What is forensic anatomy?

The police cannot be experts in all aspects of a murder investigation and as we saw in the last step, will often require additional expertise to help solve a case.

Crime Scene Investigators (CSIs), like Nicola, will assess the areas of a case to focus on in order to determine the identity of a victim, why and how a murder happened, and who the perpetrator was. Once this has been established, they can determine where in the investigation they require additional expertise and begin to identify which individuals or organisations can provide this assistance.

Universities employ individuals with a high level of training, research, and expertise in specific subject areas and for this reason, are often contacted to assist with an investigation.

When trying to identify a murder victim and the cause of death, the Police will often ask for advice from academics involved in the identification of human remains. This can include anatomists, archaeologists, anthropologists, and medics. These specialists often teach and carry out research as their primary job and are asked to give their expert opinion to the Police on a case by case basis.

In this course, we’re going to focus on the role that forensic anatomy plays in the identification of human remains. Anatomy is a branch of biology concerned with the structure of humans including the skeletal, muscular and skin biology. Forensic anatomy combines this understanding with forensic science techniques to determine the identity of human remains.

There is no one clear path to becoming involved in the field of forensic anatomy. However, all experts will have extensive training in physiological and pathological human osteology and musculoskeletal anatomy.

Forensic experts may specialise and have an in-depth knowledge of a particular aspect of forensic anatomy. For example, a Funerary Archaeologist may be asked to analyse burnt human remains, a Forensic Anthropologist may be asked to advise when the Police believe the ancestry of a murder victim is key to an investigation and an expert in facial reconstruction may be asked to consult when an identification from a human skull is required.

The biological profile of every skeleton is unique. An analysis of skeletal features can answer many questions about an unidentified person. This enables the police to target specific aspects of a missing persons database and to release information to the general public who may be able to assist with the identification.

In the next step, we'll discover just how much information a skeleton can reveal.

What information can you learn from a skeleton?

Our skeleton is an extensive record of our lives. The food we eat, the rate at which we grow as a child, the injuries we sustain, whether we have given birth; all can be determined from our bones. In cases where the identity of the deceased is unknown, the skeleton can be key in determining who the person was in life.

Experts can determine sex, age, and ethnicity, relatively easily from the skeleton, with the skull and pelvis playing pivotal roles in this analysis. Later this week, we'll be taking a more detailed look at how to determine sex and ethnicity from a skull.

Teeth can reveal information about diet and a comparison between dental records of the deceased and the recovered skull is often the primary method of identification.

The bones of the skeleton can disclose injuries, illnesses or surgical procedures that occurred during life and they can also give an indication of the occupation of the deceased.

Experts are able to determine if damage to the skeleton has occurred post mortem and the nature of that damage. This allows inferences to be drawn regarding the cause of death and whether the location where the body was discovered was the location where the individual died.

Every skeleton tells the story or *osteobiography* of an individual's life. In the next step, we'll discover what information the police could learn about Mr. X from the information written in his bones.

Finding Mr. X: What did the skeleton reveal?

With insufficient evidence to identify the body, the police required the expertise of a pathologist to study the skeleton and decipher any information that may be contained within Mr. X's bones.

The pathologist, in this case, was Professor Martin Evison, then Regional Forensic Anthropologist working out of the Department of

Forensic Anthropology at The University of Sheffield. Martin also led the Medico-legal unit at Sheffield and it was here that he undertook an osteological examination of the remains.

Height

From the length of the long bones: the femur, tibia and fibula in the leg and the radius, ulna and humerus in the arm, it was estimated that, in life, he had been about 168 cm in height, so a fairly short man.

Age

Age can be estimated from a skeleton in many ways. One approach involves taking X-rays of the necks of the femurs (thigh bones) and measuring their bone density.

Looking at the auricular surface of the ilium (where the pelvis joins the sacrum at the base of the spine) and at the surface of the pubic symphyses (where the two halves of the pelvis join together) can also provide useful clues.

Replica of an aged pelvic bone

In youth, these surfaces appear highly organised, but as we age they become more disorganised in appearance and are often pitted. Martin applied these techniques and suggested that the man was at least middle-aged.

