Chapter Overview

Bones seem to not move or have any obvious function besides making our bodies rigid, but they are living tissue capable of storing calcium and forming attachments for muscles. Forensic scientists realize that by analyzing bones through measurements, texture, shape, and DNA extraction and analysis, clues to one's age, sex, race, height, and health can be revealed. Forensic anthropologists are able to study skeletal remains and create what is called an osteobiography, or physical record of a person's life as told by his or her bones. Forensic anthropologists study bones to help reveal what happened to a person before or after death.

The Big Ideas

Osteoblasts are cells in our body that aid in the production and deposition of minerals that harden to form bone. Throughout our lives, bone is broken down, deposited, and replaced. There are visible differences between the male and female skeleton, especially in the skull, jaw, brow ridge, pelvis, and femur. By studying a human skull and other bones, a forensic anthropologist can determine the race of the individual, as well as the approximate age a person was when he or she died. The effects of injuries and disease are visible in our bones. Even if nuclear DNA is no longer present, scientists can extract mitochondrial DNA from bones to create a DNA profile of genes received from an individual's mother.

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CHAPTER 13

Forensic Anthropology: What We Learn from Bones

BURN BARREL EVIDENCE LINKS SUSPECT TO MURDER

Four days passed before 25-year-old Teresa Halbach was reported missing. Teresa, a photographer working for the *Auto Trader Magazine*, spent much of her time driving across eastern Wisconsin in her 1999 Toyota RAV 4 taking pictures of old cars. On Friday, October 31, 2005, her last stop was at the Avery Auto Salvage yard in Gibson, near Lake Michigan. She was there to meet co-owner Steven Avery and to take pictures of a Plymouth Voyager minivan he had for sale.

The police knew Steven and his brothers from earlier encounters. Recently in a very public trial, Steven was convicted of rape and attempted murder and then released as innocent when DNA evidence pointed to another man. He filed a $36 million lawsuit against the state for wrongful conviction. When the police showed up Monday afternoon after tracing Teresa's movement to his salvage yard, he announced he was "being set up because of my lawsuit."

In the yard, officers found a "burn barrel" with remains of a camera, cell phone, clothes, teeth, and bones. A team of forensic anthropologists were called in to investigate, and they determined that the remains were of an adult human female. Damage to some of the bones also suggested the body had been mutilated.

When Steven's nephew confessed to participating in the crime, Steven was arrested on numerous charges involving Teresa's death. Do the bones in the barrel and the account of a 16-year-old tell the same story? Will they convict a man who still maintains his innocence?

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Steven Avery.

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SCENARIO

Since age 18, Steven Avery had served jail time for burglary and cruelty to animals. In 1985, Avery was jailed again, this time for rape and two other charges. Avery served 18 years in prison before being exonerated. In 2007, Avery was convicted for the murder of Halbach and was sentenced to life in prison with no possibility of parole.

KEY SCIENCE CONCEPTS

Biology: bone formation; mitochondrial DNA; cranial suture marks; DNA technology

Mathematics: determining height from long bones; bone proportions

Teaching Resources

- Instructor's Resource CD-ROM includes:
  - PowerPoint Presentation
  - Lesson Plan and extended Objective Sheets
  - Instructor Notes and Activities
  - Activity Forms
  - Rubric
- ExamView CD-ROM
- E-book on CD-ROM

Web site: school.cengage.com/forensicscience

Differentiated Learning

Teaching English-Language Learners

Students may find the vocabulary terms in this chapter difficult. Help them create flashcards for each term. Dissecting the words and identifying the word origin (e.g., *osteo-* comes from the Greek word for bone) may be helpful in remembering the word definitions.

Engage

After reading the Introduction, ask students to brainstorm about what they think a medical examiner would be looking for to help identify bones. Other options include showing an X-ray of a pelvis and asking students to predict whether it is male or female, reading selected passages from Maples' *Dead Men Do Tell Tales*, and showing clips from the TV series *Bones*.

Teaching Tip

Take an opportunity with your students to deconstruct all of the vocabulary terms that begin with *osteo-* and have different endings. What do these individual parts of the term mean? *Osteo-* is from the Greek word bone; *osteoclast-* means bone and broken; *osteoblast-* means bone and germ (which means growth in this case); *osteocyte-* means bone and cell.

Explore

As students browse through this chapter, they may begin to feel concern as they see all of the scientific terminology. Help students suppress an initial concern when they see multiple terms of which they are unfamiliar, and assure them they will be able to read and understand the text. If students learn basic prefixes such as *osteo-*, they will have a better understanding of multiple terms that begin with the same prefix.

Teaching Tip

Remind students about what they learned from previous chapters on Alphonse Bertillon, the French police officer who developed a system (anthropometry or Bertillonage) of physical body measurements to help identify repeat offenders.

CHAPTER 1 2 3 4 5 6 7 8 9 10 11 12 **13** 14 15 16 17

INTRODUCTION

In forensics, analyzing bones is important for identification of a possible victim or suspect. If the remains of bones are found in association with a suspect, being able to identify the bones can be a critical step in linking the suspect to the crime (Figure 13-1). This chapter will examine how someone's identity, sex, age, height, race, and background can be revealed through an analysis of his or her bones.

Figure 13-1. *People of different races have differently shaped facial bones.*

Studying bones may also reveal what happened to a person before or after death. Bone evidence can help an investigator reconstruct a crime.

HISTORICAL DEVELOPMENT

Anthropology is the scientific study of all aspects of human development and interaction. It studies tools, language, traditions, and social interactions and how we relate to other societies. Physical anthropology studies human differences, especially those by which we can be identified. **Forensic anthropology** studies these identifying characteristics on the remains of an individual. These unique characteristics can be used to demonstrate the sex, race, height, and physical health of a victim from his or her remains.

- In Europe in the 1800s, the origins of the races of humans were heatedly discussed. Scientists began using skull measurements to differentiate among individuals. The differences between male and female anatomy, and the formation, aging, and fusing of bones were also examined, laying the framework for today's knowledge.
- The Luetgert murder case of 1897 accused a sausage maker of killing his wife and boiling down her corpse. Remains found in the factory appeared to be fragments of his wife's skull, finger, and arm.
- In 1932, the FBI announced the opening of its first crime lab. The Smithsonian Institution became a working partner, aiding in the identification of human remains.
- In 1939, William Krogman published the *Guide to the Identification of Human Skeletal Material.*

The founder of modern criminology, Dr. Cesare Lombroso, claimed to be able to identify people with criminal tendencies based on physical characteristics, including head size and the distribution and abundance of facial wrinkles and eye defects. His theories were later proved wrong.

Differentiated Learning

Teaching Gifted Students

Suggest that students research and report on the FBI's first crime lab, the Luetgert murder, or the Krogman book.

- The remains of soldiers killed during World War II were identified using anthropologic techniques.
- More recently new techniques in DNA found in the mitochondria of cells has been used in identification, such as the analysis of the skeletons of Nicholas and Alexandria Romanov.

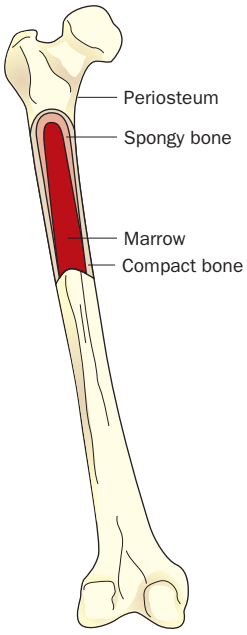
CHARACTERISTICS OF BONE

Our bones are alive; they may not move or appear to have any obvious function besides making our bodies rigid, but they do have other purposes. Bones carry on a type of respiration called cellular respiration and consume energy like any other living cells. Inside of bones is a tissue called marrow, where blood cells are made (Figure 13-2). Bones are regulated by hormones that affect the amount of calcium in the blood and in the hard part of the bone. Since bones are alive, they are capable of growth and repair.

DEVELOPMENT OF BONE *Obj. 13.1*

Bones originate from living cells called **osteoblasts.** During the development of the fetus, bones begin as soft cartilage, the same flexible material that makes up our ears. Osteoblasts migrate to the centers of cartilage production and deposit minerals, such as calcium phosphate, that harden to form bone. This process is called **ossification** and begins during the first few weeks of pregnancy. By the eighth week of pregnancy, the outline of the skeleton has formed and is visible in an X-ray. As bone develops, a protective membrane layer that contains nerves and blood vessels covers the surface of the bone. This membrane, called the perisoteum, serves an important role in keeping bones moist and aiding in the repair of injuries.

Figure 13-2. *A cross section of bone, showing its different longitudinal components.*



Throughout our lives, bone is deposited, broken down, and replaced. When an arm or leg is broken, the blood vessels at the area have the ability to increase calcium phosphate deposition to help heal the break. Newly trapped osteoblasts, called **osteocytes,** form the new bone framework. These cells can no longer produce new bone and become the basic framework for the new bone.

Osteoclasts, the second type of bone cell, are specialized to dissolve bone. As bones grow, they need to be reshaped. Simply adding layer upon layer of calcium phosphate would not maintain the proper shape of the bone. Therefore, as bones grow, the osteoclasts secrete enzymes that help dissolve certain areas of the bone.

Osteoclasts also aid in maintaining homeostasis within the body. Calcium, a mineral that

Bones can reveal if a person had tuberculosis, arthritis, and leprosy, as well as iron and vitamin D deficiency. Although long healed, a record of any broken bones can be detected.

Teaching Tip

Some students may be interested in reading books written by Patricia Cornwell about medical examiner Dr. Kay Scarpetta and also by Jefferson Bass (Bill Blass and Jon Jefferson), based on actual cases from the real Body Farm in Tennessee. You might also mention the writings of Michael Baden, chief medical examiner of New York, and William Maples, forensic anthropologist for University of Florida.

Evaluate

Remind students that vertebrates are organisms with a backbone, and invertebrates are those without a backbone. Ask students to identify different vertebrates and invertebrates. Ask why bones are considered living.

Teaching Tip

Remind students that in order for an organism to survive, it must maintain a constant and stable internal environment, even though the external environment is fluctuating. *Homeostasis* is the ability of an organism to maintain its internal environment.

Teaching Tip

The internal support structure of an animal is called an *endoskeleton.* The prefix *endo-* means "within" or "inside" indicating the skeleton is inside the organism. You might tell students that organisms such as the lobster have an exoskeleton, which means their support structure is on the outside of the organism.

Science

Biology

Inside our cells are genes. These genes have sets of instructions to produce particular proteins. A special type of protein, called an enzyme, controls the chemical reactions within cells.

Explore

Articulation is the joining of structures such as bone at a joint. How bones connect to one another and the degree of movement between the articulating bones are the two ways in which joints are classified.

Teaching Tip

Students may have difficulty remembering the difference between tendons and ligaments. Help them to remember by asking them to feel their Achilles tendon in their ankle. Ask them where and to what this tendon is attached. One end of the tendon is attached to bone in the heel and the other is attached to the calf muscle.

is vital to normal metabolism, may be borrowed from bone when levels in the blood are low. Osteoclasts dissolve the bone and release calcium into the blood. Continued failure to eat enough calcium can result in a weakening of bones. This condition is called **osteoporosis.** A third function of the osteoclasts is to remove cellular wastes and debris from the bones. When bones become injured, the osteoclasts secrete enzymes that dissolve the injured or damaged part of the bone so that new, healthy bone can be laid down.

NUMBER OF BONES

How many bones are in the human body? Most medical students will tell you 206. That answer is only partially correct. An adult has 206 bones after all bones have become fully developed (Figure 13-3). A baby has 450 bones!

Figure 13-3. *As we grow older, bones in our body fuse together.*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HOW BONES CONNECT

A **joint** is the location where bones meet (articulate). Joints contain basically three kinds of connective tissue:

- *Cartilage.* Wraps the ends of the bones for protection and keeps them from scraping against one another (Figure 13-4).
- *Ligaments.* Bands of tissue connecting together two or more bones (Figure 13-5).
- *Tendons.* Connect muscle to bone (Figure 13-6).

