DNA evidence

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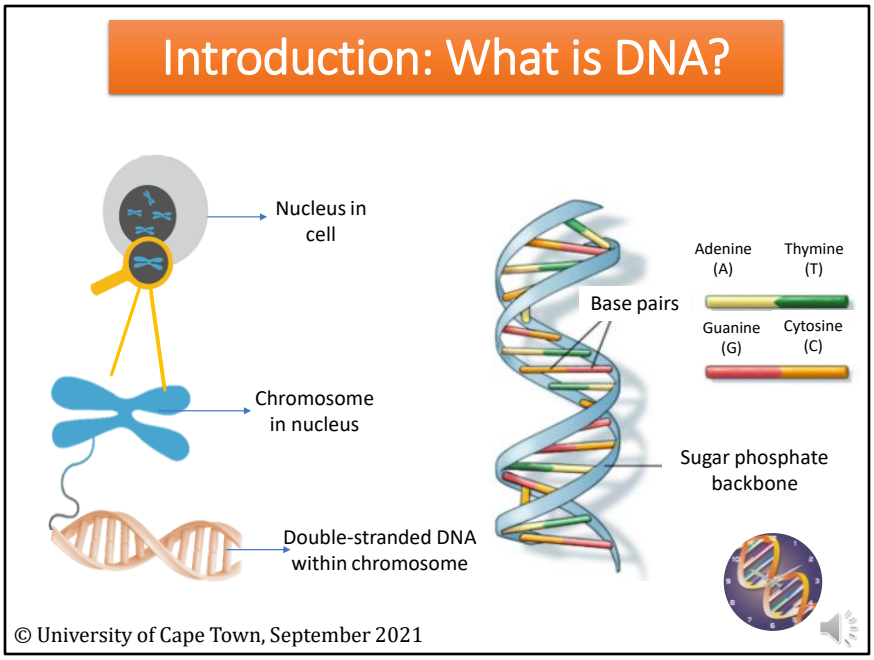
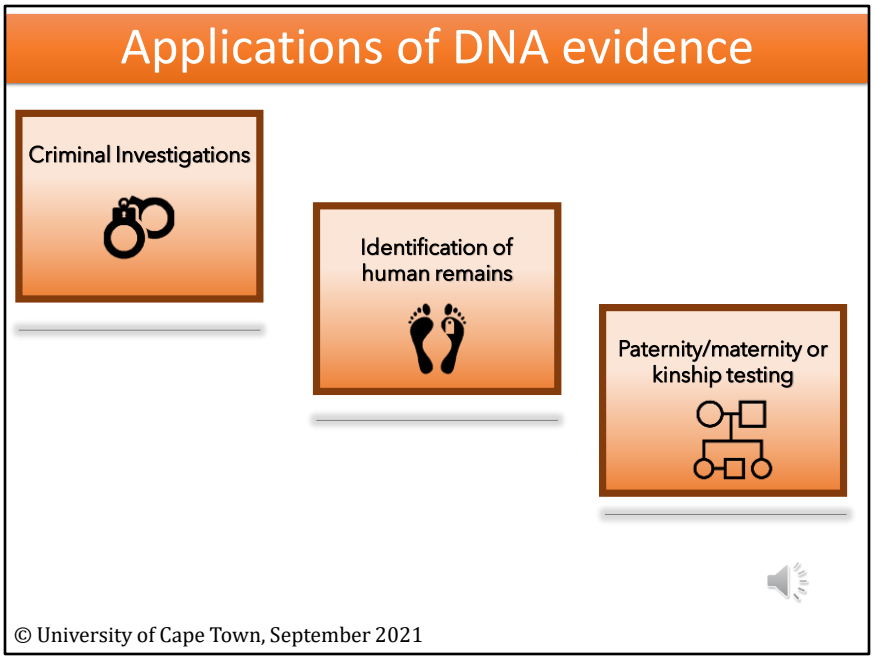
Tip: Whenever you see this icon; press Ctrl + Click to check out a short video explaining an important concept.

