactly alike.

Since there is DNA in every one of your cells, it is very easy to find at a crime scene. There is DNA in your blood, hair, skin, and bodily fluids, so those are things that police will look for in their investigations (Krishnamurthy, 2011). In a lab, they can isolate and extract that DNA from those samples and analyze it to build a DNA profile. What might be in a DNA profile? Glad you asked.

You might think since we want to find a suspect, we look at the DNA to see what kinds of physical traits they have. That's actually not true. The problem with physical traits is that they can be changed. For example, my DNA might code for blonde hair, but I can easily dye it brown if I wanted. So physical traits aren't reliable. We look for parts of your DNA that don't code for physical traits, but rather parts of your DNA that can change from person to person but can't necessarily be seen with the naked eye (Krishnamurthy, 2011). What are these regions called? You'll have to tune into our cover article to find out. But now that you know the basics of DNA, you're ready to dive in!

CODIS DATABASE

VERSUS

CONSUMER DATABASE

COMPARING THE 2 TYPES OF DNA DATABASES

CODIS	CONSUMER
Criminal database with over a million profiles nationwide	Big data companies including 23andMe (10 million users), MyHerritage (2.5 million users), FamilyTreeDNA (2 million users), GED match (1 million users)
Uses short tandem repeats (STRS)	Uses single nucleotide polymorphisms (SNPs)
DNA is not taken out unless individual is acquitted or exonerated	Different user agreements can determine whether DNA can be removed from the database
Most of the DNA profiles in the CODIS are of people of African American and Hispanic descent	Most of the DNA profiles in DTC databases are of people of European descent
Created for law enforcement	Created for public consumers

Could Genetic Databases Unfairly Target Minority Communities?

The CODIS database is the system of DNA databases at the national (NDIS), state (SDIS), and local (LDIS) level for storing and searching DNA records contributed by forensic laboratories for law enforcement identification purposes. The CODIS database has been around for a long time and overtime has collected many different DNA profiles. However, interestingly enough, most of these profiles belong to African American and Hispanic people. African Americans make up roughly 13% of the US population, yet around 40% of the profiles in the CODIS database are of people of African descent (Mares, 2011). The amount of Hispanic profiles are not as high but there is still a clear targeting of minority communities within this database. With this unequal distribution of profiles in the CODIS database there is a fear that African Americans will be suspects more than any other racial group (Mares, 2011).

In contrast, Direct to Consumer databases are fairly new and have just started to gain popularity within the last couple of years. DTC companies are large companies that offer genetic services regarding health or ancestry information to consumers. The majority of these

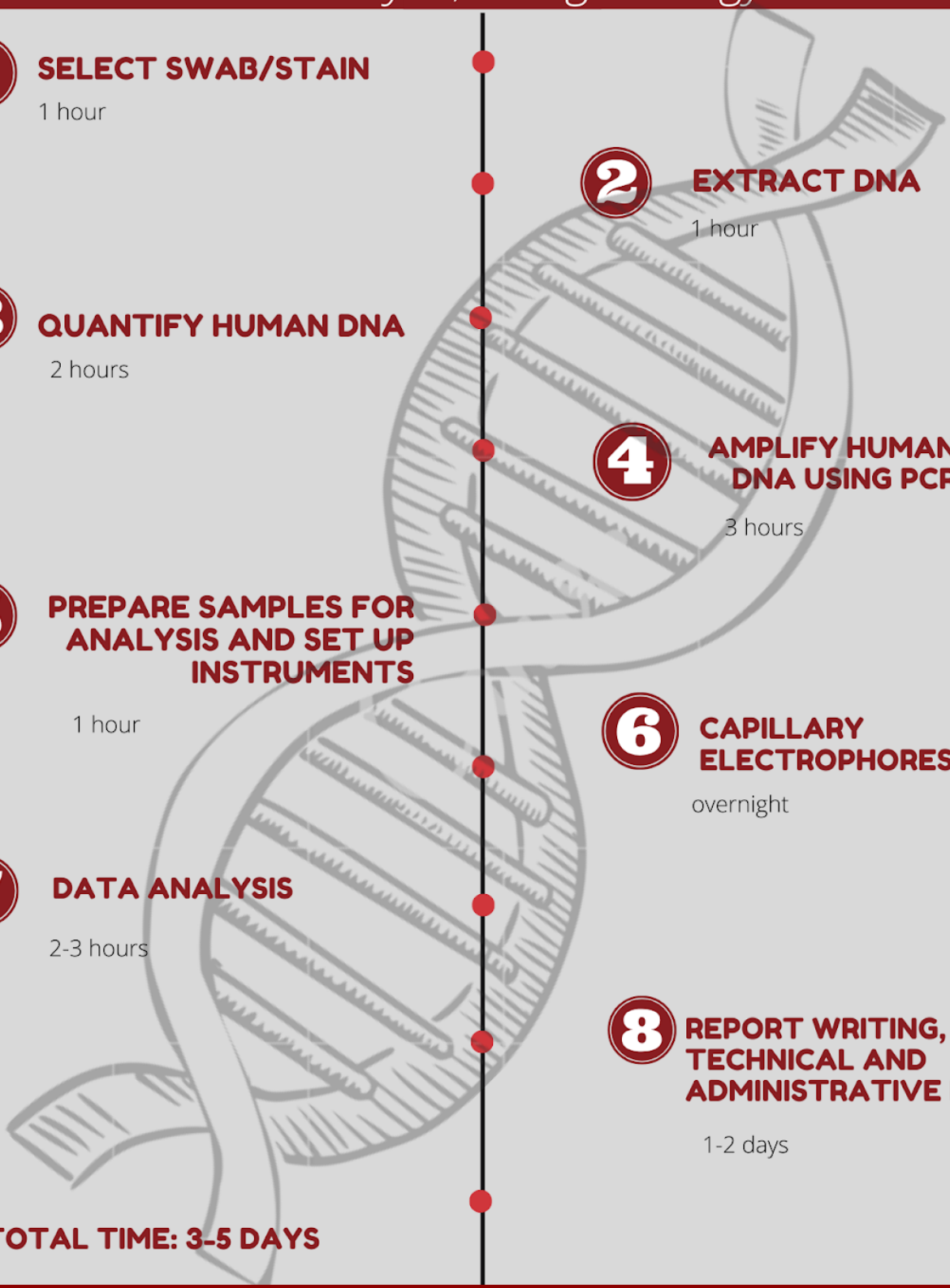
companies have users of European descent and thus have much more information regarding European populations (Letzer, 2018). This creates a very interesting contrast between these two genetic databases. Many people frame the expansion of these DTC databases in a positive light saying this trend and popularization of DTC genetic testing could be really helpful in leveling the playing field and equalizing the distribution of ethnic groups within genetic databases. People believe that with DTC databases and law enforcement's involvement with them, the data would not be so easily skewed to target minority communities (Letzer, 2018).

However, the truth is that minority communities are still terrified about the expansion of genetic databases and are especially fearful of large DTC databases. Studies have shown that ethnic minorities showed the highest level of awareness on the potential risks of forensic DNA testing (Machado, 2019). Their fears are wide ranging and include everything from social discrimination, excessive state surveillance, and misuse of data. Even though DTC databases users are mainly those of European descent, these ethnic minority communities still feel that they are in more danger than any other community. One of their main fears is that their community will continue to be targeted at higher rates than others. With DTC databases, many people within the Hispanic community fear with genetic genealogy they will be targeted at higher rates due to their high population growth and large families (Grimm, 2007). They believe that because of these factors, threats to privacy rights due to genetic genealogy may not be equally distributed throughout the population. This is a valid concern considering that the Hispanic population is predicted to have more family units with three or more children under the age of eighteen than any other ethnic group (Grimm, 2007).

DNA is often talked about in terms of science, but we must not forget about the social impacts as well. As DNA continues to advance, people must also consider the ethical implications of techniques like genetic genealogy and how this could disproportionately affect certain communities. Racial issues should be a part of this conversation and regulations should be put in place to protect communities who may feel that this process is unfair or harmful to them.

DNA Profiling Process

From DNA sample collection, extraction, analysis, and genealogy



1 SELECT SWAB/STAIN

1 hour

2 EXTRACT DNA

1 hour

3 QUANTIFY HUMAN DNA

2 hours

4 AMPLIFY HUMAN DNA USING PCR

3 hours

5 PREPARE SAMPLES FOR ANALYSIS AND SET UP INSTRUMENTS

1 hour

6 CAPILLARY ELECTROPHORESIS

overnight

7 DATA ANALYSIS

2-3 hours

8 REPORT WRITING, TECHNICAL AND ADMINISTRATIVE REVIEWS

1-2 days

TOTAL TIME: 3-5 DAYS

INTERVIEW WITH HARRY KLANN

Former Lead Criminologist at the Los Angeles Police Department

This week, I sat down with Harry Klann, former Lead Criminologist of the Los Angeles Police Department. We're getting the inside scoop on his experience in the LAPD and how forensic evidence is analyzed. Plus, we get an exclusive on a police perspective of using genetic genealogy and genetic genealogy to put a perpetrator behind bars.

Maddie Gehrich: ***Hi Harry, thanks so much for sitting down with me today. Let's go ahead and dive right in with your experience in the LAPD.***

Harry Klann: Of course, thanks for having me. I started in the LAPD in the Serology/DNA unit in 1990. I spent three years there and studied Forensic DNA Analysis in the FBI Academy in 1991 in the middle of my time there. I then transitioned into the Blood Alcohol Unit for a couple years before returning to the Forensic Accident Investigation Team and was appointed to the American Board of Criminalistics. I then was a Criminalist for eleven years before becoming the Supervising Criminalist for the last nine years of my time in the LAPD. I retired in July of 2017.

MG: ***Wow, you've had a long and expansive career in the LAPD. How did you decide to go into criminology?***

HK: I initially wanted to be in the field as a police officer, but in the last stage of my examinations I had to have a physical done, in which I failed the hearing test because I am partially deaf in my left ear. I was devastated because I'd always dreamt of being a police officer, but the Sergeant giving me the examination said that he had a job for me in the criminology lab. I told him I didn't want it and tossed the application he gave me on the kitchen counter in my house. The sergeant called my house six months later and my wife promised him that she'd get me to fill out the application. I was hired two months later and the rest was history.

MG: ***So if it wasn't for your wife you wouldn't have even had this career?***

HK: She reminds me of it far too often.

MG: ***Wow. So what exactly is the process by which DNA is collected at a crime scene?***

HK: All of our detectives have to wear latex gloves at the scene. We are looking for any kinds of evidence that might be useful. We look for specific pieces of evidence that belong to our suspect, like latex gloves that might have been discarded by the perpetrator, open beverage containers, chewed gum, or partially consumed food left at the scene. You'd be surprised how often perps help themselves to a drink or something to eat at the scene, so we look for any remnants of that. We also collect swabs of different things the perp may have touched and gather any sources of DNA evidence.

MG: ***What kinds of sources of DNA do you look for?***

HK: We look for what I like to call the Big Four: blood, semen, saliva, and hair. Those are the items you'll get the best DNA extraction from. We can also use teeth, bone, or tissue but it is more difficult so it is extremely rare.

MG: ***After DNA is collected, how is it stored?***

HK: Regular evidence is stored lockers, and any bodily fluids that contain DNA are stored in refrigerators in the criminology lab to preserve the DNA.

MG: ***After the DNA is taken to the criminology lab, what is the process of creating a DNA profile?***

HK: Our first step is to run PCR analysis to amplify our DNA sample. Then we do STR analysis and typing at 20 different loci.

MG: ***Can you explain to our readers what you mean by that?***

HK: STRs are short tandem repeats, or small sequences of repeated DNA in our genome that are inherited like any other gene. We can isolate these sequences at various places on our DNA genome, and we use 20 to build an STR profile that is essentially our suspect's DNA profile. We compare profiles from our evidence to our suspect to see if it's a match.

MG: ***Where do these profiles get stored?***

HK: They get stored in CODIS, or Combined DNA Index System, which is our DNA database.

MG: ***How do you compare profiles from suspects to CODIS?***

HK: We compare them by uploading all of our new suspect DNA into the database. Not all of the DNA evidence at a scene gets uploaded to CODIS, because some of it belongs to our victim. We isolate what is known to be suspect DNA for the upload. The system takes hours to process a hit after our STR profiling, so we usually do all of our CODIS input at the end of the work day and check back the next morning to see if we got any hits for perpetrators who are already in our system. Our system has profiles who have known identities and unknown identities.

MG: ***I thought the whole point of DNA was to give you a known identity of a person?***

HK: Right, but only if we already have them in the system from a prior crime where we know their identity. Having DNA evidence isn't like having the suspect's ID. It doesn't tell us their name or what they look like, we only know that if it matches a suspect of known identity. So our ideal situation is that we upload DNA from a cold case and get a hit of known identity so we can track them down. Either that or when we have a suspect in custody and compare their DNA swab to the evidence, it comes up as a hit.

MG: ***Do CODIS profiles get shared between police departments state-wide? Nation-wide?***

HK: Yes, they get shared between departments because perpetrators are always on the move to try and escape the police.

MG: ***How long do profiles stay in CODIS?***

HK: They stay in CODIS indefinitely unless the suspect is exonerated of all crimes.

