



# Lecture 1: Introduction to Forensic Genomics

Summer 2026

# Welcome to MBB 463 Forensic Genomics!



## CONTACT INFORMATION

Dr. Sophie Sneddon

[sophie\\_sneddon@sfu.ca](mailto:sophie_sneddon@sfu.ca)



Please **email** me or use the **Canvas inbox** with any questions/concerns and I will get back to you ASAP! Or talk to me after class.

I also encourage you use the **discussion board** for more involved questions about the course content.



## CLASS TIMES


Wed/Fri 2.30-4.20pm SWH 10041

My office: SSB 7157

Office number: 778-782-7140

**You are highly encouraged to participate in each class by asking questions by raising your hand.**

# Topics

- 
- Introduction to forensic genomics
  - Brief history of forensics
  - Types of evidence
  - DNA fingerprinting
  - STR analysis
  - Y-STR analysis
  - Mitochondrial DNA analysis
  - SNP analysis
  - NGS analysis
  - Interpretation of DNA evidence
  - Complex profiles
  - DNA databases
  - Public DNA services
  - Genetic genealogy
  - Emerging technologies in forensic genomics
  - Applications of forensic genomics
  - Ethical considerations of DNA collection

# Case studies

- Case studies will be included but not examinable
- These may be in the form of lectures or videos
- Topics of case studies may be changed without notice

# Midterms – 50%

2 midterms throughout the semester worth 25% each

Midterm Number	Date	Lectures Covered
1	June 17	1-9
2	July 24	11-18

# Midterm policies

- Midterms are scheduled during class time – no exceptions
- Midterms are **closed book**
- You are expected to adhere to SFU's academic integrity policies on cheating as if it were an in-person exam, and you are expected to have read the policies (<https://www.sfu.ca/students/academicintegrity.html>) and are assumed to have agreed to abide by them

## Missing a midterm due to illness:

- You **MUST** provide proper documentation (<http://www.sfu.ca/content/dam/sfu/students/pdf/certificate-of-illness.pdf>)

## If you have a family emergency:

- A note from a family member stating the nature of the emergency, the relationship of that family member to you, and a phone number so that the authenticity of the note can be verified. The instructor's discretion will be used to determine if the emergency constitutes a valid excuse for missing an exam.

# Midterm policies

## Marking challenges:

- If you choose to challenge the marking of a question or questions then the **entire exam must be remarked** by the instructor and given that there will be consistency in marking the exam you just got back - there needs to be a very, very, very obvious reason to challenge a question.
- Challenges to marking must be brought to the TA **after 24 hours and within 1 week** of reviewing your grades. **Challenges will not be addressed at the end of term.**

## Exam review:

- Should you require further review, you can schedule a zoom or in-person meeting with me.

# Assignment (40% total)

Two-part assignment:

## PART ONE:

- ▶ Group presentation
- ▶ Written analysis
- ▶ Weight: 15%
- ▶ Peer evaluation

## PART TWO:

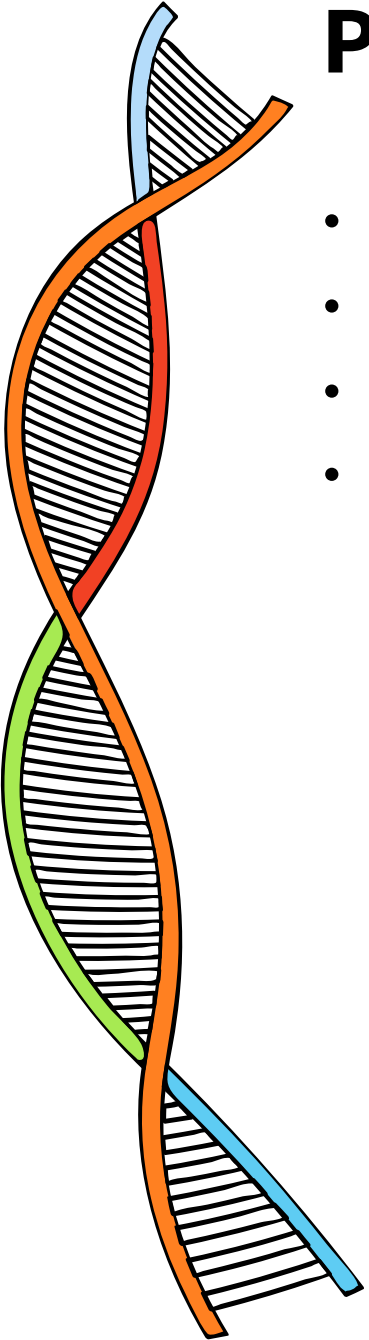
- ▶ Individual assignment
- ▶ Weight: 25%
- ▶ Due end of semester

**\*\* More details will be provided in the coming weeks**



# Participation – 10%

- There will be discussion topics posted each week onto the Discussion section on Canvas.
- There's an “Introduce Yourself” discussion thread already there.
- There will be chances to discuss things during class.
- We will have a discussion-centred class on the ethics of DNA collection and testing at the end of term.



# This course deals with topics of a sensitive nature

- Forensic science is interesting by nature but deals with issues that can be uncomfortable to talk about. I will do my best to provide content warnings before each class.
- If at any time you feel that you need support *for any reason*, you can contact the **SFU counselling service**.

**Information:** <http://www.sfu.ca/students/health.html>

**App:** <http://www.sfu.ca/students/health/support/mental-health/my-ssp.html>

# What can you do now?

There's a couple of things you can do now to prepare.

- **Find a group for your group presentation.** You can self sign up on Canvas (**People → Groups → Project Groups**)
- **Introduce yourself on the discussion board.** You get a free participation point for doing this!



# Beyond MBB 463

The school of criminology has a **Forensic Studies Certificate**

- You must take CRIM 335 (and CRIM 101 recommended)
- Then take 15 units from a list
- MBB 463 counts towards the certificate!

<https://www.sfu.ca/students/calendar/2023/summer/programs/forensic-studies/certificate.html>

ARCH 373 - Human Osteology (5)

ARCH 383 - Ancient and Forensic DNA (3)

ARCH 442 - Forensic Anthropology (4)

ARCH 452 - Ancient Health and Disease (4)

CRIM 356 - The Forensic Sciences II (3)

CRIM 357 - Forensic Anatomy (3)

CRIM 358 - Forensic Entomology (3)

CRIM 402 - Biological Explanations of Crime (3)

CRIM 416 - Current Issues in Criminology and Criminal Justice (3) \*

CRIM 417 - Current Issues in Criminology and Criminal Justice (3) \*

CRIM 418 - Current Issues in Criminology and Criminal Justice (3) \*

CRIM 451 - Advanced Techniques in Forensic Science (3)

CRIM 452 - Skeletal Pathology and Criminalistics (3)

CRIM 480 - Computer Forensics and Cybercrime (3)

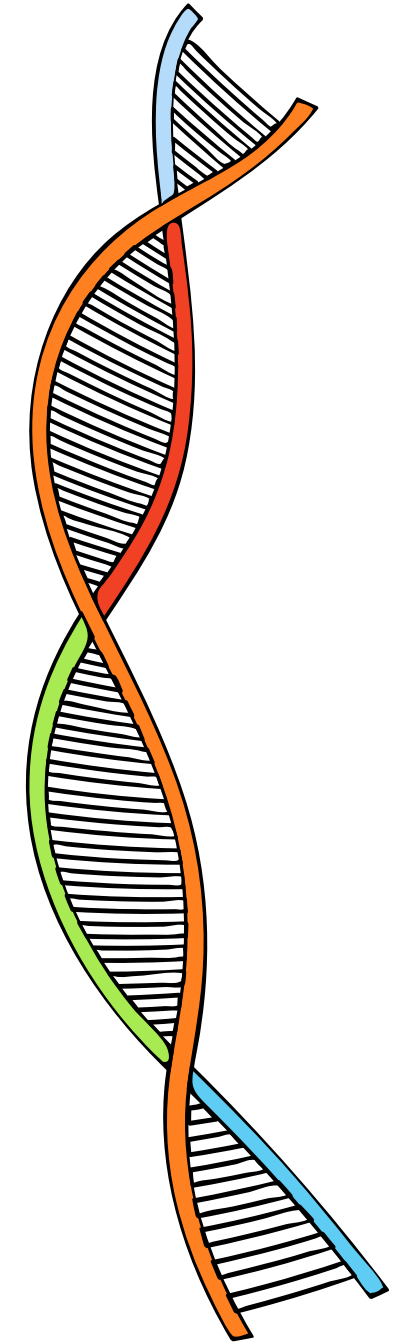
PSYC 376 - Experimental Psychology and Law (3)