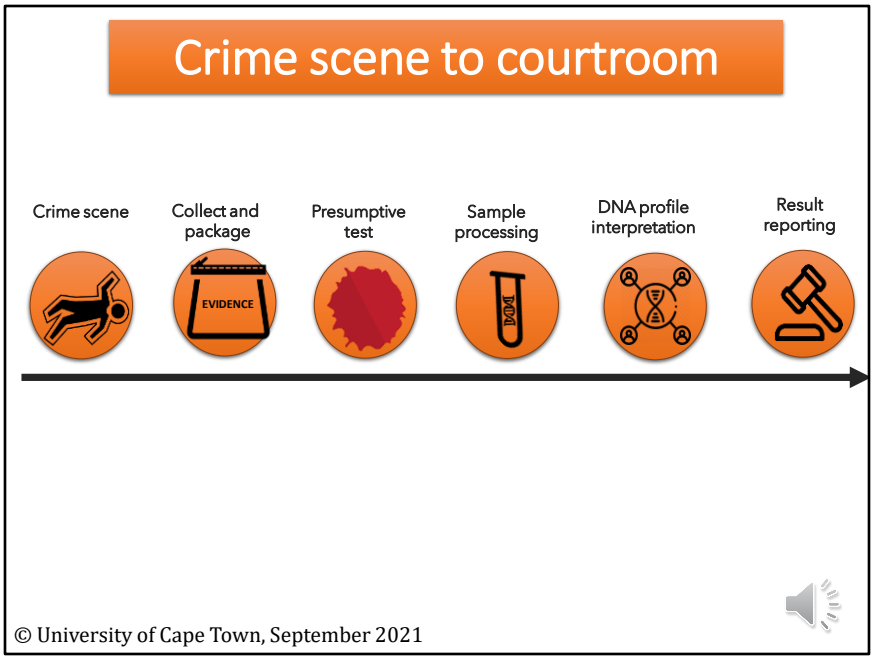
This lecture will focus on DNA evidence. a brief introduction to the use of DNA in forensics applications will be given. We will then have a look at a typical crime scene to courtroom workflow and how and where DNA evidence fits in. We will also touch on some sources of DNA and the collection of DNA evidence at the scene.



To understand DNA evidence, we need to understand what DNA is. To put it simply, DNA, which is short for Deoxyribonucleic acid, is a molecule found inside cells in your body, and it contains the genetic instructions for the development, functioning, growth and reproduction of an organism. In the nucleus of each cell, the DNA molecule is packaged into thread-like structures called chromosomes. Each chromosome is made up of DNA that is tightly coiled many times around proteins that support its structure. The information in DNA is stored as a code made up of four chemical bases: adenine (A), guanine (G), cytosine (C), and thymine (T). DNA bases pair up with each other, A with T and C with G, to form units called base pairs. Each base is also attached to a sugar molecule and a phosphate molecule. Together, a base, sugar, and phosphate are called a nucleotide. Nucleotides are arranged in two long strands that form a spiral called a double helix. The structure of the double helix is somewhat like a ladder, with the base pairs forming the ladder's rungs and the sugar and phosphate molecules forming the vertical sidepieces of the ladder. Because DNA is unique between every individual except for identical twins, we can use it to identify an individual. We will go into more detail in later lectures about the variations in DNA and how we can use it to identify an individual.

