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BARE BONES

Our ancestors' bones have a lot to say

Efthymia Nikita
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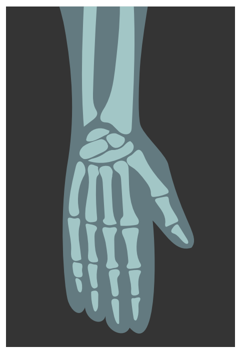
introduction

Have you ever dressed up as a human skeleton for Halloween?



Have you marvelled at what the human skeleton looks like in an X-ray?

YOU ARE NOT THE ONLY ONE!

The human skeleton has fascinated anatomists, artists, and everyday people for centuries.

The human skeleton has been also systematically studied by archaeologists as it can give unique information about how our ancestors lived and died.

Why study bones?

The human skeleton can provide fascinating information about the life of the individual to whom it belongs.

Our diet, activities, health, ancestry and many other important aspects of our life leave traces on our bones.

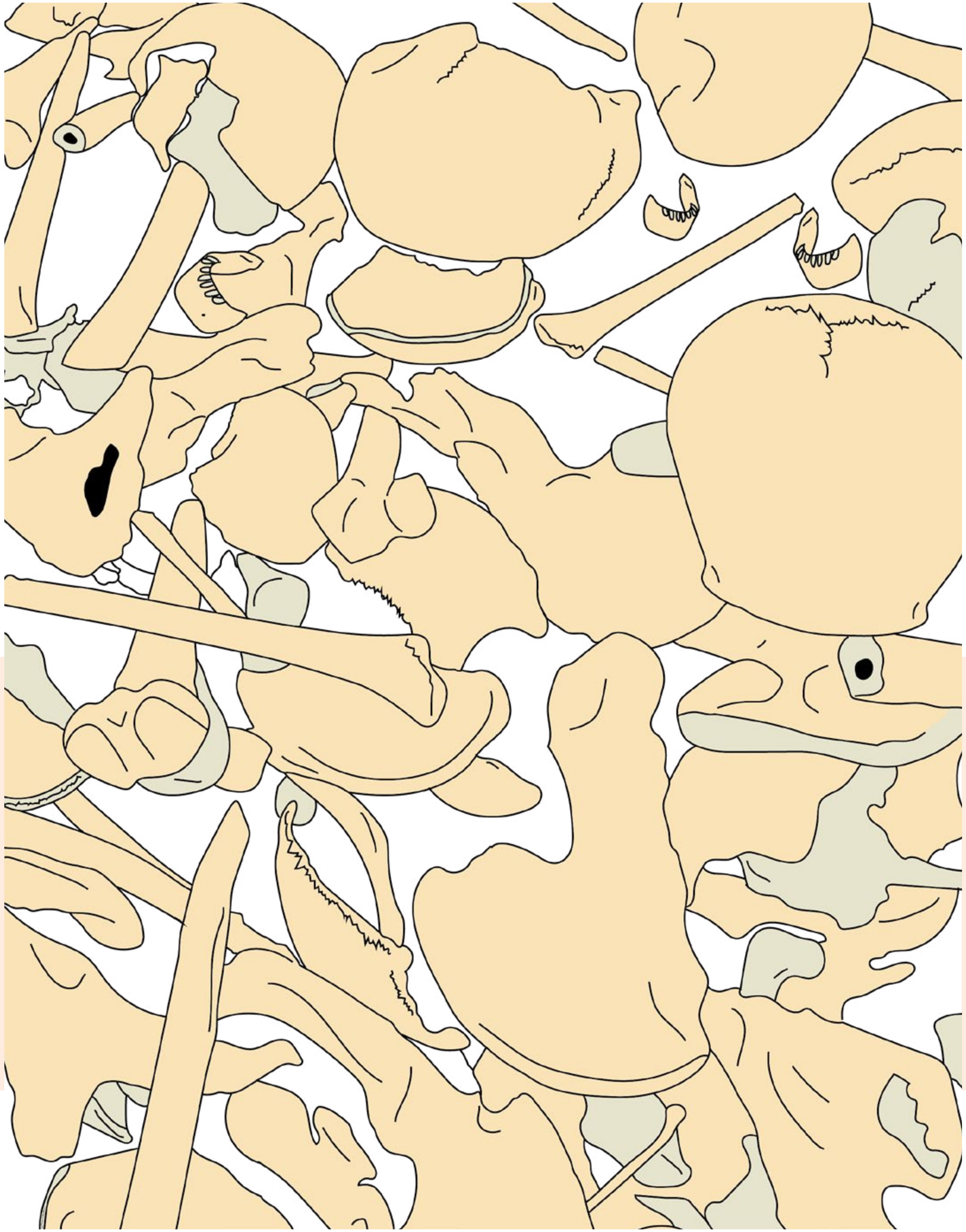
Specialists called **osteoarchaeologists** or **bioarchaeologists** examine skeletal remains found in archaeological excavations in order to decipher life in the past. Their job involves the identification of bones, which are often very fragmented, and recording skeletal markers of activity, pathology, diet and other aspects of past life.

Through the study of ancient human skeletons, we can see how people, often invisible in written records, used to live.

Example: A lot of the information about the daily life of women in ancient Greece comes from pottery scenes depicting women weaving or performing other tasks. However, most aspects of the life of these women cannot be explored though artistic representations... How healthy were they? How much did they travel? What were their biological kin ties to each other? This is where osteoarchaeology comes in!

Forensic anthropologists also study human bones but from recent crimes, warfare, or natural disasters. Their aim is to identify the deceased and the circumstances of death. Therefore, emphasis is placed on identifying whether the deceased were male or female, how old they were at the time of death, what their ancestry was, and any evidence pointing to the time and cause of death (e.g. trauma).

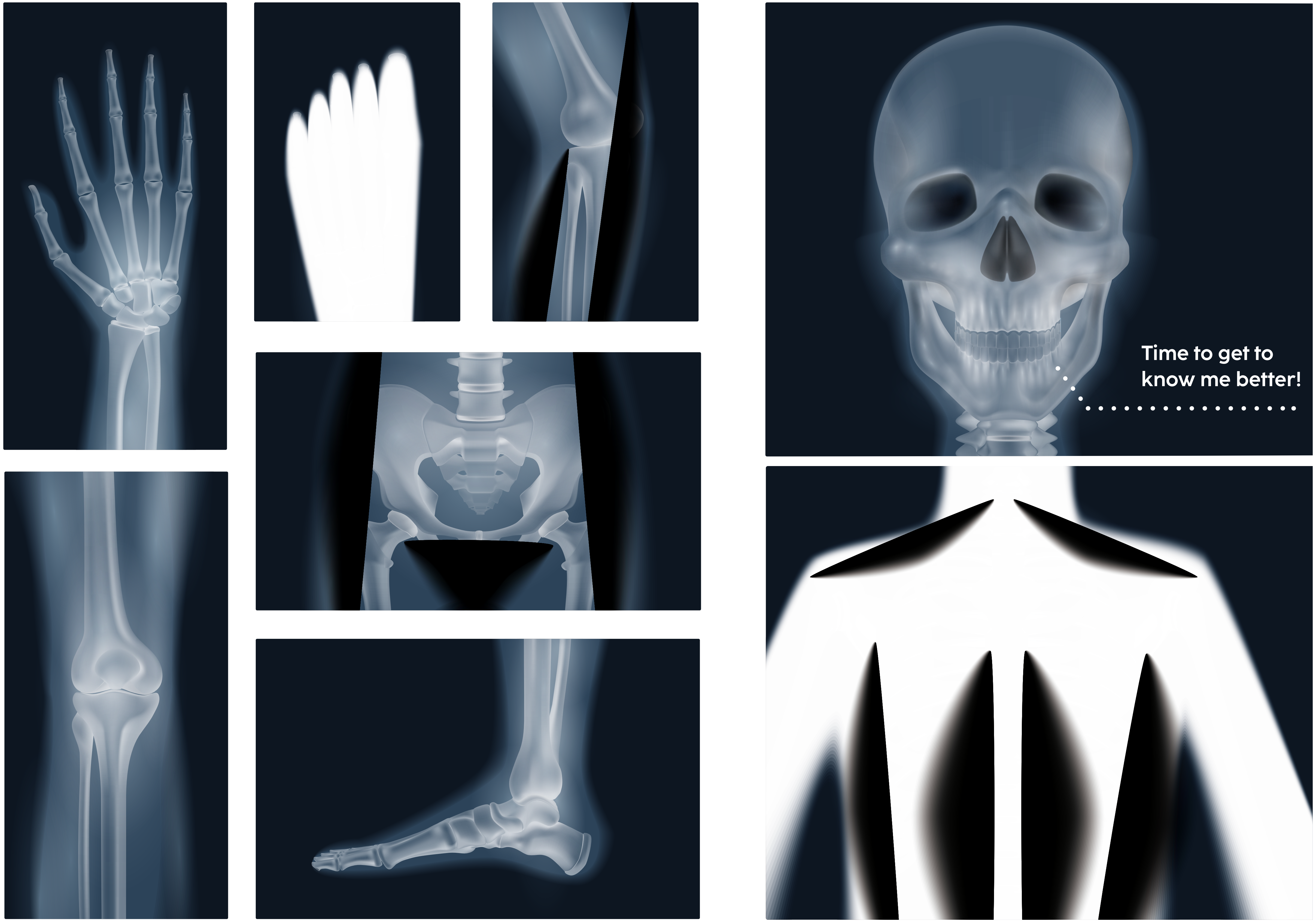
Forensic anthropology places emphasis on **taphonomy**, that is, the factors that affect the body after death. Human bones may disintegrate, be burnt or broken and moved around due to the action of animals, intentional or unintentional human activities etc. It is the task of a forensic anthropologist, and to some extent of an osteoarchaeologist, to track back the agents that interfered with the remains.



So, human skeletons can give critical evidence both in ancient and in modern contexts.

Let's start with some basic bone and tooth facts before we take a closer look at the information written on our bones...

basic skeletal anatomy

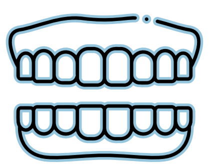


Have you ever wondered how many bones there are in your skeleton and what they look like?

You could probably count many of them by touching your skeleton under your skin, but I bet you would miss most!

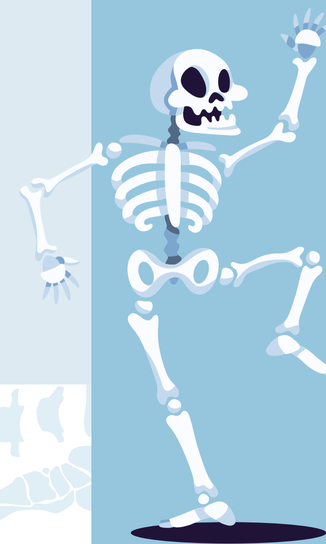
On the other hand, using a mirror, it is easy to count your teeth and see what they look like.

Why don't you try to count the teeth in your mouth and guess the number of bones in your skeleton before reading further down to discover more?



A few basic bone facts!

The human skeleton has
206
bones



You probably think that's a lot but when we are born, our skeleton has around
300
bones!

How can we 'lose' bones between birth and adulthood?

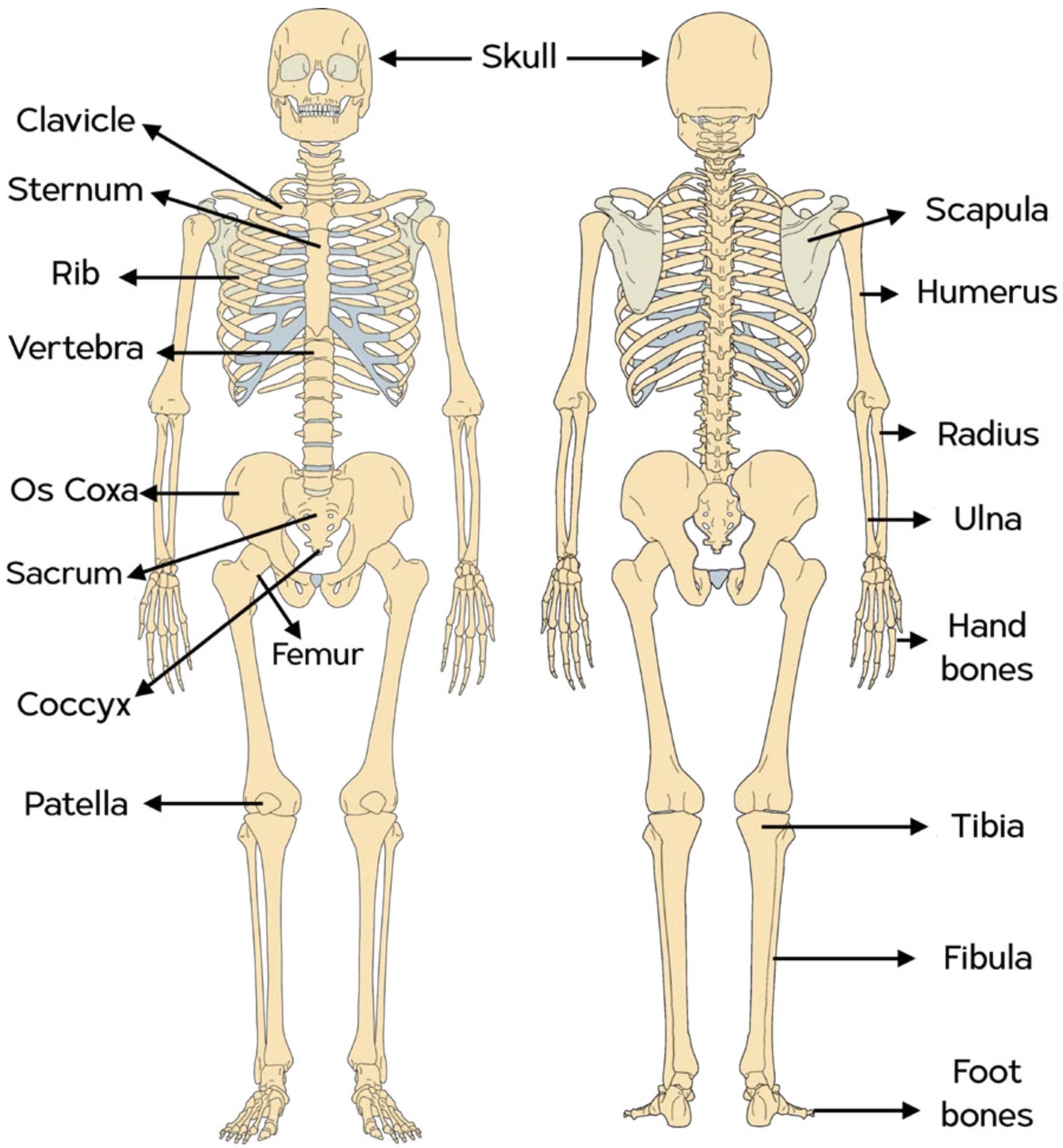
Most of our bones originally consist of multiple parts; this allows them to grow. During our childhood and especially during adolescence many of these parts fuse together. This fusion marks the end of the growth of our skeleton...

The human skeleton performs many different functions, which are essential for our everyday living!

- It gives shape to our body ... without it, we would be like jelly!
- It protects our internal vital organs; for example, the cranium protects our brain, while the thorax protects our heart and lungs.

- It stores minerals (e.g. calcium and phosphorus), energy (fats) and blood forming cells.
- It supports our body and allows us to move around. For example, the spine, pelvis and legs allow us to stand upright and support the weight of our body.

The human adult skeleton



Classifying our bones

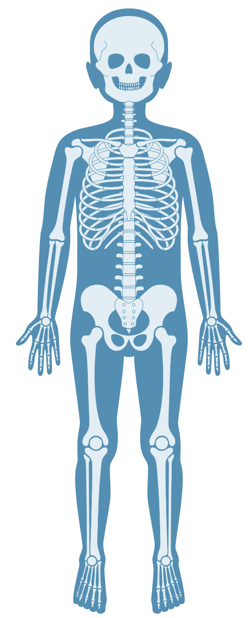
The human skeleton has two main parts:

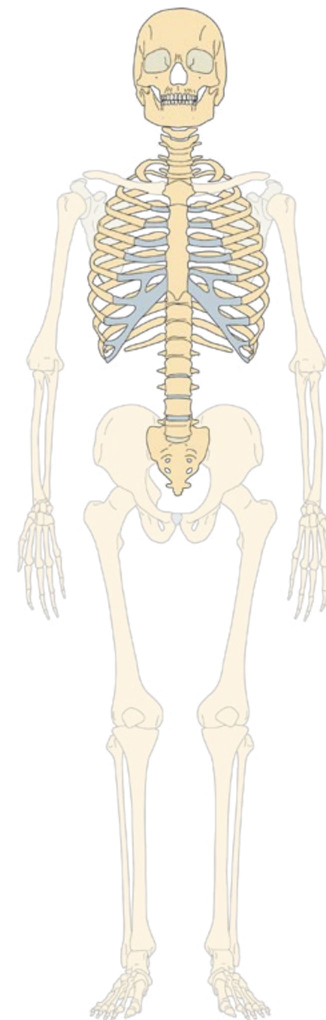
- the **axial skeleton** and
- the **appendicular skeleton**

The ***axial skeleton*** is composed of

80 bones

and includes the skull, spine and ribs

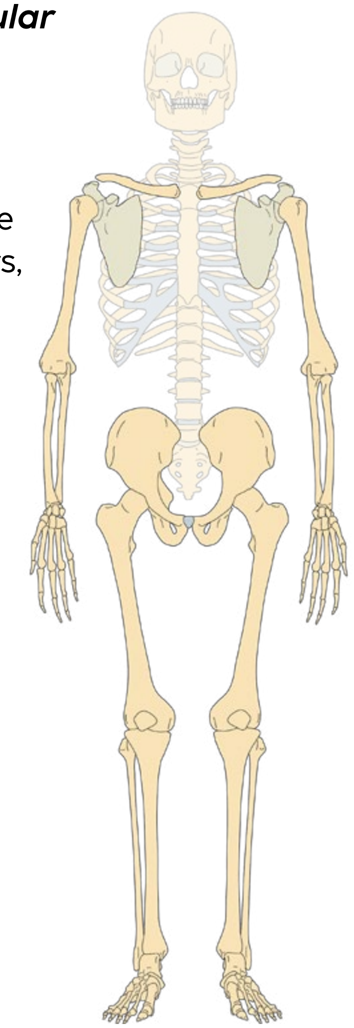




The ***appendicular skeleton*** is composed of

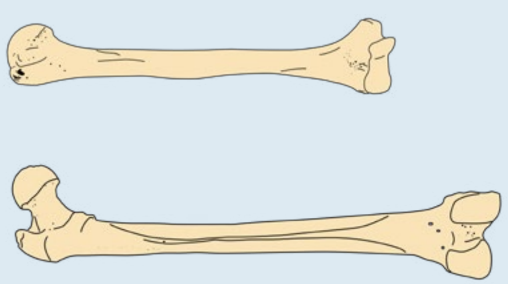
126 bones

and includes the pelvis, shoulders, arms and legs



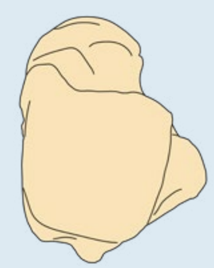
Types of bones according to shape

Long: Elongated bones with a tubular central part and an articular area at each end (e.g. femur, humerus)

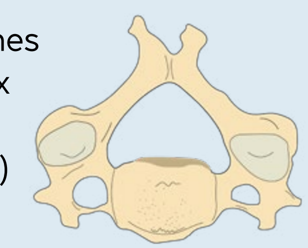


Flat: Flat, thin, and broad bones (e.g. parietals, occipital)

Short: Bones with all dimensions almost equal and somewhat cubic shape (e.g. carpals, tarsals)



Irregular: Bones with a complex morphology (e.g. vertebrae)

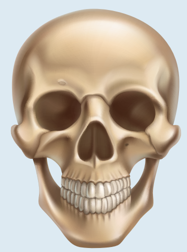


Our skull is is composed of the cranium and the mandible. The cranium is not a single bone but many different bones that articulate through interlocking joints called *sutures*.

At birth

the human skull has **45** bones

In adulthood



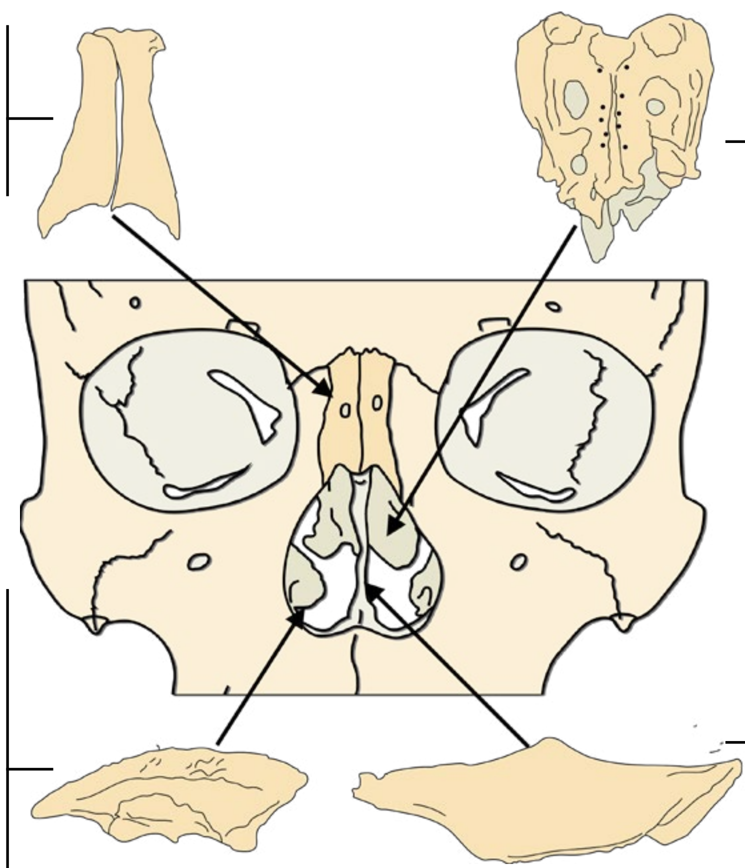
many of these gradually fuse, so the adult skull has **26** bones

The sutures that interconnect the cranial bones allow the skull to grow and, similarly, allow the growth of our brain.

As we get older, the sutures gradually fuse, thus uniting different cranial bones.

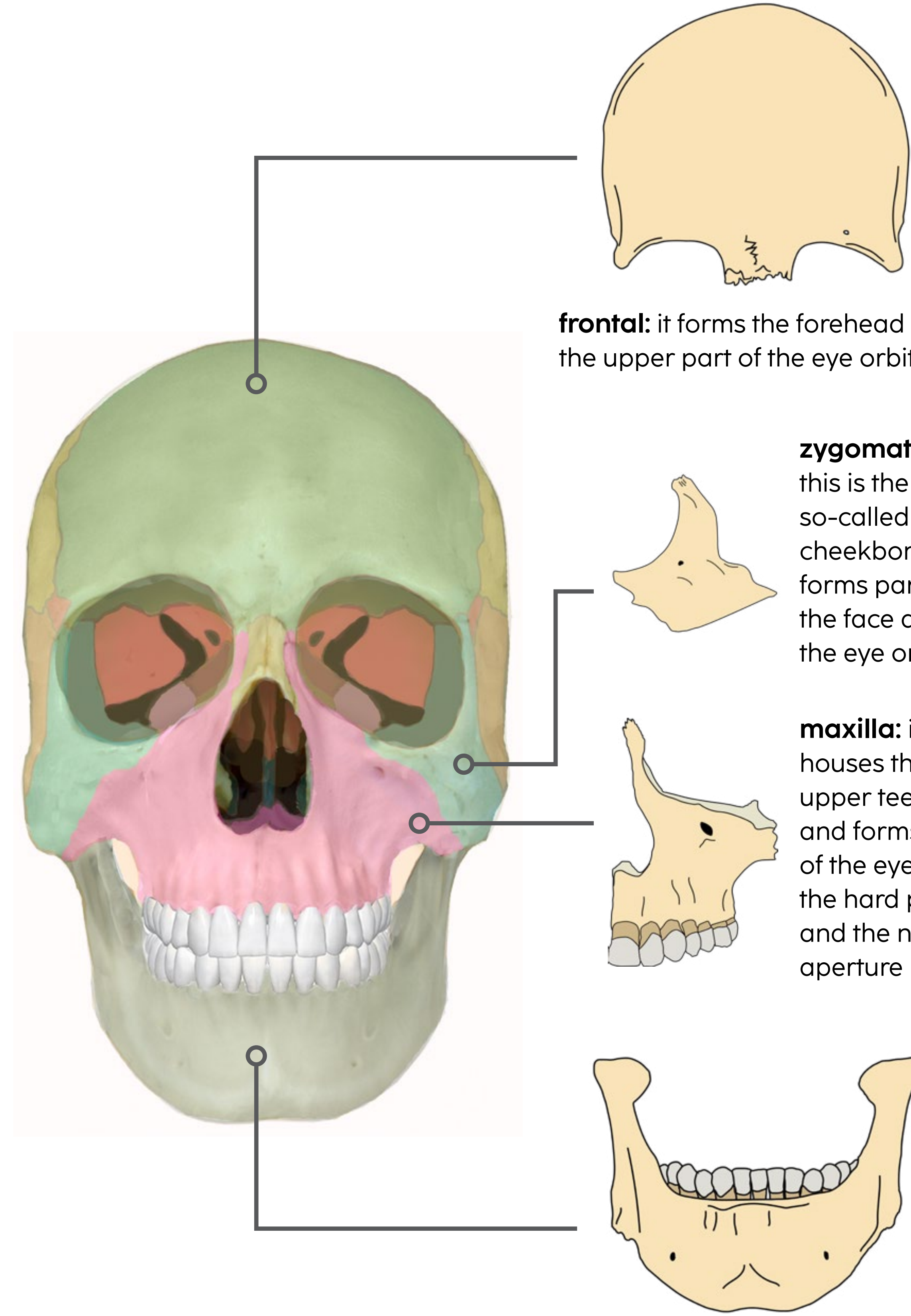
nasal bones: they form the roof of the nasal aperture

ethmoid: fragile bone found between the orbits



inferior nasal conchae: fragile bones attached to the lateral wall of the nasal cavity

vomer: thin, flat bone, part of the nasal septum

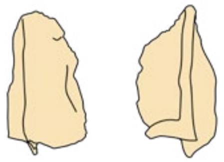


frontal: it forms the forehead and the upper part of the eye orbits

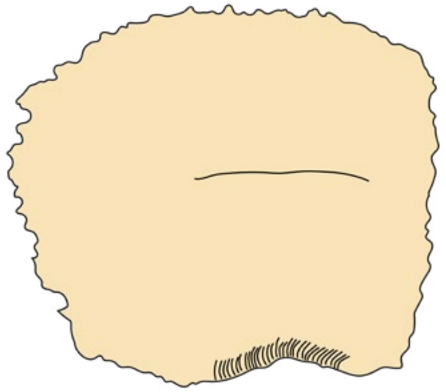
zygomatic: this is the so-called cheekbone; it forms part of the face and the eye orbits

maxilla: it houses the upper teeth and forms part of the eye orbits, the hard palate and the nasal aperture

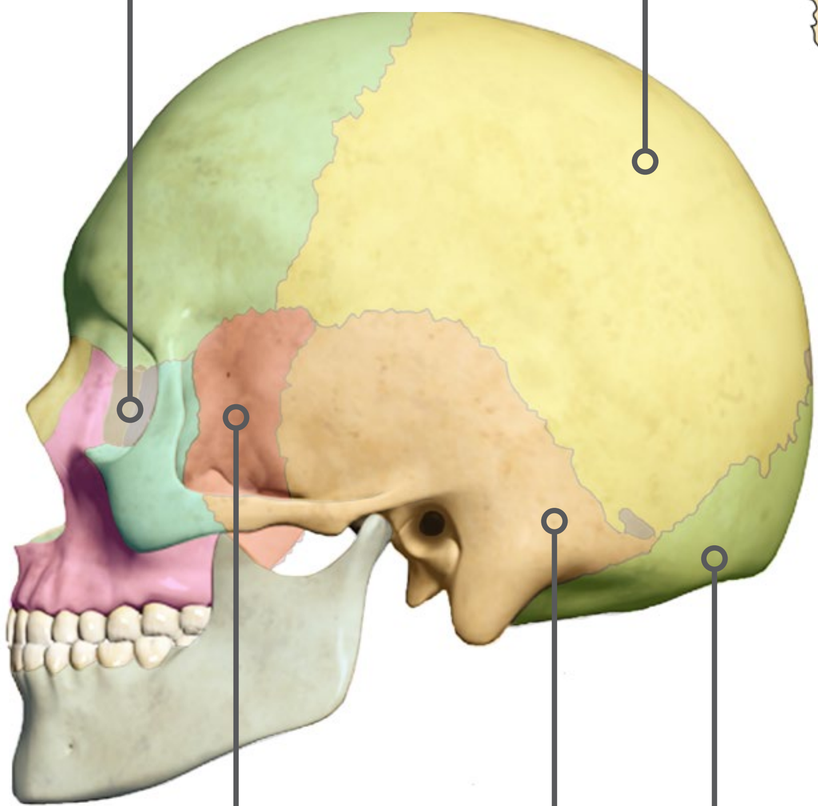
mandible: it allows the attachment of muscles of mastication (chewing) and the tongue, and houses the lower teeth



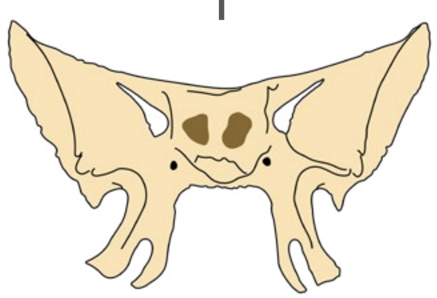
lacrimals: delicate bones that form part of the wall of the orbits



parietal: it forms the roof and sides of the cranial vault



occipital: it forms the back and lower part of the cranium

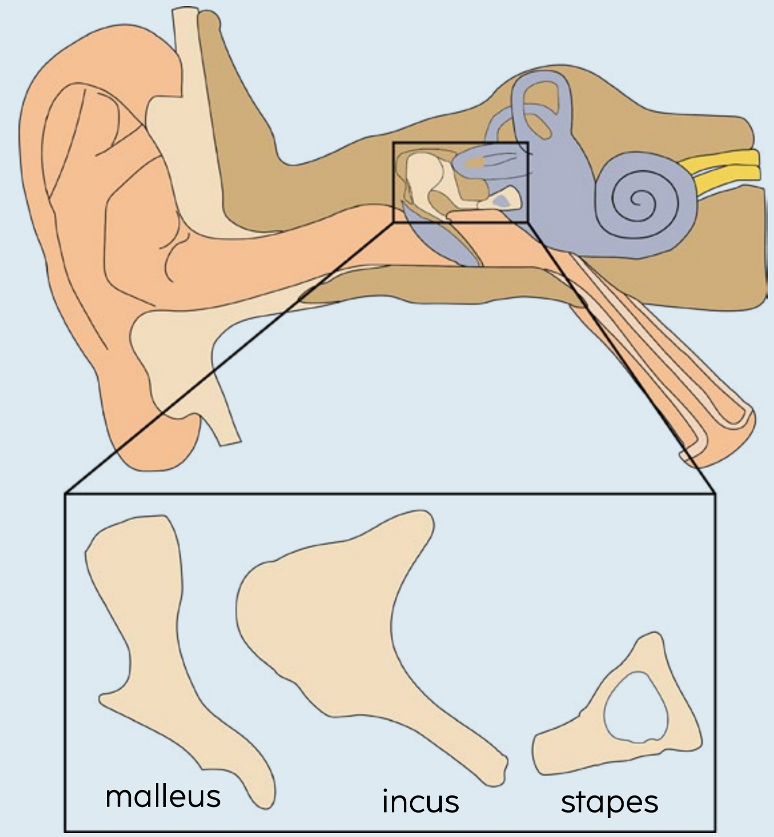


sphenoid: irregular element found at the front part of the cranium

temporal: it forms part of the side and base of the cranium, and contains the organs of hearing

Ear ossicles: these are three small bones inside the temporal bone. The **malleus** is the largest one and it attaches to the tympanic membrane.