PSYC 379 - Clinical Forensic Psychology (3)

PSYC 476 - Advanced Topics in Law and Forensic Psychology (4)

# Meet Professor Shortcake aka “Shorty”







# Lecture 1

Summer 2026

# Learning objectives



Define forensic science



Understand why chain of custody is important to evidence collection




Explain Locard's Exchange Principle



List common sources of DNA at crime scenes

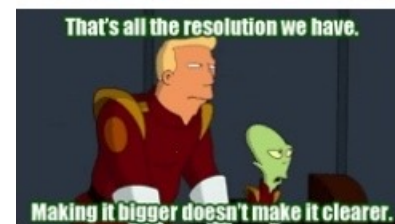


Understand the limitations of DNA evidence



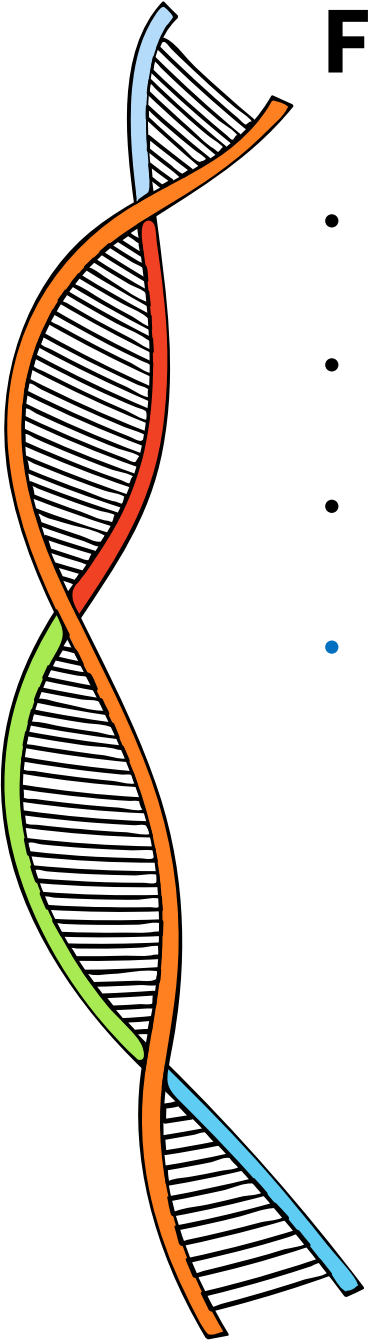
Compare and contrast forensic DNA analysis and forensic genomics

# The CSI effect



# Forensics is the application of science to law

- Forensic science is just regular old science performed in a specific context
- It is used to assist the criminal justice system in determining guilt when crimes occur
- Based on the scientific evaluation of evidence
- **Forensic genomics:** the application of genomics to forensic science



# Solving crimes depends on...

## Police

- Respond to call for help
- Examine crime scene
- Collect evidence
- Interview witnesses
- Write reports

## Scientists

- Analyse evidence
- Store evidence
- Liaise with police & courts
- Write reports

## Courts

- Make cases against/for suspects
- Determine guilt
- Determine sentence
- Evaluate appeals

# Forensic science is a multi-disciplinary field

## Biology & Toxicology

The analysis of biological evidence as it pertains to a crime.

## Pathology

Involves the determination of the cause and time of death as well as the extent of injuries.

## Psychology

The application of psychological theory to criminals in order to understand the “why.”

## Anthropology

The study of skeletal remains to determine characteristics of the victim of a crime.

## Botany

The study of pollen, seeds, plants material, fruits and wood in relation to crime scenes.

## Entomology

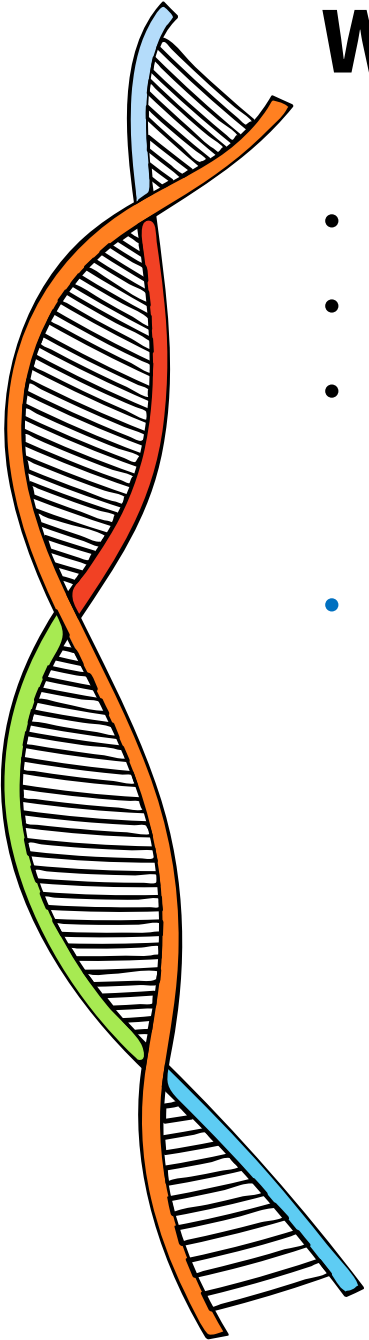
The study of insects and how they can be used to solve crimes. Yes, bugs!

# Evidence

- **Fyre Standard (1923):** To be admissible, scientific evidence must be “sufficiently established to have gained general acceptance in the particular field in which it belongs.”
- **Daubert Standard (1993):** “Evidence must be testable with accepted error rates and must be subjected to peer review and accepted in the scientific field.”

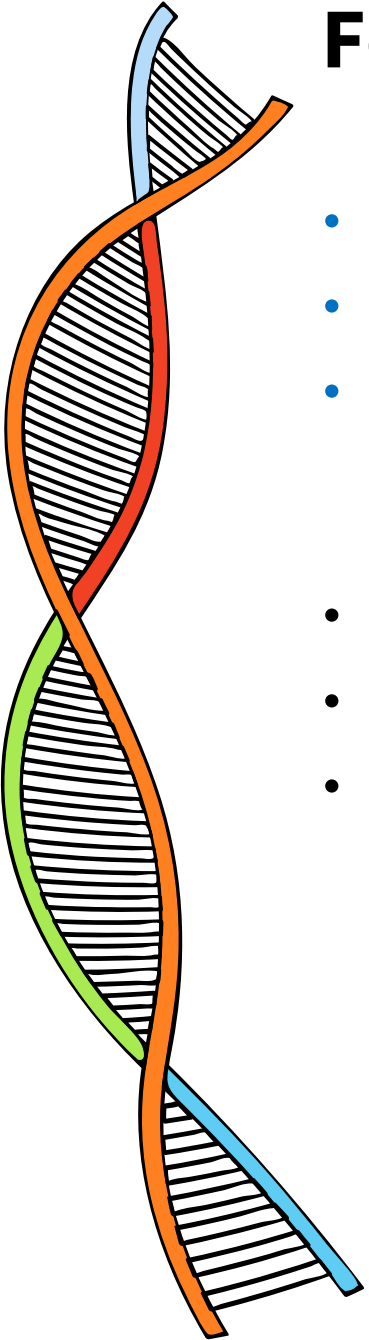
# What is forensic genomics?