MG: ***What is the process of getting your DNA out of CODIS if you are innocent?***

HK: If you want to get your DNA out of CODIS, you have to fill out an application after your exoneration. This can take up to two weeks for processing. We used to charge a fee in addition to the application, but we don't do that anymore. If you're innocent, you shouldn't have to pay to get your information out of a criminal database.

MG: ***How has DNA held up in court, in your experience?***

HK: DNA holds up extremely well. In the early days, it was a different story. I remember that I wasn't on call the night of the OJ Simpson case and I thank God every day that I didn't have to be involved in that sh*t show. Good lawyers can argue against anything. Luckily these days it's almost impossible to argue against DNA. There are always lawyers who try to ask me tough questions and make police methods seem fallible, but once I drop the statistics on them you can see in their face, and the faces of the jury, that it's all over. The defendant is guilty.

MG: ***What statistics are you referring to?***

HK: We are working with astronomical probabilities here. There is a one in a septillionth chance that the suspect we have in court is not our perpetrator if we have a DNA match.

MG: ***How big is a septillion again?***

HK: It's 10_{24} ... that's 10 with 24 zeroes following it. You really can't get any better than that.

MG: ***Wow, that's insane. Have you ever had a case where DNA evidence wasn't enough to convict? It seems like those numbers would be good enough to convince anyone.***

HK: In the early days, it wasn't enough. OJ is our prime example of DNA not holding up to the test. But as time went on DNA got more and more reliable. Now that we're working with such crazy numbers, I've never seen it fail unless there was a colossal mistake by the prosecuting lawyer. They still go through the whole process of having witnesses and telling the story of the crime so the jury can put together a story from start to finish and take into consideration more than one type of evidence, which I still think is important.

MG: ***I agree. And speaking of controversial cases like OJ, we're now seeing a huge controversy over the Golden State Killer case. Have you ever used a DNA company to perform genetic genealogy to find your suspect?***

HK: I personally have not, no. But the controversy has been an interesting one for forensic criminologists like myself to see the extension of the investigative work being done beyond our roles in the lab.

MG: ***What are your opinions on the use of genetic genealogy to catch perpetrators? Do you think it's a violation of privacy rights?***

HK: I tend to always err on the side of catching perpetrators and getting them off the streets. To me, it doesn't have to be a black or white situation where it is wrong or not wrong. The idea is whether or not the practice is necessary in a certain situation and whether or not it is warranted for the crime at hand. I personally think if the family didn't agree to being searched they have a right to exercise their privacy rights. However, if it were me, I would give over my genetic information for the common good. If it can help stop more bad people from committing terrible crimes, I find that the ends would justify the means.

MG: ***Do you think genetic genealogy will become a more common practice for law enforcement in the near future?***

HK: I think there have been so many changes to privacy agreements on private DNA company sites that not many people will opt-in to their information being shared. I do think we will see an increase in the number of subpoenas that we will see for DTC DNA companies to hand over information that can help law enforcement, now that we know its power. The question will be how the courts will handle it. The Golden State Killer set a legal precedent for future cases, but it will be interesting to see if anyone appeals cases on the grounds of these methods and what will happen if it gets taken to the Supreme Court.

MG: ***Thank you so much for coming out and speaking with us today, Harry! It's been great getting your wisdom and perspective on DNA profiling. And, of course, thank you for your 25+ years of service to the LAPD.***

HK: Thank you so much for having me. The honor of serving has always been mine.

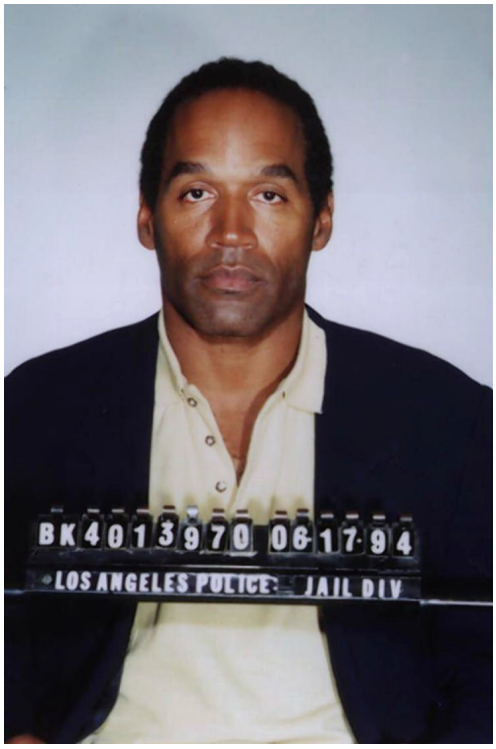
LAPD detectives solve 48-year-old cold case

Detectives asked a criminalist to run DNA again, hoping improved technology would finally help them ID enough markers to upload the sample in the state's system

SPOTLIGHT
COURT CASES
O.J. SIMPSON

The night of June 12, 1994, Nicole Brown Simpson and Ronald Goldman were brutally murdered in front of Nicole's home in Brentwood, CA. With a long history of battery and domestic abuse, Orenthal James (O.J.) Simpson, Nicole Brown Simpson's ex-husband and football legend, was charged with their murders on account of multiple sources of evidence pointing his direction:

* *Simpson lacked an alibi for the time frame of the murders. During that time, his limousine driver came to pick him up and there was no answer at his estate for 25 minutes. He saw a man in dark clothing running up the driveway, and then a few minutes later Simpson answered.*
* *A leather glove was found at Simpson's Rockfield estate matching its supposed counterpart at the scene of the crime.*
* *The blood found on the glove left at the crime scene matched that of the two victims as well as Simpson.*
* *Nicole's blood was found on a pair of socks found at Simpson's Rockfield estate.*
* *Simpson had recently purchased a Stiletto knife, matching the one used for the lacerations and stab wounds at the scene of the crime.*
* *Shoe prints in the blood at the scene of the crime matched Simpson's shoe size and a pair of shoes he was later proved to own.*



Simpson's mugshot, taken the day he was arrested under charges for the murder of Nicole Brown Simpson and Ronald Goldman. *Time* magazine famously darkened the photo (making OJ look "blacker") for their cover in June of 1994.

Simpson pictured at his trial with "dream team" defense lawyers: Johnnie L. Cochran Jr., Peter Neufeld, Robert Shapiro, Robert Kardashian, and Robert Blasier after closing defnse arguments.

This evidence was overwhelming enough to charge Simpson with the murders, which resulted in his fleeing and a long, publicly covered police escort while Simpson's friend drove an apparently suicidal Simpson in a white Bronco. Simpson pleaded not guilty to the crimes.

Simpson assembled a superstar defense, who were widely known as the "dream team." The lawyers argued that Simpson was being charged as a result of widespread racism within the LAPD, leading to a strong divide amongst the public with a majority of African Americans believing he was innocent, with the majority of Caucasians believing he was guilty.

After a long, 252-day trial, the prosecution was unable to convince the jury to convict Simpson and he was acquitted of all charges. This trial was a landmark case for the use of DNA in the courtroom that completely failed. The confusing delivery of the expert testimony of DNA profiling was not enough to charge Simpson with a guilty verdict. DNA was relatively new as a suspect-placement mechanism in the courtroom, and it was too much for the jury to fully understand. Perhaps DNA was ahead of its time, but in reality, it boils down to a failed prosecution strategy and inefficient use of the expert witness testimony. While it is unclear what might have changed in that trial if the jury could have fully understood the implications of DNA placement, it seems to be no mystery how Simpson's blood found its way to the crime scene.

Simpson has found himself in a variety of other legal troubles since the murders. He was sentenced to 33 years for armed robbery and kidnapping in 2008, but was recently released on parole in 2017.

Simpson pictured after prosecutor Christopher Darden requests that he try on the leather gloves containing blood evidence from Simpson, Nicole Brown Simpson, and Ron Goldman. One was found at Nicole's Brentwood home (scene of the crime) while the counterpart was found at Simpson's Rockfield estate.

• • •

*Case synopsis cited from history.com, citation found on page 51.

If you know someone who may be wrongly accused please contact us. The Innocence Project works to fight for criminal reform and to exonerate wrongfully convicted individuals who were unjustly imprisoned.

SAVE LIVES AND DONATE TO THE INNOCENCE PROJECT

40 Worth Street, Suite 701, New York, NY 10013
info@innocenceproject.org
press@innocenceproject.org
212.364.5340

INNOCENCE PROJECT

DIRECT -TO -CONSUMER TESTING

FAST FACTS

2005

DTC genetic testing emerges in the early 2000s as a way to allow consumers to access health information without the involvement of a physician

DTC genetic testing industry grows slowly but genealogy is the golden ticket to convincing consumers that there is value in having your DNA analyzed

2007

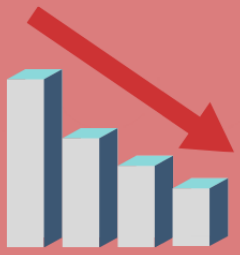
23andMe becomes the first company to offer autosomal DNA testing for ancestry

2008

23andMe named "INVENTION OF THE YEAR" by *Time* magazine

2013

The US Food and Drug Administration (FDA) constitutes 23andMe tests as medical devices and orders 23andMe to cease selling their products until they receive FDA authorization



A study done in 2013 finds that 85.3% of DTC customers reported reduced anxiety as a result of using DTC genetic tests

2015

Armed with new data, the industry begins redefining DTC testing and 23andMe receives device approval from the FDA for its carrier screen for Bloom syndrome, marking the start of the DTC 2.0 model

2016

$109M

AncestryDNA spends $109 million on advertisements in the United States alone

2017

AncestryDNA sells 1.5 million testing kits over the 'Black Friday' sales weekend

2019

More than 26 million consumers have used DTC genealogy tests by the beginning of 2019

"...the commercialization of genetic testing is here to stay."

-Journal of Community Genetics

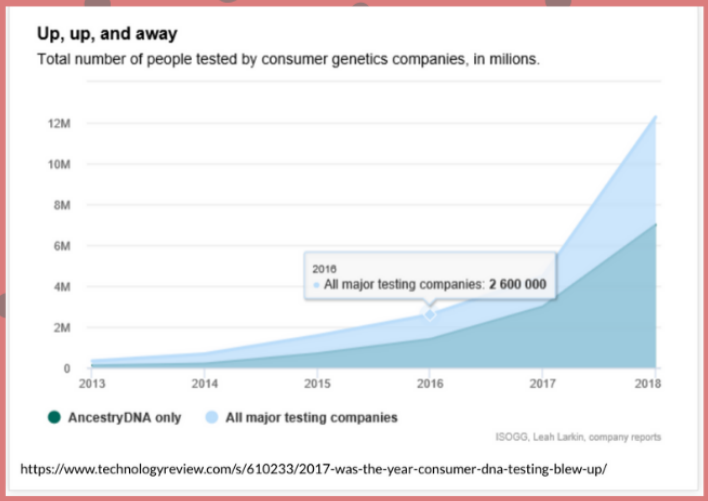
2020

23andMe lays off 14% of its workforce due to declining sales, which CEO Anne Wojcicki attributes partly to heightened privacy fears in the aftermath of the Golden State Killer case

2022

$388M

DTC genetic testing market is expected to more than triple by 2022



Q&A WITH LULU LIDZBARSKI

Lulu Lidzbarski, a 23andMe user, is intertwined in the controversy of DNA in the courtroom without fully being aware of it. For many, there is an attraction to learn about one's ancestry, and the rise of DTC tests means that more individuals are taking them, often without considering the implications before purchasing their test kit. Many users, including Lulu, take these tests, receive their results, and never think about where that information goes, or how it could be used in the future. If you're looking to take a test like 23andMe, you might want to read the terms and conditions first!

What motivated you to take a DTC genetic ancestry test?

It was gifted to me, so I decided to use it. I didn't ask for it, but I had mentioned that it was interesting to my family. For my case, it confirmed what I already knew about my identity, but I know in a lot of cases it can connect people to their culture and ancestry.

Are you aware that law enforcement has accessed consumer genetic databases to solve criminal investigations? What are your opinions on the use of genetic genealogy to catch perpetrators?

Yes, I actually was aware of law enforcement's use of consumer genetic databases when I took the DTC genealogy test. I actually don't feel super bothered by this. If someone is committing a serious crime, I believe that they should be caught and if this is going to help solve cold cases and bring justice, I don't really see the problem with it. In a way, perhaps it should be illegal to do this regarding issues of consent, but in the greater scheme of moral ethics, it feels okay to me.

Are you familiar with the Golden State Killer case?

Yes, a little. Wait, did they catch him using a genealogy database?

The Golden State Killer case was controversial in that it potentially set the precedent that anyone could use someone else's DNA and upload it into a genealogy database. Do you think this lack of transparency is a violation of privacy rights?

I think there needs to be transparency. At the level of the Golden State Killer case, the lack of transparency most likely means that users were not consenting to this. You also mentioned that they targeted a different relative before they had a successful match, which makes me feel like that could definitely be a violation of privacy.

Do you think it is justified as long as law enforcement is transparent about it? Is it justified in every case?

I definitely hold the opinion that whatever you can do to solve a crime and bring justice is fine. I think in practical use, law enforcement wouldn't go this extreme use to catch people unless it were a very serious crime. I guess that way of thinking could be problematic because you really never know how this could change going forward. I think it would and should only be used for extreme crimes, like murder and sexual assault.