Figure 13-4. *Cartilage*

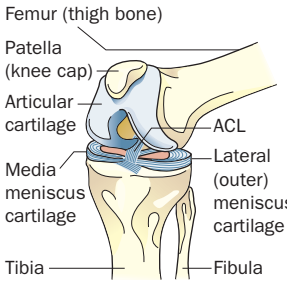


Figure 13-5. *Ligaments*

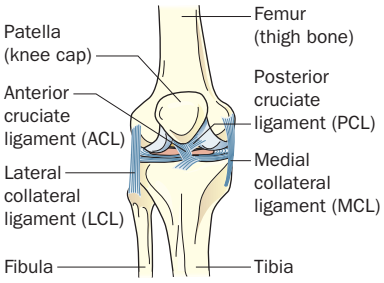
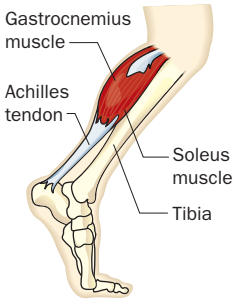


Figure 13-6. *Tendons*



Differentiated Learning

Teaching At-Risk Students

Organize students into a group. To help them understand cartilage, ligaments, and tendons, have students take turns explaining the illustrations above to the group.

AGING OF BONE

Throughout our lifetime, bones are being produced and being broken down. Children build more bones at a faster rate than the rate of bones being broken down. As a result, bones increase in size. After 30 years, the process begins to reverse; bones deteriorate faster than they are built. This deterioration can be slowed with exercise. Without exercise, bones can become frail and less dense and are easily broken later in life.

People with osteoporosis are at risk of breaking bones because their bones have lost calcium and tend to be porous. As the vertebrae lose calcium, they begin to collapse and can give someone a hunched appearance. Some elderly people do, in fact, shrink; the loss of height is caused by the vertebrae collapsing.

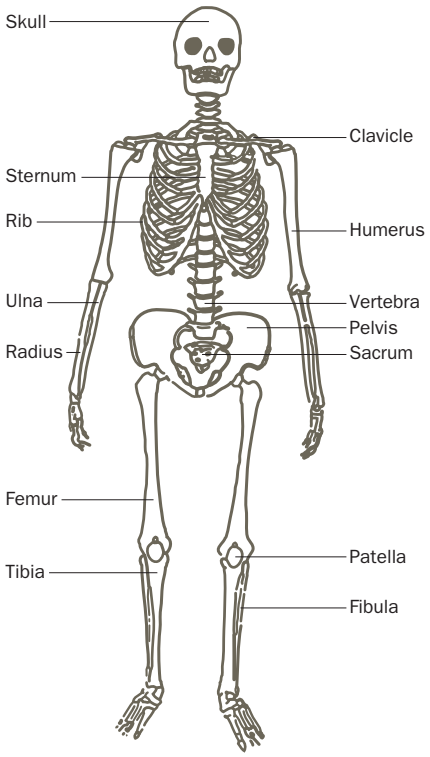
The number of bones and their condition can tell an investigator about a person's age, health, and whether they had enough calcium in their food.

The smallest bone in your body is 2.5 to 3.3 mm long. It is the stirrup bone, located behind your eardrum.

WHAT BONES CAN TELL US

So much about a person is revealed by examination of his or her bones (Figure 13-7). The term **osteobiography** literally translates as *the story of a life told by the bones.* Bones contain a record of the physical life. Forensic scientists know that analyzing the bones reveals clues to one's age, sex, race, approximate height, and health. For example, a loss of bone density, poor teeth, or signs of arthritis can point to nutritional deficiencies and disease. The bones of a right-handed person's arm would be slightly larger than the bones of the left arm. If someone lifted heavy objects regularly, the bones would be denser than someone who did not work physically hard. The type of sports one plays could be detected by the extra wear and tear on different joints and the sizes of the bones in general. An X ray of the bones taken during an autopsy would show previous fractures, artificial joints, and pins.

Figure 13-7. *Our skeletons reveal information about us.*



HOW TO DISTINGUISH MALES FROM FEMALES *Obj. 13.2*

Often, a detective's first question to a forensic anthropologist is whether the skeleton belongs to a male or female. How can one differentiate sex from bone fragments? The overall appearance of the female's skeleton tends to be much smoother (gracile) and less knobby than that of a male's skeleton (robust). A man's skeleton is usually thicker, rougher, and appears quite bumpy. Because of male hormones, muscles are more developed in the male. When muscles are larger, they require a stronger attachment site on the bones. To accommodate the larger muscles and their tendons, the surface of the bone where a muscle and tendon attach is thicker, creating the appearance of a rough or bumpy area. One

Evaluate

Ask students why a right-handed person's bones would be larger in his or her right arm.

Explore

Point out that *orthopedics* (derived from the Greek words for straight and child) is a medical specialty dealing with prevention, diagnosis, and treatment of problems and diseases associated with the skeletal and muscular systems of children.

Teaching Tip

Explain that forensic anthropologists must also be knowledgeable about other animal bones, not just human bones, so they can attest to the fact that bones found at a crime scene are human.

Explore

One of the most famous archaeological frauds is the Piltdown Man, which was originally thought to be the fossilized remains of an early human. Skull fragments and a jawbone were discovered in 1912 in a gravel pit in Piltdown, England. It took more than 40 years for researchers to discover that the Piltdown Man was actually a sham and that the bones were actually a jawbone of an orangutan and the skull of a modern man. Have students view the NOVA program "The Boldest Hoax."

Differentiated Learning

Teaching At-Risk Students

To help students understand the concept of osteobiography, have them make a list of events in their life that would probably show up on their bones. These might include broken bones, serious sprains, and severe illnesses.

Differentiated Learning

Teaching Gifted Students

Have students research Fosamax, a drug used to prevent bone loss. Ask students to explore how Fosamax works to reduce bone loss.

Teaching Tip

Ask students if there is an easy way to tell a male from a female by looking at the ribs. Many people have the misconception that men have one fewer rib than women because of the biblical story of the creation of Eve. Explain that both men and women have 12 pairs of ribs.

Teaching Tip

Have students look at a diagram of infant and adult skulls. Ask them to count how many individual plates are present on the infant skull before they fuse together. Then, have them count how many plates are present on the adult skull after they have fused together. Next, ask why the cranial plates must remain unfused during childhood.

Explore

The Discovery Channel Show *Dirty Jobs* showed an episode called "Skull Cleaner," which premiered on July 11, 2006. Try to get a copy of this episode and show it to students. It is available at The Discovery Channel's Web site.

Explore

Sharpey's fibers are the connective tissue that holds cranial bone together.

Teaching Tip

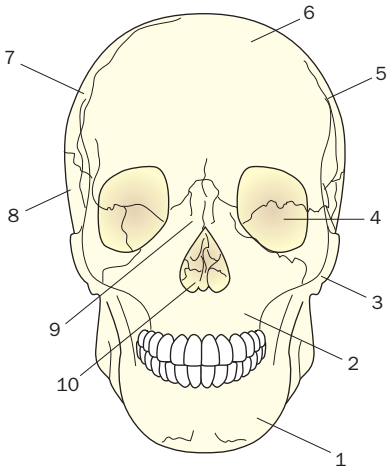
Ask students to bring in X-rays they may have had taken. Tape them to classroom windows or a light table and discuss what you see.

place this is especially noticeable is in the knees, because the bones of the knees are more obvious than other areas of the body.

Skull

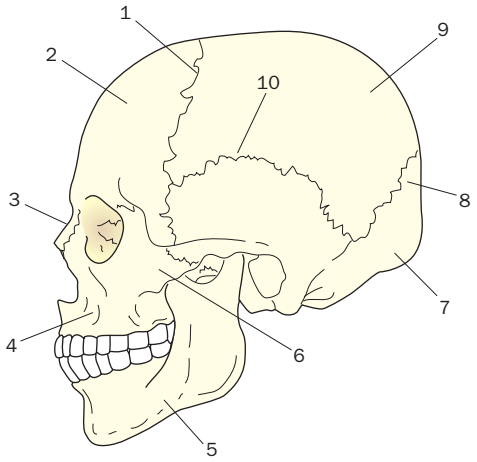
Generally, the male skull is more massive and bumpier than the female skull. There are many specific differences, but the first step is to review Figures 13-8 and 13-9 depicting the major bones of the skull.

Figure 13-8. *Front view of skull with major bones labeled.*



Number	Name of Bone
1	Mandible
2	Maxilla
3	Zygomatic
4	Orbits of the eye; Sphenoid
5	Coronal suture
6	Frontal
7	Parietal
8	Temporal
9	Nasal
10	Vomer

Figure 13-9. *Side view of skull with major bones labeled.*



Number	Name of Bone or Suture
1	Coronal suture
2	Frontal bone
3	Nasal bone
4	Maxilla
5	Mandible
6	Zygomatic complex
7	Occipital protuberance
8	Lambdoidal suture
9	Parietal bone
10	Squamous suture

In Figures 13-10 and 13-11, note the differences between the male and female skulls. The male's frontal bone is low and sloping, whereas the female's frontal bone is higher and more rounded. The male eye orbits tend to be square, whereas the female's eye orbits are more circular. The male's lower jaw is square, with an angle of about 90 degrees. The female's lower jaw is sloped, with an angle greater than 90 degrees. Males also have squarer chins; females' chins are rounder or more V-shaped.

The occipital protuberance, a bony knob on the male skull, serves as an attachment site for the many muscles and tendons of the neck. Because the muscles in a man's neck are larger than the muscles in a woman's neck, the area of attachment needs to be thicker, creating the protuberance on the male skull.

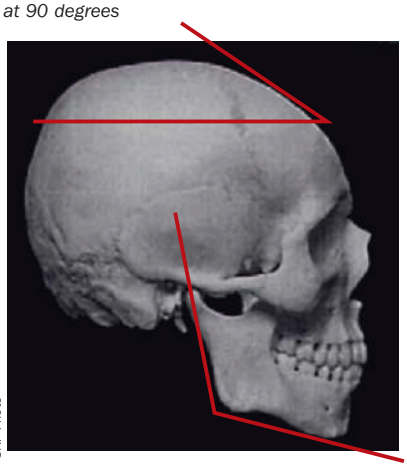
Differentiated Learning

Teaching At-Risk Students

Students might be interested in learning about bones as they relate to sports. Ask students how they think the bones of someone who regularly works out with weights—either their own bones or the bones of someone like Arnold Schwarzenneger—would look compared to someone who does not. Ask them what they would expect to find from the bones of athletes of various sports, such as soccer, football, and basketball. Ask students why using steroids to build muscle may cause bones to break. Then ask them to compare their bones to the bones of a fashion model.