- The forensic analysis of genomic evidence at scale
- Requires that biological evidence is left at the scene of a crime
- Utilizes a range of methods to yield results for analysis
  - Direct analysis of DNA from biological material using traditional, scientifically established methods
  - Next generation sequencing?
- **The only forensic discipline that meets the Daubert Standard.**



# Forensic genomics answers the question of “who?”

- **Who** committed the crime?
  - **Who** is this victim?
  - **Who** is the father?
- 
- Not how or why the crime was committed
  - Not how or why the person died
  - Not how or why an event occurred

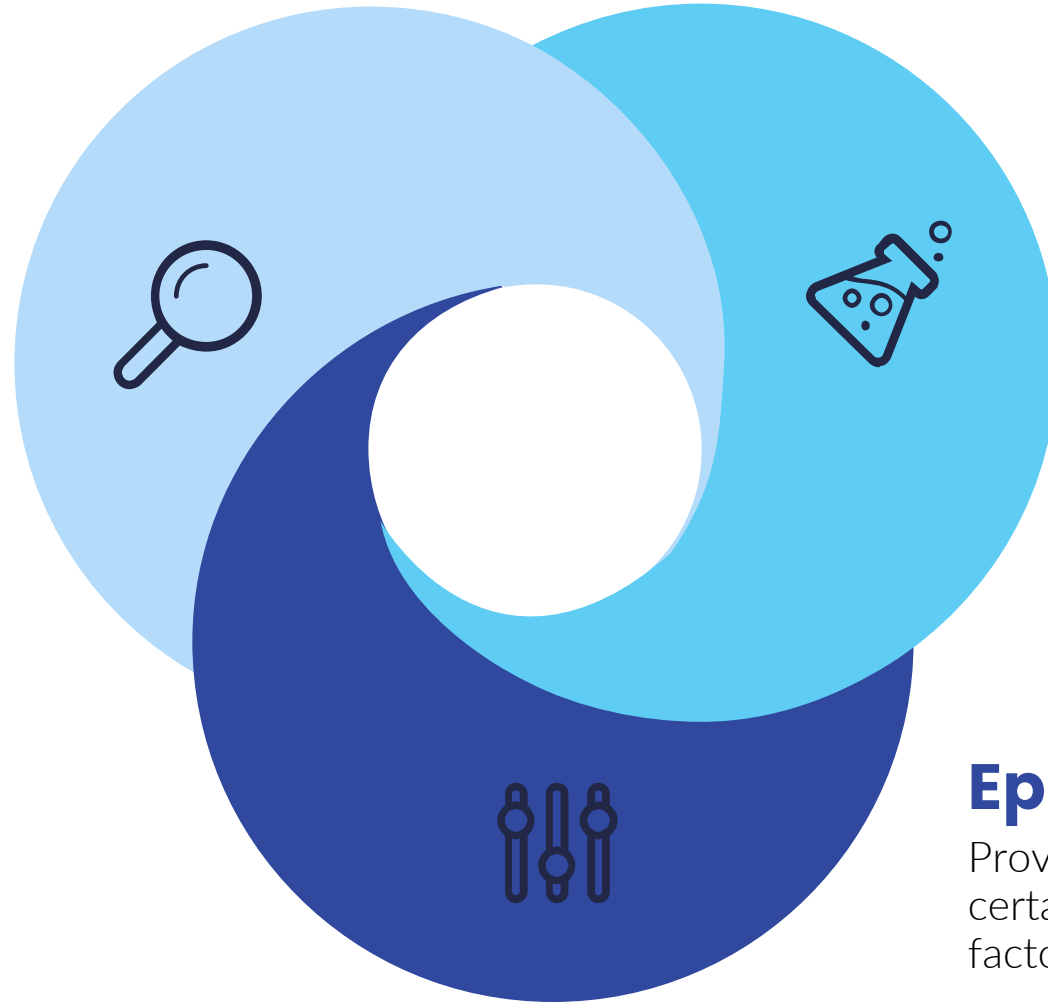


# Forensic genomics is not just about DNA



## DNA

Direct analysis of DNA material left at the scene of a crime.



## RNA

Analysis of RNA markers that indicate properties about the source of the genetic material.

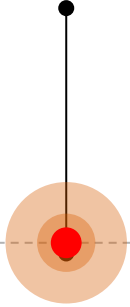
## Epigenetics

Provides a measurement of certain environmental factors.

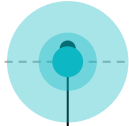
# The timeline of an investigation



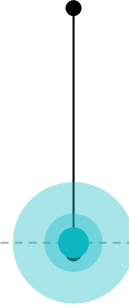
crime occurs



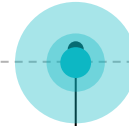
police collect  
evidence



evidence  
analysed




suspect  
convicted



Is it really that simple?

# Chain of custody is crucial

- **Chain of custody** is one of the biggest differences between forensic science and standard science
- Must be able to account for where evidence is at all times from the point of collection until conclusion of a trial including who has handled it and when



CHAIN OF CUSTODY	- EVIDENCE -	- EVIDENCE -
Received From: _____ Received By: _____ Date: _____ Time: _____ am/pm	Submitting Agency: _____ Case No.: _____ Item No.: _____ Date of Collection: _____ Time of Collection: _____ Collected by: _____ Badge No.: _____ Description of Enclosed Evidence: _____	Submitting Agency: _____ Case No.: _____ Item No.: _____ Date of Collection: _____ Time of Collection: _____ Collected by: _____ Badge No.: _____ Description of Enclosed Evidence: _____ Location Where Collected: _____ Type of Offense: _____ Victim's Full Name: _____ Suspect's Full Name: _____
Received From: _____ Received By: _____ Date: _____ Time: _____ am/pm	Location Where Collected: _____ Type of Offense: _____ Victim's Full Name: _____ Suspect's Full Name: _____	- CHAIN OF CUSTODY - Received From: _____ Received By: _____ Date: _____ Time: _____ am/pm
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TRITECH FORENSICS 800.435.7554 • tritechforensics.com Recorder No.: TAGCC436	TRITECH FORENSICS 800.435.7554 • tritechforensics.com Recorder No.: TAGEV336	TRITECH FORENSICS 800.435.7554 • tritechforensics.com Recorder No.: TAGEV436

# When forensics goes wrong: OJ Simpson

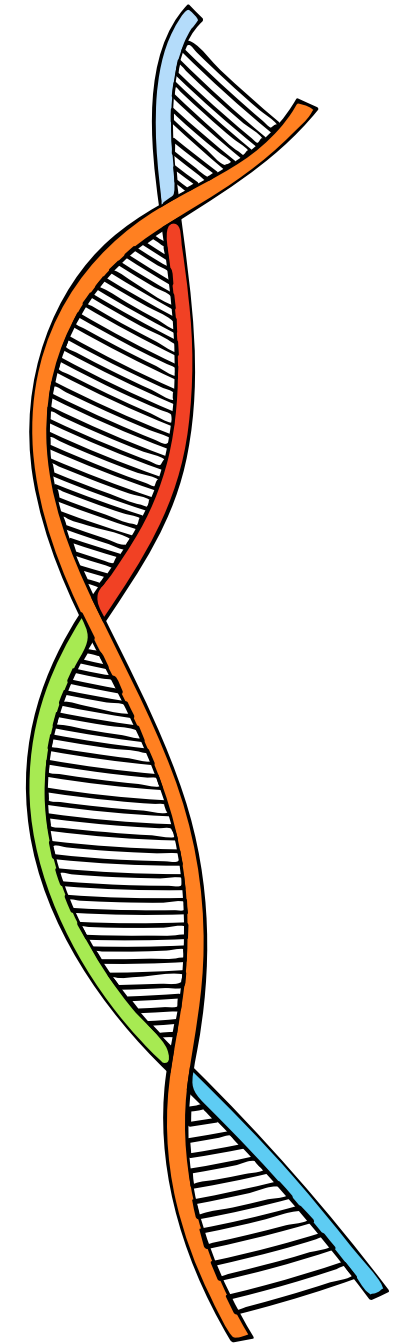
- Arrested for the murder of ex-wife Nicole Brown and her friend Ron Goldman.
- Led police on a much-publicized pursuit in his Ford Bronco.
- **Acquitted at criminal trial!**
- Evidence was not properly entered into chain of custody
- Bloody fingerprint not documented
- Other evidence mishandled
- Vial of Simpson's blood was tampered with
- Was evidence planted?
  - EDTA in collected blood
- Jury was confused by the DNA evidence