The **incus** lies between the malleus and stapes, while the **stapes** is the smallest bone in the human body and has a length of about 2.8 mm.



A few

Fun facts...

regarding our ears

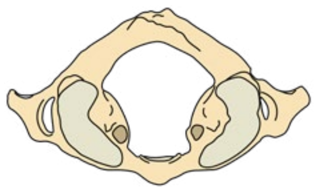
Besides housing the smallest bones of the skeleton, our ears:

- never stop working; we keep hearing sounds even when we are asleep.
- are essential for maintaining our balance.
- self-clean!

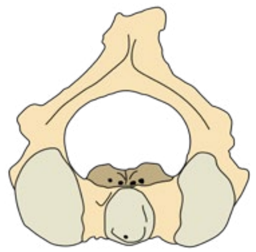
The spine consists of seven cervical (C1-C7), twelve thoracic T1-T12), five lumbar (L1-L5), five sacral (S1-S5), and three to five coccygeal vertebrae.

The spine protects the spinal cord and supports the head and the trunk of the body. It is very flexible, allowing a broad range of movements.

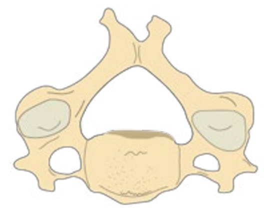
Our spine is not straight; rather it has four curves: the cervical, thoracic, lumbar and sacral curve. These curves help it withstand many kinds of mechanical stress.



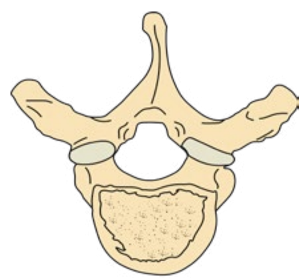
atlas: the first cervical vertebra; it connects the spine with the skull



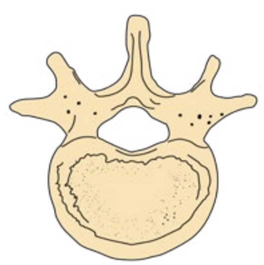
axis: the second cervical vertebra; it allows our skull to perform a broad range of movements



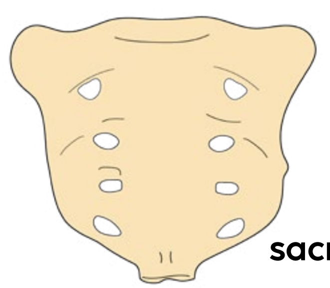
typical cervical vertebra

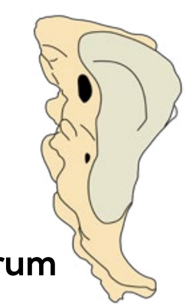


typical thoracic vertebra



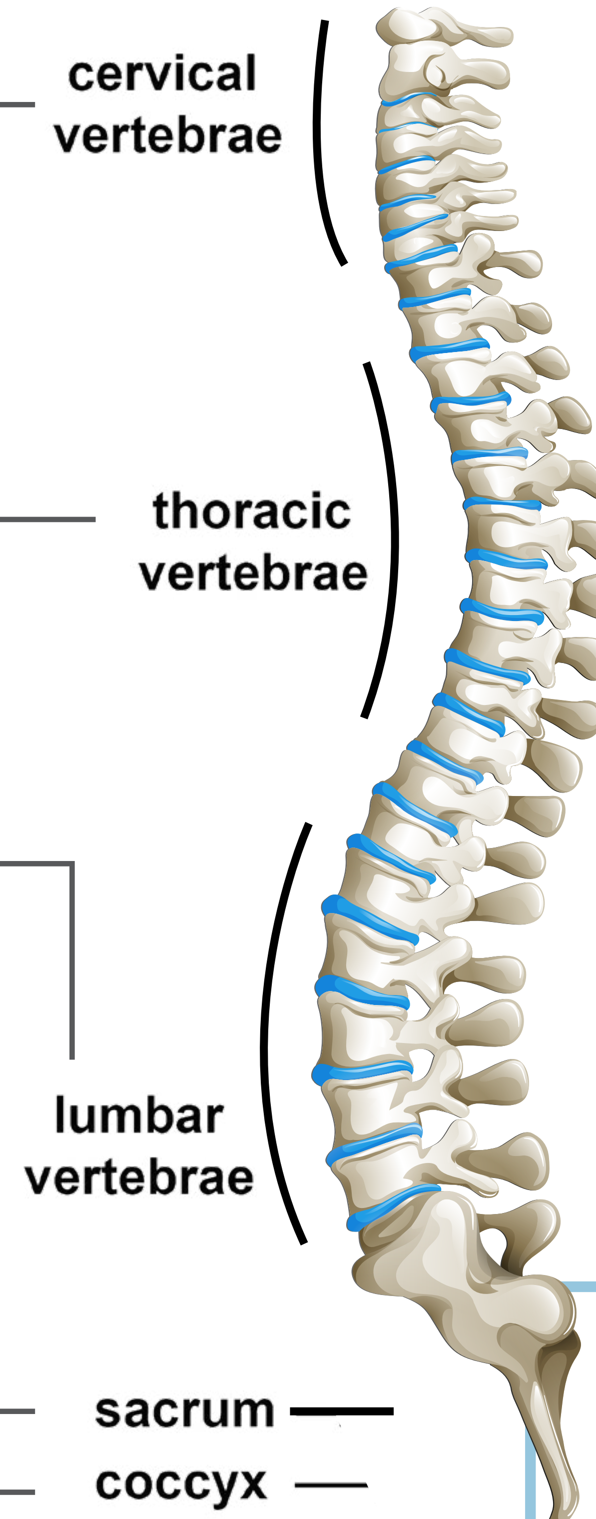
typical lumbar vertebra





sacrum

coccyx: this is what's left of our tail!



The first cervical vertebra is called **atlas**, referencing the Greek mythological titan Atlas, who was burdened with carrying the celestial sphere (heavens) on his shoulders…sort of like the neck carries the weight of the head.

The sacral and coccygeal vertebrae normally fuse by adulthood, and form the sacrum and coccyx.

Did you know...

that **both humans and giraffes** have **seven cervical vertebrae**?

Over HALF

of the body's bones are in the hands and feet!!

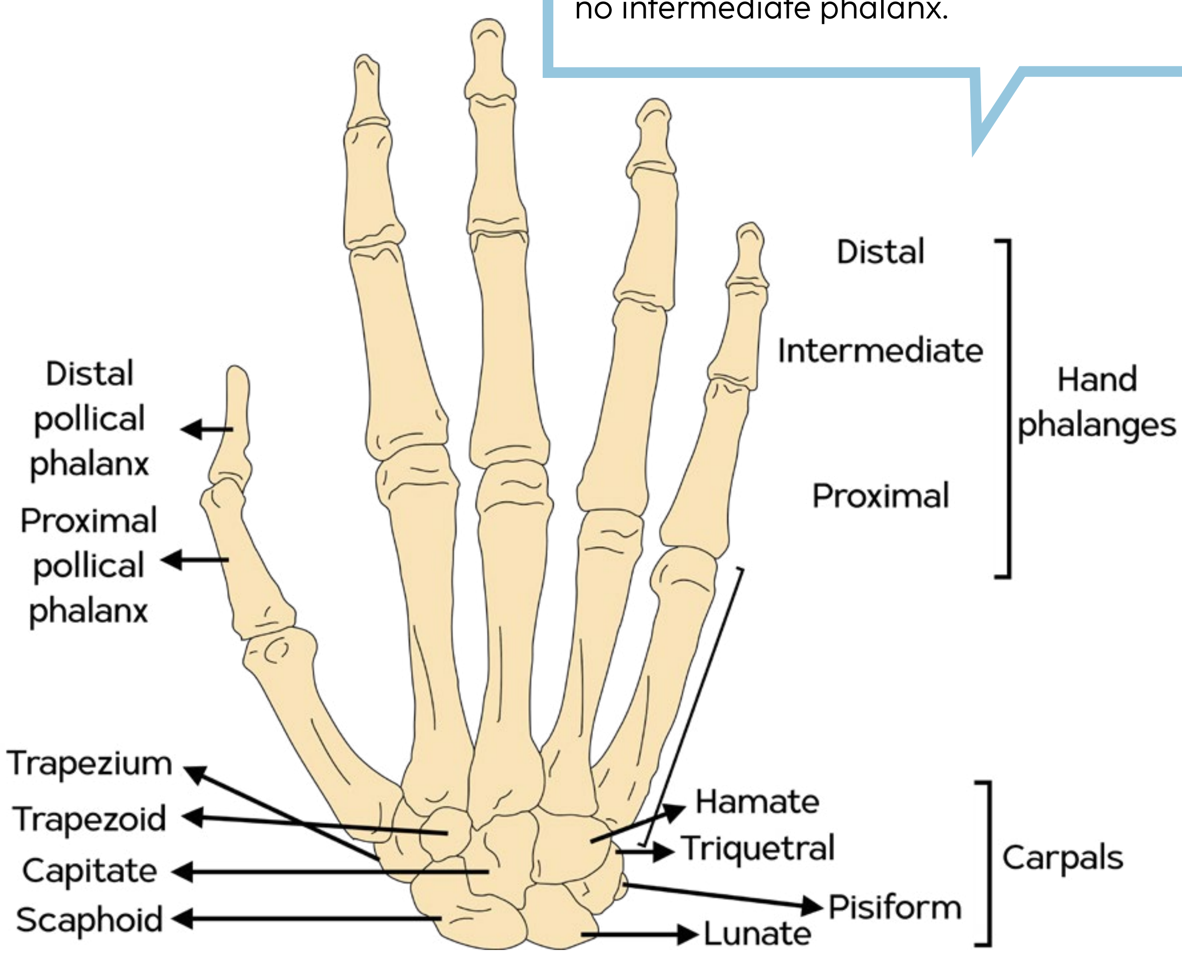
The human hand has

27

bones...

- **8 carpals**
- **5 metacarpals**
- **14 phalanges**

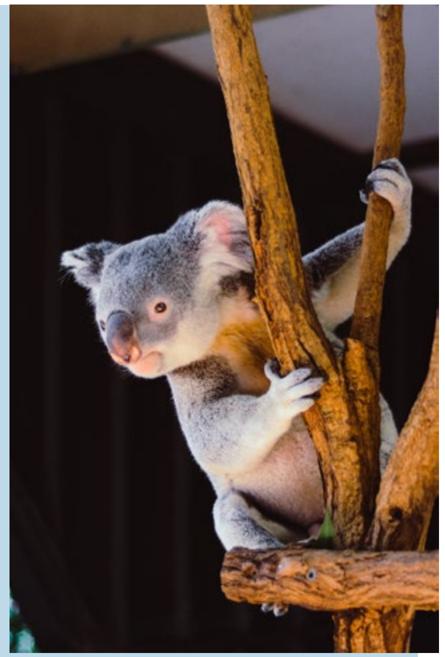
The **phalanges** in all fingers are arranged in three rows (proximal, intermediate, distal). The thumb is the exception as it has no intermediate phalanx.

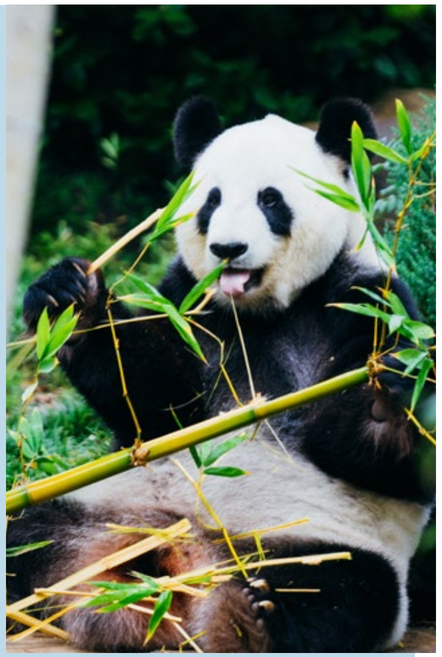


Fingers don't have muscles — tendons in our fingers are moved by the muscles of the forearm.

What sets our hands apart from many animals is our **opposable** thumbs, which make us much more dexterous.

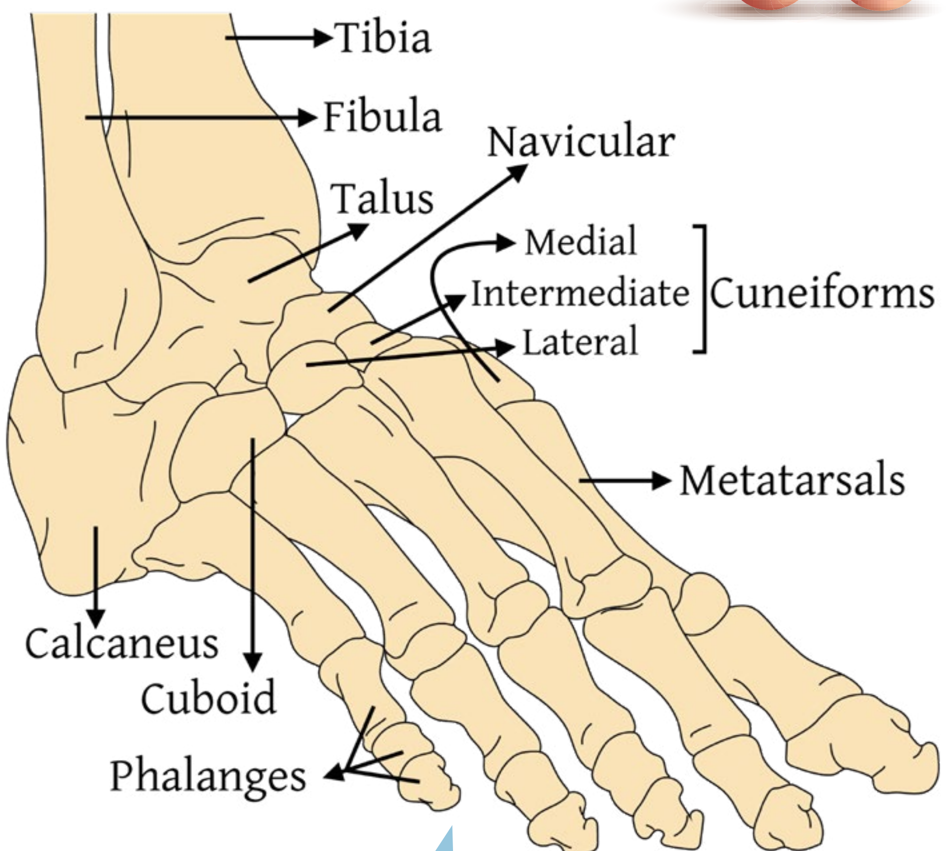
Many animals also have opposable thumbs: gorillas, chimpanzees, orangutans, koalas, pandas, opossums, and others.



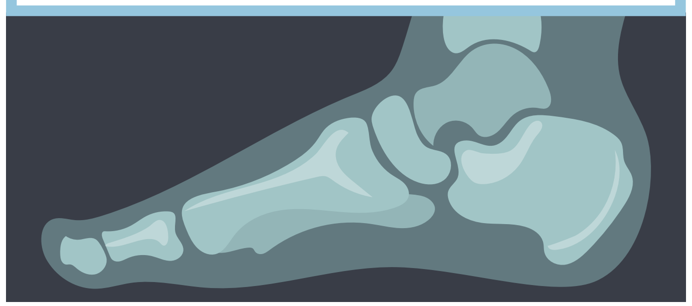


The human foot has **26** bones!

- 7 tarsals
- 5 metatarsals
- 14 phalanges



Foot phalanges are also arranged in three rows, and the hallux (big toe) is lacking an intermediate phalanx, just like the thumb in our hands.



There are more sweat glands per square centimeter in the soles of our feet than anywhere else in our body.

The big toe used to be a kind of foot thumb. It allowed better grasping and helped our ancestors climb trees and hold onto their mothers as children.

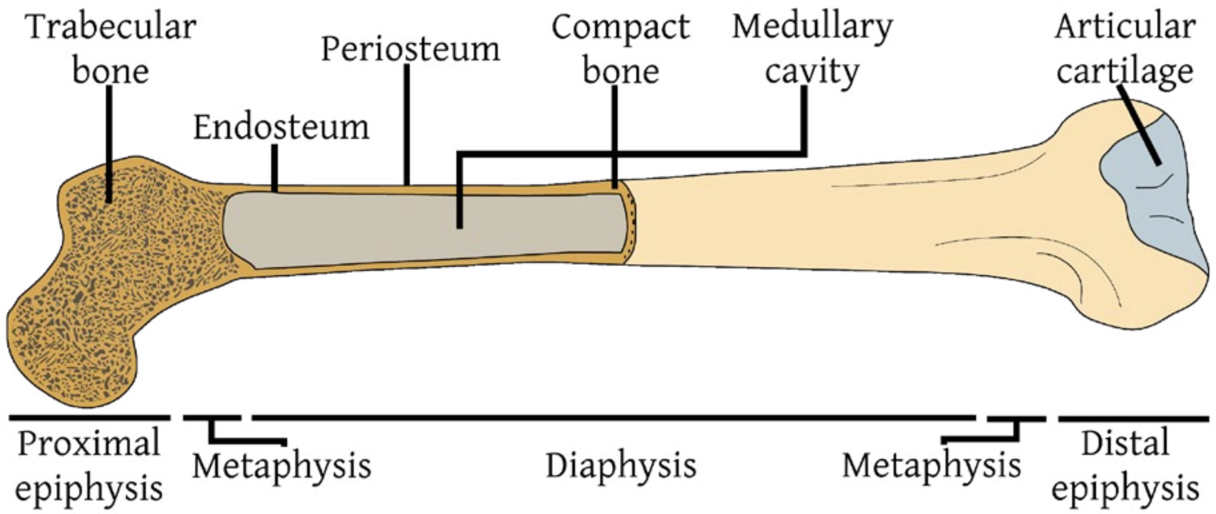
In a single day, the average person takes 8,000 to 10,000 steps...

This amounts to

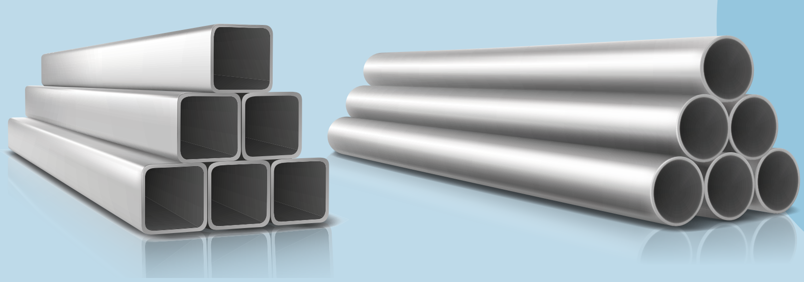
4 trips

around the world over a lifetime

Bone structure with the naked eye



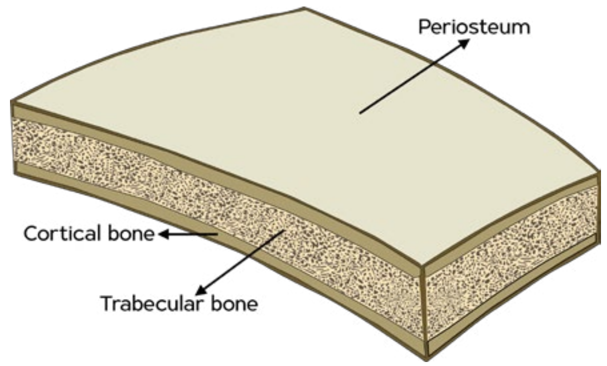
In the middle of **long bones** there is a long tubular part called **diaphysis**. The two ends of the long bones are called **epiphyses**, while the sections between the diaphysis and the epiphyses are the **metaphyses**. Inside the long bones we find the **medullary cavity**, which contains yellow bone marrow.



By weight, bone is stronger than steel.

In fact a steel bar measuring the same dimensions as a bone would be around

x4 heavier!



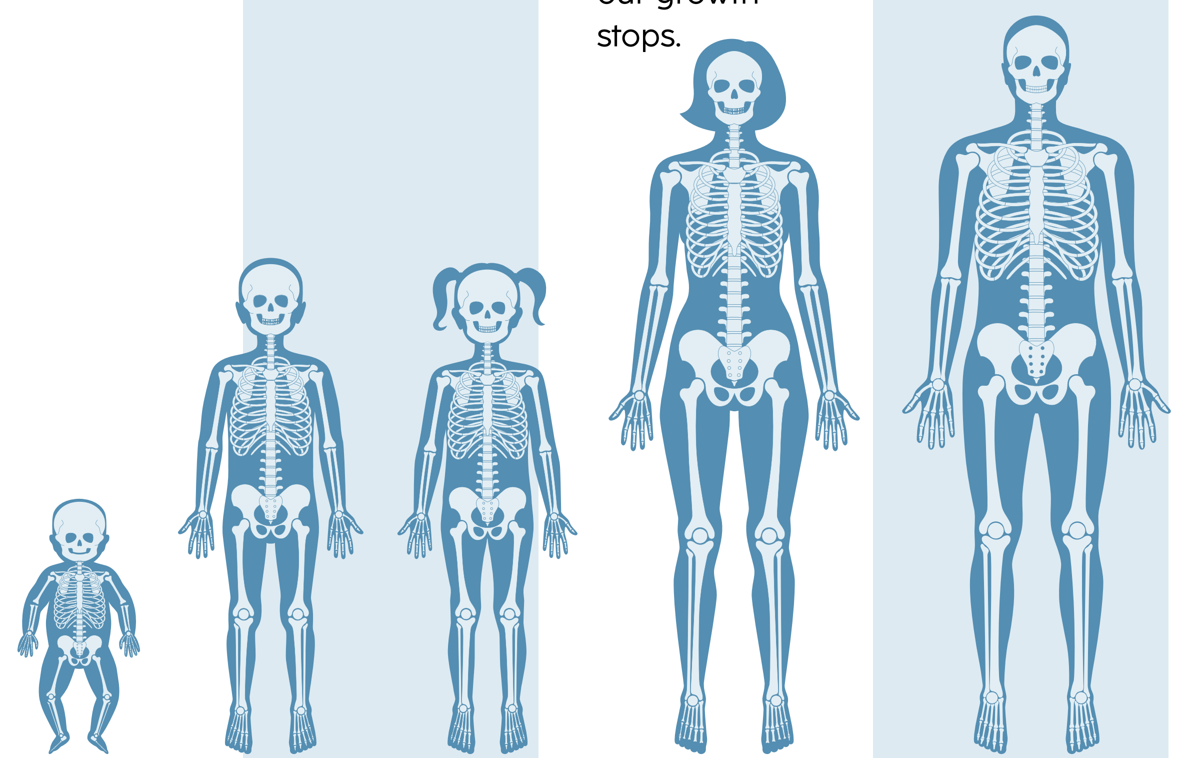
Short, flat and **irregular bones** have a simpler structure: they are composed of **trabecular bone** covered by **cortical bone**.

Interesting fact...

During the early years of our lives the epiphyses are separated from the diaphysis.

At that stage, the metaphyses contain a **growth plate**, which consists of cartilage and allows our bones to grow.

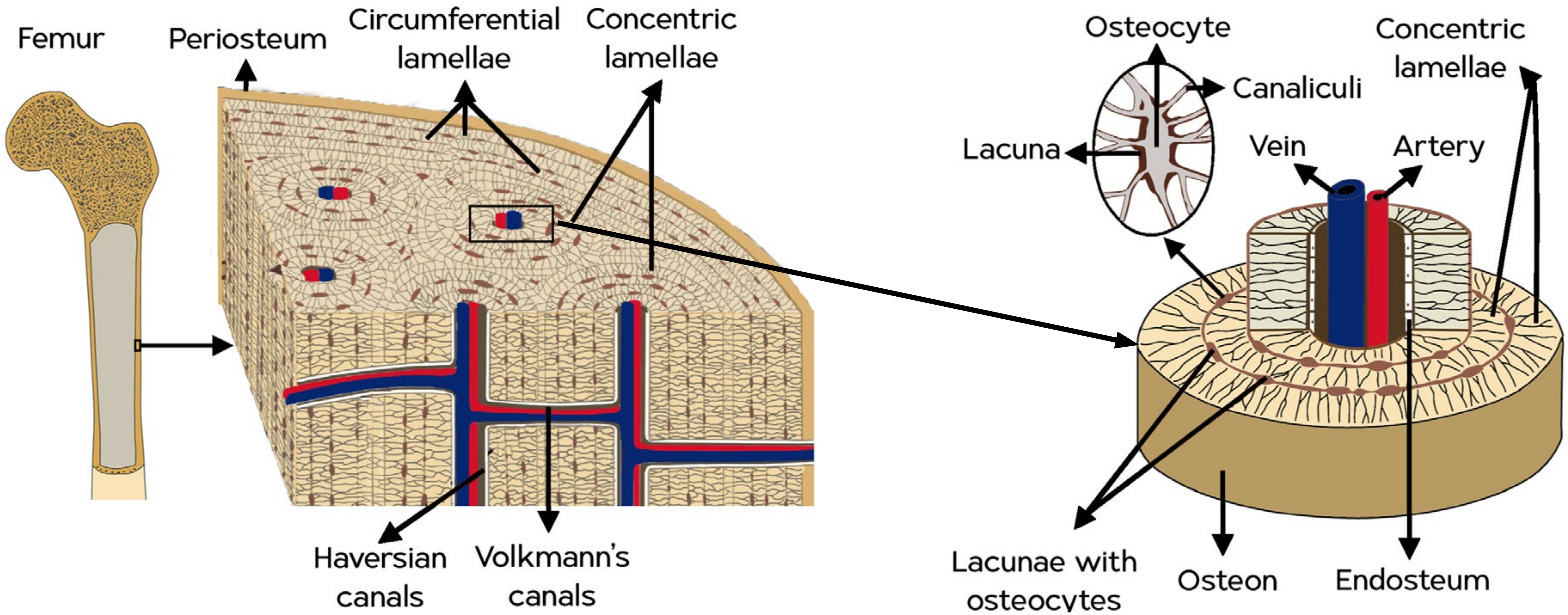
During adolescence, the cartilage of the growth plate ossifies, thus the epiphyses unite with the diaphysis and our growth stops.



Bone structure under the microscope

The human skeleton has two main types of bone tissue:

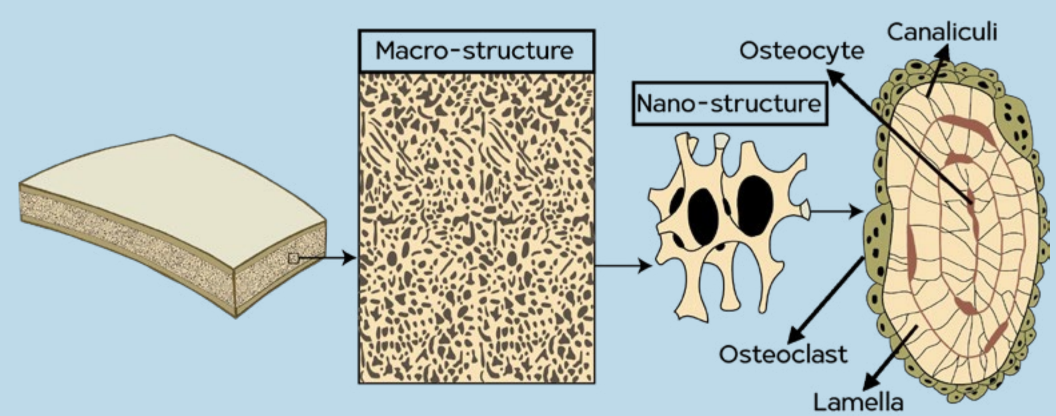
- **cortical bone** and
- **trabecular bone**



Cortical bone is dense and consists of **osteons**. Each osteon has a central canal, **Haversian canal**, which allows the passage of blood vessels and nerves. Around each Haversian canal there are layers of bone called **lamellae**. Small cavities, **lacunae**, are found within the lamellae and inside them there are **osteocytes**, cells that maintain important bone functions.

Trabecular bone is composed of thin bony spicules called **trabeculae**. Each trabecula consists of a few layers of **lamellae**. **Lacunae** containing **osteocytes** lie within each trabecula.

The trabeculae are arranged irregularly in a honeycomb structure. Because of this structure, trabecular bone has minimal weight but at the same time provides great strength to the skeleton.

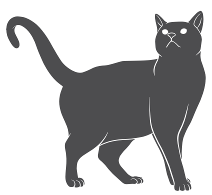


A few basic tooth facts!

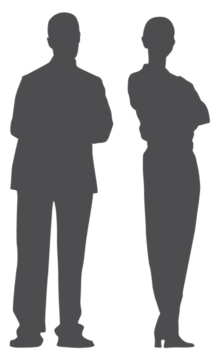
Humans first have **deciduous teeth (baby teeth)**. During childhood, baby teeth are replaced by **permanent teeth**.

For some years, as this replacement takes place, children have both deciduous and permanent teeth in their mouth, like this girl.

Teeth start forming when we are still foetuses. However, they don't really show up in our mouth until we are born and turn about 6 months.

