

Forensics Presenter Notes:

Today, you will have a chance to do a variety of things to help you solve a crime using DNA, and you'll see how DNA has been used to free innocent people from prison.

What is DNA Day?

The story of DNA began on April 25, 1953, where doctors James Watson and Francis Crick determined the structure of DNA. 50 years later, in April 2003, the Human Genome Project determined the entire sequence of human DNA. Research scientists are using the knowledge and technology generated by this project to further understand how your DNA is causing or contributing to disease.

DNA

Take a few minutes to discuss what DNA stands for, what DNA is, what is its structure, and whether it is positively or negatively charged.

DNA stands for deoxyribonucleic acid and it is the chemical compound that contains the genetic information for the function of living organisms. DNA is made of two twisting, paired strands of chemical units called **nucleotide bases**, which form the double helix described by Watson and Crick. DNA is negatively charged. Remember this, because it will be important for later.

DNA alphabet:

Each nucleotide base corresponds to a letter that makes up our DNA. How many different types of nucleotide bases are there and what are their names?

There are four nucleotide bases called adenine, thymine, cytosine, and guanine. For short, they are often referred to as letters A, T, C, and G. Different combinations of these letters in a long sequence make up our genes. What the Human Genome Project determined was the order of these bases in all of our genes.

From Genes to Proteins

Genes in your DNA code for your genotype. Cells use the DNA to make proteins. DNA is first converted into RNA in a process called transcription. Then, the RNA is translated into proteins by instructing the cell in which order to place amino acids. These proteins combined make up a physical characteristic called a phenotype.

What Makes you You?

Who you are is generally thought of as what you look like. We all appear different, like the game Guess Who. We have different hair color, eye color, face shape, skin tone, etc.

So, in your DNA, the gene for your eye color is your genotype. If you have eyes that are the color brown, then brown eyes is your phenotype. In forensic science we identify people based on genotype, not on phenotype. The proteins that are encoded by your DNA make you, you.

Classroom Skit – See attached script

You can just read the principal part, or select a few students to join you with the student parts.

Facts and Figures about DNA

To solve this crime, we need to know more about DNA and how it is analyzed by forensic scientists

Alright, see how well you can answer a couple of questions on DNA.

So remember, we have four different types of bases in our DNA, A, T, G and C. What do you think is the total number of bases are there in the human genome?

A) 3,000 b) 300,000 C) 3 million or D) 3 billion e) 3 trillion

If you answered D) 3 billion, you are correct!

As humans, our DNA is similar to one another, but we look different from one another. What percent of your DNA is similar to any other person in the world?

A) 99.9% B) 98% C) 90% D)60% E)10%

Surprisingly, our DNA is 99.9% similar to any other person's. If we 0.1% different, how many bases would that be? If you did your math right, you realized that we differ by 3 million bases. Its these 3 million bases that make us unique.

These variable regions are also used by forensic scientists focus on to generate a DNA fingerprint for each individual

Sources of DNA

Before we get to analyzing the DNA, we need a sample of it. Take a minute to name a few sources of DNA.

There are many sources of DNA in your body, including sweat and blood. Today we'll be focusing on DNA from saliva.

DNA Isolation

I will now be teaching you how to extract your own DNA! And how it can be analyzed by forensic scientists to create DNA fingerprints!

First, it is important to know that is not the protocol that forensic scientists use in the laboratory to analyze DNA from a crime scene, but an adaptation for a classroom that follows the same principles to extract DNA.

DNA is found in every cell of every living organism, including cells found in your saliva that have come from the inside of your mouth.

We first need to collect about 1ml of saliva, so in order to get your salivation glands going you should work your tongue against your cheeks and teeth as you think of your favorite thing to eat, such as chocolate cookies.

Now that we have our saliva, we need to break open the cells that it contains. And to do this we will add ½ drops of soap to the tube and mix well

Now that we freed our DNA it is now found in solution in water, given that DNA is hydrophilic meaning water loving. BUT in order to extract DNA we need to solidify it and salt will have us do this.

