The Human Skeleton

Bone and Bone Growth

Bone is living tissue, and, as such, can grow and remodel during a person's lifetime. The three types of bone cells are the osteoblasts, which are responsible for bone growth; the osteoclasts, which are active in bone resorption; and the osteocytes, which serve a regulatory function, adjusting the circulating levels of bone minerals. Because bone is malleable, it can be modified through exercise, disease, injury, and diet.

Osteology

Osteology is the study of the human skeleton, which includes all bones of the body. It is important to know the correct descriptive terminology when speaking of the various bones and regions, i.e., the bone of the upper leg is the femur, not the thigh-bone. **Craniology** is the study of the head and face. This portion of the body formerly received attention because it was thought to provide more detailed information than the rest of the body with respect to the evolutionary trends in human physical morphology. However, in recent years the postcranial body has been studied extensively for evidence of age at time of death, estimate of stature and bodily proportions, and presence of injury and disease.

Although we will focus on the human skeleton, the same bones, with some modification in shape, are found in non-human primates and other mammals, for example, the dog. Learning the 206 bones of the skeleton sounds like a formidable task, but many bones are paired, such as the right and left femur (pl. femora), right and left parietals, and right and left ribs. If the non-paired bones are identified first, the paired bones are much easier to recognize. The skeleton may be separated into two parts, the **cranial** (skull) portion (usually also includes the hyoid) and the **postcranial portion**, that is, all bones below the skull. The **axial region** includes those bones of the trunk and thorax, including the sacrum. The **appendicular region** includes the bones of the upper and lower limbs, shoulder and pelvic regions, hands, and feet.

The next few pages will illustrate the bones of the cranial and the postcranial skeleton as well as provide for you a list of general and directional definitions. This list will introduce you to terminology that often is used in human skeletal studies.

As you work with the diagrams and other materials, note the articulations of the various bones. For example, observe that one nasal bone **articulates** with (that is, meets or touches another bone by way of a suture, the juncture edge of each bone) the other nasal bone, one of two maxilla bones, and the unpaired frontal bone. Some bones, like the occipital bone, are easily observed, but others, like the vomer and ethnoid bones, are difficult to identify because they are part of the internal support structure of the nose and midfacial region. These bones are illustrated in the diagram of a sagittal sectioning of the skull. **Pterion** refers to the region where the frontal, parietal, temporal, and sphenoid bones meet**. Asterion** refers to the region where the occipital, parietal, and temporal bones meet. Note that there is a right and left pterion and asterion region.

Turning to the postcranial skeleton, note which bones are part of the **pectoral** (shoulder) girdle and the **pelvic** girdle. Use the articulated skeleton in the laboratory as well as the diagrams provided to distinguish the bones of the **hands** (carpals, metacarpals, and phalanges) and **feet (**tarsals, metatarsals, and phalanges).

Planes of Orientation

In studying the human body and skeleton, it is convenient to use certain properly defined planes of orientation for descriptive purposes. It can readily be seen that an infinite number of possible planes can be thought to pass through the body in any direction. In **osteometry** the following planes are particularly important.

