

# Introduction to biomedical forensic science



UNIVERSITY OF CAPE TOWN  
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Division of Forensic Medicine  
& Toxicology

Introduction to forensic science.

This is the first in a series of forensic science lectures designed to introduce you to scientific principles applied in medicolegal investigations. Forensic science refers to use of science in the field of law, in this case, criminal law. Different kinds of forensic investigators have different roles, these may include analysing crime scenes, performing autopsies or conducting tests in a laboratory. While their exact roles may differ slightly, they have the one thing in common: they use scientific techniques to find, gather and analyse evidence that can be used in court.

## Navigating these lectures



The science



The evidence



The reports

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The use of forensic science in medicolegal investigations will be described using the South African context as an example. Some foundational principles critical to understanding evidence collected, processed and analysed by scientific experts will be described. The first series of lectures titled “The Science” will be centred around understanding the science used in medicolegal investigations. The second collection of lectures titled: “The evidence” will describe the scientific procedures used to collect, process and analyse evidence. The third series of lectures “The reports” provide a practical explanation of the science presented in some reports relating to cases of suspected sexual assault and homicide. In addition to these lectures, there are a series of Spotlight videos, which provide quick answers to frequently asked medicolegal questions.

# Forensic science



Application of science to legal matters.



Collection, examination, and analysis of physical evidence.



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So what is biomedical forensic science? This involves the application of science to legal matters. It also involves collection, examination and analysis of physical evidence. Different kinds of forensic investigators have different roles like analysing crime scenes, running tests in a lab.

Generally forensic scientists have an undergraduate degree in a scientific field like chemistry, genetics or biology or a more targeted degree in forensic science itself. Some have a postgraduate degree too. Forensic pathologists have a medical degree.

# Medicolegal investigations

- In response to a suspected criminal offence.
- Who? What? When? Where and How?
  - Evidence collection.
  - Evidence analysis.
  - Reporting: Affidavits or testimonies.



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That is the use of medical knowledge about human body, its function and appearance and applies it to a legal context. In the event a suspected criminal incident, medicolegal investigations aim to answer the following questions: Who is the affected person? What exactly happened? When did this incident happen? Where did it happen? Did someone cause this to happen or do this to another person? Medical knowledge is applied to evidence collection, analysis and reporting. Medicolegal investigations use medical knowledge about human body, its function and appearance and applies it to a legal context.

## The South African legal context



- Inquests Act (No. 58 of 1959, as amended, 1996).
  - Procedures followed in cases of death due to unnatural causes.
  - Authorised by a magistrate.
  - Does not require consent.
- National Health Act (Act 61 of 2003).
  - Medical investigation of natural deaths.
  - Requires consent of deceased or next-of-kin.



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Before someone we explore the science, medicine, and investigative techniques used in a medicolegal death investigation, it is important to understand the legal mandate and confines of the system in which one operates.

In South Africa, investigation of deaths due to unnatural causes is mandated by the Inquests Act (no 58 of 1959, as amended in 1996). This Act provides for procedures to be followed in cases of death due to other than apparent natural causes

- All unnatural deaths must be reported to police.
- Unnatural deaths include homicides, suicides, fatal accidents , unexpected or unexplained deaths, and procedural-related deaths. It is estimated that approximately 60% of unnatural deaths in South Africa are murders.
- It is authorised by a magistrate, regardless of familial or next of kin consent to determine identity of descendants, time and place of death, cause of death, manner of death and liability of person/s.

The National Health Act (2003) provides for the medical investigation of natural deaths, these require consent of deceased prior to death or the next-of-kin. It also stipulated categories for the unnatural death. The supplement to this Act is called the Rendering of Forensic Pathology Services.