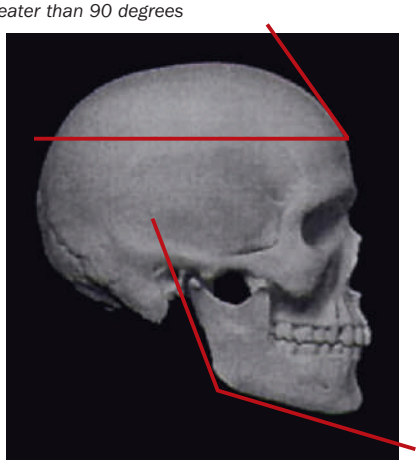
Figure 13-10. *A side view of male and female skulls, noting the differences.*

Male; note the low sloping frontal bone and a jawbone set at 90 degrees



©AP Photo

Female; note the rounded frontal bone and jawbone greater than 90 degrees



©AP Photo

Figure 13-11 *Summary of male and female skull differences.*

Male Front View	Male characteristics	Trait	Female Characteristics	Female Front View
	More square	Shape of eye	More rounded	
	More square	Mandible shape from underside	More V-shaped	
	Thick and larger	Upper brow ridge	Thin and smaller	
Male Side View	**Male Characteristics**	**Trait**	**Female Characteristics**	**Female Side View**
	Present	Occipital protuberance	Absent	
	Low and sloping	Frontal bone	Higher and more rounded	
	Rough and bumpy	Surface of skull	Smooth	
	Straight	Ramus of mandible	Slanting	
	Rough and bumpy	Nuchal crest	Smooth	

Pelvis

One of the easiest methods of determining the sex of a skeleton is to examine the pelvis. Because of the anatomical differences needed for child-bearing, this region of the body exhibits many differences. The surface of a woman's pelvis is engraved with scars if she has borne children. During the fourth month of pregnancy, hormones are released that soften the tendons in the pelvic area to help accommodate the developing fetus. These scars can be detected on the pubic symphysis, a cartilaginous area where the bones meet. Review the different bones of the pelvis in Figure 13-12, on the next page.

Teaching Tip

The angle formed by the greater sciatic notch can be measured using a protractor. Ask students to research the differences in the angle for males and females.

Teaching Tip

Point out that Figure 13-17 does not show the sagittal suture that runs along the top of the skull from the coronal suture to the lamboidal suture. The sagittal suture closes at about age 32.

Differentiated Learning

Teaching English-Language Learners

Ask students to draw a male and a female skull using the images in the textbook as models. In the drawings, they should differentiate between the slope of the frontal bone, eye orbits, angle of jawbone, shape of chin, and occipital protuberance. Express to students that they should slightly exaggerate the difference between a male and female skull to help them better identify these differences on a test or quiz.

Teaching Tip

Point out to students that the female pelvis also weighs less than the male pelvis.

Teaching Tip

Tell students that the coccyx (*kok-siks*) is commonly called the tailbone. It is the last of the vertebrae in our spinal column. The largest muscle in our body, the gluteus maximus, is attached to the coccyx.

Teaching Tip

Explain that *foramen* means hole or opening. Write in large letters some anatomical terms from the chapter and their definitions, and display them in the room to help students become familiar with the terms. Include terms such as foramen, dorsal, ventral, medial, lateral, proximal, and distal.

Evaluate

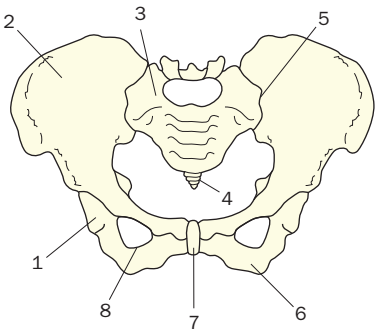
Ask students with which bone the pelvis articulates.

To distinguish between the male and female pelvis, compare the following:

- Subpubic angle (Figure 13-13)
- Length, width, shape, and angle of the sacrum (Figure 13-14)
- Width of the ileum
- Angle of the sciatic notch

Figure 13-15 has a summary of these differences.

Figure 13-12. *The major bones of the pelvis.*



Number	Name of Bone
1	Joint
2	Ileum
3	Sacrum
4	Coccyx
5	Joint
6	Ischium
7	Pubis symphysis
8	Obturator foramen

Figure 13-13. *The subpubic angle is greater than 90 degrees on the female and less than 90 degrees on the male.*

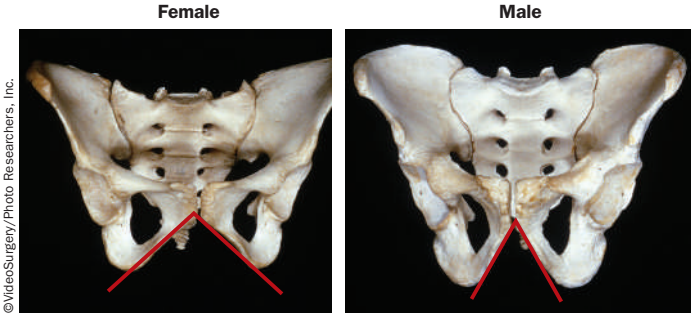


Figure 13-14. *The female's pelvic cavity is more opened than the male's.*

Female pelvic cavity (oval shaped)

Male pelvic cavity (heart shaped)

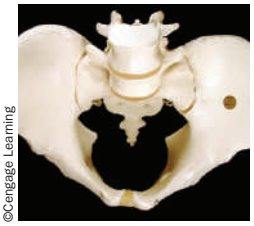


Figure 13-15. *Summary of Male and Female Pelvis Differences*

Region	Bone	Male	Female
Pelvic	Subpubic angle	50–82 degrees	90 degrees
	Shape of pubis	Triangular pubis	Rectangular pubis
	Shape of pelvic cavity	Heart-shaped	Oval-shaped
Sacral	Sacrum	Longer, narrower, curved inward	Shorter, broader, curved outward

Differentiated Learning

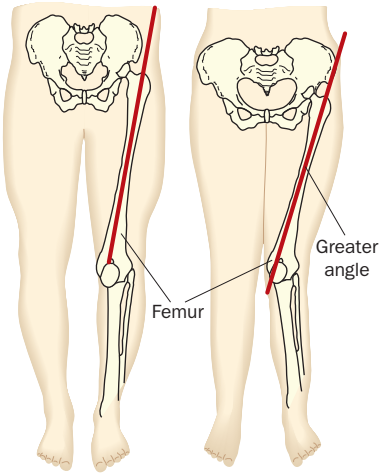
Teaching English-Language Learners

Help students with the pronunciation of scientific terms such as ilium (*il' e-um*) and coccyx (*kok-siks*). To help acquaint students with the names of the different bones in their body, have them play a game of "Simon Says" and ask them to touch different bones as you call the name.

Thigh Bones

The thigh bone, or femur, also provides information about sex (Figure 13-16). The angle of the femur in relation to the pelvis is greater in females and straighter in males. The male femur is also thicker than that of a female.

Figure 13-16. *The male femur is thicker and joins the pelvis at a straighter angle than the female femur.*



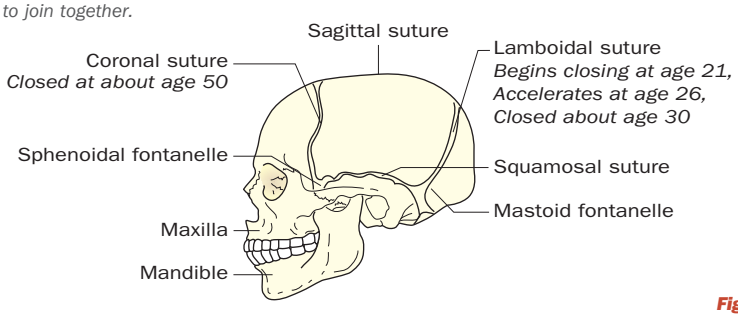
HOW TO DISTINGUISH AGE *Obj. 13.4*

The age of a person can be determined by examining particular bones and by looking for the presence or absence of cartilage. Because bones do not reach maturity at the same time, it is possible to estimate the age of a person by looking for the absence or presence of specific characteristics on a range of bones (e.g., suture marks on the skull or the presence or absence of cartilage lines).

Suture Marks

Suture marks with a zigzag appearance are found on the skull where bones meet. In an immature skull, areas of softer tissue, such as the soft spot of the baby's skull (fontanel), gradually become ossified (harden). The suture marks slowly disappear as the bones mature, giving the skull a smoother appearance. There are three main areas of suture marks, marking three main areas where skull bones meet and grow together (Figure 13-17).

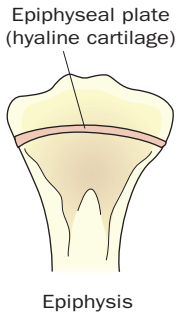
Figure 13-17. *The main suture marks on a skull, marking where the bones are growing to join together.*



Cartilaginous Lines

Recall that we are born with more than 450 bones that later join together to form 206 bones. As the cartilage is slowly replaced with hard, compact bone, a cartilaginous line is visible, called an **epiphysis** (Figure 13-18). When the cartilage is fully replaced, a line is no longer visible. The age for the completion of growth for each bone varies. The presence or absence of these cartilaginous lines can therefore be used to approximate someone's age.

Figure 13-18. *During development, a visible line occurs as the bone replaces cartilage.*



Long Bones

When the head of a long bone, like the thigh or upper arm bone (femur and humerus, respectively), has totally fused to its shaft, it is another indication of age. Various charts have been developed to help in this determination (Figure 13-19, on the next page). Because this fusing occurs at different times with different bones, this information can be used to approximate age.

Evaluate

Point out that the femur is the longest and strongest bone in the body. Ask students to speculate why it is the strongest bone.

Teaching Tip

Tell students that in Latin, *femur* means thigh.

Explore

Ask students if they have ever eaten a bone-in ham. Tell them that the bone they see is a femur.

Teaching Tip

Help students perform a chicken leg dissection to discover the femur, tibula and fibula. In addition, ask students to identify cartilage, tendons and ligaments.

Evaluate

Ask students why the angle of the femur in relationship to the pelvis is greater in a female. Suggest that students review the section in the text on the pelvis if they do not know the answer.

Explore

Explain that the pubic symphysis is the cartilaginous joint at the midline of the pelvis. In forensic anthropology, analysis of the pubic symphysis is the primary tool for determining a victim's age. The surfaces of the pubic symphysis are worn at an expected rate throughout life. Anthropologists can examine the wear on these surfaces and estimate age.

Explore

Long bones are so called because they are longer than they are wide. The bones of the legs, arms, fingers, and toes are all long bones. They generally grow by elongation.

Evaluate

While discussing this section in the text, ask students how they would judge a skull with fully closed lambdoidal and sagittal sutures but a coronal suture that is not fully fused. Although the relationship between age and skull sutures is addressed in Activity 13-1, students will be better able to answer the activity questions if this is discussed now.

Teaching Tip

The two soft spots, or fontanelles, of a newborn's skull are the locations of the unfused skull bones. Soft spots allow the plates of the skull to move when the baby is traveling through the birth canal. Both fontanelles are typically hardened by age two. The fontanelles are later converted to hard, compact bone as the cartilage becomes ossified.

Teaching Tip

Tell students that computer programs exist that can "age" a person's picture. Have interested students research how these programs work and how they are used.

Teaching Tip

Tell students that *auxology* is the study of human height.

Science

Mathematics

Measuring long bones can help determine the approximate height of an individual. However, the mathematic formula using bone length to estimate height varies with race and the bone used. Databases of averages have been compiled for different ethnic groups.

Science

Mathematics

Students can measure the length of their femur in centimeters, multiply by 2.6, and add 65 to estimate their approximate height. Suggest students use a measuring tape to measure their actual height, in centimeters, and see how good the estimate is. Point out that estimating a teenager's height is less accurate than estimating an adult's height. (For this reason, the formula also carries with it a + or − factor.) Ask why the estimation on a teenager might be less accurate.

Figure 13-19. *Estimation of age using bones.*

Region of the Body	Bone	Age
Arm	Humerus bones in the head fused	4–6
	Humerus bones in the head fused to shaft	18–20
Leg	Femur: Greater trochanter first appears	4
	Less trochanter first appears	13–14
	Femur head fused to shaft	16–18
	Condyles join shaft	20
Shoulder	Clavicle and sternum close	18–24
Pelvis	Pubis, ischium are almost completely united	7–8
	Ileum, ischium, and pubic bones fully ossified	20–25
	All segments of sacrum united	25–30
Skull	Lambdoidal suture close	Begins 21 ends 30
	Sagittal suture close	32
	Coronal suture close	50

HOW TO ESTIMATE HEIGHT

Measuring bones like the humerus or femur can help determine the approximate height of an individual. Many databases have been established that use mathematical relationships to calculate the overall height of an individual from one of the long bones of the body. There are separate tables for males, females, and different races (Figure 13-20). The mathematical formula between bone length and estimated height varies depending on the race and the bone used. If the race and sex of an individual are known, the calculation of height will be more accurate.