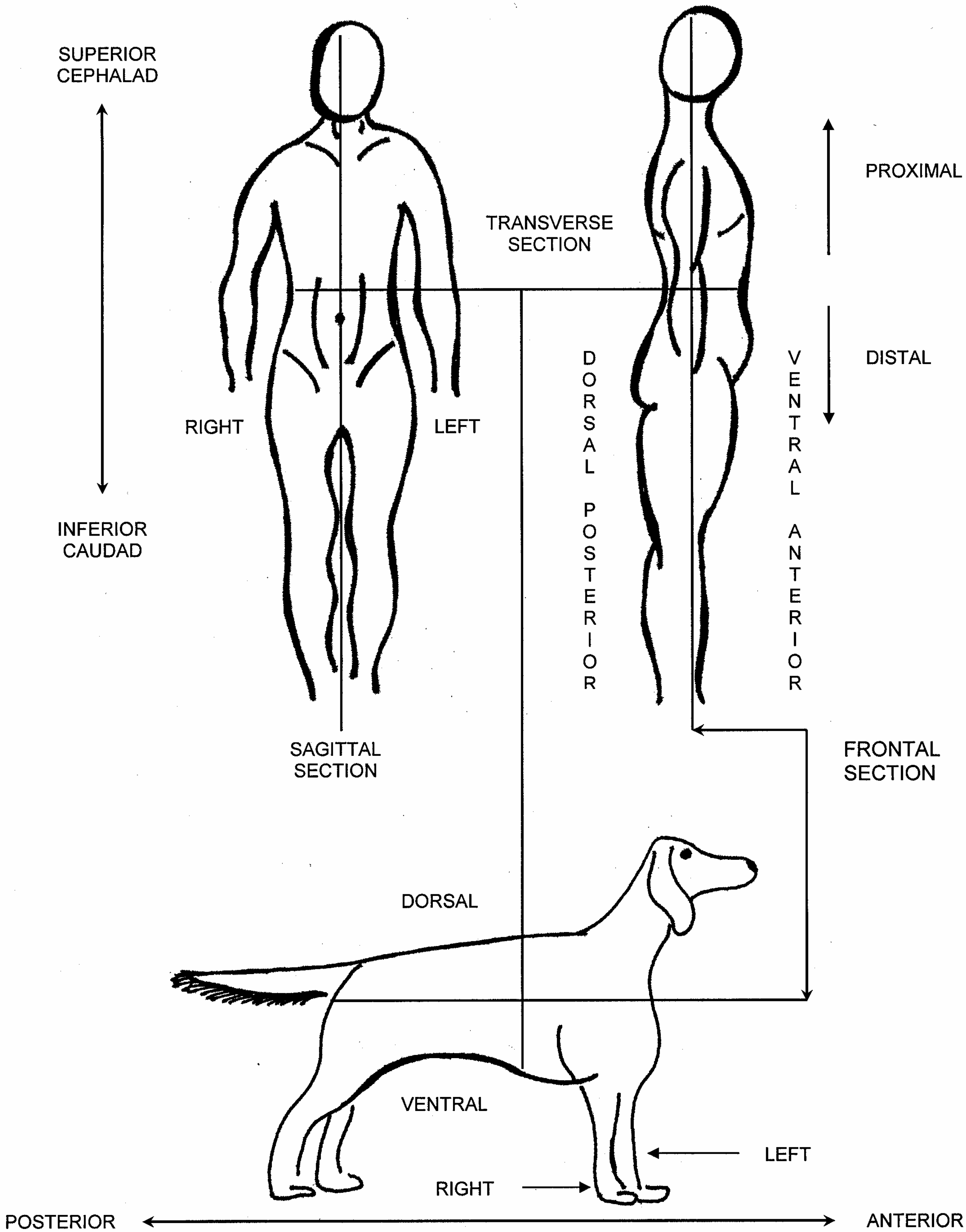
The **Frankfurt plane** is defined as the horizontal plane of the skull determined by the landmark called the **porion** (left or right) and the lowest point on the inferior border on the left orbit (**orbitale**). It is often called the eye-ear plane. This position roughly corresponds to that of the head of an individual standing at attention and looking straight ahead. Proper orientation of the skull is important since some landmarks (i.e., opisthocranion), and the measurements involved, will be in error without it.

Except for the internal organs, the bodies of all vertebrates are bilaterally symetrical along a median plane. This plane, called the **median sagittal plane**, passes from the **sagittal suture** of the skull downward, thus dividing the body and skull into symmetrical left and right halves.

Directional Definitions

Dorsal	the back or upper side (posterior in human anatomy)
Ventral	the under side, stomach side (anterior in human anatomy)
Lateral	to the side, right and left
Anterior, cephalic, or cranial	nearer the front of the body (in bipeds this means ventral)
Posterior, caudal	the tail end of the animal (inferior in anatomy)
Median	mid-line of the body, also called sagittal
Central	the part of a system nearest the middle of the animal
Peripheral	the part nearest the surface
Proximal	mass of the body, as the thigh
Distal	away from the main mass of the body, as the toes
Superficial	on or near the surface
Deep	some distance below the surface
Superior	above (anterior in animals)
Inferior	below (posterior in animals)
Medial	toward the mid-line of the body
Mid-Sagittal Plane	the imaginary plane that transects the body along the mid-point into the mirrored left and right sides

Vick, Robbins, Smith; *A Laboratory Manual of Methods and Techniques in Physical Anthropology*



Vick, Robbins, Smith; *A Laboratory Manual of Methods and Techniques in Physical Anthropology*

General Descriptive Definitions

The **skull** consists of all of the bones that comprise the head. The **cranium** or **calvarium** refers to the skull minus the **mandible** or lower jaw. The skull cap, or the **calvarium** minus its base, is called a **calva** or **calotte**.