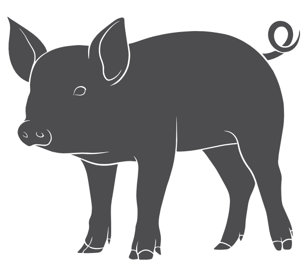


cats have **30 teeth**

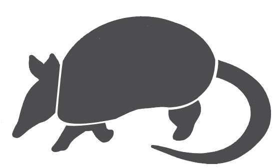


Humans have **32 teeth**

dogs have **42 teeth**



pigs have **44 teeth**



Armadillos have **100 teeth**

The part of the tooth which is visible in our mouth is the **crown**

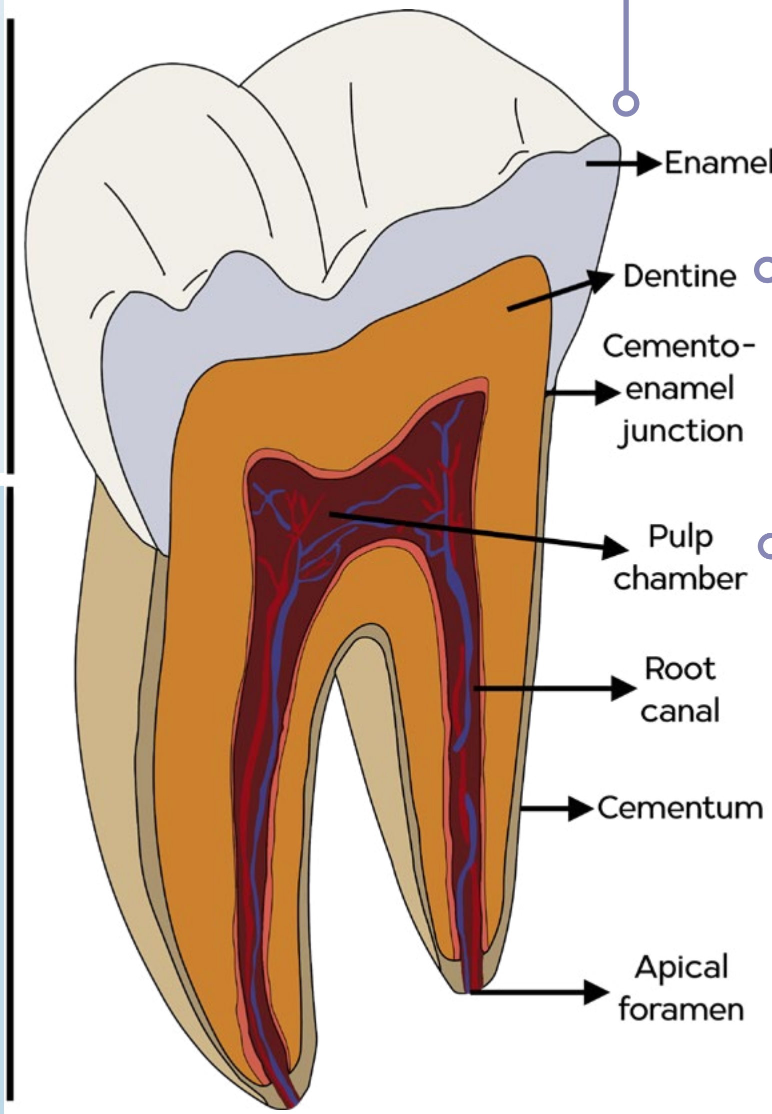
Crown

Root

The part embedded in our jaws is the **root**.

The **enamel** covers the crown and is almost 100% inorganic, which makes it very hard.

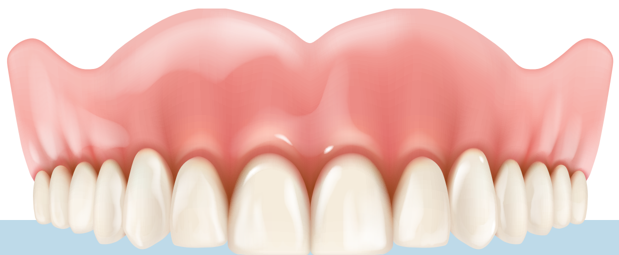
The **dentine** extends along the crown and root.



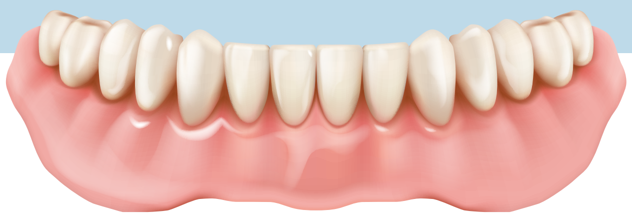
In the interior of the tooth lies the **pulp chamber,** which houses nerves and blood vessels.

The **cementum** covers the dentine at the root.

Tooth enamel is the hardest tissue in the human body!



Teeth are often the best preserved part of the skeleton, especially in ancient remains. This is very important because teeth provide key information about an individual's age-at-death, diet, and ancestry… **So, even if all that remains from a skeleton is the teeth, we can still make very interesting observations!**



Dentition of a young adult. Notice how the third molars are either erupting (upper jaw) or still within the jaw (lower jaw). As we will see in the following pages, the stage of dental development (tooth formation and eruption in the mouth) is a very useful method that osteoarchaeologists use to estimate the age of young individuals.

Over the course of their lifetime, people on average spend

38.5 days

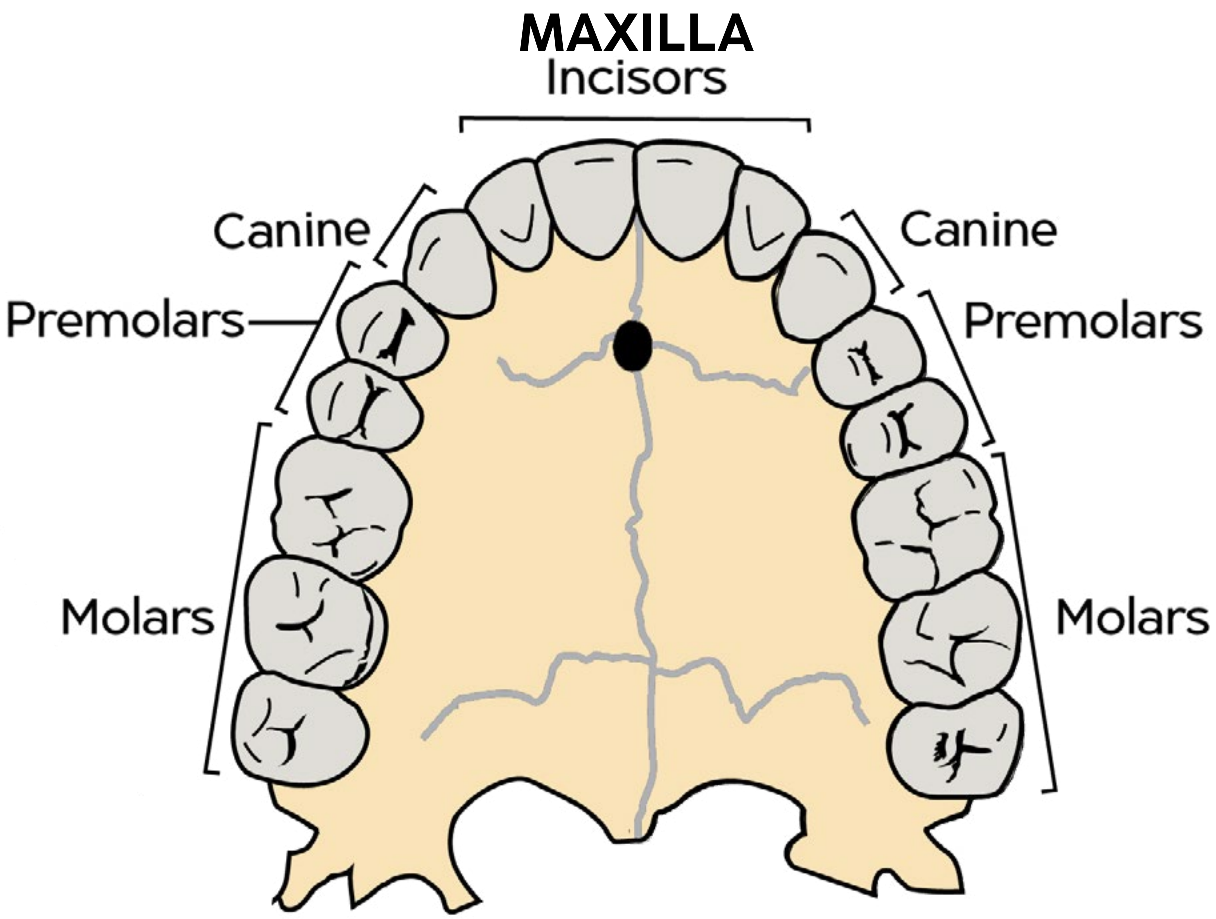
brushing their teeth

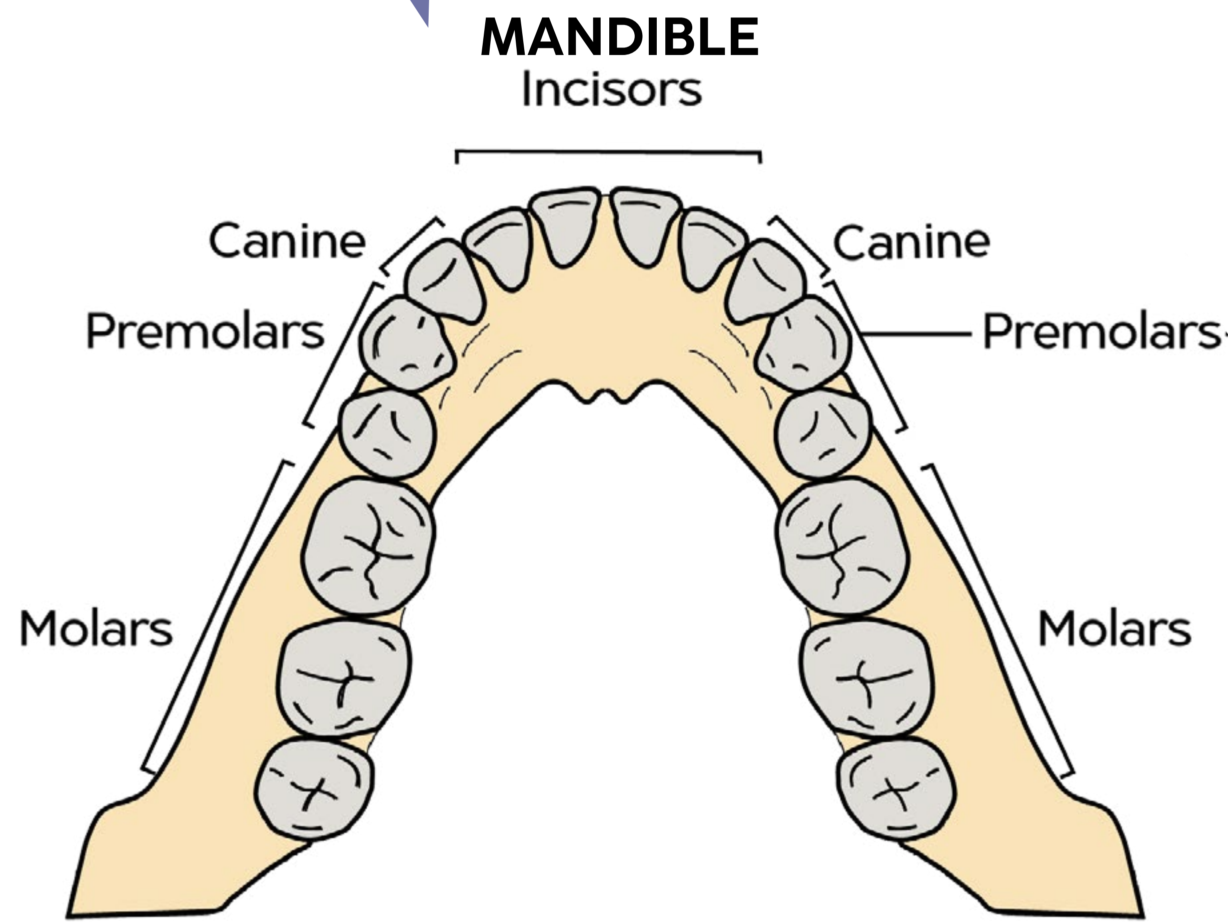
Pipe smoking was common in several past societies. When people spend a lot of time holding a pipe between their teeth, the dental tissues gradually wear off and a notch eventually forms between the teeth that traditionally held the pipe. Osteoarchaeologists have found such notches in past skeletons from very different parts of the world. **So the study of teeth gave us a record of smoking in the past!**

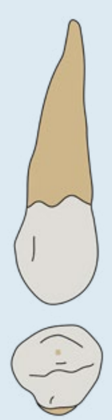
Although there is variation, each quarter of the adult human mouth generally has: 2 incisors, 1 canine, 2 premolars and 3 molars

Our teeth have different sizes and shapes and this allows them to perform different functions.

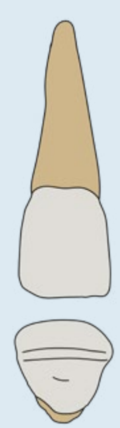
Just like fingerprints, teeth are unique to every human being. No two humans will have identical teeth.



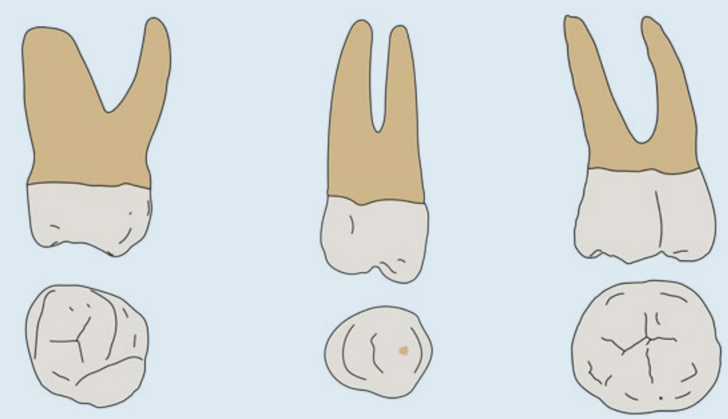




Canines grip and tear food, hence they have a pointed and sharp cutting surface



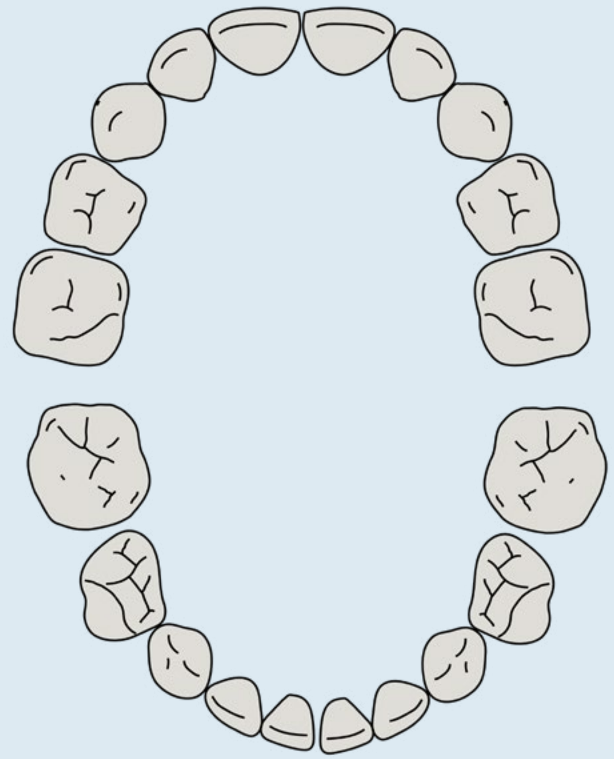
Incisors are primarily responsible for cutting food and this is why they have a broad and sharp cutting surface

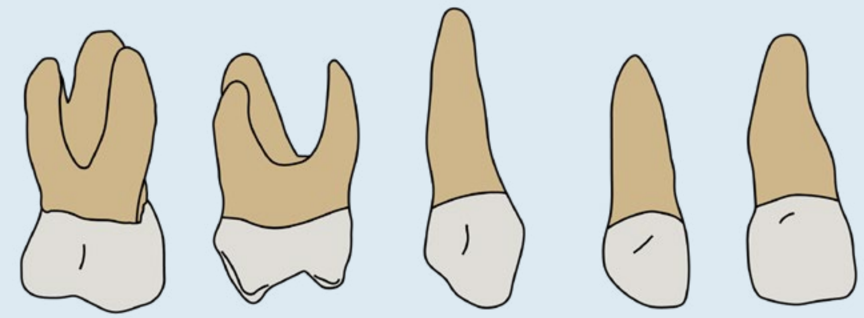


Premolars and **molars** crush food and, for this reason, they have broad and flat surfaces

The deciduous dentition has smaller and fewer teeth:

2 incisors, 1 canine, and 2 molars in each quarter of the mouth

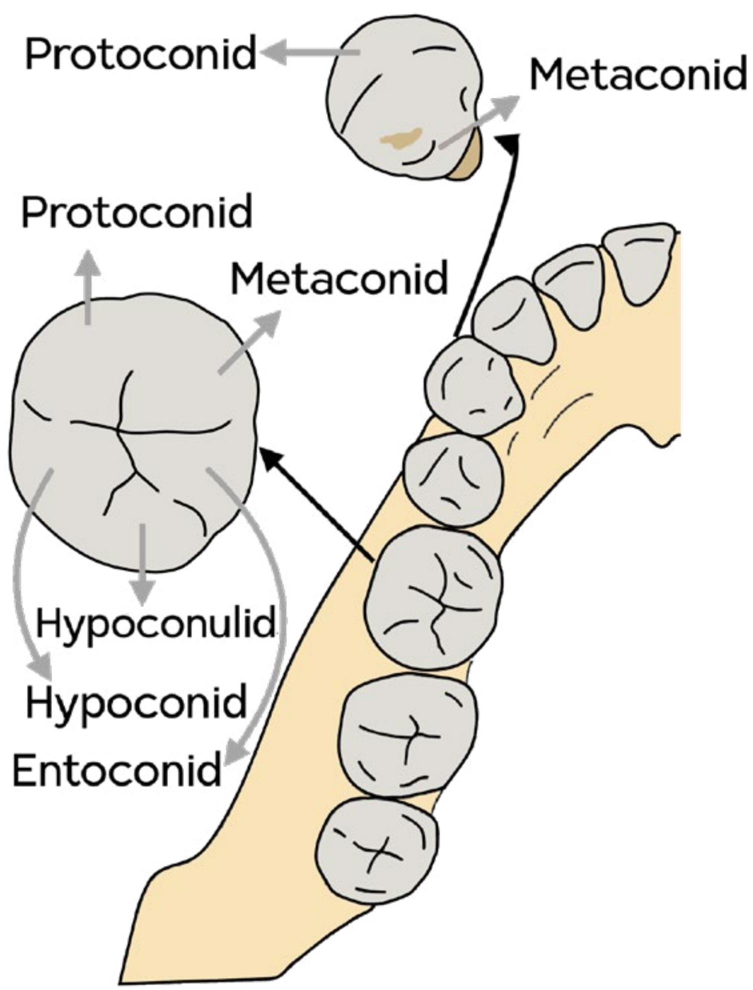


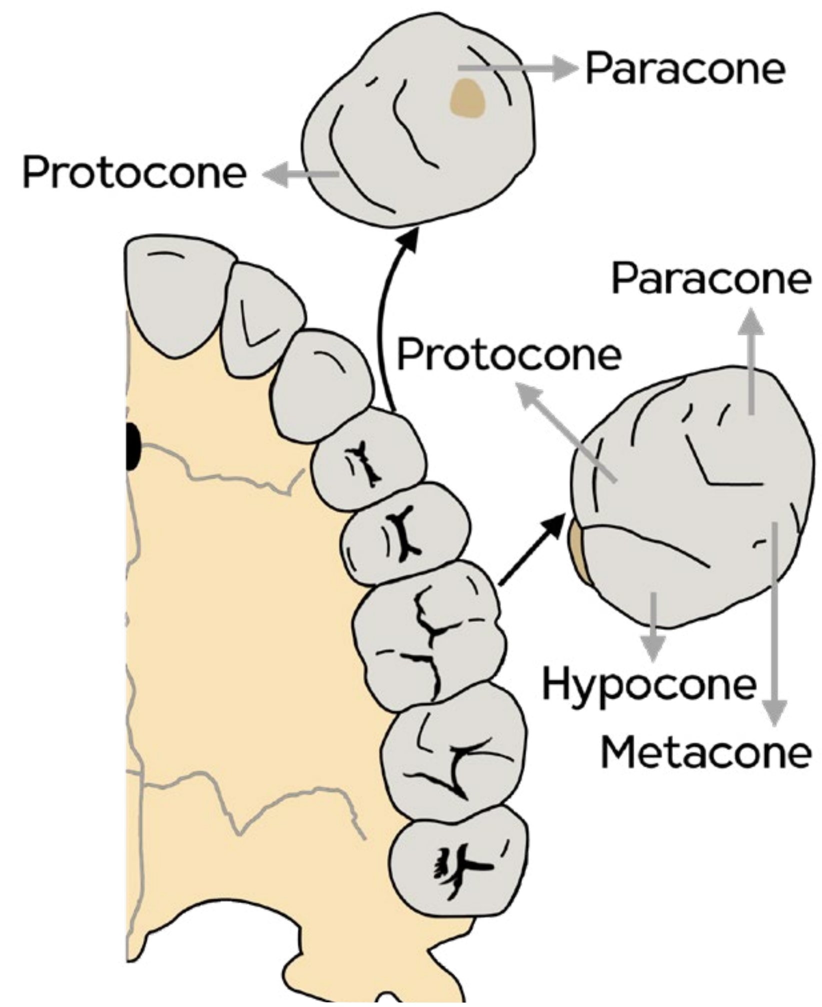


deciduous teeth

Molars and premolars have rather complex surfaces with many protrusions, called **cusps**.

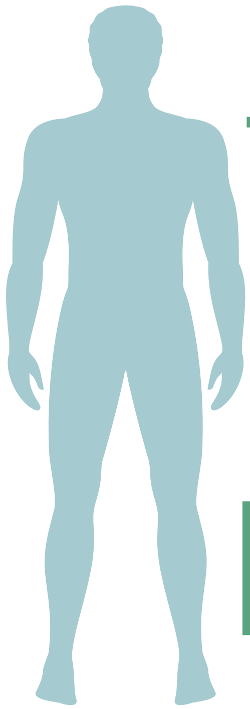
To identify each cusp, we use specific names.





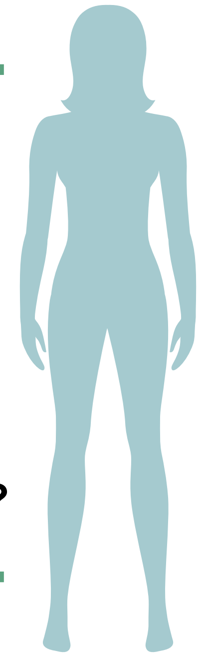
demography

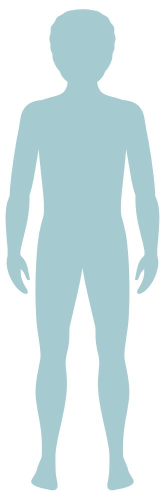

We are actually
a lot more similar
than meets the eye!
We are
soooo different!



Surely you have noticed that males and females differ in their anatomy.

Have you ever wondered how their skeletons may differ?





What about how a child's skeleton changes as it grows older?

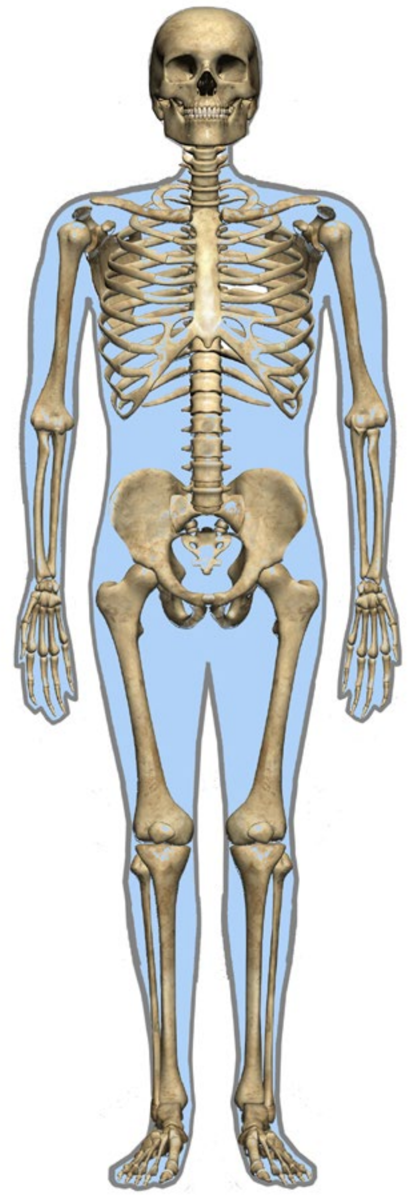
There is a lot of variation in skeletal anatomy, which relates to our age, as well as to our sex.

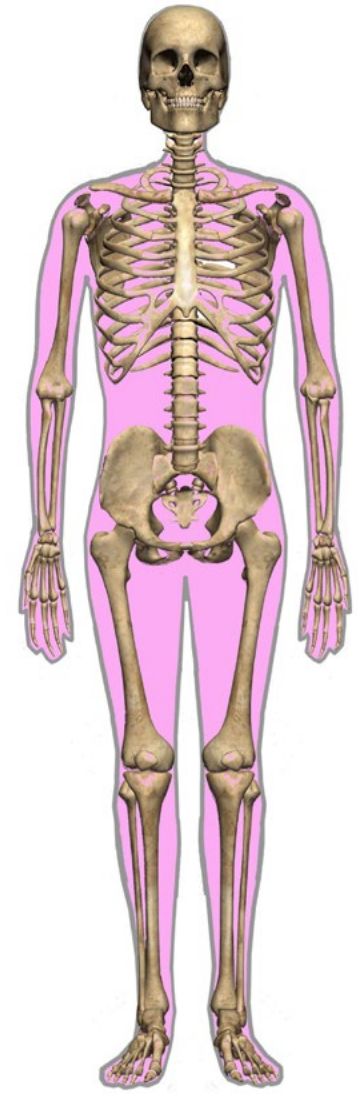
At the same time, we are all remarkably similar to each other, as you are about to discover....

Is it male or female?

Males and females are slightly different in their body shape and size. Therefore, by looking at an individual's skeleton, we can tell the sex of this individual.

However, this only applies to adults. Sex-related skeletal differences in children are minimal because the levels of testosterone, the hormone largely responsible for the development of male physical characteristics, are low before puberty.



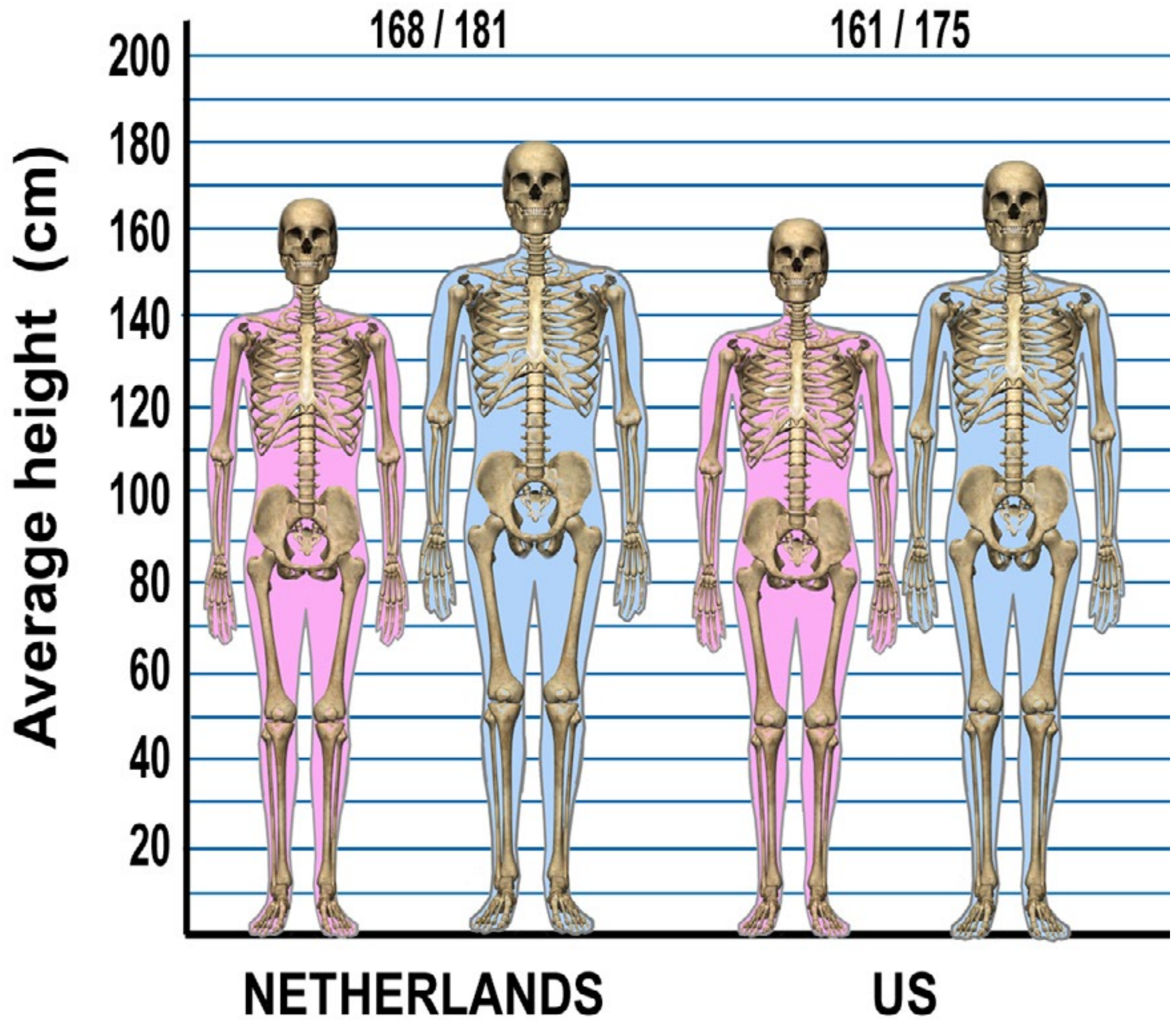


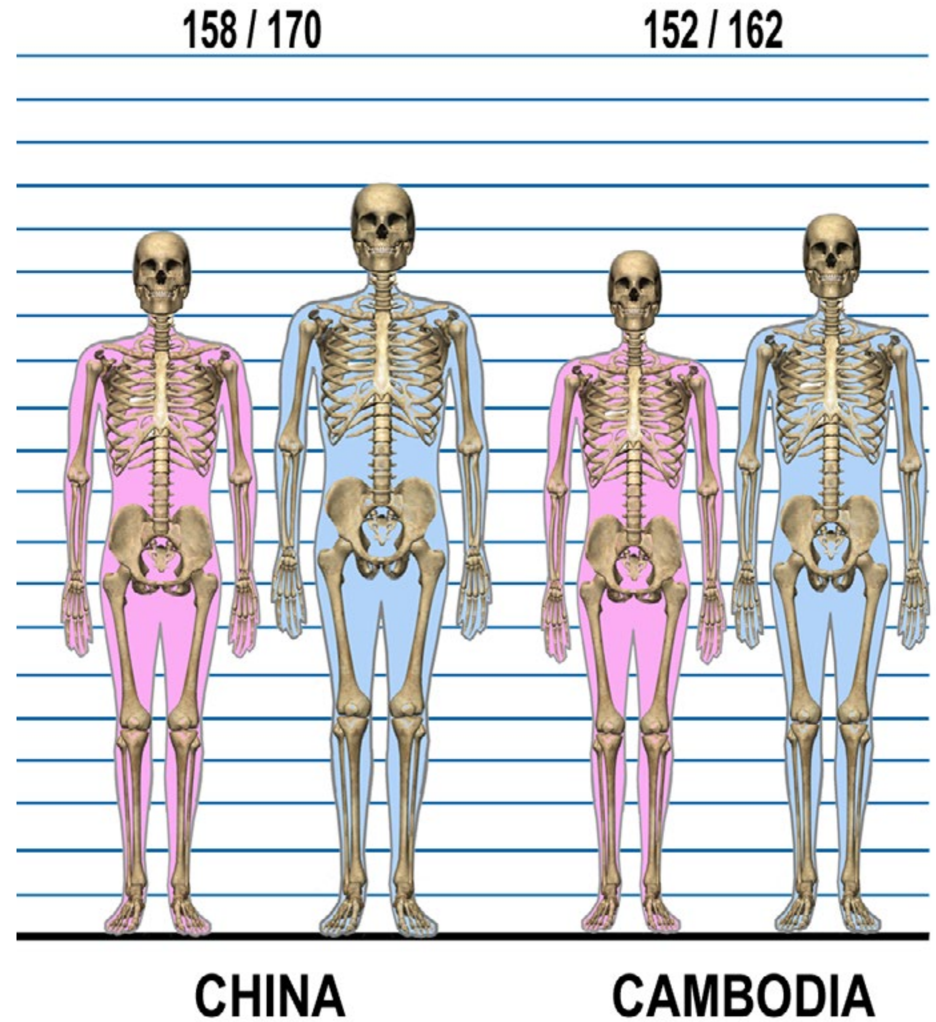
Females are generally smaller and more gracile than males.
So, if we measure the bones of a female skeleton and compare the values against those of a male skeleton, they are usually lower.

