Avoiding miscarriages of justice: Issues in Forensic Biology

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DNA

- DNA is present in all cells (except red blood cells)
- DNA is the same regardless of where it comes from (blood, semen, saliva)
- DNA is inherited from both the mother and the father
- DNA is different in siblings, except for identical twins

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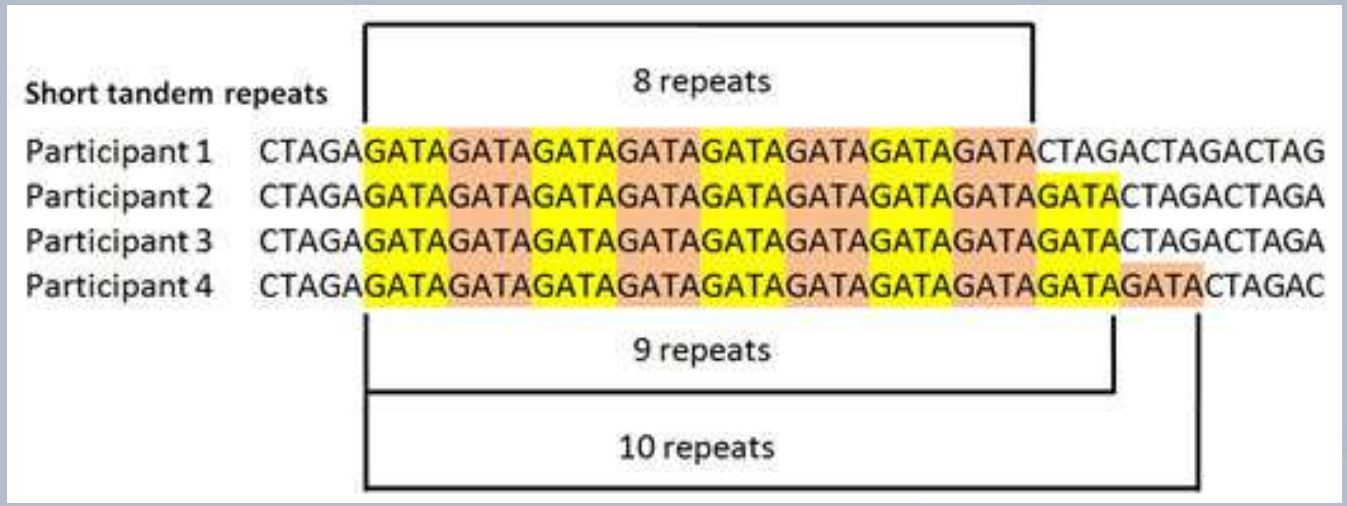
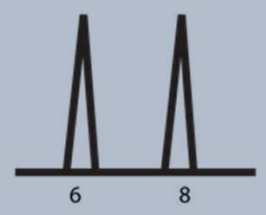
Forensic DNA analysis

- We don’t look at the entire genetic code, only a very small portion
- This is why biologists have to report a statistic, not an identification like fingerprints
- Most commonly used system Powerplex 21 which looks at 21 areas of the DNA molecule
- Short Tandem Repeats (STRs) = repeating sequences
- Different people have different numbers of repeating units



DNA profiling

- DNA is tightly packaged into pairs of chromosome
- One chromosome inherited from mum, one from dad
- Target same area of DNA on each of the pair of chromosomes
- And simply measure the number of repeating units (short tandem repeats)



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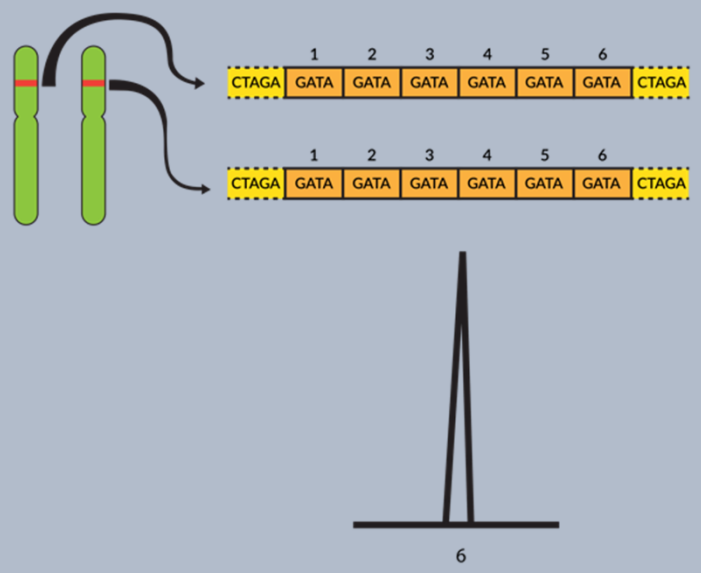
DNA profiling