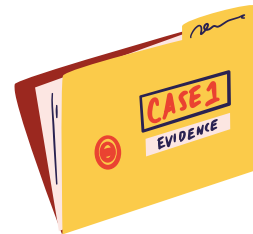
# Medicolegal systems



Judicial inquiries/inquests



Medical investigations

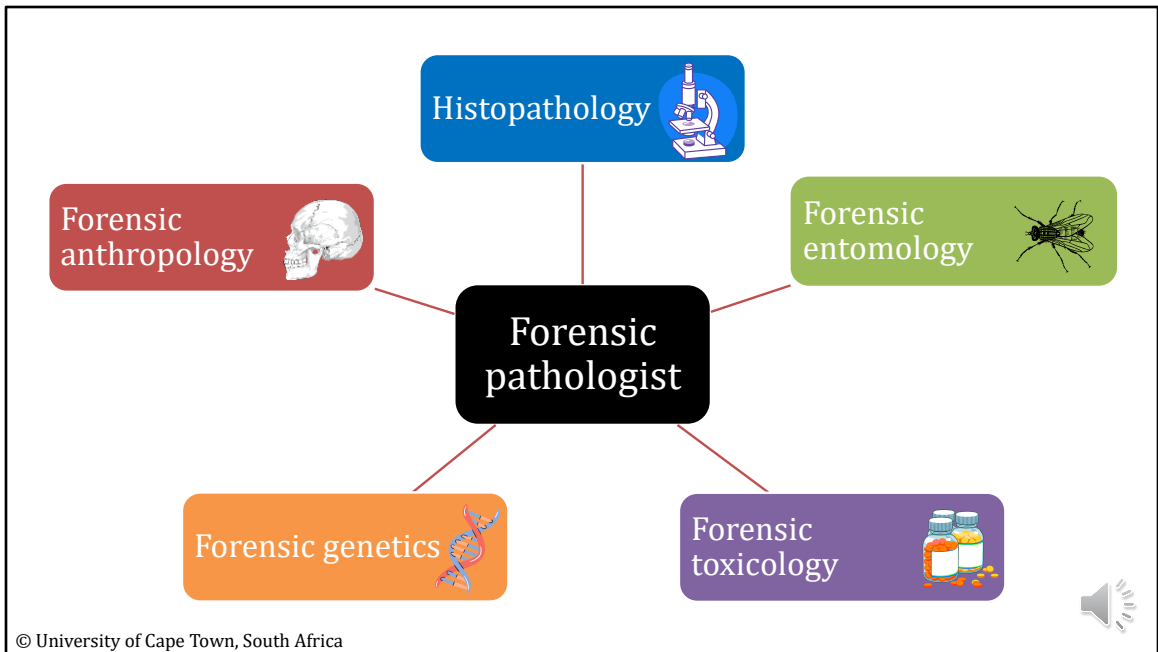


Criminal investigations

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Medicolegal death investigative systems vary worldwide, despite they generally represent three main arms in medicolegal investigation: judicial inquiries, medical investigations and criminal investigations. Death investigations are carried out by coroners or medical examiners in the USA and some parts of the UK. In Africa, several countries use a hybrid while in others use a hybrid Medicolegal Death Investigation (MLDI) system involving a Coroner and Medical Examiner system. In Zambia, coroners are magistrates tasked with conducting inquests into deaths. When unnatural deaths are suspected, a Coroner will order an autopsy from the Office of the State Forensic Pathologist (OSFP) to determine the cause and manner of death. Coroners and Medical examiners fall under the mandate of the Department of Home Affairs in Zambia. This system is different in South Africa where magistrates conduct inquests into unnatural deaths. The medical investigations of unnatural deaths are conducted by State Forensic pathologists and criminal investigations by the police. In the event of a suspected sexual offence or assault in a living individual, criminal investigations are conducted by the police (SAPS) and medical examinations by doctors or forensic nurses at stationed at clinical forensic units or emergency facilities. Some countries have established centralised centres for victims of sexual offences. In SA, Thuthuzela centres, and provide all the necessary medical support for the victims of sexual assault, while ensuring evidence is collected correctly.



In medicolegal investigations, a forensic pathologist may request the services of experts in different fields. Forensic pathologists are tasked with conducting autopsies of deceased individuals. They may require the help of forensic entomologists who are trained to use insects to estimate post-mortem interval, while forensic toxicologists can help determine the presence or absence of certain substances in the human body. Histopathologists provide confirm macroscopic findings linked to diseases or cause of death. Pathologists may send samples of hair, urine, blood or tissue to a forensic toxicologist to assess the presence of various substances in the body. Forensic geneticists process samples to detect the presence of DNA and compile a profile of DNA samples. This is useful in identifying decedents and perpetrators. Forensic anthropologists are experts in bone, also called hard tissue, and they may be called upon to facilitate in generating a profile of a decedent, assist with trauma analysis and post-mortem interval estimation. There are also other fields such as medical microbiology, virology, criminology and odontologists.