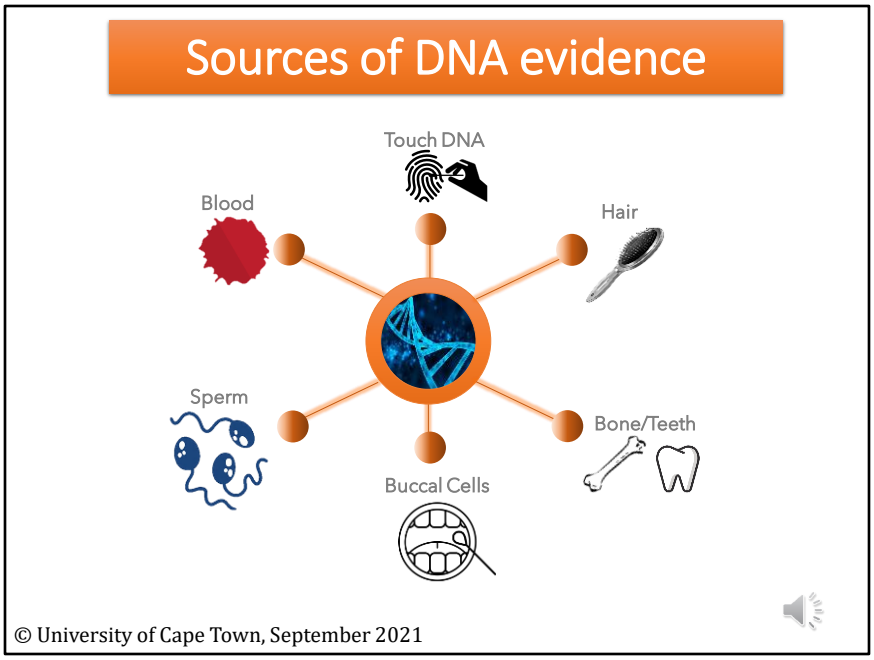


The applications of DNA in forensic science include: assisting in criminal investigations, where a crime scene sample is matched to a suspect sample, in medico-legal investigations where it is used in the identification of human remains, in Mass disasters and in missing persons investigations, as well as paternity, maternity and kinship testing,

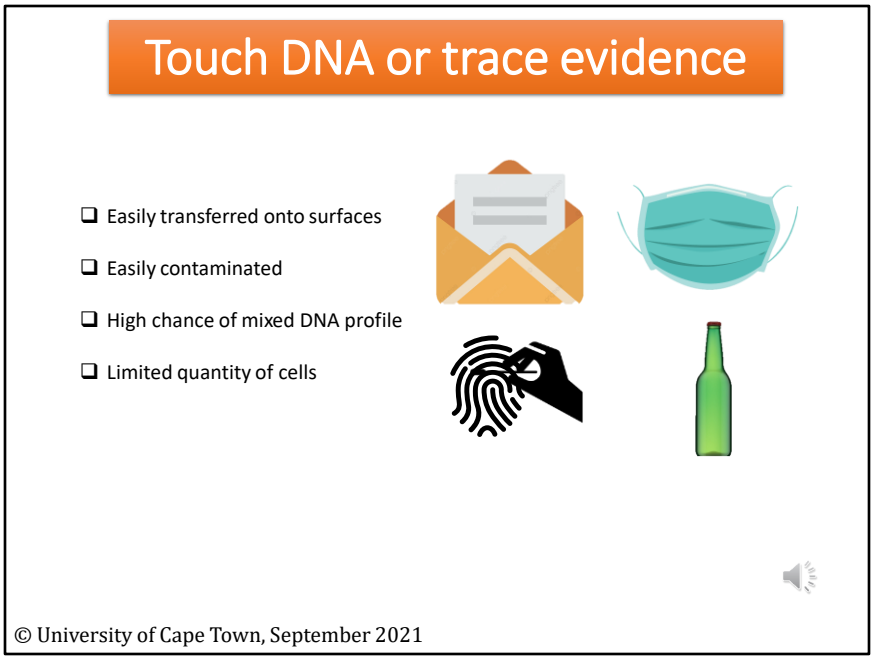


So how can we use DNA to solve crimes? Let's take a look at a typical and simple crime scene to courtroom workflow. If someone deposits traces of their blood, hair, saliva or semen at a crime scene, crime scene investigators collect, package and transport these samples to the laboratory.