Do you understand where your data goes once it's uploaded to 23andMe?

I definitely don't understand it as completely as I should. People aren't reading what they should be. People skim through everything, terms and conditions that probably are providing some sort of transparency about where your information goes.

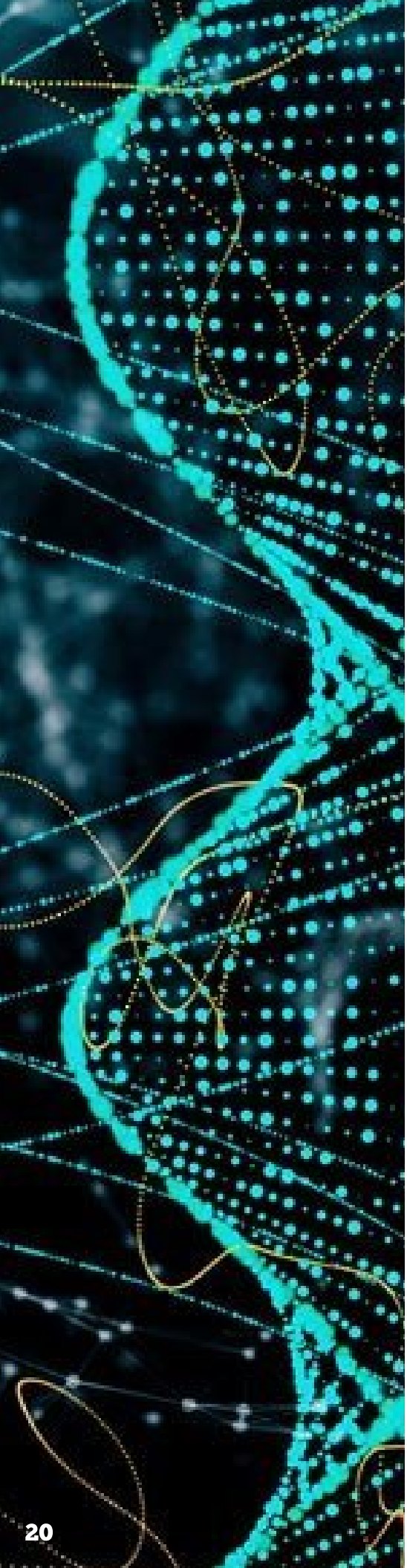
"People skim through everything, terms and conditions that probably are providing some sort of transparency about where your information goes."

Some people see the use of genealogy databases as a way to level out inequalities in the criminal justice system, as CODIS is a database that predominantly has minority information, while these DTC tests are mostly used by people with European descent. What are your thoughts on this?

To start, if a case is only relying on genetic information, it is probably not being solved very well. I don't think our legal system should rely on DNA so heavily. I definitely think it could be beneficial to have another pool added to our legal system just in regards to inequalities in our current legal system.

Can you elaborate on what you mean about DNA not being used so heavily?

In the legal system, if you are trying a case, there are a number of factors that you want it to be dependent on. Recently, the criminal justice system has seemed to realize the errors in, not only DNA testing, but eye-witness accounts and other factors. If you are basing a case around one thing, it really isn't reliable and I personally believe that there needs to be proof on several accounts. But I'm sure there are gaps in knowledge within the legal system regarding DNA and I personally don't think it should be seen as the sole piece of evidence in a case.



DNA in the Courtroom

BACKGROUND: GOLDEN STATE KILLER CASE & FRAMING THE CONTROVERSY

The man known as the Golden State Killer committed a series of burglaries, rapes, and homicides across California from 1974 to 1986 (Molteni, 2018). After decades of being unsolved, the perpetrator was finally identified as Joseph James DeAngelo in April 2018. DNA evidence linked crimes that had occurred in different places and times, which had previously been seen as unrelated, to a single perpetrator. Despite the fact that investigators had DNA evidence from the perpetrator, the case remained cold for over 40 years because no matching profile was found in the criminal DNA database, the Combined DNA Index System (CODIS) (Molteni, 2018). A break in the case happened when the perpetrator's DNA evidence was further analyzed and entered into an open source DNA database called GEDmatch. This was the first time investigators used a technique known as familial DNA searching, where the suspect's DNA profile is compared to a DNA database to look for relatives, in a consumer DNA database. This search resulted in a match with a third cousin.

After several months of investigation, the suspect pool was narrowed down to three men. This investigative method, known as genetic genealogy, combines familial DNA searching in DNA databases with traditional genealogical methods to trace suspects through their family tree. One Oregon man was asked to supply a DNA sample, after which he was ruled out as a suspect (Oresekes, 2018). Finally, investigators narrowed down their search and placed Joseph James DeAngelo under surveillance. Using "abandoned DNA" from a discarded tissue and a swab taken from a door handle, investigators found that DeAngelo's profile matched the crime scene DNA and he was arrested (Fuller, 2018). On April 24, 2018, Joseph James DeAngelo was charged with eight counts of first-degree murder.

Because of California's statute of limitations on rape cases, he was not charged with rape but in August 2018 he was charged for related kidnapping and abduction.

Against the backdrop of the Golden State Killer case, we explore the biology, ethics and legal considerations of emerging forensic DNA techniques, including genetic genealogy, unprecedented law enforcement tactics, and the collection of "abandoned" DNA. Forensic scientists and geneticists are developing increasingly powerful DNA analysis techniques and must grapple with the practical applications of their work. The law enforcement community has incorporated these new techniques into investigations, allowing cold cases to be solved, and improving the efficiency of current investigations. On the flip side, hundreds of exonerations have been based on new DNA evidence. Others have approached the controversy over the use of forensic DNA techniques from an ethical perspective, raising concerns about the genetic privacy of citizens while also considering the benefits to public safety. In the aftermath of the Golden State Killer case and other investigations that utilized consumer DNA databases, direct to consumer genetic testing companies and public genealogy databases have had to adapt their policies in response to concerns about genetic privacy and proper informed consent of their database users. Legal scholars have debated what genetic privacy means in a legal sense, and courts have ruled on the constitutionality of DNA collection and related practices. Finally, policymakers at a national and state level are beginning to implement legislation addressing the issue of genetic privacy, and regulating law enforcement practices related to DNA.

With forensic DNA technology advancing so rapidly, many questions remain unanswered and an ongoing dialogue between biological, legal, and ethical communities is necessary. The implications for law enforcement investigators, suspects in criminal investigations, their relatives and the millions of users in these consumer genealogy databases whose data may be available to law enforcement must be considered. As such, forensic DNA practices are becoming intertwined with ethical and legal issues such as genetic privacy and informed consent.

THE POWER OF DNA

Eyewitness testimony is no longer cutting it in the legal system. How did we ever put our faith in something so deeply unreliable? Then came the evidence that changed everything: DNA. DNA has the ability not only to identify people from microscopic traces left at a crime scene, but it also has the ability to connect people with one another, something that law enforcement has recently tapped into as shown by the groundbreaking Golden State Killer case. DNA has far more power than ever thought possible, and considering the relative newness of DNA being used in the courtroom, it has gained a lot of traction in the field. Taking advantage of our molecule of life to take down hard criminals brings a whole new unique perspective on serving justice. The question is whether or not the techniques used to bring justice are actually justified. In order to answer this fundamental question, we first need to fully understand the capacity that DNA has as a connective tool and its unique characteristics that make it so valuable.

DNA stands for deoxyribonucleic acid, the fundamental unit of life. DNA is made up of four distinct nucleotides: adenine (A), thymine (T), guanine (G), and cytosine (C). It has various scientific features that make it a unique biomolecule, but the most important characteristic that creates biological uniqueness is that there is no constraint on the nucleotide sequence (Good-

-win et. al, 2011). Having no constraint on the sequence means that it has no cap for length, although the typical human genome consists of about 3 billion base pairs, and the order of the nucleotides is not limited in any way (Goodwin et. al, 2011). This is the inherent reason each person you pass on the street looks completely different from the next: the sequence of nucleotides. Every human has a vast majority of conserved sequences that make up 99 percent of our genome. These are called the introns, or the noncoding regions of our DNA. These regions are often between different gene sequences, and tend to affect how much or little a gene is expressed a particular time. The differences lay in the coding regions of our DNA, or the 1 percent of our genome that can vary from person to person. These are called exons, or the regions of our DNA that code for protein (Goodwin et. al, 2011). Proteins are what allow our body to function and process genotypes, or the genetic makeup of genes, and express various phenotypes, or the physical manifestation of a gene that we can see with our naked eyes.

Before law enforcement used DNA in the courtroom, they focused on phenotypic profiling. Eyewitness testimonies were the end-all, be-all, and we needed a physical description of what a person looked like in order to catch suspects. Victims and witnesses would often pick out people from a lineup to confirm or deny their involvement with a case. This is based on phenotype, because it is using physical appearance to make distinctions. For example, a witness might describe a suspect's height, skin color, hair color, and eye color as well as other key features. It would even be a bonus if they had cosmetic features to showcase, like a particular tattoo. The presence of DNA has changed is the way we profile suspects because suspects are no longer distinguished phenotypically, but rather genotypically: at the genetic level.

The process by which suspects are genotypically profiled is not through differences in the coding regions of their genome, but the differences in their non-coding regions. One might wonder why you would use more highly conserved regions in the genome to find genetic differences … it doesn't really make sense at first glance. But as we mentioned before, there is no constraint on sequence. This means that there is no constraint to the size of a particular gene, and various forms of a gene, or alleles, can have many diverse sizes. If we are comparing different alleles in a coding region, then there is no way to estimate the sizes of those different forms of the same gene. How would we go about isolating a gene that comes in so many forms and sequences, especially for genes that have hundreds of different allele possibilities?

The answer lies in the noncoding regions of our genome. While they are highly conserved, there are also different biological processes that cause changes in inheritance of those regions. Enter variable number tandem repeats, or VNTRs. A VNTR occurs in the noncoding region of the genome, and is a short string of nucleotides that have a repeated sequence. A good fifty percent of our genome is repeated sequences, and the number of times these sequences are repeated have absolutely no impact on our phenotypic expression. These sequences have an impact on gene regulation (Robertson, 2018). Not much is truly known about the exact role these areas play in our gene expression, but they have become very useful for forensic DNA profiling. The key lies in the fact that they are conserved. Because these sequences are highly conserved among humans, every single person has the same repeated sequence at the same locus, or position on a chromosome.

Then how are VNTRs useful for creating DNA profiles if we all have the same sequence? Every human, while containing the same sequence, has it repeated a different, or

variable, number of times. This means that instead of trying to decipher through potentially multi-million base pair sequence differences in a coding region, we can narrow it down to the varying number of times a sequence appears in our genome. These sequences get repeated an unequal amount of times in history through unequal crossing-over in meiosis, when the genetic material from our parents separate into gamete cells with half the original genetic material (Jamieson et. al, 2016). Alleles are distributed by chance, but crossing over between our two homologous chromosomes can cause movement along that chromosome and initiate a transfer of genetic material. Thus, VNTRs can expand or contract in meiosis, although this is rare. Most of the time, VNTRs are inherited just like any other allele, so you inherit one of your mother's two copies and one of your father's two copies (Jamieson et. al, 2016). This gives us the diversity we need to distinguish from person to person in a DNA profile while maintaining a consistency (location and sequence) that we need in order to make it a method that can be universally applied and mass-produced.

So here's how it works. Forensic scientists will take a sample from some kind of evidence that contains DNA from their intended suspect. Ideally, this is some sort of bodily fluid (blood, saliva, or semen), but even leftover skin cells from touching a doorknob can give scientists usable DNA. Scientists will take this DNA into the forensic lab and place it in a test tube with restriction enzymes, which are a type of biological enzyme whose function is to cleave double-stranded DNA (Neufeld et. al, 1990). Restriction enzymes originated in bacteria as an immune defense system against viruses. Restriction enzymes recognize very specific sequences that are palindromic, meaning that they are the same forwards and backwards. This is useful because DNA has two strands that are not identical, but are complementary to one another. So when a sequence of DNA is palindromic, the sequence reads the same way whether the enzyme is reading the top strand or the bottom strand in the 5' to 3' direction, the designated polarity of DNA (Goodwin et. al, 2011).

In forensic science, the lab will use restriction enzymes that cleave sequences that are known to flank each side of the repeated VNTR sequence, so as to get it as close to the start and end of those repeats as possible. By using the restriction enzymes, they are isolating a specific strand of DNA that has those repeated sequences (Neufeld et. al, 1990). These sequences,

though, are often different lengths between our own two homologous chromosomes, because we get one set of chromosomes from our father and the other from our mother. So at a particular locus, we have two different numbers of repeats for a specific sequence. We have all of our cleaved DNA in a test tube, and then we separate out that material by gel electrophoresis, a method that separates molecules of DNA by size (Neufeld et. al, 1990). We can then see the size of the repeats for our two pieces of DNA at that locus. One of our DNA fragments might have three repeats while the other has 10. This would then form our genetic VNTR profile for that locus: 3, 10.