# Forensic Pathology

- Medicolegal death investigation under the Inquests act
- Cause of death (opinion on a manner of death)
- Postmortem interval
- Identity



Forensic entomology



Histopathology



Forensic genetics



Forensic toxicology



Forensic anthropology



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Forensic pathologists are medical doctors tasked with the investigation of unnatural and sometimes natural deaths. They are medical doctors, which means they spend six years of medical school, one year of internship under supervision, two years of COSMOS (community service medical officer service) and four years of registrar training at a medical school. There are several services that they may request as part of their medicolegal investigation, the role of the forensic pathologist is to estimate the cause of death based on evidence obtained at autopsy. They are also involved in estimating a post mortem interval which is when someone dies. This is determined relative to the body was discovered. They are also provide a possible identity description of an individual when a body is severely decomposed



# Histopathology

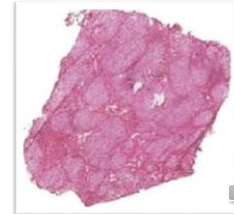
- Tissue samples taken during autopsy
  - may determine cause and manner of death
- The forensic histopathologists role includes:
  - Confirming macroscopic findings.
  - Detecting/excluding pathology.
  - Establishing/confirming cause of death.



Normal liver



Cirrhosis



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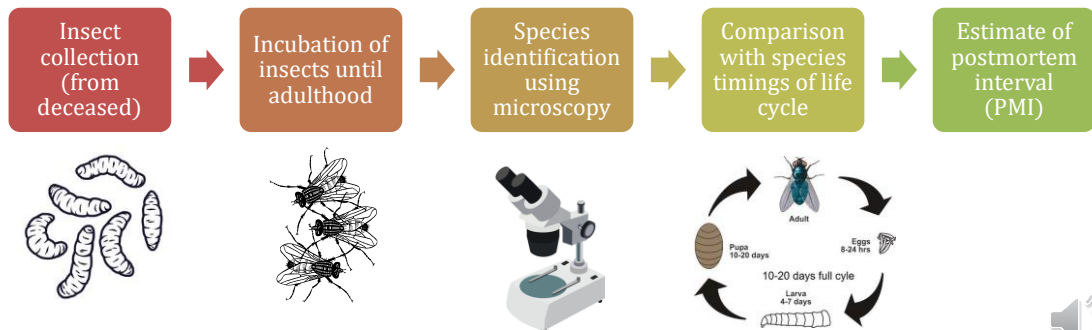
(Histology from (Naour, Sandt *et al.* 2012))

Histopathologists may be asked to assess tissue samples taken during autopsy. These samples are preserved in formalin and taken to the laboratory, where they are cut into thin sections and mounted on slides. Slides are viewed under magnification to assess pathology. Histology analysis may prompt postmortem further toxicological investigation. The forensic histopathologists role includes confirming macroscopic findings, detecting/excluding pathology, establishing/confirming cause of death.

This mounted sample can be a source of DNA of the deceased if no other source is available.

# Forensic entomology

- Use of insects and arthropods as evidence
- Postmortem interval (PMI) of the deceased



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Forensic entomology involves the use of insects and other arthropods biology to criminal matters. Shortly after death, insects are attracted to the decomposing body and may lay eggs in it. By studying the insect population and the developing larval stages, forensic scientists can estimate the post-mortem interval, which is the time interval between death the discovery the body. Entomology can also be used at the crime scene to identify change in position of the corpse.

Generally, insects (mostly maggots, beetles and blowflies) are collected from the deceased. They are incubated until adulthood. The species can then be identified using microscopy. Comparison with the known timings of the specific species' life cycle is used to estimate a postmortem interval.