Osteoarchaeologists determine the **sex** of past individuals, that is, whether individuals had anatomically male or female characteristics at birth. This should not be confused with **gender**, that is, the social roles associated with men and women in different societies.

BE CAREFUL!

There is a large degree of overlap between male and female size. This means that male values do NOT begin where female ones end!





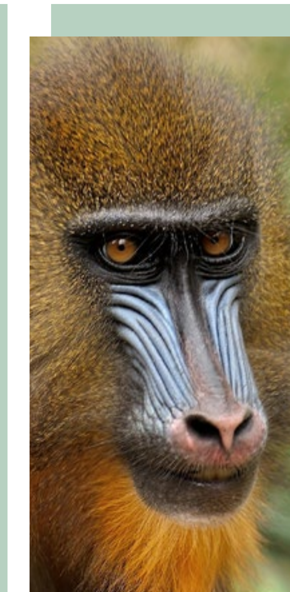
Different populations have different dimensions because they have adapted to different environments. For example, groups from southern Europe are generally smaller than groups from northern Europe because the climate is different in these regions.

Determining whether a skeleton is male or female is one of the first steps in an osteoarchaeological study. Such information allows us to:

- examine the **demography** of past populations
- explore differences in the way males and females were **treated after death**
- examine differences between males and females in **pathology**, **activity, diet** and other **skeletal markers**

Sexual dimorphism is the term we use to express all morphological differences between males and females. In humans sexual dimorphism is visible but not as pronounced as in other species....

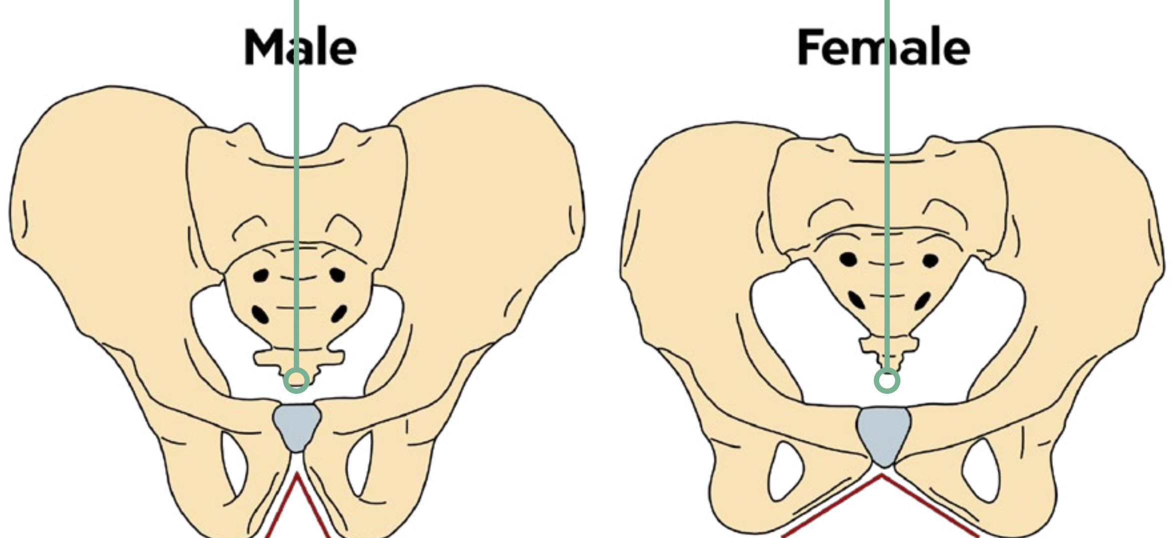
Mandrills are among the most sexually dimorphic mammals. Males have more vibrant colors on their faces and behinds, and are much larger than females: the average female mandrill weighs about 12 kilos, while male mandrills can weigh up to 37 kilos!



Sex differences in the pelvis

The biggest differences between males and females are found in the pelvis. In **males** the pelvis is **narrower** as it has evolved in order to allow **walking long distances** without spending too much energy. In contrast in **females**, the pelvis has evolved to **enable both walking and giving birth**, thus it is **broader** than that of males.

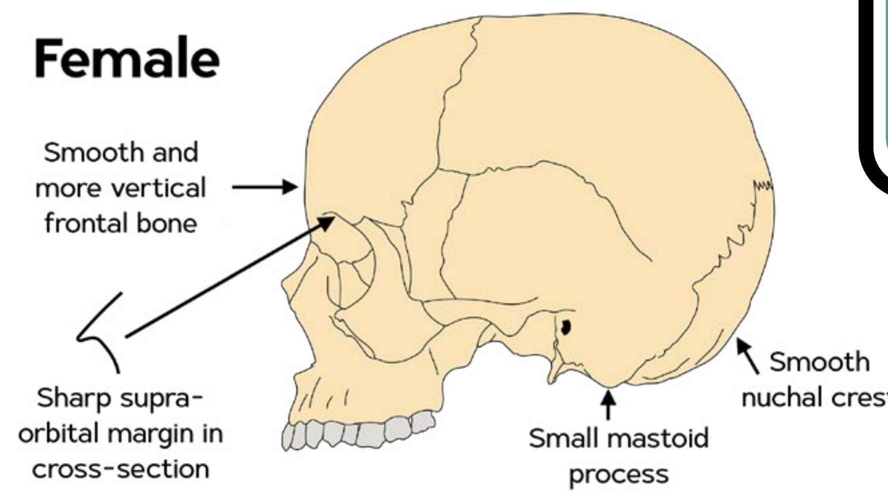
Note the broad female pelvic inlet, compared to the much narrower male one

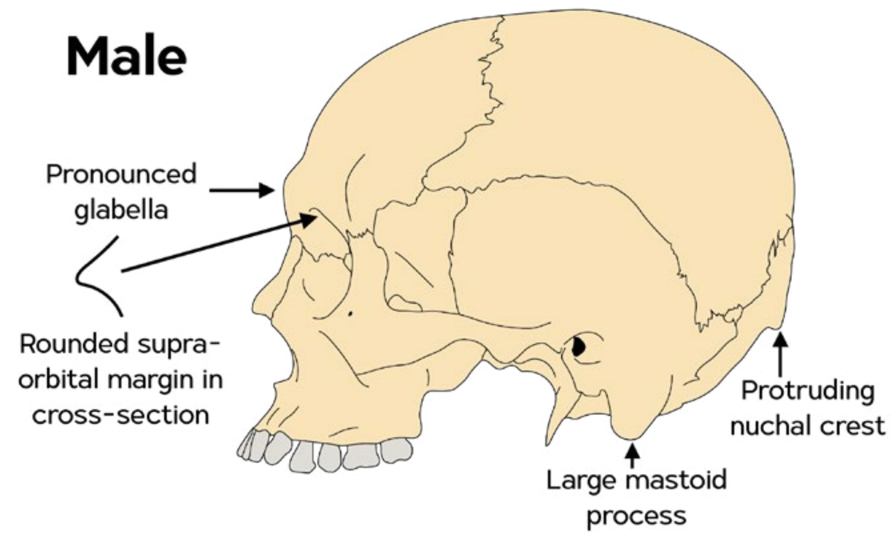


Note also the wide female subpubic angle, compared to the male narrow angle

Sex differences in the skull

Males are generally **more muscular** and robust than **females**, and this is rather obvious in specific cranial structures, as shown in the following images.

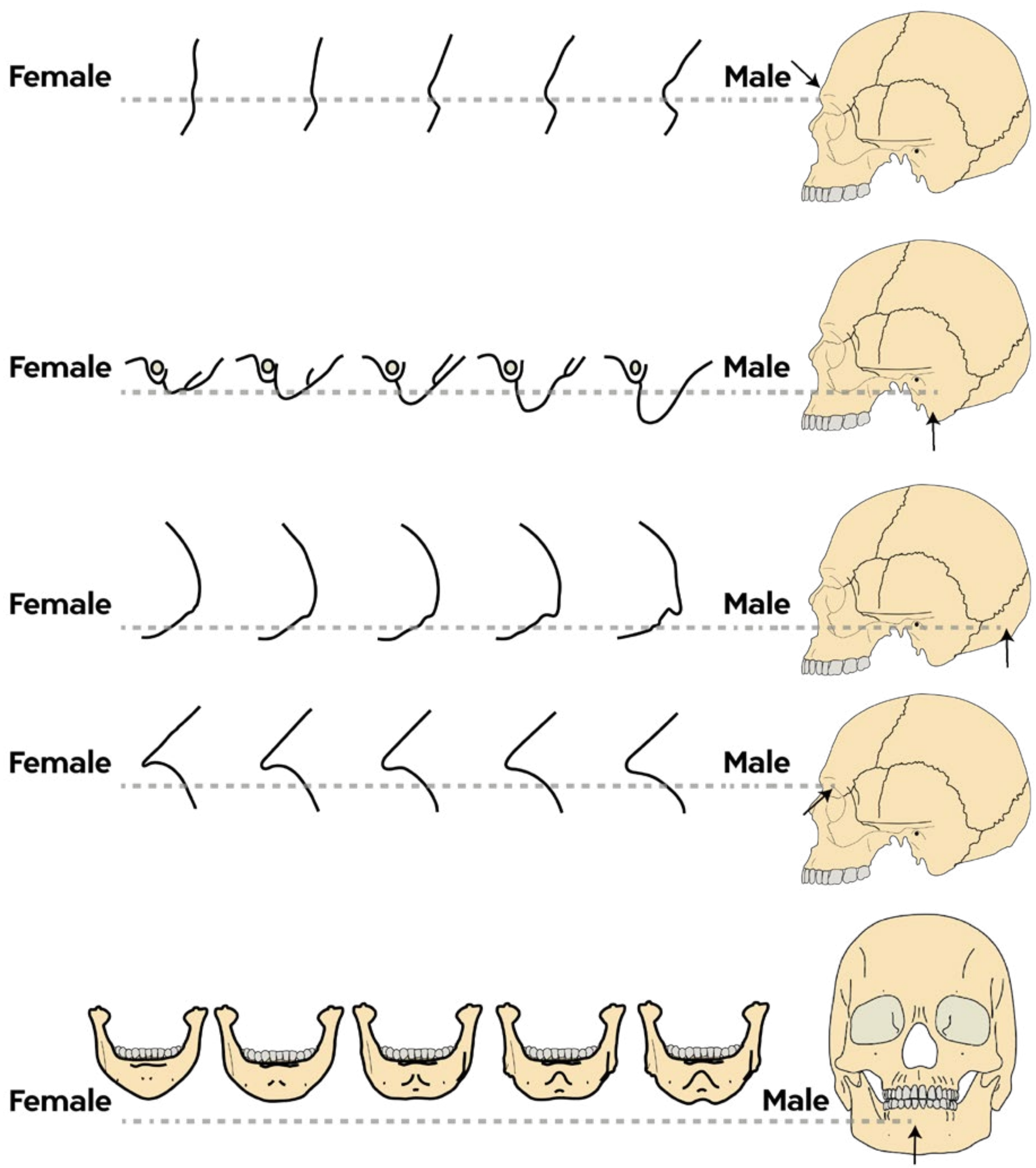




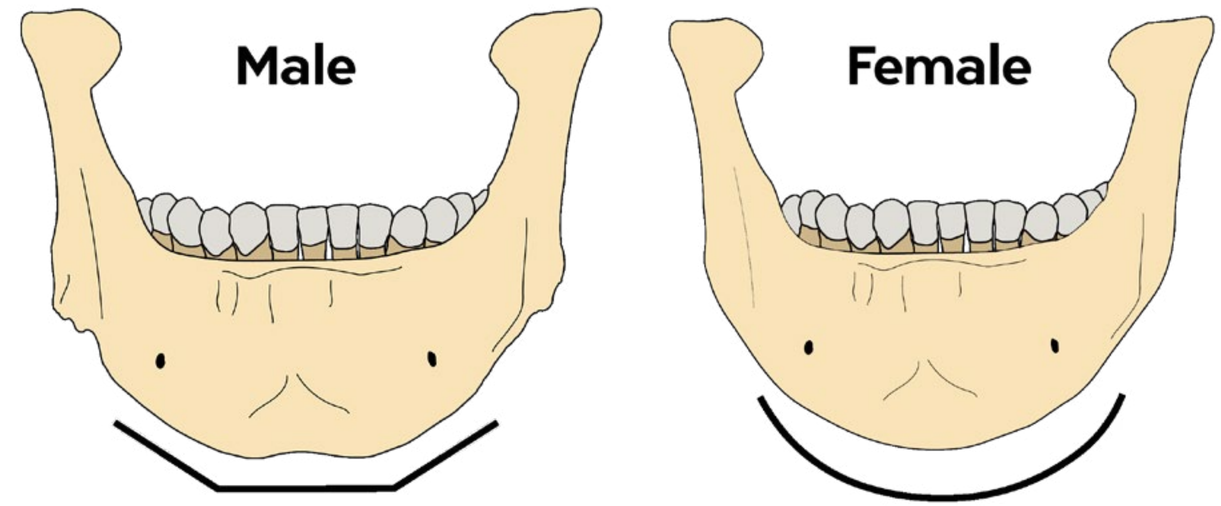
BE CAREFUL!

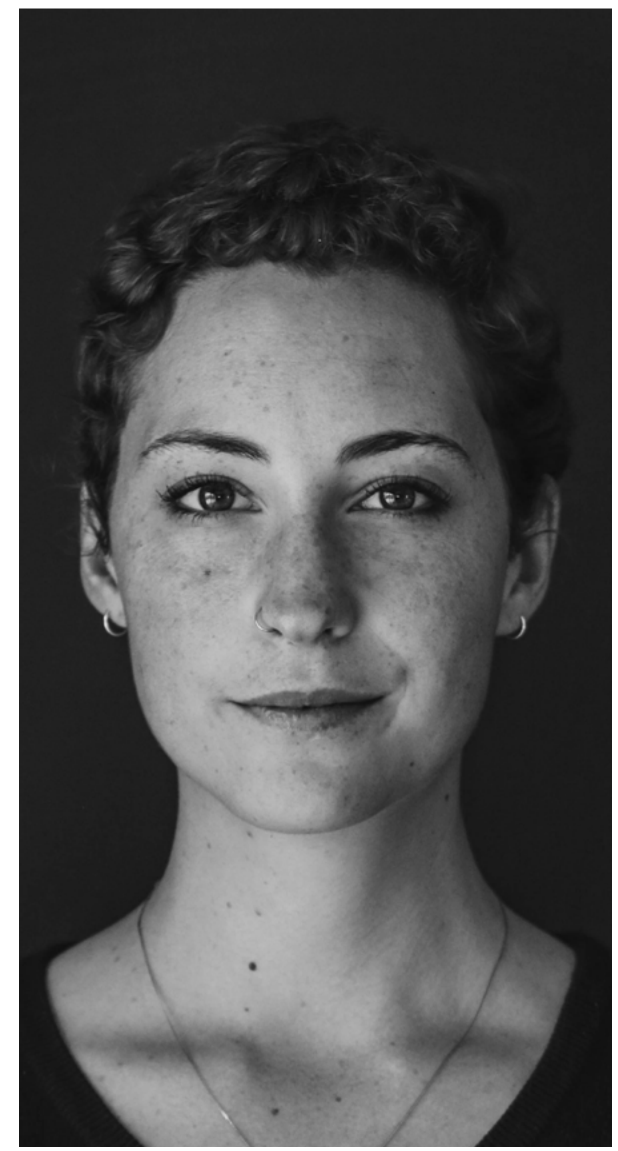
While the differences between males and females seen in the pelvis are universal, cranial robusticity is strongly related to the diet and other activities that involved the mouth of ancient people (e.g. fiber processing using the teeth), as well as climatic and other factors. Thus, the expression of cranial differences between males and females may differ among populations!

Sex differences in the skull (continued)



Scale showing the expression of cranial traits used in assesing if a cranium is male or female



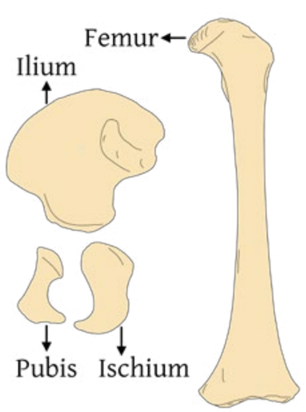


HOW OLD

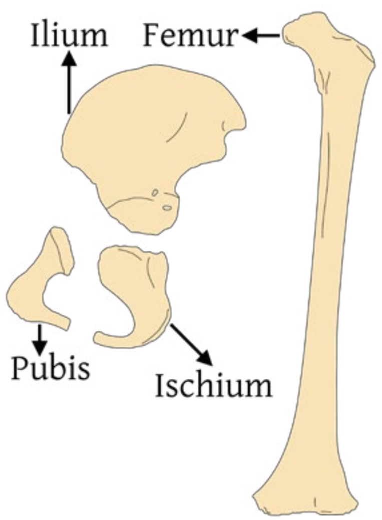
are they?

Age-at-death estimation, that is, the estimation of the age at which an individual passed away, **is also one of the first tasks of an osteoarchaeologist. It gives information on the *demography* of past populations, and it is a key factor to consider when examining *activity*, *pathology*, and *other aspects of past life*.**

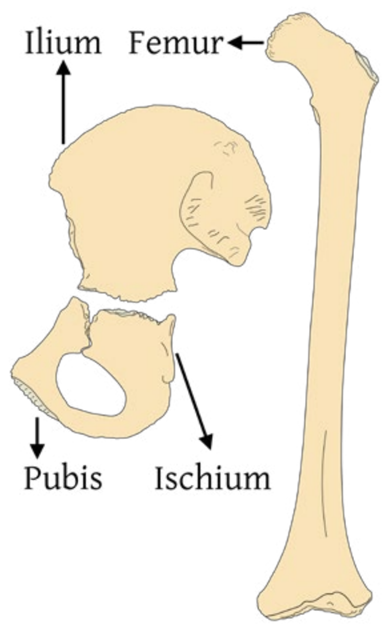
In **juveniles** age estimation is based on skeletal changes that occur during the gradual development of the body.



14-16 weeks old

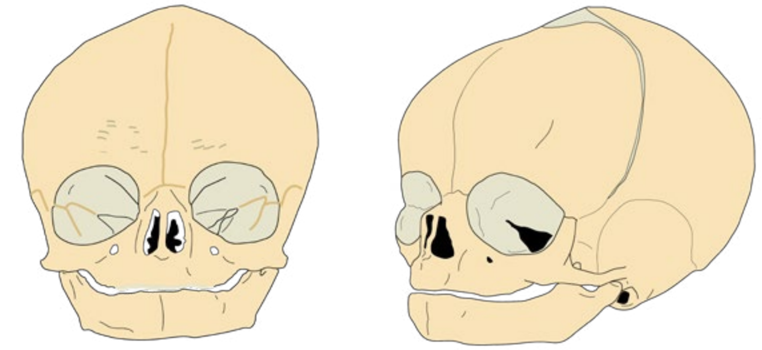


5 years old

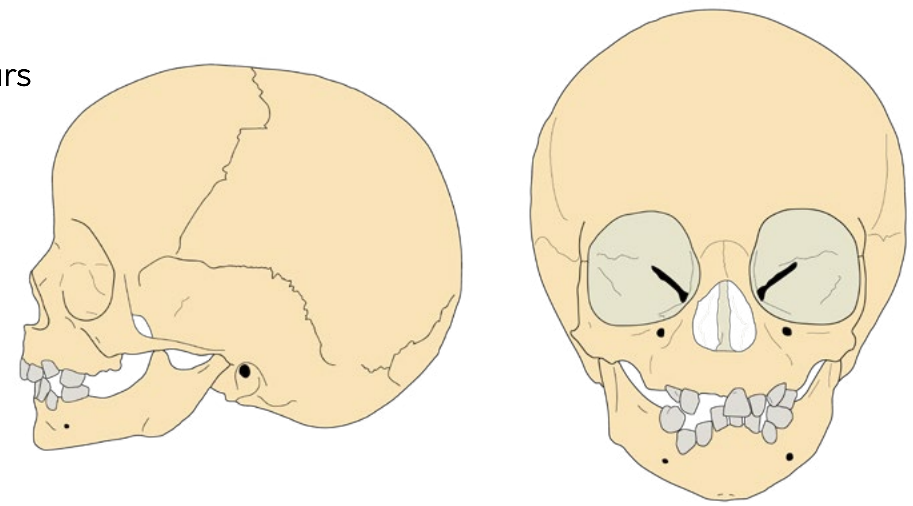


13 years old

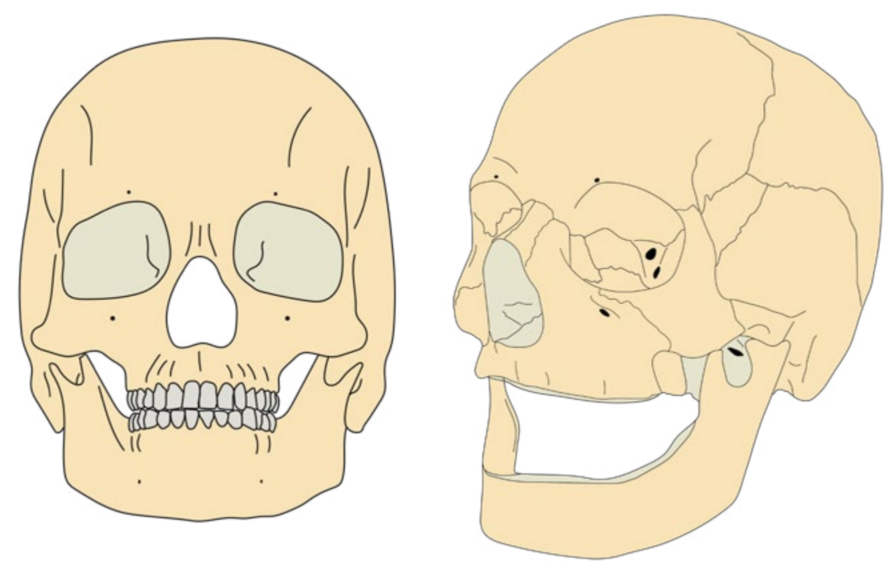
40 weeks old



2 years old



young adult



In **adults** the development of the skeleton is complete and all the changes we examine are degenerative. This means that in adults, age estimation is affected by multiple factors, such as activity, diet, and disease, and it is not as accurate as age estimation in juveniles.

older individual who lost all teeth while still alive!

Tricky business...

The estimation of age-at-death using skeletal remains is based on the biological changes that occur on the skeleton with time. What we are actually estimating is the individual's **biological age**. However, this is not the same as **chronological age**, that is, how much time has passed since the birth of the individual. Whereas chronological age progresses steadily, biological age is affected by factors such as activity, diet, and disease. As a result, chronological and biological age become more and more divergent from each other as an individual ages, making the estimation of chronological age from biological age problematic.

more tricky business...

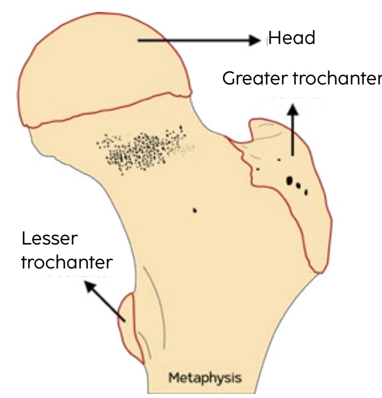
All age-at-death estimation methods have been developed based on modern populations. We study how the skeleton changes with increasing age in modern individuals and organize these changes into successive stages. Then we use these stages to predict the age of individuals for whom we don't know it in advance. However, it is very likely that people in the past aged at a different pace compared to modern people. Also, remember that an individual's diet, physical activity and health affect the rate of degeneration of different parts of the skeleton!

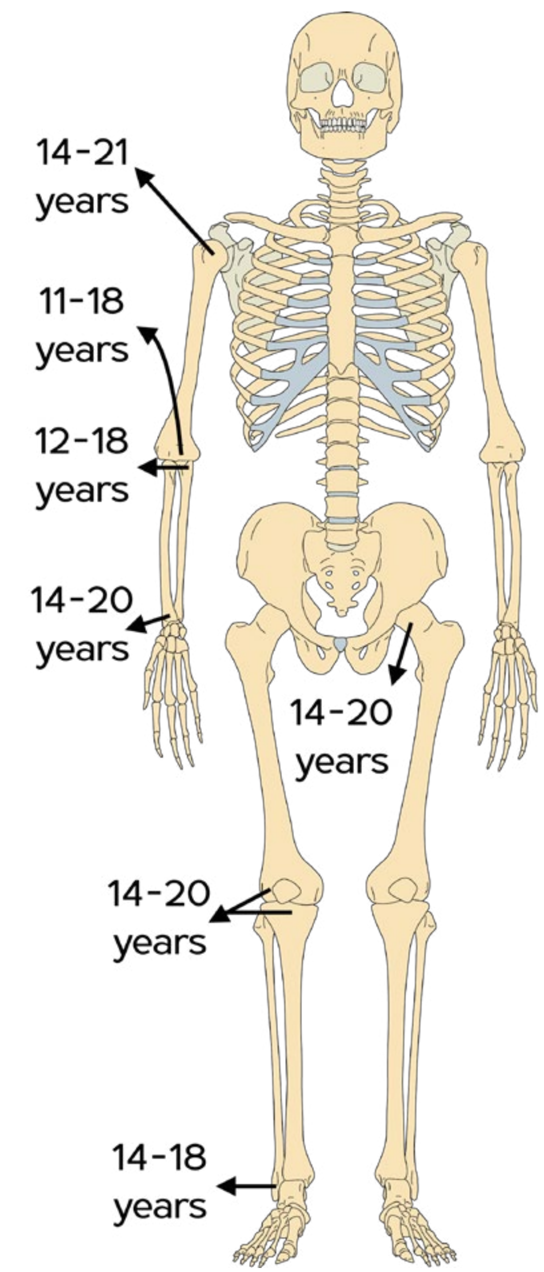
Age-at-death estimation for juveniles

Remember we said our long bones consist of a diaphysis and two epiphyses, which are originally separate elements but then they gradually unite, and the development of the skeleton is complete?

The age when different parts of bones fuse together in order to form the final adult skeleton varies between individuals and populations. However, some general patterns have been observed in modern groups and, based on these, we can estimate the age of past individuals according to the degree of fusion of the epiphyses to the diaphysis.

Left femur: Notice how the head and greater trochanter are in the process of fusing with the diaphysis





When is this method useful?

This method is mostly useful for estimating the age of individuals in adolescence, when most elements are in the process of fusing. Once fusion is complete, all we can say is that an individual is "adult".