This process then gets repeated for a total of 20-23 various loci where VNTRs are found along the genome where VNTRs occur (Cavanaugh et. al, 2018). We need to test multiple loci because our profile needs to be as diverse as possible in order to compare it to others. For example, if one person has a (3, 10) profile at a particular locus, there could be another person that, by random chance, also has that (3, 10) genotype. However, if we test multiple loci, the probability goes down that a profile can occur again in the population by random chance. When we repeat this process, we use different restriction enzymes that recognize different VNTR sequences. The only issue is that crime scene DNA can be hard to come across, or present in scarce amounts. This process wasn't as reliable before the invention of PCR, or the polymerase chain reaction. PCR can take a microscopic amount of DNA and amplify it to make an infinite amount of copies (Butler, 2010). Thus, we can use as many restriction enzymes intended to degrade DNA as are necessary, because we have an infinite supply of a particular sample.

With an infinite supply of DNA from a crime scene, we test 20-23 loci to get the probability of a random match as close to zero as possible, and as is necessary to ensure a clear profile that can be matched with certainty. Using 20 loci may not sound like a lot, but when the probabilities get compounded at each locus, the chance of a random match gets really small really quick. To put it into perspective, let's say that each one of the 7.5 billion people have the ability to move to their own planet, and then repopulate it to the current size of this earth. That is 7.5 billion separate planets with 7.5 billion people each. With the odds that forensic scientists work with now, the probability works out that there still would not be a person that has the same VNTR profile as our suspect among any of those earths.

Those are the astronomical probabilities used in forensic science today, which gives judges and juries full confidence in the courtroom to make the right convictions.

The new controversy arising in forensic science is not the methods by which we can analyze DNA to find a perpetrator (although it was controversial when it was first introduced), but rather how we go about finding the actual person to whom the DNA at the crime scene belongs. The Golden State Killer case opened up a whole new world for forensic scientists: the world of genetic genealogy. There are now private companies whose sole purpose is to analyze DNA and connect it to that of another human being to indicate familial relation, something that law enforcement has just now realized they can take advantage of as well.

Direct-to-consumer DNA companies do not use VNTRs like forensic scientists do. Rather, they use single nucleotide polymorphisms, or SNPs. SNPs are a single nucleotide change in the genetic code at a particular locus, and these changes tend to be carried in specific ethnic populations through time (Kayser et. al, 2012). Genetic genealogists at these companies trace the inheritance of these SNPs through families and then through ethnic groups to create a potential family tree as well as a breakdown of a given person's ethnic mosaicism. In the case of the Golden State Killer, police uploaded the suspect DNA to GEDmatch, a private company, as an anonymous profile to get results on potential family members. This allowed them to find the killer's relatives, some of whom had used various private ancestry sites, and narrow down potential leads (Barbaro, 2019). In combination with census and other government data at the disposal of law enforcement, the police finally cornered their perp: Joseph James DeAngelo. These methods were never used before, and combined the use of two different DNA analysis methods to find their suspect.

Such is the power of DNA. It has the power not only to identify, but also to connect people. The microscopic molecule of life, present in every one of our human cells, has the ability to identify and connect people without ever having a physical description of what they look like. Eyewitness testimony's reliability has now gone out the window. Law enforcement now rely more on collection of DNA evidence over all else, and prioritize it more than anyone would've ever thought they would when this technology was introduced. If you have the DNA, you have everything … right?

LIMITATIONS OF FORENSIC DNA EVIDENCE

As technology advances and DNA use becomes more prevalent, people have started to see DNA as an infallible tool. While DNA does have many uses in forensic science, it must be paired with other investigative techniques to make arrests and convictions. In the first section we saw the power of DNA, however, here we will discuss some of the limitations of DNA due to its complexity and wide reaching effects.

DNA is extremely complex. Each person on the planet shares 99.9% of their genes with everyone else (Shaer, 2016). This means the genetic information that sets us apart from others is very small. Yet, when it comes to DNA evidence, people are so willing to believe its infallibility. In the courtroom, there is a strong belief that DNA evidence is key to any investigation. Studies done on the public's view of DNA showed that sexual assault cases involving DNA evidence were two times as likely to reach trial and 33 times as likely to reach a guilty verdict. In homicide cases where DNA evidence was presented, the case was 14 times as likely to reach trial and 23 times as likely to end in a guilty verdict (Shaer, 2016). These statistics show how people's faith in DNA may sway their opinion in the courtroom.

There is a clear disconnect between people's belief and understanding of DNA and its true power. As we will continue to highlight, DNA is a lot more complex that we think and even experts may not always be able to find the correct suspect. What many people don't acknowledge is that in the Golden State Killer Case itself, investigators initially targeted the wrong man. Through genetic genealogy, law enforcement originally targeted a 73-year-old man in an Oregon nursing home (Oresekes, 2018). Since this man closely fit the killer's description, the judge allowed investigators to get a DNA sample by swabbing the inside of the man's mouth. However, this test found he was not the suspect and investigators had to keep looking until they found the current suspect, Joseph DeAngelo. This is a prime example of how genetic genealogy can narrow down the suspect pool, but it does not always give a clear answer to who the criminal may be. Therefore, we will continue to emphasize the importance of examining DNA evidence along with other factors before making any key decisions.

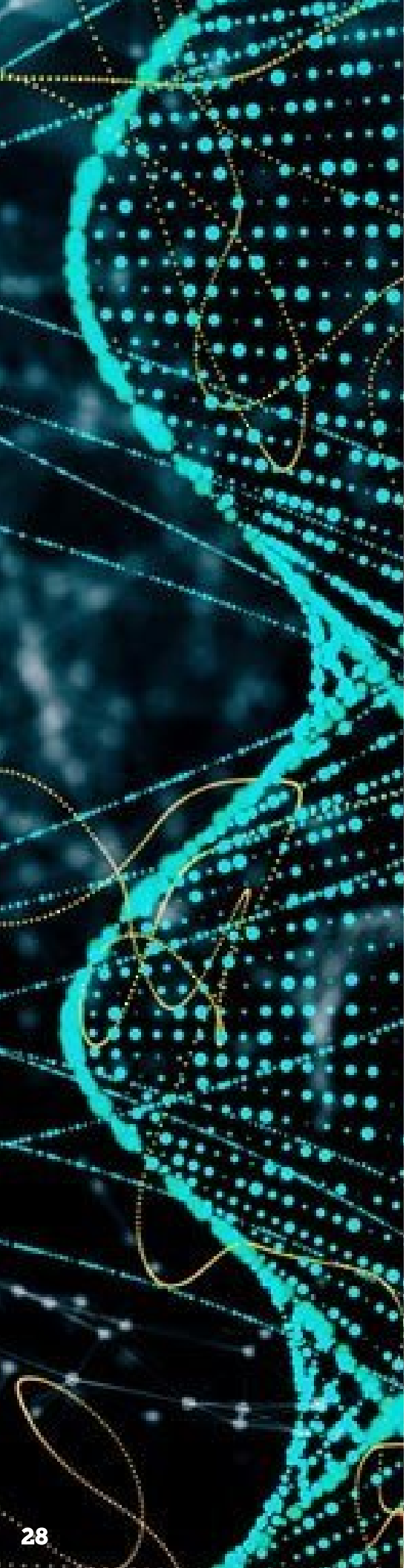
Although it may seem like this was a small misstep in the investigation to reach the real killer, it happens much more that you would think. Here is the tragic story of Josiah Sutton. In this case, a victim was abducted at gunpoint and raped by two young men. Five days later, this woman saw Sutton driving around town and identified him as one of her attackers. Soon, Sutton was taken into custody and asked to provide DNA samples, even though he was able to provide a solid alibi and did not match the original suspect description. However, the DNA evidence concluded that Sutton was a possible match and thus DNA became the key evidence of the trial. Sutton pleaded his innocence throughout the investigation, but it did nothing in the face of DNA evidence. Eventually, Sutton was sentenced to 25 years in prison (Shaer, 2016). His mother, who believed in his innocence, decided to keep fighting back in any way possible. His mother reached out to reporters who eventually took on Sutton's case and dug deeper into the investigation. After four long years in prison, the reporters were finally able to prove that the lab had made clear mistakes and was completely wrong in their genetic report. The lab failed at many different points and showed that not only were DNA errors possible, they were also common. When re-tested, it was clear that the semen source from the crime scene did not match Sutton's and he was innocent (Shaer, 2016). Sutton's story is a clear wakeup call about the risk of believing DNA is an infallible technique to prove culpability. Knowing he was innocent from the start, Sutton's mom also talked about how she reached out to lawyers at the Innocence Project. However, even they rejected her son's case because they could not take a case where a definitive DNA match was made (Shaer, 2016). Sutton's story shows how heavily people trust DNA evidence and how this trust may sometimes be misplaced.

Next is the story of Dwayne Jackson. In November of 2001, a woman and her two young daughters were approached by a man with a ski mask and baseball bat who demanded money from them. Thankfully, the husband soon returned home and the attacker was forced to flee. The family then investigated the attacker and gave police a brief description. With the description, police came upon Jackson and decided he closely fit the description. Jackson was arrested and forced to provide a DNA sample. When the results came back, his DNA was a match to the DNA found on the woman's sweatshirt (Shaer, 2016). With this match, he was taken and charged with burglary, robbery, and kidnapping. Jackson was sentenced to prison in January 2003 (Shaer, 2016). However, eight years later, it was discovered that the lab had accidentally switched Jackson's DNA sample and that he was actually innocent. In 2011, Jackson was fully exonerated (Shaer, 2016). While he evenly

gained his freedom, Jackson lost eight years of his life to prison and missed out on many opportunities. Just as Sutton's case, Jackson was wrongly accused because people placed such importance on DNA linking suspects to the crime and failed to realize that the other evidence did not add up.

These examples are extremely sad, yet they speak to the true complexity of DNA. To show how difficult it can be to interpret DNA evidence, we will look at a 2002 Georgie rape trial. This case hinged on DNA evidence. In this case, DNA evidence was sent to 17 different lab technicians for examination. They provided no background information about the case to keep it as unbiased as possible. These technicians were not new to the job, together they had an average of nine years of experience in the field. Law enforcement asked the technicians to determine if the mixture of DNA given included the defendant's DNA. The results were astounding. Out of the 17 labs, only one said with certainty that the defendant could not be excluded and was a possible DNA match. 12 of the labs said that the DNA was exclusionary and the defendant was not a match. Finally, 4 labs said the results were inconclusive (Shaer, 2016). Ironically, so many people believe that DNA takes away subjectivity and gives clear and absolute evidence, but the truth is subjectivity is still there because DNA is very hard to interpret.

Besides the difficulty of interpreting DNA evidence, there are also issues of DNA transfer or DNA contamination. Any type of DNA contamination can be extremely disastrous because it can lead to false reports of a DNA match between samples that originated from different people (Thompson, 2012). We saw real life examples of this in the cases of Josiah Sutton and Dwayne Jackson. DNA transfer is the migration of cells from person to person or between people and objects (Shaer, 2016). This can make investigations difficult because DNA can move from one object to another. For example, a study showed that sperm cells from one item of clothing made its way onto every other item of clothing in a washer (Shaer, 2016). The more people or objects that are involved in a crime scene, the harder it would be for law enforcement to parse through the details and determine what DNA evidence is actually valid.
In another murder case, investigators found traces of DNA on a woman's dead body. This DNA led them to her ex-partner who claimed he had not seen the woman in months. He suggested that the DNA came from their child's



clothes or toys. To see how realistic this situation could be, investigators mimicked the situation. One volunteer held a toy for one minute then proceeded to rub this toy against a lab coat. Investigators tested the coat and found that there was actually enough of the volunteer's DNA to identify him (Geddes, 2012). This brief experiment shows that DNA transfer is a very real phenomenon and can likely lead to mix ups in investigations. DNA can easily travel from one surface to another and this creates even more controversy surrounding the validity of DNA in the courtroom.

Another very interesting issue is that DNA shows up differently depending on the person, object, and amount of time. For example, two people can pick up the same knife. Person one can hold the knife for just a minute and person two can hold onto the knife all day. However, after testing the knife, the DNA of person one might show up more strongly than the DNA of person two (Shaer, 2016). There is no exact science to find out whose DNA is "stronger" than others so most of the time, investigators have a complex puzzle in front of them that they must solve. There are clear limitations of DNA due to its complex nature and our limited understanding of everything it can do. Therefore, it is important to acknowledge that the presence of DNA at a crime scene should not be the only type of evidence relied on in criminal investigations.

As technology continues to advance, new techniques involving DNA are being created each day. One technique that has been recently discussed is Forensic DNA Phenotyping (FDP). This technique is lauded for its ability to circumvent the issue of genetic genealogy which has had many privacy implications which we will later discuss (Kayser, 2015). However, as with other techniques, it is also important to consider the dangers that could arise from these new techniques. With Forensic DNA Phenotyping, analysts are able to use small samples of DNA, directly from a crime scene or suspect, to infer a donor's externally visible characteristics (EVCs). EVCs refer to a person's visible physical traits. Right now, the only molecular prediction tests available are pigmentation tests. This means that with the FDP technique, analysts could conclude EVCs such as eye color, hair color, and skin color. However, there are also various studies looking into genes that can indicate other physical traits such as body height/stature, hair loss/baldness, age, hair structure, and face structure (Kayser, 2015). If the science continues to advance, soon

analysts could create a virtual image of a suspect with even a tiny amount of DNA. This would allow law enforcement to have investigative leads to trace unknown perpetrators.

