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# Academia Open



*By Universitas Muhammadiyah Sidoarjo*

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## Review on Forensic Chemistry: Importance in Identifying Unidentified Bodies and Mass Graves and Missing Persons: Perancangan Model Pengembangan Pariwisata Perkotaan yang Berkelanjutan untuk Karbala didasarkan pada Aspek Sosial, Budaya, dan Keagamaan Kota Karbala

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### Abstract

**General Background:** Forensic chemistry plays a crucial role in criminal investigations by analyzing non-biological evidence and supporting identification processes. **Specific Background:** In cases involving mass graves and missing persons, forensic chemistry works alongside forensic anthropology to identify skeletal remains and reconstruct events. **Knowledge Gap:** Despite growing attention, there is limited integrated understanding of how forensic chemistry techniques support identification in complex mass grave contexts. **Aims:** This study reviews the role of forensic chemistry in identifying unknown bodies and analyzing mass grave evidence. **Results:** The findings highlight that forensic investigations rely on evidence collection, skeletal analysis, age estimation methods, and advanced imaging technologies to support identification processes. **Novelty:** The study integrates forensic chemistry principles with anthropological and technological approaches in the context of mass grave investigations. **Implications:** The results emphasize the importance of multidisciplinary approaches and technological advancements to support accurate identification and provide answers for affected families.

**Keywords:** Forensic Chemistry, Mass Graves, Skeletal Identification, Forensic Anthropology, Crime Scene Analysis

### Key Findings Highlights

Evidence collection procedures form the basis of identification processes  
Advanced imaging supports detailed skeletal examination  
Multidisciplinary collaboration strengthens investigative outcomes

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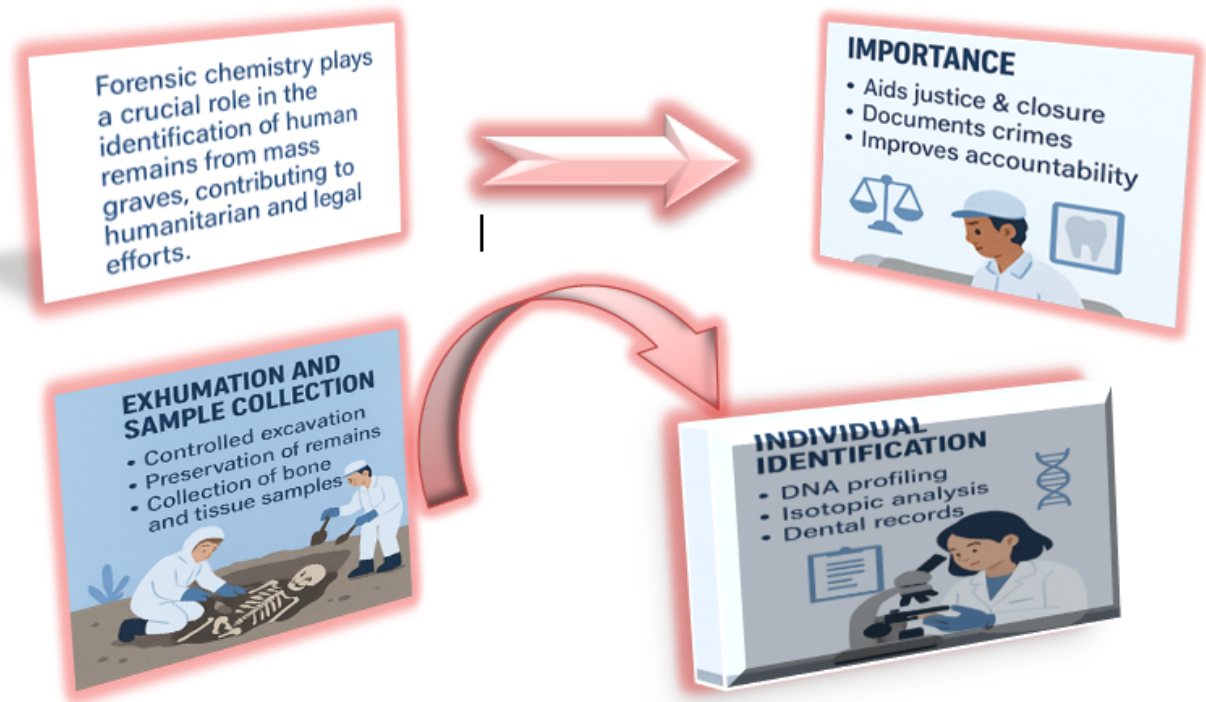


Figure 1.