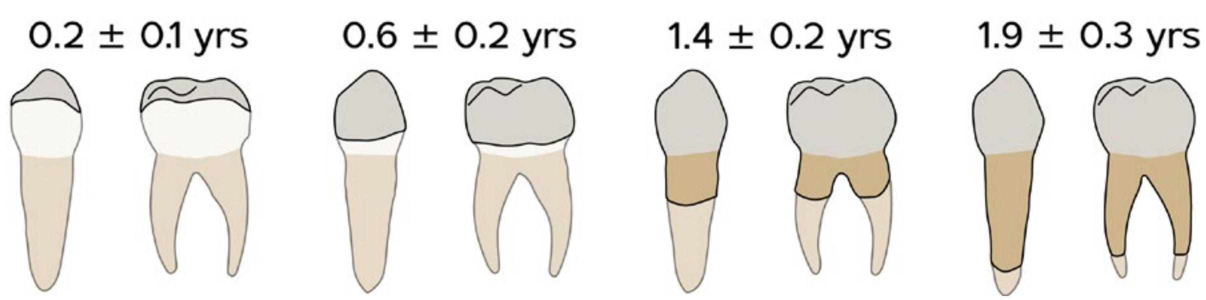
Sex differences

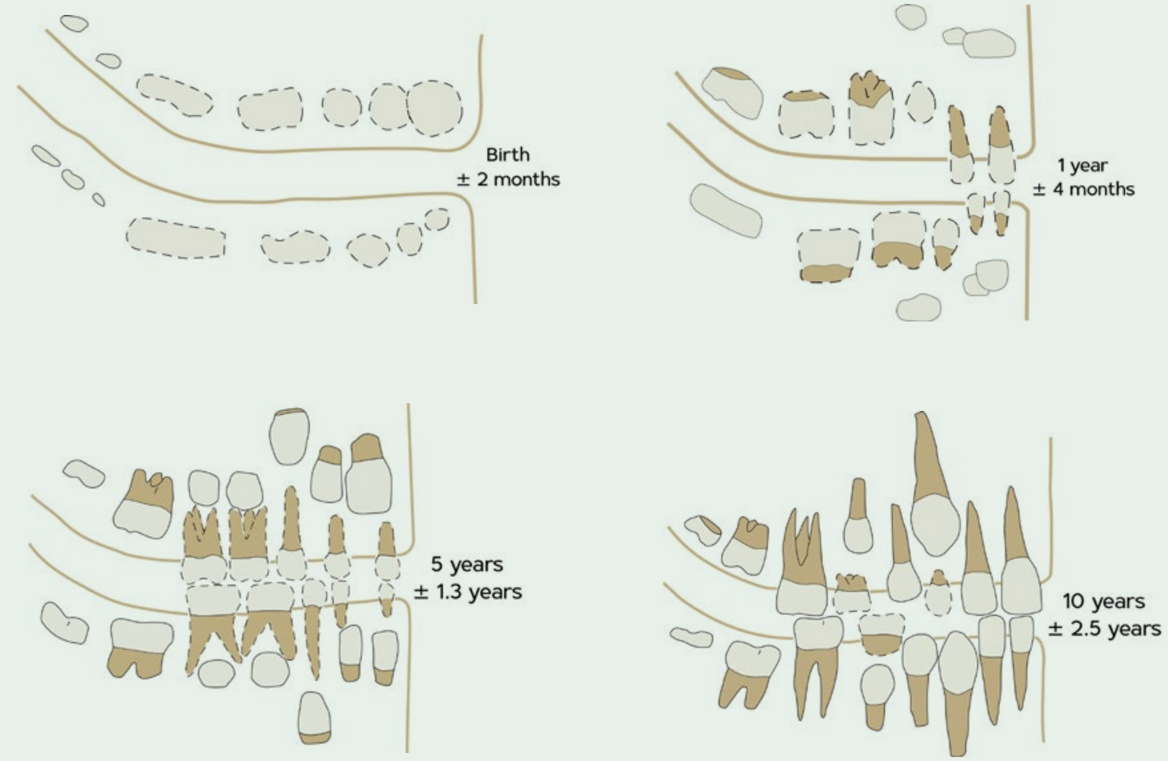
Many epiphyses start fusing earlier in females than in males. However, we cannot accurately tell if an immature skeleton is male or female. The safest option is to use the data for both males and females and estimate age with a higher margin of error.

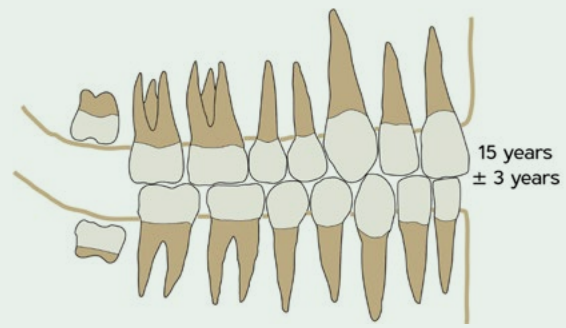
Age-at-death estimation for juveniles (continued)

The **development of the human teeth** and the **replacement of deciduous teeth by permanent teeth** follow a specific pattern. Therefore, teeth are also very useful in estimating the age of juveniles. Many studies in modern populations have recorded in detail the stages of dental development in children of different age and we use these standards in archaeological skeletons so that we estimate age-at-death.

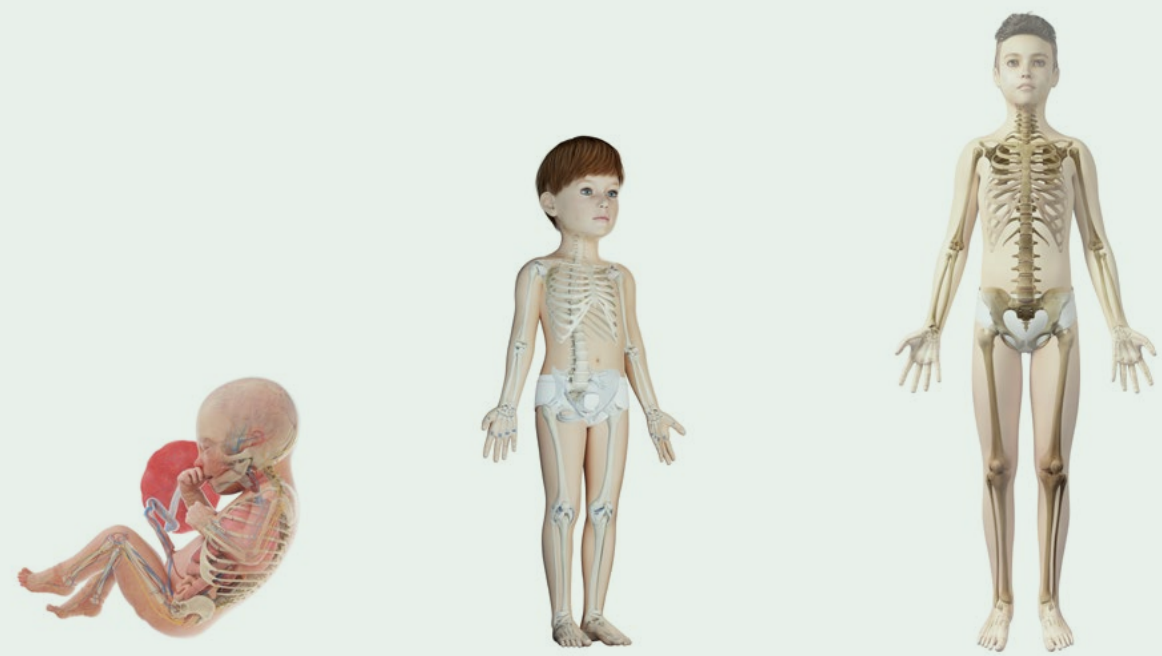
Some methods estimate age-at-death based on the development of specific teeth.





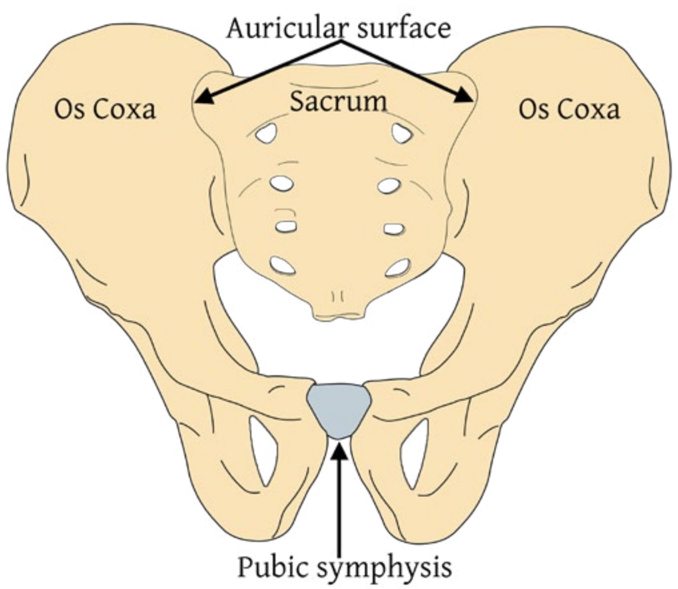


Other methods estimate age-at-death based on the overall development of the dentition. Thus, we look at all preserved teeth simultaneously and determine at which stage of dental development the individual falls using published 'atlases' of dental development.

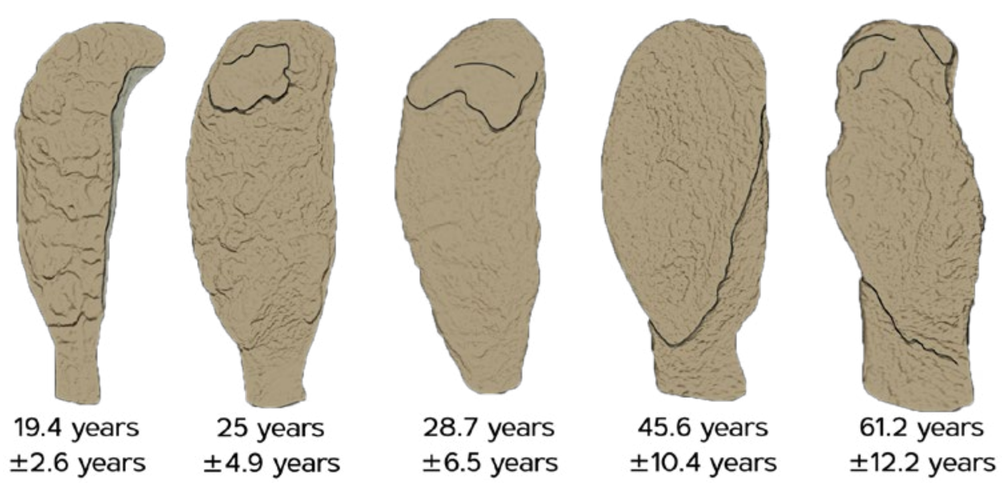


Age-at-death estimation for adults

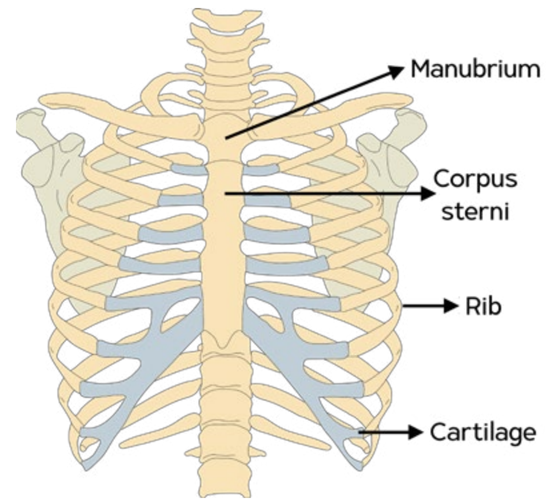
To estimate the age-at-death from adult skeletons, we focus on the degeneration of specific joints.



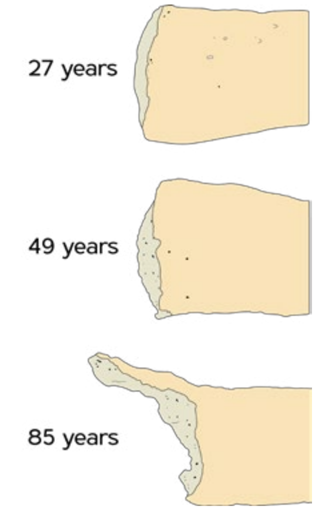
The most common joints examined are the **pubic symphysis**, which is the point where the two os coxae articulate with each other, and the **auricular surface**, which is where the os coxae articulate with the sacrum. **The older we turn, the more 'deformed' these joints get.**



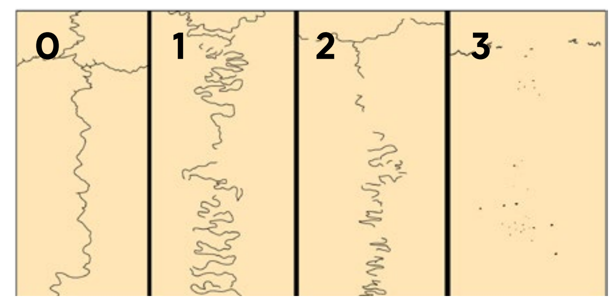
Notice the gradual degeneration of the surface of the pubic symphysis as the age of the individual increases. The original wavy surface disappears and a rim is formed around the joint, which in the end breaks down.



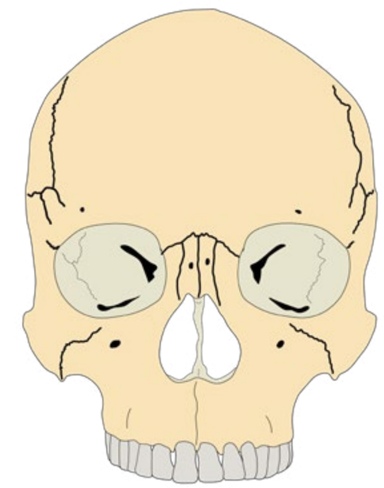
Most of the ribs articulate with the sternum through cartilage. The older we get, the more deformed the sternal rib ends become and this can also be used as an age marker.



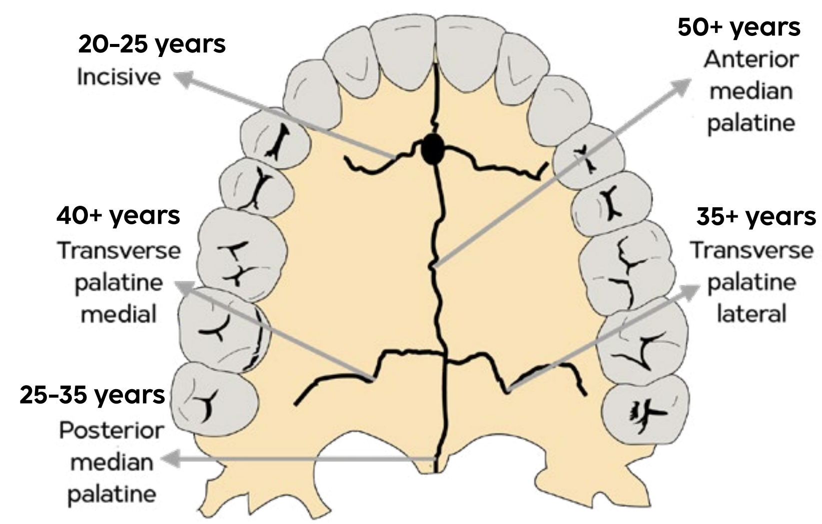
As we saw before, even though we refer to the cranium as if it is one big bone, in reality it consists of many different bones. These bones are connected through joints called **sutures**.



Note how the sutures are open in stage 0 but they have almost disappeared in stage 3

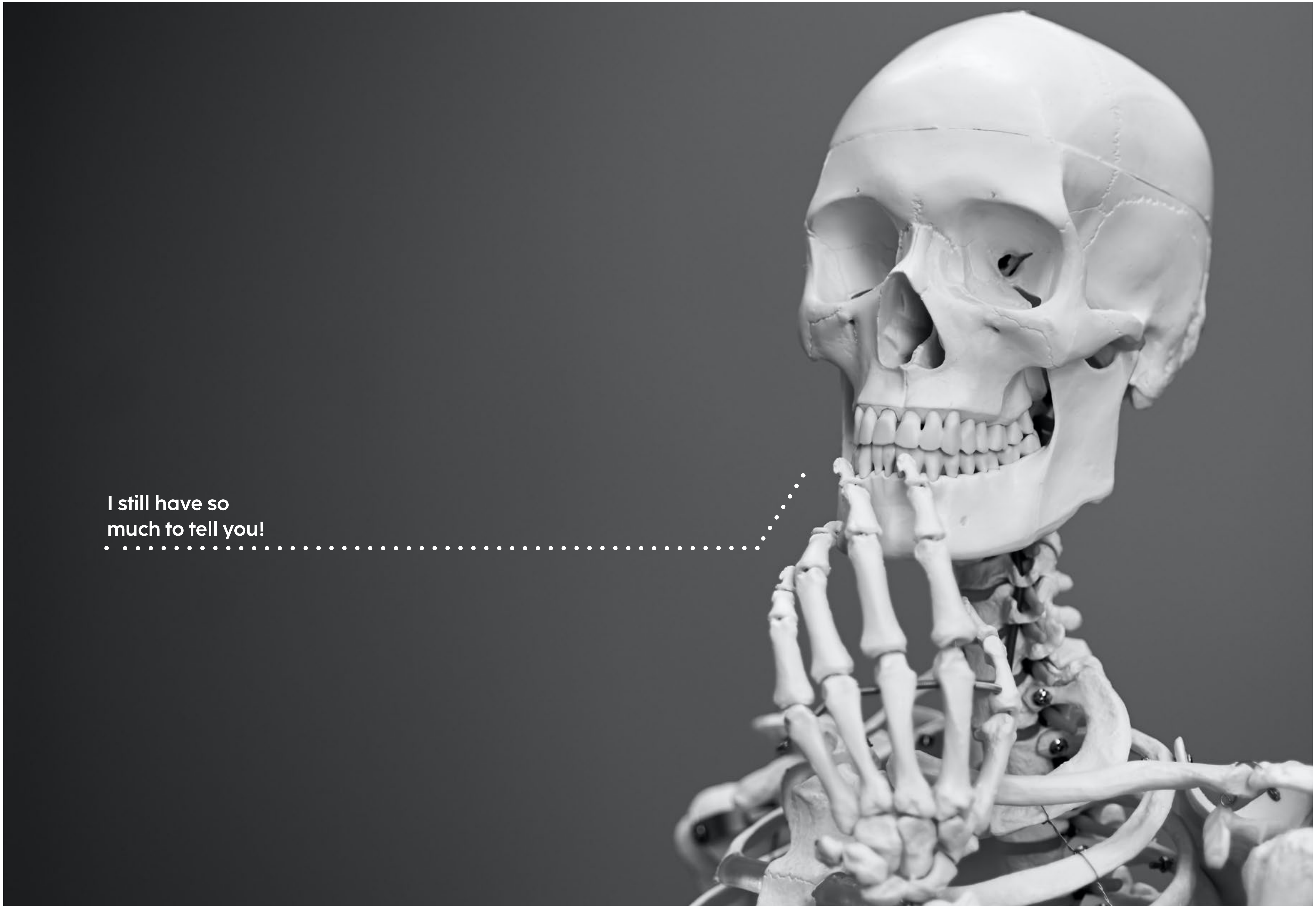


When we are young, the sutures are clearly visible but as we get older, they gradually disappear and the individual cranial bones unite with each other.



Besides the sutures we see on the outer surface of the cranium, there are sutures on the palate. These also fuse together as we grow older and may give us at least a broad indication of an individual's age.

past life written on bones



Our skeleton provides a permanent record of many aspects of our daily life. You can think of it as a book that you can read and find out how people in the past lived and died.

Like with every book, in order to read it, you must know the language in which it has been written.

The following pages will present some of the main methods osteoarchaeologists use to study ancient skeletons and draw conclusions about our ancestors' life...

Growing tall...or not!

In osteoarchaeology, estimating an individual's height gives us an idea of what people looked like in the past. In forensic anthropology, height helps to identify the individual to whom the skeleton belongs.

Our height depends on our genes, meaning that **tall parents tend to have tall children and vice versa**. However, the environment in which we grow determines if individuals will reach their genetic potential. Children who are not well fed or who suffer from various diseases will not grow to be as tall as they could have been.

Growth finds its way!

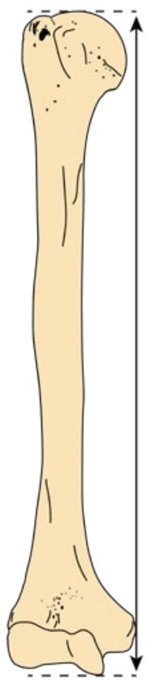
Even though during stressful periods, individual growth rates slow down, if the stressor is eliminated, growth may accelerate and individuals catch up with their peers. This phenomenon is called **catch-up growth**.

Estimating height from the skeleton

Once we have estimated an individual's age-at-death and sex, we can start exploring other issues, such as "how tall was this individual?"

THEN THIS...

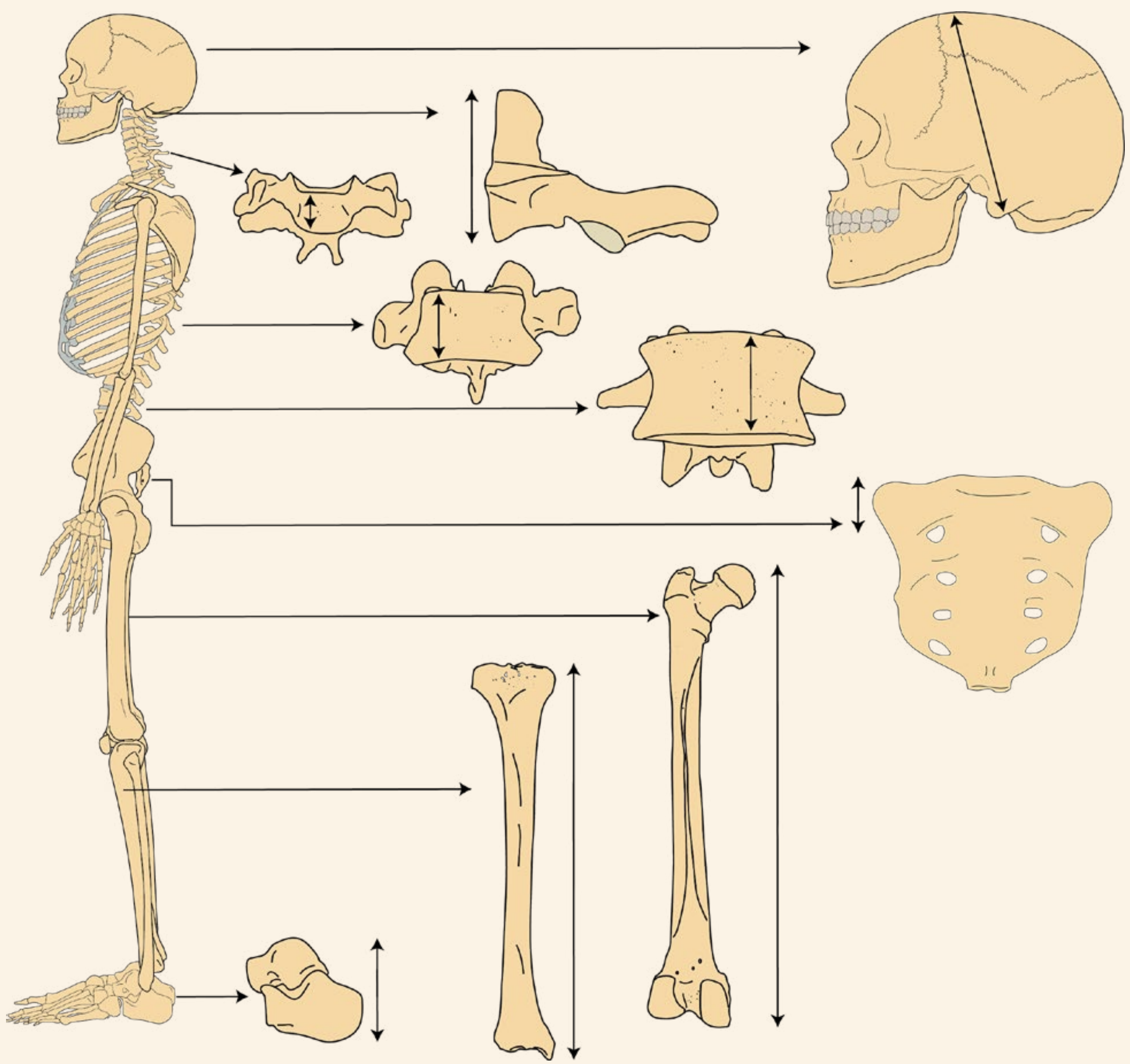
Often the skeleton is broken and bones are missing, thus the anatomical method can't be used. In such cases, we measure the length of the humerus, radius, ulna, femur, or tibia and then use statistical equations to estimate height. This is the **mathematical method** and it is based on the fact that tall people have longer bones.



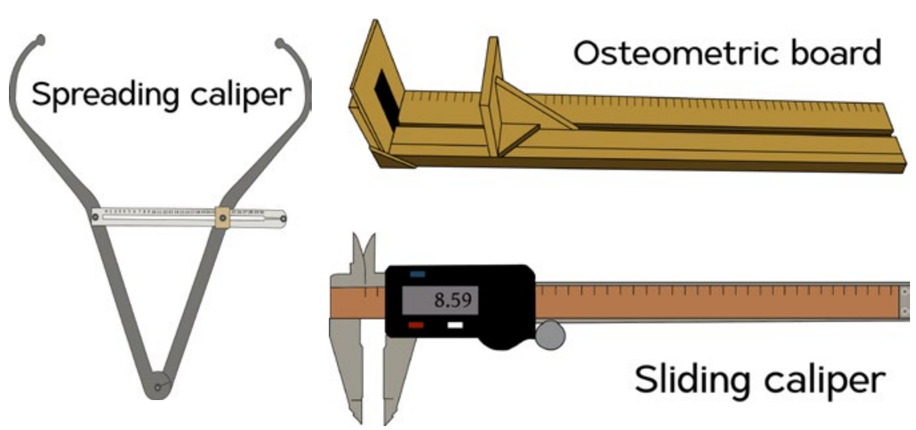
READ THIS FIRST!

The most accurate way to estimate an individual's height based on the skeleton is the **anatomical method**.

First, we measure the length/height of every bone that contributes to our stature: talus and calcaneus, tibia, femur, first sacral vertebra, all lumbar, thoracic and cervical vertebrae (except the atlas), and skull. Then, we add all these measurements and add also a value that expresses the contribution of the soft tissues, which have disintegrated.



We use various instruments to measure bones, depending on how big the bones are and which dimensions we want to capture.



Growth: a complex process!

Growth describes the changes that happen in our body size from the moment we are foetuses until we become adults. There are periods of really fast growth and in between these there are periods of very slow growth or no growth at all.

The two periods of our life during which growth is particularly rapid are infancy and adolescence.

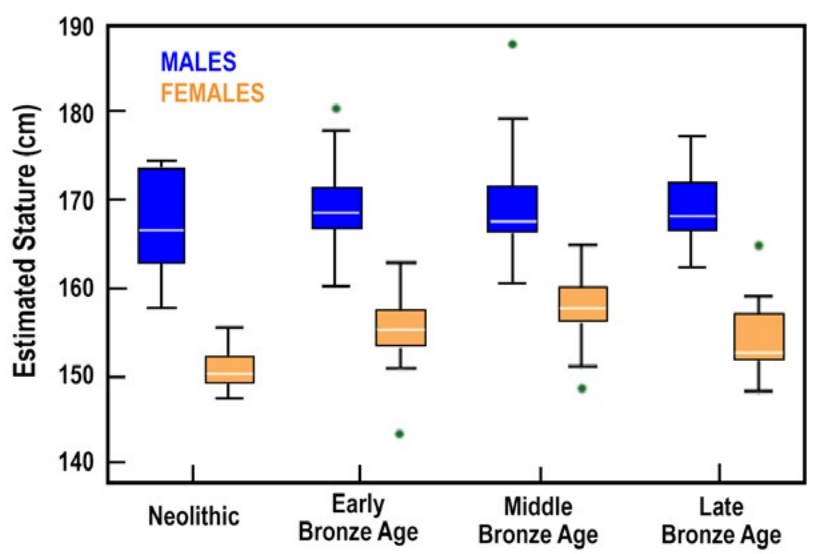
TO EAT RICE?

Or *not* to eat rice?

It has been suggested that when past societies moved from hunting-gathering to a more sedentary lifestyle, relying on agriculture, their health declined. This has been linked to two main factors: *1)* greater numbers of people living close to each other, which increases the risk of exposure to infectious pathogens, and *2)* the shift from a diverse hunting-gathering diet to a diet heavily reliant on carbohydrates, which is the main nutrient we get from eating plants.

A team of osteoarchaeologists from the University of Otago, New Zealand, examined how the health of ancient Thai populations from the site of Ban Non Wat changed when they became more reliant on rice agriculture.

To explore this issue, researchers examined the height of prehistoric (1750-420 BCE) Thai adults as a way of measuring stress during late childhood. As we saw, individuals who suffered from some stressful episode, such as illness or malnutrition, as children, may not grow as tall as they could have.



Clark AL, Tayles N, Halcrow SE. 2014. Aspects of health in prehistoric mainland Southeast Asia: Indicators of stress in response to the intensification of rice agriculture. American Journal of Physical Anthropology 153: 484-495.

The scientists also examined dental lesions known as **linear enamel hypoplasia**, which occur when an individual suffers from a stressor during early childhood when the teeth are still forming.

The results showed that height increased and enamel hypoplasia decreased in frequency from the Neolithic to the Middle Bronze Age. In contrast, there was an increase in the frequency of enamel hypoplasia and a decline in height from the Middle to the Late Bronze Age. Interestingly, the change in height was visible only in females and not in males. So, it is hypothesized that men and women were not equally affected by the change in the living conditions of these groups.

Interpretation

Health initially improved in Ban Non Wat when the local populations started practising rice agriculture more systematically. Very likely this was because rice agriculture provided the locals with a nutritious diet. The deterioration in health in the following periods probably does not relate to the diet of these individuals but to a change in the environmental and sociocultural conditions.

Who is related to whom?

Human skeletons can tell us if two or more people were related to each other. To examine this relationship, we can use genetic data, performing ancient DNA analysis on skeletal or dental tissues.

Alternatively, we may use skeletal morphological variation. We can see around us that parents and their children often look similar. For example, we often have the same skin colour, hair colour, and facial characteristics as our mother or father, or a combination of their characteristics. **Our skeletons are also similar in size and shape to that of our parents**.

Osteoarchaeologists explore the genetic relationship of past individuals to answer different questions:

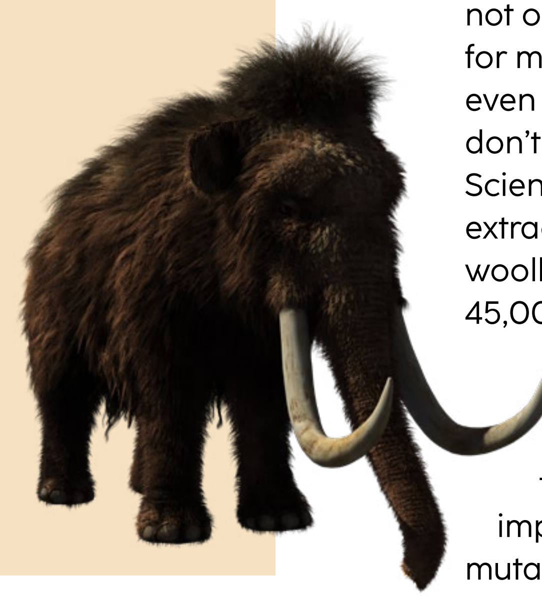
- Are the individuals buried together in a cemetery family members or not? What was the structure of ancient families? Were they nuclear or extended?
- What was the degree of intermarriage among different ancient communities? Were past societies closed, that is, members preferred to marry other members of the same society, or were they open?