The perk about FDP is that there would be no need to go through genetic databases to look for relatives through genetic genealogy. Investigators would instead be able to essentially create their own suspect profile. FDP is said to be so exact that it could act as a biological eye witness from a crime scene. Researchers contrast a biological eye witness to a human eye witness and explain that with a biological eye witness you would have unbiased and accurate information every time. With a human eye witness, however, sometimes there is risk of receiving wrong information due to their emotional distress or exhaustion (Kayser, 2015). New techniques like FDP are arising each year and thus, the conversation surrounding DNA will continue to be at the forefront of biological, legal, and ethical issues. It is very clear that DNA has various uses and is an extremely powerful tool for law enforcement. Yet, it is also very clear that with this powerful tool there are many dangers that could arise from any type of misuse or from a lack of understanding. DNA can have controversial impacts on criminal investigations. As such, it is fundamental to examine DNA evidence from multiple perspectives without trusting it as infallible evidence .

PRIVACY ISSUES

The Golden State Killer case introduced an unorthodox approach to solving criminal investigations through an open source database known as GEDmatch. GEDmatch is an online service that has files from various genetic testing companies and was intended to be a resource for individuals to get a fuller sense of their ancestry. At the time of its creation, GEDmatch was revolutionary as it was a culmination of different testing companies and would help connect individuals more than ever before. But this open access to genetic information was ultimately used by law enforcement in a much different way than its original intention. The Golden State Killer case drastically changed the way genealogical databases are used and introduced complex questions regarding ownership of genetic information, privacy, and informed consent. GEDmatch and other genealogy databases have the potential to provide investigators with new pools of genetic data, which could help solve cold cases, exonerate individuals, and bring justice to victims and families. But the extent of law enforcement's access to genealogy databases remains unclear as concerns over the ethics of genetic genealogy arise, especially among direct-to-consumer (DTC) genetic testing users.

The field of genomics is rapidly expanding. The first human genome was sequenced just twenty years ago. Now, more and more Americans are using direct to consumer genetic testing services (Molteni, 2019). In fact, about 60% of Americans of Northern European descent — the primary group using genetic ancestry services — have at least a 3rd cousin in a consumer genetic database, meaning they can be identified whether or not they are users themselves. Within 2-3 years, as more people use these services, that number may increase to 90% (Erlich et al., 2018). With the rise of direct to consumer genetic testing comes higher stakes regarding genetic privacy. At the same time, genetic ancestry databases have the potential to aid law enforcement in solving serious criminal investigations that may otherwise remain unsolved. The two extremes of this issue can be better understood through the principles of bioethics, which are autonomy, beneficence, non-maleficence, and justice. There is an evident clash between an individual's autonomy over their genetic information and bringing justice to victims and their families. In the context of

familial DNA searching, it can be difficult to balance the ethical considerations of public safety and bringing justice to victims, and the genetic privacy of consumer DNA database users (Wickenheiser, 2019). Maximizing public safety through complete genetic surveillance would undoubtedly increase the number of crimes that could be solved. Picture this: there have been almost 500,000 hits to the 944,750 forensic profiles in CODIS. A hit is a match between two or more DNA profiles that provides investigators with a lead. If all genetic genealogy databases were an available resource to investigators, imagine the amount of hits there could be (Wickenheiser, 2019). This extreme level of genetic surveillance would most likely be impossible in our society as it would completely infringe on our rights to genetic privacy. But on the other end, a complete right to privacy and autonomy would eliminate any search of genetic data, undermining its potential use for public safety. Ultimately, at the center of this controversy is navigating a middle ground that values justice and public safety while respecting rights to privacy.

Familial searching involves the use of evidence from a crime scene to try and find relatives of the perpetrator in instances where an exact match is not found within CODIS (Dolan and Stevens, 2018). The Golden State Killer case was monumental because it found relatives through GEDmatch, using a method known as genetic genealogy (Wickenheiser, 2019). This sort of familial searching is unique because it involves relatives of the perpetrator who play no direct role in the crime (Guerrini et al., 2018). While familial searching is also possible through CODIS, a relative must have committed a crime to be in the CODIS database. Thus, while the technique is the same in both databases, there is an expectation of privacy that comes with using a consumer database, like GEDmatch. DNA may be unique to an individual, but it provides information about biological relatives. That is, genetic information has implications beyond just the individual. To add to the controversy, genealogical databases can reveal more personal information than CODIS, like health conditions, ancestry and even phenotypic traits (NIH). The prevailing view in society is that genetic information is more sensitive than other personal information, which explains much of the anxiety over genealogical forensic searching. This belief that genetic information is more sensitive than other information and therefore requires stricter regulations is known as genetic exceptionalism (Clayton et al., 2019). Why is genetic privacy important to individuals? To start, there are concerns about employment or insurance discrimination. While the Genetic Information Nondiscrimination Act (GINA) prevents health insurance providers in the United States from using genetic information to make decisions regarding patient coverage, it does not apply to other forms of insurance, such as disability and life insurance (NIH). Furthermore, genetic genealogy exposes genetic information to law enforcement, which can lead to the identification of a distant cousin. While many users of genealogy databases might be willing to share their DNA information to convict distant kin who committed serious crimes, it is still worth considering the potential consequences that could come with having one's identity exposed. There could be someone out there who is seriously impacted by these cases who decides to go after a genetic informant because of their unintentional role of identifying a criminal (Russell, 2019).

Clearly the issue is complex. Finding a balance where genetic privacy rights are respected while law enforcement can protect public safety is key. The ethical principle of proportionality can

be useful for framing the debate. Proportionality is a principle used to drive decision-making that aims to find a solution that maximizes the good with as little harm as possible (Wickenheiser, 2019). There may be a lot of value in genetic genealogy due to the high cost of violence on victims, public safety, and even the cost of investigations that go unsolved for long periods of time. For many, a loss of privacy can be justified by the opportunity to catch criminals like the Golden State Killer. In 2018, a group of researchers conducted a survey to better understand public perceptions regarding law enforcement's access to genetic genealogy databases. Out of 1,600 responses, people overwhelmingly supported the use of genetic genealogy databases to identify genetic relatives, and 65% even supported the creation of fake profiles by law enforcement, which happened in the Golden State Killer case (Guerrini et al., 2018). Levels of support, however, varied depending on the crime; 80% of respondents were supportive of familial searching for violent crimes, crimes against children, and missing persons cases, while 39% supported familial searching for nonviolent crimes (Guerrini et al., 2018). From studies like this, it is clear that many people see the benefit of familial searching in certain instances. To maintain trust with consumers, it may be best that law enforcement view genetic genealogy as a last resort option when traditional investigational methods have failed (Wickenheiser, 2019).

Keeping the principles of bioethics in mind, it is important that individuals are properly informed about the use of their genetic information. Informed consent ensures that individuals are aware of the risks and benefits of uploading DNA to DTC genetic testing companies prior to participating (McGuire and Beskow, 2011). When consumers upload their information to open source genealogy databases, they are consenting to have their DNA analyzed in order to create a profile and find relatives (Wickenheiser, 2019). In the case of genetic genealogy, informed consent is necessary. Individuals deserve autonomy over the decision to have their profile searched during criminal investigations. Many people found the Golden State Killer case so controversial because GEDmatch users were not informed about law enforcement's use of their genetic information. Law enforcement discreetly created a profile from crime evidence, and as such there was no way for those in the GEDmatch database to consent to this use of their information. Some companies are now

implementing opt-out systems, which would exclude law enforcement from accessing those profiles. But this gets tricky when considering informed consent. Informed consent should not be passive; it seems like a stretch to think that if we do not opt-out and clearly say no, then we must be saying yes (Russell, 2019). If, for example, an individual fails to log into their profile to opt-out, or even does not understand the notice, then there has not been proper informed consent. As more companies consider their role in criminal investigations, they must remember that opt-out features are not synonymous with informed consent.

A study done in 2017 revealed just how large the knowledge gap is among DTC genetic testing consumers regarding the privacy practices of various DTC genetic testing companies. 35 of the 90 companies lacked information regarding the fate of genetic samples and the subsequent data (Clayton et al., 2019). With the explosion of DTC genetic testing companies, this newfound openness of genetic information brings in issues of ownership. While many companies do not claim explicit ownership over user data, nearly half of the companies in the study noted that data could be shared with third parties (Clayton et al., 2019). Even if certain companies do inform users about third party use, it may be embedded in terms of service, which we all know rarely gets read (Guerrini et al., 2018). The wide variation in regulation regarding consumer privacy stresses the importance of gathering proper informed consent and highlights the need for uniform policies and transparency in terms of law enforcement's use of genetic data.

LEGAL ISSUES AND POLICY IMPLICATIONS

The Golden State Killer case sparked a national conversation about the uses of DNA in criminal investigations. The controversial practices which were vital to identifying the Golden State Killer -- genetic genealogy and the collection of "abandoned" DNA -- raise complex legal questions about informed consent, privacy, and the ownership of genetic information. DTC companies like 23andMe and public consumer DNA databases like GEDmatch have also had to respond to public concerns about genetic privacy and update their policies in light of this new law enforcement practice.

Familial DNA Searching & Genetic Genealogy

Genetic genealogy is used when law enforcement cannot match a recovered DNA sample from a crime scene to a profile in the criminal DNA database. In these cases, investigators

can search for relatives of the perpetrator in DNA databases, and build family trees to trace relatives back to the perpetrator. In recent years, familial searches have been conducted not only in the criminal database, CODIS, but in consumer DNA databases as well. To do these searches, an expanded panel of SNP DNA markers is generated for comparison to SNP profiles in publicly accessible genealogy databases. The Golden State Killer investigation was the first case that brought genetic genealogy in consumer DNA databases to the national spotlight. It exposed how consumer genetic testing data could be used in criminal investigations. Since then, law enforcement agencies have used consumer databases to identify suspects in more than 70 cases of murder, sexual assault, and burglary (Hill & Murphy, 2019). While it has been used to identify many suspects in criminal investigations, some questioned whether this new practice would hold up in court. The answer came in July 2019, marking the first guilty verdict for a case where genetic genealogy was used. A possible defense strategy could have been to challenge the practice on privacy grounds, but the defense team chose not to do so (Murphy, 2019).

Policies and practices on familial DNA searching, both in criminal databases and in consumer databases, vary greatly by state. Currently, only Maryland and the District of Columbia outlaw the practice (Field et al., 2017). When crafting laws and regulations regarding familial DNA searching, policymakers must determine in what circumstances such a controversial practice is justified. In California, for example, familial DNA searches are allowed only for major violent crime cases where all other reasonable and viable investigative leads have been pursued and the investigating agency must submit a formal request to do a familial search before proceeding (California Department of Justice). Most state policies limit familial searching to violent crime investigations, but critics worry that without proper regulation, the practice could be expanded to include non-violent crime cases.

When thinking about policy implications of genetic genealogy and familial searching, legal experts and policymakers should consider the costs and benefits of the practice on a case by case basis, balancing its utility in solving crime with the threat to genetic privacy of relatives whose genetic information will be used.

Implications for DTC Companies and Consumer DNA Databases

GEDmatch was used in the Golden State Killer case because it is a publicly accessible database. Its entire purpose is to aggregate data from many sources - users can upload DNA profiles obtained by other DTC genetic testing services and search for relatives in the GEDmatch database. Both DTC companies and public genealogy databases must abide by the Federal Trade Commission's consumer privacy protections laws (Hendricks-Sturrup et al., 2019). When they upload their DNA profile to GEDmatch, users affirm a privacy statement acknowledging their genetic DNA information will be available for searching for the purposes of being found by a family member (Wickenheiser, 2019). After the details of the Golden State Killer case went public, GEDmatch faced a lot of criticism about failing to protect its users' privacy and not explicitly informing them that the database could be searched by law enforcement. As of May 2019, GEDmatch changed its policy so that new users and people who had uploaded their DNA to its site now have to opt in to allow law enforcement to access their information. Just 185,000 of the site's 1.3 million users have opted in thus far, greatly limiting law enforcement agencies ability to identify suspects using genetic genealogy with GEDmatch (Hill & Murphy, 2019).

GEDmatch and FamilyTreeDNA, both of which are publicly accessible genealogy platforms, have acknowledged that they allow law enforcement to search their DNA database (Ram, 2019). FamilyTreeDNA has an agreement with the FBI which allows the agency to access its database of more than 1 million users (Hendricks-Sturrup et al., 2019). On the other hand, 23andMe and Ancestry.com, two of the largest DTC companies, have stated that they do not share consumer information with law enforcement, meaning law enforcement must obtain a court order or warrant to search these private databases (Hill & Murphy, 2019).

Despite GEDmatch updating its policies to limit law enforcement's ability to search its database, a Florida judge recently approved a warrant from the Orlando Police Department to search the full GEDmatch database. Legal experts say this ruling, the first of its kind, could set a precedent for other law enforcement agencies to request search warrants for larger consumer DNA databases like 23andMe and Ancestry.com which have thus far not allowed law enforcement to access their users' information (Hill & Murphy, 2019).