Medical history

If diseases carried during life have left a mark on the skeleton, some indication of a person’s medical history can be obtained.

There was clear evidence that the man had suffered from moderately severe arthritis of his lumbar spine (lower back) and cervical spine (neck) to the extent that he would have had difficulty walking and turning his head.


Replica of a fused spine

He also had arthritis of the knuckle joint of the middle finger of both hands. Normally there is a fluid-filled capsule that separates the two halves of the joint, but the capsule had degenerated in his case causing bone-on-bone contact which had worn the bone on both sides of the knuckle, smooth. This is known as eburnation. Clearly,

the man would have sought medical attention for these painful conditions.
He had bunions on both big toes. This is a painful inflammatory condition that causes swelling of the metatarsal phalangeal joint. Treatment in severe cases involves fusing the joint by inserting a screw. An X-ray of his feet revealed that the metatarsal phalangeal joint on his left big toe had been fused and that there was a screw present. Furthermore, it was a Sherman screw, a type of screw that had not been used for this purpose for about 30 years, suggesting that the treatment had been performed many years before he died.

Replica of a toe (metatarsal phalangeal joint) with a screw present from a historical bunion operation

The metatarsal-phalangeal joint on his right big toe was not fused, but there was a facet in the bone which indicated that it had been fused and for some reason, at a later time, the screw had been removed.
The most intriguing information was derived

from an examination of his fifth right rib. There was a small ridge of bone that had become attached to the underside of the rib.

Martin and his team concluded that this bony ridge had originated from the vessels and nerves that ran beneath the rib. For some reason, they had themselves, turned to bone.

The most likely cause of this unusual finding is a reaction to surgery. At some time in his life, a surgeon had performed a thoracotomy (opened up his chest), most likely to treat a serious lung condition.

At some stage, he had also lost the tip of a finger, long enough ago for the bone to have remodeled beneath the missing joint.

Habitual behaviours

Unusual wear and tear in particular parts of the skeleton can also provide clues for habitual behaviours performed many times during life.

The tendon that had once attached Mr. X’s triceps muscle to his elbow had turned to bone, generating a little bony projection at the elbow. This indicated that during life he had flexed his right arm constantly, probably hundreds of times a day, for many years. What was he doing? Almost certainly something related to his occupation.

Conclusion

The skeleton had so far revealed Mr. X’s age and stature, and key details about his medical history and habitual behaviours.

In the next section, we’ll move on to investigate the skull. Studying the skull can enable forensic experts to establish a number of key elements about a person’s identity including their sex and ethnicity.

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In the next section, we'll move on to investigate the skull. Studying the skull can enable forensic experts to establish a number of key elements about a person's identity including their sex and ethnicity.

Identifying the sex of a skull

The sex of the deceased is usually one of the first elements to be assessed and is best undertaken by an examination of the pelvis and skull. When identifying the sex of a skull, a single characteristic is not used, rather a number of factors are considered and used collectively to determine the sex of the human remains.

There are a number of features of the skull that are more commonly found in males compared with females and these are the indicators used by forensic archaeologists to determine the sex of an individual.

Generally, male skulls are **heavier**, the bone is **thicker** and the areas of **muscle attachment are more defined** than in females. There are also key differences in the appearance of the forehead, eyes and jaw, between men and women that are used to determine the sex of a skull.

Forehead and brow ridge

When viewed in profile, female skulls have a rounded forehead (frontal bone). Male frontal bones are less rounded and slope backwards at a gentler angle. This ridge along the brow is prominent in males and much smoother in females. As this ridge lies above the eyes (orbits) this structure is known as the supraorbital ridge.