# When forensics goes wrong: Amanda Knox

- Arrested for murdering her roommate in Italy while on exchange
- Boyfriend was arrested too
- **Originally found guilty in 2007**
- Knox's DNA & that of the victim's was found on a knife
- Boyfriends DNA found on clasp of victim's bra (but not the fabric)
- Victim's boyfriend's DNA found on fabric of bra
- Excessive contamination of crime scene & evidence
- DNA was all insufficient to prove conclusive guilt
- **Acquitted in 2011**

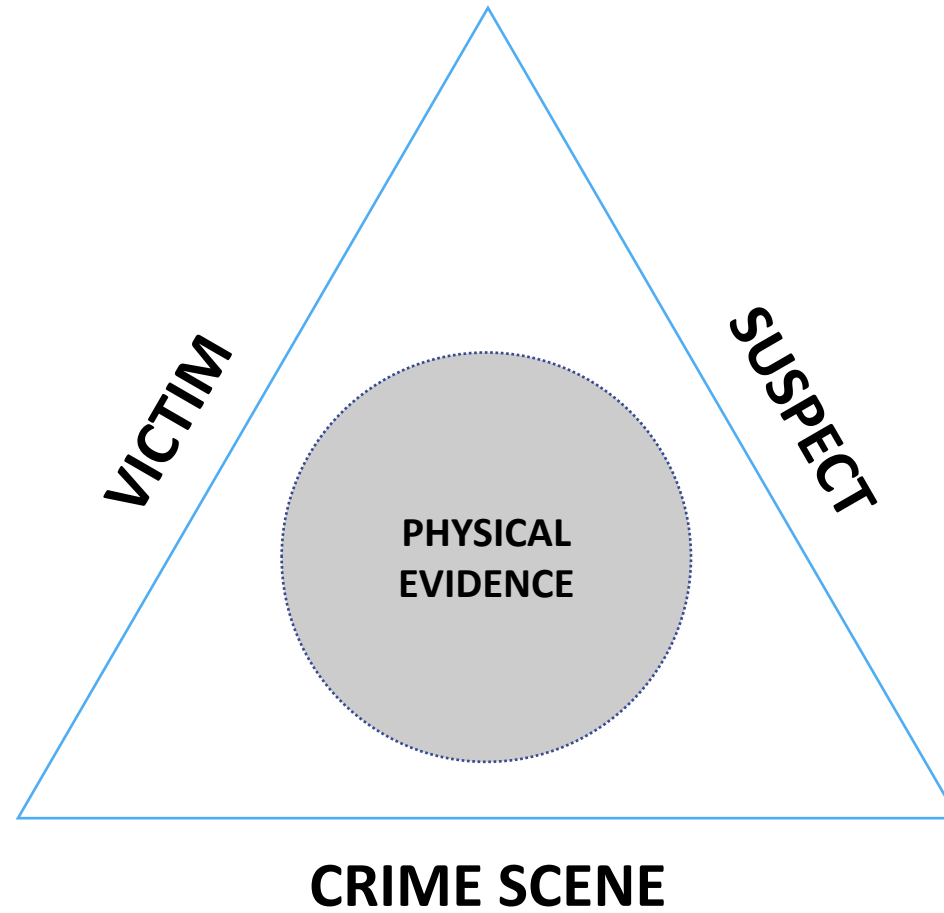




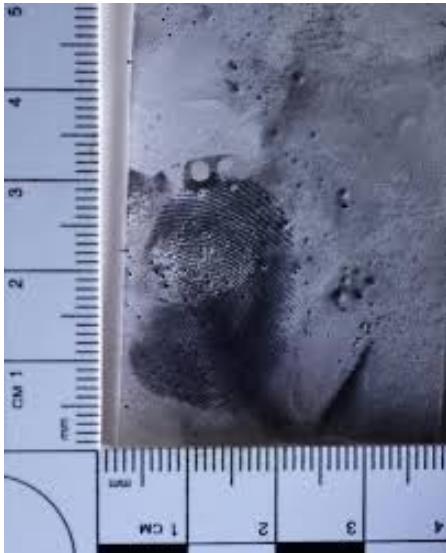
***Every contact leaves a trace.***

-- Edmond Locard, 1877-1966

# Locard's exchange principle

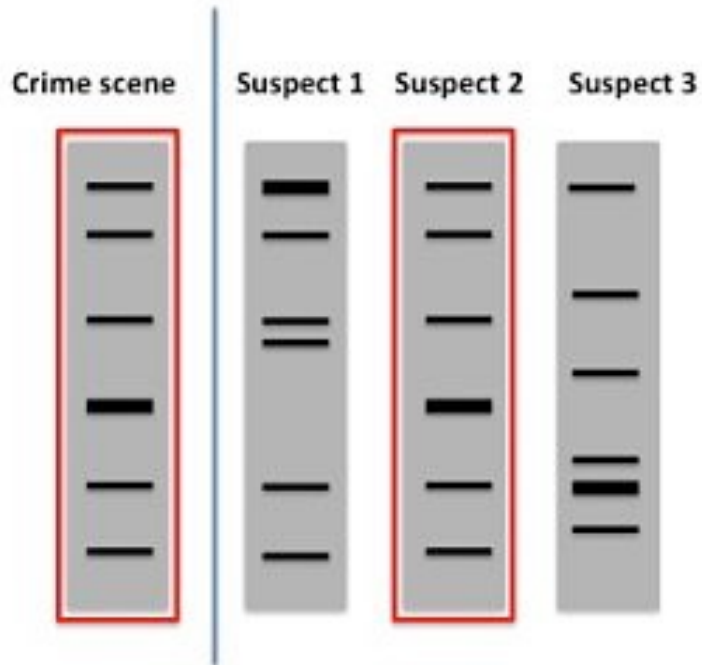


# Common sources of DNA at crime scenes



# DNA from one sample has little value

- In order for DNA to have any value when a crime occurs, **you need a sample to compare it to.**



## Contaminating DNA:

- Victim's DNA
- DNA of people who have been in the area
- DNA of crime scene investigators
- Animal DNA
- DNA of forensic analysts

# There is no such thing as a perfect match

- Even with a sample from the crime scene and a sample from a suspect, **there is no such thing as a 100% match.**
- There are 3 scenarios where you can't distinguish one sample from another:



## The samples came from the same person

The suspect you have tested is the guilty party.



## The samples came from two people with the same DNA profile

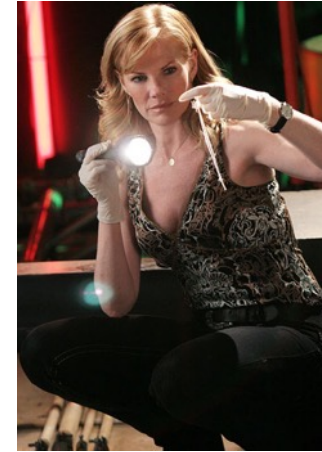
The suspect has the same DNA profile as the guilty person.



## The samples were contaminated

This happens more often than you would think!

# What is wrong with these pictures?



# Must use proper PPE!



# The time travel murder

- 1997: a woman is brutally murdered in London
- Evidence taken from the crime scene and at autopsy
- Fingernail cuttings underwent DNA analysis – there was a hit!
- Unfortunately, it was for another woman who had died 3 weeks before
- Forensic scientist Mike Silverman looked into contamination
- The scissors used to cut the fingernails had been used the day before to cut the fingernails of the previous murder victim!



# How does this happen?

- **Touch DNA:** DNA obtained from epithelial cells transferred to an object when it is handled or touched
- 1997 communication to Nature stated that DNA profiles could be identified from objects handled by several people and even people that did not handle the object

## DNA fingerprints from fingerprints 1997

Forensic scientists regularly generate genetic profiles from old blood stains, seminal stains, vaginal swabs, hair, bone, urine and cigarette butts<sup>1-6</sup>. We show that an individual's genetic profile can now also be generated from swabs taken from objects touched by hands, providing a new tool for crime scene investigations. Our findings also demonstrate the need for caution when handling exhibits and when interpreting results.