## Introduction:

Forensic chemistry as the branch concerned with the analysis and examination of non-living materials related to crime elements was witness huge attentions in the mid-twentieth century. The concept of this branch is often confused with forensic medicine, [1] although both are closely related to crimes of various types, forensic medicine differs from forensic chemistry in its function, as it specializes in the analysis and examination of biological elements such as DNA and blood. [2] Forensic chemistry relies on and examining the chemical composition of crime scenes, such as pieces of glass, fabric, explosives, and fire-fighting agents, in addition to examining various types of toxins. [3] The identification of the missing and justice for victims in mass graves is a long and complex process that requires a comprehensive approach involving forensic science, legal frameworks, and community engagement. Governments and civil society can help to ensure that victims are identified, perpetrators are held accountable, and communities can begin to heal. [4].



Figure 2. **Fig. 1.** The photos for general proposed steps for detecting and primary identification bodies in crime scene.

### 1.1 Forensic Chemistry Fields Forensic chemistry is applied in the following cases:

In this section we highlight in general cases which is first: Murder, robbery, and bombings, Arson, where it detects the materials used for starting the fire, Rape cases, detecting driving under the influence of drugs or alcohol, [5] . the second cases : Detecting the causes of death, whether natural or due to other factors, such as an overdose. The third cases: Detecting the type of poison causing death, examining fingerprints to identify the perpetrator. Fourth cases:[6],Detecting forgery in documents and paperwork, detecting counterfeit banknotes and determining standards for monitoring narcotic substances in circulation. [7]

The Identifying skeletal remains from mass graves is a common task for forensic experts investigating human rights crimes as Shown in **Figure (1)**. The critical task challenging, which, regardless of the amount of time that has passed since burial. According to the Geneva Conventions, the primary objectives of these investigations are to identify victims and return their remains to their families. [8] Typically, a missing person's positive identification is achieved by comparing findings with ante mortem information about the missing person. [9] This data includes general anthropological factors, particularly pathological features and skeletal trauma, such as bone diseases, deformities, and injuries, as well as medical and dental history. [10] Identification requires knowledge of the person's sex, age, height, and other physical characteristics. The individualization process may also benefit from life histories and witness accounts, particularly information regarding victims' clothing and personal effects, conditions at the time of death, and manner of death. [11]

The long period between death and skeletal recovery, the detrimental effect on witnesses' memories, the quality of the preserved identifiable data, and the fact that mass graves contain skeletons of homogeneous groups, such as young men wearing clothing, reduces the likelihood of obtaining this information for war victims. [12]. In some circumstances, such as when only one person is buried in a grave or when skeletal remains are cataloged, it is easy to determine how many people are represented by a particular skeletal group. Some academics focus on identifying the person in these situations by making assumptions about their sex, age, height, and, in some cases, their race or demographic affiliation. However,

individuals are often not maintained as distinct units [13], due to dating is widely used in archaeological work, when excavating ancient and historical skeletons, as well as the survival of these tissues (when most of the soft tissues have decomposed) [14].

Age at death and year of birth determination in forensic cases are essentially two sides of the same problem. The most common techniques are sometimes referred to as age-at-death procedures because many of them were created for use in archaeological anthropology. [15] It is rarely possible to place an archaeologically discovered person into a precise chronological context (unless, for example, (Through tombstones, inscriptions on coffins, coffin slabs, etc.) as reported in **Figure (2)**). However, in forensic cases, age at death is often converted to a probable year of birth (or a range for this), as this is part of the information that can be recorded and thus lead to identification [16].