Fourth Amendment & DNA

Central to the legal debate around DNA in the criminal justice system is the Fourth Amendment. The Fourth Amendment ensures the right of people to be "secure in their persons, houses, paper and effects" and protects against unreasonable searches and seizures. There must be probable cause for a warrant to be issued, permitting the search or seizure. Within the meaning of the Fourth Amendment, a search is when an agent of the government violates a person's reasonable expectation of privacy. A seizure is when there is a "meaningful interference with a person's possessory interest in their property" (U.S. Const. amend. IV). For courts to determine that Fourth Amendment rights were infringed upon, the claimant must have a reasonable expectation of privacy which the government violated. How does this apply to genetic information in consumer DNA databases? Does law enforcement conducting familial DNA searches in consumer databases violate the Fourth Amendment rights of users? What about "abandoned" DNA? Is our expectation of privacy for our DNA different from other objects we discard, like trash or food scraps? Finally, is collecting arrestees' DNA before they've been convicted of a crime a violation of their Fourth Amendment rights? All of these questions are central to the legal debate around the constitutionality of forensic DNA practices.

Third Party Doctrine & Familial Searching

The courts have not yet ruled on how Fourth Amendment rights apply to genetic information in DNA databases (Kody, 2019). Still, looking at relevant court cases helps frame the legal debate around this issue. In particular, the Supreme Court's "third-party doctrine", which considers an individual's privacy interests in information shared with third parties, is applicable when considering the rights of individuals who provide DNA samples and share their genetic information with DTC companies and public DNA databases (Kody, 2019).

In *United States v. Miller*, a landmark 1976 ruling which marks the beginning of the third-party doctrine, the Court held that bank records were not protected under the Fourth Amendment. The court argued that Miller had no justifiable expectation of privacy for his bank records once he had given this information to the bank. This established the third-party doctrine, which rests on the

individual voluntarily gives their information to a third party, they can no longer claim a reasonable expectation of privacy in that information (Kody, 2019).

The Supreme Courts' latest examination of the third-party doctrine is in *Carpenter v. United States*, a recent case which considered the privacy of cell phone location records. In this case, the Court held that the government violated individuals' Fourth Amendment rights by accessing their cell-site location records from a third-party company without a search warrant (Carpenter v. United States, 2018). The majority opinion acknowledged the changing expectations of privacy in the digital age and was particularly concerned with the level of intrusiveness involved in accessing cell-site location information (CSLI). Thus, the third-party doctrine was not extended to CLSI because of the reasonable societal expectation that the government would not have access to such sensitive information.

The third-party doctrine has direct implications for determining the constitutionality of genetic genealogy. Legal scholars have challenged the application of the third-party doctrine to genetic information shared with third parties. Like CSLI, genetic information is highly sensitive. DNA profiles contain deeply personal information about individuals' lives and SNP profiles contained in consumer DNA databases in particular reveal identity, ancestry, health problems and even phenotypic information about individuals. Thus, legal experts have applied the logic used in *Carpenter v. United States* to genetic information in consumer DNA databases, arguing that there is a reasonable expectation of privacy that is violated by law enforcement when they search these databases (Kody, 2019).

"Abandoned" DNA Collection

"Abandoned" DNA is biological material from which DNA can be extracted and analyzed that has been left behind by an individual. Hence, collection of abandoned DNA is done without the person's consent (Joh, 2006). In the Golden State Killer case, Joseph James DeAngelo became the prime suspect but his guilt could not be confirmed without matching his DNA to the crime scene profile. Investigators eventually obtained his DNA from a discarded tissue and a swab taken from a door handle.

There are many ways of approaching the question of "abandoned" DNA collection from a Fourth Amendment standpoint. Two main arguments have been used to say that it is a violation of the Fourth Amendment. The first

is that law enforcement collecting abandoned DNA is an invasion of privacy and should thus be considered an unreasonable search. Alternatively, if your DNA is considered your private property, law enforcement collecting it without a warrant would be a seizure (Joh, 2006). Abandoned DNA does not fit neatly into existing legal categories, highlighting the need for legal interpretations to catch up with evolving forensic practices.

Abandoned DNA is often equated to any other object we discard. Warrantless seizure of abandoned property does not violate the Fourth Amendment, because having an expectation of privacy to abandoned property is not considered reasonable (Joh, 2006). If DNA is treated like any other abandoned property, the logic follows that people do not have a reasonable expectation of privacy when they leave their DNA behind and law enforcement is therefore free to collect and analyze that abandoned DNA without a warrant. While the collection of abandoned DNA collection is not currently protected under the Fourth Amendment, some legal scholars have questioned the constitutionality of the practice. Elizabeth Joh, a professor of Law and UC Davis, argues that DNA fundamentally differs from other objects we discard because of how sensitive the information it contains is. It is also different from other identifying features, such as a fingerprint or a blood sample, because DNA does so much more than simply identify an individual - it contains information about health, physical characteristics, ancestry and familial relationships (Joh, 2006). Joh argues that we hardly have a realistic choice in leaving behind our DNA, it is unavoidable. Thus, the warrantless acquisition of abandoned DNA in a criminal investigation circumvents the individual's reasonable expectation of privacy.

Those concerned with genetic privacy rights are pushing for stricter regulations on the collection of abandoned DNA, while the law enforcement community insists that the collection of abandoned DNA is essential for crime solving.

Pre-conviction DNA Collection

A final legal issue surrounding DNA in the criminal justice system is pre-conviction DNA collection. DNA arrestee laws authorize the analysis of DNA samples collected from individuals arrested or charged, but not convicted, of certain crimes.

In the *Maryland v. King* case, King argued that the Maryland law allowing the warrantless, suspicionless collection of DNA

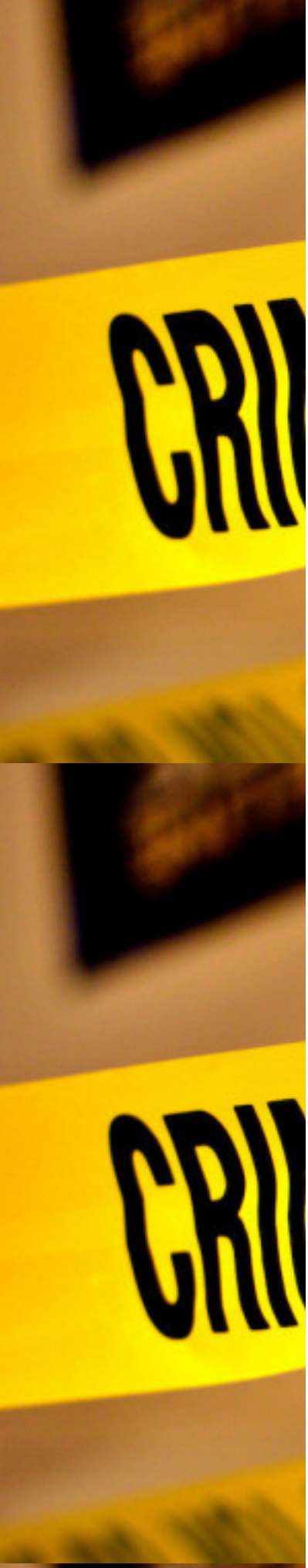
upon arrest violated his Fourth Amendment rights. In a 5-4 decision, the Supreme Court held that "when officers make an arrest supported by probable cause to hold for a serious offense and bring the suspect to the station to be detained in custody, taking and analyzing a cheek swab of the arrestee's DNA is, like fingerprinting and photographing, a legitimate police booking procedure that is reasonable under the Fourth Amendment" (Maryland v. King, 2013). In this ruling, the Court set the precedent that the government's interest in identifying an arrestee outweighed the minimal privacy intrusion to the individual.

Currently, twenty-nine states collect DNA upon arrest for at least some felonies (National Conference of State Legislature, 2013). On a federal level, the Katie Sepich Enhanced DNA Collection Act of 2012 directs the Attorney General to make grants to help states cover the costs implementation of DNA arrestee collection process (H.R.6014). Law enforcement agencies as well as state and local governments argue that it is an effective crime-prevention tool (National Conference of State Legislature, 2013). Yet, despite the *Maryland v. King* ruling, critics of DNA arrestee laws have challenged them on Fourth Amendment grounds, arguing that DNA samples contain too much private genetic information to be surrendered without a criminal conviction, making it an unreasonable search.

SO ... WHAT?

Forensic DNA techniques have the power to help in major criminal cases but we have to be cognizant of the potential social implications, especially when it comes to innocent citizens who become implicated in investigations through their DNA, often without their consent. Before a new scientific method or procedure can be introduced as analytical evidence in the courtroom, it needs to be verified by the scientific community under the Frye Standard (now superseded by the Daubert decision in some states) (Lyons). Genetic genealogy, despite its relative newness, has been used to make arrests and convictions, namely the Golden State Killer. We have yet to see how it will hold up in court in the Golden State Killer case, with preliminary hearings set for May 12, 2020 (goldenstatekillertrial.com). While prosecution will bring forward witnesses and present evidence, the judge will make the final determination regarding whether the evidence is admissible in court. Will the methods of genetic genealogy hold up in trial or will the Golden State Killer walk free on a technicality? We'll all be waiting anxiously as the court date approaches.

With such a new scientific technique, the legal and ethical considerations have not been fully explored yet so it is important to engage in these debates now. It still remains unclear how this technique will be embraced in the future: the Supreme Court may find that this is not a violation of the Fourth Amendment or they may rule it as a complete invasion of privacy. Throughout this article we highlight the many perspectives on the biological, ethical, and legal debates surrounding DNA in the criminal justice system, particularly the less represented voices in the controversy. We don't have a definitive answer for how DNA should be used in the criminal justice system, but that's not really the point. The point is to make sure we're looking at these methods with a critical eye and thinking twice before blindly using that 23andMe kit your aunt gave you for your birthday this year.



Are Crime TV Shows Lying to You?

Crime TV shows overwhelmingly portray DNA as a marker of innocence or guilt. As it is often the deciding factor for arrest and conviction, a lot of weight is placed on DNA evidence and its authority is rarely disputed.

While forensic DNA evidence has proved an invaluable tool in solving a wide variety of criminal cases, it is important to keep a critical perspective on its use - blindly trusting DNA in the courtroom, particularly more controversial or emerging techniques such as genetic genealogy, or overly relying on it to make arrests and convictions could be a mistake.

When crime TV shows like CSI, Law and Order, or Bones portray DNA evidence as being free from human bias or error, they contribute to the myth that forensic DNA evidence is infallible.

For a non-expert public, TV shows and other media are often their main (or only) exposure to forensic DNA practices. While these shows are fictional and were not created for educational purposes, the messages embedded in them undoubtedly influence viewers' perception of forensic DNA evidence. Ultimately, this may have consequences on the outcome of criminal trials.

The idea that jurors are biased by the glorified portrayals of forensic genetics in mainstream media, and crime TV shows in particular, has been dubbed the "CSI effect".

Source: Jane, S. (n.d.).*DNA detectives: A look at DNA in four prime time television crime dramas*. 128.


This phenomenon has been explored and debated in social science literature. While not all experts agree on the extent of the "CSI effect", or even whether it truly exists, it is nonetheless important to recognize when and how complex issues are sometimes oversimplified or misrepresented in mainstream media.

Public perception of forensic DNA evidence, and to what extent it is influenced by mainstream media, is an important component of the controversy our project is exploring. Cultural and pop culture representations of DNA have ramifications beyond the criminal justice system.

As people become more trusting of DNA as a unique symbol of identity and more comfortable with its various uses, the general mindset on genetic privacy rights and genetic surveillance may shift. Are we slowly becoming accustomed to yet another invasion of our privacy by companies, law enforcement and the government without even realizing it?

In light of this question, the "CSI Effect" could be expanded to include how the portrayal DNA in popular culture affects public perception of DNA not only as an investigative technique in the criminal justice system, but also a marker of identity and a tool for surveillance.

This expanded notion of the "CSI Effect" is particularly relevant for our project, which centers on the controversy over DNA's use in the courtroom but must necessarily explore other uses and conversations surrounding DNA, including the rising popularity of consumer genetic tests and genealogy databases.

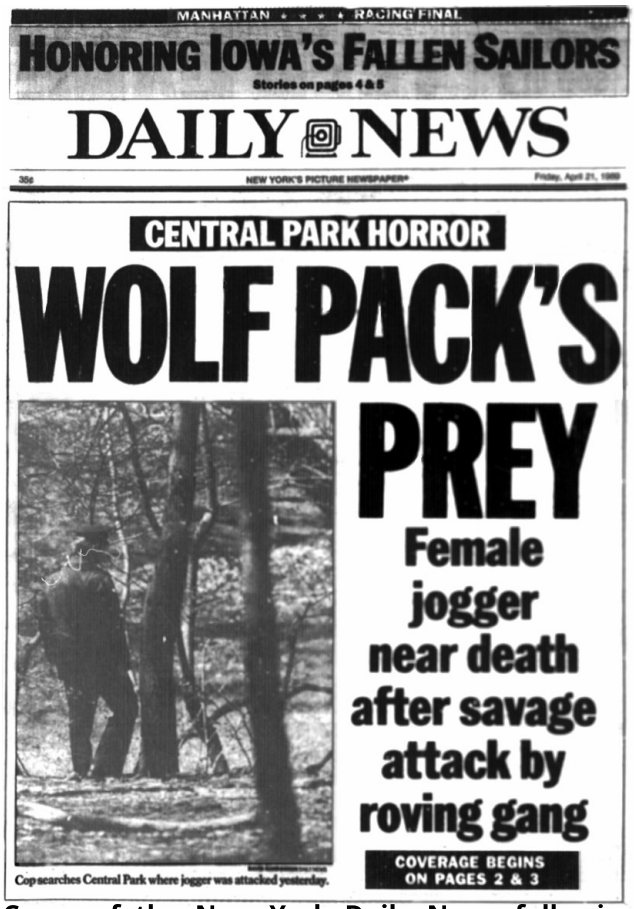
SPOTLIGHT COURT CASES

THE CENTRAL PARK 5

The morning of April 20, 1989, Trisha Meili's body was found in New York City's Central Park with severe trauma after a brutal beating and repeated rape. As it was a particularly violent time in New York City, the New York Police Department quickly made arrests of 5 minority teen boys who were reportedly part of a 30 person "wolf pack" that launched attacks on various people throughout the city that same day. They're known as the Central Park 5.