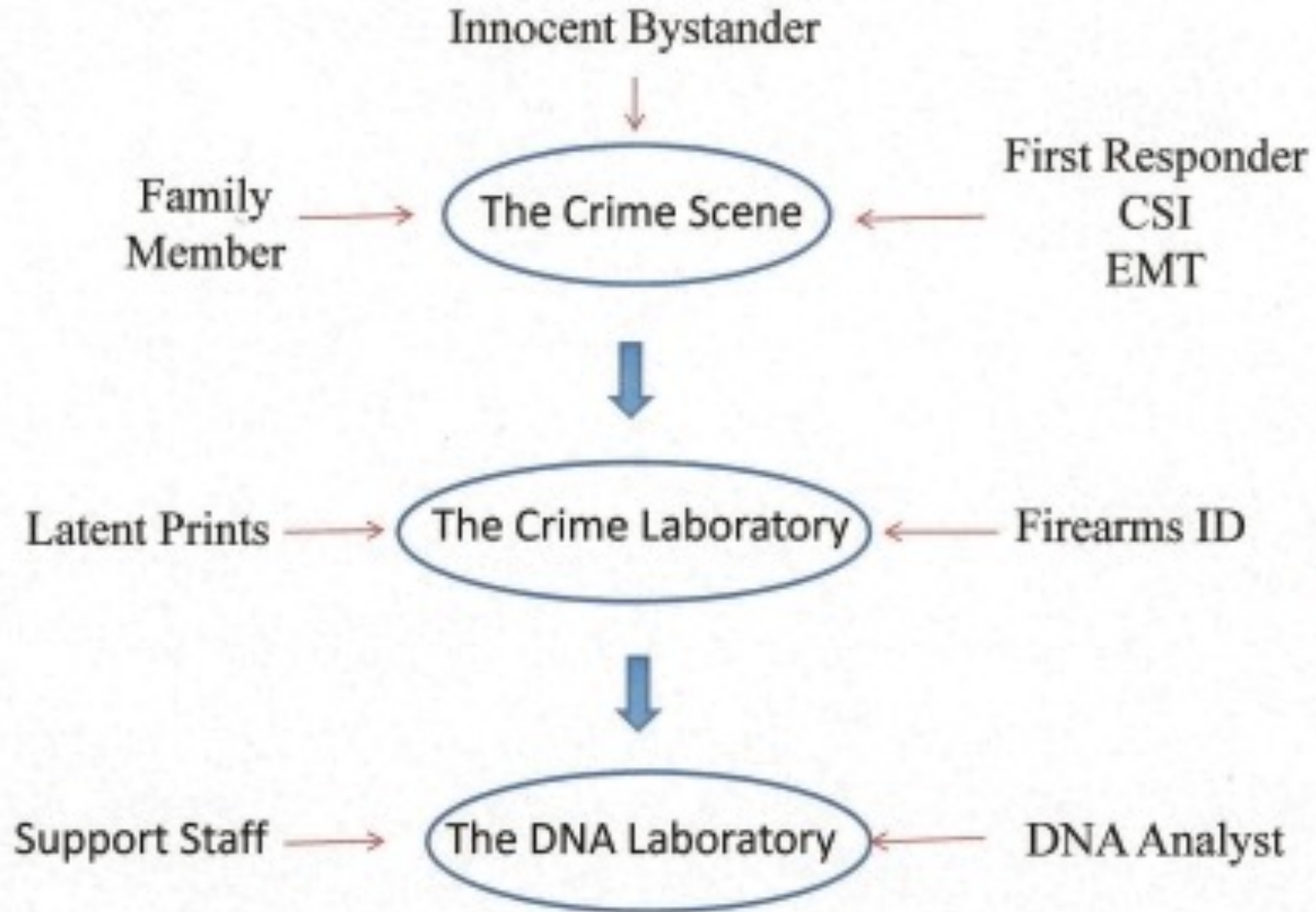
<https://www.nature.com/articles/42838.pdf>

# Lukis Anderson: Framed by his own DNA

- 2007 – a man is murdered during a burglary
- DNA found on the victim matched a known local homeless man who had been in the system before – Lukis Anderson
- However, he had been taken to hospital that night and was there during the time of the home invasion
- Anderson had been taken to hospital just hours before the murder by the same two paramedics that attended the murder scene
- **Secondary transfer** by the paramedics



# Huge potential for contaminating DNA



# Forensic genomics is not just for recent crime

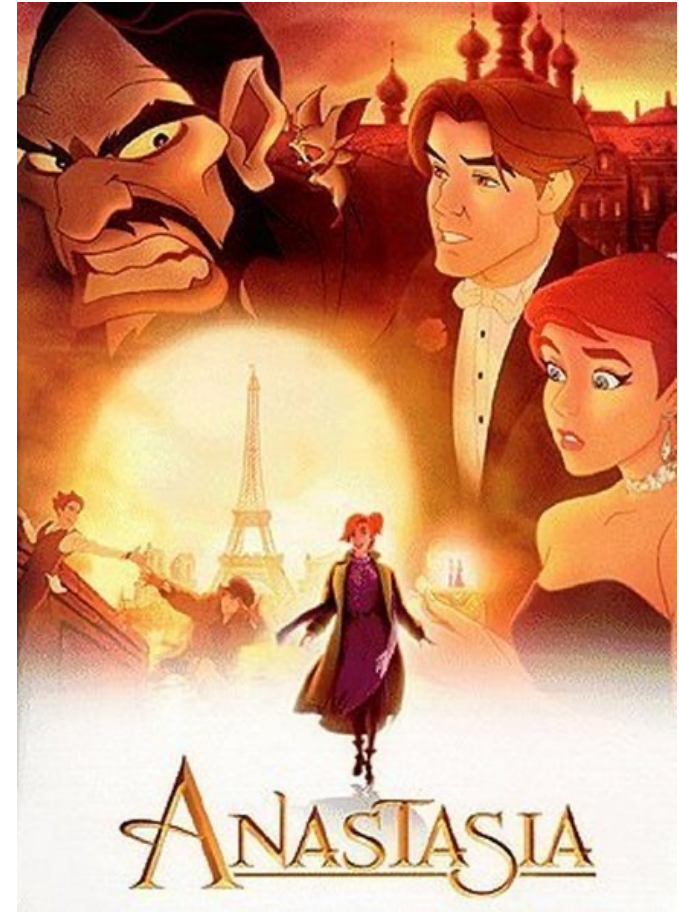
- Historical identification is possible using forensic genomics
- 1917 – Russian revolution began, the monarchy was abolished, Tsar Nicholas Romanov II abdicated and his family was placed under house arrest by the Bolsheviks
- 16 July 1918 – family executed



# Forensic genomics is not just for recent crime

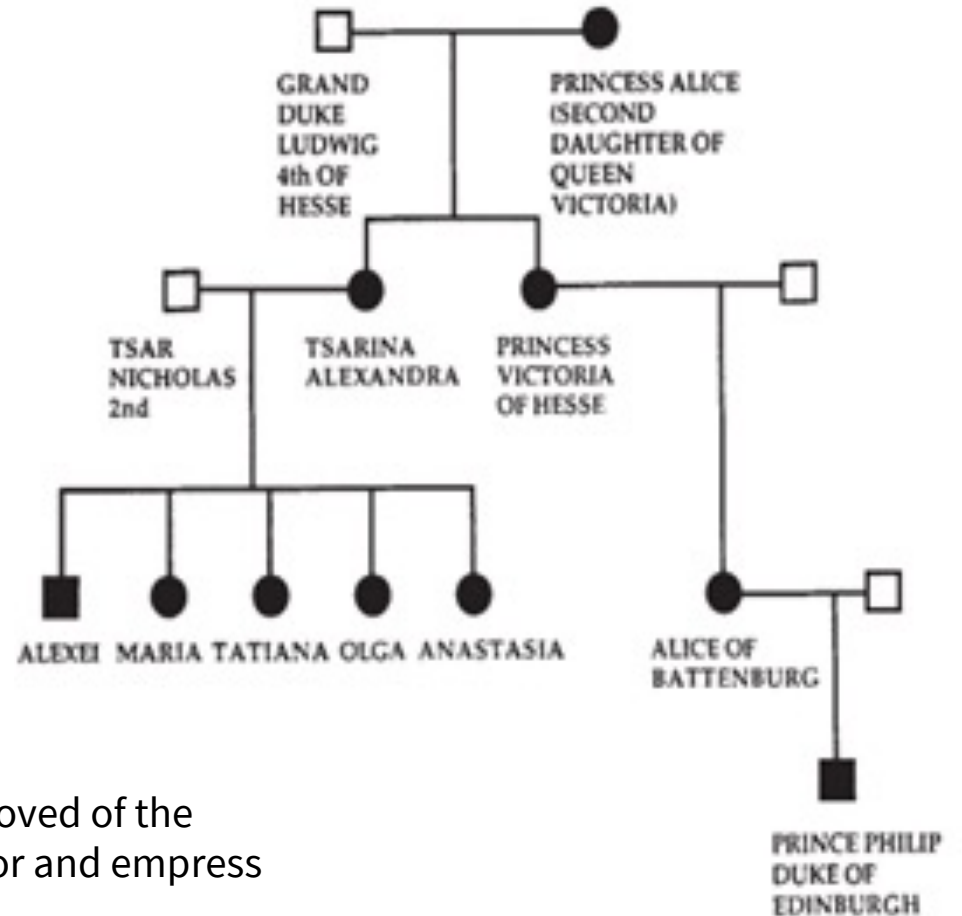
- The bodies had been taken to a mine shaft, burned, soaked in acid and discarded
- In 1979, remains found by an amateur historian
- The emperor, empress and 3 of their children identified using DNA analysis
- Son Alexei and one daughter (either Anastasia or Maria) were still missing