Here is an example of the formula: A femur measuring 40 cm belonging to an African American male is found. Use the formula on the next page to estimate his height:

Height (cm) = 2.10 femur + 72.22 cm (± 3.91)
= 2.10 (49 cm) + 72.22 cm
= 102.9 cm + 72.22 cm
= 175.12 cm or 69 inches (5 ft 9 inches)

By examining Roman skeletons, archaeologists determined that Roman males were 5'7" on average and Roman females were 5'3" on average. The average height in the United States today is 5'9" for males and a little less than 5'4" for females.

HOW TO DISTINGUISH RACE *Obj. 13.5*

Determination of race from skeletal remains is often difficult because through years of intermarriages, physical traits have blended and this distinction is losing its significance. Race is probably best indicated by the bones of the skull and the femur. Characteristics of the skull that differ with race include the following:

- Shape of the eye sockets
- Absence or presence of a nasal spine
- Measurements of the nasal index (the ratio of the width of the nasal opening to the height of the opening, multiplied by 100)
- Prognathism (the projection of the upper jaw, or maxilla, beyond the lower jaw) (*continued on page 372*)

Differentiated Learning

Teaching Gifted Students

Ask students to research the average heights of males and females in different countries around the world. Then present their research to the class in a poster.

Differentiated Learning

Teaching At-Risk Students

Ask students to draw a sketch for an ideal gymnast, jockey, football, basketball or soccer player. Ask: Why are they different?

Figure 13-20. *Height estimation formula.*

Bone length for American Caucasian males.

Factor × bone length	**plus**	**Accuracy**
Height (cm) = 2.89 × humerus	+ 78.10 cm	± 4.57
Height (cm) = 3.79 × radius	+ 79.42 cm	± 4.66
Height (cm) = 3.76 × ulna	+ 75.55 cm	± 4.72
Height (cm) = 2.32 × femur	+ 65.53 cm	± 3.94
Height (cm) = 2.60 × fibula	+ 75.50 cm	± 3.86
Height (cm) = 1.82 × (humerus + radius)	+ 67.97 cm	± 4.31
Height (cm) = 1.78 × (humerus + ulna)	+ 66.98 cm	± 4.37
Height (cm) = 1.31 × (femur + fibula)	+ 63.05 cm	± 3.62

Bone length for American Caucasian females.

Factor × bone length	**plus**	**Accuracy**
Stature (cm) = 3.36 × humerus	+ 57.97 cm	± 4.45
Stature (cm) = 4.74 × radius	+ 54.93 cm	± 4.24
Stature (cm) = 4.27 × ulna	+ 57.76 cm	± 4.30
Stature (cm) = 2.47 × femur	+ 54.10 cm	± 3.72
Stature (cm) = 2.93 × fibula	+ 59.61 cm	± 3.57

Bone length for Caucasians, both sexes.

Factor × bone length	**plus**	**Accuracy**
Stature = 4.74 × humerus	+ 15.26 cm	± 4.94
Stature = 4.03 × radius	+ 69.96 cm	± 4.98
Stature = 4.65 × ulna	+ 47.96 cm	± 4.96
Stature = 3.10 × femur	+ 28.82 cm	± 3.85
Stature = 3.02 × tibia	+ 58.94 cm	± 4.11
Stature = 3.78 × fibula	+ 30.15 cm	± 4.06

Bone length for African-American and African males.

Factor × bone length	**plus**	**Accuracy**
Height (cm) = 2.88 × humerus	+ 75.48 cm	± 4.23
Height (cm) = 3.32 × radius	+ 85.43 cm	± 4.57
Height (cm) = 3.20 × ulna	+ 82.77 cm	± 4.74
Height (cm) = 2.10 × femur	+ 72.22 cm	± 3.91
Height (cm) = 2.34 × fibula	+ 80.07 cm	± 4.02
Height (cm) = 1.66 × (humerus + radius)	+ 73.08 cm	± 4.18
Height (cm) = 1.65 × (humerus + ulna)	+ 70.67 cm	± 4.23
Height (cm) = 1.20 × (femur + fibula)	+ 67.77 cm	± 3.63

Bone length for African-American and African females.

Factor × bone length	**plus**	**Accuracy**
Stature = 3.08 × humerus	+ 64.67 cm	± 4.25
Stature = 3.67 × radius	+ 71.79 cm	± 4.59a
Stature = 3.31 × ulna	+ 75.38 cm	± 4.83
Stature = 2.28 × femur	+ 59.76 cm	± 3.41
Stature = 2.49 × fibula	+ 70.90 cm	± 3.80

Bone length for All ethnic groups or, if ethnicity is unknown, both sexes.

Factor × bone length	**plus**	**Accuracy**
Stature = 4.62 × humerus	+ 19.00 cm	± 4.89
Stature = 3.78 × radius	+ 74.70 cm	± 5.01
Stature = 4.61 × ulna	+ 46.83 cm	± 4.97
Stature = 2.71 × femur	+ 45.86 cm	± 4.49
Stature = 3.01 × femur	+ 32.52 cm	± 3.96
Stature = 3.29 × tibia	+ 47.34 cm	± 4.15
Stature = 3.59 × fibula	+ 36.31 cm	± 4.10

Explore

Anthropologists can study the curvature of a femur and determine the race of an individual. The femur of a Caucasian curves enough to allow you to place your hand underneath the bone when it lies flat, but an African American femur bone does not.

Explore

Encourage interested students to research and report on the African Burial Ground, the site in New York where the remains of slaves were buried. They can go to the Web site www.africanburialground.gov/ABG_Main.htm.

Teaching Tip

Point out that because so many people are of mixed backgrounds and ethnicities, the word *race* is more of a societal term rather than a scientific one. In fact, there are more differences within a group of people of the same race than there are differences between people of different races. For this reason, anthropologists often have a difficult time estimating the race of an individual.

Teaching Tip

Try to obtain images of three to five skulls of different races to show students. There are many images available on the Internet.

Teaching Tip

Tell students that alternative formulas have been given for stature and femur length.

Digging Deeper

Some people believe if you measure the circumference of your head and multiply it by three, the result will be your height. Allow students to try this and record their results in a class data table. Discuss how closely the results were to their actual heights. For more information about calculating height from bones, go to the Gale Forensic Science eCollection at school.cengage.com/forensicscience.

Explore

Have interested students research and report on facial reconstructions for identification and crimes.

Explore

In the movie *Face/Off*, a reconstruction of one character's face is placed over another's. Show the class just the clip from this movie where the new face is being created. (Note: This is an R-rated movie and not appropriate for school; therefore, do not show the entire movie.)

Teaching Tip

Facial reconstruction modeling kits are available for Julius Cesar and Neanderthal Man from PegSculpture (The Natural History Museum).

Teaching Tip

Have students view an episode of the television series *Bones* showing facial reconstruction.

Digging Deeper
with Forensic Science e-Collection

Can the size of your head compared to your height determine if you are a thief? Can you determine a motive for crime by the size of the eye sockets? For more than a century, scientists have been measuring our bones to derive useful information from them. Compare and contrast the modern science of *anthropometry* and the traditional practice of *Bertillonage*. Search the Gale Forensic Science eCollection on school.cengage.com/forensicscience for the following article: K. Lerner and Brenda Lerner, eds. "Anthropometry," *World of Forensic Science,* Vol. 1. Detroit, MI: Gale, 2005; pp. 33–34. 2 vols.

- Width of the face
- Angulation of the jaw and face

Other racial comparative characteristics are listed in Figure 13-21.

Many other characteristics of a person can be determined by examining bones, such as whether the person was right- or left-handed; diet and nutritional diary, especially the lack of Vitamin D or calcium; diseases and genetic disorders, such as osteoporosis, arthritis, scoliosis, and osteogenesis imperfecta; previous fractures; type of work or sports based on bone structure; surgical implants, such as artificial joints (with code number stamped on them) and pins, and, in women, childbirth.

Figure 13-21. *Comparing the racial characteristics of bones.*

	Caucasoid	Negroid	Mongoloid
Shape of Eye Orbits	Rounded, somewhat square	Rectangular	Rounded, somewhat circular
Nasal Spine	Prominent spine	Very small spine	Somewhat prominent spine
Nasal Index	<.48	>.53	.48 – .53
Prognathism	Straight	Prognathic	Variable
Femur	Fingers fit under curvature of femur	Fingers will not fit under curvature of femur	Fingers will fit under curvature of femur

FACIAL RECONSTRUCTION

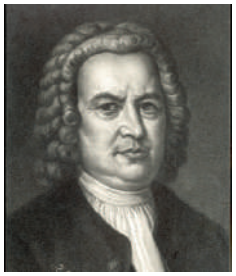
The exact size and shape of bones not only vary from person to person, but are also related to the overall shape and size of the muscles and tissues that lay on top of bones. Theoretically, it should be possible to rebuild a face from the skeleton up. The use of bones to reconstruct faces has been helpful in some crime investigations.

In 1895, Wilhelm His used the skull of Johann Sebastian Bach in an attempt to reconstruct his face in clay (Figure 13-22). His measurements of tissue depth taken from cadavers are the basis for the system of facial reconstruction used today. Victims of explosions or blunt force trauma often do not have enough bone structure in place to facilitate identification. Today, facial markers are positioned at critical locations on the face, and the clay is contoured to follow the height of the markers.

Reconstruction of the faces of famous historical figures has been attempted, including the reconstruction of King Tutankhamen (King Tut) (Figure 13-23). Notice the differences in the results.

The computer program Faces® (Interquest) performs a similar function today, allowing a facial manipulation and reconstruction in seconds. Investigators generate an image of the skull on a computer screen based on actual measurement and can manipulate the facial reconstruction. Features can be added, deleted, and easily modified. Nose and jaw length can be adjusted, as well as hairline, hairstyle, and the color of the skin and shape and size of the eyes.

Figure 13-22. *A painted portrait of the 18th-century composer, Johann Sebastian Bach.*



Differentiated Learning

Teaching Gifted Students

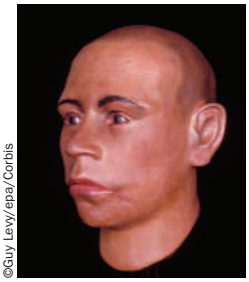
Ask students to conduct a survey of local and state law enforcement agencies to determine the methods they use for facial reconstruction.

Differentiated Learning

Teaching At-Risk Students

Go to the PBS Web site at www.pbs.org/wnet/secrets/lessons/index.html and view the lesson "Making Faces." In this lesson, students learn about the myth of the Amazon Warrior Women and can try facial reconstruction.

Figure 13-23. *American reconstruction (left) and Tutankhamen lotus image (right).*



The skull fragments of Josef Mengele, a Nazi officer who performed experiments on Jews during World War II, were reconstructed and identified by this process.

This technique, known as video-superimposition, can be used to match an existing photograph to someone's remains for the purpose of identification. The facial landmarks are measured and overlaid on a photograph of the skull for comparison.

These same techniques can be used to age missing persons and criminals who are still at large. Video cameras installed in banks and businesses can use this technology to apprehend criminals. Facial recognition systems may be used in the future to recognize terrorists and other criminals who attempt to superficially disguise their appearance.

DNA EVIDENCE

Obj. 13.6

DNA profiling usually uses nuclear DNA, which is found in the nucleus of white blood cells and other body tissues. Bone contains little nuclear DNA, but it does contain **mitochondrial DNA.** Mitochondria are organelles found in all cells that contain DNA inherited only from the mother. There is no genetic information in mitochondria from our fathers. Long after nuclear DNA had been lost through tissue degeneration, mitochondrial DNA can be extracted from bone and profiled. The results can then be compared with living relatives on the mother's side of the family to determine the identity of skeletal remains.