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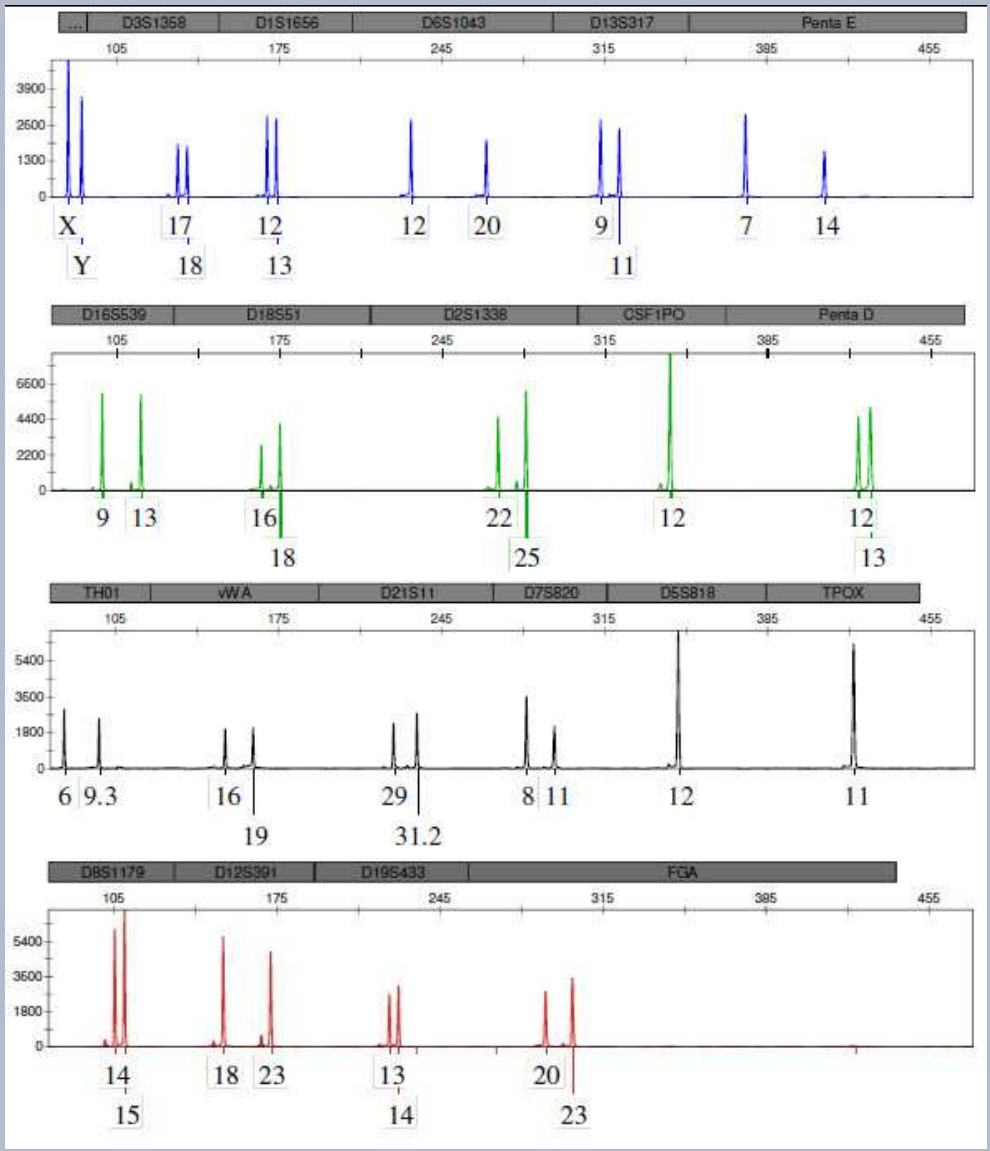