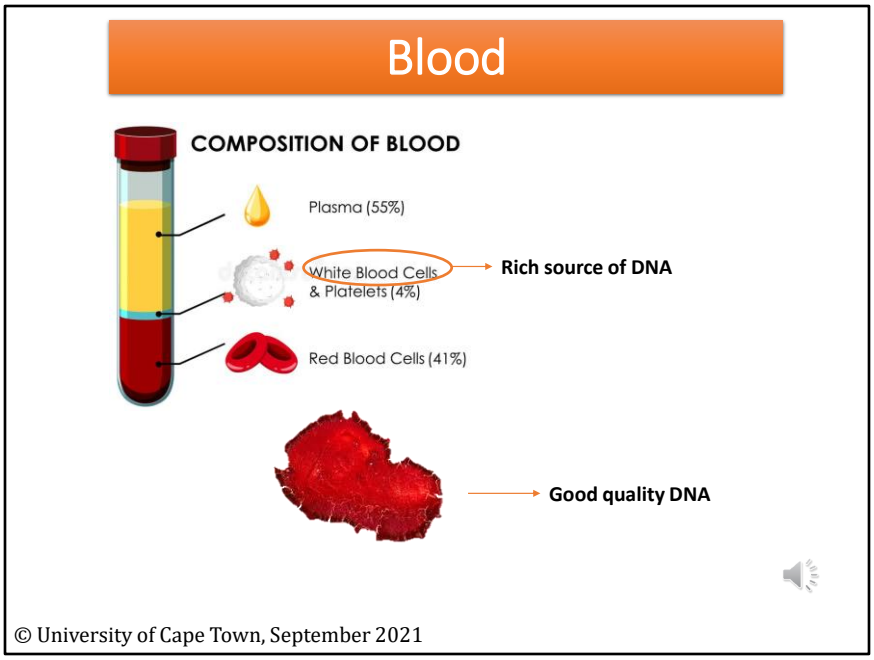
Scientists can perform a screening test known as a presumptive test to get an indication of what the stain might be. If the stain is a biological sample, then DNA will be isolated. The DNA will be quantified to determine how much DNA is present, and then specific areas of the DNA are amplified to generate what we call a forensic DNA profile. This forensic DNA profile can then be compared to DNA profiles of known people, for example those from suspects, in search for a match. If a match is found, the statistical strength of the match is then calculated and the results are reported in an Affidavit, which is then used as evidence in court. Don't worry if this is not clear to you yet - we will go over this in more detail in later lectures.



So, where can we find DNA? DNA can be found in different body fluids such as saliva, semen and blood. It can also be found in bones, teeth, hair and nails. An individual's DNA can be directly transferred onto a crime scene through their body fluids or skin cells. If an individual leaves traces of their skin cells on surfaces at crime scenes, this is known as touch DNA (or trace DNA) and although it is sometimes tricky, it is possible to obtain a DNA profile from these types of samples. Blood, semen and buccal cells on the other hand are good sources of DNA. Swabs used to collect buccal cells from the inside of the cheek are also good sample types and are non-invasive, and are therefore routinely used to collect reference samples from suspects and victims. DNA can also be isolated from bones, teeth and hair and this is very useful when identifying decomposed, skeletonized, dismembered and even burnt human remains.



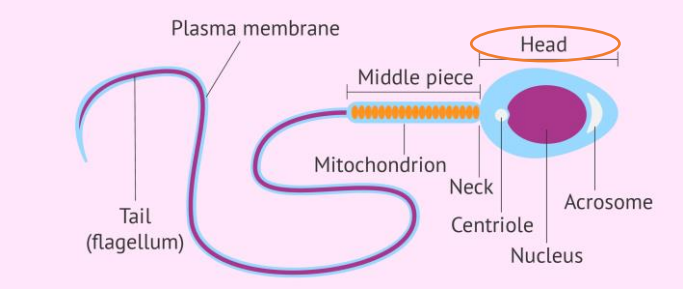
As I've mentioned before, if an individual leaves traces of their skin cells on surfaces at crime scenes, this is known as touch DNA (or trace DNA). Touch DNA can be found in a variety of locations, for example, you can find it from saliva left on the inside of an envelope, the inside of a face mask, fingerprints on a bottle or any surface which an individual has left traces of their skin cells, sweat or saliva. The cells that are useful to obtain a DNA profile are known as epithelial cells. These are cells that line the surfaces of your body and can be found on your skin and on the outer surfaces of blood vessels and organs in your body. Although it is very easy to transfer touch DNA, it is a bit more tricky to obtain a DNA profile from it, as it is easily contaminated due to the limited quantity of DNA present in touch DNA evidence. DNA profiles from touch DNA are often mixtures and the DNA recovered from the touch DNA evidence may not be from the last person who has touch that evidence item. In this case, it is important to take into account the DNA profiles of crime scene personnel, police officers, lawful owners of the property, as these will assist in resolving mixed DNA profiles that are obtained from touch DNA evidence.