In 1997, Disney's romantic retelling of Anastasia's escape from Rasputin was made



# However...

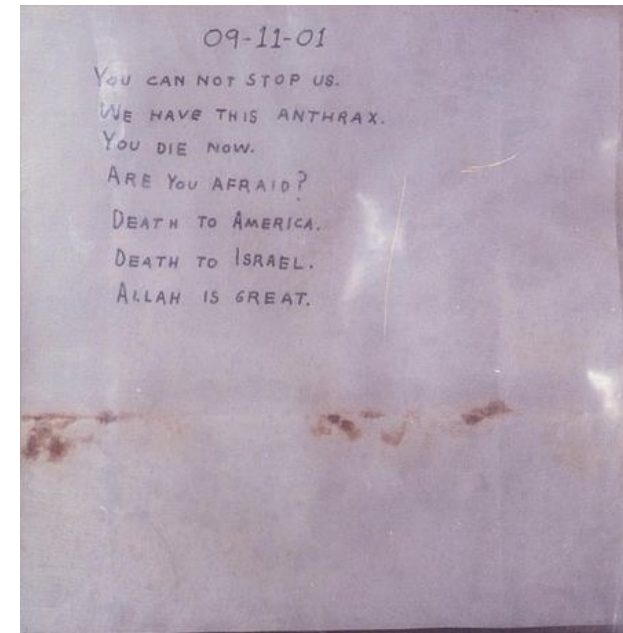
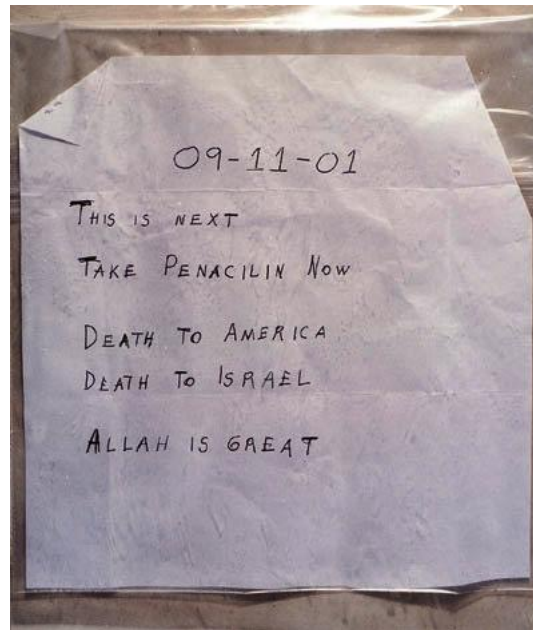
- In 2007, the bones of a boy and a young woman were found
- DNA analysis showed that the bones belonged to children of Nicholas II
- Additional DNA testing in 2015 showed that all remains were indeed those of the Imperial family



Prince Phillip is the first cousin once removed of the children and the great nephew of the emperor and empress

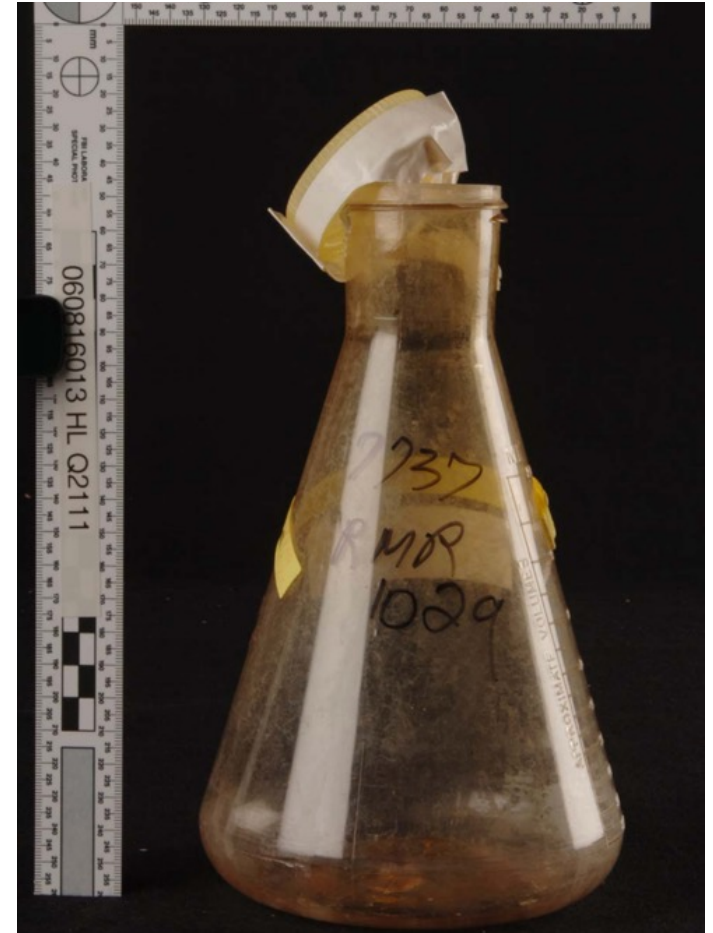
# Forensic genomics is not just for human crime


- All living organisms have DNA in their cells
- In 2001, the US was hit with a bioterrorism attack where anthrax spores were mailed to media offices and senators
- *Bacillus anthracis* – Gram-positive, rod-shaped bacterium
- Mortality rate for inhalation anthrax - 90%



# Forensic genomics is not just for human crime

- The media letters contained a brown material while the senators' letters contained a fine powder
- DNA testing performed on the anthrax spores including genome sequencing
- Mutations found within the sequences
- Spores identified as the Ames strand which was researched in 16 biolabs around the country
- Specifically identified as having come from flask RMR-1029





# Comparative Genome Sequencing for Discovery of Novel Polymorphisms in *Bacillus anthracis*

Timothy D. Read,<sup>1</sup> Steven L. Salzberg,<sup>1</sup> Mihai Pop,<sup>1</sup>  
Martin Shumway,<sup>1</sup> Lowell Umayam,<sup>1</sup> Lingxia Jiang,<sup>1</sup>  
Erik Holtzapple,<sup>1</sup> Joseph D. Busch,<sup>2</sup> Kimothy L. Smith,<sup>2</sup>  
James M. Schupp,<sup>2</sup> Daniel Solomon,<sup>2</sup> Paul Keim,<sup>2</sup>  
Claire M. Fraser<sup>1\*</sup>

Comparison of the whole-genome sequence of *Bacillus anthracis* isolated from a victim of a recent bioterrorist anthrax attack with a reference reveals 60 new markers that include single nucleotide polymorphisms (SNPs), inserted or deleted sequences, and tandem repeats. Genome comparison detected four high-quality SNPs between the two sequenced *B. anthracis* chromosomes and seven differences among different preparations of the reference genome. These markers have been tested on a collection of anthrax isolates and were found to divide these samples into distinct families. These results demonstrate that genome-based analysis of microbial pathogens will provide a powerful new tool for investigation of infectious disease outbreaks.

