


Lecture 3: Types of Evidence

Summer 2026

Learning objectives



🔍 Define the probative value of evidence and prejudicial effect

🔍 Explain the difference between a presumptive and confirmatory forensic test

🔍 Define and describe the two main categories of evidence

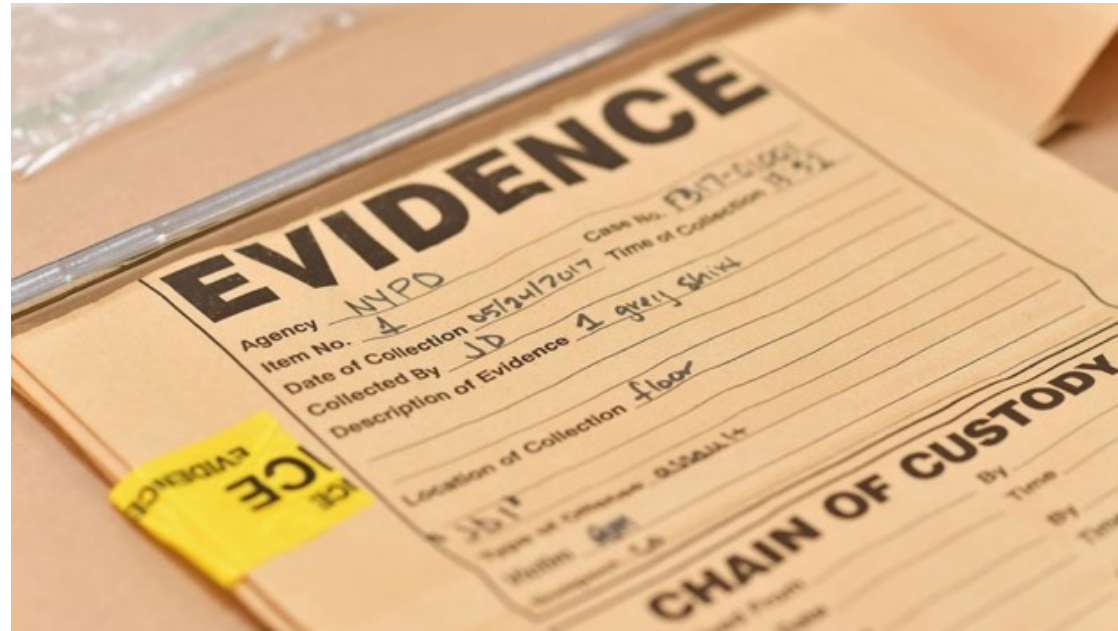
🔍 Calculate the number of suspects based on class evidence

🔍 Explain which types of evidence have the potential to carry DNA

🔍 Rate evidence by its discriminatory power

Evidence is information

- Evidence is at the heart of every investigation
- Understanding the potential sources, types and uses is important
- Used to make a case against a suspect
- As forensic scientists, we need to know about different types of evidence and how they can be used



The four rules of evidence

Evidence must be...

1. Relevant

- Locally relevant (supports a material fact)
- Legally relevant (cost/benefit)

2. Material

- Contributes to proving a fact

3. Admissible

- Not prohibited due to exclusionary rules

4. Probative and not prejudicial

Probative value vs. prejudicial effect

- Probative value:
 - The **weight** put on evidence (not the admissibility)
 - Includes reliability of the evidence
- Prejudicial effect
 - Evidence that creates unfairness/distraction/confusion
 - Prejudicial effect may outweigh the probative value – exclusion of evidence

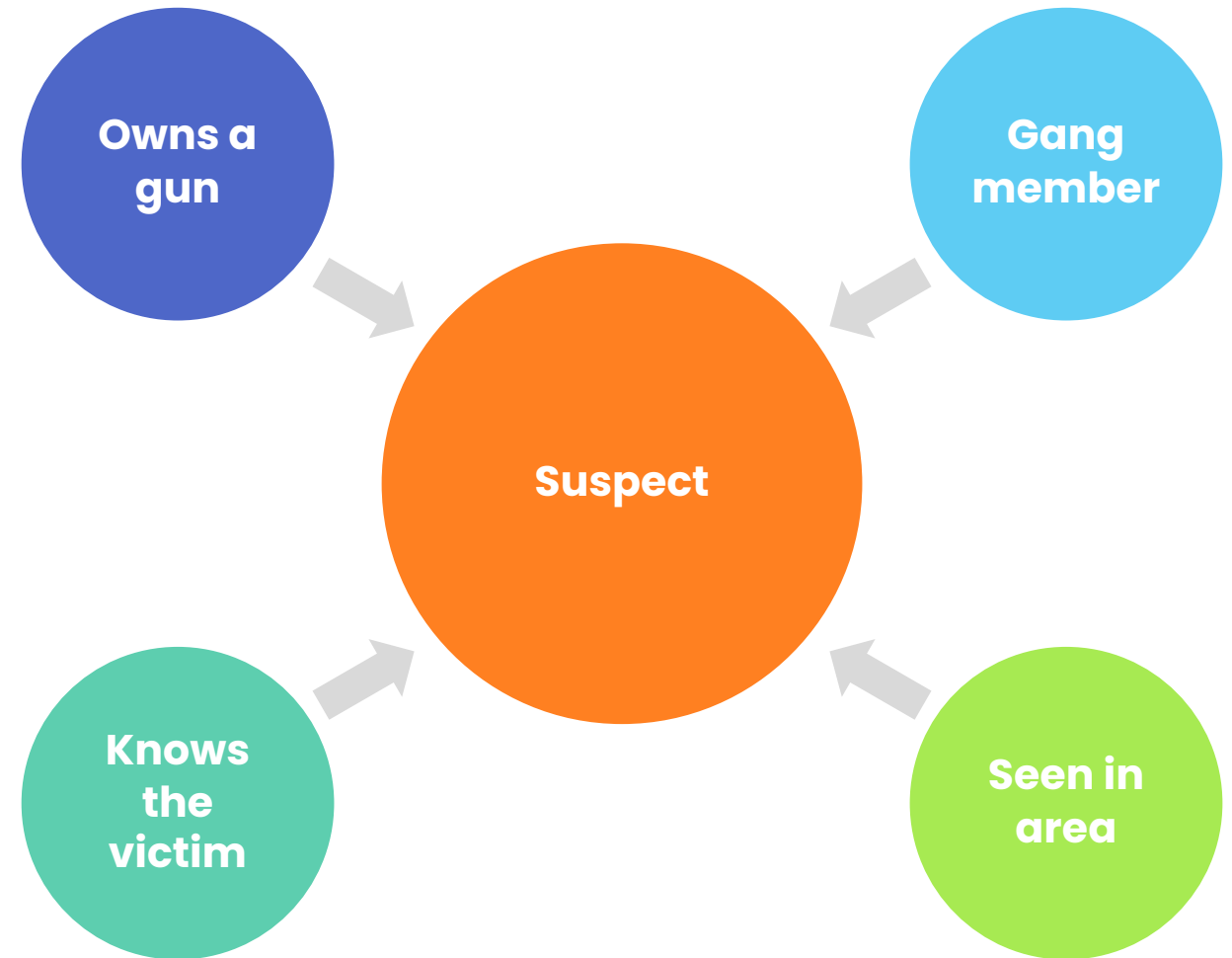
Example: probative vs. prejudicial evidence

Scenario

A man was shot to death randomly outside of a Tim Hortons at approximately 2.43 am on Saturday 8th February 2020.

Evidence was collected and proper chain of custody was established.

Which of the evidence holds probative value, and which may be prejudicial?



Categories of evidence



DIRECT EVIDENCE

Requires no reasoning or inference to arrive at a conclusion based on the evidence.



INDIRECT EVIDENCE

Circumstantial evidence that requires an amount of inference for a conclusion to be drawn.

Direct vs. indirect evidence: did it rain?



“I saw that it was raining.”

“I went outside and the ground was wet.”

“My friend told me it was raining.”

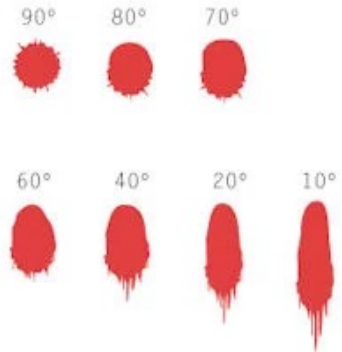
Biological evidence

- The most common and useful type of evidence at crime scenes
- Can be either secreted or excreted
- Most biological evidence found at crime scenes have the potential to contain DNA

Secreted	Excreted
Blood	Sweat
Semen	Faeces
Saliva	Vomit
Serum	Breast milk
Urine	Earwax

Blood

- Violent crimes typically leave behind a lot of blood
- Excellent source of DNA material
- Victim's blood and often suspect's blood is left behind
- Blood spatter can be used to tell the narrative of the crime

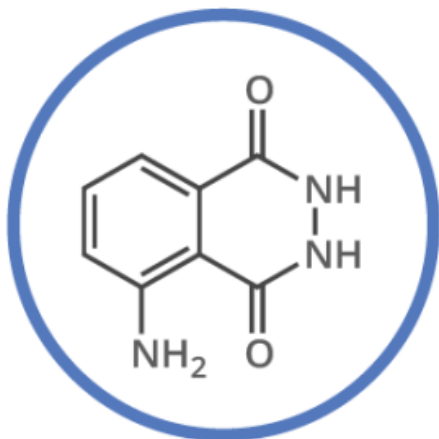


Blood

- Can be detected even if the suspect has tried to clean it up
- Blood does not fluoresce by without the addition of chemicals, e.g. luminol, fluorescene, BlueStar
- Alternate light source (UV) will cause blood traces to fluoresce with the addition of chemicals



CRIME SCENE CHEMISTRY – LUMINOL



WHAT TRIGGERS LUMINOL'S CHEMILUMINESCENCE?



BLOOD



BLEACH



FAECES



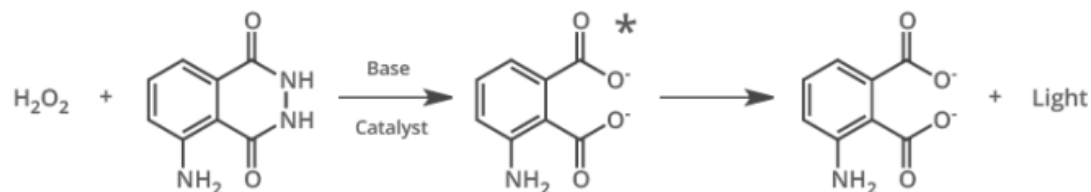
URINE



HORSERADISH

The reaction that triggers luminol's chemiluminescence has to be catalysed. The iron in blood can carry out this role, but luminol can also be oxidised by bleach to achieve the same effect. Enzymes in faeces and horseradish can also help trigger the reaction.

HOW DOES LUMINOL REACT TO PRODUCE LIGHT?



Luminol solution also contains an oxidising agent, such as hydrogen peroxide, and a base. In the presence of a catalyst, the reaction produces energy, promoting electrons in the product to higher energy levels, before they fall back down and release their excess energy as light.