Blood is a complex mixture of cells, enzymes, proteins and inorganic substances. It is composed of plasma, which is the liquid suspension, red blood cells, which carry oxygen, white blood cells, which fights diseases and platelets, that are involved in blood clotting. The component we are most interested in is the white blood cells, as they are a rich source of DNA. There is no DNA in red blood cells or platelets. Common blood samples found on crime scenes are blood spots and blood spatter. Small dried blood spots provide good quality DNA because the cells in the blood have been fixed due to dehydration or drying.

Semen

- Sperm found in liquid semen, semen stain or vaginal swab samples.
- DNA found in the head of the sperm cell



Sperm cells are a rich source of DNA and can be found in liquid semen, a semen stain or a vaginal swab sample. The DNA is found in the head of the sperm cell where the nucleus is located. Sperm is extremely robust and is very difficult to get rid of in the lab and at a crime scene. It also binds well to cotton. After cotton underwear has been washed, it is still possible to obtain intact sperm.

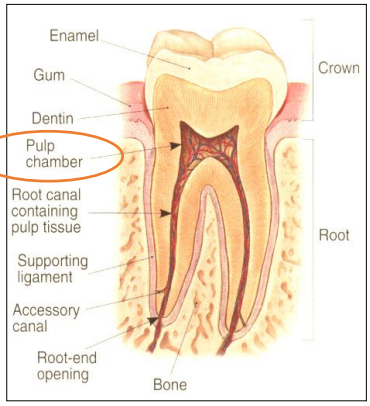
Bone

- No consensus for "best" bone
- Difficult to extract
- High calcium content
- Important in identification of human remains

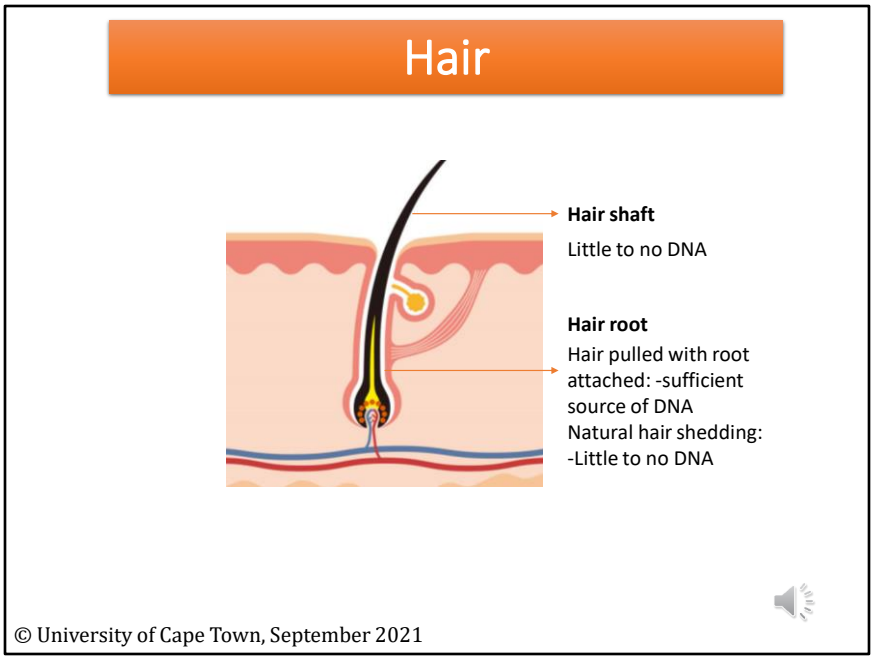
It is also possible to obtain a DNA profile from a bone sample. It should be noted that there is no consensus for which bone would be the most preferrable source of DNA. Different bones will give you different quantities and quality ranges of DNA. It is often difficult to extract DNA from bone due to the high calcium content. The ability to obtain DNA from bone is particularly useful in human identification, where remains have been decomposed or burnt to the point of skeletonization.