Single source DNA profile

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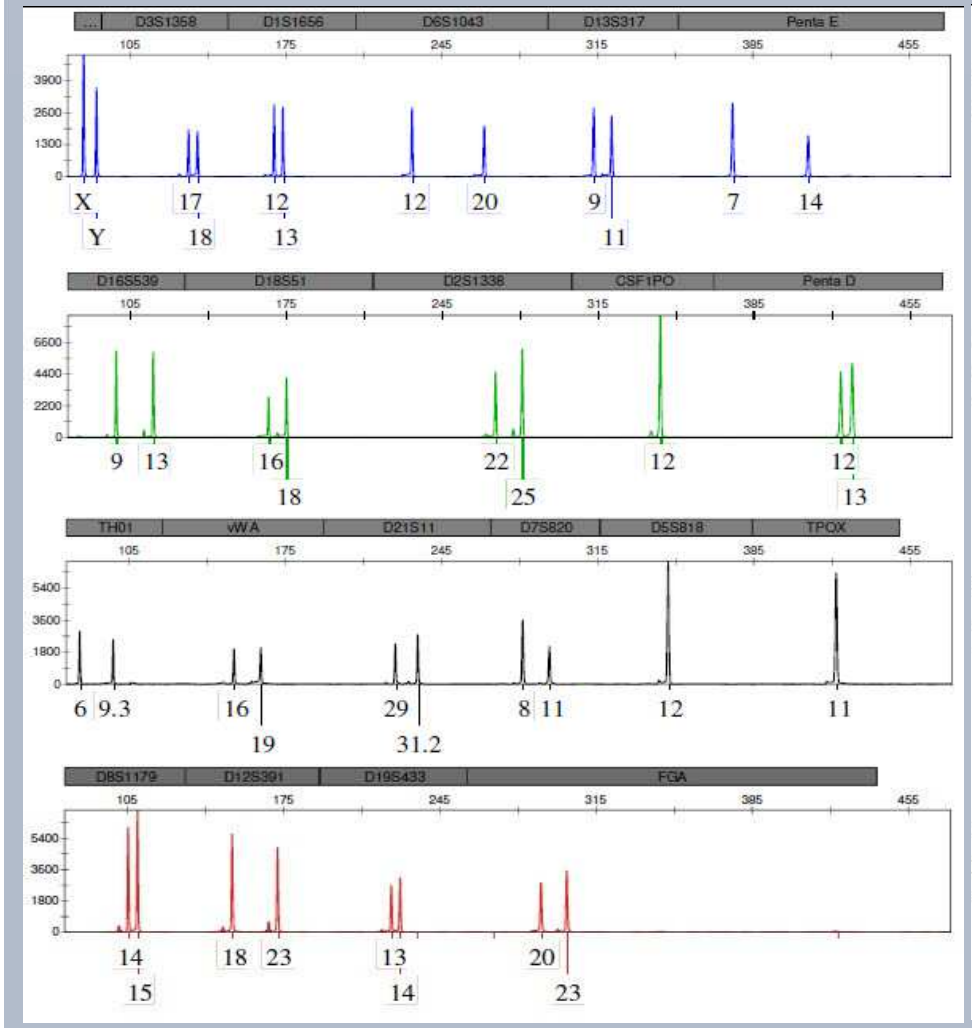
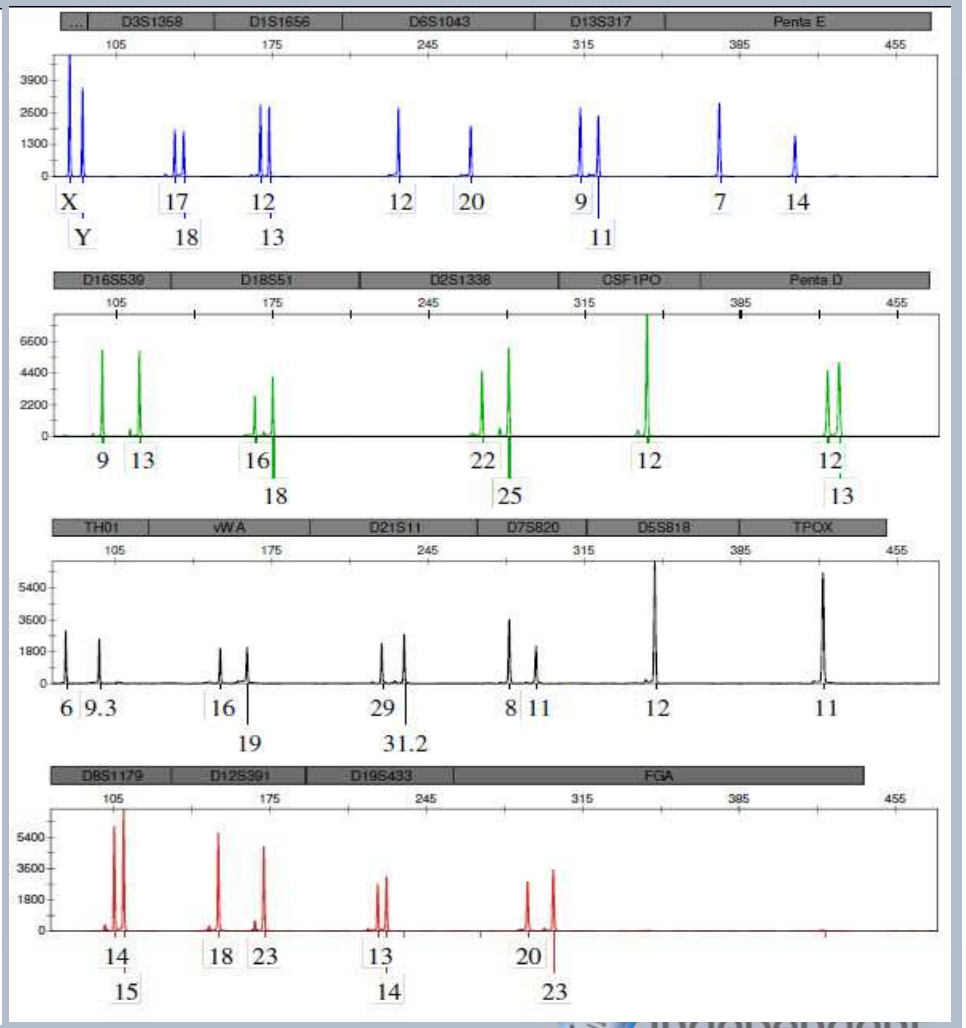
Single source comparison