A female forehead

A male forehead

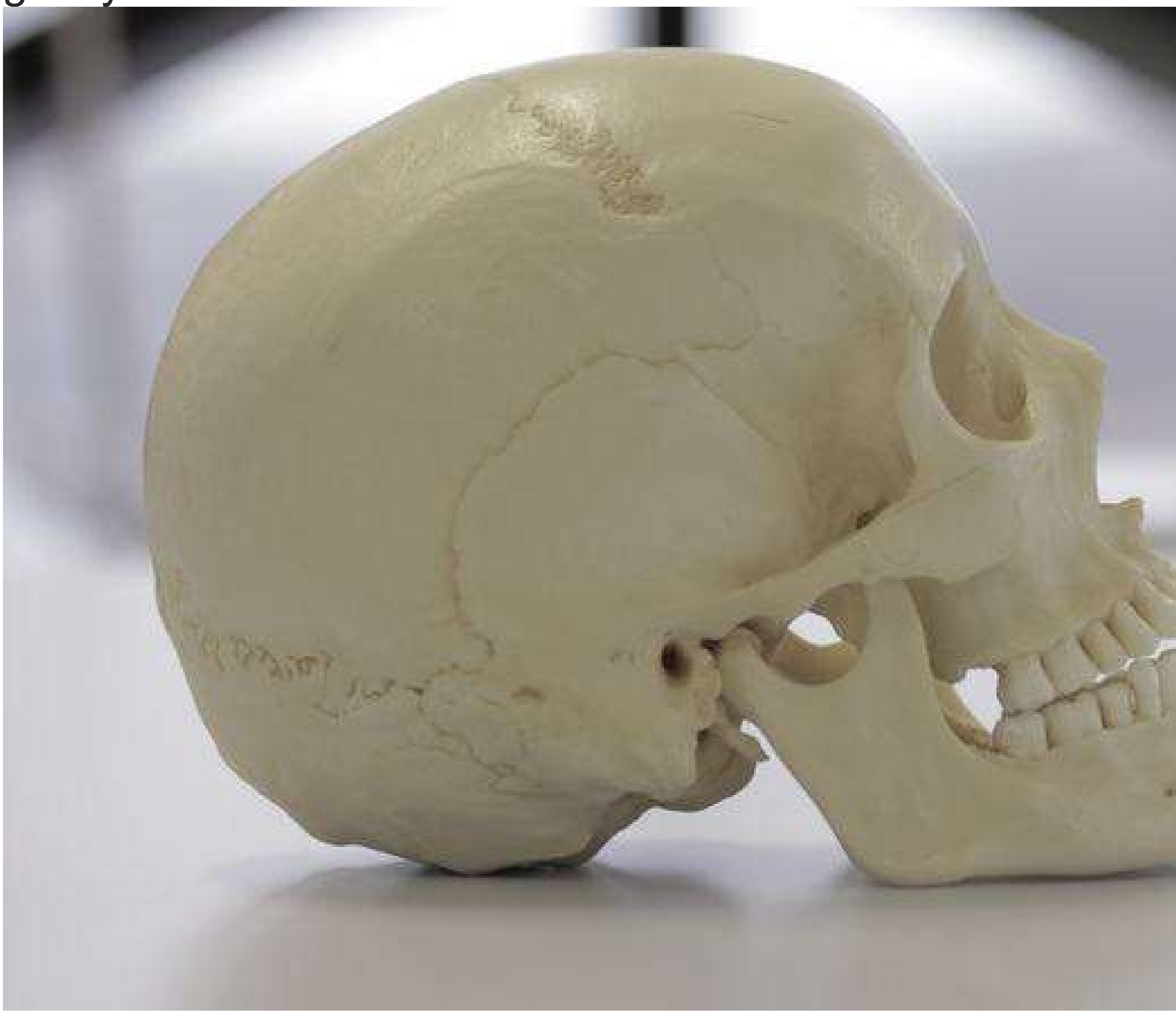
Eye sockets

Females tend to have round eye sockets with sharp edges to the upper borders. In contrast, male skulls have much squarer orbits with blunter upper eye margins.


Male eye sockets

Female eye sockets
Jaw
Males have a square jawline and the line

between the outer edge of the jaw and the ear is vertical. Conversely, in females the jaw is much more pointed and the edge of the jaw slopes gently towards the ear.