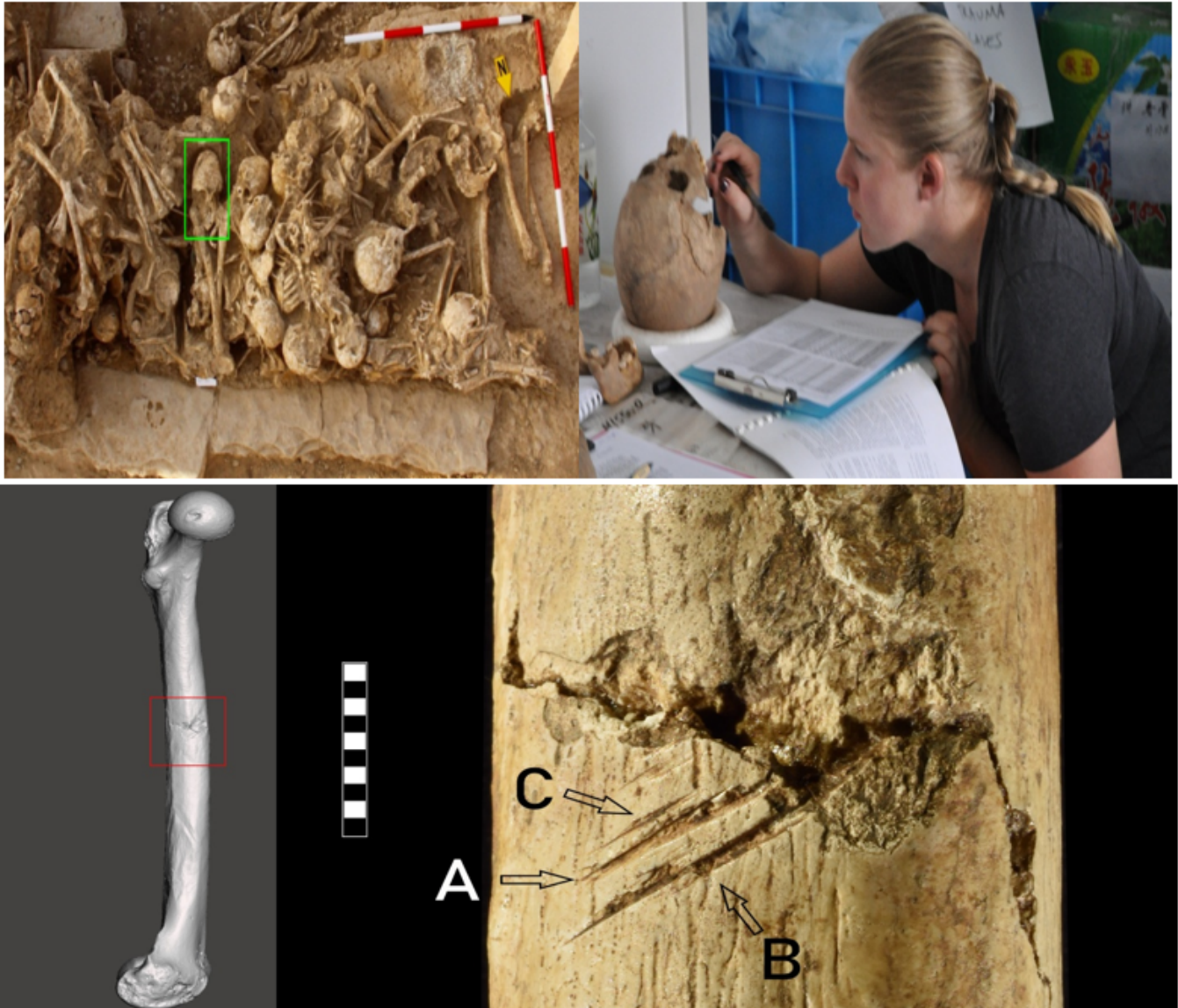


Figure 3. **Fig. 2. The photos for primary identification of remaining bones in forensic lab.**

## 1.2 Mass graves:

There is currently no universally accepted definition for a mass grave, but forensic specialists commonly describe it as a burial site containing the often-commingled remains of multiple individuals typically six or more that may include men, women, children, or even entire families [17]. As illustrated in Figure (3), investigators from the international war crimes tribunal unearthed a mass grave near the village of police in Bosnia and Herzegovina in September 1996, revealing the remains of over 100 individuals who had been executed [18]. Mass graves continue to serve as grim evidence of armed conflict and serious human rights abuses, and their emergence has become increasingly prevalent in recent years. For survivors, uncovering the truth about the fate of their missing relatives is not only a deeply personal need but also a legal

right protected under both international and national frameworks. These frameworks mandate the pursuit of truth, justice, and reparations [19]. States are legally obligated to support survivors by ensuring that victims' remains are properly identified and returned to their families for dignified burial and appropriate commemoration [20].