•••

Media sources were quick to jump on the story and perpetrated an animal-like depiction of the teen boys, calling them savages. Even Donald Trump had jumped on the bandwagon by paying for advertisements calling to bring back the death penalty as a result of their crimes. The teens were all arrested, and 4 out of the 5 arrestees confessed to the crimes on video after hours of interrogation. One of the boys recanted and later pled not guilty under the pretense of coercion for the video confessions.


MANHATTAN RACING FINAL

HONORING IOWA'S FALLEN SAILORS

Stories on pages 4 & 5

DAILY NEWS

35¢ NEW YORK'S PICTURE NEWSPAPER Friday, April 21, 1989

CENTRAL PARK HORROR

WOLF PACK'S PREY

Female jogger near death after savage attack by roving gang

COVERAGE BEGINS ON PAGES 2 & 3

Cop searches Central Park where jogger was attacked yesterday.

Cover of the New York Daily News following Meili's brutal attack in Central Park.

The stories had inconsistencies, and there were no eyewitnesses to the crime. Most shockingly, none of the 5 boys matched the DNA left at the crime scene. Despite all of these factors, all 5 of the boys were charged with a guilty verdict on counts of rape, assault, robbery, and even attempted murder. Between the 5 of them, they spent anywhere from six to thirteen years in prison as a result of their guilty verdicts.

Pictured: the Central Park 5 sitting in their court trial after coercion into guilty pleas. Prison sentences ranged for the 5 young men.

The case seemed like a done deal until everything changed in 2002. Convicted rapist Matias Reyes confessed to the attack on Meili while he was already serving time for other rape and murder charges. A DNA sample confirmed a match to the DNA left at the scene. In December of that year, a justice serving on the New York Supreme Court let the 5 men go free.

•••

The Central Park 5 later sued the city of New York for damages and settled for $41 million. They went on to lead relatively normal lives, but not without the trauma of being wrongfully convicted and spending multiple undeserved years in the prison system as a result of racial profiling and haphazard police work.

•••

This case is a landmark in blatantly ignoring DNA evidence that did not implicate any of the Central Park 5 in Meili's attack. Despite the lack of match or any evidence whatsoever to place them at the crime scene, they were still arrested and convicted for the crime. DNA, the very thing the police chose to ignore during the prosecution, later became the thing to exonerate these individuals from their prison sentences.

•••

Only after finding a DNA match to Reyes did the state let them go free. While DNA might not be the only thing that matters in a case, it sure is a substantial piece of evidence that cannot be fabricated or ignored. For the sake of personal liberties and rights that were overstepped for the boys, now men, involved in this case, hopefully wrongdoings like this are eradicated with the rising prominence and validity of DNA in the courtroom.

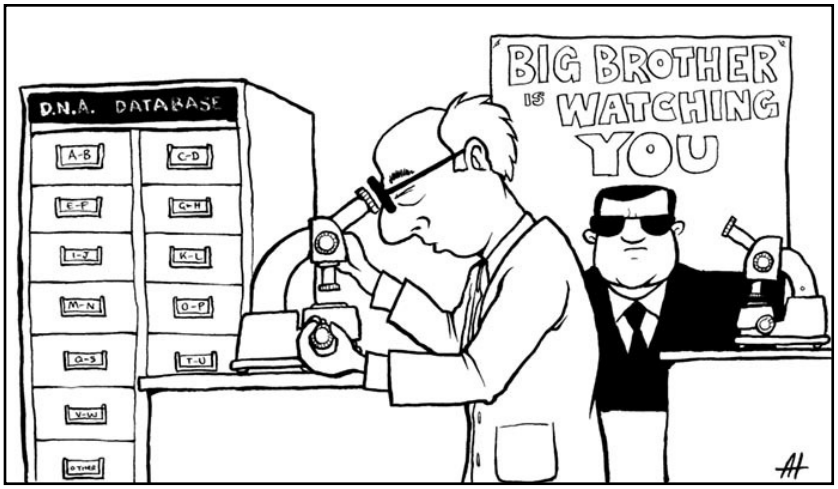
*Case synopsis cited from history.com, citation found on page 51.

A Universal DNA Database?

Weighing Pros and Cons

What if the government collected and stored DNA samples from all Americans?

Although the idea of a universal DNA database where all citizens would be required to submit a DNA sample might seem radical today, it may very well be a possibility in the future.



Considering the potential implications of a universal DNA data isn't just an interesting thought experiment, it provides a new perspective on some of the current controversies surrounding DNA profiling in the criminal justice system.

Proponents of a universal DNA database point to benefits for public safety. It would increase the efficiency and accuracy of criminal investigations, as well as potentially deter crimes from happening in the first place.

A universal DNA database would also eliminate the need for genetic genealogy, a controversial technique currently being used, so that innocent relatives of the perpetrator would no longer need to be involved in criminal investigations.

Currently, African Americans and Latinos are overrepresented in law enforcement databases due to higher incarceration and arrest rates in these populations. As a result, these groups experience higher false-positive rates in DNA profiling and are disproportionately affected by the invasive technique of genetic genealogy. Including all citizens' DNA profiles in one database would eliminate this kind of racial bias in criminal investigations using DNA evidence.

Source: Smith, M. (2018). Universal forensic DNA databases: Balancing the costs and benefits.*Alternative Law Journal*,*43*(2), 131–135.

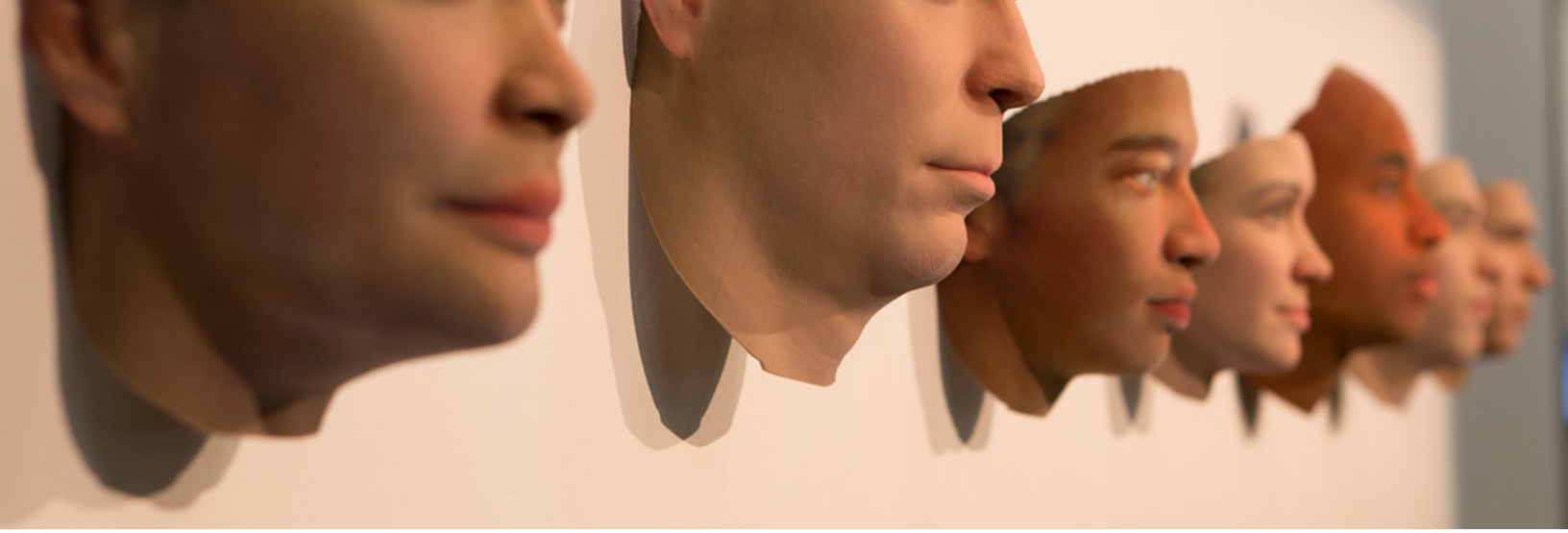
Interestingly, the argument can be made that a universal DNA database would actually improve genetic privacy. It treats all citizens equally in criminal investigations thereby addressing some of the current problems associated with the collection of DNA. For example, non-consensual DNA collection of “abandoned” DNA from suspects and DNA collection upon arrest, which potentially violates the arrestee’s Fourth Amendment rights, would no longer be necessary. Of course, the potential societal benefits must be weighed against the individual rights of citizens.

"Of course, the potential societal benefits must be weighed against the individual rights of citizens."

Genetic privacy concerns make a universal DNA database inconceivable for many. The concern that information in this universal database could be used to investigate crimes other than violent crimes, or for purposes other than criminal investigations, has also been raised.

Simply put, collecting DNA from every citizen is difficult to justify legally and ethically, which explains why no countries have adopted a universal DNA database. Still, considering a universal DNA database in light of current legal and ethical issues (e.g. genetic privacy, non-consensual DNA collection, the over-representation of minorities in criminal DNA databases, among others) is an interesting avenue to explore for our project.

And while a universal DNA database is not a reality as of now, that is all the more reason to entertain the debate.



ART, TECHNOLOGY AND GENETIC PRIVACY

In 2013, artist Heather Dewey-Hagborg worked on an art project titled Stranger Visions. Through it, she explored issues such as "abandoned DNA", genetic privacy, DNA phenotyping and genetic surveillance. She collected hair, cigarette butts, gum and other items which were likely to contain DNA from public spaces in New York City. Using cutting-edge forensic DNA analysis, she extracted and purified the DNA. Then she tested the samples for phenotypic traits such as gender, eye color, hair color and racial ancestry. She also looked at genetic markers associated with variations in facial structure. Using a computer program, she generated 3D portrait sculptures of what the individuals might've looked like.

These sculptures were exposed in various galleries and museums, and photos can be viewed on her website

The artist emphasizes that these portraits are not exact replicas of what the individuals actually look like. Rather, they represent a general likeness based on a few key features of the face. For example, she was unable to determine age from the DNA samples, so all the faces are made to look around 30.

The technique Heather Dewey-Hagborg used, known as DNA phenotyping, was just beginning to gain traction at the time that she worked on this project.

Two years later, a company called Parabon Nanolabs began to offer DNA "snapshot" services to police departments where they generate phenotype predictions and a DNA phenotype composite image using crime-scene DNA. Forensic DNA phenotyping has been used to find missing persons and narrow down suspects in many criminal investigations since then.

It has, however, been criticized for potentially increasing racial bias and discrimination in criminal investigations.

In addition, many have made the "slippery slope" argument – they warn that allowing DNA phenotyping in criminal investigation could open up the door for more widespread genetic surveillance.

The Stranger Visions project also directly relates to the practice of collecting "abandoned" DNA, which has been hotly debated in law enforcement, bioethics and legal circles.

Critics highlight the ethical and legal concerns of collecting someone's DNA without their consent.

Abandoned DNA has been used in several high profile murder cases, including the Golen state Killer.

Another example is serial killer Lonnie David Franklin Jr ("The Grim Sleeper"), who was caught in 2010 using a DNA sample that detectives obtained from a discarded pizza and utensils he used. Few laws exist to govern this practice, and it has been and continues to be used by law enforcement.

Winner of an Ars Electronica honorary mention 2015 and a special mention at VIDA 15.0, Stranger Visions has mostly received positive attention. However, in an effort to shed light on the issue of genetic privacy and genetic surveillance, some worry that the artist may have gone too far and that, in fact, her artwork was a violation of her subjects' genetic privacy. Her response is that, as an artist, her intention was to spark difficult ethical questions about genetic privacy and raise concerns about a future where genetic surveillance becomes the norm.

She explains that, "[Stranger Visions] is meant to be an exploration at the intersection of art and technology and science," she said. "And it's meant to be a provocation." (CNN).

"Stranger Visions is meant to be an exploration at the intersection of art and technology and science. And it's meant to be a provocation."

Genetic Genealogy

When no match is obtained through NDIS, should law enforcement turn to genealogy databases?