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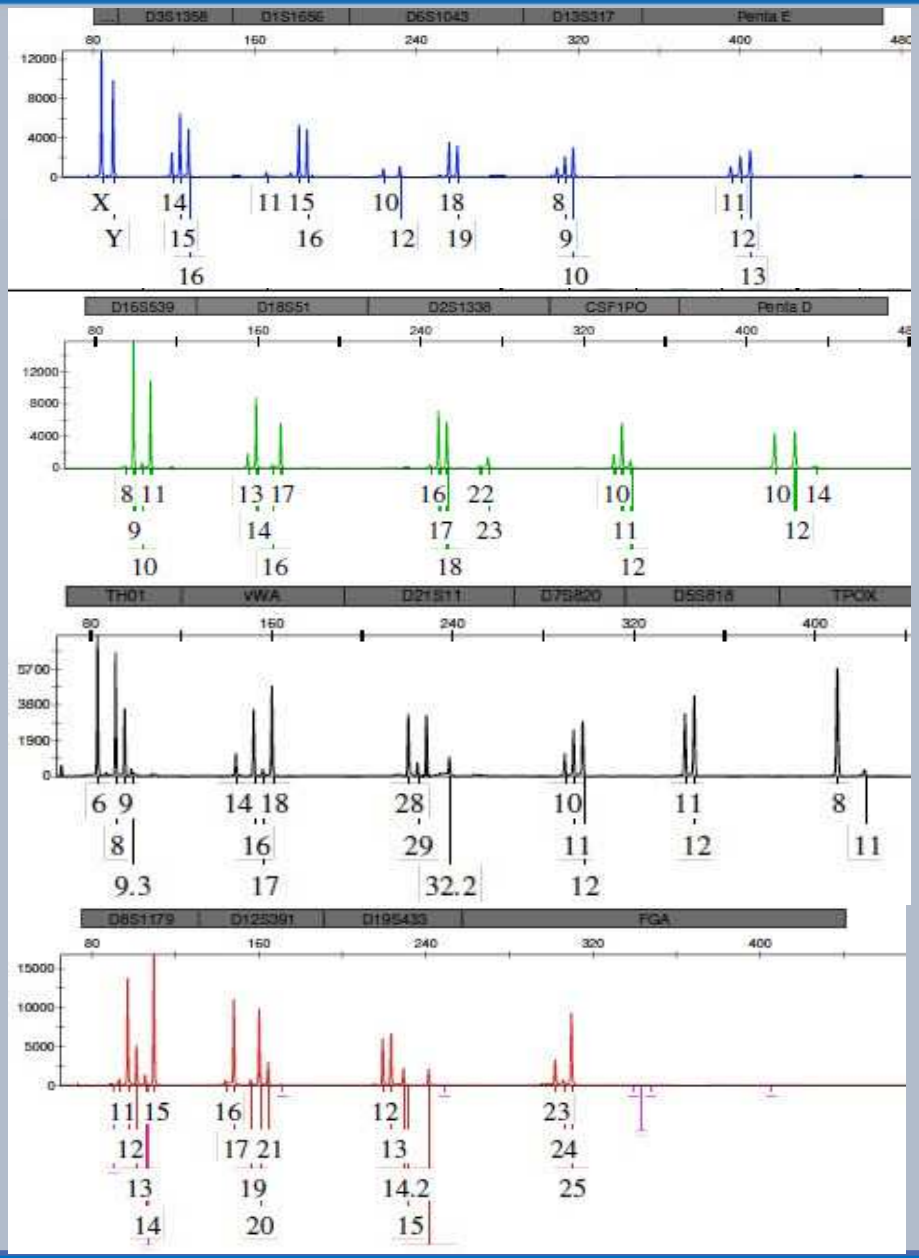

Mixed DNA profile

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The potential for DNA evidence to contribute to miscarriages of justice

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Miscarriages of justice

Four key areas:

1) Bias
2) Robustness of statistical calculations
3) Trace DNA
4) Lack of contextualisation of the evidence

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Bias

Two main types of bias:

- Cognitive - the tendency to search for or interpret information in a way that confirms one preconceptions

- Motivational - generally a conscious bias towards a particular party which is either self serving or personal motivation

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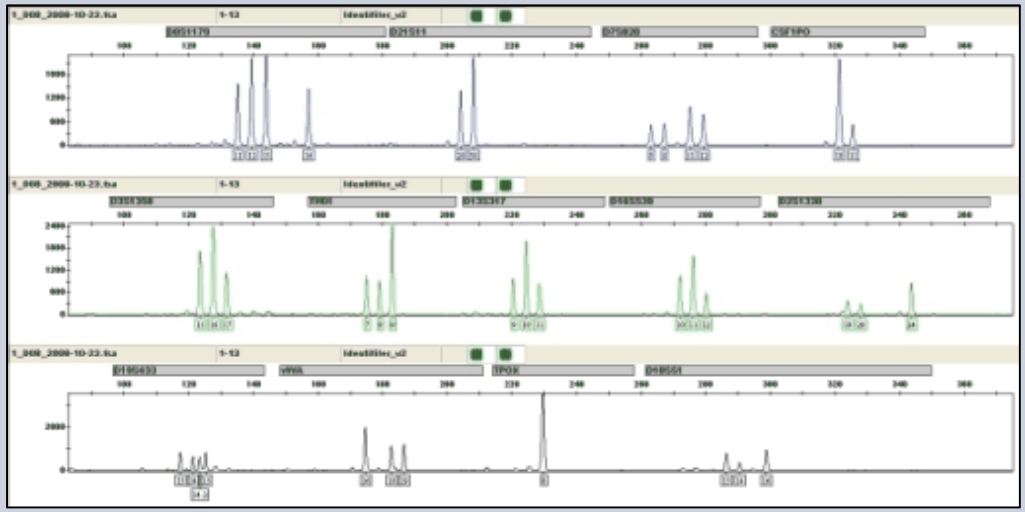
Case example – motivational bias