SKELETAL TRAUMA ANALYSIS

Obj. 13.3

Weathering and animals often damage bones that are exposed to the elements for long periods. Forensic anthropologists are trained to recognize these marks (Figure 13-24). A knife wound may leave parallel scoring on a rib, but mice and rodent chew marks can look very similar. **Skeletal trauma analysis** attempts to

Digging Deeper
with Forensic Science e-Collection

Some forensic scientists are experts on the condition of old bones. Others can easily see the difference between a blow from a hammer and one from a bullet by the scarring on a rib. Others can draw information from the soil and environment in which a body is buried to provide evidence for a crime. Discuss the three different subspecialties of forensic anthropology and crime scenes where these three skills would be required to solve the crime. Go to the Gale Forensic Science eCollection on school.cengage.com/forensicscience to find the following article: K. Lerner and Brenda Lerner, eds. "Skeletal Analysis," *World of Forensic Science*, Vol. 2. Detroit, MI: Gale, 2005; pp. 621–23. 2 vols.

Science
Biology

DNA can be extracted from skeletal remains. DNA is found inside a bone cell's nucleus and in the mitochondria in the cytoplasm of a bone cell.

Science
Biology

There is actually nuclear DNA in bone, especially if the bone is fresh. Scientists may still be able to extract nuclear DNA from marrow tissue in bones or pulp cavities in teeth, even if the victim has been dead for years. Nuclear DNA has been successfully extracted from Egyptian and Incan mummies that are thousands of years old, and from a frozen plant in Siberia that was 400,000 years old.

Explore

Since the advent of DNA extraction and analysis from bones and teeth, students may wonder if the assessment of skeletal remains is even necessary. Explain that despite the technological advances in molecular biology, the examination of a skeleton remains a vital part of the identification process. Examining the skeletal record allows relatively fast and accurate inferences about the victim's identity. Also, studying bones can quickly establish a biological profile to allow investigators to narrow their search, and may be used as collaboration in the forensic investigation to support DNA evidence.

Explore

After the World Trade Center attacks in 2001, victims were primarily identified using DNA profiling, which requires a reference sample of some type. A DNA analysis was performed either by taking a sample directly from a toothbrush or hairbrush of a victim or gathering DNA from a close relative and comparing the sample with DNA found at the scene. Nuclear DNA would have been used if personal effects were available to make an exact identification. Mitochondrial DNA would have been used if nuclear DNA was not available. Mitochondrial DNA identifies a similarity between a victim and a close maternal relative.

Digging Deeper

Ask students to compare and contrast the job of a forensic anthropologist with that of an archaeologist. For more about forensic anthropology, go to the Gale Forensic Science eCollection at school.cengage.com/forensicscience.

Teaching Tip

Explain to students that mitochondrial DNA can never be inherited from the father, because mitochondria in human sperm are destroyed when the egg and sperm unite. Note, however, that some sources dispute this, saying the sperm's mitochondrial DNA is present up to about the eight-cell stage of embryo development and then appears to dissolve, but the mechanism is not yet known.

Teaching Tip

Find images of bones with weapon trauma and show them to the class. Encourage interested students to read *Human Skeletal Remains, Excavation, Analysis and Interpretation* by Ubelaker, or search the Internet for information.

Explore

Dead Men's Tales is a series presented on PBS. In the episode "A Texan Tall Tale," forensic scientists examine the tale of Wild Bill Longley. Go to www.pbs.org to get a copy of this episode and show it to your class.

Evaluate

Ask students how various marks on the bones might help police solve crimes. Have interested students research examining knife marks on bones to solve a crime.

Teaching Tip

Attacks leaving knife marks are described in Chapter 5 of *Dead Men Do Tell Tales*.

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Figure 13-24. *Forensic anthropologists are often required to determine if damage to bones occurred before or after death.*

make distinctions between the patterns caused by weapons and the damage and wear caused by the environment after death to decipher what happened to a body before and after death.

Generally, forensic anthropologists try to determine the weapon that caused death. Sharp-force and blunt-force trauma, gunshots, and knife wounds all have distinctive patterns. For blunt-force and sharp-force trauma, there is a difference in the shatter pattern and the amount of impact damage to the bone. Blunt objects generally have more cracks radiating from the site of impact, as well as causing more damage to the surface of the bone.

The strength of bone decreases as it ages and dries out. Living bone is actually quite flexible when compared to dry and brittle bones, and therefore they break in different ways. Living bones will usually shatter in a spiral pattern parallel to the length; old bones often break perpendicular to the length.

SUMMARY

- Bones are alive and carry on all life functions. Living cells replace the cartilage of our skeleton at birth by depositing calcium phosphate, creating a hard, compact material. This process is called ossification.
- The condition of bones can tell an investigator about a person's health and nutrition during life.
- Male and female skeletons differ in many ways, including roughness and thickness of bones, size and shape of frontal bone in the skull and the shape of the eye cavity, the angle of the pelvis, and the presence or absence of childbirth scars.
- The age of a person at death can be estimated by the number of bones, the sutures that mark bone joints, and the presence and location of cartilaginous lines.
- The height of a person can be estimated by the length of the long bones in the arms and legs. (Estimates are most accurate when the sex and race of the skeleton is known.)
- Facial reconstruction is possible using the physical measurements of the skull. Forensic investigators can match a skull's size and shape to a photograph of a person's head to make a positive identification.
- Mitochondrial DNA can be extracted from bone and used to help identify skeletal remains by comparing to maternal DNA.
- Skeletal trauma analysis examines the bones for evidence of damage. This damage may provide clues to injuries sustained when the person was alive or damage to bones after death.
- X-rays are a critical tool during an autopsy to reveal skeletal features, number of bones, conditions or bones, previous fractures, implants, disease, and disorders of the bone.

Differentiated Learning

Teaching Gifted Students

Ask students to create a PowerPoint presentation on one of the following notable forensic anthropologists: Mildred Trotter, T. Dale Stewart, William Maples, Sue Black, Jane Buikstra, Emily Craig, Michael Finnegan, Lee and Richard Jantz, Jerry Melbye, or Douglas Ubelaker.

CASE STUDIES

Alfred Packer (1874)

After serving as a soldier in the Civil War, Alfred Packer worked as a guide and prospector in Colorado. During the winter of 1874, he and five other prospectors went into the mountains and disappeared. In April, Packer returned with a horrifying tale. The six men had been forced by cold, starvation, and sickness to resort to cannibalism, and only Alfred survived. He was accused of murder, but he professed innocence, saying he had acted in self-defense when he killed the last of the five prospectors. When their bodies were found two weeks later, significant amounts of flesh had been removed from them, and one body was headless.

Packer (known as the Colorado Cannibal) escaped from custody, but was recaptured nine years later, tried, and found guilty of murder. The remains of the five prospectors allegedly killed by Packer were exhumed in 1989 and re-examined. The bones showed distinctive marks of filleting, with defensive wounds on the arms and head trauma. Four of the victims had been bludgeoned to death, three with a hatchet-like implement and the fourth with perhaps a rifle butt. Distinctive scraping marks to the bone implied each body had been carefully stripped of flesh. The question of Packer's guilt still remains.

Elmer McCurdy (1911)

Train robber Elmer McCurdy was cornered in a hayloft and killed by gunshot. His body was embalmed with arsenic by the undertaker but remained unclaimed. The undertaker put Elmer on display, charging five cents to view the "Bandit Who Wouldn't Give Up." Several years later, his body was claimed by someone claiming to be his brother, and taken to California, where it was coated in wax and displayed in several circuses and amusement parks, and then forgotten.

Recently, during the filming of a TV show at the Nu-Pike Amusement Park, someone tried to move what they thought was a dummy and accidentally pulled off his mummified arm. The body was well preserved, yet no medical or dental records existed to give the body a name. Forensic anthropologists measured his facial dimensions, the lengths of his arms and legs, and the symphysis of his pubic bone. These details provided identification evidence for the state to put Elmer McCurdy to rest, once again.

The Romanovs (1918)

On July 16, 1918, the last royal family of Russia—Tsar Nicholas II, his wife Alexandra, four daughters, one son, and their servants—died at the hands of a firing squad (Figure 13-25). Bolshevik Jacob Yurosky, who commanded the death squad, boasted that the world would never know what had happened to the royal family.

That was true for the next 75 years, until a team of specialists including Michael Baden, William Maples, and forensic odontologist Lowell Levine examined the skeletons discovered in a shallow grave outside of Ekaterinburg, Russia (Figure 13-26). The team was able to determine the age and sex of all nine skeletons. Five were identified as females and four as males. The skulls had all been crushed, making identification difficult.

Evaluate

Ask students to read the Case Study of Alfred Packer. Then ask them these questions: What does cannibalism mean? If Packer was telling the truth (that he acted in self-defense and was forced into cannibalism), should he be tried for murder, or was he just doing what he needed to do to survive? You might want to relate this to the book *Alive*, the true story of the survival of the Uruguayan rugby team after their plane crash in the Andes Mountains. They were forced to resort to cannibalism of dead bodies in order to survive. This was also made into a movie by the same name in 1993.

Explore

Explain that bodies are embalmed to delay decomposition. In the past, arsenic was used as an embalming fluid, but arsenic is poisonous. There have been cases of arsenic poisoning caused by arsenic from cemeteries being released into groundwater and contaminating the nearby drinking water. Embalming fluid used today is typically a mixture of formaldehyde, methanol, ethanol, and other solvents.

Teaching Tip

Discuss with students the importance of X-rays in uncovering evidence in bone remains.

Teaching Tip

Have students reread the case study about the Romanovs before performing Activity 13-3. Refer them to books, the Nova program, or movies, as well as articles about the "mystery of the Romanovs."

Close

Organize students into three groups and assign each group one of the following: skull, pelvis, and long bones. Have the group describe what information about a person can be detected from the bones and how it is done.

The bones and teeth helped. One female had poor dental work and calcification of knee joints, indicating a person who had spent time scrubbing floors and doing manual labor. One male skeleton was mature, probably the remains of the royal family physician, Dr. Botkin. The recovered dental plate and skull similarities to a photograph provided evidence to the doctor's identity. Expensive dental repairs and dental records identified the rest of the royal party. Because some of the leg bones were crushed, height estimations were calculated using arm length. The remains of Anastasia and Alexei, who were 17 and 14, respectively, were not found.

Figure 13-25. *The last royal family of Russia.*

Figure 13-26. *Location of bones from the mass grave of the Romanovs.*

Think Critically **Select one of the Case Studies and explain what forensic anthropology techniques were used for identification.**

Differentiated Learning

Teaching Gifted Students

Fragments of bones can be aged from microscopic examination. Research this topic in *Bones*, by Dr. Douglas Ubelaker and Henry Scammell.

CAREERS IN FORENSICS

Clyde Snow: The Bone Digger

"The bones don't lie and they don't forget. And they're hard to cross-examine." So says Clyde Snow, one of the world's leading forensic anthropologists, as he explains why it is so important to present the evidence of skeletal remains in court.

©AP Photo/Victor Ruiz C

Clyde Snow

Clyde has studied thousands of skeletons all over the world, revealing their secrets. Over the last two decades, Clyde has been heavily involved in international human rights. He served on the United Nations Human Rights Commission, working in Argentina, Guatemala, the Philippines, Ethiopia, Bosnia, and Iraq. Closer to home, he's worked on several important cases, including those of mass murderers John Wayne Gacy and Jeffrey Dahmer, as well as the victims of the 1995 Oklahoma City bombing. He also participated in some historic investigations, searching for the remains of Butch Cassidy and the Sundance Kid in Bolivia, digging up the bones at the site of Custer's Last Stand, and examining King Tut's mummy.