Figure 4. **Fig. 3.** Photo for the Crimes Tribunal work at a mass grave where they discovered the remains of more than 100 executed people.

### 1.3 Evidence Collection and Forensic Site Assessment:

Forensic site assessment includes gathering information such as location, time spent in the grave, approximate date of grave, origin, and other information about humidity, weather, and molecular needs. Figure 4 reported the Anthropological remains are requested by Friendship Team members. [21] after collection the evidence from crime scene, firstly should the forensic worker make the primary identification which is physical identification before translate forensic labs.

### 1.4 Identification of the Missing and Justice

Identifying victims in mass graves and ensuring justice involves a multi-faceted approach combining forensic science, legal frameworks, and humanitarian efforts. This includes establishing protocols for excavation, exhumation, and identification, often utilizing DNA profiling, as well as addressing the broader need for truth, justice, and reparations for families and affected communities. Mass graves provide many answers. They tell the story of what happened to peoples and when in addition to confirm stories about who bears responsibility. These answers are essential to promoting reconciliation and justice. [22]

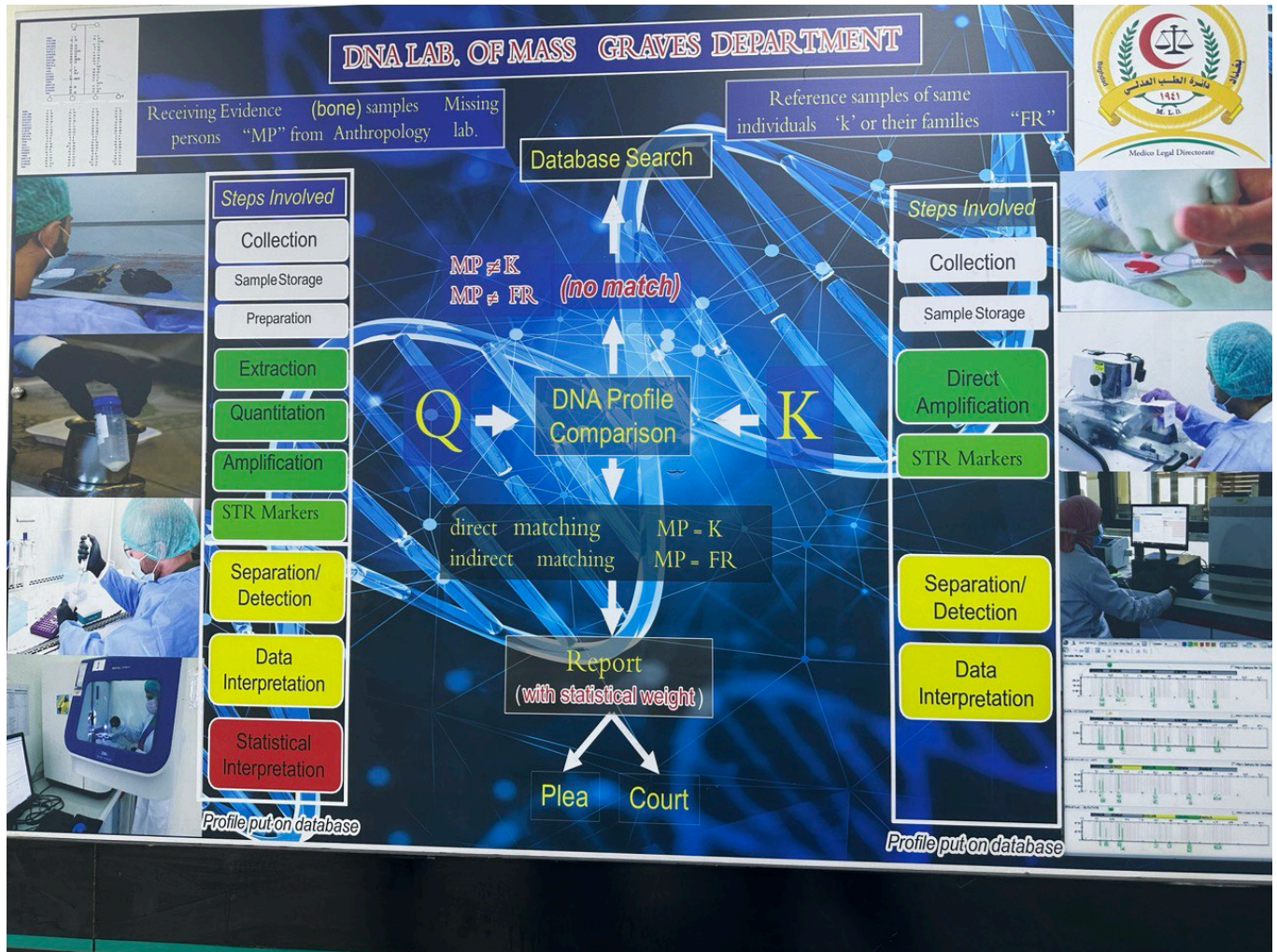


Figure 5. **Fig. 4.** shows the basic steps for Evidence Collection and Examination.