- Murder - DNA lab instructed to identify suspect's DNA on victim's clothing
- Mixed DNA profiles were obtained (at least 3 people)
- Suspect is a contributor – statistical analysis done
- However, the same 'unknown individual' appears to be a minor contributor in multiple profiles



Not identified or disclosed by lab, but this 'unknown' contributor could be the true offender

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Case example – motivational bias

- Example of Government Laboratory Standard Operating Procedure that states:

Mixture/Statistical Analysis can be performed '…where the scientist deems the mixture to be <u>of value</u> to the case'

Of value to who?

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2) Robustness of DNA Statistical calculations

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Statistical Calculations in Forensic Biology

- Two types of statistical calculations that you will see in forensic biology reports
  - Match Probability or Frequency Estimate
  - Likelihood Ratio

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Single source DNA profiles

- Match Probability or Frequency Estimate
- The statistics behind single source profiles are simple
- Use a database to calculate the frequency of the DNA profile in the population
- In Australia, for a full single profile (i.e. a result at each of the 21 areas tested), conservative default value of 1 in 100 billion

'The DNA recovered has the same profile as Mr Smith. This profile is estimated to occur in fewer than 1 in 100 billion individuals in the general population.'

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DNA interpretation – Likelihood Ratio

- Likelihood Ratio
  - The evaluation of 2 propositions
  - Generally one aligned with prosecution proposition (Hp) and one with defence proposition (Hd)
  - Propositions are variable and can be changed based on the case circumstances
  - Can calculate manually up to 3 contributors to a DNA profile

Reported along the lines of

- ***"The DNA evidence is 100 million times more likely of Mr Smith and an unknown person are the sources of the DNA rather than two unknown, unrelated individuals."***

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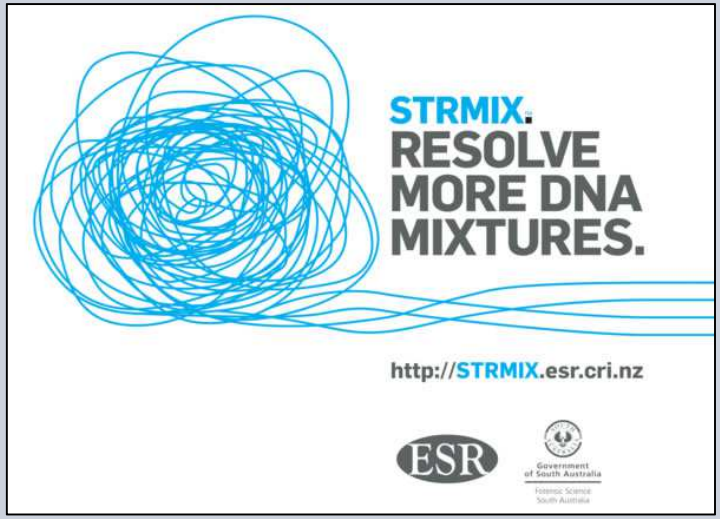
DNA interpretation

- Recent software developments have led to the ability to be able to interpret mixtures with a greater number of contributors
- Previously these profiles would be described as ‘too complex for interpretation’
- Deconvolutes DNA profile and calculates likelihood ratio
- TrueAllele® and STRmix™



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DNA interpretation - STRmix™

- A software program developed by Australian and New Zealand scientists
- Already in use in forensic labs in Australia and New Zealand
- Commercially available as of Feb 2014
- Uses biological and mathematical modelling approach to the interpretation and analysis of a DNA profile.
- Designed to include **all available information** in DNA profile i.e. fully continuous

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DNA Interpretation - STRmix™

Limitations:

- Calculations cannot be manually replicated and replications in the software will yield different results, however the methodology is robust
- Subjective determinations about the DNA profile are made prior to STRmix™ analysis
- Low statistical values may be reported that are unreliable – i.e. supporting inclusion when a person has not contributed

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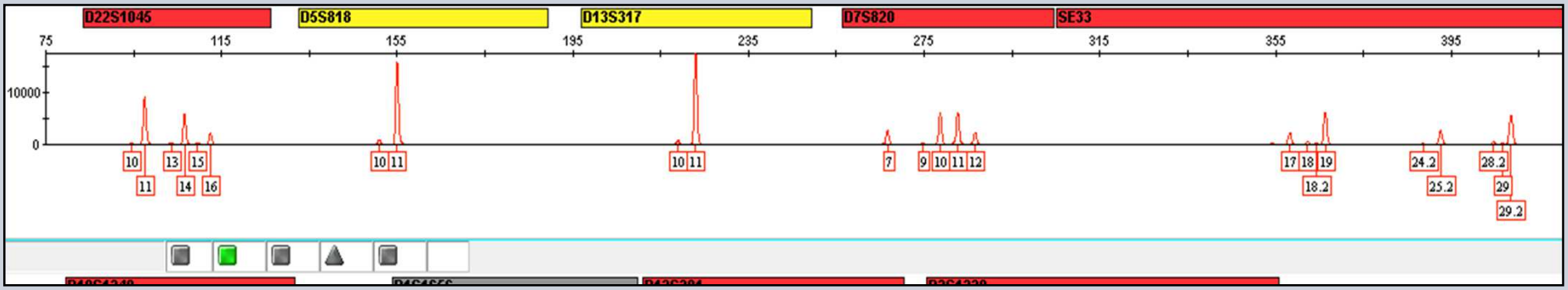
Determining the Number of Contributors