Clyde Snow's accomplishments are great—much greater than his early experiences in school might have suggested. Born in 1928 in Texas, Clyde was expelled from high school and transferred to a military school, where his grades dropped. When he finally made his way to college, Clyde flunked out on his first attempt, but then went on to achieve a Ph.D. in anthropology. He began his career working for the Civil Aeromedical Institute examining the bodies of victims of air crashes. It wasn't until 1979 that he decided to focus entirely on forensics.

Only a few years later, Clyde found himself on a plane to Argentina to see if it was possible to investigate—and ultimately hold accountable—those responsible for the genocide committed by the previous Argentinean government. It is believed the Junta militia killed tens of thousands of civilians. Mass killings on a similar scale have been investigated by Snow in Guatemala and Iraq. In 2006, Snow testified against Saddam Hussein in the trial involving the mass murder of Kurdish people. Snow has dug up the remains of victims all over the world, many who were killed by their own or a neighboring government.

Why does he do it? He's forthright about his reasons. One is to identify the remains of victims and return them to their families. Another is to try to bring about some justice. A third is to let the governing people worldwide who have power over others know that they cannot kill their citizens without anyone trying to do something about it. His final reason is to provide a historical record. It is pretty emotional work. Clyde tells his students to "do the work in the daytime and cry at night."

Learn More About It
To learn more about careers in forensic anthropology, go to school.cengage.com/forensicscience.

CAREERS

Lead students in a discussion of whether they would feel comfortable having a job like Dr. Snow's.

Chapter 13 Review

True or False

1. True
2. True
3. False (Tell students to ignore the word "greater.")
4. True
5. True
6. True
7. False
8. True
9. False
10. True

Short Answer

11. Sample answer: Features found on a female skeleton, age 40, would include, but not be limited to: lambdoidal suture closed, coronal suture open, sagittal suture closed, but perhaps not fully; hips have a subpubic angle greater than 90 degrees, and scarring would be present on the pelvis if she had a child; skull would be smooth; overall skeletal appearance would be smooth.
12. Sample answer: Bones originate from living cells called osteoblasts. Osteoblasts migrate to the centers of cartilage production and deposit minerals such as calcium phosphate that harden to form bone. This process is called ossification. Throughout our lives, bone is broken down, deposited, and replaced. When an arm or leg is broken, the blood vessels at the area have the ability to increase calcium phosphate deposition and help heal the break. Newly trapped osteoblasts, called osteocytes, form the new bone framework. Therefore, as bones grow, the osteoclasts secrete enzymes that help dissolve areas of bone.

CHAPTER 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17

CHAPTER 13 REVIEW

True or False

1. Osteoblasts are bone-building cells. *Obj. 13.1*
2. Bones can help us determine the age, sex, and health of a person. *Obj. 13.2, 13.3, and 13.4*
3. Female hips have a subpubic angle less greater than 90 degrees. *Obj. 13.2*
4. Male skulls tend to have a lower, more sloping frontal bone than female skulls. *Obj. 13.2*
5. It is possible to estimate someone's height based on the length of a humerus. *Obj. 13.4*
6. Approximate age can be determined by studying the suture lines of the skull. *Obj. 13.4*
7. A woman's skull is usually bumpy compared to a man's skull. *Obj. 13.2*
8. A man's jawline usually forms a 90-degree angle. *Obj. 13.2*
9. If a person were right-handed, then his or her skeleton on the left side would be slightly larger than the skeleton on the right side. *Obj. 13.1*
10. Mitochondrial DNA contains no genetic information from the father. *Obj. 13.6*

Short Answer

11. Describe the features you would expect to find in a female skeleton, age 40. *Obj. 13.2 and 13.4*

_____

_____

12. Describe the process of ossification of the skull using each of the following terms: *Obj. 13.1*

a. Cartilage

_____

b. Blood vessels

_____

c. Osteoblasts

_____

d. Osteocytes

_____

e. Osteoclasts

_____

f. Enzymes

_____

g. Calcium

_____

h. Phosphates

_____

13. Calculate the approximate height of a Causasian male if one of the following bones is found: *Obj. 13.2*

a. radius bone equal to 25 cm

_____

b. humerus bone equal to 30 cm

_____

c. ulna bone equal to 21 cm

_____

14. Suppose that the two bones found belonging to the male in questions 13b and 13c were his ulna, which is 21 cm long, as well as his humerus, which is 30 cm. Calculate his height using both the ulna and the humerus bone measurements. Show your work. *Obj. 13.2*

_____

_____

15. Refer to your answers for questions 13b and 13c and 14. Explain which value for height should be more accurate (the two separate values or the combined values). *Obj. 13.2*

_____

_____

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Books and Journals

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Lerner, K., and Brenda Lerner, eds. *World of Forensic Science*, Volume 1. Detroit: Gale, 2005; 33–34.

Maples, W., and M. Browning. *Dead Men Do Tell Tales*, Main Street Books, 1995.

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Web sites

Gale Forensic Sciences eCollection,school.cengage.com/forensicscience.

American Society of Bone and Miner al Reconstruction, http://depts.washington.edu/bonebio/ASBMRed/ASBMRed.html.

http://www.dnai.org

13. a. (3.79 × 25 cm) + 79.42 cm = 174.17 cm

    b. (2.89 × 30 cm) + 78.10 cm = 164.8 cm

    c. (3.76 × 21 cm) + 75.55 cm = 154.51 cm

14. (1.78 × (30 cm + 21 cm) + 66.98 cm = 157.76 cm

15. Using two bones from the same body should provide a closer estimation to actual height.

ACTIVITY 13-1

Background

In this activity, students work in groups of two to study the cranial suture marks to estimate the age of a skull.

Teaching Tip

Models of infant "skulls" can be purchased from Wards or other scientific supply companies. If models are unavailable, use photos from the Internet.

Safety Precautions

There are no safety precautions for this activity.

Procedures

A week or two before you plan to perform this activity, ask your school librarian to set aside some reference books for you to have available in your classroom on the day of the activity.

Answers

Part A

1. Approximately 32 to 49 years.
2. Approximately 26 to 30 years.
3. Approximately 50 or more years.
4. Less than 21 years.

Part B

1. Sample answer: Comparison of infant and adult skulls should include:

   Similarities: composed of the same types of growing tissues using calcium phosphate to build bone.

   Differences: the growth rate is greater in infants, who have more cartilage and more nonfused bones. The infant's head is one-third to one-half its body length, where the adult human head is approximately one-eighth of the body's length.
2. Sample answer: Specific features of the baby's head apparent in photographs can be compared to the recovered skull.

ACTIVITY 13-1 *Ch. Obj. 13.4*

DETERMINING THE AGE OF A SKULL

Objectives:

By the end of this activity, you will be able to:
Estimate the age of a skull by studying the cranial suture marks.

Safety Precautions:

None

Time Required to Complete Activity:

15 minutes (groups of two students)

Materials:

textbook (Figure 13-17)
access to the Internet or reference books

Procedure:

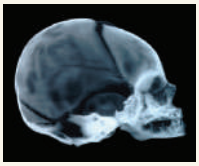
Part A:
Using Figure 13-17 in your textbook showing the relationship between age and skull sutures, determine the approximate age of a skull with the following features:

1. Lambdoidal and sagittal sutures fused. Age _____
   Coronal sutures not fused.
2. Lambdoidal sutures almost fused. Age _____
   Sagittal and coronal sutures not fused.
3. All sutures fused. Age _____
4. Lambdoidal wide open. Age _____
   Sagittal and coronal sutures open.

Part B:

1. Research and then compare the infant to the adult skull with respect to:
   a. similarities
   b. differences in numbers of bones, composition
   c. percentage of body length
2. Describe the process of ossification of the skull using each of the following terms:
   Cartilage
   Blood vessels
   Osteoblasts
   Osteocytes
   Osteoclasts
   Enzymes
   Calcium
   Phosphates

An infant's cranium



An adult's cranium

Teaching Tip

Remind students that the sagittal suture runs along the top of the skull from the coronal suture to the lamboidal suture (not pictured in text). The sagittal suture closes by age 32. The lambdoidal suture starts to close by age 21, accelerates by age 26, and closes by about age 30. The coronal suture closes around age 50.

ACTIVITY 13-2 *Ch. Obj. 13.2*

BONES: MALE OR FEMALE?

Objectives:

By the end of this activity, you will be able to:
Determine if the remains of a skeleton belong to a male or female

Safety Precautions:

None

Time Required to Complete Activity:

15 minutes (groups of two students)

Materials:

textbook figures throughout the chapter
pencil or pen

Procedure:

Refer to the figures in Chapter 13 of your textbook to help you determine if the skeletal remains listed below belong to a male or female skeleton. Complete the following questions:

Case # 1 _____
Round eye orbits, subpubic angle of 103 degrees, rectangular-shaped pubis, smooth skull. Explain your answer.

Case # 2 _____
Pelvis narrow, protuberance on occipital bone, sloping forehead. Explain your answer.

Case # 3 _____
The skull was found to be smooth with small brow ridges; would you expect to find a subpubic angle larger or smaller than 90 degrees? Explain your answer.

Case # 4 _____
A long, narrow sacrum with triangular pubis; would you expect to find the subpubic angle larger or smaller than 90 degrees? Explain your answer.

Further Research

A smooth (gracile) skull of a female appears quite different from the bumpy (robust) appearance of the male skull. What causes the male skull to be thicker with more dense bone? Research the effect on bones of each of the following:

a. XX or XY chromosomes
b. Production of higher levels of testosterone in males
c. Effect of larger muscle mass on bones

After researching these factors, form a hypothesis to account for the differences in the adult male and female skulls.

ACTIVITY 13-2

Background

In this activity, students work in groups of two to determine if the remains of a skeleton belong to a male or female.

Safety Precautions

There are no safety precautions for this activity.

Procedures

1. If possible, try joining with other teachers (e.g., anatomy/physiology, sports medicine) in your school to purchase bones as a group.
2. Good sources for purchasing bones include Bone Clones, Skulls Unlimited, and Wards Biological.
3. Make sure students read all directions *before* beginning the activity.

Answers

Case 1: Female; These characteristics imply a female.
Case 2: Male; These characteristics imply a male.
Case 3: 90 degrees or larger; Smaller brow ridges imply a female.
Case 4: Smaller than 90 degrees; Narrow sacrum and triangular pubis imply a male.

Further Research and Extensions

Ask students to create their own case scenarios describing a skull that was found. Then have them switch scenarios with other students and identify the skull as male or female.

ACTIVITY 13-3

Background

In this activity, students use the Internet to examine how the Romanovs were identified using their remains, what the remains revealed about how the family was killed, and how DNA technology can be used in these types of cases.

Safety Precautions

There are no safety precautions for this activity.

Procedures

1. Before planning this activity, go to the Web site www.dnai.org/.
2. Remind students that this determination after death is called taphonomy.
3. Make sure students read all directions before beginning the activity.
4. Explain to students that the number of the questions pertains to the number of that slide. For example, Question 4 pertains to slide number 4.
5. Make sure students understand that they are to only visit the Web sites listed in this activity.

Answers

Part A

1. Empress Maria
2. Germany
3. a. 4; b. 1; c. Alexi and Anastasia
4. a. Hemophilia; b. Uncontrolled bleeding; c. His mother Alexandria.

ACTIVITY 13-3 *Ch. Obj. 13.2, 13.4, 13.5, and 13.6*

THE ROMANOVS AND DNA: AN INTERNET ACTIVITY

Objectives:

By the end of this activity, you will be able to:

1. Examine how the Romanov family was identified from their remains.
2. Describe what the remains revealed about the family's fate.
3. Describe how DNA technology was used to help identify the skeletal remains of the Romanov family.