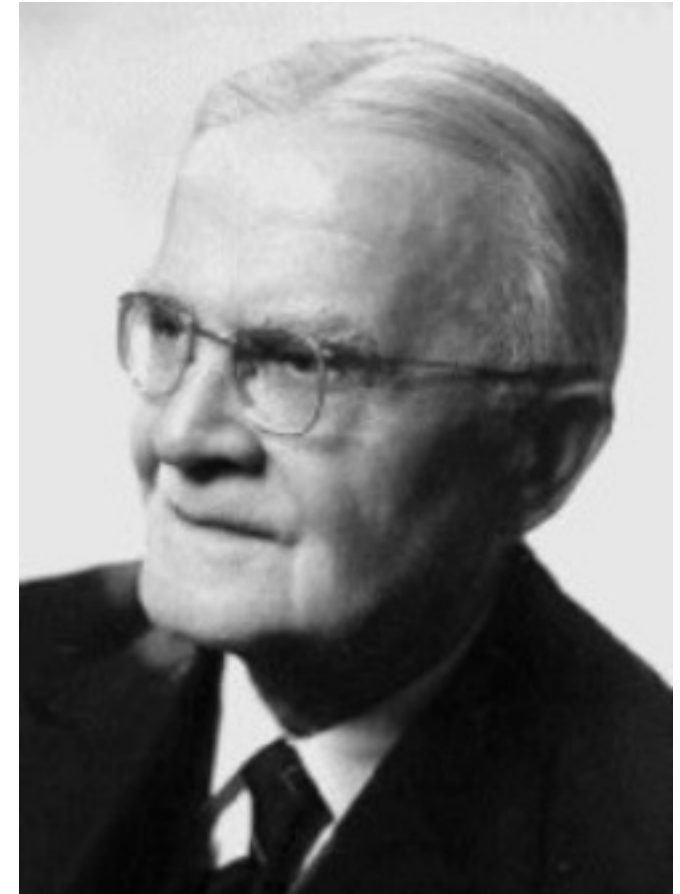


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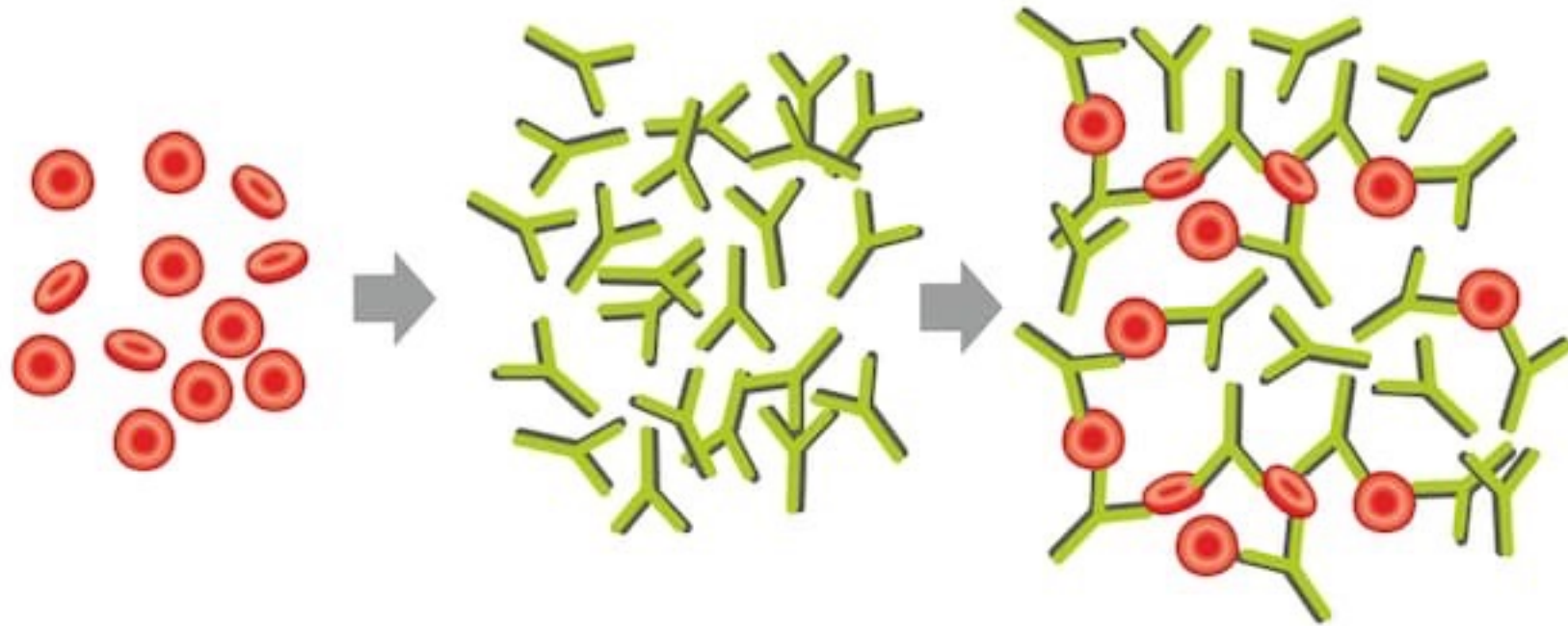
Determining the source of blood

- 1900: scientists determined that animals injected with diphtheria toxin developed a defensive substance in the blood
- Paul Uhlenhuth injected hen's blood into a rabbit, then took serum from the rabbit and mixed it with egg white
- Antibodies in the serum bound to the antigens (proteins) in the egg white to form an insoluble complex – a **precipitin**
- This formed the basis of the **precipitin assay**



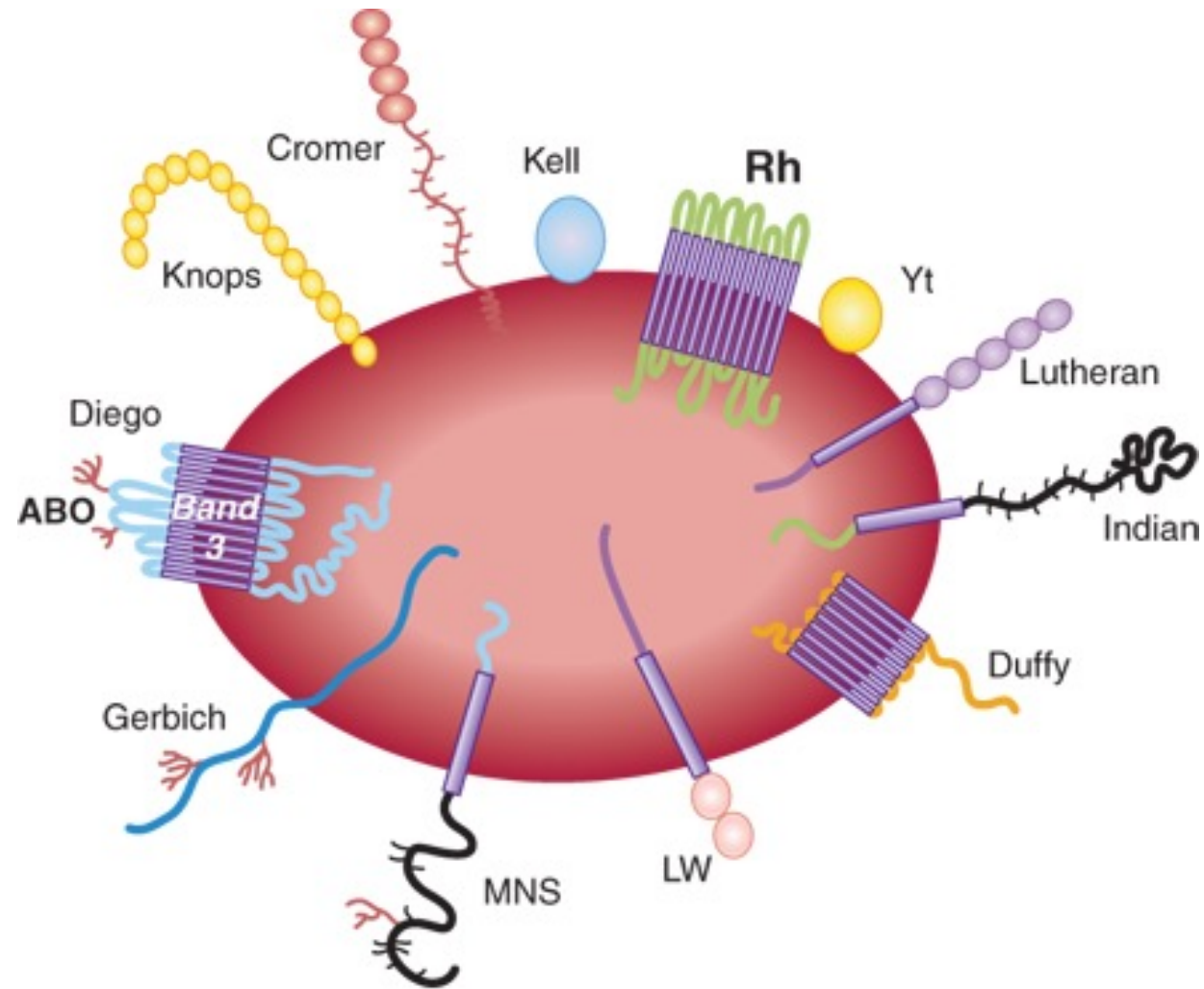
Agglutination

- When antigens and antibodies interact, **agglutination** occurs
- If the antigens are present on cell surfaces, it causes the cells to clump together
- This is the basis of the precipitin assay and modern blood typing methodology



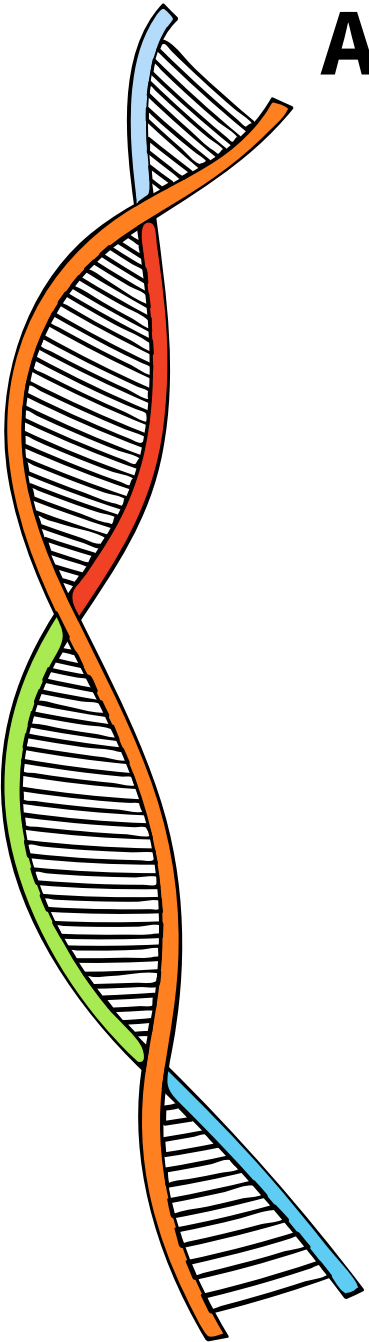
Blood typing

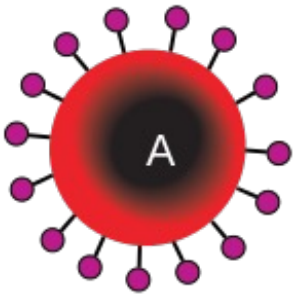
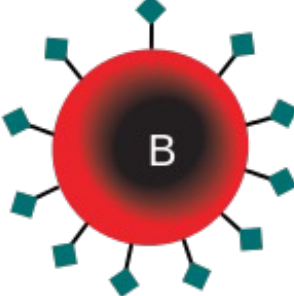
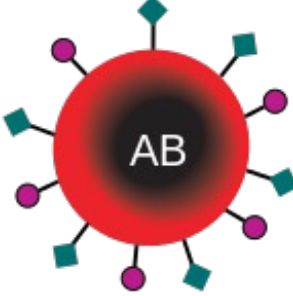
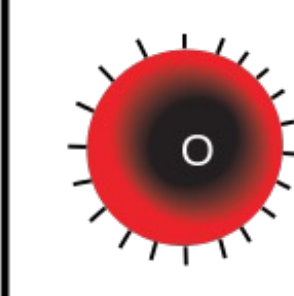


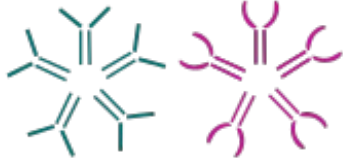



- A blood group or blood type is based on the presence or absence of inherited antigenic substances on the surface of red blood cells.
- These antigens can be proteins, carbohydrates, glycoproteins or glycolipids.
- Other markers present too, not shown here.