### 1.5 Forensic chemistry analyzes non-biological evidence at crime scenes:

while forensic medicine focuses on biological evidence like DNA and blood. Forensic chemistry identifies substances, examines fire debris, and investigates toxins, whereas forensic medicine determines cause and manner of death in suspicious cases. [23] in addition to any gases (smells or without smells), liquids, solids materials that could be physical identified or may required for specific instrument to identified before went to forensic labs.

### 1.6 Sex estimation techniques based on skulls in forensic anthropology:

Sex estimation plays a crucial role in the process of individual identification within forensic anthropology. In recent years, a growing number of techniques have been explored for estimating sex based on the human skull, as illustrated in Figure (5) [24]. Advanced scanning technologies are increasingly employed in forensic investigations, as they facilitate rapid, non-destructive documentation of human remains and allow for precise measurements that are not feasible with dry bones. To ensure the reliability of these methods, rigorous testing and validation are essential. This paper reviews existing literature to evaluate and compare three widely used advanced imaging techniques computed tomography (CT), structured light scanning (SLS), and photogrammetry in the context of forensic sex estimation. The comparison centers on their application to 3D models of the cranium, mandible, and pelvis, with each technique assessed for its accuracy, processing speed, cost-effectiveness, portability, required user expertise, and software demands within a forensic framework. [25]