Safety Precautions:

None

Time Required to Complete Activity:

Part A: 40 minutes
Part B: 60 minutes

Materials:

access to the Internet
pen and paper

Part A: Romanov Family

Procedure:

1. Open the Internet and type in the Internet site: http://www.dnai.org/
2. Refer to the title: DNA Interactive.
3. Refer to the menu bar at the far left of the page and double-click on the fifth heading: Applications.
4. Use the scroll bar to the right to pull the screen down. At the bottom of the screen, double-click on the second module entitled "Recovering the Romanovs."
5. Move the scroll bar up to the top of the screen to double-click on the Romanov family.
6. Move the scroll bar down to the bottom of the screen. You will see 10 circles. Click on each numbered circle and answer the questions as you progress through the material. Note the number of the circle corresponds to the numbered questions below.

Questions:

1. Refer to the pedigree of Tsar Nicholas II. What was his mother's name?
2. Alexandria was born in what country?
3. Refer to the pedigree of Tsar Nicholas II's family.
   a. How many daughters did he have?
   b. How many sons did he have?
   c. Who were the two youngest children?
4. Prince Alexei suffered from blood disorder.

a. What is the name of the blood disorder?
b. What are the symptoms of this disorder?
c. From whom did Alexei inherit this genetic disorder?

5. What other family members of Alexandra also suffered from this disorder?
6. View the four movie clips of the Tsar's family.
7. In what year did Nicholas II abdicate his throne?
8. During World War I, the leadership of Russia changed.
   a. Who became the leader?
   b. What was the political party?
   c. What was the reason for the overthrow of the government?
9. a. What was the significance of the Ipatiev House?
   b. What happened there in 1918?
10. In addition to the Tsar's family, who else was executed?
    a. What was inserted into the corsets of the women that prevented some of the bullets from entering their bodies?

Part B: DNA Science Solves a Mystery

Procedure:

Go to: http://www.dnai.org

1. Applications (left side of screen)
2. Recovering the Romanovs (bottom of screen)
3. Science Solves a Mystery (top of the screen)

Questions:

1. In 1991, where was the supposed burial site of the Tsar and his family?
2. Listen to the 2 video clips narrated by Dr. Michael Baden.
   a. Why was an American team called in to help identify the bodies?
   b. Review the video Remains in Yekaterinburg.
      What type of information can be gained by a study of the following?
      1. Ridges and thick muscular insertions
      2. Orbits of the eye and mandible and maxilla of the jaw
      3. Pelvic girdle measurements
      4. Ridges in the pubic bone
      5. Leg and arm bones
3. Click on the box: Count the Skeletons.
   a. How many skeletons were recovered?
   b. How many people died in the massacre?
4. What can be determined by examination of:
   a. Wisdom teeth
   b. Vertebrae
   c. Pelvic regions
5. Click on the box Analyzing the Skeletons.
   Follow the directions to determine the age and sex of each of the skeletal remains.
6. What 2 people were determined to be missing from the gravesite?
   a. How was this determined?
7. The bodies were buried for over 75 years. What type of evidence was preserved that enabled scientists to determine who was buried in the grave?
8. a. Click on Nuclear DNA box.
      Click on the next button in the upper right-hand corner.

5. Alexandra's brother Frederick and two nephews.
7. 1917
8. a. Lenin; b. The Bolsheviks; c. Political unrest
9. a. It was the prison and site of execution for the Romanov family.
   b. The Romanov family was executed.
10. a. A doctor, a nurse, and two servants.
    b. Jewels

Part B

1. Yekaterinburg, Siberia
2. a. Russian experts were undecided.
   b. 1. Whether the body is of a male or a female.
   2. Whether the body is of a male or a female.
   3. Whether the body is of a male or a female.
   4. The age and child-bearing activity.
   5. Handedness.
3. a. 9; b. 11
4. a. Age; b. Age; c. Sex
6. a. Anastasia and Alexi; b. The age of the remains did not match them.
7. Mitochondrial DNA

9. a. They are both inherited
   b. Mitochondrial DNA comes only from the mother.
10. Mother
11. a. Their mother; b. From her mother; c. No; d. He and his wife had different mothers.
12. Queen Victoria
14. An adult nurse
15. He was a maternal relative of Nicholas II.
16. The skeleton of Nicholas II.
17. Two adult male servants
18. To determine if she was Anastasia
19. He was a maternal relative of Franziska (Anna Anderson).
21. a. From a previous surgery;
    b. No, not based on the scientific evidence previously stated; c. Their bodies were burned after the execution.

8. b. Click on the Mitochondrial DNA (mDNA).
   Click on the next button located in the upper right-hand corner.
9. Compare and contrast mitochondrial DNA (mDNA) with nuclear DNA.
   a. Compare (How are they alike?)
   b. Contrast (How are they different?)
10. From whom do we inherit our entire mitochondrial mDNA?
    Click on maternal inheritance.
11. Test yourself on Mitochondrial DNA:
    a. From whom did the Romanov children inherit their mDNA?
    b. Where did that person get his or her mDNA?
    c. Does Nicholas II have the same mDNA as his children?
    Explain your answer.
12. Double click on Tsarina's Pedigrees located in the lower right-hand corner. Find Nicholas II and Alexandria in the Pedigree chart.
    a. All mitochondrial DNA of the Tsar's children can be traced back to whom?
    b. According to this pedigree, who is the relative still alive today to have the same mDNA as the Romanov children?
13. Go to Bioserver Sequence Server.
    Recall that differences in the mDNA sequence is highlighted in yellow. You will need to close out of this window by clicking on the X in the upper right hand corner.
14. Whose skeleton was #9?
15. Why was James, Duke of Fife, selected to have his DNA examined?
16. Go to Bioserver's sequence server.
    Which of the male skeleton's matched with the mDNA of James, Duke of Fife?
    (You will need to close out of this box by clicking on the X in the upper right hand corner.)
17. It is believed the identity of the other male skeletons were:
18. Why was Anna Anderson's mDNA being compared to the mDNA of Prince Philip?
19. Why was Carl Maucher's mDNA being examined?
20. Double click on the Hair sample video.
21. Listen to the two videos by Michael Baden and Syd Mandelbaum.
    a. If Anna Anderson was cremated, then how did they obtain a sample of her cells?
    b. Based on Michael Baden's and Syd Mandelbaum's findings, were Anna Anderson and Anastasia, the daughter of the royal family, the same person? Explain your answer.
    c. What is believed to have happened to the bodies of the two youngest children, Anastasia and Alexei?

Further Research and Extensions

This is a good place to revisit Bertillon and anthropometry. Ask students what happens to these formulae when the individual is known or thought to be of a mixed racial heritage.

ACTIVITY 13-4 *Ch. Obj. 13.1*

ESTIMATION OF BODY SIZE FROM INDIVIDUAL BONES

Objectives:

By the end of this activity, you will be able to:

1. Determine the approximate height of a person from one of the long bones of the body.
2. Explain how it is possible to estimate someone's height from a single bone.

Safety Precautions:

None

Time Required to Complete Activity: 40 minutes

Materials:

textbook Figure 13-20
pencil or pen
calculator (optional)

Procedure:

1. Refer to the bone length tables in your textbook (Figure 13-20).
2. For each problem, locate the appropriate formula to calculate a person's height based on the size of the recovered bone.

Questions:

Calculate the approximate height of the person if a humerus bone was found in each of the following situations. Show your work.

a. Caucasian male femur of 50.6 cm
b. African-American female femur of 49.5 cm
c. A Caucasian person, sex unknown, tibia of 34.2 cm
d. Caucasian female humerus of 33.4 cm
e. African-American male humerus of 41.1 cm
f. Person of unknown sex or ethnic group, humerus of 31.6 cm

Further Research and Extensions

To extend the length of this activity, ask students to measure the length of their own humerus and femur and see if those measurements accurately predict their own height. Have students measure their heights in centimeters, then work these formulae backwards to estimate their bone lengths. You can hold a 30 cm ruler or a meter stick next to your arm or leg and see how close the calculation is.

ACTIVITY 13-4

Background

In this activity, students determine the approximate height of a person from a femur.

Safety Precautions

There are no safety precautions for this activity.

Procedures

1. This activity should not take the entire 40 minutes if your plan is to just have students calculate the results. If possible, try to obtain different samples of humerus and femur bones and have students make calculations on bones that have slightly different lengths.
2. Make sure students read all directions before beginning the activity.

Answers

Check students' calculations.

a. Stature in cm = (2.32 × 50.6 cm) + 65.53 cm = 182.92 cm
b. Stature in cm = (2.28 × 49.5 cm) + 59.76 cm = 172.62 cm
c. Stature in cm = (34.2 × 3.02 cm) + 58.94 cm = 162.22 cm
d. Stature in cm = (3.36 × 33.4 cm) + 57.97 cm = 170.19 cm
e. Stature in cm = (2.88 × 41.1 cm) + 75.48 cm = 193.85 cm
f. Stature in cm = (4.62 × 31.6 cm) + 19.00 cm = 164.99 cm

ACTIVITY 13-5

Background

In this activity, students apply their knowledge of bone and teeth analysis to case studies to help provide characteristics that would help lead to the identity of a person.

Safety Precautions

There are no safety precautions for this activity.

Procedures

1. Print, copy, and distribute the reference tables from the IRCD.
2. Make sure students read all directions *before* beginning the activity.

Answers

1. a. Age approximately 30; b. Male; c. Male
2. a. Female; b. Approximately 18+ years old; c. Came from a young person
3. a. Slight build; b. Age 50+ may indicate calcium loss; c. Stature = (47 cm (3.01) + 32.52 cm = 173.99 cm
4. a. Female; b. Male; c. Person 1; d. Person 1; e. Person 2; f. Person 2; g. Person 3; h. Male; i. 3; j. Based on the number of femurs found; k. The person was overweight or had been used to lifting heavy materials; m. An athletic build

ACTIVITY 13-5 *Ch. Obj. 13.2, 13.3, 13.4, and 13.5*

WHAT THE BONES TELL US

Objectives:

By the end of this activity, you will be able to:
Apply knowledge of bone and teeth analysis to several case studies in an effort to describe the person based upon bone and teeth examination.

Safety Precautions:

None

Time Required to Complete Activity: 40 minutes

Materials:

textbook
pen and paper

Procedure:

Using all of the information in your textbook, describe as much as you can about a person from their bones and teeth, as described in the following case studies.

Questions:

1. A skull has been found: What can you tell about the skull described below?
   a. Lambdoidal suture nearly closed
   b. Large brow ridge
   c. Large supraorbital ridge
2. Only the jaw has been found: What can you tell about the jaw from this information only?
   a. Angle = 100 degrees
   b. Wisdom teeth have emerged
   c. No fillings or bridgework
3. Femur only: What can you tell about the femur from this description?
   a. Thin
   b. Osteoporosis present
   c. Length of femur = 47 cm
4. A mass grave is found: What can you tell about the remains?
   a. Jaw angle = 105 degrees
   b. Subpubic angle = 80 degrees
   c. Left femur = 49 cm
   d. Right femur = 49.1 cm
   e. Left femur = 45.5 cm
   f. Right femur = 45.3 cm
   g. Left femur = 48 cm
   h. Skull: one partial skull found with rectangular orbits (eye sockets)
   i. How many individuals (minimum) are buried at this one site?

j. How did you determine this number?
k. Two of the femurs, one right and one left, had thick bones. What can you infer from this about this person? Explain your answer.
l. Two femurs showed very large attachment sites for tendons. What clue might this provide about the owner? Explain your answer.

5. A female was reported missing in the area. The family of the missing woman was wealthy, and their slightly built, missing daughter never did any strenuous work but did bear three children. How could you verify if the woman buried in the gravesite:
   a. had three children
   b. did not engage in much manual labor
   c. was over the age of 21
   d. was slightly built
   e. was from a wealthy family

5. a. Look at female pelvis, dorsal side of pubic symphysis for pregnancy scarring.
   b. A thinner build lacking bone density and smaller joint attachments would indicate a smaller, less active female.

Further Research and Extensions

Have students learn all of the bones of the body. Give them a quiz on this information for extra-credit points or regular lab points.

ACTIVITY 13-6

Background

In this activity, students apply their knowledge of bone and teeth analysis as well as information regarding time of death to specific case studies.