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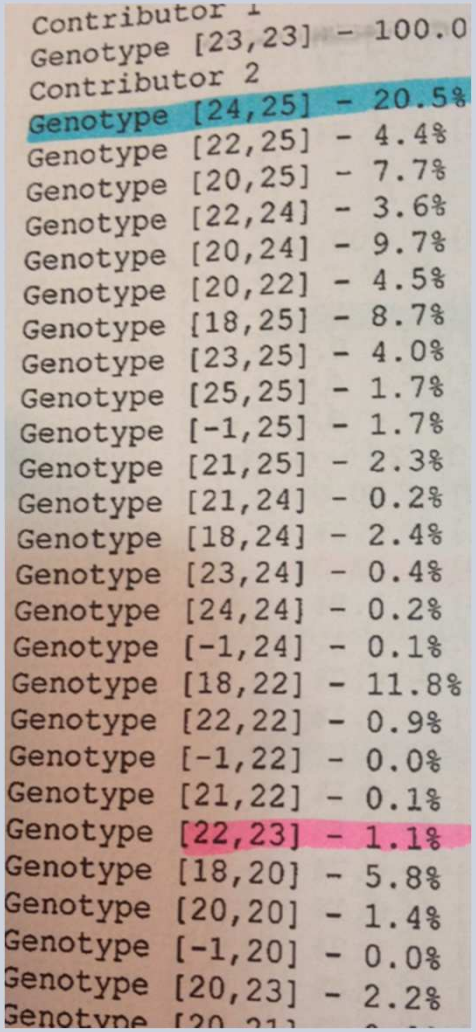
DNA interpretation - STRmix™



Contributor 1
Genotype [23,23] - 100.0
Contributor 2
Genotype [24,25] - 20.5%
Genotype [22,25] - 4.4%
Genotype [20,25] - 7.7%
Genotype [22,24] - 3.6%
Genotype [20,24] - 9.7%
Genotype [20,22] - 4.5%
Genotype [18,25] - 8.7%
Genotype [23,25] - 4.0%
Genotype [25,25] - 1.7%
Genotype [-1,25] - 1.7%
Genotype [21,25] - 2.3%
Genotype [21,24] - 0.2%
Genotype [18,24] - 2.4%
Genotype [23,24] - 0.4%
Genotype [24,24] - 0.2%
Genotype [-1,24] - 0.1%
Genotype [18,22] - 11.8%
Genotype [22,22] - 0.9%
Genotype [-1,22] - 0.0%
Genotype [21,22] - 0.1%
Genotype [22,23] - 1.1%
Genotype [18,20] - 5.8%
Genotype [20,20] - 1.4%
Genotype [-1,20] - 0.0%
Genotype [20,23] - 2.2%

- Clear sign that there is a problem with the modelling
- Most likely – the number of contributors is wrong

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3) The complexities of trace DNA

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Trace DNA

- DNA testing has become increasingly sensitive
- Is it possible to obtain DNA profiles from as little as 6 cells

However,

- It is not possible to identify the biological origin of trace DNA
- It is not possible to make any conclusion about transfer and persistence of trace DNA i.e. who last handled the item

WHY?

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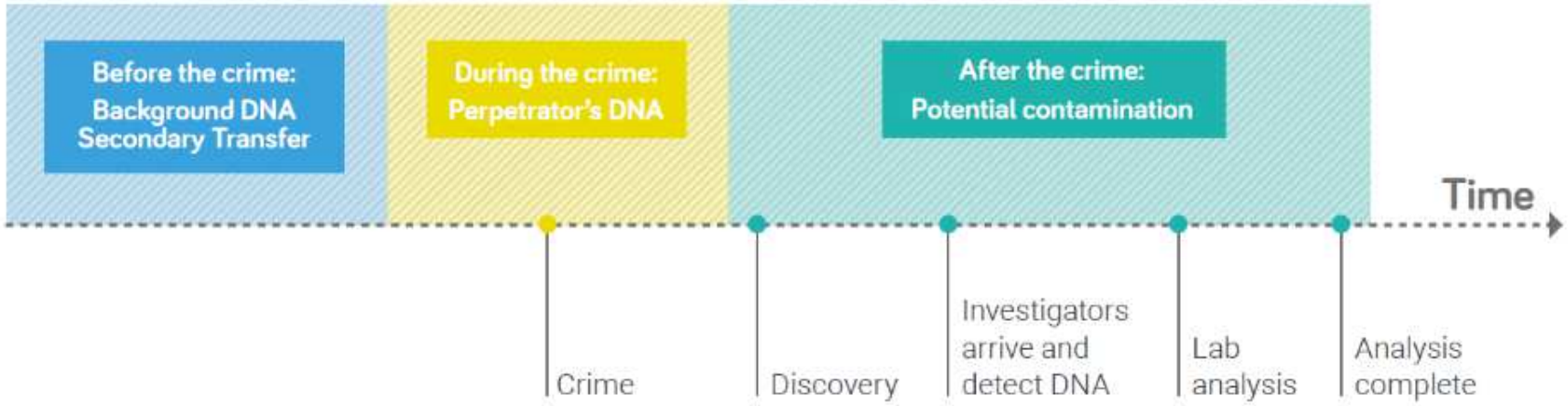
Trace DNA

WHEN COULD DNA BE DEPOSITED?