<https://science.sciencemag.org/content/296/5575/2028.abstract>

# Bruce Edward Ivins

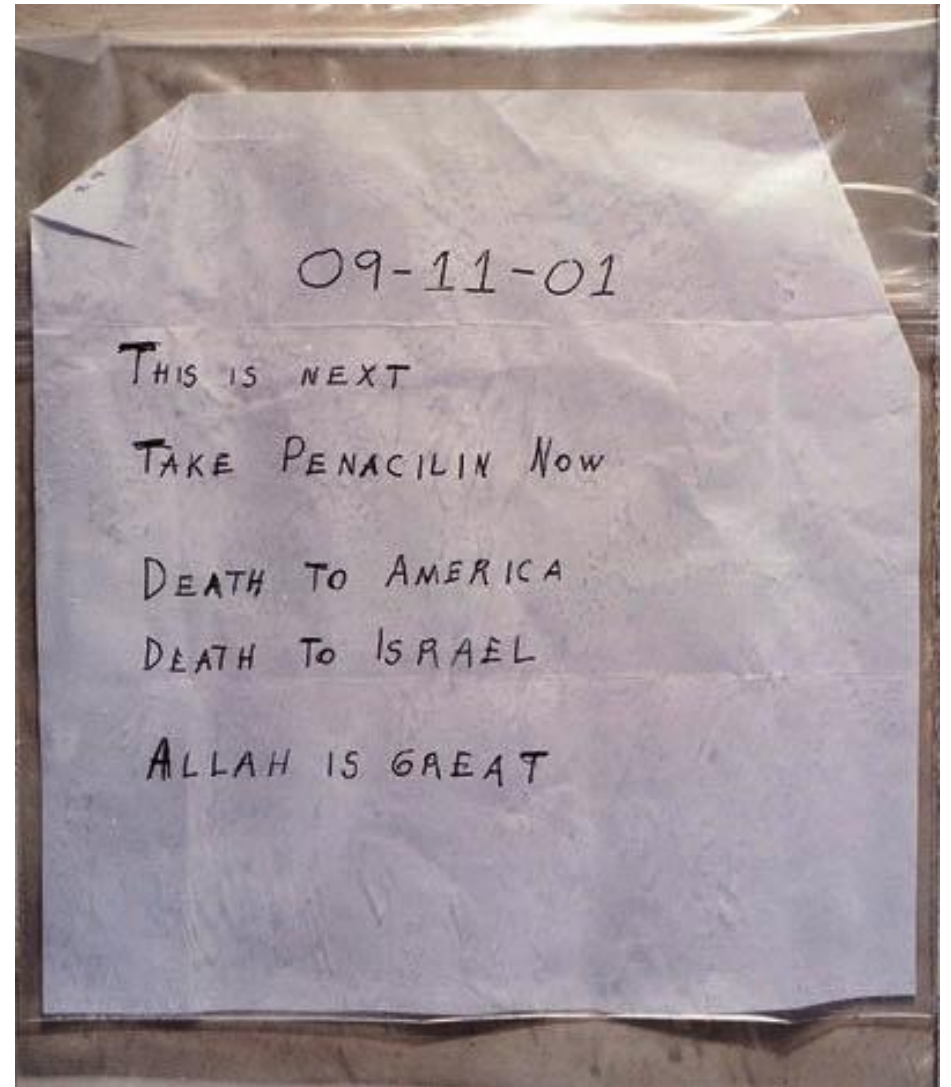
- Given the content of the letters, the act was first attributed to al-Qaeda
- However, the anthrax powder was “too consistent”
- An activist stated that the most likely person was an FBI or a CIA agent
- Bruce E. Ivins – senior biodefense researcher, microbiologist and vaccinologist
- In 2006 – declared the “sole perpetrator of the crime”
- Remember flask RMR-1029?

*"The genetically unique parent material of the anthrax spores... was created and solely maintained by Dr. Ivins."*



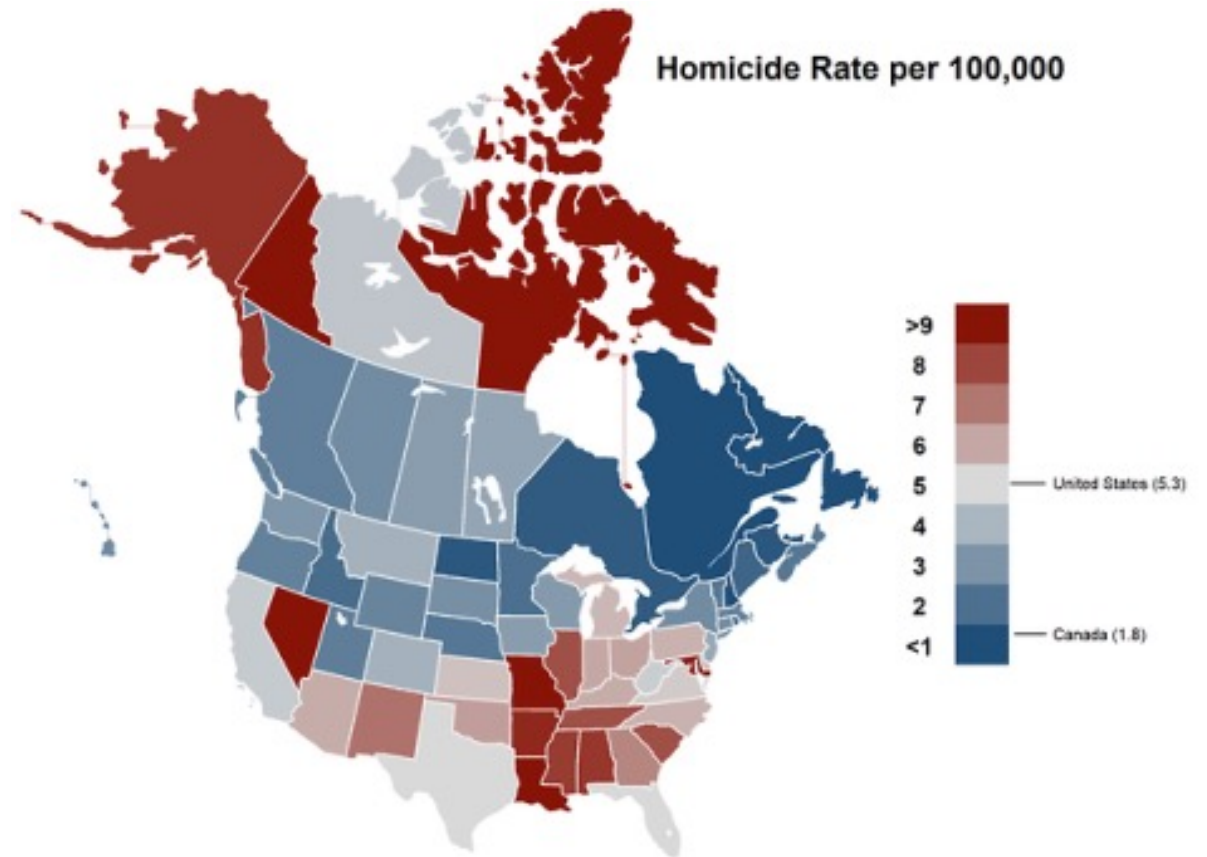
# So did he do it?

- Ivins made some damning statements to his therapists
- He pioneered the ability to distinguish the source of anthrax strains
- 75% of samples from the RMR-1029 flask were ID'd using his method
- BUT – others had access to the flask
- He was so angry about the investigation that he stated he was going to kill all of his co-workers and “go out in a blaze of glory”
- Sending secret messages??
- Committed suicide in 2008



# Forensic genomics: why do we need scale?

- Canada has a higher than average rate of homicide than other countries (though not the US)
- Scale allows us to reduce backlogs
- What if a disaster happens?