Very importantly, the relationship of past human groups offers information regarding past mobility patterns since it is often the outcome of individuals/groups moving around and interbreeding. Therefore, relevant studies can also address questions such as:

- Can we identify mobility in specific archaeological groups based on their patterns of morphological similarity?
- What parts of different groups relocated?

To see if two people are genetically related, we can analyse their DNA, thus examine directly their genotype. We can extract DNA from the teeth or the bones. However, the more ancient the skeleton, the less likely it is to preserve DNA, but specific environments (e.g. freezing conditions) allow the preservation of DNA for many thousands of years...

Did you know...



Ancient DNA can give fascinating information not only for humans but for many other species, even species that don't exist any more. Scientists in the USA extracted DNA from a woolly mammoth dating 45,000 years ago and concluded that mammoths went extinct because they suffered from important genetic mutations.

Rogers RL, Slatkin M. 2017. Excess of genomic defects in a woolly mammoth on Wrangel island. PLoS Genetics 13: e1006601

Ancestry… a debated topic!

ANCESTRY expresses an individual's geographic region of origin.

The study of ancestry based on skeletal remains has been criticized strongly because early studies tried to classify individuals into *races*, with some of these races perceived as "superior" to others.

Race, in fact, is not something that exists in our DNA. The fact that biological human races do not exist does not mean that there is no temporal and geographical variation in human morphology. This variation is evident if we simply look around us and it has been created through the adaptation of different human groups to different environments. Therefore, ancestry studies may give us information about an individual's origin. Such studies are mostly useful in forensic anthropology since an individual's ancestry could help to determine who the deceased individual is.

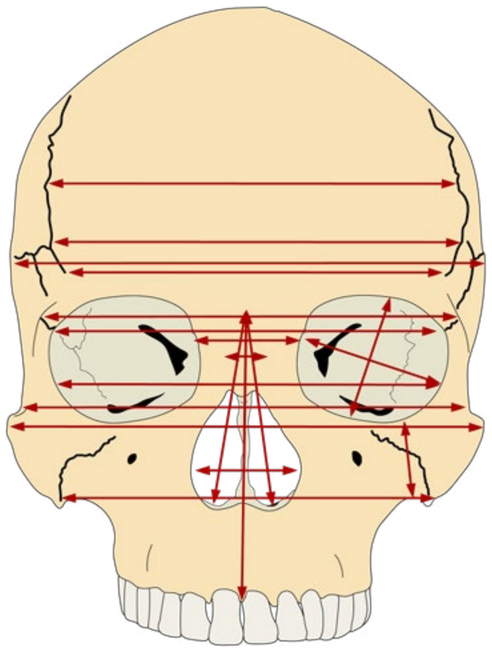
We are more similar than you imagine

DNA studies have shown that genetic variation is much greater within populations than between populations…

Only a tiny part of our DNA relates to our skin color and other morphological traits that we traditionally use to identify an individual's ethnic background.

What if we can't use genetic data?

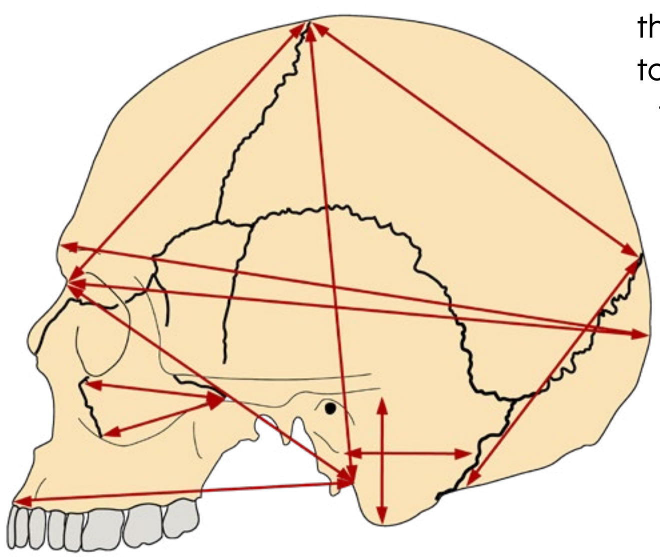
If it is not possible to perform DNA analysis due to the preservation of the skeleton or the cost (DNA analysis is pretty expensive!), instead of using the **genotype**, we focus on the **phenotype**.



What is the phenotype?

The **phenotype** is our morphological traits, the way we look. Because the way we look is to some extent controlled by our genes, we can use the phenotype as an indirect way of examining our **genotype**, that is, our genetic material.

The main skeletal element we examine to explore the relationship between individuals is the cranium. Cranial shape depends on the climatic conditions where we live, the food we consume and how tough or processed it is, and other factors. At the same time, our cranial shape is similar to that of our parents.



To compare the cranial shape of different individuals, we take many linear measurements, like the ones shown in these figures, from each cranium and analyse them using statistical methods.

Using instruments called **3D scanners**, we can capture cranial shape even more efficiently.

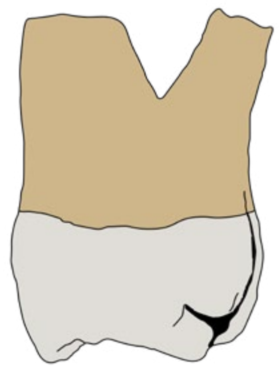
Now, instead of analysing linear measurements, we can analyse the **coordinates** of specific **landmarks** (points).

Instead of taking measurements, we can examine **specific morphological non measurable traits of the cranium, the teeth and the rest of the skeleton**, the presence of which is also partly controlled by our genes. In other words, these traits are part of our phenotype and we may inherit them from our parents.

These traits may take many forms, such as:

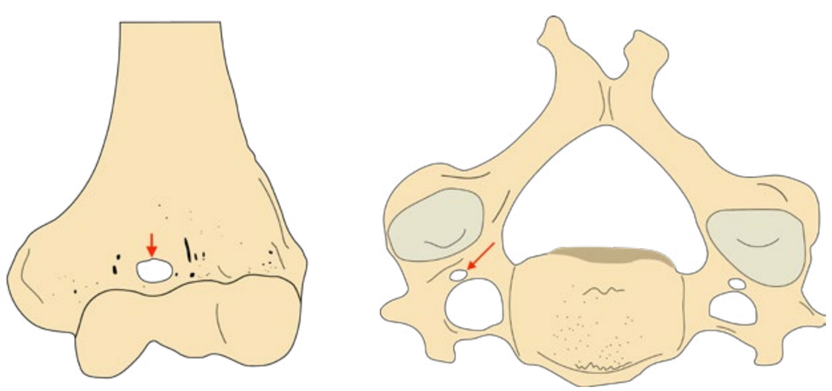
...an extra root in one of our teeth

...an extra tooth cusp

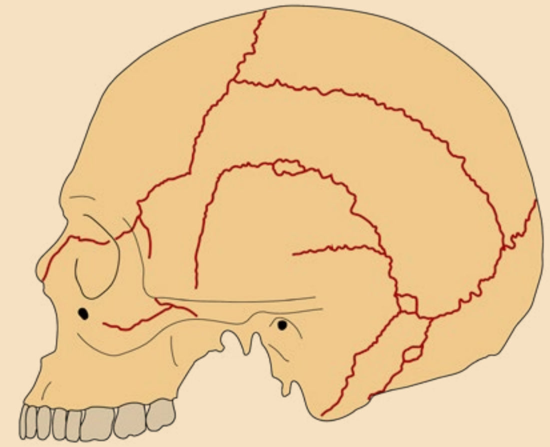


...variation in the relative size of the tooth cusps

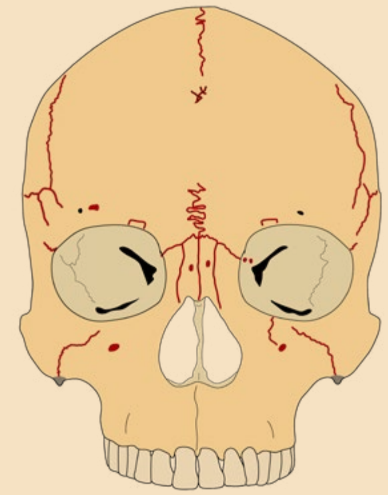
...an extra hole on various bones of the skeleton



...an extra suture on the cranium

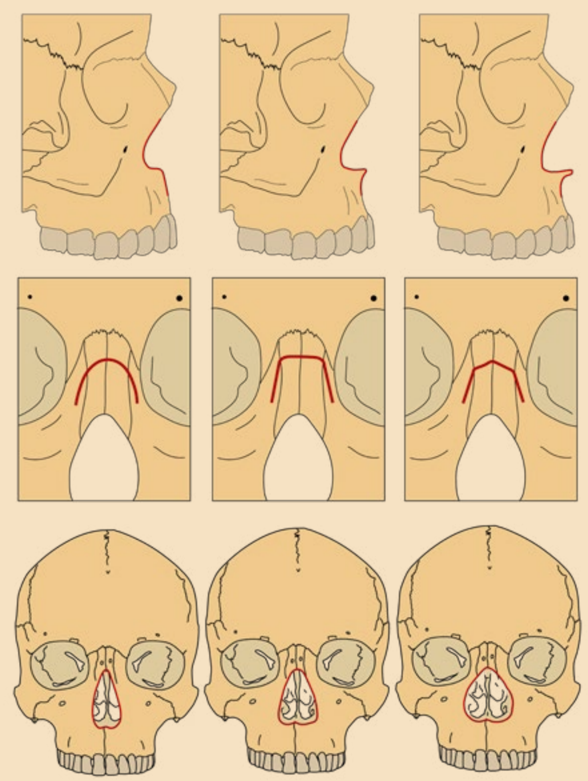


...an extra hole (foramen) that allows the passage of nerves and blood vessels on the cranium



... and many others

In **forensic anthropology**, methods have been developed for ancestry estimation based on specific morphological traits of the facial bones. The expressions of these traits are sometimes found in higher proportion among individuals of shared ancestry, although it is not always the case.



Living in the desert

The Garamantes of Fezzan

When we think of the Sahara Desert, what comes to mind are endless sand dunes that limit traveling and promote the isolation of different groups who live across this desert. However, archaeological evidence shows extensive trade networks across North Africa, which supports that human groups were traversing the desert despite the extreme temperatures and rough terrain.

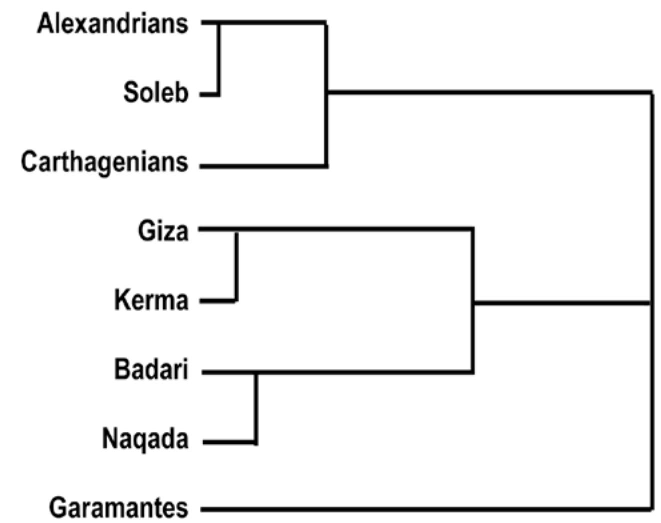
A study examined the biological distance among human groups that lived across North Africa to examine the degree of isolation imposed by the Sahara Desert. The main focus was a group called Garamantes, who lived in the heart of the Sahara Desert from 900 BCE to 500 CE. Based on imported objects found in Garamantian towns and written sources, the Garamantes were strongly involved in trans Saharan trade.

The research questions were:

- To what extent did the Sahara Desert impose limitations in the contact between the Garamantes and their neighbours in North Africa?
- Did the trade networks involve only a few individuals (e.g., merchants) or did they express wider contact and intermarriage between the Garamantes and other North African groups?

The biological distance of North African populations was examined using cranial morphology and the results identified four broad groups:

- Garamantes,
- Kerma and Giza,
- Badari and Naqada, and
- Carthagenians, Soleb and Alexandrians.



Most importantly, the distance of the Garamantes to their neighbours was substantial as this population clearly stood out from the others.

These findings suggest that the Sahara Desert imposed important limitations to the contact between the Garamantes and other North African groups; thus, the trade networks likely involved only a small part of the population.

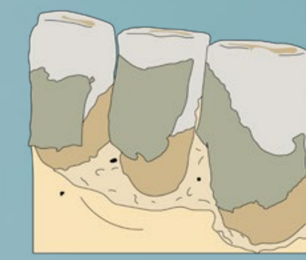
Nikita E, Mattingly D, Mirazon Lahr M. 2012. Three dimensional cranial shape analyses and gene flow in North Africa during the Middle to Late Holocene. Journal of Anthropological Archaeology 31: 564-572.

We are what we eat

Food holds a central place in our life as it ensures our survival but it also has an important social role. Finding out what people were eating in the past can help us explore differences in the economy and availability of different foodstuff across time and space, identify social inequalities by determining what part of the population had access to high quality food, compare the diet between males and females or adults and juveniles, test the association between dietary patterns and skeletal markers of disease and stress, and address many other questions.

The easiest way to deduce what people were eating based on their skeletons is to examine the presence and distribution of dental conditions in their mouths as certain pathologies can be the result of dental diseases associated with diet.

When we eat **carbohydrates** (e.g. sugar, cereals, jams, bread, potatoes), bacteria that naturally live in our mouth produce acids. These acids gradually destroy our teeth and create cavities. These cavities are called **dental caries**.

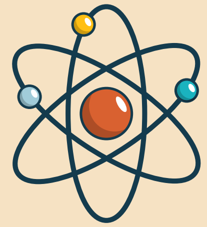


On the other hand, when we consume a lot of **protein** (e.g. meat, cheese, yogurt, eggs, certain types of fish), we are more likely to develop **dental plaque**.

Many factors other than diet affect the expression of dental diseases! These factors include **oral hygiene**, **hormonal differences** between males and females (especially during pregnancy and lactation), the composition and flow rate of the **saliva**, **food preparation** techniques (e.g. softening food through boiling makes it more likely to cause caries), the **amount of time the food stays in the mouth** (the longer food is in the mouth, the more likely it is to cause a disease), the **frequency of eating** (more frequent meals imply more frequent presence of food in the mouth), and **tooth wear** (high levels of wear remove food debris from the teeth and protect them from caries and calculus).

Ancient diet at the atomic level!

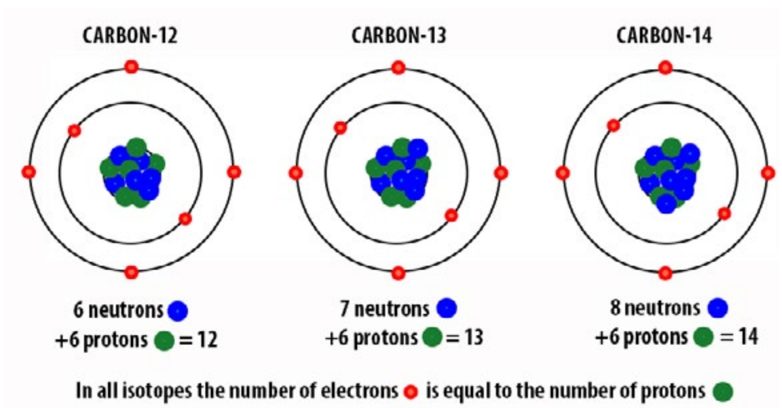
Atoms are the basic building blocks of ordinary matter. They are composed of particles called **protons**, **electrons**, and **neutrons**. The protons and neutrons are found together in the nucleus of the atom, while the electrons orbit the nucleus. The number of protons in the nucleus determines which element the atom belongs to.



Isotopes are atoms of the same element that have the same number of protons but different number of neutrons. These atoms are analysed using an analytical instrument called a **mass spectrometer**. Archaeologists use the ratio of specific isotopes to explore a wide range of questions surrounding ancient diet. Differences in the ratio of isotopes are often expressed as 'delta' values.

Carbon stable isotopes

All foods contain carbon, which has three naturally occurring isotopes: ^{12}C, ^{13}C and ^{14}C. Carbon-14 is used for radiocarbon dating but the other two isotopes can give information on past diets.



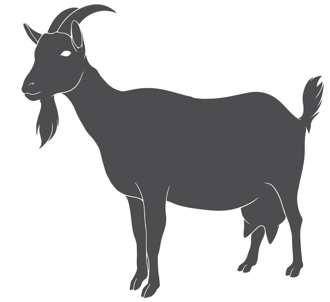
Grasses from hot, arid environments follow the C4 photosynthetic pathway, and will have $\delta^{13}C$ higher than trees, shrubs, and grasses from temperate regions, which follow the C3 photosynthetic pathway. Marine foods also have higher $\delta^{13}C$ than terrestrial foods.

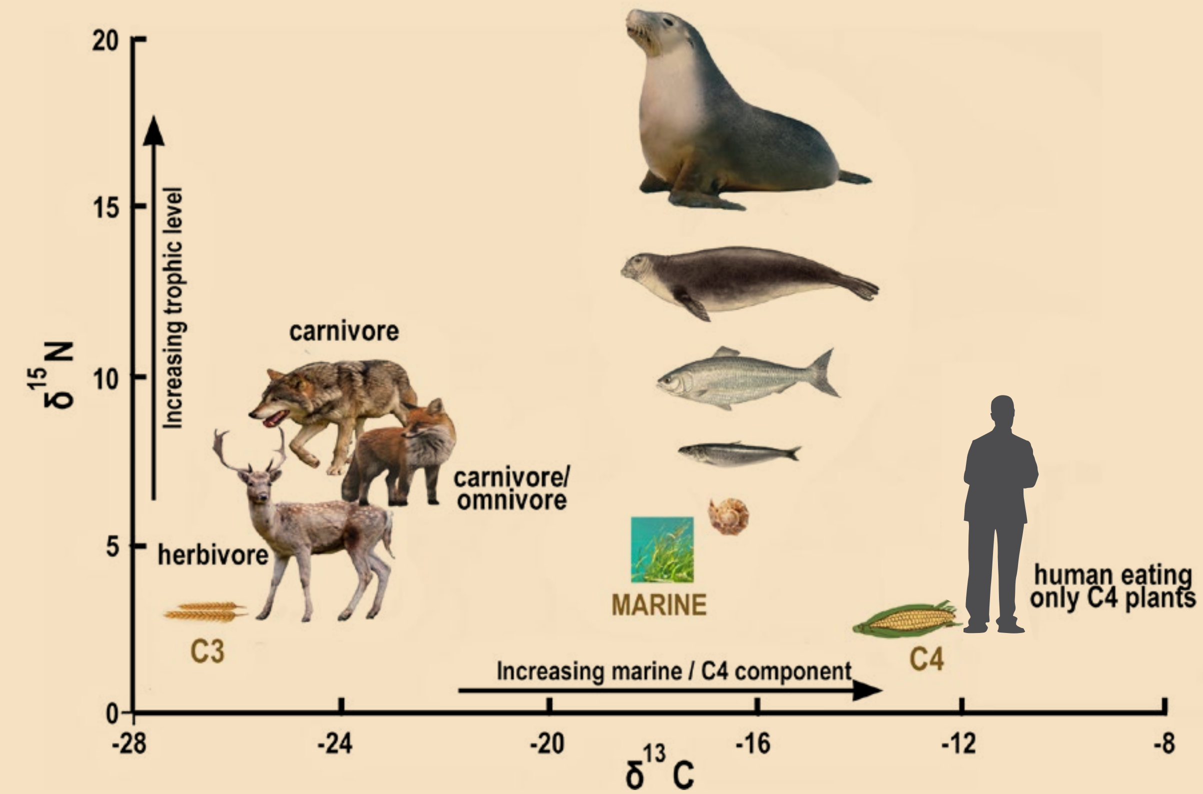
Note that $\delta^{13}C$ is a measure of the ratio of stable isotopes ^{13}C : ^{12}C, while $\delta^{15}N$ is a measure of the ratio of stable isotopes ^{15}N : ^{14}N, reported in parts per thousand (‰).

Nitrogen stable isotopes

Nitrogen stable isotope ratios reflect an animal's position in the food chain. The ratio of ^{15}N to ^{14}N generally increases from food source to consumer.

So, carnivores have higher values than the herbivores they eat.



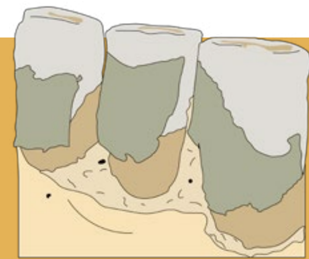


Different tissues, different answers

Our bone cells are constantly renewed. This is known as **bone remodeling** and it happens throughout our lives. Therefore, the isotope values we measure on our bones reflect an average of an individual's diet for the last several years of their life. In contrast, tooth enamel does not change once it is formed during childhood, so the isotope values we find in it reflect the individual's diet during the age of tooth crown formation.

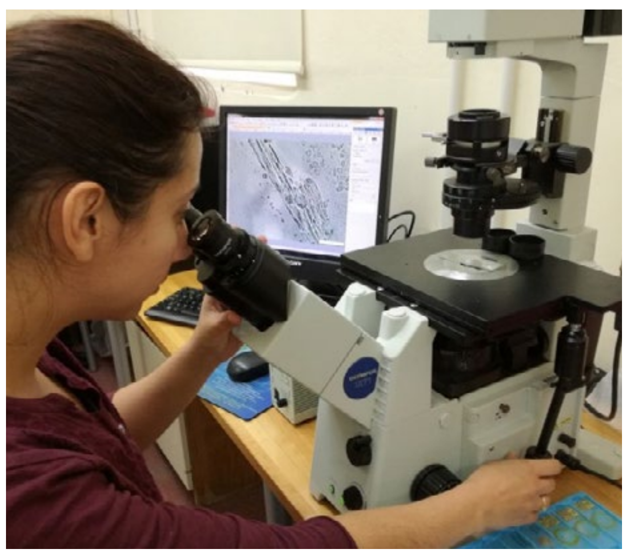
Micro-excavating dental plaque!

Remember the dental plaque that forms in our mouth?



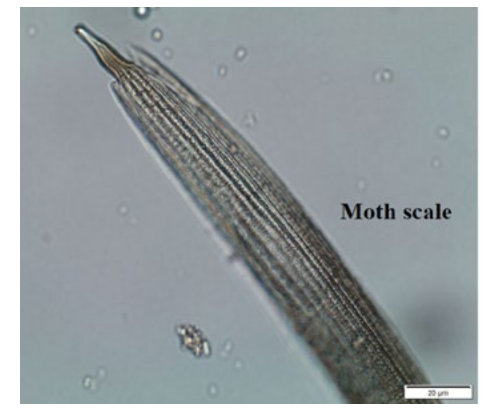
While **dental plaque** forms in our mouth, it can **trap plant** and **animal tissues** from the food we eat. So, when we examine the plaque under the microscope, we can identify these inclusions and **see what different individuals ate**.

How can we tell what we see?

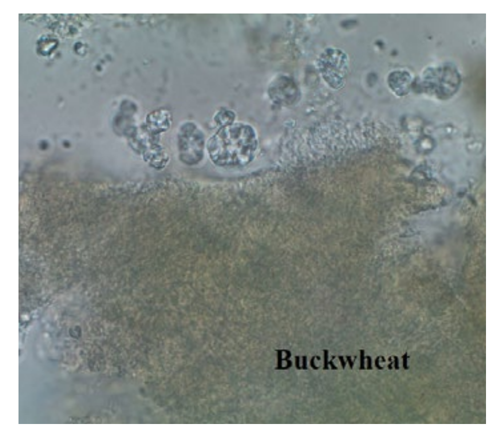


To identify different types of microscopic inclusions in the dental plaque, we have to put together **reference collections** that show what parts of different plants look like under a microscope. As plant species differ in different geographic areas, it is important to have reference collections that are specific for the region we examine.

Dental plaque does not capture only food items; it can also trap **various microscopic particles that enter our mouth when we inhale or when we use our teeth as tools** (for example to hold something). As a result, we can find a number of weird inclusions inside the plaque, such as minerals or even insect body parts!



Buckwheat



What did ancient Egyptians eat?

Our knowledge of the diet of ancient Egyptians comes mostly from ancient works of art that depict food, as well as cereals and fruits being processed into bread, beer, and wine.

An additional source of information comes from written records. The salaries paid in kind to pyramid workers and craftsmen suggest that ancient Egyptians consumed vegetables, legumes and cereals. Meat is not mentioned and probably represented a small part of the diet, except for the wealthiest people.

Depiction of ancient Egyptians carrying food, including plants and animals.

Food and cooking practices can also be explored through the analysis of food remains preserved in ancient graves or habitation sites. Such analysis is standard practice in archaeological sites and it is often our only source of information about the ancient foods consumed. The scientific field that studies ancient plant remains is called **archaeobotany**, while the field that examines ancient animals is called **zooarchaeology** or **archaeozoology**.

In addition to giving information about past diet, archaeobotany and archaeozoology provide important information regarding ancient agricultural and pastoral practices, the vegetation available, and other aspects of the interaction between humans and their environment.

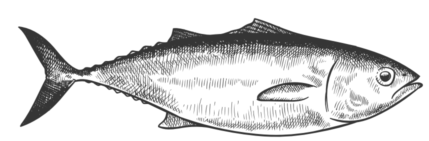
A French research team examined carbon, nitrogen and sulfur stable isotope compositions in Egyptian mummies dating between 3500 BCE and 600 CE to explore what they ate.

Touzeau A, Amiot R, Blichert Toft J, Flandrois J P, Fourel F, Grossi V, Martineau F, Richardin P, Lécuyer C. 2014. Diet of ancient Egyptians inferred from stable isotope systematics. Journal of Archaeological Science 46: 114-124.

Carbon isotopes showed that ancient Egyptian diet was based almost exclusively on C3 plants, such as wheat and barley. In contrast, C4 cereals, like millet and sorghum, were only a minor part of the diet. Moreover, animal protein (i.e. the consumption of meat, dairy products etc.) had a moderate contribution to the total dietary protein (no more than 50%).

Sulfur isotope ratios produced a surprising result: freshwater fish, such as the Nile perch, was not consumed in significant proportions...

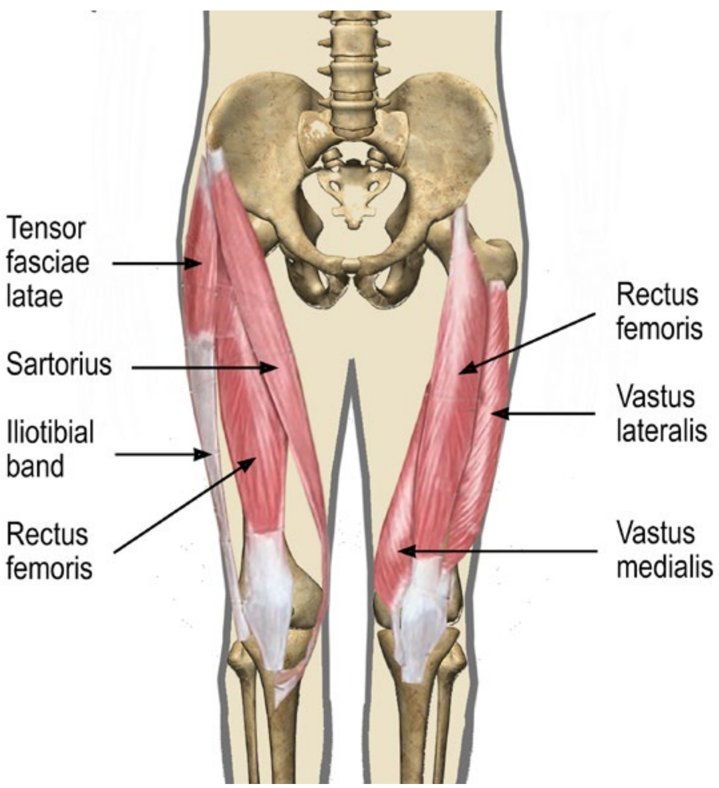
So, even though the ancient Egyptians lived along the Nile, they did not consume as much fish as one would expect!



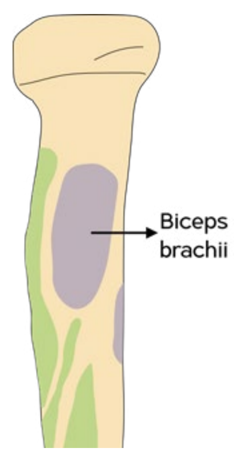
Staying active!

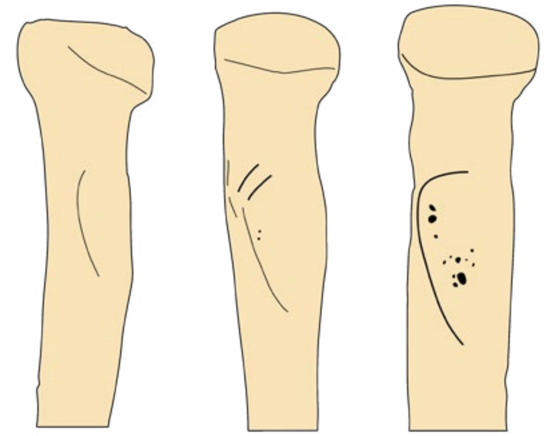
Our bones react to the mechanical strains imposed on them by altering their shape in order to withstand these strains more effectively. Therefore, small changes in bone shape can give important information about the physical activity of past individuals.

Salt harvesting in Vietnam

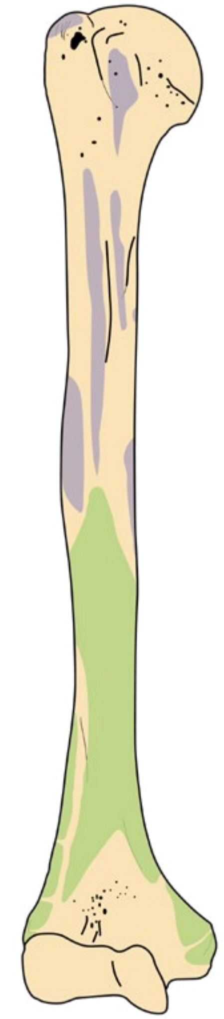


When we use our muscles, there is stress imposed on the skeleton at the sites where the muscles attach. The skeleton responds to this stress by forming new bone or by losing bone at the attachment sites.





Increasingly pronounced changes on the biceps brachii (upper part of radius)



See how the bone surface of the right humerus is largely covered by sites of muscular attachment (green and blue highlighted areas)

Besides activity, the expression of changes at the sites of muscular attachment (a.k.a. **entheseal changes**) is affected by age, body size, sex and other factors:

- **Age** is the main factor affecting entheseal changes as older individuals show more pronounced changes.
- **Males** and **females** differ in the expression of entheseal changes, partly because they engage in different activities and partly because of hormonal differences between them.
- **Bigger** individuals show more pronounced entheseal changes than **smaller** ones because individuals with greater body size require more effort to perform physical activities.