Aperture	opening on surface of space within a bone, e.g., nasal aperture
Boss	a rounded eminence or bulging of bone, e.g., parietal bosses
Canal	long perforation in bone, e.g., occipital condyloid canal
Capitulum	a small articular swelling, e.g., capitulum near head of rib
Caput	rounded articular eminence generally with a neck, e.g., head of radius
Condyle	bony enlargement bearing an articulating surface, e.g., occipital condyle
Foramen	short perforation through bone, e.g., mental foramen
Crest	prominent border or margin, a distinct linear elevation or ridge, e.g., supramastoid crest
Fissure	narrow slit through bone, e.g., superior orbital fissure on sphenoid bone
Fovea	a shallow pit on the bone, e.g., fovea on head of femur
Lines	roughened ridge on the bone, e.g., *linea aspera* on femur
Meatus	outlet, opening in temporal bone, e.g., auditory meatus
Fossa	deeper pit in single bone or formed by several bones, e.g., mandibular fossa of temporal bone
Process	a marked projection or prominence on a bone, e.g., mastoid process
Sinus	closed space within the bone, e.g., maxillary sinuses, frontal sinuses
Spine	a slender narrow or pointed bony projection, e.g., the spines of thoracic vertebrae
Tubercle	small bony tuber (projection), e.g., genial tubercle

Tuberosity broad thick rough eminence, e.g., ischial tuberosity

Vick, Robbins, Smith; *A Laboratory Manual of Methods and Techniques in Physical Anthropology*

Evidence Used in Determination of Sex

(Sexual Dimorphism)

Humans vary in their degree of **sexual dimorphism** (difference in body form between male and female). Humans vary approximately 10-12% between male and female. Sexual dimorphism varies in form mostly by body size and features such as robustness and muscularity. Sexual dimorphism can be used to determine the sex of unknown individuals. In general, males are larger and more robust, with heavier muscle markings and larger teeth. Generally, in humans, the skull, long bones, and pelvis are all used to estimate sex. The best diagnostic evidence is the pelvis, however.

PELVIS	MALE	FEMALE
Greater Sciatic Notch	Narrow angle relatively deep	Wide angle relatively shallow
Preauricular Sulcus	Infrequent, sometimes absent	Common, mostly present
Pubic Symphysis (less reliable)	Deeper in males	
Obturator Foramen (less reliable)	Relatively large and oval	Relatively small and triangular
Subpubic Angle	Under 90 degrees, narrow	Generally 90 degrees or higher, wide

SKULL		
	Paired	Sometimes absent, but if present , single and in the midline

Orbital Rim Sharpness	Rounded and dull to the touch	Distinct and sharp edged
Temporal Ridges	Muscle attachments larger, more rugged	Muscle attachments slight
Nuchal Ridges	Muscle attachments larger, more rugged	Muscles attachments slight
Supraorbital Ridges	Larger, heavier	Smaller or absent
Mastoid Process	Medium to large (thumb size), usually projecting below the below of the skull	Small, (little finger size), usually does not project below the skull
Posterior Zygomatic Root	Continues into supramastoid crest above auditory meatus, heavier, greater length	Underdeveloped, lighter and more compressed
Mandible	Heavier jaw, more "square" chin that has two points connected by more or less a straight line. The gonial angle is generally < 125 degrees	More narrow and "pointed"(single prominence), ramus is more gracile. The gonial angle is generally > 125 degrees
Skull Overall	Rougher, larger, more rugged	Smoother, smaller, more rounded, adolescent-like

OTHER		
Postcranial General	Heavier; heavy muscle marking compared to female; larger head of humerus; larger head of femur	Light muscle markings; smaller bones and joints in general

Vick, Robbins, Smith; *A Laboratory Manual of Methods and Techniques in Physical Anthropology*