Euroforgens 2017

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Trace DNA – interpreting the evidence

1. The trace DNA profile was transferred during the crime event itself

   E.g. - handling the murder weapon

2. The trace DNA profile was part of the background DNA of the crime scene (innocent transfer – including secondary/tertiary)

   E.g. – the suspect resides at the address and has access to the items in question

3. The trace DNA profile was investigator/lab mediated contamination

   E.g. – CSI did not change gloves between collecting each exhibit

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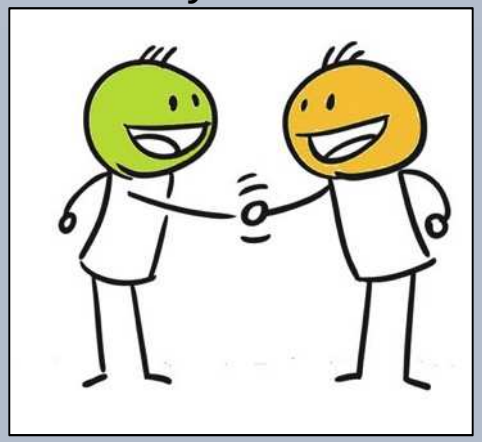
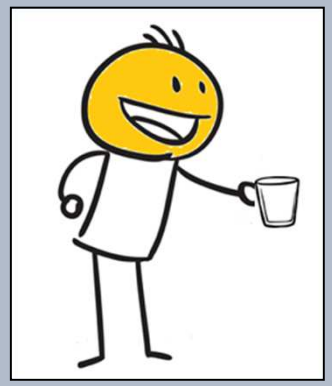
Trace DNA - transfer

Secondary transfer





Who's DNA is on the glass?

- Orange man
- Green man
- Both
- Neither
- Someone else

Tertiary transfer

Who's DNA is on the glass?

- Orange man
- Green man
- Both
- Neither
- Someone else

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Complexities of secondary transfer

- Shedder status
- Substrate
- Hand washing
- Nervousness/sweatiness
- Habitual face touching etc

AND REMEMBER: absence of evidence is not evidence of absence

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Secondary transfer – Case Example

- Sexual assault case
- Alleged that a step father has orally assaulted step daughter
- Victim and defendant reside in the same house

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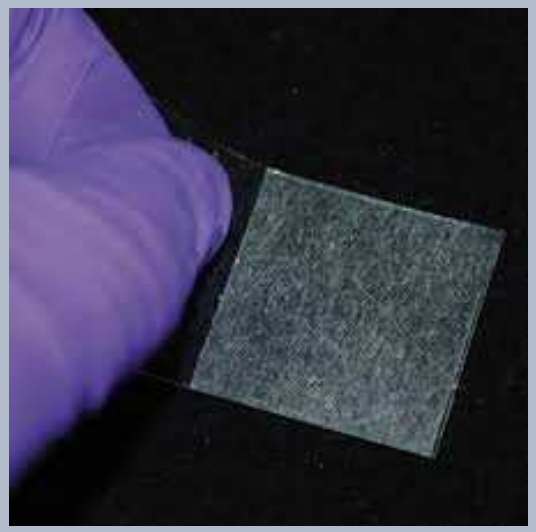
Secondary Transfer - Case example
The evidence

- Tapelift collected from underwear
- DNA profile that matches victim and defendant obtained
- No serological testing
- Reported as defendant matches DNA profile from underwear



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Secondary Transfer - Case example

- Sample considered trace DNA (don’t know the biological origin)
- Successfully argued that as victim and defendant reside in the same premises that there was the reasonable possibility that the DNA could have been deposited or transferred by other means
- Serological testing would have allowed for a greater interpretation of evidence
- Also see R v Fitzgerald

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4) Contextualisation of the evidence

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DNA in the real world

- Important to remember, the calculated statistic is not the “odds that defendant did it”
- It is an estimate of the chances of another unrelated person from the population leaving the evidentiary DNA
- Depending on how the material was deposited and the biological source (i.e. blood, semen, saliva, skills cells) of the DNA, it may have no relevance to the actual offence

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DNA in the real world

- It is one of the most high profile forensic sciences
- DNA evidence is expected to be produced in criminal cases
- Readily taken on face value and trusted by judges, juries (and the legal community)

However,

- Your DNA may be in a room even if you weren't
- DNA alone does not solve crimes (and can result in miscarriages of justice if it is)
- DNA needs to be used and considered within a framework of other evidence

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What a Forensic Biologist can do

- Detection and confirmation of body fluids
- DNA profiling
- Interpretation of DNA profiles
- Gives an OPINION on the evidence