Source: H. Franklin Bunn, Jon C. Aster: Pathophysiology of Blood Disorders
www.accessmedicine.com
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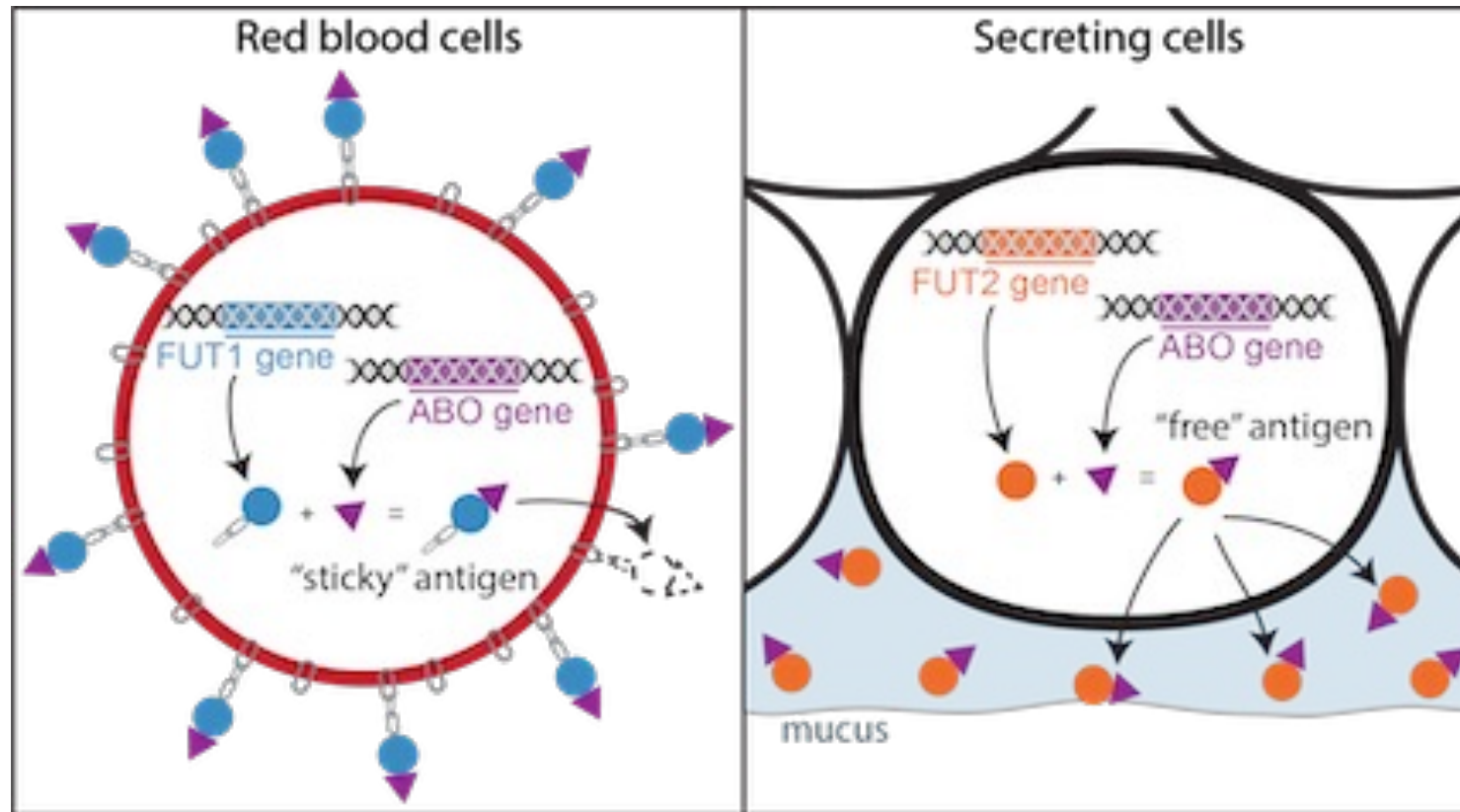
ABO system



	Group A	Group B	Group AB	Group O
Red blood cell type	 <p>A</p>	 <p>B</p>	 <p>AB</p>	 <p>O</p>
Antibodies in Plasma	 <p>Anti-B</p>	 <p>Anti-A</p>	<p>None</p>	 <p>Anti-A and Anti-B</p>
Antigens in Red Blood Cell	 <p>A antigen</p>	 <p>B antigen</p>	 <p>A and B antigens</p>	<p>None</p>

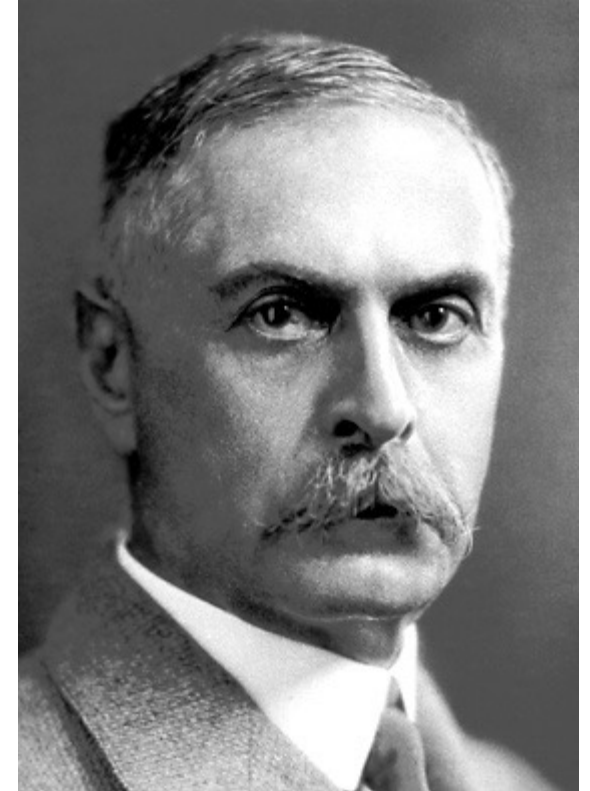
Secretors

- 80% of Caucasians have a secretor phenotype – A/B antigens are secreted into bodily fluids by other cells




Rh system











- 1937: Karl Landsteiner made another discovery about blood antigens
- Originally discovered in Rhesus monkeys – hence the name
- Serum from women who reported hemolytic newborn disease and transfusion reaction reacted with over 80% of blood from ABO-matched controls
- Of the 49 antigens in the Rh group, D is the most important
- Rh antibodies develop only upon exposure to Rh antigens



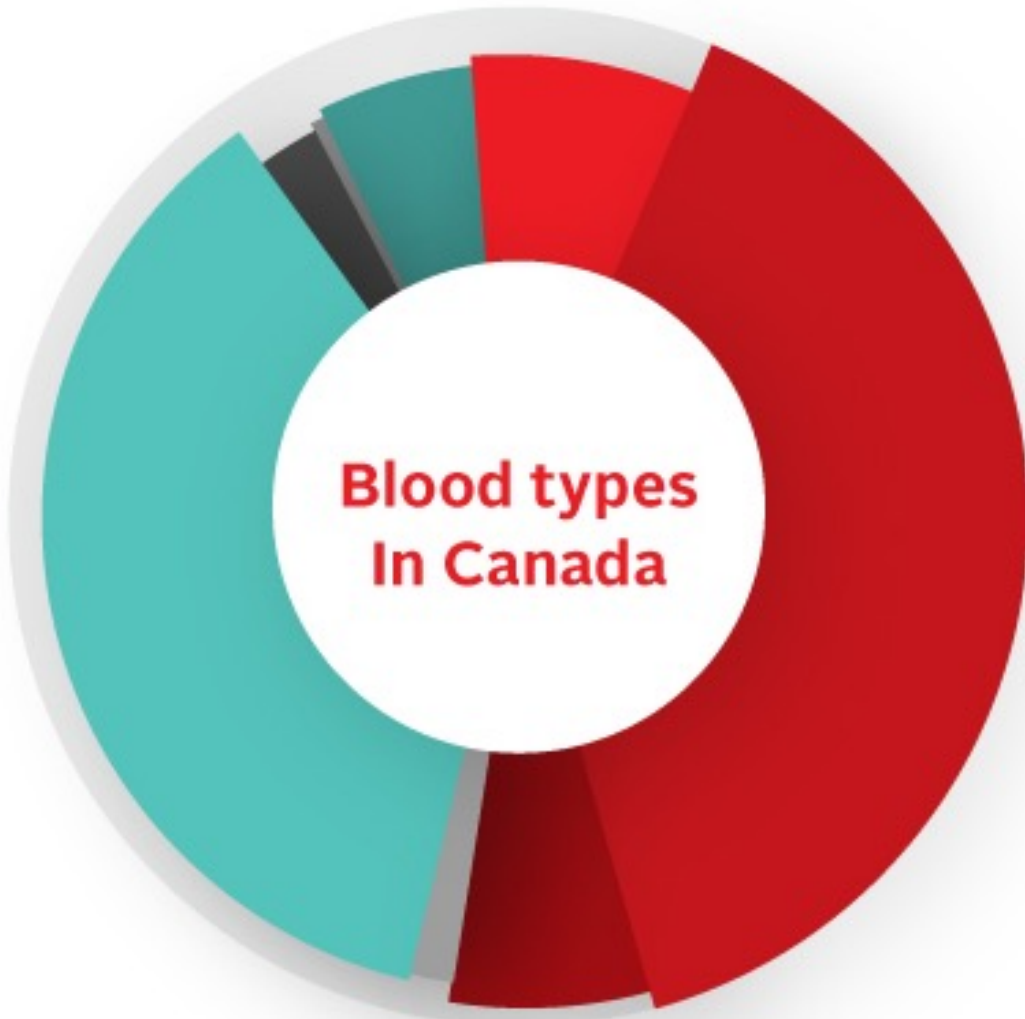
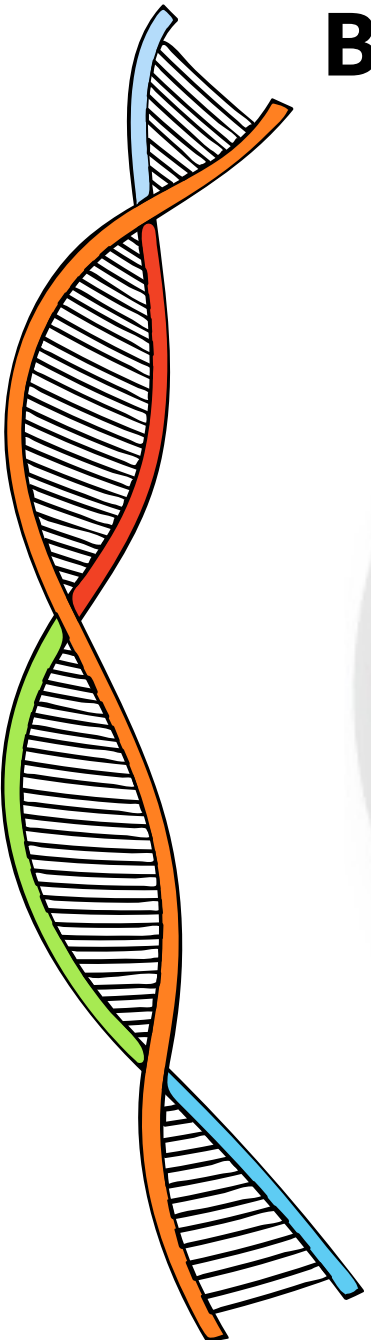
Nobel prize in Physiology or Medicine in 1930









Rh system



	A -	A +	B -	B +
Red blood cells				
Antigens present	 A antigen	 A antigen  Rh antigen	 B antigen	 B antigen  Rh antigen

Blood types in Canada



 A+ 36%	 B+ 7.6%
 A- 6%	 B- 1.4%
 O- 7%	 AB- 0.5%
 O+ 39%	 AB+ 2.5%

Excluding suspects based on blood type

Blood types can only be used to definitively **exclude** a suspect.

Evidence	Blood type
Crime scene	AB+
Victim	B-
Suspect 1	O
Suspect 2	A+
Suspect 3	A-

Who can we exclude?

Is this helpful?

What if we had no suspect?