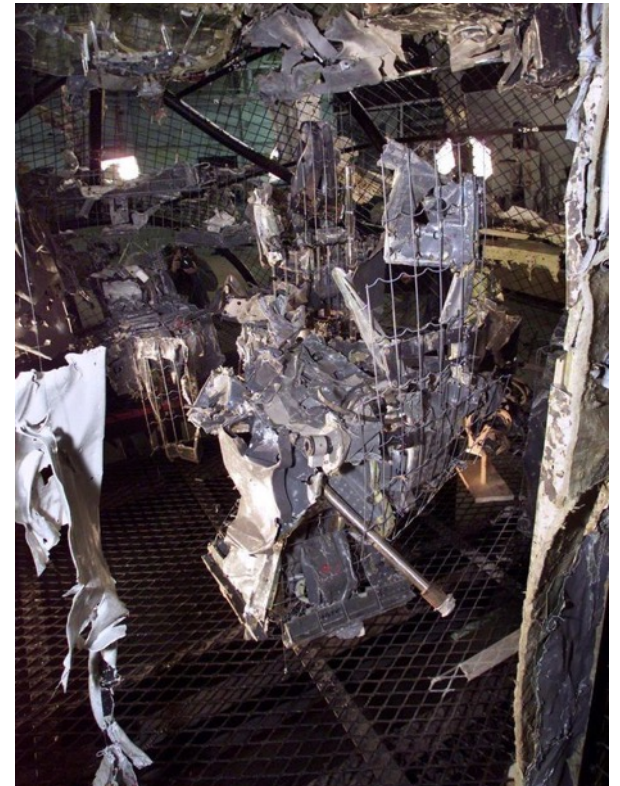
# Swissair Flight 111

- 2 September 1998
- 229 passengers and crew heading to Geneva, Switzerland from New York
- 52 minutes after takeoff – crew smells an odor in the cockpit
- Flight redirected to Halifax Intl. Airport
- Crew turned off power to cabin per protocol, fire then spread to cockpit
- Plane struck the ocean at 555 km/h
- Disintegrated instantly, killed all on board



# Swissair Flight 111

- Body parts recovered by divers – over 15,000 parts
- Next of kin contacted for dental records, blood samples
- Police from 12 countries searched victims' homes for items that might contain DNA for comparison
- Over 100 victims were identified using DNA profiling on 1,370 samples
- It took only 10 weeks!



# RCMP forensic backlogs

Canada

## Backlog, quality concerns plague RCMP DNA testing: AG



CBC News · Posted: May 01, 2007 2:27 PM ET | Last Updated: May 1, 2007

The RCMP's forensic labs are failing to provide timely DNA analysis in a high percentage of cases, including some involving murder and other violent crimes, according to Canada's auditor general.

In a highly critical report Tuesday, Sheila Fraser said the force's Forensic Laboratory Services frequently miss their deadlines, contrary to assurances from senior Mounties who testified at parliamentary committees.



# RCMP forensic backlogs

## RCMP forensic lab ‘drowning in work’ as it misses all response targets, internal figures show

By SAMANTHA WRIGHT ALLEN [DEC. 12, 2018](#)

Lawyer Rick Woodburn says prosecutors have to wait too long for samples from the lab, leading to worrying court delays and cases being thrown out.

# RCMP forensic backlogs



**SPECIAL SERIES**

## B.C. police investigations slowed as backlogs hit evidence processing



FILE (CityNews Image)

**By Sonia Aslam**

Posted Nov 7, 2022, 6:21AM PST. Last Updated Nov 7, 2022, 7:02AM PST.

# Your role as a forensic genomics expert

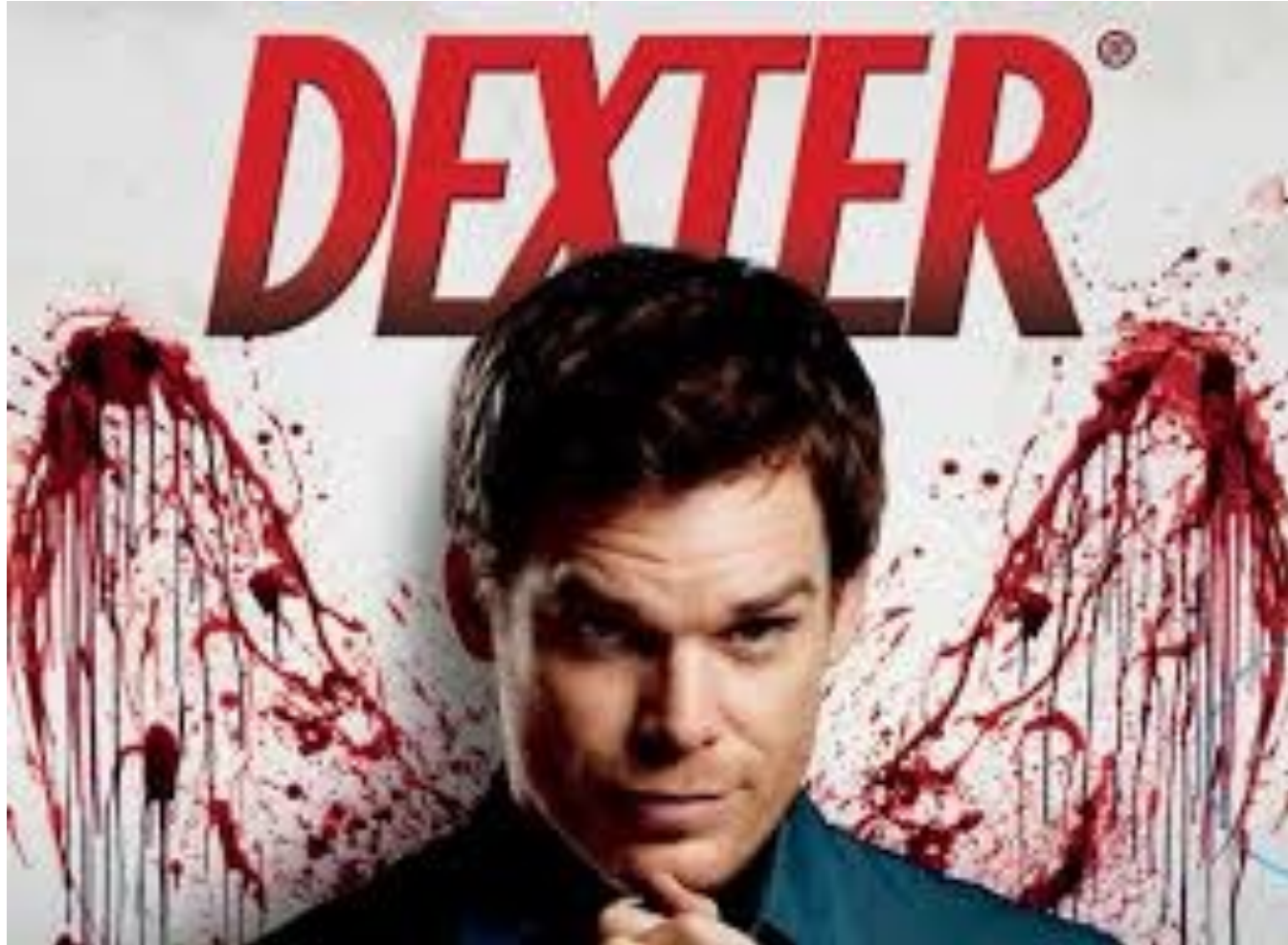
- You will be an expert at one thing
- You won't work on one case at a time
- Cases will take months if not years to finalise
- You will receive very little follow up



TV needs a nice tidy package in order to be entertaining!

Real life is much more mundane.

# This is not really forensics



- Blood spatter expert
- Crime scene photographer
- DNA analyst
- Crime scene technician
- Toxicologist
- Serial killer

# Summary

- Forensics is the application of science to law
- Forensics is centered around the idea that all contact leaves a trace
- Forensic genomics is DNA analysis at scale
- There are many potential sources for DNA evidence at crime scenes
- For DNA to have any evidentiary value, there must be a sample to compare it to

## Optional reading:

- Fundamentals of Forensic Science Chapter 1 – **Introduction to Forensics** (available on Canvas)
- Fundamentals of Forensic Science Chapter 2 – **Crime Scene Investigation** (available on Canvas)