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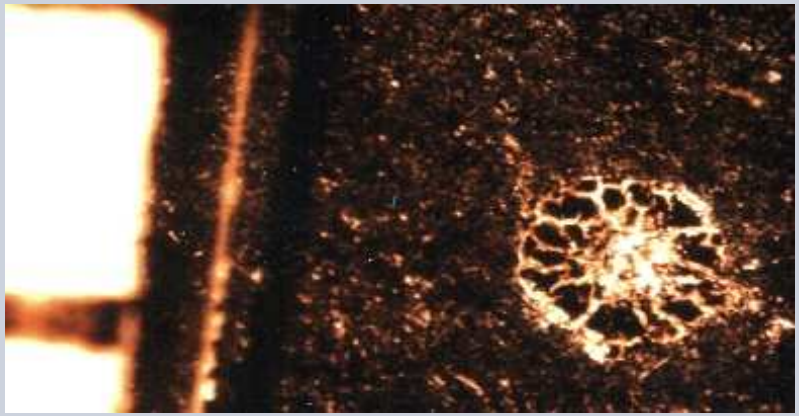
How does a biologist interpret the evidence?

- Appearance / description of the stain
- Results of any presumptive testing
- Results of any confirmatory testing
- DNA quantitation value from DNA sample examination sheet
- Quality of DNA profile, including the presence of mixtures



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Interpreting the Evidence

Knife 1

Knife 2

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Interpreting the Evidence

Knife 1

Item no	Item Description	Results
1	Knife – swab bloodstain from blade	The DNA recovered has the same profile as Mr Smith (Barcode number XPS0123456). The profile is expected to occur in approximately 1 in 100 billion individuals in the Australian population

Knife 2

Item no	Item Description	Results
2	Knife – swab bloodstain from blade	The DNA recovered has the same profile as Mr Smith (Barcode number XPS0123456). The profile is expected to occur in approximately 1 in 100 billion individuals in the Australian population

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Interpreting the Evidence: Knife 1

Conclusion with Interpretation:

"A DNA profile matching that of Mr Smith was obtained from a passive blood stain which appears to have dripped onto the blade from directly above. In my opinion, these findings support the proposition that Mr Smith was in close proximity to the knife whilst injured and bleeding but the knife has not be used to cause injury."

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Interpreting the Evidence: Knife 2

Conclusion with Interpretation:

"*The presence of the wiped bloodstains and apparent fat staining on the knife are indicative of the knife having been used to cause a penetrative injury to Mr Smith. The diluted blood staining in my opinion could be accounted for by an attempt to clean the knife*"

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Context Matters

- Previous secondary transfer case example
- If detection of biological fluids was attempted, it could have:
  - Provided context for the DNA result
  - Allowed for better interpretation of the evidence
  - Ultimately, assisted in answering the questions posed by the court

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Context matters - Case example

- Alleged sexual assault
- Victim consumed significant amounts of alcohol as well as drugs on a night out
- Went home with defendant (they were known to each other), more drinks
- Witness concerned for welfare when victim did not attend family function the next day went to look for her
- Witness saw defendant on top of victim. Victim's underwear disturbed and vagina exposed
- Sent to IFS to review in 2016

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Context matters - Case example
The Evidence

- One single spermatozoa observed on the high vaginal smear
- High vaginal and low vaginal swabs combined for DNA testing
- Mixed DNA profile was obtained that was consistent with originating from victim and defendant
- Reported as single spermatozoa with DNA profile that matches defendant that is expected to occur in fewer than 1 in 100 billion individuals

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Contextualising evidence

- No presumptive test for semen was conducted
- A slide made from the internal swab found one sperm head. It is possible that this was from previous activity and DNA was not detected
- Information contained in casefile that recent sexual intercourse had occurred
- Forensic Biology report contained no information about the significance of the evidence in relation to the allegation

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Contextualising evidence

- If the case was considered more holistically:
  - The presence of a single sperm head is **not** what would be expected if penetrative ejaculation occurred given the time frame from incident to sample collection.
  - Many other plausible explanations for the evidence
  - However, the presence of a sperm and a DNA match is all that is reported. What is the jury to think?

What did we learn from the wrongful conviction of Farah Jama?

CONTEXT IS KEY!

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What can we do?

Scientists:

- Interpret the evidence (impartially) – be the expert!
- Disclose the limitations of trace DNA in their court report
- Maintain their expertise and not rely on ‘black box’
- Ensure clear communication with the courts surrounding the limitations of the statistical analyses/software

Lawyers:

- Do not interpret scientific evidence yourself – ensure the expert does it
- Have a basic understanding of the analysis so that you can question/challenge
- Instruct independent expert

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Conclusion

(something a good scientific report should always contain!)

- DNA analysis remains an invaluable tool
- Despite DNA interpretation being more complex than ever, the general trend is that lab DNA reports are becoming more simplified
- Caution should be taken regarding the significance of the DNA evidence. Remember context matters
- In order to avoid miscarriages of justice it is a necessity for the expert to be the expert and not rely on reporting factual DNA evidence that may be mis-leading
- Lawyers (prosecution or defence) can seek a second opinion from an independent expert

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