Reducing the potential suspect pool

- 36% of Canadians have A+ blood (13M!)
- Is this specific enough?
- Adding more RBC markers will reduce the pool of potential suspects

Marker	Frequency
A+	36%
EAP	25%
GPT	15%
PGM	6%

Probability of finding two people with this blood type is very small:

$$0.36 * 0.25 * 0.15 * 0.06 = 0.00081$$

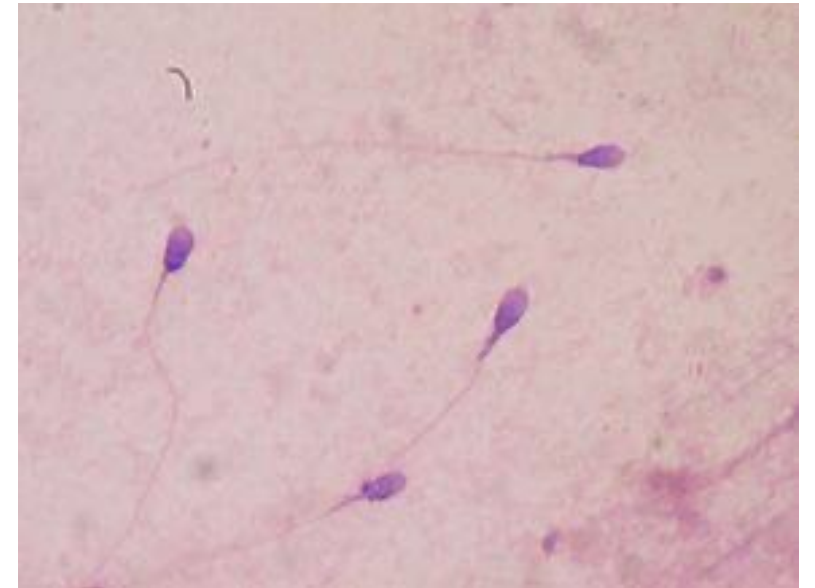
Reducing the potential suspect pool

- If you found someone with the same blood type, given that there is an 0.00081 chance of finding two people with the same type, would you be convinced?
- Juries often are.

$0.00081 * 37.59M = 3,044$ potential matches to the same blood type in the Canadian population!

Semen

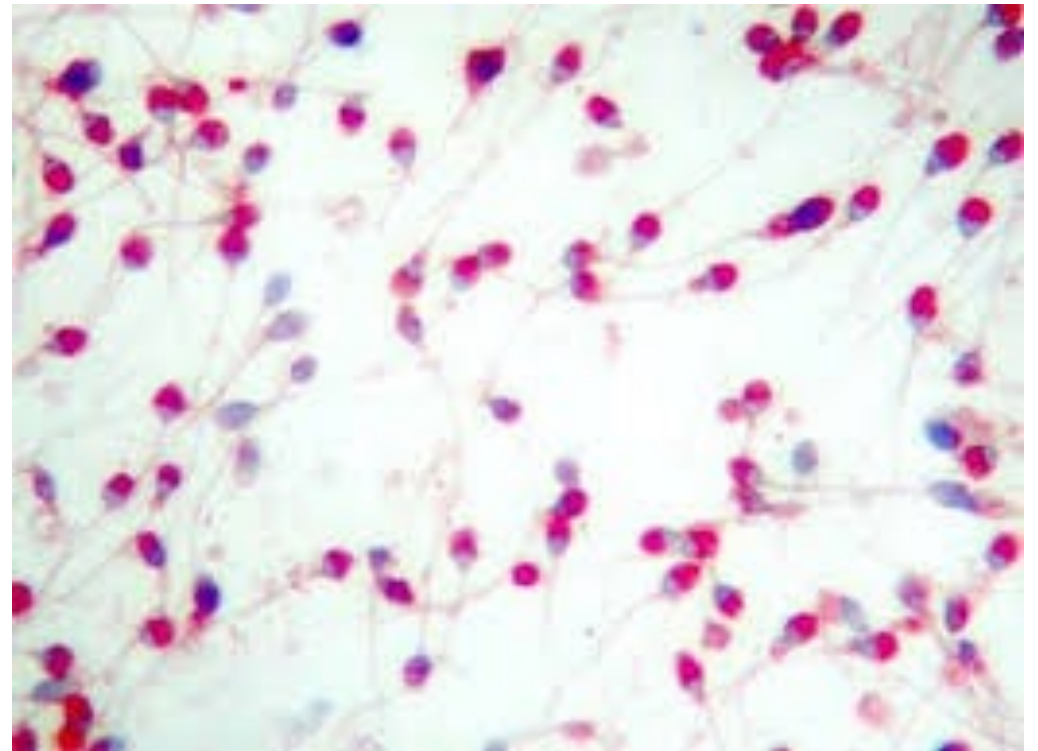
- Semen is extremely important evidence in cases involving sexual assault
- Contains sperm + seminal fluid (enzymes, plasma, fructose, mucus, etc)
- Can be tested for on clothes or surfaces and as part of a rape kit
- Two types of testing:
 - Presumptive
 - Confirmatory
- High amounts of DNA available if sperm are present
 - What if the perpetrator had a vasectomy?



Confirmatory testing for semen

Christmas tree stain

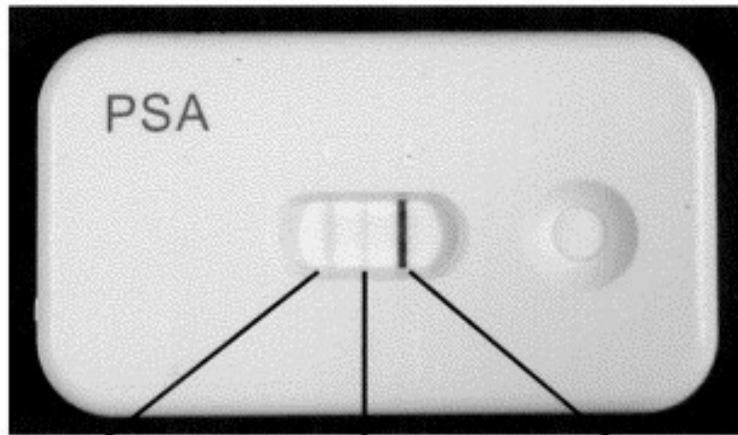
- Head of sperm are stained red using nuclear fast red reagent
- (Intact) tails are stained green with a green stain reagent
- Visualised under a microscope



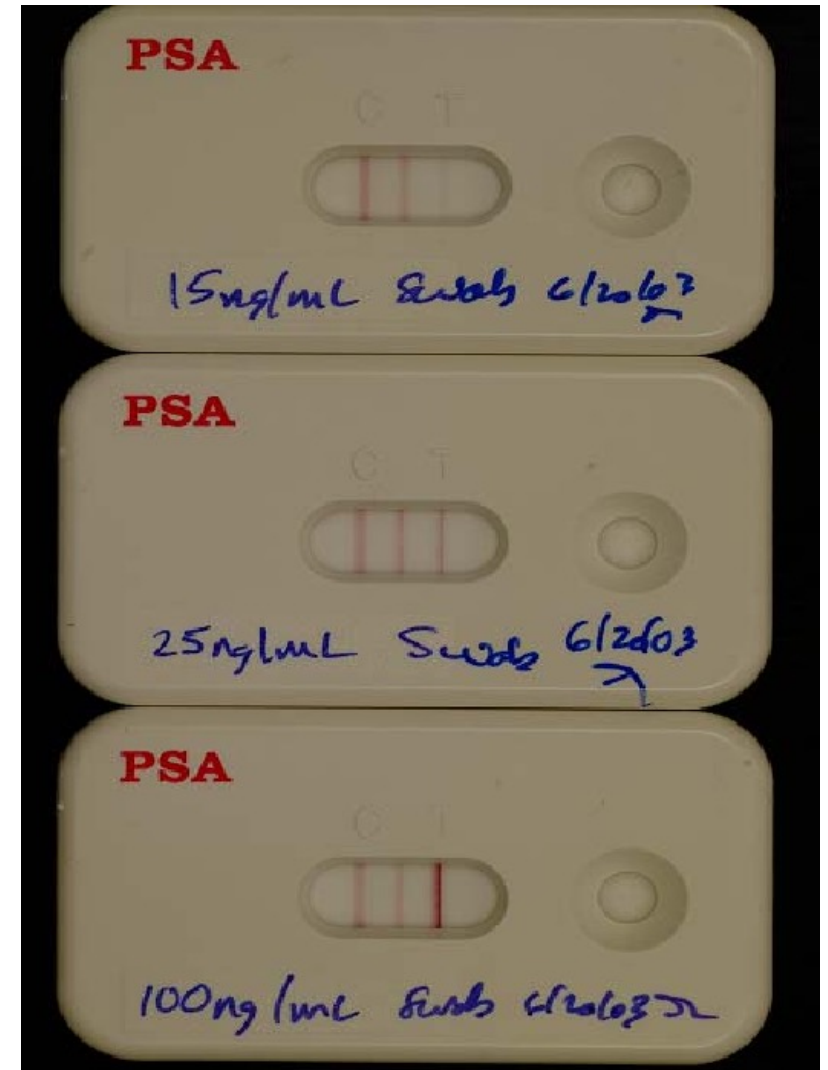
Presumptive testing for semen

Prostate Specific Antigen (PSA)

- Secreted by the prostate into the seminal fluid
- Used when sperm are not present



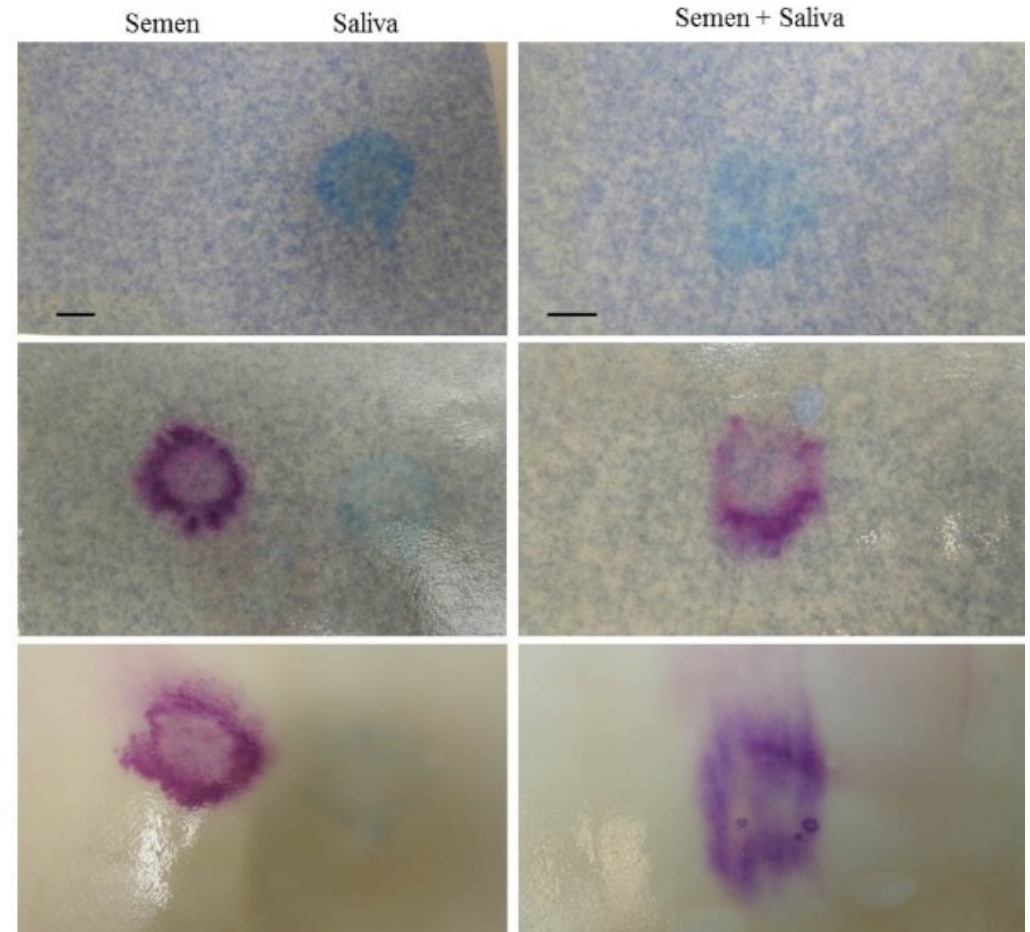
Control region Internal standard Test region