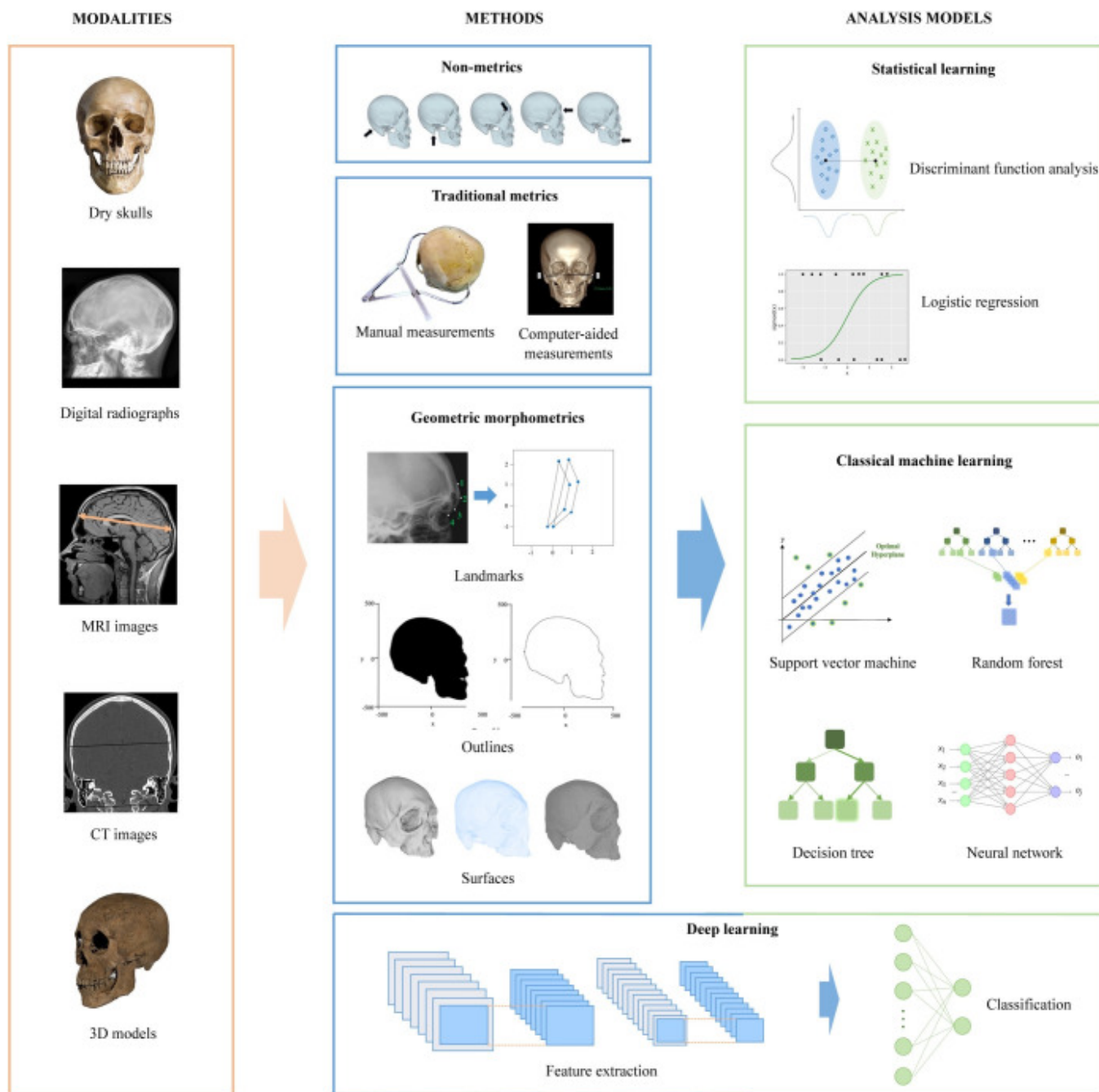


Figure 6. **Fig. 5.** The skim for sex estimation framework based on skulls.

## 1.7 Typical Procedures for Exhuming Bodies and Analyzing Skeletal Remains:

These standard procedures for exhuming human remains and examining skeletal material typically follow a structured checklist outlining the key steps in a basic forensic analysis. The objectives of an anthropological investigation are largely aligned with those of a forensic medical examination conducted on a recently deceased individual primarily to establish identity and determine the cause and manner of death, whether it be homicide, suicide, accidental, or natural causes [26]. However, the anthropologist's methodology differs due to the distinct nature of the remains. While a forensic pathologist generally performs autopsies on intact corpses, anthropologists are often tasked with analyzing skeletal remains [27]. Autopsies rely heavily on soft tissue examination, whereas anthropological analyses emphasize insights derived from bones and hard tissues. Despite this distinction, their work may intersect, especially since decomposition is a dynamic and continuous process. In some cases, anthropologists may handle relatively fresh bodies where bones are exposed or when skeletal trauma needs to be assessed. The presence of mummified tissue may also necessitate the involvement of a skilled dissector. [28] figure 6, reported the general Anthropological examination devotes more time and attention to basic questions. The skim represents the steps of examination which start from left to right, sometime the sequence of steps

would be change according to the circumstance of crimes.