Despite these factors, **entheseal changes can offer information about past activity patterns**, as confirmed by experimental studies on laboratory animals and modern athletes. For this reason, several researchers use such changes as skeletal markers of ancient activity.

Social inequality in ancient Kerma

Entheseal changes have been employed to explore social inequality in the ancient city of Kerma, which used to be the capital of ancient Sudan. The skeletal material examined dated from 3,200 to 1,500 BCE and came from diverse burials.

The results supported **significant differences in entheseal changes between individuals buried in different burial types**.

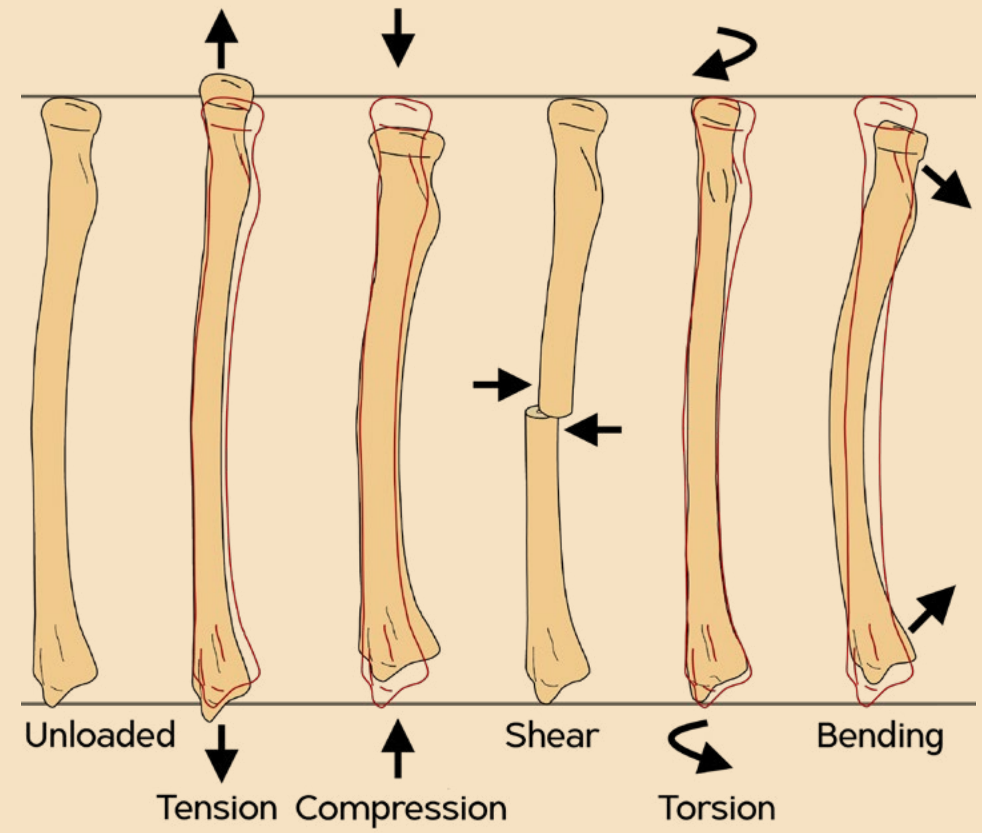
In addition, a significant difference was found between males and females, with **males showing more pronounced changes compared to females.**

These findings demonstrate some degree of social inequality in ancient Kerma, where part of the population was involved in very demanding daily physical activities, such as the activities required in an agropastoral economy and other kinds of manual labour.

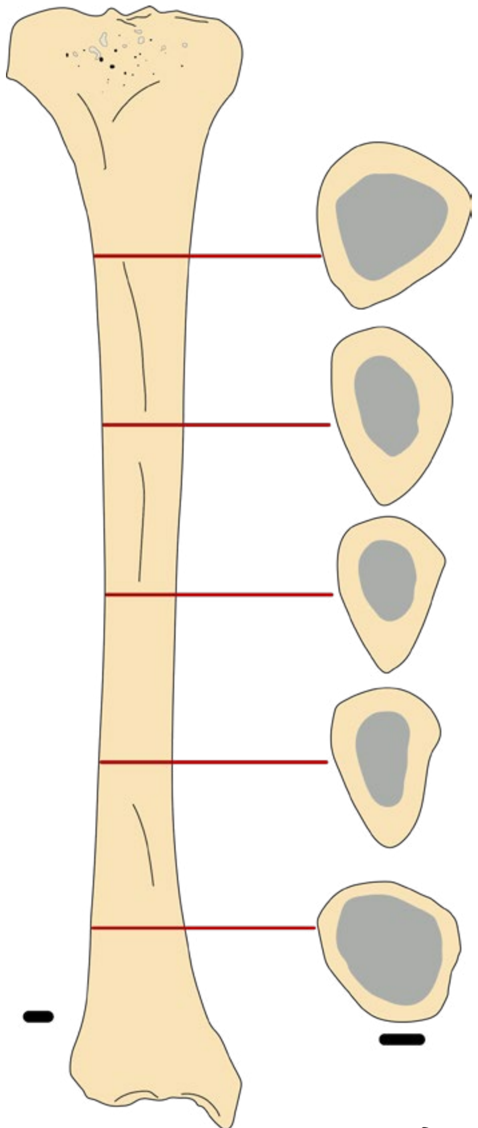
Schrader SA. 2015. Elucidating inequality in Nubia: an examination of entheseal changes at Kerma (Sudan). American Journal of Physical Anthropology 156: 192-202.

Adaptable bones!

Different types of stress are applied on a human bone when we perform different activities. Each type of stress produces a different type of deformity in the bones. Most of the time, many types of stress are applied on our bones at the same time. For example, a certain activity may cause bending **and** torsion at once.

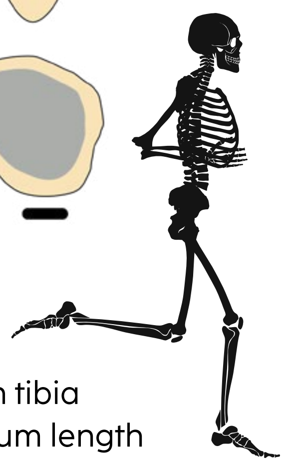


Biomechanics is the application of mechanical principles to biological systems in order to assess mechanical loading on the bones.



Physical activity affects the shape of long bones overall, not just at the sites of muscle attachment. The skeleton responds to stresses caused by our daily activities by depositing new bone where it is needed. Therefore, **if we examine the shape of the long bone diaphysis, we can draw conclusions about the type and direction of the stress applied on it**.

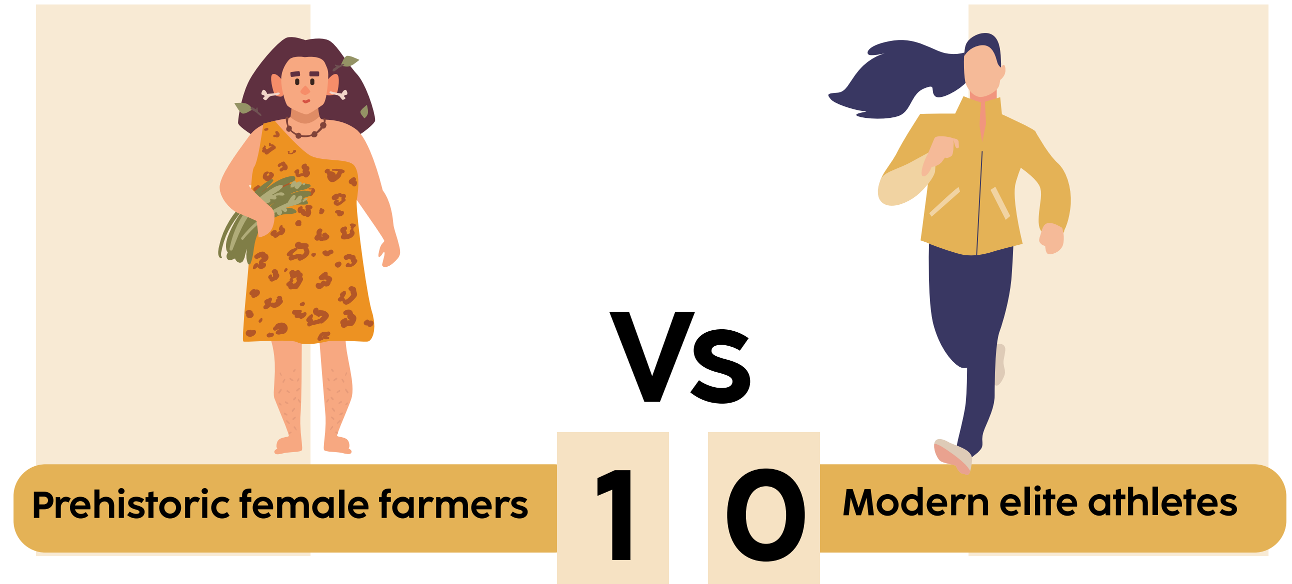
When an individual runs, there is increased mechanical stress to the front and the back of the bones of the legs, which produces an elongation of the cross section of these bones along this plane.



Cross-section of human tibia
at the middle of maximum length

regular shape

elongated antero-posteriorly, that is, to the front and back



A study examined the cross sectional shape of the upper and lower limbs of Central European females from early Neolithic times to the Middle Ages, and compared it against that of modern females who engage in different physical activities (runners, rowers, footballers), as well as females with a sedentary lifestyle.

Ancient female lower limb rigidity did not differ much on average from living sedentary females, and was notably lower than that of runners and football players. In contrast, the arm bones of Neolithic females were stronger than the rowers' and much stronger than the typical university students'. Upper limb strength was even more pronounced in Bronze Age females.

In many modern agricultural societies, women are responsible for most tasks related to gathering and hoe agriculture, as well as domestic animal care. Grinding of grain must have imposed considerable mechanical stress on the arms, while prior to the invention of the plough, planting, tilling and harvesting the crops were also manual activities. Women were additionally likely to have been responsible for feeding domestic livestock, and processing animal secondary products.

These findings suggest that for thousands of years, women were involved in strenuous manual labour, which must have held a central role in early farming economies.

Macintosh AA, Pinhasi R, Stock JT. 2017. Prehistoric women's manual labor exceeded that of athletes through the first 5500 years of farming in Central Europe. Science Advances 3: eaao3893

Health and disease

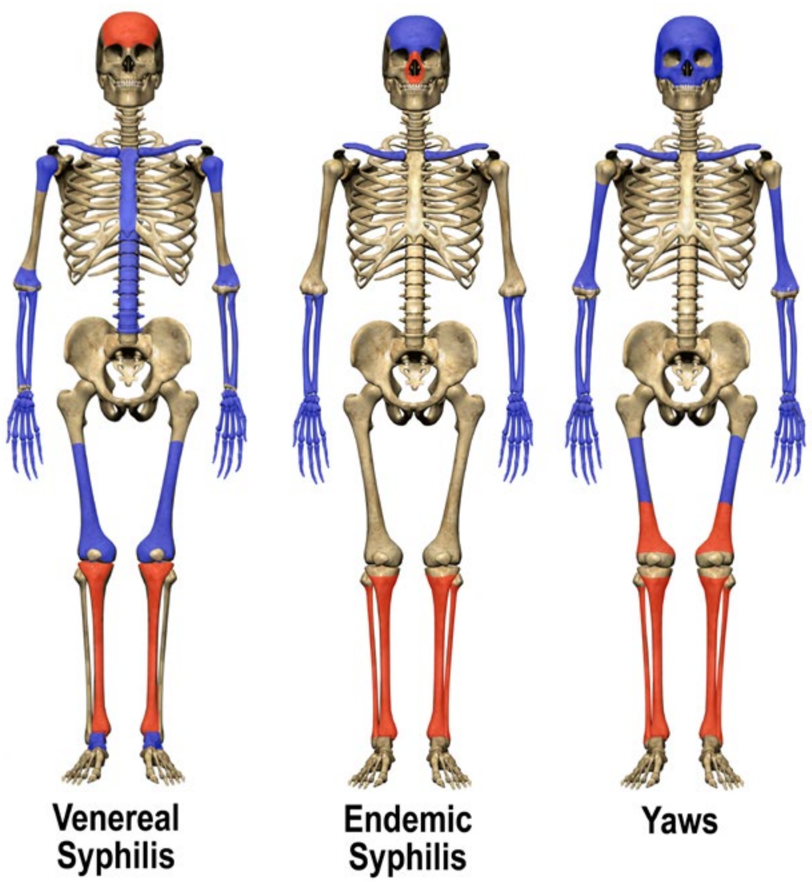
The study of the diseases that afflicted past humans is called **palaeopathology**. Palaeopathology helps us understand **health and disease** patterns in ancient societies, the **antiquity of different diseases**, and the **medical knowledge** of past groups.

How easily can we identify different diseases on the skeleton?

It depends... our skeleton is a living tissue and, therefore, it can respond to different stresses applied on it. The problem is that the skeleton can only respond in a limited number of ways:

- abnormal new bone,
- abnormal loss of bone,
- abnormal bone size, and
- abnormal bone shape.

So, many diseases will affect the skeleton in a similar manner. Although we can generally identify broad disease groups (e.g., trauma, arthritis), stricter diagnosis is often difficult.

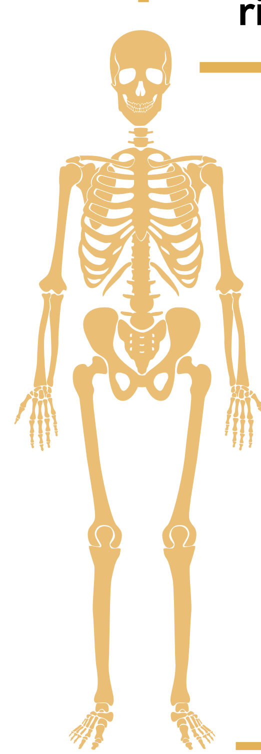


Skeletal elements affected by different treponemal infections.

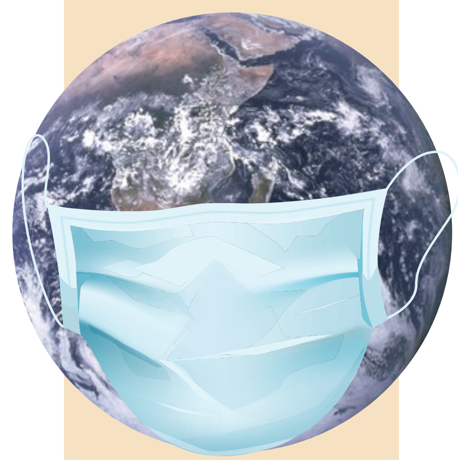
Differential diagnosis is the main approach osteoarchaeologists use to identify a disease. Basically they look at the **expression and distribution of the skeletal changes and start eliminating the conditions that could *not* have caused them** until they reach a small group of diseases (or a single disease) that the individual may have suffered from.

During differential diagnosis, **demographic and environmental information** is also considered as specific diseases affect more males or females of a certain age and/or people in specific climatic and other conditions. For example, yaws is found in hot and humid tropical regions, endemic syphilis is seen in warm, arid to semiarid environments, while venereal syphilis has no climatic predilection.

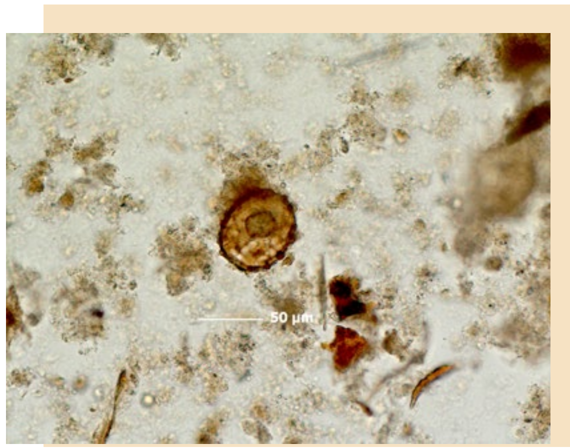
You would assume that when you see two skeletons, one with signs of disease and one without, the skeleton with pathological changes was weaker than the one without skeletal signs of pathology, right? WRONG!



The skeleton usually takes time to respond to disease. Therefore, individuals who show skeletal signs of disease may be those strong enough to endure the disease long enough for their skeletons to be affected. So, individuals exhibiting pathological lesions may have actually been healthier and stronger than those who passed away before the disease could spread to their bones! This is one of the aspects of the **Osteological Paradox**.



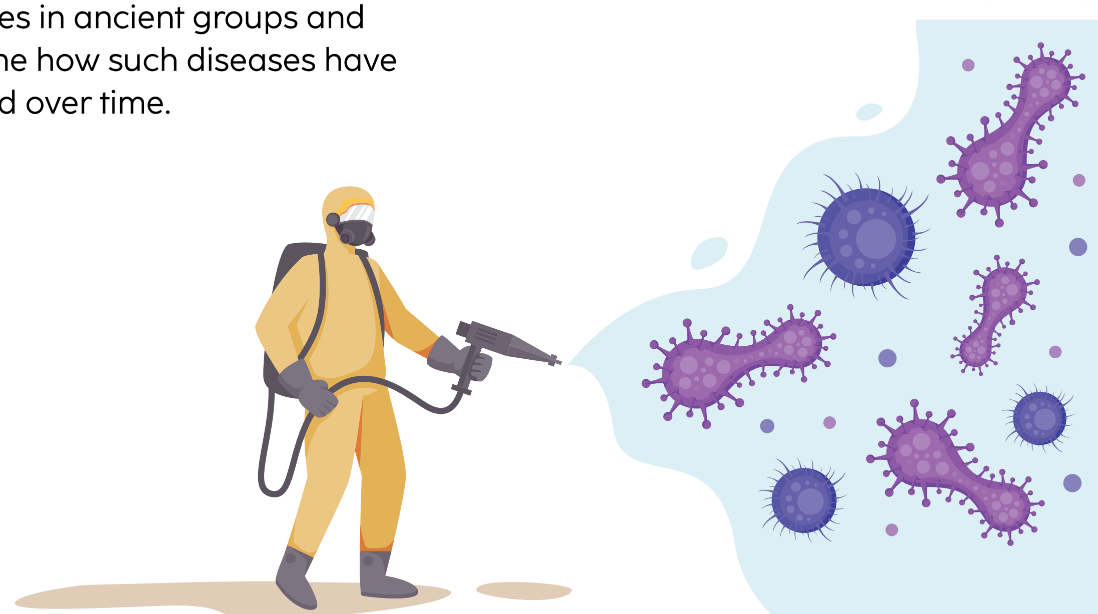
The easiest and most inexpensive way to study ancient diseases is through the visual identification of skeletal alterations. More advanced techniques can also be adopted to confirm the original diagnosis or identify conditions not visible with a naked eye.



The scientific field of **palaeo-parasitology** examines parasites from the past and their interaction with humans or other hosts.

Analysis of ancient DNA has been used to identify **ancient pathogen genetic material** and allows us to trace the existence of infectious diseases in ancient groups and examine how such diseases have evolved over time.

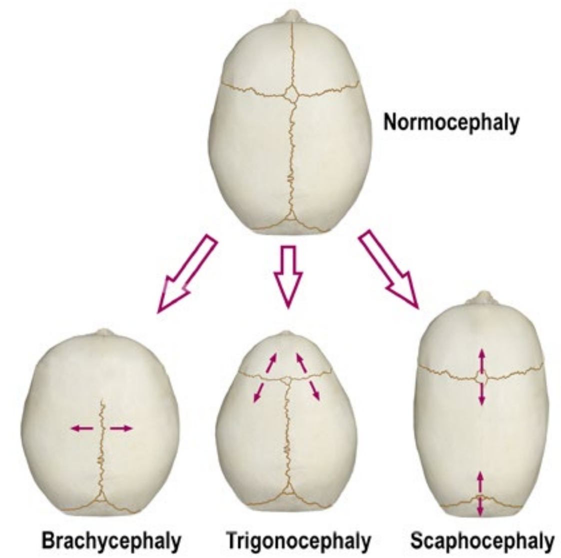
If we examine the structure of bone under a microscope, we can see minuscule alterations in bone **histology** produced by various diseases.



What diseases can we identify on the human skeleton?

All sorts!

Many different diseases, with various causes can affect the skeleton.



Developmental anomalies appear before birth or during the development of the skeleton. Thus, they are either inherited from our parents or acquired during the first years of our lives.

For example, if the **sutures** between different cranial bones **fuse earlier** than usual, the **cranium acquires a peculiar shape**. The specific suture affected determines the directions in which the skull will be deformed.

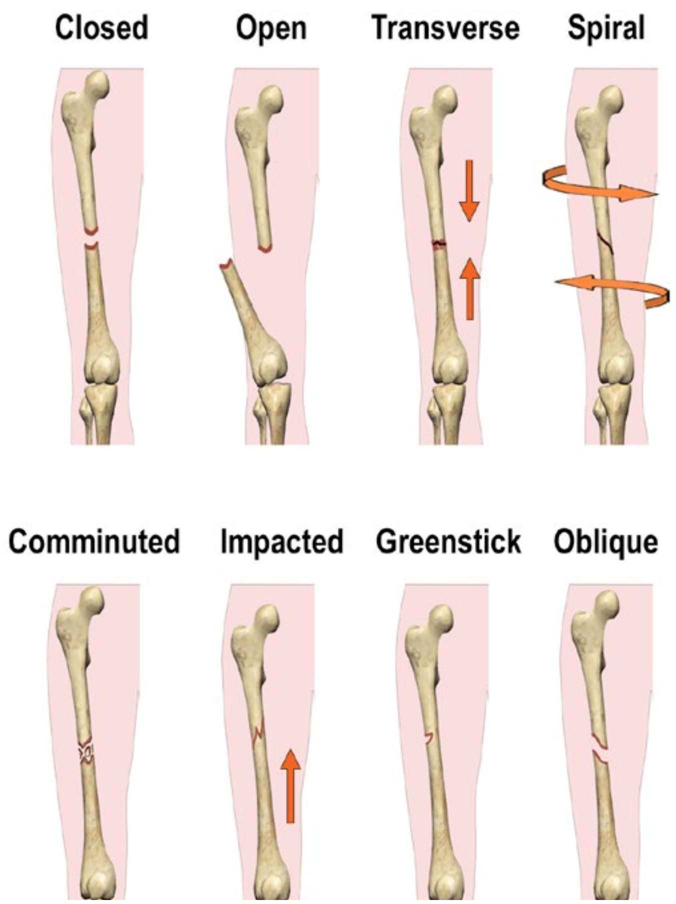
Metabolic diseases are caused by the disruption of bone modeling and remodeling, that is, skeletal development and growth (modeling) or renewal of the skeleton that continues throughout life (remodeling).

Among metabolic diseases, **osteoporosis** is characterized by a reduction in bone tissue, resulting in increased fragility of the skeleton.

Infectious diseases have had a major impact on humans throughout history. The relationship between infectious agents and their hosts is complex and depends on how serious the agent is, how strong the host's immune system is, and many other factors.

For example, **tuberculosis** is caused by bacteria of the **Mycobacterium tuberculosis** complex. In the human skeleton, it usually leads to a destruction of the vertebrae, which results in the deformity of the spine (kyphosis).

The study of **trauma** in archaeological contexts can offer important insights to past violence, as well as accident rates. In addition, aspects related to the healing process provide information on medical knowledge and social support.

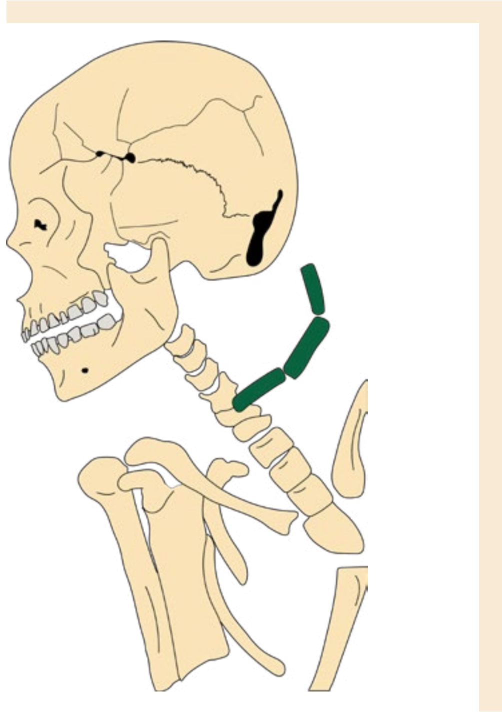


Among the most common types of trauma are fractures. Fractures express a break in the bones.

Depending on their severity, fractures may be simple or comminuted, greenstick or complete, open or closed:

- In **simple fractures** the bone has broken in one point only. In **comminuted fractures** there are many broken bone segments.
- If the break does not extend across the bone, the fracture is incomplete (**greenstick**). If the break extends across the bone, it is **complete**.
- If the fractured bone protrudes through the skin, the fracture is **open**. If the fractured bone still lies within the soft tissues, it is **closed**.

Depending on the direction of the force that caused them, fractures may be **transverse**, **spiral**, **impacted**, or **oblique**, as shown in the figure.



Violence in pre-Hispanic Andes... an osteoarchaeological account

A team from the USA examined 145 crania from the Pre-Hispanic cemetery of **Uraca, Peru,** and compared **trauma patterns** between males and females, as well as between individuals of different social status.

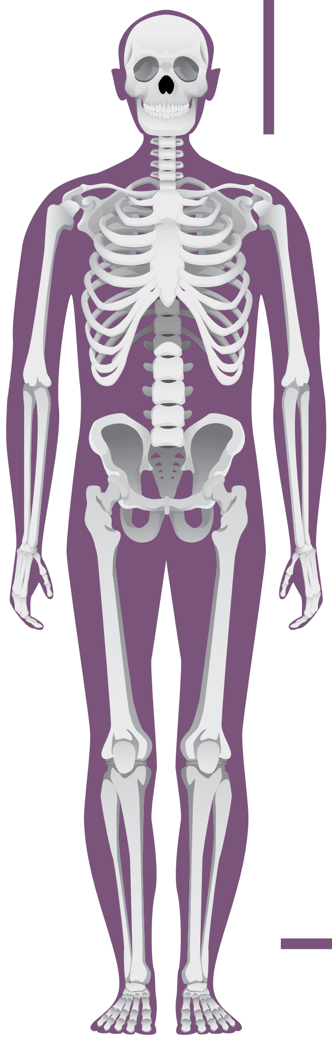
67% of adults had trauma, with males being significantly more afflicted than females. Among males, elite ones showed more injuries, and were the only ones with bladed and penetrating lesions.

These results suggest the Uraca community was involved in raids/war with other groups, and engaging in violence was a sign of elite status for males.

Scaffidi BK, Tung TA. 2020. Endemic violence in a pre-Hispanic Andean community: A bioarchaeological study of cranial trauma from the Majes Valley, Peru. American Journal of Physical Anthropology 172: 246-269.

being an osteoarchaeologist

Studying
the skeletal remains
of our ancestors is
a privilege and
big responsibility



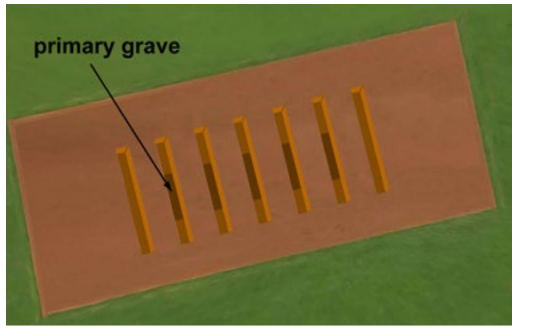
Human skeletons are a unique type of archaeological material.

They are at the same time remnants of our past that should be studied in order to help us understand better earlier periods of our history, but also remains of once living humans, who should be treated with respect and dignity.

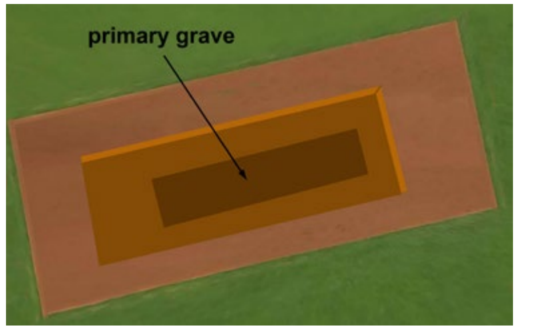
In the following pages you will see how osteoarchaeologists work in the field when they excavate skeletal remains, and then how they study these remains in the laboratory…

Digging in the field

One of the first tasks when excavating a tomb, is to **determine the limits of this tomb**. In some cases, for example, when excavating a monumental burial construction, the limits are rather obvious, but in most cases, such as when individuals have been buried in pits, the limits of the tomb are not directly visible. Two methods can be used: **trenching** and **area (or surface) stripping**.



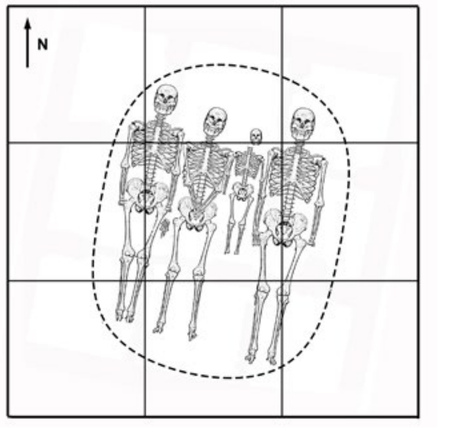
Trenching: Cutting a narrow trench (long ditch) across the area of interest to identify the boundaries of the tomb based on soil differences and human or other remains.



Area or surface stripping: Removing surface soil layers until the boundaries of the tomb are identified by soil changes and human or other remains.

Documentation of the tomb

The tomb and all excavation activities must be documented at each step. A site plan should be drawn to depict all features (tomb, skeleton(s), grave goods etc.) in relation to each other and in relation to the grid. Additionally, site photographs may be printed and used for on-site notes, while tablets can also be employed in site documentation.



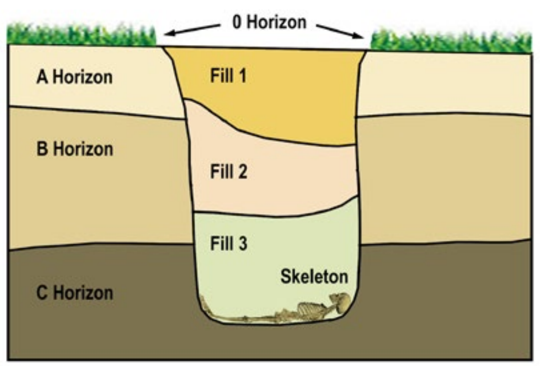
Reference grid: Once the location and size of the tomb have been determined, a reference grid is constructed to document the excavation activities that will follow. The grid has equally sized rectangles and helps record the location of the excavation findings.