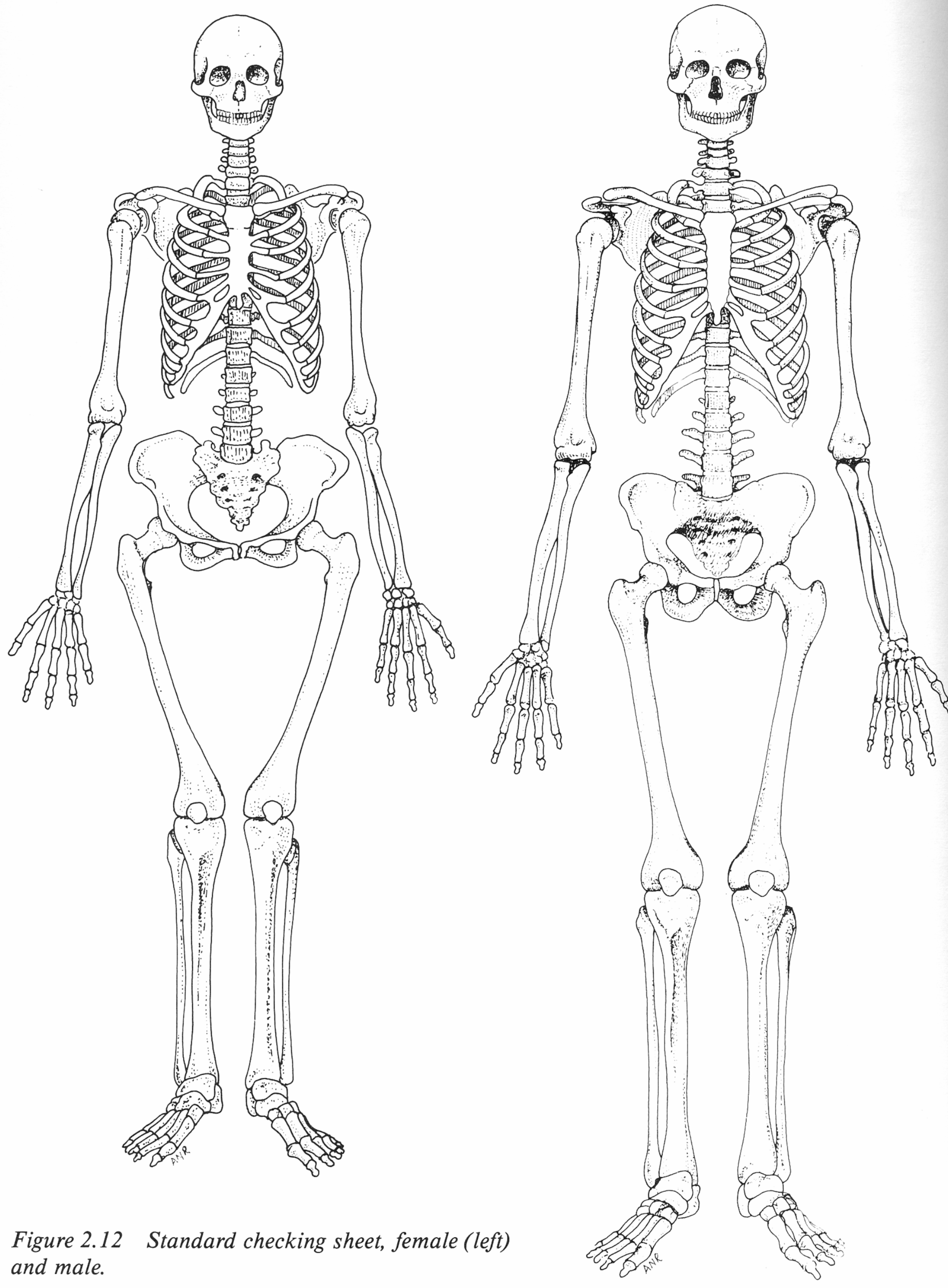


Figure 2.12 Standard checking sheet, female (left) and male.

The narrow sciatic notch is a good indicator that the pelvis belongs to a male.

This wide subpubic angle is a good indicator that this pelvis belongs to a female.