A male skull

A female skull

Summary

Female	Male
Smaller and lighter skull	Larger and heavier s

Rounded forehead (frontal bone)	Sloping, less rounde (frontal bone)
Smooth supraorbital ridge (brow)	Prominent supraorbi (brow)
Round eye sockets (orbits)	Squarer eye sockets
Sharp upper eye margins	Blunt upper eye mar
Pointed chin	Square chin
Sloping (obtuse) angle of the jaw	Vertical (acute) angl

By combining analysis of all the key features of the skull, a conclusion can be drawn regarding sex.
As we learned at the start of this step, the information taken from a skull is compared with data from any other osteological remains available and an overall deduction regarding sex of the individual is made.

It can be challenging to identify the sex of an individual purely from the skull as it may not show all of the characteristics usually found in one sex or another, but by looking at each feature and identifying whether a skull prominently favours one or two characteristics from one sex, we can make an estimation.
In the next step, we'll ask students at The University of Sheffield to put this information into practice to determine the sex of a skull.

Our demonstrators investigate: Identifying the sex of a skull

Now that we know how to estimate the sex of the skull, let's see those techniques in action.

As part of their Biomedical Science undergraduate degree, students here at Sheffield undertake a Forensic Anatomy module where they are given a box of 'anatomical evidence' relating to an unidentified person. This evidence includes a skull, long bones, dental information and a post mortem report.

Students apply forensic techniques to this evidence, including a facial reconstruction, to determine the identity and cause of death.

One of the first tasks they are faced with is to analyse the bones in order to determine age, sex, ethnicity and pathology.

Here, we'll watch three recent graduates from the course undertake an initial investigation of two skulls as they try to determine their sex.

We have added a PDF download of the skulls featured in the video in the ‘downloads’ section in the bottom of this page, so if you want to play along and examine the skulls yourself as you watch the demonstrators, you can refer to the image on the PDF.

Pay close attention to the characteristics that distinguish the male and female skulls - in the next step, we’ll ask you to try out these techniques for yourself.

Your turn: male or female?

Intro	**Question 1 not attempted**	Question 2 not attempted	Question 3 not attempted

Question 1

Take a look at these images of a male and female skull, paying particular attention to the frontal bone (forehead).

Which skull do you think is female? A or B?

Skull A

Skull B

A is female.

B is female.

Skull A has a smaller, rounder, less sloping, frontal bone compared with Skull B. The brow ridge (supraorbital ridge) is also less prominent.

Question 2

Now examine the orbits (eye sockets) of these two skulls. Which skull is likely to be male?

Skull A

Skull B

A is male.

B is male.

Male eye orbits (Skull A) are squarish in shape with rounded upper (superior) margins whilst female eye orbits (Skull B) are more circular with sharp-edged superior margins.

Question 3

Take a look at the jaws of these two skulls. Which skull do you think is female?

Skull A

Skull B

A is female.

B is female.

Question 3

**Take a look at the jaws of these two skulls.
Which skull do you think is female?**

Skull A

Skull B

A is female.

B is female.

On female skulls (Skull A), the chin is more pointed with the jaw having a gradual sloping (obtuse) lateral edge.

Male chins tend to be square and the angle of the outside (lateral) edge of the jaw is fairly vertical (acute).

Examine this skull closely. Do you think it is male or female?

On a male skull, the upper eye margins are rounded rather than sharp, the lateral edges of the orbits appear square, as does the chin, and the angle of the jaw is acute.

Our demonstrators investigate: determining the ethnicity of a skull

Let’s return to our demonstrators as they try to determine the ethnicity of three different skulls.

We have added a PDF download of the skulls featured in the video in the ‘downloads’ section in the bottom of this page, so if you want to play along and examine the skulls yourself as you watch the demonstrators, you can refer to the image on the PDF.

You’ll have a chance to do this for yourself in the next step.

Question 1

Which of these skulls is of African descent?

Skull A

Skull B

Skull C

Finding Mr. X: What did the skull reveal?

The skeleton had so far revealed Mr. X’s age and stature, and key details about his medical history and habitual behaviours. Professor Martin Evison continued his osteological examination by studying the skull.