Presumptive testing for semen

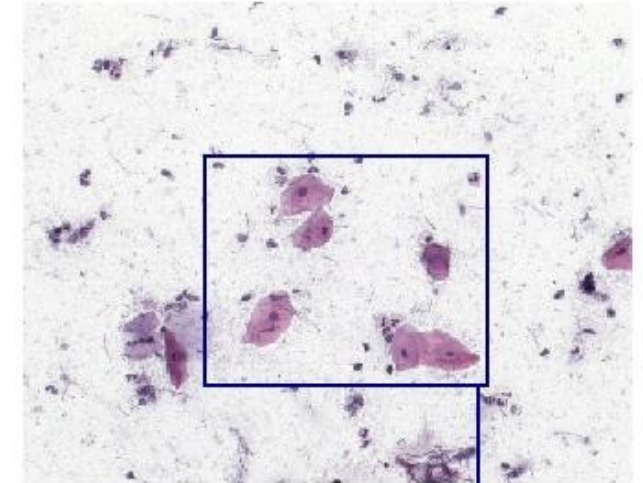
Acid phosphatase

- Present in seminal fluid
- Can be identified using a chemical reaction
- Takes 30s – 3 minutes to develop
- Purple colour change means that it is reasonable to accept that the test sample contains semen

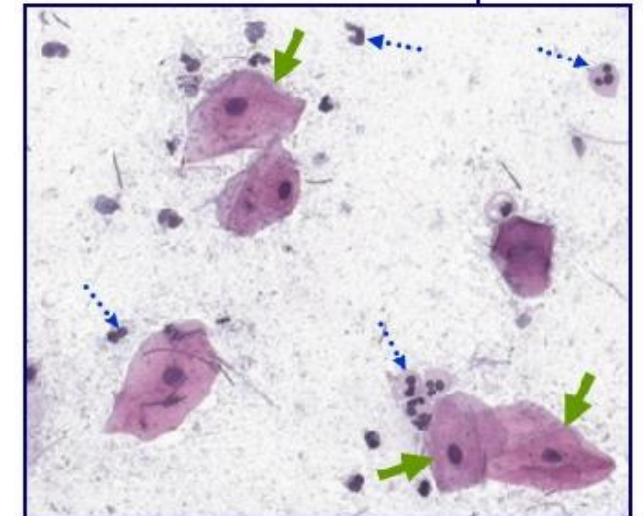


Saliva

- Chances are, anything you put to your mouth will come away with saliva on it
- Saliva is secreted from the parotid, sublingual and submandibular glands in the mouth
- Contains a high level of amylase which is the basis for saliva testing
- Excellent source of DNA due to the presence of buccal cells and white blood cells



Smear of saliva stained with H&E at 200X magnification to demonstrate cell distribution

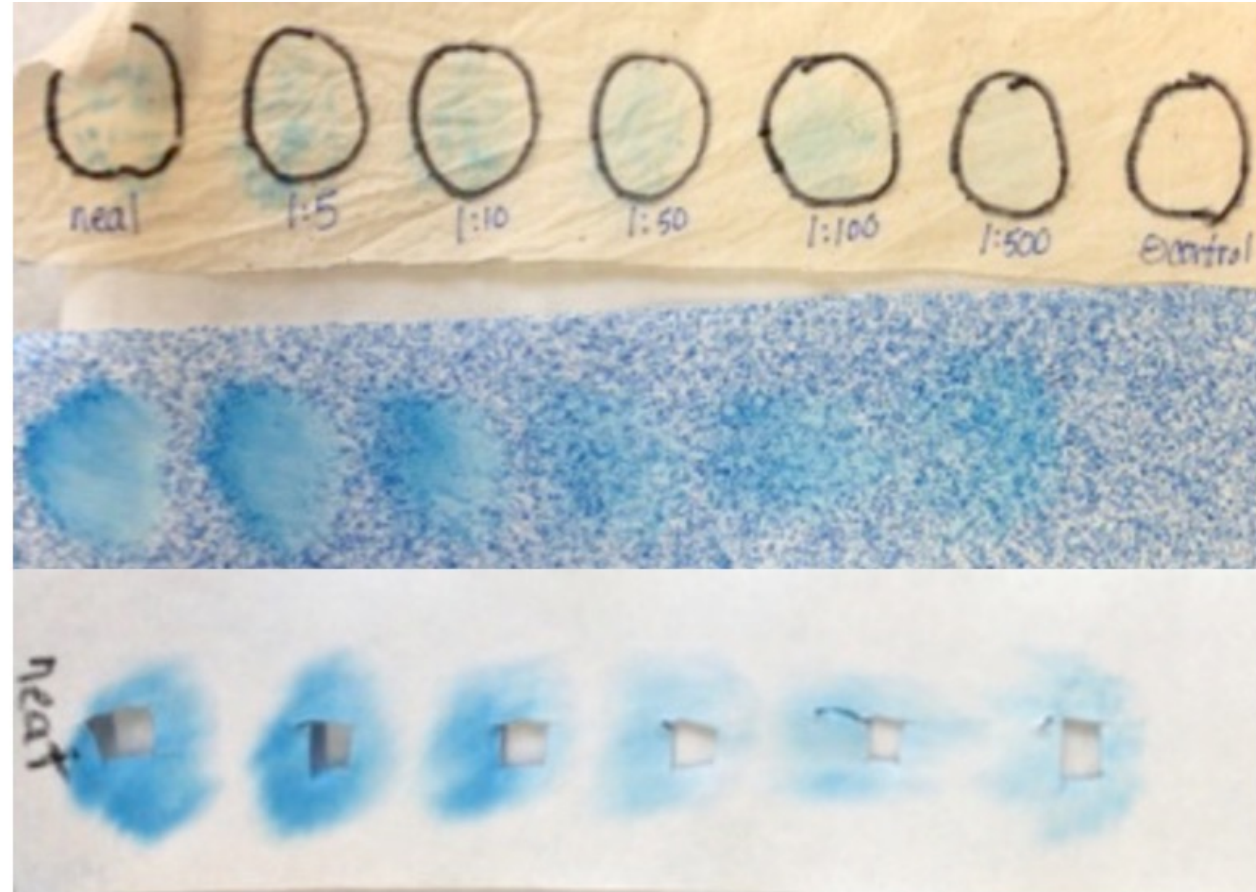


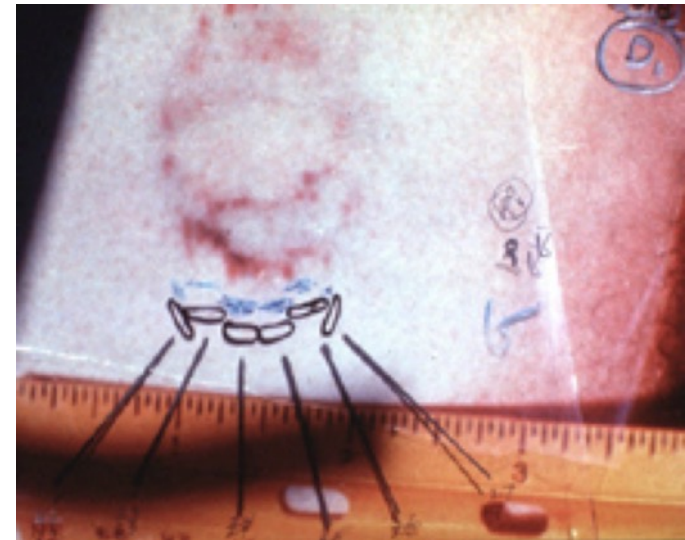
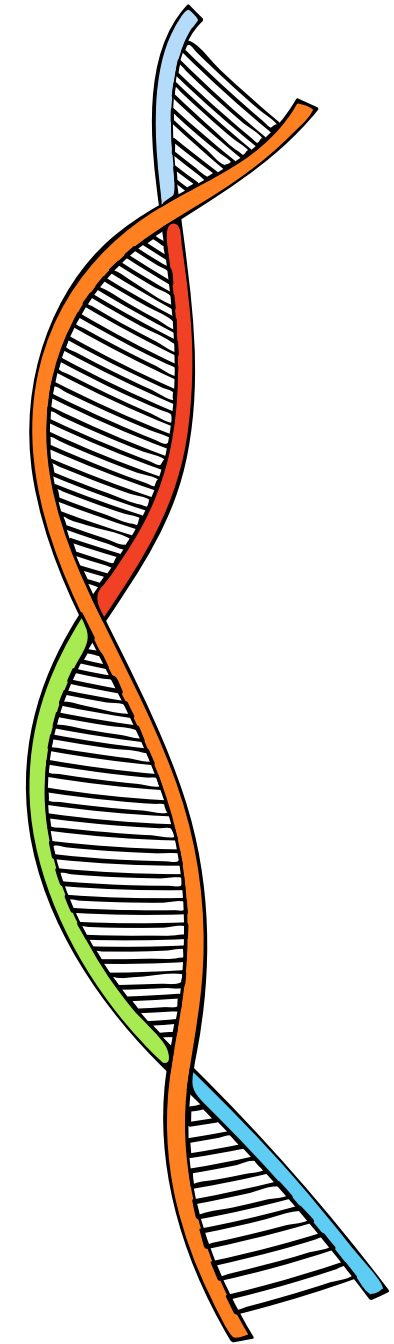
▲ Examples of white blood cells ▲ Examples of buccal epithelial cells

Further enhanced portion of the previous image to demonstrate examples of white blood cells and buccal epithelial cells within the smear.

Saliva - presumptive testing

- Phadebas test – reacts with amylases in saliva





Murder of Sherri Rasmussen

- In 1986, 28-year-old Sherri Rasmussen was found dead in her Van Nuys apartment
- Beaten and shot three times
- Signs of a struggle
- Bite mark on forearm from which a swab was used to collect evidence
- Case quickly became cold when the police considered it a burglary gone wrong by a local gang



Murder of Sherri Rasmussen

- LAPD formed a cold case department in the late 1990s
- Even still, the swab wasn't tested until 2004!
- No sample to compare to, but testing determined the source was female
- Detective found that Rasmussen's file described continued harassment of the victim by a "third-party female"
- However, no one wanted to pursue the case as the third-party was a former LAPD detective who used to date Rasmussen's husband

Murder of Sherri Rasmussen

- Case reopened AGAIN in 2009
- 5 suspects identified, including Stephanie Lazarus, a high-level LAPD detective
- Police collected DNA from saliva from a cup that Lazarus discarded
- Lazarus was arrested in 2009
- Convicted after a 3-week trial in 2012



Urine

- Urine can often be found at crime scenes involving burglary or sexual assault
- Not a great source of DNA – not many cells shed in urine
- Quality of DNA from urine degrades more quickly than from other sources
- Presumptive tests used but there is no confirmatory test for urine



Presumptive tests for urine

- Urease test – tests for ureas
- Not human specific!



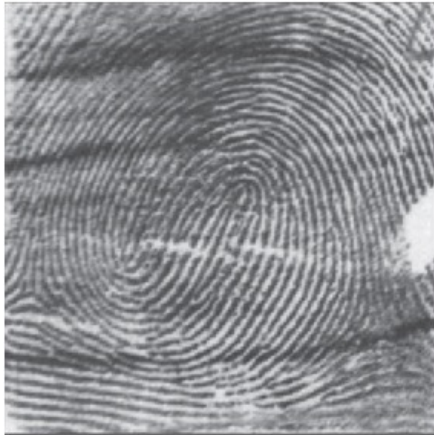
Physical evidence

- Physical items that can be used as part of an investigation
- All physical evidence has the potential to carry DNA (remember Locard's principle!)

“Every contact leaves a trace.”

Fingerprints

- Made up from a number of morphological features
- Each person has a unique set of fingerprints
- Considered one of the standard methods of identifying individuals



Fingerprints



ARCH



TENTARCH



RIGHT LOOP



LEFT LOOP



DOUBLE LOOP



RIGHT POCKET LOOP



LEFT POCKET LOOP



WHORL



MIXED FIGURE

Fingerprints – not just for solving crime

- Immigration
- Exams
- Security clearances
- RCMP background checks

Royal Canadian Mounted Police / Gendarmerie royale du Canada
1200 Vanier Parkway / 1200 promenade Vanier
Ottawa, Ontario / Ottawa (Ontario)
K1A 0R2 / K1A 0R2

Cur File / Notre référence: 1150540018380100
Reference Number / Numéro de référence: 382350

February 23, 2015 / Le 23 février 2015

WORLDWIDE FORENSIC SERV
55 TOWN CENTRE CT, SUITE 642
SCARBOROUGH ON M1P 4X4

Dear Sir / Madame: / Madame, Monsieur
This certifies that a search of the National Criminal Records repository maintained by the RCMP concerning the person whose fingerprints, name, and date of birth appear below could not be associated to any existing Criminal Record of conviction which may be disclosed in accordance with Federal Laws.
La présente atteste que la recherche effectuée au répertoire national des casiers judiciaires tenu à jour par la Gendarmerie royale du Canada (GRC) concernant la personne dont les empreintes digitales, le nom et date de naissance apparaissant ci-dessous n'a révélé l'existence d'aucun dossier ou relevé de condamnation qui peut être divulgué en vertu des lois fédérales.