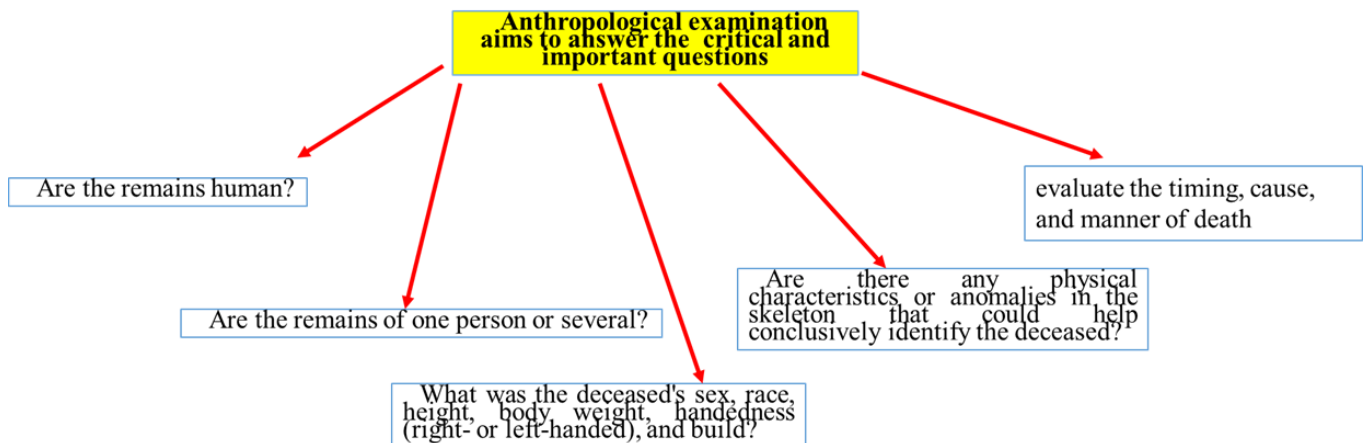


Figure 7. Figure 6: The skim for general steps of anthropological examination

however, their assessments typically carry a higher margin of error compared to autopsies conducted soon after death [29]. While these standardized procedures are applicable across a wide range of scenarios, their effectiveness may be compromised by challenging environmental conditions, limited funding, or time constraints [30]

## 2. Measuring the age of the corpse:

As long as a plant or animal is alive, it exchanges carbon with its surroundings, so that the proportion of carbon-14 it contains will be the same as the proportion of carbon-14 in its biosphere. Once it dies, it stops acquiring carbon-14 and begins to decay at a constant rate over time through the release of beta particles. It is not replaced, as is the case with a living organism. [31] Electron radiation (beta radiation) is measured from a sample of known weight, which can determine the amount of carbon-14 remaining in the sample. Carbon-12, on the other hand, remains constant in the organism's body both before and after death [32]. The equation governing the decay of radioactive isotopes is:

$$N = N_0 e^{-\lambda t}$$

Figure 8.

Where  $N_0$  is the number of atoms of the isotope in the original sample at time  $t = 0$ .

$N$  is the number of atoms remaining after time  $t$ .

$\lambda$  is a constant that depends on the isotope. For carbon-14, the average expected time before it undergoes radioactive decay is 8.267 years. Therefore, the above equation can be rewritten as follows:

$$t = 8267 \cdot \ln(N_0/N)$$

Figure 9.

The percentage of carbon-14 atoms in the original sample ( $N_0$ ) is assumed to be the same as the percentage of atoms in the biosphere.

The calculation of the remaining atoms in the sample,  $N$ , allows us to calculate the time  $t$ , which represents the age of the sample.

The half-life of a radioactive isotope, usually denoted by  $T_{1/2}$ , is at carbon 5,730. This relationship between half-life and average lifetime

$$T_{\frac{1}{2}} = \tau \cdot \ln 2$$

Figure 10.

The above calculations are not that accurate because we made several assumptions. For example, we assumed that the level of carbon-14 remained constant in the biosphere. In reality, the level of carbon-14 in the biosphere has varied significantly over the past millennia. As a result, the values provided by the equation above must be corrected using data from other sources, using a calibration curve. [33]