Phase 1: DNA Analysis

Biological evidence collected at crime scene and sent to crime lab → Crime lab generates STR profile → STR profile searched through NDIS, and no match is obtained → Biological evidence is outsourced to generate a SNP profile

Phase 2: Genealogy

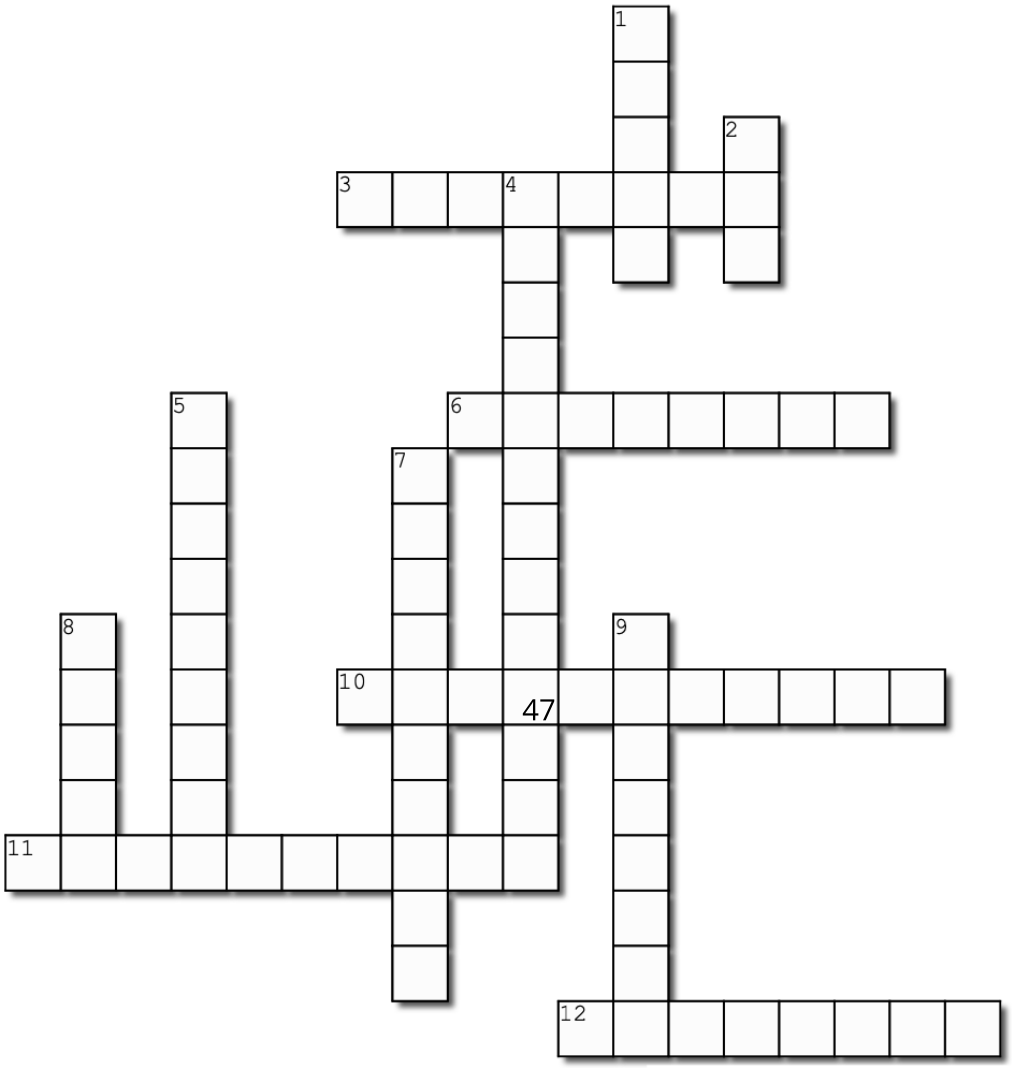
SNP profile searched through genealogy database → Family tree constructed based on centimorgan values and genealogical data → Evaluate data to identify areas of overlap within the family tree → Comparison to crime scene information develops suspects for direct sampling

Phase 3: Investigation

DNA samples obtained from family members → DNA samples analyzed at crime lab to develop STR profiles → Candidate STR profiles compared to STR profiles collected from crime scene → **Investigative leads** / **Elimination**

FORENSIC FUN!

HOW WELL DO YOU *REALLY* KNOW DNA?



ACROSS

3. Polymerase chain _____; method used to amplify DNA

6. State involved in landmark Supreme Court case against Alonzo Jay King, Jr. that ruled a DNA swab is not an unreasonable search and seizure

10. Location of Trisha Meili's brutal attack that led to the wrongful conviction of 5 teen boys

11. The astronomical number used for DNA random match probabilities; "1 in _____ people"

12. DNA company used by law enforcement to track down the Golden State Killer

DOWN

1. Criminal DNA database

2. Molecule of life, used to build suspect profiles

4. Can lead to false reports of a DNA match between non-match samples

5. The idea that jurors are biased by glorified portrayals of forensic genetics in mainstream media and crime TV shows

7. Single _____ polymorphism; property of DNA used to trace human heritage in DTCs

8. Piece of evidence that carried DNA from OJ Simpson and both murder victims

9. _____ number tandem repeat; property of DNA used to create DNA profiles

An Investigative Journalism Podcast

Visit our website at
https://serialpodcast.org

SERIAL

A year inside a typical American courthouse. This season we tell you the extraordinary stories of ordinary cases.

REFERENCES

Barbaro, M. (Host). (2019, June 6). *A New Way to Solve a Murder, Parts 1 and 2* [Audio podcast].Retrieved from https://www.nytimes.com/2019/06/06/podcasts/the-daily/dna-genealogy-crime.html.

Butler, J. M., & Butler, J. M. (2010). *Fundamentals of forensic DNA typing*. Amsterdam: Elsevier Academic Press.

California Department of Justice (n.d.). Memorandum of Understanding Familial Searching Protocol. https://oag.ca.gov/sites/all/files/agweb/pdfs/bfs/fsc-mou-06142011.pdf.

Carpenter v. United States, 585 US _ (2018).

Cavanaugh, S. E., & Bathrick, A. S. (2018). Direct PCR amplification of forensic touch and other challenging DNA samples: A review. *Forensic Science International: Genetics*, *32*, 40–49.

Clayton, E. W., Evans, B. J., Hazel, J. W., & Rothstein, M. A. (2019). The law of genetic privacy: Applications, implications, and limitations. *Journal of Law and the Biosciences*, *6*(1), 1–36.

Dolan, M., & Stevens, D. (2018, April 27). How familial DNA searches work. Retrieved from https://www.latimes.com/local/lanow/la-me-g-familial-dna-how-it-works-20180426-story.html.

Fuller, T. (2018, April 26). How a Genealogy Site Led to the Front Door of the Golden State Killer Suspect. *New York Times*. Retrieved from https://www.nytimes.com/2018/04/26/us/golden-state-killer.html.

Geddes, L. (2012, January 11). How DNA contamination can affect court cases. Retrieved February 28, 2020, from https://www.newscientist.com/article/mg21328475-000-how-dna-contamination-can-affect-court-cases/.

Goodwin, W., Linacre, A., & Hadi, S. (2011). *An introduction to forensic genetics* (Vol. 2). John Wiley & Sons.

Grimm, D. (2007). The Demographics of Genetic Surveillance: Familial DNA Testing and the Hispanic Community. *Columbia Law Review, 107*(5), 1164-1194. Retrieved February 16, 2020, from www.jstor.org/stable/40041746.

GSK Trial Commentator Group. (2020, January 23). Category: Pre-Trial. Retrieved from http://goldenstatekillertrial.com/category/pre-trial/.

Guerrini, C. J., Robinson, J. O., Petersen, D., & Mcguire, A. L. (2018). Should police have access to genetic genealogy databases? Capturing the Golden State Killer and other criminals using a controversial new forensic technique. PLOS Biology, 16(10).

Hendricks-Sturrup, R., Prince, A., & Lu, C. (2019, May 21). Direct-to-Consumer Genetic Testing and Potential Loopholes in Protecting Consumer Privacy and Nondiscrimination. *Journal of American Medical Association*.

History.com Editors. (2019, May 14). The Central Park Five. Retrieved from https://www.history.com/topics/1980s/central-park-five.

Jamieson, A., & Bader, S. (Eds.). (2016). *A Guide to Forensic DNA Profiling* Chichester, West Sussex, UK: John Wiley & Sons. (2016).

Joh, E. E. (2006). RECLAIMING "ABANDONED" DNA: THE FOURTH AMENDMENT AND GENETIC PRIVACY. *NORTHWESTERN UNIVERSITY LAW REVIEW*, 28.

Kayser, M., & Knijff, P. D. (2012). Erratum: Improving human forensics through advances in genetics, genomics and molecular biology. *Nature Reviews Genetics*, *13*(10), 753–753.

Kayser, M. (2015). Forensic DNA Phenotyping: Predicting human appearance from crime scene material for investigative purposes. *Forensic Science International: Genetics*, *18*, 33–48.

Kennett, D. (2019). Using genetic genealogy databases in missing persons cases and to develop suspect leads in violent crimes. *Forensic Science International*, *301*, 107–117.

Kody, H. L. (n.d.). *Standing to Challenge Familial Searches of Commercial DNA Databases*. *61*, 33. Katie Sepich Enhanced DNA Collection Act of 2012,H.R.6014, 112th Cong., (2012).

Krishnamurthy, V., Manoj, R., & Pagare, S. S. (2011). Understanding the basics of DNA fingerprinting in forensic science. *Journal of Indian Academy of Oral Medicine and Radiology, 23*(4),613-616. Retrieved from https://search.proquest.com/docview/926220633?accountid=14512

Letzter, R. (2018, June 4). How Do DNA Ancestry Tests Really Work? Retrieved January 23, 2020, from https://www.livescience.com/62690-how-dna-ancestry-23andme-tests-work.html.

Lyons, T. (n.d.). Frye, Daubert and Where Do We Go From Here? Retrieved March 7, 2020, from https://www.sfandllaw.com/Articles/Frye-Daubert-and-Where-Do-We-Go-From-Here.shtml.

Machado, H., & Silva, S. (2019). What influences public views on forensic DNA testing in the criminal field? A scoping review of quantitative evidence. *Human genomics*, *13*(1), 23.

Mares, B. (2011). A Chip Off the Old Block: Familial DNA Searches and the African American Community. *Law & Inequality*, *29*(2), 395–424.

Maryland v. King, 569 U.S. 435 (2013).

McGuire, A. L., & Beskow, L. M. (2010). INFORMED CONSENT IN GENOMICS AND GENETIC RESEARCH. *Annual Review of Genomics and Human Genetics*, *11*, 361–381.

Molteni, M. (2019, December 3). The US Urgently Needs New Genetic Privacy Laws. Retrieved from https://www.wired.com/story/the-us-urgently-needs-new-genetic-privacy-laws/.

Murphy, H. (2019, July 1). Genealogy Sites Have Helped Identify Suspects. Now They've Helped Convict One. Retrieved from https://www.nytimes.com/2019/07/01/us/dna-genetic-genealogy-trial.html.

National Conference of State Legislature (2013). DNA Arrestee Laws. https://www.ncsl.org/Documents/cj/ArresteeDNALaws.pdf.

Neufeld, P.J. & Colman, N. (1990). *When Science Takes the Witness Stand*. Scientific American, 262 (5).

O.J. Simpson acquitted. (2019, October 3). Retrieved from https://www.history.com/this-day-in-history/o-j-simpson-acquitted.

Oreskes , B., Serna, J., & Winton, R. (2018, May 4). False starts in search for Golden State Killer reveal the pitfalls of DNA testing. Retrieved February 13, 2020, from https://www.latimes.com/local/lanow/la-me-ln-golden-state-killer-dna-20180504-story.html.

Ram, N. (2019, March 19). The U.S. May Soon Have a De Facto National DNA Database. *Slate*. Retrieved from https://slate.com/technology/2019/03/national-dna-database-law-enforcement-genetic-genealogy.html.

Reference, G. H. (n.d.). *Can the results of direct-to-consumer genetic testing affect my ability to get insurance?* Genetics Home Reference. Retrieved March 1, 2020, from https://ghr.nlm.nih.gov/primer/dtcgenetictesting/dtcinsurancerisk.

Russell, J. G. (2019, March 31). *Opt-out is not informed consent*. The Legal Genealogist. Retrieved from https://www.legalgenealogist.com/2019/03/31/opt-out-is-not-informed-consent/.

Shaer, M. (2016, May 16). The False Promise of DNA Testing. Retrieved January 20, 2020, from https://www.theatlantic.com/magazine/archive/2016/06/a-reasonable-doubt/480747/

Thompson, W. C. (2012). 15 Forensic DNA Evidence The Myth of Infallibility. *Genetic Explanations*.

United States v. Miller, 425 US 435 (1976).

U.S. Const. amend. IV.

Watson, J., & Berry, A. (2003). *Dna : The secret of life* (1st ed.). New York: Alfred A. Knopf.

Wickenheiser, R. A. (2019). Forensic genealogy, bioethics and the Golden State Killer case. *Forensic Science International: Synergy*, *1*, 114–125.

cold case

brought to you by:

Madelyn Gehrich
Alizée Natsoulis
Taylor Ann Yamane
Maria Zarifis