Application Type / Genre de demande: Visa/Border Crossing/Foreign Travel/Work
Application Specifics / Détails sur la demande:
Date Fingerprinted / Date de prélèvement des empreintes: 2015-02-23

Applicant Full Name / Nom complet du demandeur: _____
Address / Adresse: _____
Date of Birth / Date de naissance: -11-18
Sex / Sexe: Male

Date Fingerprint Search Completed / Date de la recherche d'empreintes dactyloscopiques : 2015-02-23

THUMB - POUCE
Index
Right Thumb / Pouce droit
Right Index / Index droit
Photo
Left Thumb / Pouce gauche
Left Index / Index gauche

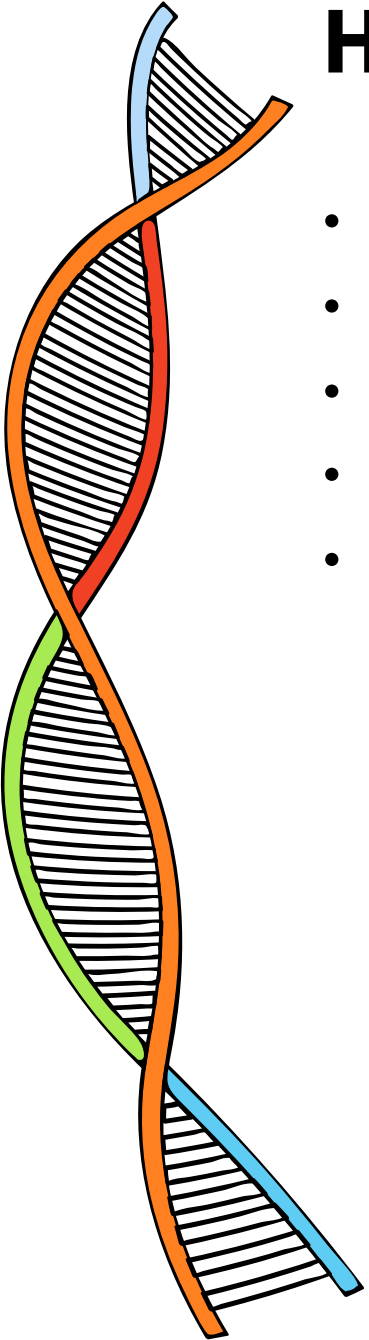
B. Heffernan
Director General / Directeur général
Canadian Criminal Real Time / Services canadiens d'identification
Identification Services / criminelle en temps réel

Note: The fingerprint form originally submitted to process this application has been destroyed. The provisions of the Privacy Act pertaining to access, collection, accuracy, completeness and amending records/data apply. This information is revised in P18.
Remarque: La formule dactyloscopique originale transmise aux fins du traitement de cette demande a été détruite. Les dispositions de la Loi sur la protection des renseignements personnels régissant l'accès aux renseignements, la collecte, l'exactitude, l'exhaustivité et la modification des données s'appliquent. Cette information se trouve dans les dossiers P18.

Canada
0913-08 RTD/IR 100-01 v1.3.2.13

Hair analysis

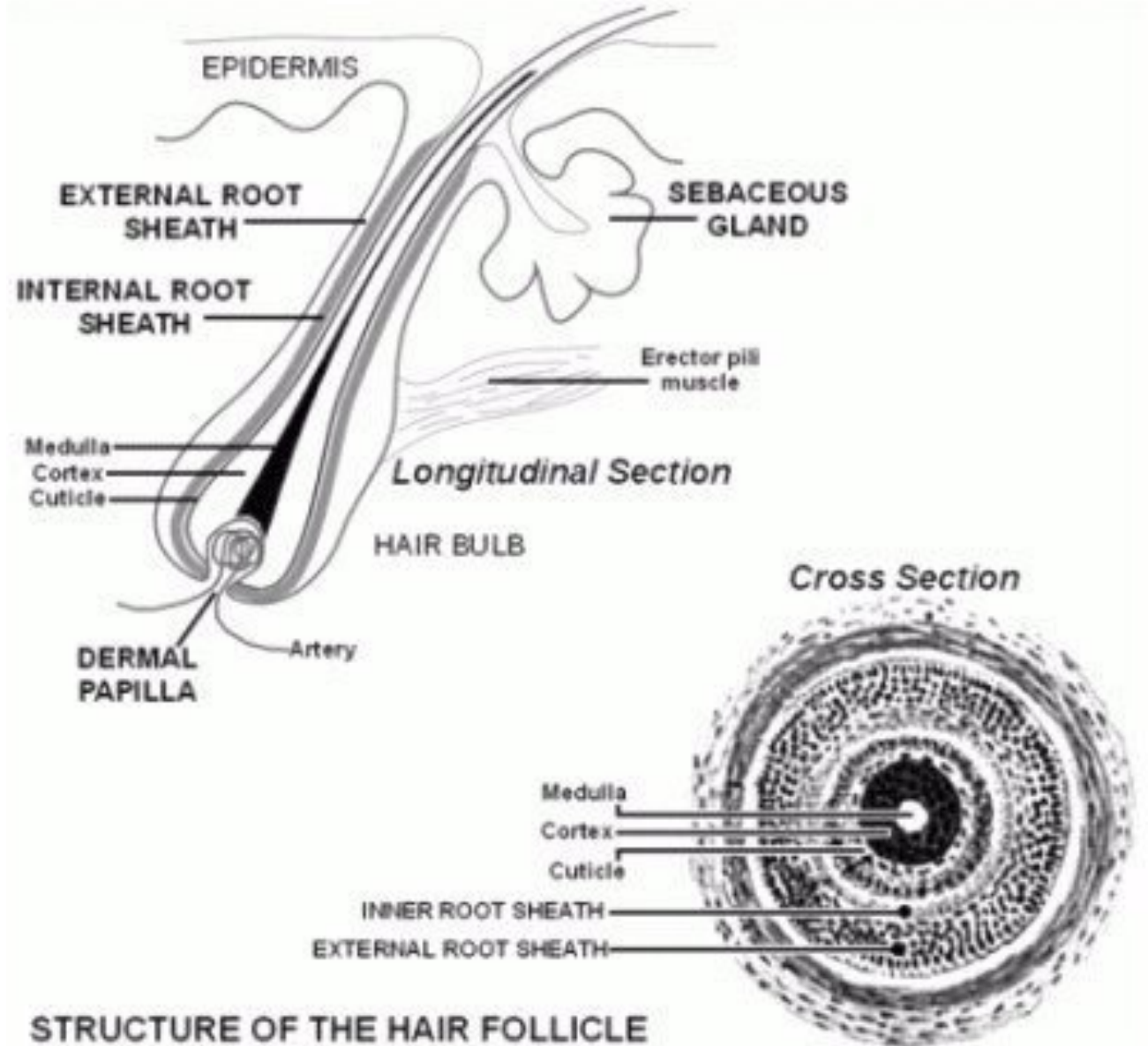
- The body is covered in hair that is in a constant cycle of shedding and regrowth
- Often left at a crime scene unknowingly
- Chemically stable and does not break down
- Can be used for comparison to a known sample
- Can be used for DNA evidence only if it is removed with the follicle intact (not shed or cut)



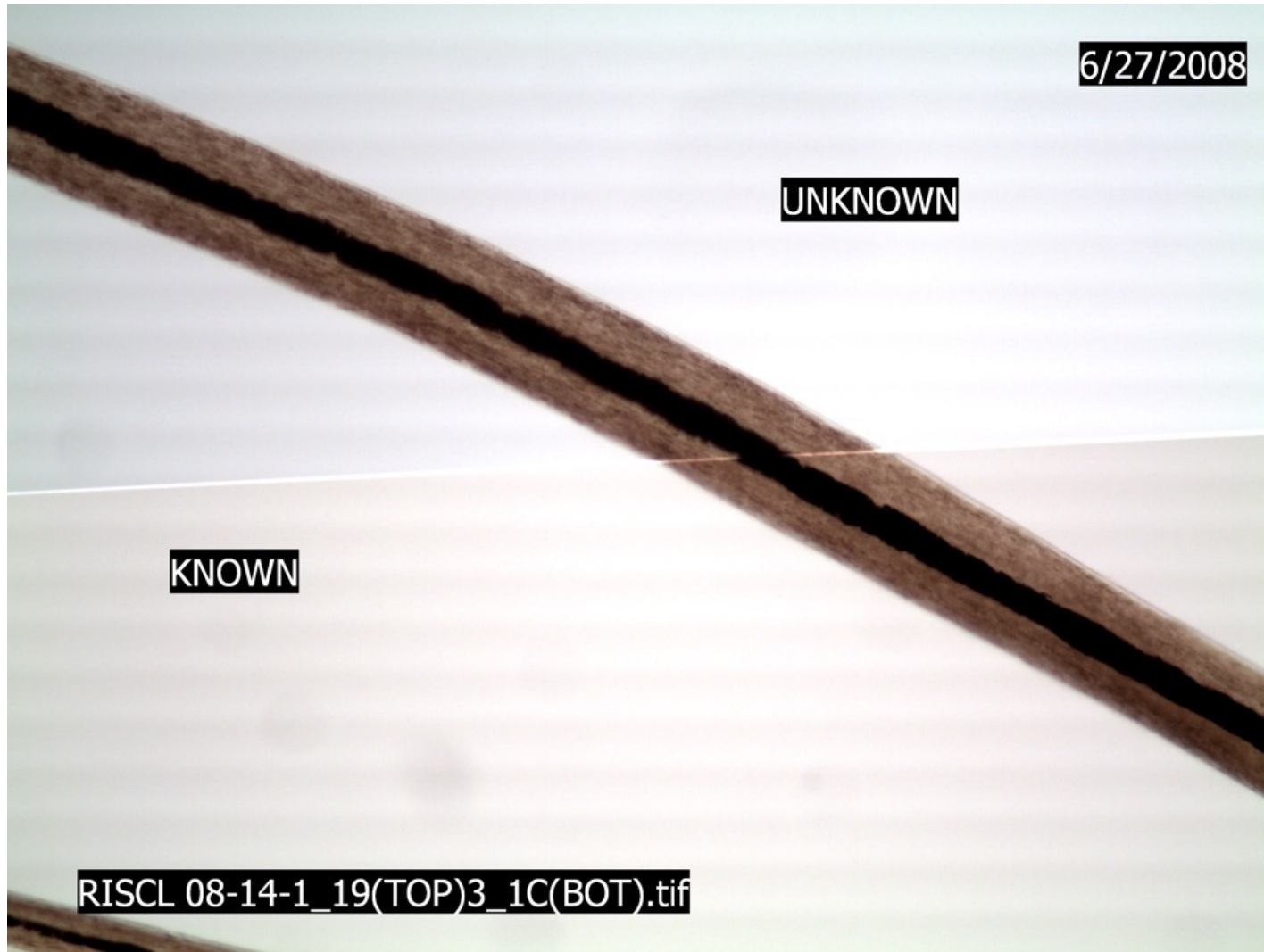
Hair analysis

3 phases of hair growth:

- Anagen (2-6 yrs)
- Catagen (2-3 wks)
- Telogen

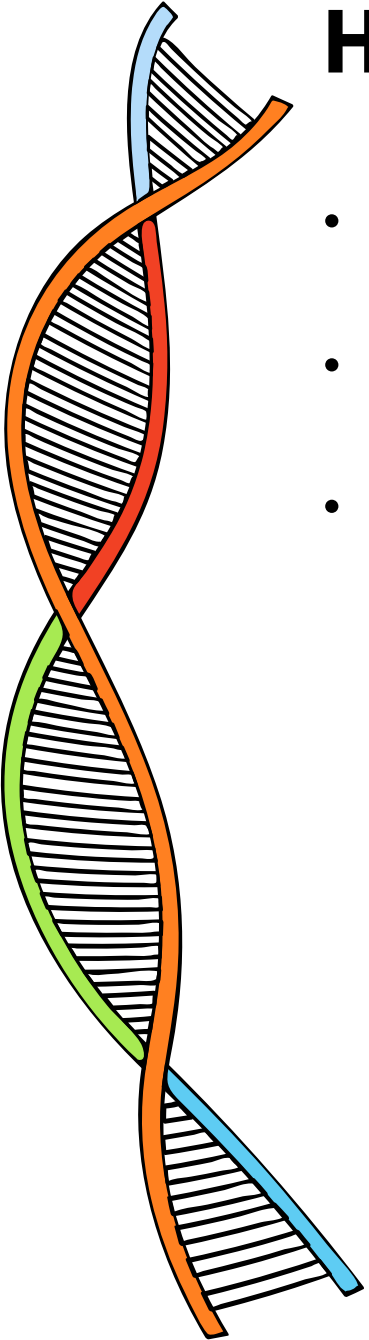


Hair analysis



Hair mineral analysis

- Hair is a permanent record of exposure to elements
- Trace elements are absorbed during growth
- Can provide an estimation of whether someone lived in a certain area and for how long



Fibres

- Found everywhere in the world
- Can be natural, synthetic or a blend

Natural

- Plant or animal based
- Rough in appearance

Synthetic

- Polymers of small molecules, e.g. petrochemicals
- Smooth in appearance

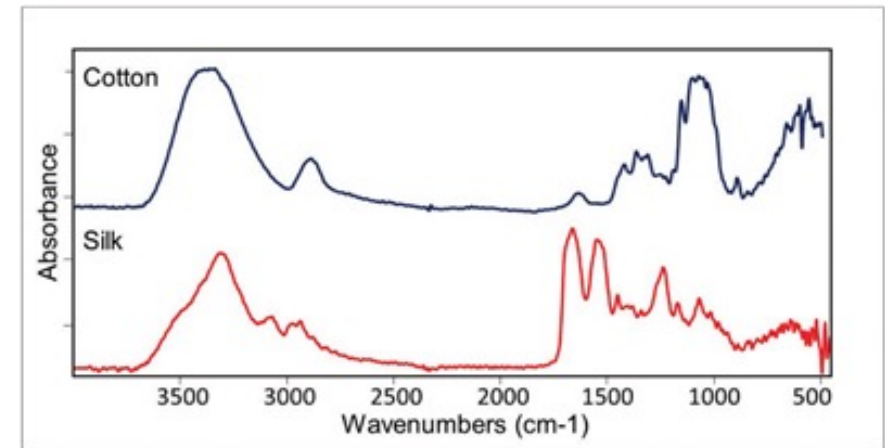


Fourier transform infrared spectroscopy (FITR)

“The likelihood of two or more manufacturers duplicating all aspects of the fabric type and color exactly is extremely remote.”

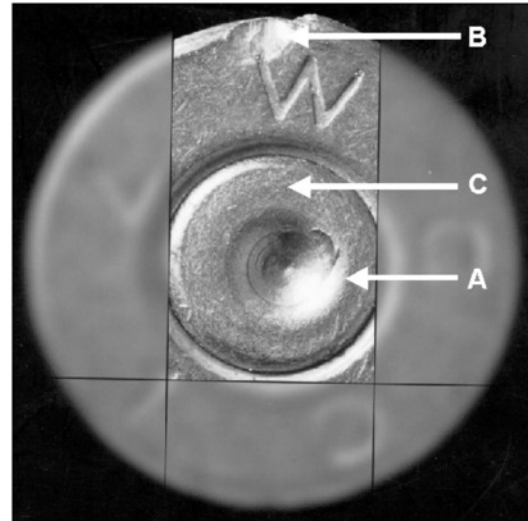
-- Douglas Deedrick, FBI

- Simple macroscopic comparisons are not suitable for textile fibres
- FITR used to measure the chemical composition of fibres



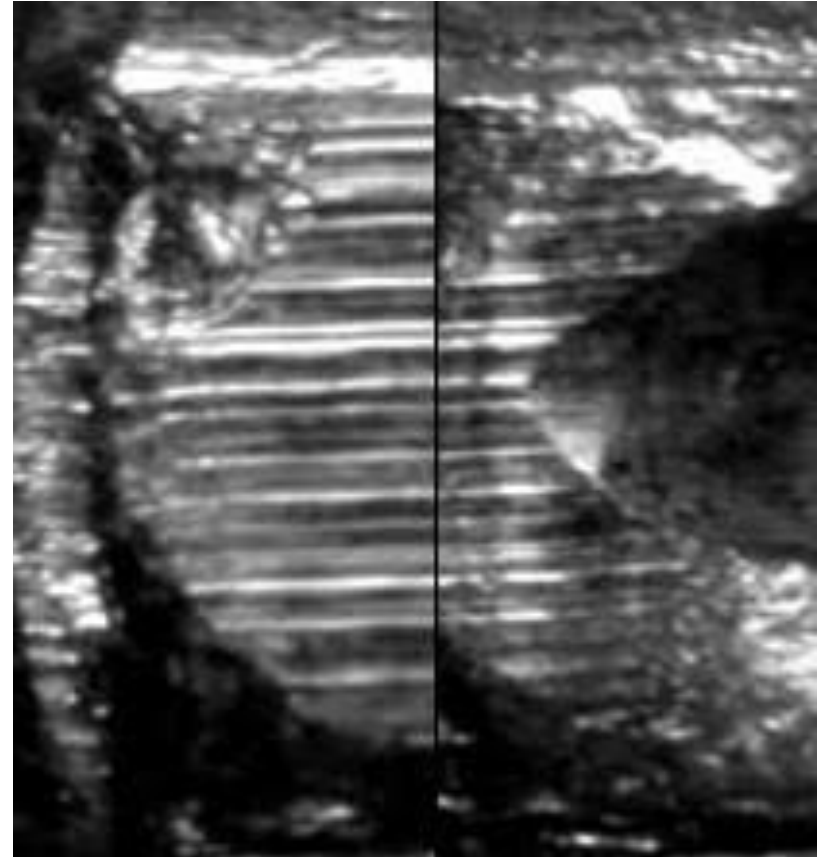
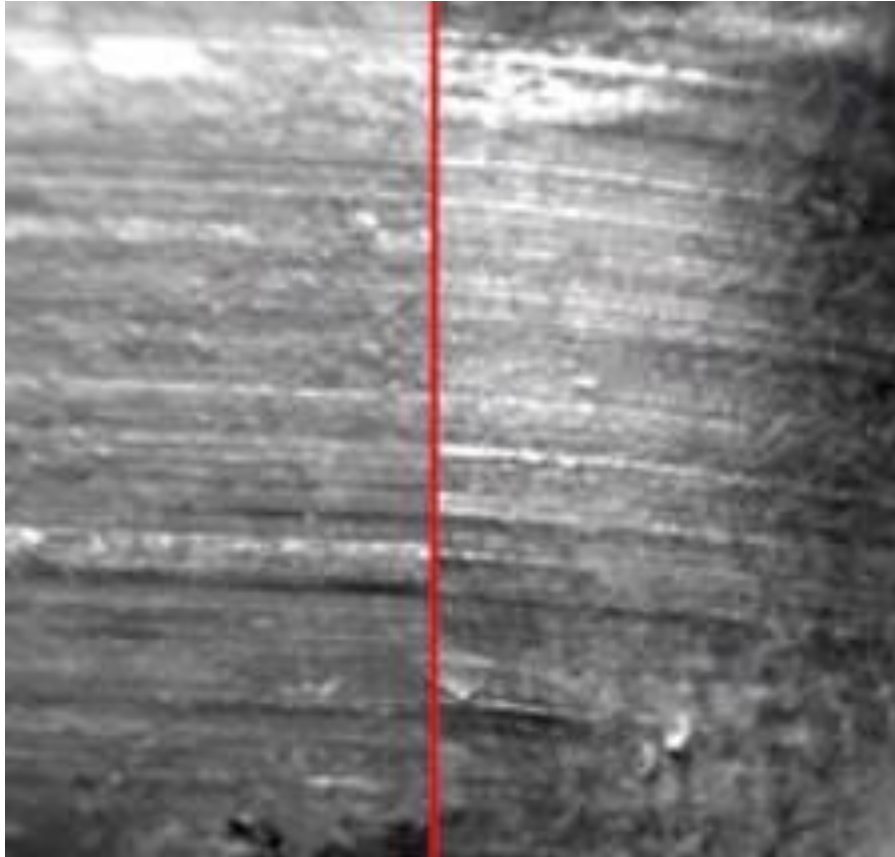
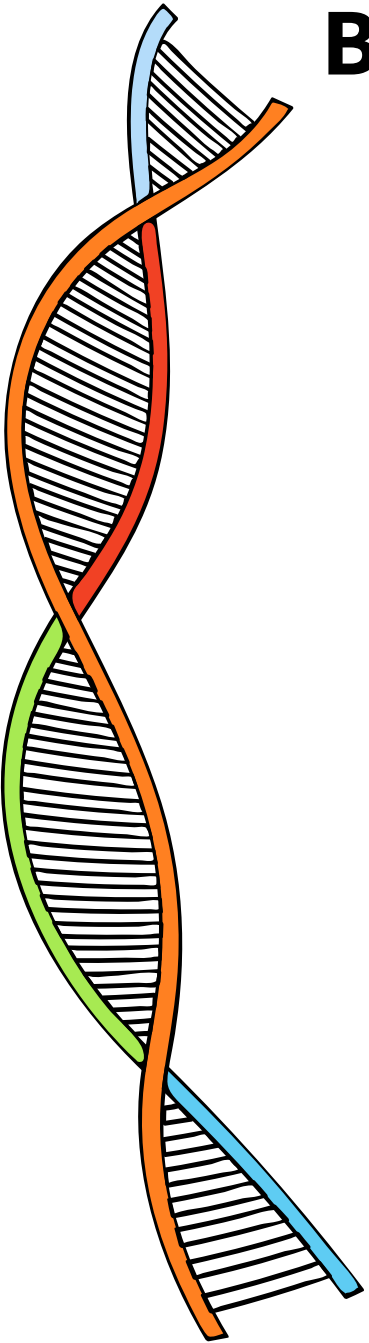
Ballistic/firearm analysis

- Bullets can provide a wealth of information during shooting investigations
- High evidential value if there is a suspected firearm to match it to
- Each firearm leaves a unique set of markings on bullets due to the individual characteristics of the barrel of the weapon
- **Bullets are handled – thus they may carry DNA of the shooter**