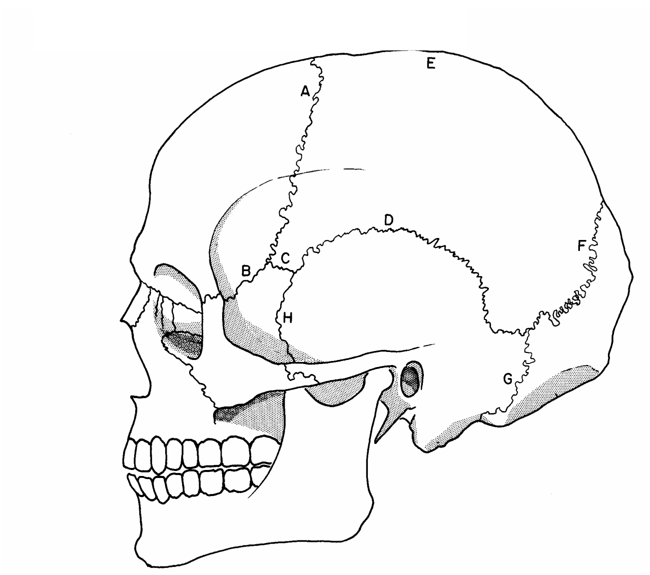
Evidence Used in Determination of Age

Skeletal Evidence

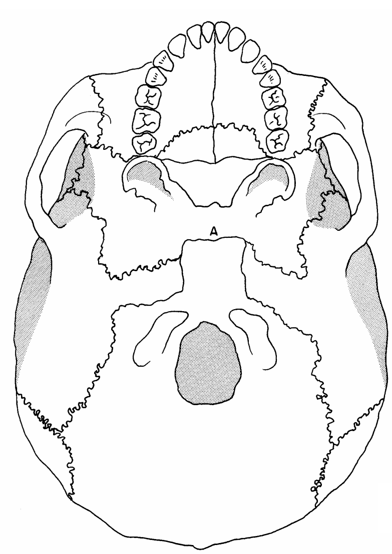
Lines of evidence used in the determination of age involve examination of epiphyseal union, closing of cranial sutures, and changes in the pubic symphysis. The **epiphysis** is a cartilaginous area of bone growth located near the ends of long bones. As individuals mature, these epiphyses gradually ossify and join the diaphysis, in a timed sequence. In flat bones, such as the skull, growth occurs from the center of the bone. Upon maturation, growth stops and the sutures gradually close. The pubic symphysial face also changes over time.

Times of epiphyseal union of long bones vary somewhat due to nutrition and individual variability and can therefore serve only as an <u>approximate</u> indicator of age up to about 25-30 years. The sutures of the skull begin closing at approximately 17 years of age; finally, in very old age, the sutures are completely fused. Suture fusing begins on the inside of the skull and proceeds to the outside. Average ages for suture closing have been determined. However, because of inter-individual variation, one should be very cautious in using suture closure data for age estimation. Stages in the aging of the pubic symphysis have also been determined. This measure is more useful than other measures since the changes extend into later life.

A. Fused by 40 years of age
B. Fused by 65 years of age
C. Fused by 72 years of age
D. Fused by 80 years of age
E. Fused by 40 years of age
F. Fused by 50 years of age
G. Fused by 80 years of age
H. Fused by 65 years of age



A. Fuses between 18 and 25 years of age



Wolfe, 1983

Age Estimation of Immature Skeletons

In general, immature remains are those of individuals who are less than 20 years old. Complete fusion of all major epiphyses has occurred and all teeth have erupted. Of course, the age of occurrence of these events varies depending on sex, race, nutrition and other factors.

I. Appearance of Ossification Centers
   A. Appearance of ossification centers occurs from birth to 15 years.
   B. The centers themselves rarely survive in archeological/forensic context because of their fragile nature.

II. Epiphyseal Union
   A. Most commonly used in teenage years (10-20 years)
   B. Standards available for humerus, clavicle, scapula, hip, elbow, hand, wrist, foot, ankle and knee.
   C. Epiphyseal union should be considered a process rather that a event.
   D. A range of four years is seen between fusion onset in early-maturing and completion of fusion in late-maturing individuals.
   E. Females are an average of two years in advance of males in epiphyseal union.
   F. Radiographs of the epiphysis provide earlier age estimates.

III. Bone Size
   A. In individuals from the prenatal period to about 6-7 years, the length of the long bone diaphyses can be used to estimate age.
   B. Growth rates vary greatly among groups and sexes.

C. For prenatal to birth skeletons, use long bone length to get an estimate of body length, then use body length to get estimate of age.