Safety Precautions

There are no safety precautions for this activity.

Procedures

1. Make sure students read all directions *before* beginning the activity.
2. For Case 3, you will need to discuss in advance the possible tests that can be performed if a drug overdose is suspected. Students will have a difficult time coming up with this answer (e.g., blood, liver, or urine) if not discussed ahead of time.

Answers

Case 1

1. Less than 18 years old
2. Male
3. Approximately 181 cm
4. Trauma to skull

Case 2

1. Less than 21
2. Female
3. Approximately 159 cm
4. Strangulation

ACTIVITY 13-6 *Ch. Obj. 13.2, 13.3, 13.4, and 13.5*

MEDICAL EXAMINER'S FINDINGS

Objectives:

By the end of this activity, you will be able to:

1. Apply knowledge of bone analysis to describe an individual from skeletal remains in several case studies.
2. Apply knowledge of lividity, rigor mortis, and algor mortis to estimate time of death
3. Apply knowledge of insect development to estimate time of death
4. Apply knowledge of digestion to estimate time of death

Safety Precautions:

None

Time Required to Complete Activity: 40 minutes

Materials:

textbook (Chapters 11 and 13)
pen and paper

Procedure:

As the medical examiner, you have collected information from the crime scene investigator as well as from autopsies. You need to provide information regarding the deceased person, his or her death, and the time of death to the police. Using your textbook for a reference answer the police's questions as completely as possible.

Questions:

Case 1: Bones found still partially clothed at bottom of a ravine.

a. Subpubic angle = 87 degrees
b. Length of femur = 50 cm
c. Many fillings in teeth, no wisdom teeth
d. Skull shows fracture marks

Based on the information available, determine the:

1. Age of the individual
2. Sex of the individual
3. Height of the individual
4. Possible cause of death

Case 2: A body was found in a wooded area. There was bruising on the neck, defensive wounds on the arms and hands, and a broken finger.

a. Subpubic angle = 106 degrees
b. Length of tibia = 34 cm
c. No fillings in teeth
d. Suture lines of skull have not begun to close

Based on the information available, determine the:

1. Age of the individual. Explain your answer.
2. Sex of the individual. Explain your answer.
3. Height of the individual. Explain your answer.
4. Possible cause of death

Estimate the time of death for each of the following. Refer to your notes on time of death from Chapter 11.

Case 3: Body found in apartment house bedroom at 9 a.m. on Monday.

a. Male, overweight, found dead on bed. No evidence of foul play.
b. Body temperature = 93°F (64°C)
c. Room temperature = 83°F (58°C)
d. Lividity showed no movement of body after death
e. Rigor had begun

Based on the information available, can you determine the:

1. Time of death
2. What factors led to the determination of the time of death?
3. Possible cause of death
4. What tests could have been done if a drug overdose was suspected?

Case 4: Body found in dumpster at noon on Tuesday. Dumpster had been emptied on Monday.

a. Permanent lividity was found along abdomen, chest, and front of the legs.
b. Body temperature found to be 80°F (27°C), with the average ambient temperature being 70°F (22°C) for the past three days.
c. Stomach was empty, but food was found in small intestine.
d. Rigor present throughout body.
e. Lungs filled with fresh water.

1. What is your estimated time of death?
2. Explain how you determined the time of death from the data provided.
3. Can you provide a cause of death? Explain.
4. Can you state a mechanism of death? Why or why not?
5. Can you provide the manner of death? Why or why not?
6. What other tests should be performed during the autopsy to provide more information to help identify this person?

Case 5: Woman found dead lying on her back on kitchen floor at 4 p.m. on Thursday.

a. No blood loss. No signs of struggle.
b. No lividity visible. Flies and eggs found on the body.
c. Stomach contents show some undigested food, with some digested food in small intestine.
d. Body temperature: 97°F; ambient temperature: 87°F

Provide as much information as possible from the above information regarding the death of this woman. Explain your calculations.

Case 6: Woman found in freezer at 6 p.m. on Thursday.

a. Ligature marks on neck
b. Body temperature: 30°F, same as freezer
c. Undigested food in stomach

Provide as much information as possible from the above information regarding the death of this woman. Explain your calculations.

Case 3

1. Time of death = approximately 5.6°F / 1.4°F per hour = 4 hours ago, but the man was overweight, so it probably took longer.
2. Sample answer: Rigor starts usually in at least two hours, but in an overweight condition, it would have been delayed.
3. Sample answer: Probably natural causes, such as a heart attack.
4. Sample answers: Blood tests, liver biopsy, urine tests might provide clues.

Case 4

1. Sample answer: Time of death calculations: 98.6°F − 80°F = 18.6°F temperature difference. If the body loses 1.4°F per hour for the first 12 hours = 16.8°F, leaving 1.8°F difference. The rate of heat loss drops (hypothetically) to about 0.7°F per hour for the next two-plus hours. This provides a total time of 12 + 2.5 = 14.5 hours for a normal-sized man. Lividity begins in about 12 hours. Probably a drowning in a lake or pool, (lungs filled with water), died elsewhere (little blood), died 12 hours or more ago (stomach contents), left dead on abdomen for a while.
2. Sample answer: Drowned elsewhere about 9:30 a.m. Monday and was moved more than 12 hours ago. Lividity begins in about 12 hours. Probably a drowning in a lake or pool (lungs filled with water, died elsewhere, little blood), died 12 hours or more ago (stomach contents), left dead on abdomen for a while. Drowned elsewhere about 9:30 AM Monday and moved more than 12 hours ago.

Case 5

1. Sample answer: She died within the last one to two hours, but no lividity present, so it was probably less than two hours ago. Flies can appear in minutes and lay eggs immediately. Her last meal was three to six hours before.
2. Sample answer: Unless other evidence is present, she probably died of natural causes.

Case 6

1. Sample answer: She was placed in the freezer within a few (four to six) hours of her death. Freezing interfered with normal heat loss at death. The time of death cannot be accurately determined.
2. Sample answer: death by strangulation

Background

In this activity, students determine which of the relationships about body proportions most accurately parallel their body proportions in estimating height.

Safety Precautions

There are no safety precautions for this activity.

ACTIVITY 13-7 *Ch. Obj. 13.2 and 13.4*

HEIGHT AND BODY PROPORTIONS

Background:

Leonard da Vinci drew the "Canons of Proportions" around 1492 and provided a text to describe what the ideal proportions of a perfect man should be. The drawing was based on the earlier writings of Vitruvius, a Roman architect. Some of the relationships described include:

- A man's height is 24 times the width of his palm.
- The length of the hand is one-tenth of a man's height.
- The distance from the elbow to the armpit is one-eighth of a man's height.
- The maximum width at the shoulders is one-half of a man's height.
- The distance from the top of the head to the bottom of the chin is one-eighth of a man's height.
- The length of a man's outstretched arms is equal to his height.

Leonardo da Vinci's "Canons of Proportions"

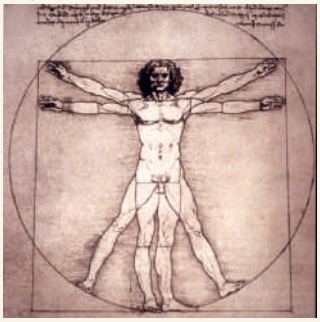


Photo by Susan Van Etten

Objectives:

By the end of this activity, you will be able to:

1. Determine which of these relationships most accurately parallels your body proportions in estimating height.
2. Describe how to apply the Canons of Proportions to forensics by estimating someone's height from a limited number different body parts.

Safety Precautions:

None

Time Required to Complete Activity:

40 minutes

Materials:

(students working in pairs)
metric ruler
pen and paper
calculator (optional)
graphing paper

Part A:

Procedure:

1. Standing in your stocking feet with your back to a wall, have your partner carefully measure your height to the nearest tenth of a centimeter. Keep the top of your head level (parallel to the floor).
2. Record your results on Data Table 1.

3. Have your partner measure to the nearest .1 cm and record each of the following measurements of your body:
   a. width of your palm at the widest point
   b. length of the hand from first wrist crease nearest your hand to the tip of the longest finger
   c. distance from elbow to highest point in the armpit
   d. maximum width of shoulders
   e. the distance from the top of the head to the bottom of the chin
   f. the length of outstretched arms
4. Repeat steps 1 to 3, taking the body measurements of your partner and record in Data Table 2.
5. Your partner records your data in his or her Data Table 2.
6. Calculate and record your and your partner's estimated height using the proportions given on the data tables.
7. Determine and record the difference between your actual height and your calculated height on data tables 1 and 2. Use + and – symbols.

Data Table 1: Your Body Relationships
All measurements recorded in centimeters
Gender of person measured _____

A	B	C	D	E
Trait	**Size (cm)**	**Multiply by**	**Calculated Total (cm)**	**Difference between actual and calculated height (cm)**
Height		x 1 =		
Palm width		x 24 =		
Hand length		x 10 =		
Distance from armpit to elbow		x 8 =		
Width of shoulders		x 4 =		
Head to chin length		x 8 =		
Outstretched arms		x 1 =		

Procedures

1. Print, copy, and distribute Activity Sheet 13-7 from the IRCD.
2. It is possible to share the contents of a single bone kit, having different groups of students within the class analyze a specific body region at one time, and rotate the contents of the kit to another group. This way one kit can service an entire class over a period of several days.
3. Make sure students read all directions *before* beginning the activity.

Answers

Part A

Check students' data tables.

Questions

1. Answers will vary.
2. Answers will vary.
3. Answers will vary.
4. Answers will vary.
5. Teenagers are still growing and have not yet reached adult size.
6. A handprint found at a crime scene can approximate the height of a person.

Data Table 2: Your Partner's Body Relationships
All measurements recorded in centimeters
Gender of person measured _____

A	B	C	D	E
Trait	**Size (cm)**	**Multiply by**	**Calculated Total (cm)**	**Difference between actual and calculated height (cm)**
Height		x 1 =		
Palm width		x 24 =		
Hand length		x 10 =		
Distance from armpit to elbow		x 8 =		
Width of shoulders		x 4 =		
Head to chin length		x 8 =		
Outstretched arms		x 1 =		

Questions:

1. Which measurement and relationship most accurately reflected your height?
2. Was this the same measurement that most people of your gender found to most accurately estimate their actual height? Explain.
3. Which measurement and relationship most accurately reflected your partner's height?
4. Which measurement was the least accurate in estimating your height?
5. Explain why using the Canons of Proportions on teenagers to estimate height would provide less accurate data than using the canons of proportions on adults.
6. Describe a crime scene that could use the Canons of Proportions to help estimate the height of a person.

Part B:

Procedure:

1. The distance from your elbow to armpit is roughly the length of your humerus. Record the humerus length and actual length from everyone in your class and complete Data Table 3.
2. Graph the length of the humerus (*x* axis) vs. height (*y* axis). Be sure to include on your graph the following:
   - Appropriate title for graph
   - Set up an appropriate scale on each axis
   - Label units (cm) on each of the *x* and *y* axes
   - Circle each data point

Data Table 3: Comparison of Humerus to Actual Height

Name	Length of Humerus (cm)	Actual Height (cm)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		

Questions:

1. Plot the data and create the best-fit line.
2. Suppose a humerus bone was discovered at a construction site. From the graph, explain how you could estimate the person's height from the length of the humerus.
3. List the variables that would need to be considered when trying to estimate someone's height from a single bone.

Part B

Check students' data tables and graphs.

Questions

1. Check students' graphs.
2. Sample answer: Find the size of the humerus on the best-fit line and follow it across to where it intersects with the y-axis. That value should be the approximate height.
3. Sample answer: genetic variations in physical development, age, sex, nutrition, illness

Further Research and Extensions

Give students this additional scenario: Part of a skeleton containing a humerus, pelvis, and mandible is found in the woods. What can be determined about the individual from these bones?