We now add a pinch of salt and mix. DON'T overmix, just invert the tube back and forth a couple of times

As I told you earlier, DNA is negatively charged, thus when it's in solution it wants to repel other DNA strands. The positive ions in salt will come in contact with the DNA and allow it to aggregate and clump

We now add ethanol to our solution. You'll begin to see some snotty cloud stuff that will appear between the saliva and the alcohol, this is your DNA coming out of solution!

Now use a stick to SLOWLY spool out your DNA by slowly swirling, trying to wind the filaments around the tip of the toothpick. Transfer to a new tube. You can now add some water and DNA will go back into solution. HOW COOL IS THAT?

Analyzing DNA - PCR

Polymerase chain reaction allows us to make millions of copies of a specific stretch of DNA in a short amount of time, starting with a small amount of DNA

Polymerase is a protein obtained from a bacteria that can tolerate extremely high temperatures. Which is important because

In the first step of PCR the DNA solution need to be brought to 94 degrees celcius, remember that the temperature at which water boils is 100, so this is really hot! This allows for the single stranded filaments to separate from each other

So now we cool down our solution to allow primers to anneal. Primers are short single stranded pieces of DNA that serve as a starting point for DNA synthesis. Remember, A pairs with T and G pairs with C. The ideal temperature for primers to anneal to their complimentary sequence in the sample DNA is 55 degrees.

After the primer has annealed, the temp needs to be raised to 72. This is the optimal temperature for the polymerase to elongate the strands to DNA by adding nucleotides to the primers, once again creating a DNA double strand of the region of interest.

You repeat this process of denaturing, annealing and elongating several times and at the ends it leads to the creation of millions of copies of DNA in a short amount of time.

How do We Generate a Fingerprint?

By the use of restriction enzymes. REs are molecular scissors that have also been derived from bacteria that recognize very specific sequences of DNA and cut at a specific place every time. For example this one - EcoRI. EcoRI recognizes the sequence GAATTC and only that sequence. Notice that the final number of fragments equals one more than the number of cut sites!

There are thousands of Restriction enzymes that recognize different DNA sequences and cut in diff. places. We will be solving the mystery of the stolen mascot by using ECOR1.

After the DNA has been amplified and digested, we now have to analyze the fragments that were created in an electrophoresis gel.

Electrophoresis Gel

This gel is made up of agarose, which is a sugar derived from the cell walls of red algae. Agarose creates a matrix that very much feels like jello. DNA is able to move through the small openings that exist in the matrix.

A marker is a solution of DNA that contains fragments of known sizes.

It's used as a reference to compare the fingerprint of the DNA found in a crime scene to that of the suspect's after they have been amplified and digested.

An electric current is applied with a positive charge at the bottom of the gel and a negative charge at the top of the gel. Remember DNA is negatively charged, so it moves toward the bottom (the positively charged end) when the electric current is applied.

The smaller fragments have greater mobility through the small apertures of the gel and thus are able to travel much faster than larger fragments. Think about a crowded hallway of students. The little small guy can duck through smaller openings in the crowd and move through more quickly.

Analyze this DNA Sequence

Now that we know how to analyze DNA fingerprints let's try analyzing this sequence of DNA.

Using the restriction enzyme EcoRI, this fragment can be cut twice, into 3 pieces. If you were to run this mixture of DNA on a gel, the smaller fragment would move more quickly than the larger fragments, which would move more slowly. Therefore, the smallest fragment would travel farther down the gel than the larger ones. The DNA on the gel would look something like this.

Solve this Crime

Forensic scientists use the variable areas of our genome, for example the person whose DNA in sample 1 belongs to has one cut site, whereas the DNA found in the crime scene has 2 cut sites. Can you tell me which sample's DNA matches the fingerprint of the DNA found at the crime scene? Sample 3

Back to the Crime We Must Solve

So now that we know to analyze DNA fingerprint it is time to solve our mystery!

Let's meet our suspects

For the analysis of the suspects' DNA we will once again be using ECORI. You will all be given a sequence of DNA to analyze. Find all of the EcoRI cut sites in your sequence, determine each of the fragment sizes produced by the digestion, and draw the bands on the gel according to their lengths

Let's take a look at the suspect cards you will be analyzing

Now draw a large gel on the board such as this one so each group can record their findings. Have students determine who committed the crime.