This is a replica of Mr. X’s skull. This skull is of Asian ancestry and has worn molars and missing incisors in a similar manner to Mr. X

Sex

Mr. X’s skull had a sloping forehead with a prominent supraorbital ridge. The upper eye margins did not appear to be sharp and the lateral corners of the orbits were square. The chin appeared rather square and the angle of the outer edge of the jaw bone was quite acute. These characteristics indicated that the skull was likely to be male.

Age

Dental eruption is particularly important in attempting to age the skeleton of a child, but in adulthood, the extent of tooth wear can also

provide clues.
One of the best approaches is to measure tooth root translucency. As we age, we lose density in our teeth and by taking thin sections of the roots and measuring the amount of light that passes through them, an estimate of age can be made. Combined with his examination of the pelvis, Martin was able to confirm the man was at least middle-aged and estimate that he could have been over 60.

This is a replica of Mr. X’s demonstrating significant tooth loss of adult teeth

Ethnicity

Mr. X’s craniofacial dimensions, particularly the width of his nasal aperture and width of his nasal bridge fell within the Indo-European average suggesting that he was either European, Middle Eastern or from the Indian Subcontinent. This information also matched the partial DNA profile that was obtained.
A partial DNA profile was obtained which suggested that he was three times more likely to

have originated outside the United Kingdom and more likely, he was from the Middle East or Indian Subcontinent.

This is a replica of Mr. X's skull showing that the surface of the molars had been ground away by repetitive chewing

Habitual behaviour

An unusual habitual activity had worn his molars down and had caused some of his tooth enamel to dissolve. He had clearly chewed something regularly that was causing both physical and chemical abrasion of his teeth. Did he constantly chew tobacco or something similar?

Put together with the partial DNA evidence, it was surmised that the substance he could have chewed was khat, a narcotic tobacco-like substance used in Yemen.

Finding Mr. X: So what did we know?

Forensic anatomy expertise had enabled the South Yorkshire Police to build a preliminary picture of Mr. X.

From the bones and wisps of hair found in the bag, an osteological examination by Professor Martin Evison was able to determine the following details about this unknown person's identity:

Sex	Male
Age	Most likely in his fifties
Height	5'4-5'8
Ethnicity	Middle Eastern or North African, most likely from Yemen.
Hair colour	Dark
Medical history	Operation on his feet; bunions removed. Flattened teeth; probably from chewing khat.
Occupation	Likely something physical that entailed flexing his right arm repeatedly.
Time of death	The body had become what is known as an 'adipocerous mummy', where the skin becomes waxy and soap like, indicating that the body had been "stored" in a cool moist environment for a number of years.

Although the skeleton and skull had revealed much about Mr. X, the police had reached an impasse in their investigation. No missing persons report matched this description and there had been no response to information about Mr. X in the media.

Who was he? Why did he die? Where had the body been stored all of this time?

A

B

C

Skull B is a male and skull C is a female European skull. European skulls have round eye sockets with rectangular margins, narrow nasal apertures and small closely set teeth.

Which of these skulls is from an Asian male?

Skull A

Skull B

Skull C

C. This is the skull from an Asian male. The eye sockets are circular, the nasal aperture is heart shaped, the brow ridge is prominent and the jaw is square.

Next week: reconstructing the face

The body in the bag was found in January 2000, but by March that year, the police were no closer to identifying Mr. X and moving the investigation forward.

The pathologist, botanist and the odontologist had gleaned as much information as they could from the body and from the bag. Despite this information, there was nothing that could positively identify who this person was.

When post-mortem deterioration makes it difficult to identify the dead, **forensic facial reconstruction** can hold the key to a positive identification.

Robert Varey from South Yorkshire Police had been discussing the possibility of producing a facial approximation with the pathologist Professor Martin Evison and had asked Martin if he would attempt this as a last resort in the case.

In this video, Nicola explains why a forensic facial reconstruction was the next step in moving the investigation forward. This is the point we'll return to in Week 2 of the course.