Excavation methods

Arbitrary level excavation

Soil is removed in successive levels of specific depth (e.g. 0.10m, 0.20m), without considering the existence of stratigraphic layers.

1



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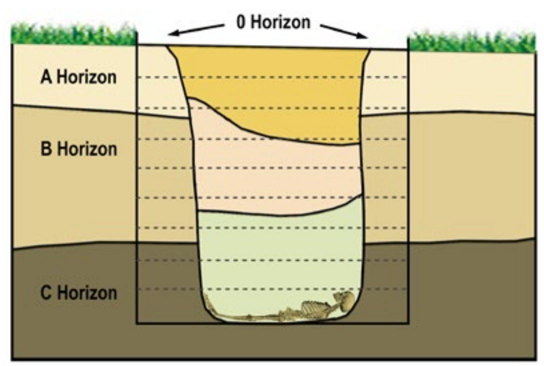

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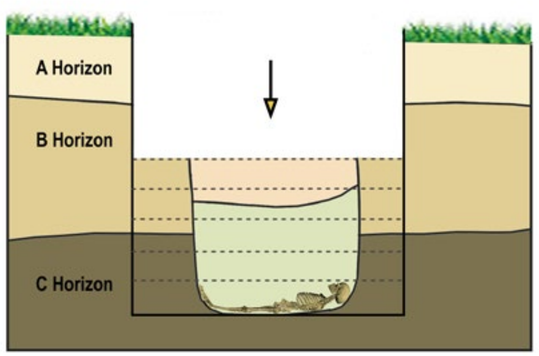

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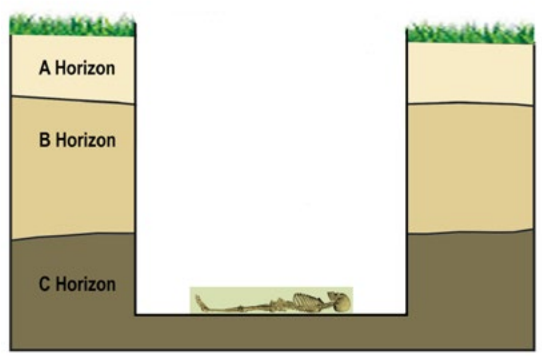

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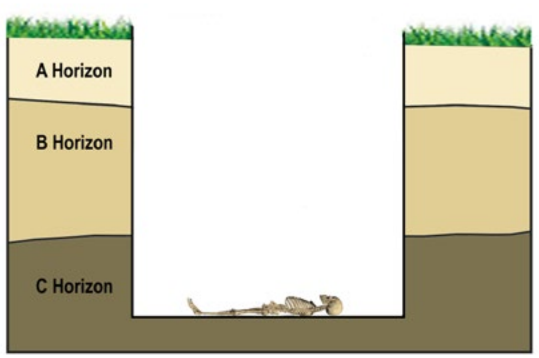
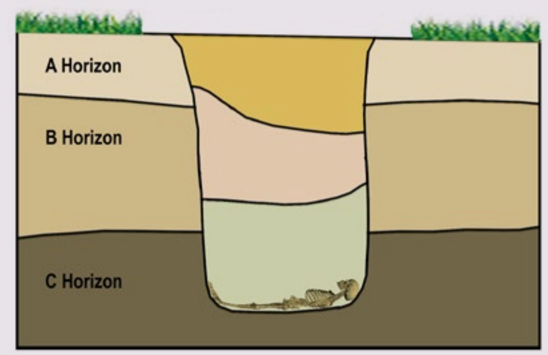


Stratigraphic excavation

Stratigraphic layers are excavated successively in order to understand the sequence of the events that led to the formation of the deposit under study. The identification of stratigraphic layers may be difficult. Evidence that may assist in the identification of layers includes bulks of soil between deposits of remains, the orientation of the bodies or the different treatment of the bodies in successive layers (e.g. undisturbed burial, ossuary).

1



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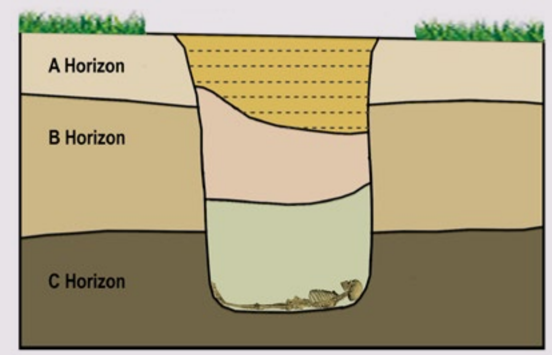

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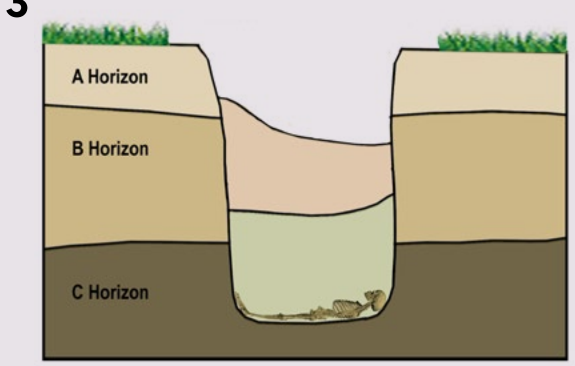

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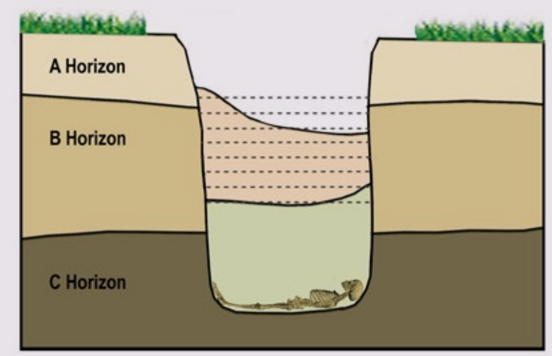

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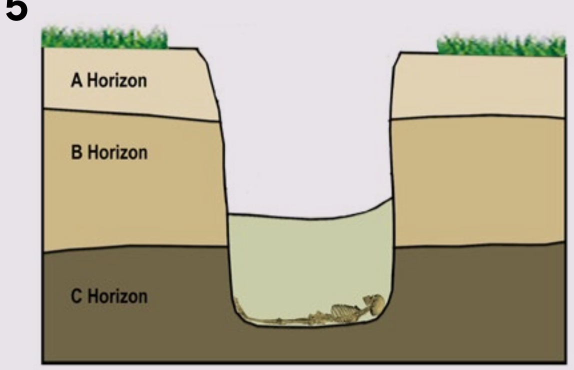

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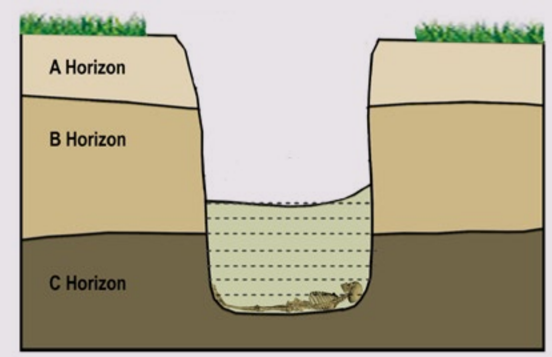

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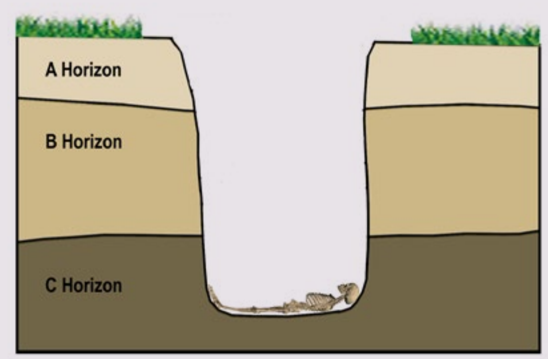
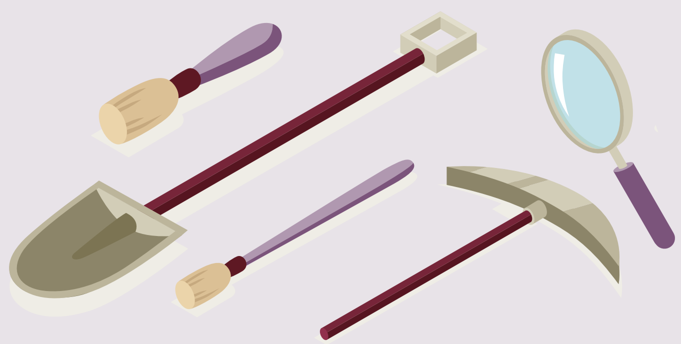
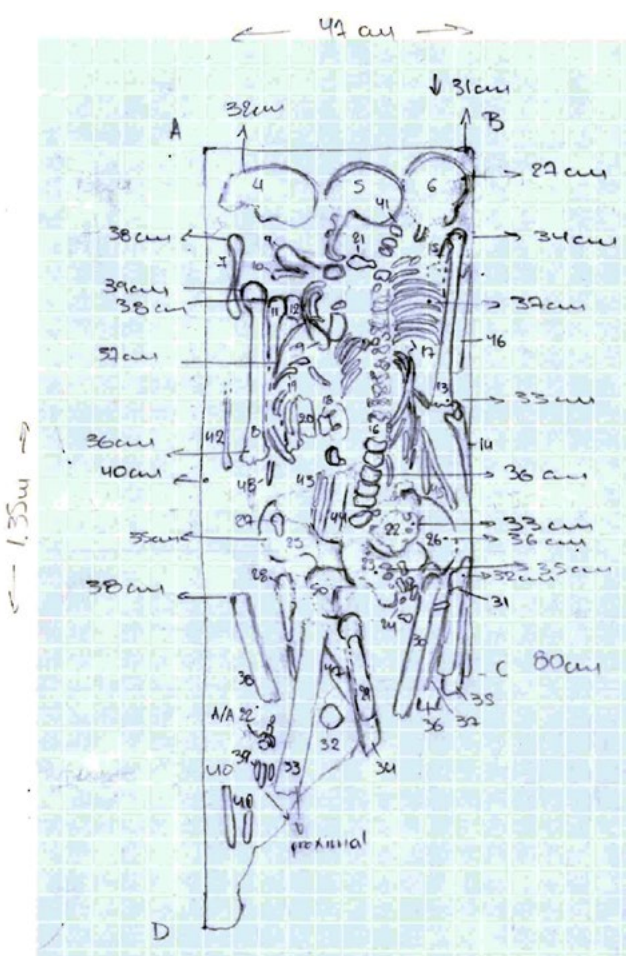
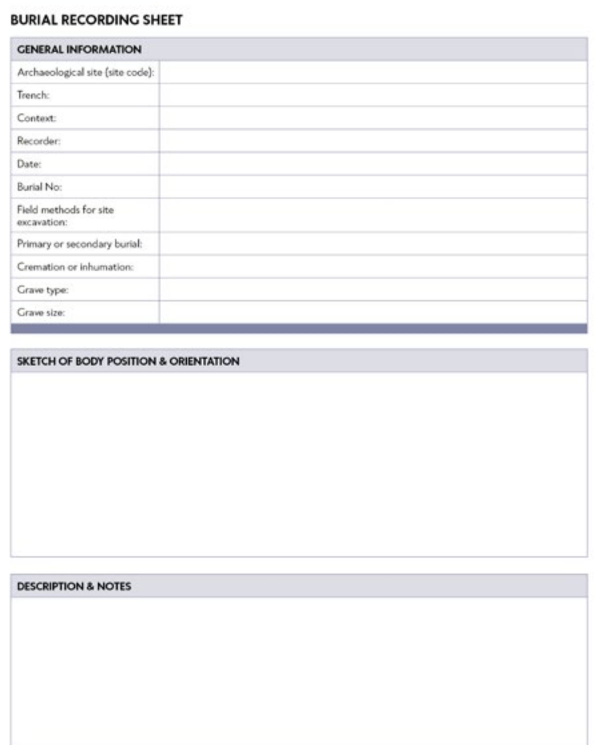




More documentation

Once the skeletal remains per stratigraphic layer have been exposed, they should be mapped on graph paper, photographed, and documented with notes prior to their collection. Photographs of the overall layer should be taken, followed by close-up images of the bones. Whenever the necessary equipment is available, the grave may be documented by 3D laser scanning or photogrammetry, which visualize the 3D structure of the burial and may be used to produce virtual animations.





RECORDING SHEETS

BURIAL RECORDING SHEET

GENERAL INFORMATION	
Archaeological site (site code):	
Trench:	
Context:	
Recorder:	
Date:	
Burial No:	
Field methods for site excavation:	
Primary or secondary burial:	
Cremation or inhumation:	
Grave type:	
Grave size:	

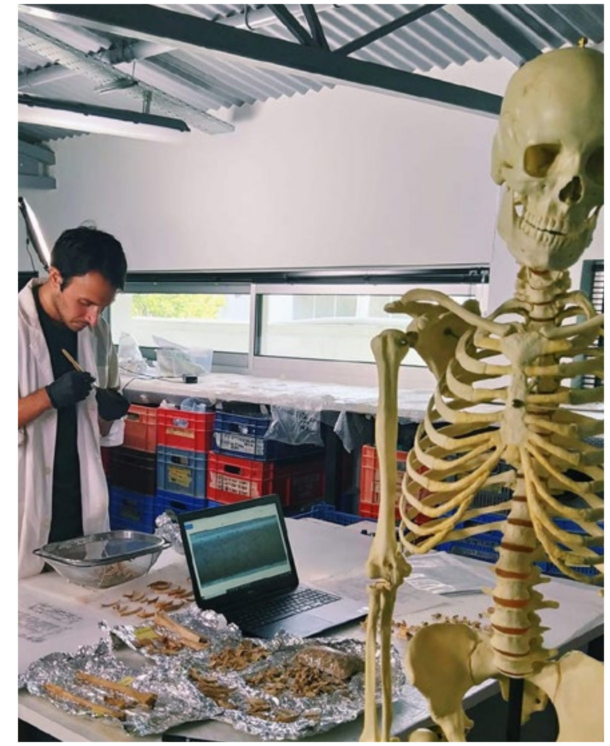
SKETCH OF BODY POSITION & ORIENTATION

DESCRIPTION & NOTES

Bone collection

Skeletal remains should be removed from the site as soon as possible after their excavation. Plastic bags should be used and the contents of each bag should be clearly marked using permanent ink. Bags should originally be left partially open so that humidity is not trapped inside. Bones should be bagged by side and element, but small bone fragments can be bagged as a group by grid square.

Working in the lab



Basic guidelines for cleaning and curating skeletal remains

Cleaning:

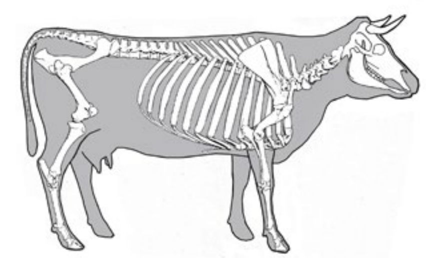
- Wash gently with tepid or cold water.
- Sieve any soil remnants to capture small bones or bone fragments.
- Let the bones dry naturally and not in direct sunlight.
- If washing is not an option, dry brush the bones using a soft brush over a sieve.

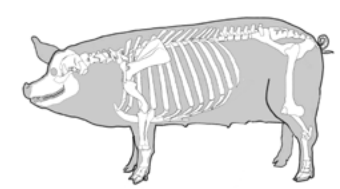
Curating:

- Place bones in plastic bags per anatomical area.
- Place multiple bags inside boxes.
- Use padding (e.g. bubble wrap) at the bottom of the boxes and/or between different layers of bags to provide additional protection.
- Fragile remains may require conservation, but the use of consolidants may compromise future biomolecular and chemical analyses.

Separation of human from animal bones

Animals may have been buried with humans, sacrificed as part of the mortuary ritual, or ended up in the tomb at a later stage (e.g., burrowed into the tomb and died there). Therefore, it is important to separate the human from the animal bones before any further analysis. The simplest way to do so is through the morphological study of the bones. Differences in the skeletal anatomy between humans and other animals are endless. In the figures to the right, you can see what a cow and pig skeleton look like!

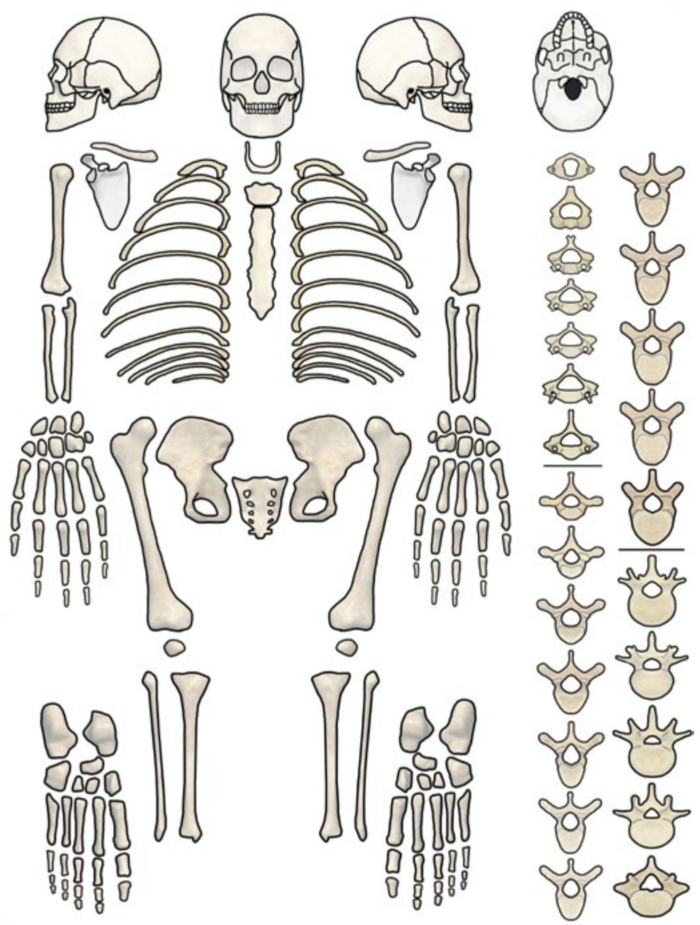




Inventory and data collection

The first step in any osteoarchaeological analysis is to construct an inventory of all bones and teeth preserved.

Once the inventory has been established, osteoarchaeologists start recording diverse skeletal information, as described in the previous pages of this book. Different scientists and different laboratories have established their own data collection protocols; however, they all use pretty much the same well established methods for morphological and metric analysis.



In these sample forms for recording sex and age-at-death, you can see that many different methods are used simultaneously and their results are combined to reach a final estimate.

SEX ASSESSMENT (ONLY FOR ADULT REMAINS)

Key: Record as 1 = Female, 2 = Probable Female, 3 = Ambiguous, 4 = Probable Male, 5 = Male, 0 = Indeterminate

Element		Score/Sex
Pelvis	Subpubic concavity	
	Ventral arc	
	Medial ischiopubic ramus	
	Greater sciatic notch	
	Preauricular sulcus	
	Auricular surface elevation	
	Iliac crest	
	Subpubic arch	
	Pubic ramus	
	Ischial tuberosity	
	Obturator foramen	
	Acetabulum	
	Sacrum	
Cranium	Glabella/supraorbital ridges	
	External occipital protuberance	
	Mastoid process	
	Supraorbital margin	
	Mental eminence	
	Frontal/parietal bossing	
	Suprameatal crest	
	Zygomatic bone	
	Zygomatic process of frontal bone	
	Orbital outline	
	Temporal lines	
	Occipital condyles	
	Palate	
	Canine eminence	
	Chin shape	
	Mandibular ramus flexure	
	Gonial eversion	
	Lower mandibular margin	
	Mandibular angle	
	Mandibular condyles	

METRIC METHODS			
Element	Method	Reference	Sex

FINAL SEX ASSESSMENT	

AGE-AT-DEATH ESTIMATION (FOR NONADULTS)

Classify individuals in one of the following categories: fetus = before birth, infant = 0-3 yrs, child = 3-12 yrs, adolescent = 12-18 yrs, nonadult = <18 yrs, indeterminate = unable to estimate age-at-death

DENTAL DEVELOPMENT

Key: Record the stage of dental development per tooth using Cunningham et al. (2016) (data drawn from Shackelford et al. 2012) and/or Moorrees et al. (1963a, 1963b)

DECIDUOUS						
		I1	I2	C	M1	M2
Maxilla	Stage					
	Age					
Mandible	Stage					
	Age					

PERMANENT									
		I1	I2	C	P3	P4	M1	M2	M3
Maxilla	Stage								
	Age								
Mandible	Stage								
	Age								

Key: Record the age of the individual based on the overall development of the dentition (tooth formation and eruption) as documented by the London Atlas (AlQahtani et al. 2010)

London Atlas	

Key: Use the equations by Liversidge et al. (1993)

Tooth	Length	Age

THE BEGINNING

This is the end of the current book. However, we hope that it is just the beginning in your journey to learn more about the diverse subfields of Archaeology and the fascinating information they can reveal regarding our past!

There are many resources that you can use during your journey; below we highlight some open access options.

Happy exploring!

Efi & Mahmoud

WEBSITES

with free resources on archaeology for children

The **Young Archaeologists' Club**, supported by the Council for British Archaeology, provides opportunities for children in the UK to participate in excavation, work with artefacts, visit sites, and engage in experimental archaeology. Free activities to do at home or in the classroom are also provided; **https://www.yac-uk.org/things-to-do** (last accessed 21/04/2022)

The **Archaeology Channel** is a streaming media website brought to users by the Archaeological Legacy Institute; **https://www.archaeologychannel.org/** (last accessed 21/04/2022)

The **Society for American Archaeology** has created resources for teaching archaeology to students, focussed on introducing archaeological inquiry, site formation processes, excavation methods, seriation dating and typological analysis of artifacts; **https://www.saa.org/education-outreach/teaching-archaeology/teaching-guidelines** (last accessed 21/04/2022)

The **Archaeological Institute of America** has developed educational resources that cover taphonomy, typology, and excavation, as well as more specific themes (e.g. Aztec culture, Greek vase painting); **https://www.archaeological.org/programs/educators/** (last accessed 21/04/2022)

The **National Endowment for the Humanities** offers free lesson plans, teacher's guides and media resources for art, culture, history and social studies, including archaeology-themed topics (e.g. ancient Egyptians, Aztecs and Australian Aboriginal art); **https://edsitement.neh.gov/** (last accessed 21/04/2022)

Many museums provide teaching guides around their collections, such as the **J. Paul Getty Museum** and the **Metropolitan Museum of Art**, which have designed a series of classroom resources around ancient art; **https://www.getty.edu/education/teachers/classroom_resources/index.html**; **https://www.metmuseum.org/learn/educators** (last accessed 21/04/2022). Similarly, museums of archaeology, such as the **Museum of London** and the **Archaeological Museum in Thessaloniki, Greece**, have prepared activity packs to engage students in a hands-on understanding of the past; **https://www.museumoflondon.org.uk/application/files/5215/9618/8932/lr-primary-schools-misc-prehistory-archaeology-activity-pack-ks2.pdf**; **https://www.amth.gr/education/ekpaideytiko-yliko** (last accessed 21/04/2022)

Archeurope Educational Resources is a website that offers material (mostly links to other useful webpages) for different time periods across the European continent; **http://archeurope.info/** (last accessed 21/04/2022)

The **Archaeology Data Service** and **Internet Archaeology** host archives and publications that form useful resources for educators and students; **https://archaeologydataservice.ac.uk/learning/schoolsResources.xhtml** (last accessed 21/04/2022)

FREE BOOKS

on archaeology activities for children

Harper Cassandra Rae. 2011. ***Beyond Artifacts: Teaching Archaeology in the Classroom*****. Florida Public Archaeology Network.** This book presents hands-on activities for general archaeology (with emphasis on field methods), prehistoric, historic and underwater archaeology, with an emphasis on Florida archaeology. **https://studylib.net/doc/8654957/beyond-artifacts---florida-public-archaeology-network** (last accessed 21/04/2022)

Lytle Whitney and Vieyra Anne. 2012. ***Archaeology Tools for Teaching. Legacy: Hands on the Past.*** **Center for Archaeological Research at the Department of Anthropology, University of Texas at San Antonio**. This book contains lesson plans, activity guides, as well as a vocabulary and list of additional resources for teaching archaeology. A lot of the material has a regional focus on Texas, but many activities cover global archaeological practices. **https://car.utsa.edu/CARLegacy/LegacyResources/TeachersResourcePacket.pdf** (last accessed 21/04/2022)

Hawkins Nancy W. 1991. ***Classroom Archaeology: An Archaeology Activity Guide for Teachers, 3rd edition*****. Office of Cultural Development at the Louisiana State Department of Culture, Recreation, and Tourism**. This guide includes a list of useful resources, activities and games, thematically focused on Louisiana, though some have a broader scope. **https://www.crt.state.la.us/dataprojects/archaeology/activity_guides/outreach/booklets/ClassroomArch.pdf** (last accessed 21/04/2022)

GLOSSARY

A

adolescence: stage in a human's development between being a child and becoming an adult

ancestry: an individual's origin/line of descent

appendicular skeleton: part of the human skeleton that includes the pelvis, shoulders, arms, and legs

archaeobotany: the scientific field that studies ancient plant remains

archaeozoology: the scientific field that examines ancient animal remains (see also zooarchaeology)

atlas: the first cervical vertebra

auricular surface: bone surface at the point where the os coxae articulate with the sacrum

axial skeleton: part of the human skeleton that includes the skull, spine and ribs

axis: the second cervical vertebra

B

bioarchaeology: the scientific field that examines ancient human remains (see also osteoarchaeology)

biological age: an individual's age estimated based on their skeletal remains

bone remodeling: the recycling of bone tissue, that is, the replacement of mature bone tissue by new bone tissue

C

cartilage: an elastic tissue that covers the epiphyses of long bones but is also found in many other parts of our body (e.g. connecting the ribs to the sternum)

cementum: dental tissue that covers the dentine at the root

cervical vertebrae: the seven vertebrae at the top of our spine

chronological age: the amount of time for which an individual has been alive

cortical bone: a dense type of bone tissue

crown: part of the tooth visible in our mouth

cusps: protrusions on the surface of our molars and premolars

D

deciduous teeth: the first set of teeth that humans develop during the first years of their life; also called baby teeth

demography: the scientific field that examines the composition of a population (e.g. number of males and females, age distribution etc.)

dental caries: tooth decay

dental plaque: the formation of deposits on the surface of the teeth

dentine: dental tissue that extends along the crown and root

diaphysis: tubular part in the middle of long bones

differential diagnosis: the process of differentiating pathological conditions with similar symptoms

E

enamel: dental tissue that covers the crown

entheses: parts of bones where our muscles attach

epiphyses: the two ends of the long bones

F

foramen: a hole in a bone

forensic anthropology: the scientific field that examines modern skeletal remains to identify the deceased and the circumstances of their death

fracture: a break in the bones

G

genotype: the genetic makeup of an organism

glabella: the most protruding point of the frontal bone between the eyebrows

H

haversian canal: the central part in each osteon that allows the passage of blood vessels and nerves

I

infancy: the early stage in a human's development

Isotopes: different forms of the same chemical element where the atoms have an equal number of protons and unequal number of neutrons

K

kyphosis: exaggerated outward curvature of the middle and upper region of the spine that creates a hunchback appearance

L

lacuna: bone cavity in an osteon that contains osteocytes

lamella: a thin layer of bone

linear enamel hypoplasia: a malformation of the enamel due to some health problem in the early life of an individual

lumbar vertebrae: the five vertebrae at the bottom of our spine

M

mastoid process: bony protrusion on the temporal bone that allows the attachment of neck muscles

medullary cavity: cavity in the center of long bones that stores bone marrow

mental eminence: a bony protrusion at the front and central part of the mandible

metaphyses: parts of the bone between the diaphysis and the epiphyses

mutation: an alteration in part of our genome

N

nuchal crest: a protrusion on the occipital bone that allows the attachment of neck muscles

O

osteoarchaeology: the scientific field that examines ancient human skeletal remains (see also bioarchaeology)

osteocytes: cells that maintain important bone functions

osteon: the basic unit of cortical bone

osteoporosis: disease characterized by the gradual loss of bone mass

P

palaeoparasitology: the scientific field that examines ancient parasites and their interaction with humans or other hosts

palaeopathology: the study of the diseases that afflicted humans in the past

palate: the roof of the mouth

permanent teeth: the teeth that replace our deciduous teeth and remain in our mouth throughout our lives (unless they fall off due to some disease!)

phalanx: one of the bones of our fingers or toes

phenotype: our morphological traits, the way we look

pubic symphysis: the joint between the os coxae

pulp chamber: the interior space of the tooth which houses nerves and blood vessels

R

radiocarbon dating: a method for determining how old an object that contains organic material is

root: the part of the tooth embedded in our jaws

S

sexual dimorphism: morphological differences between males and females

sutures: interlocking joints that articulate the bones of the skull

T

taphonomy: the scientific field that examines the factors that affect the preservation of a body after death

thoracic vertebrae: the 12 vertebrae in the middle part of the spine

trabecular bone: a type of bone tissue composed of thin bony spicules

tuberculosis: an infectious disease, skeletally it mostly affects the spine

Z

zooarchaeology: the scientific field that examines ancient animal remains (see also archaeozoology)

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Secondary tuberculosis in lungs and close-up view of Mycobacterium tuberculosis

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Efi (Efthymia) Nikita decided to become an archaeologist because she loved ancient Greece and wanted to know more about it. Initially, she hoped to become a historian but her dream was shattered when she realized that she was terrible in learning ancient Greek and she was not so fond of spending endless hours inside libraries. Instead, excavating outdoors and performing laboratory analyses fitted her much better! She chose to specialize in osteoarchaeology because she wants to give voice to the people of the past through the most direct evidence of their existence... their bones. She has had the opportunity to work as an osteoarchaeologist in Morocco, Tunisia, Libya, Greece and Cyprus; she has published several scientific papers, and she has been lucky enough to have great students who do all the hard work so that she can spend her time writing this book!

Mahmoud Mardini is a Lebanese PhD student studying ancient human bones from a place that was known as Phoenicia. Unaware of what bioarchaeology is, Mahmoud initially channeled his interest in biology and bones by pursuing the pre-med track at university for three years, until he came across an archaeology module. From thereon, he shifted his interest from pre-med to archaeology and never looked back. Since then, he has been hopping from one excavation to another all over Lebanon and explores how our ancestors lived and died by analyzing their bones! When he is not busy in the field or in the lab, Mahmoud likes to spend his time contributing whatever bone knowledge he has to the general public, as done in this book.

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