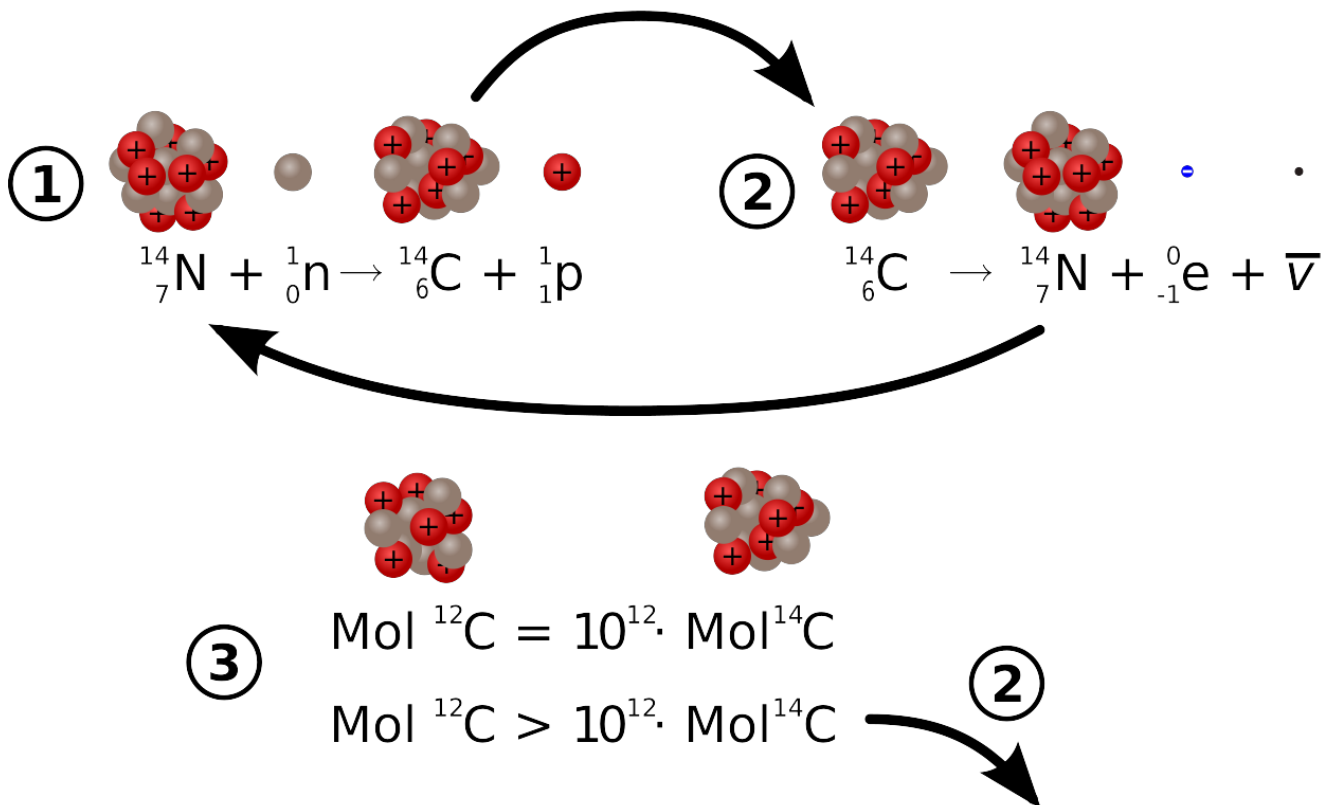


Figure 11.

Forensic chemistry is a branch of forensic science that applies chemical principles to legal investigations. It involves the analysis of physical evidence found at crime scenes [34]. Such as: **Trace Evidence:** This includes materials like glass fragments, paint chips, fibers, and gunshot residue. **Chemical Analysis:** Forensic chemists analyze substances like drugs, explosives, and fire accelerants to identify their composition and source. **Toxicology:** They investigate the presence and effects of toxins and poisons in biological samples like blood, urine, and stomach contents. **Explosives and Arson:** They analyze fire debris and explosive materials to determine the cause and origin of fires and explosions. [35]. Forensic medicine, on the other hand, focuses on the medical aspects of death and injury, often in cases of suspicious or unnatural deaths. [36]. this includes: **Determining Cause and Manner of Death:** Medical examiners and coroners investigate deaths to determine if they were accidental, suicidal, homicidal, or natural causes. **Autopsies:** They perform autopsies to examine the body, collect evidence, and determine the cause of death. **Biological Evidence:** They analyze biological samples like blood, tissue, and DNA to identify the victim, establish time of death, and potentially link suspects to the crime. [35]. In essence, forensic chemistry deals with the chemical aspects of crime scenes, while forensic medicine deals with the medical aspects, particularly in death investigations. Both fields contribute to criminal investigations and legal proceedings by providing scientific evidence to support or refute claims. [37].

## Conclusion

The integration of digital technologies, such as artificial intelligence and big data analytics, promises to improve the accuracy of data interpretation and individual identification through advanced biometric technologies. The review concern

into the jobs of forensic workers in crime scene before and after gone to forensic labs, which starting with physical evidence and the other which required instrumental to make identities. The process of locating and identifying graves containing unidentified individuals has become more accurate and easier than ever before. The ability to identify individuals from bone samples will open the door for forensic experts to identify individuals from skeletal remains recovered from mass graves or from scattered remains that have only skeletal remains, and will provide answers to grieving families who have lost loved ones in wars and disasters.

## List of abbreviations

(NO Found)

## Declarations

We are responsible for writing this work, we declare that we did not use artificial intelligence to prepare this article, nor did we use any means that might have added artificial information.

## Funding

We declare and confirm "this work was carried out through our own efforts, self-financed, and without the assistance of any funding agency".

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