D. For postnatal skeletal remains, the diaphyseal length can be used directly to estimate age.

IV. Dental calcification and eruption

A. Most accurate age indicator in subadults.

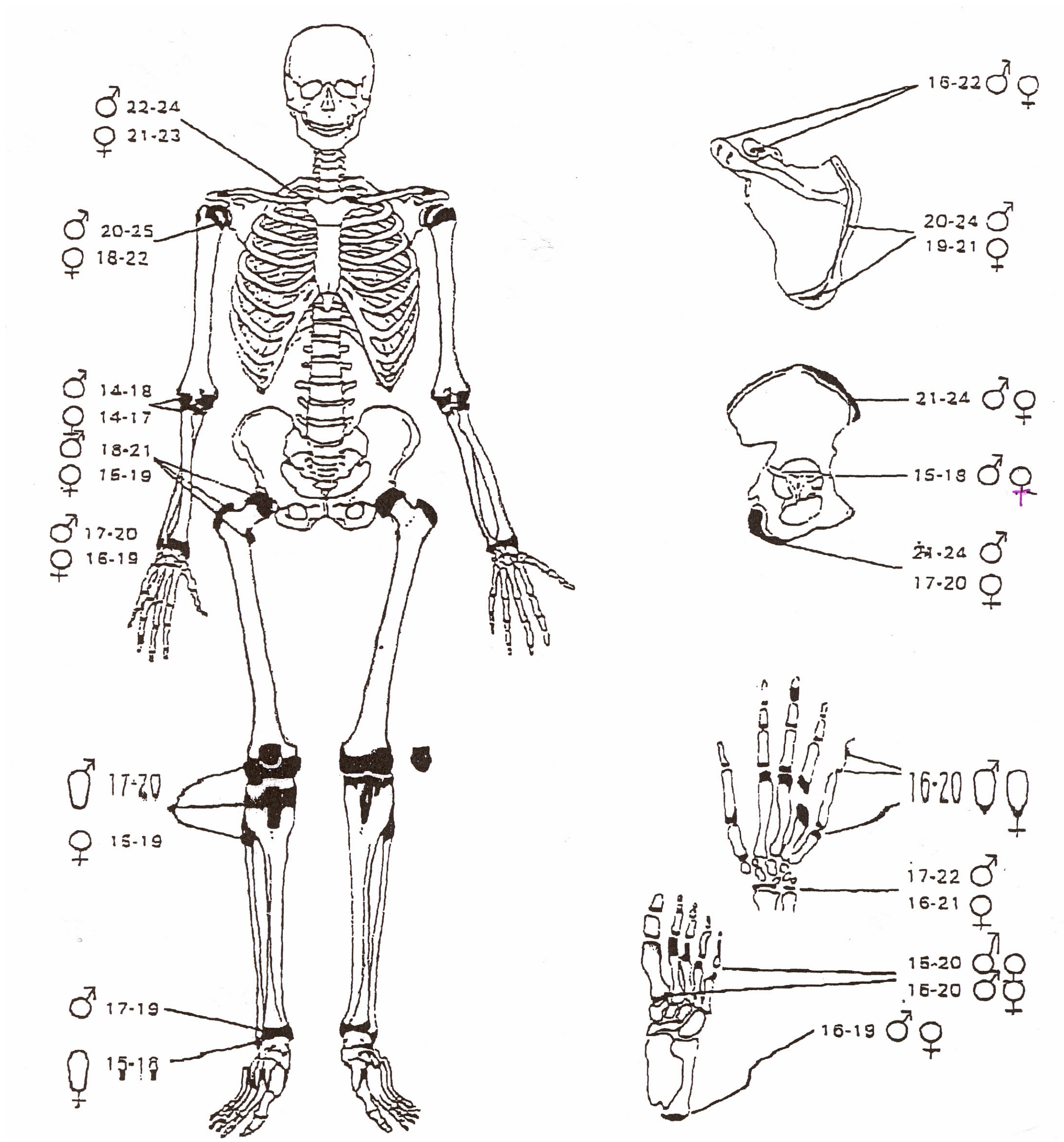
B. Dental development largely controlled by genetic factors and is, therefore, relatively less susceptible to environmental factors.