# Forensic toxicology

- Presence and quantity of substances in blood, urine and hair.
- Cause and manner of death/circumstances surrounding incident

What substance is present?  
(Qualitative)

How much of it is present?  
(Quantitative)

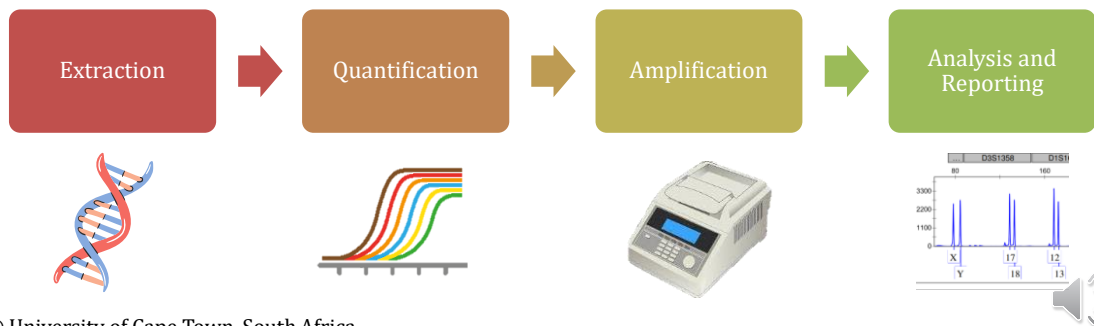


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A pathologist send samples to a forensic toxicologists to assess the presence of various substances, including drugs, toxins and poisons. Forensic Toxicologists can also provide valuable information for understanding the cause or manner of death and circumstances surrounding incident.

# Forensic genetics

- Presumptive tests for body fluid identification
- DNA profiling using STR analysis



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Forensic geneticists are trained to generate profile from DNA present in a sample so that this can be matched to an individual. DNA is the molecule that makes you who you are. Everybody except for identical twins have their own unique code. So if you have a DNA sample, that is a very good way to identify someone. They don't just sequence all your DNA, but conduct an STR analysis. Everyone's DNA has certain sections with repeating patterns of base pairs, but the number of times the pattern repeats itself varies from person to person. As this process is both costly and time-consuming, the first step often involves conducting a presumptive test on a stain, to determine if it is biological in nature. Hereafter, the DNA is extracted, quantified, and analyzed to generate a profile.

# Forensic anthropology

- Analyse bones

Biological profile

Individualising characteristics

Trauma analysis

Taphonomy



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Forensic anthropologists are called upon when skeletonized, severely decomposed and burnt remains are found. They are experts in analyzing bones and can generate a biological profile of a deceased individuals, identify individualizing characteristics to help with identification. In addition to this, their knowledge of bone biomechanics can be useful in analyzing trauma, the order of impacts to a bone or minimum number of blows. They can also provide information about the taphonomy or changes to the body since death that can be useful in estimating postmortem interval.

## The report

- Criminal Procedures Act (Act No 51, 1977).
- Affidavits and reports submitted under section 213 and 212 are accepted as *Prima facie* evidence.
  - Reported “facts” must be established by the deponent.
  - Statement of examination or process used to determine “facts”.
  - Statement of skills in one/or several fields linked to evidence.

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The abovementioned experts may write a report that can be presented as evidence in court. In criminal proceedings in South Africa, expert evidence is permissible on a large number of topics. Section 212( 4 )(a) of the Criminal Procedure Act, refers to facts established by any examination or process requiring any skill in biology, chemistry, physics, astronomy, geography, anatomy, human behavioural sciences, any branch of pathology or toxicology, or the identification of finger-prints or palm-prints. This section provides for the reception of affidavits and certificates, related to such subjects, on their production as *prima facie* proof of their contents.

- The fact(s) sought to be proved must have been established by an examination or process requiring any skill in any (of several fields)
- The deponent must explicitly allege in the affidavit *that (s)he* has established such fact(s) by means of such an examination or process and must indicate which skill(s) was/were required

Section 213 of this act provides for the admissibility of an affidavit or a written statement by any person, other than the accused, and thus forensic experts are not always required to testify in court and their reports may be presented under Section 213 of this act. These reports or affidavit are considered *prima facie* until proven otherwise.

Voice over: Elizabeth Dinkele

Slide design: Elizabeth Dinkele & Dr Laura Heathfield



**CRIME SCENE DO NOT CROSS**

Slides provided by the Division of Forensic Medicine and Toxicology,  
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