Compare Their DNA

Let's take a closer look at their DNA sequence. As you can see, very small differences in the DNA sequence lead to dramatically different DNA fingerprint patterns - point out examples

Ethical Considerations

Now let's talk about some ethical considerations about what we have discussed so far. See slide for points of discussion for the class.

TV Crime Dramas

Think of your favorite TV crime drama. What kinds of forensic analysis do they do?// Some of the evidence you may have seen are bite marks, blood spatter, handwriting, ballistics, tool marks, voices, hair, fibres, and DNA. While the characters in these shows make it seem like that all evidence is created equal, it is not. Think about it, how many people own the same shirt from the GAP? If the police find fibers at the scene of a crime that is from a GAP shirt, anyone who has that shirt is a suspect. In contrast, DNA evidence is the only evidence which can link a suspect to a crime with mathematical certainty.

DNA Databases

For this reason, DNA databases are extremely helpful in solving crimes. CODIS stands for combined DNA index system and it is the DNA database used in the United States. CODIS is funded and maintained by the Federal Bureau of Investigation. As mandated by law, DNA records can only be taken for use in CODIS from convicted felons, victims, or missing persons or their relatives. The DNA analysis stored in CODIS is from 13 STRs or short tandem repeat regions. These are regions in our genome where the same sequence of bases is repeated over and over. Individuals differ in the number of repeats they have. So when you cut out the region of DNA where the repeats are and run it on a gel, each person will have bands of different sizes; just like in the exercise we just completed. In the United States, the federal government analyzes 13 STRs for every sample included in the database. These STRs are located all over the genome, which are depicted in yellow on this slide. By analyzing all of these STRs, the probability that one person will have the same profile as another person is 1 in 100 billion. Currently there are 6.9 billion people in the world, so the match probability is higher than the current world population. This probability is the reason why DNA evidence is so powerful in court. If someone's DNA profile matches the DNA profile found at the scene of the crime, there is a 1 in 100 billion chance that it is not their DNA, and since there are not 100 billion people alive in the world, the DNA found at the scene of the crime has to be the suspect's DNA.

The Innocence Project

Before the 1990s, DNA evidence was not available like it is today. There are many people who have been put in jail for a crime they did not commit because when they had their trial, DNA evidence was not available to make sure that they were the person who did it. The Innocence Project is an organization which is dedicated to exonerating wrongfully convicted people using DNA evidence. As of February 2011, 244 people have been exonerated in the United States thanks to DNA testing. As of February 2011, there have been 7 people in North Carolina who have been exonerated by DNA testing.

Introducing Picking Cotton

One of the cases where DNA evidence exonerated an innocent man in North Carolina is the subject of the PBS Frontline special "What Jennifer Saw" and the New York Times Bestselling book "Picking Cotton," which is described as "a true story of forgiveness and hope."

Story of Picking Cotton

So what happened?// In 1984, someone broke into Jennifer Thompson's apartment and raped her.// Jennifer and the police made a sketch of the suspect based on what she remembered her rapist to look like,// When that sketch was put on TV, someone thought it looked like Ronald Cotton.// Ron was picked out of a police lineup by Jennifer, leading his conviction of rape and burglary.// Ron served 10 ½ years in prison before he was exonerated by DNA evidence in 1995.// Jennifer was distraught by guilt.// After thinking about what happened in her life in the 11 years Ron was in jail, she writes "...he had none of those things because I'd picked him."// Jennifer asked to meet with Ron two years after he was released to apologize for her wrongful identification of him as her rapist.// Ron completely forgave Jennifer, which was the beginning of a close friendship.// Today, Jennifer and Ron travel the country as advocates for justice and eyewitness identification reform, in order to try to make sure that what happened to them does not happen to others.// Eyewitness misidentifications, like what happened in Ronald Cotton's case, contribute to 75 percent or more of the wrongful convictions overturned by DNA evidence.// This occurs mainly because victims feel pressured to choose someone at all costs.

Potential Questions for Discussion in the Classroom

Does DNA evidence prove innocence?

Does DNA evidence prove guilt?

Do you think DNA databases should include everyone?

Who do you think should have access to information on people's DNA?

How could someone's DNA be used for purposes other than to solve a crime?