Teeth

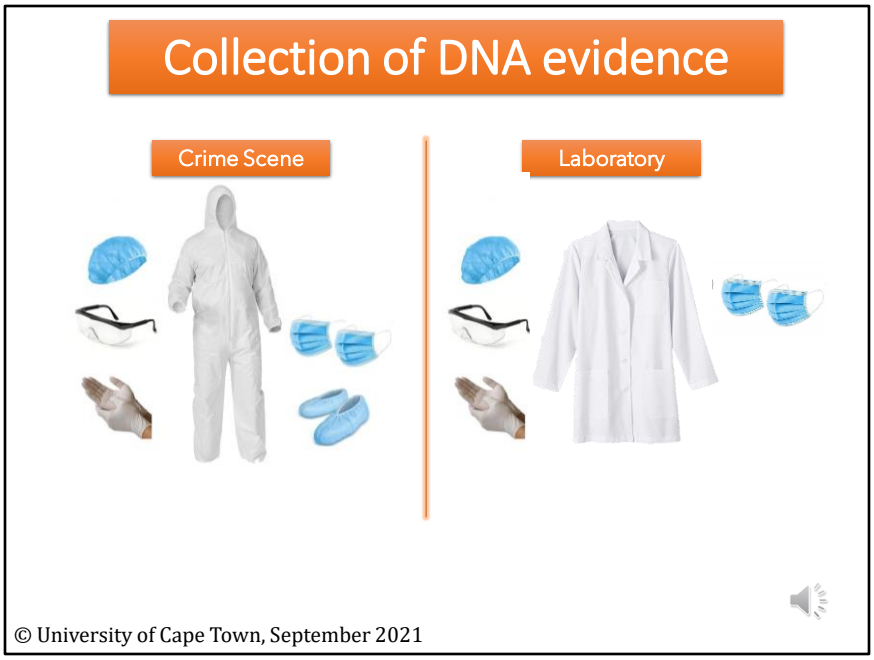
Pulp: Good source of DNA within tooth



It is also possible to obtain a DNA profile from teeth. The pulp, as seen in the image, is usually a good source of DNA within the tooth, as it is well protected.



If hair samples still contain the root, it may be possible to obtain a DNA profile from it, as there is nuclear DNA present in the root of the hair, as some tissue from the hair follicle may be present. Hair is composed of the root and the shaft. The root contains actively dividing cells, therefore it is a sufficient source of DNA. The shaft contains dead cells, and very little DNA is present here. There are challenges associated with obtaining DNA from hair, as it goes through something called a hair cycle. Each stage of the hair cycle will provide us with different amounts of DNA. If the hair is pulled out with the root still attached, it will most likely be in the first phase of the hair cycle, and contain active cells which will be sufficient for obtaining DNA. If the source of the hair is from a brush, or is hair that falls out, it will most likely be in the later stages of the hair cycle, with less active cells and will most likely be insufficient for DNA analysis.



Now that we have covered different sources of DNA evidence, let's move on to some aspects regarding the collection of DNA evidence. The most important aspect to consider when collecting DNA evidence is to maintain the integrity of the evidence, which includes preventing contamination. To do this, full personal protective equipment should be worn. At the crime scene, the PPE on the left is appropriate. This ensures that the hands, head, face, shoes and entire body is covered. This reduces the shedding of skin cells, sweat and hair onto the crime scene. It is also good practice for investigators to wear two pairs of gloves, called double-gloving, and to replace the outer pair of gloves between collection of each evidence item to prevent cross contamination. The mere spraying ethanol on gloves might sterilize the gloves but will not remove DNA. In fact, ethanol is a chemical that used in the DNA extraction process so spraying gloves with ethanol will not prevent cross-contamination of evidence. In the laboratory, the PPE on the right is appropriate of DNA analyses. I hope this has given you a broader overview of DNA evidence and how it fits in the crime scene to courtroom workflow. I look forward to explaining more about identification of body fluids and DNA analyses in later lectures.


Voice over: Donna-Lee Martin
Slide design: Donna-Lee Martin, Dr Laura Heathfield
CRIME SCENE DO NOT CROSS
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