- A. Firing pin impression**
- B. Ejector mark**
- C. Breech face impression**

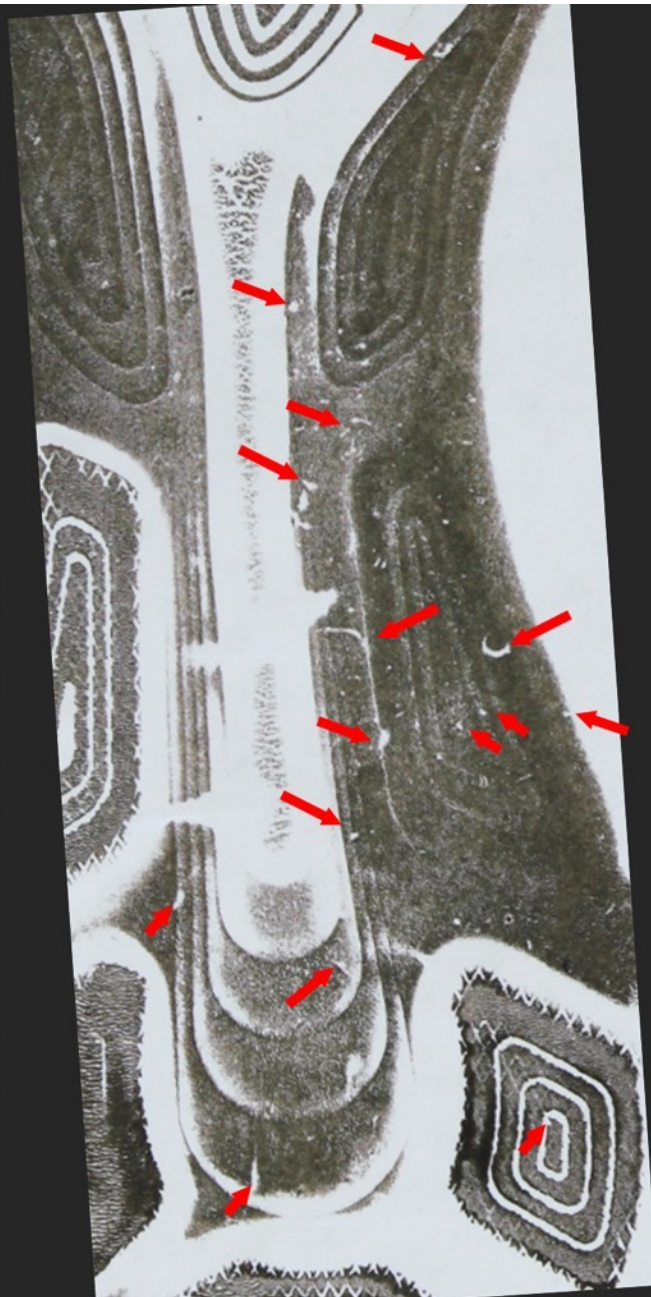
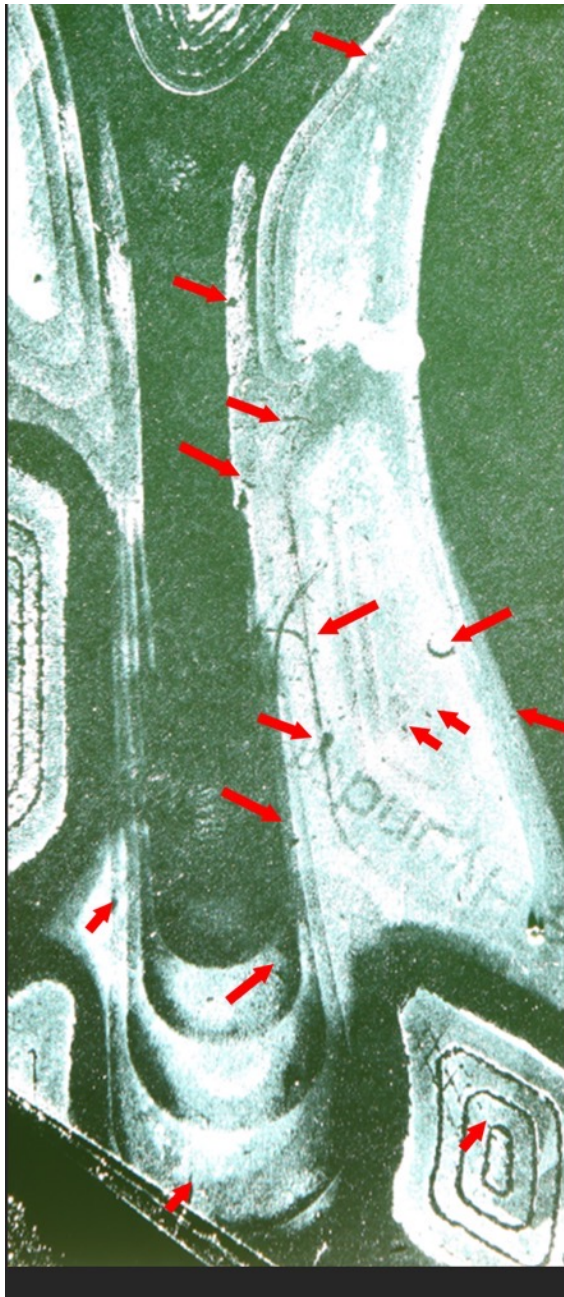
Ballistic/firearm analysis



Casts and impressions

- Footwear and tires leave impressions in soft grounds
- Plaster of Paris can be used to create a record of the print including all the imperfections that make it unique
- Little potential for DNA but important all the same
- Can be matched to a suspect's shoe or car





Non-physical evidence

- Not all evidence is physical in nature
- Non-physical evidence can be used to make a case against a suspect even if there is no physical evidence available
- Physical evidence is more scientifically reliable, but non-physical, or testimonial, evidence can be more persuasive

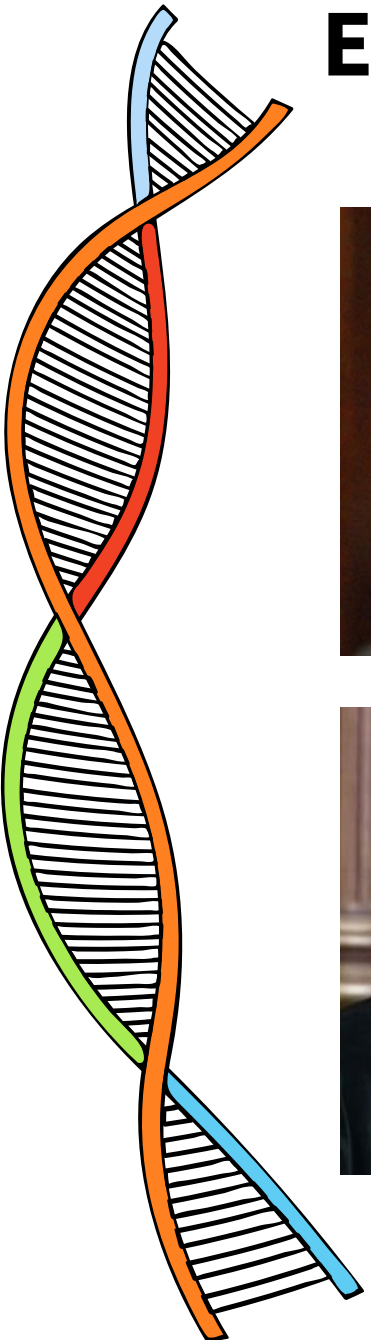


Testimonial evidence

- Very rarely can a crime occur with absolutely no one seeing it or knowing about it
- Witness statements are one of the main sources of non-physical evidence
- Can range from extremely reliable to completely unreliable
 - Victims of serious crimes often have very sharp memories
 - Witnesses are more likely to remember certain details over others
 - Questioning techniques can have a severe impact on the reliability of the account



Example: Making a Murderer



Discriminatory power of evidence

- Evidence has varying levels of discriminatory power
- **Individualized evidence** can be linked to a single, specific source
 - Fingerprints on murder weapon
 - DNA at crime scene
- **Class evidence** has characteristics common to a group of similar objects
 - Perp wearing a red t-shirt and blue jeans and so was suspect
 - Becomes a probability calculation

Class evidence probability

A man is killed at a party during a fight. The person who threw the punch was seen wearing a red t-shirt and blue jeans.

Photos from the party identify 8 other men wearing red t-shirts and blue jeans. There were 42 people at the party in total when police showed up, but the host said there was easily 150 people who came and left at some point.

8 wearing red t-shirt/blue jeans

42 people at the party

= 19% wearing red t-shirt and blue jeans

$0.19 \times 150 = 28$ possible suspects!

Class evidence probability continued

Another witness comes forward to say that they noticed the person who threw the punch was also wearing a hat.

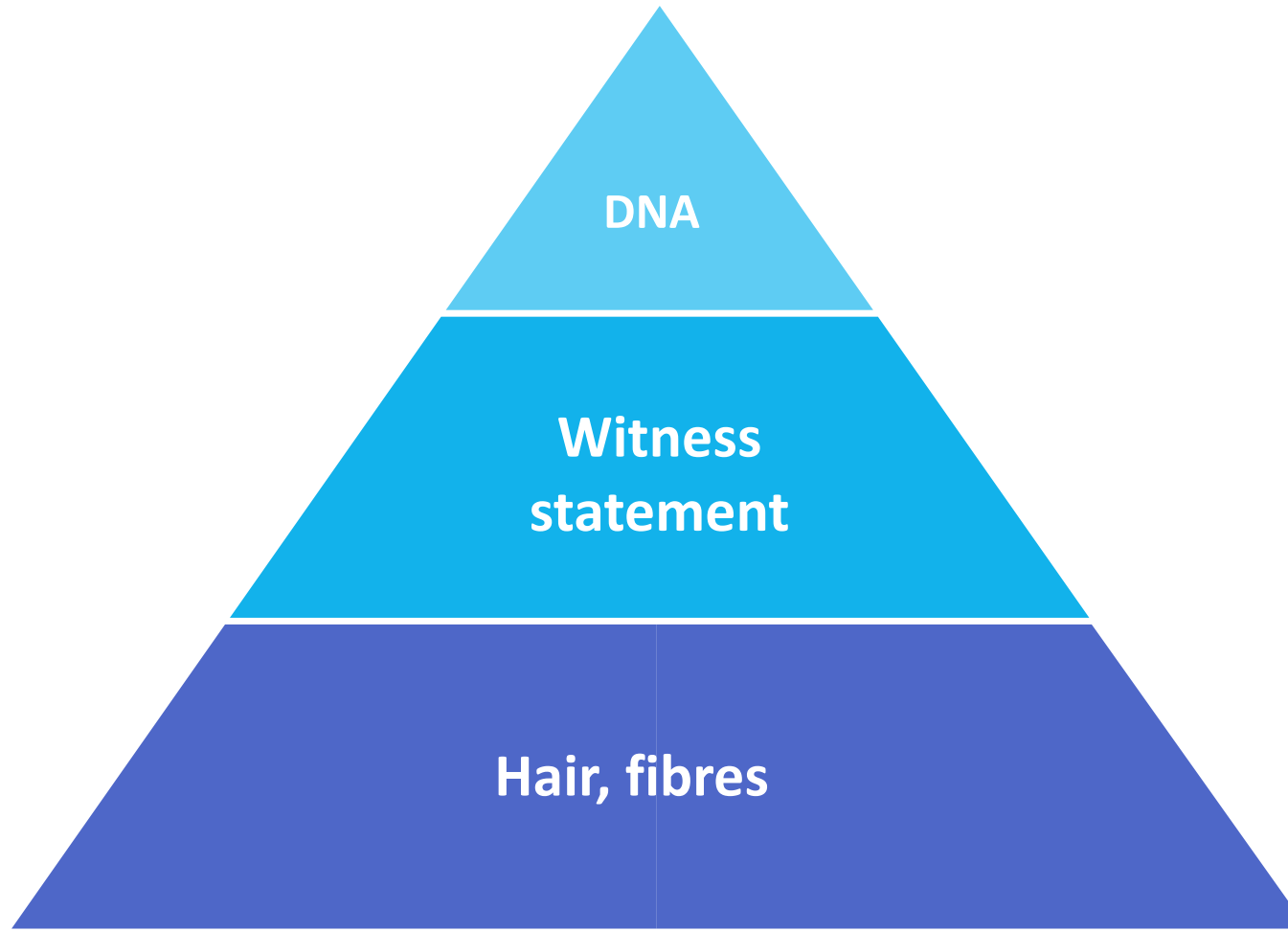
6 people at the party were seen to be wearing hats.

$$\frac{6 \text{ people wearing hats}}{42 \text{ people at the party}} = 14\% \text{ wearing hats}$$

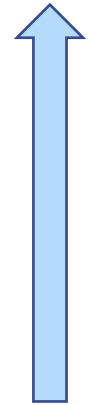
$0.19 \times 0.14 = 0.026 = 2.26\%$ of 150 people are potential suspects

Possible suspect list is cut down to approximately 4 people!

Discriminatory power of evidence



High
discriminatory
power



Low
discriminatory
power

Ways evidence can be considered

Evidence can favour either the prosecution or the defense

Inculpatory evidence

- Favours the prosecution
- Points to the guilt of the suspect

Exculpatory evidence

- Favours the defense
- May lead to the exclusion of a person as a suspect

Summary

- Evidence is either direct or indirect
- Evidence must be reliable, material, admissible and probative
- Can be biological, physical or non-physical in nature
- Individualized evidence has more probative value than class evidence
- Not all evidence has the potential to carry DNA
- Evidence may be exculpatory and be used to exclude a suspect from an investigation, or inculpatory to include a suspect

Optional reading:

- Fundamentals of Forensic Science Chapter 3 – **The Nature of Evidence** (available in Canvas)