C. Most studies provide calcification and eruption data for specific groups (e.g. white, black, Indian, male, female)

D. Age estimates are available for calcification of deciduous (milk) and permanent teeth.

Epiphyseal Union

Male and Female age ranges in years for complete fusion of epiphyses



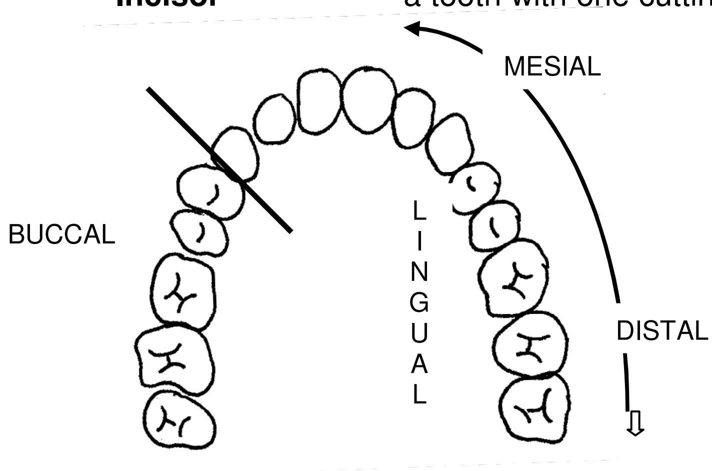
Brothwell, *Digging Up Bones*

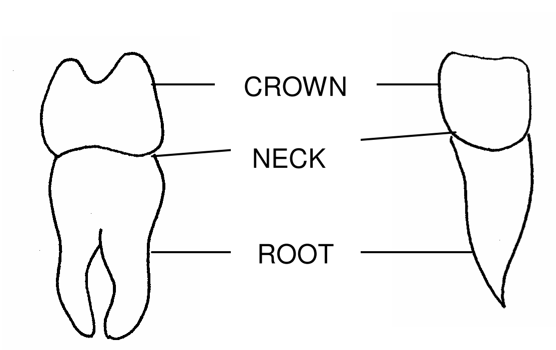
Dental Evidence

General Dentition Information

Teeth provide much useful information to the physical anthropologist. Due to their hardness, they very often fossilize. Teeth can give us insights about the life ways of the individuals to whom they belonged. For example, eruption and wear patterns can provide information about age. Moreover, teeth can provide data on nutrition and diet.

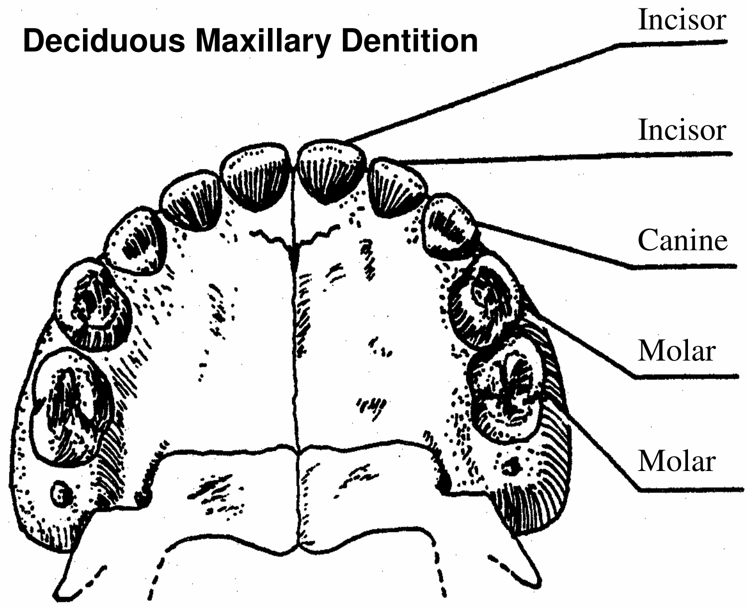
Occlusal surface	top of crown that comes in contact with teeth of the opposing jaw when the mouth is closed
Crown	part of the tooth above the alveolus
Neck	joins crown and root(at the gum line)
Root	anchors the tooth in the bone
Buccal	cheek side of tooth
Lingual	tongue side of tooth
Mesial	toward the midline of chin
Distal	away from the midline of chin
Groove	natural valleys between cusps or other tooth parts
Alveolus	socket in the maxilla and mandible in which the root of The tooth is anchored
Cusp	a pronounced elevation on the crown surface of the tooth
Bicuspid	a tooth with two cusps (premolars)
Incisor	a tooth with one cutting edge



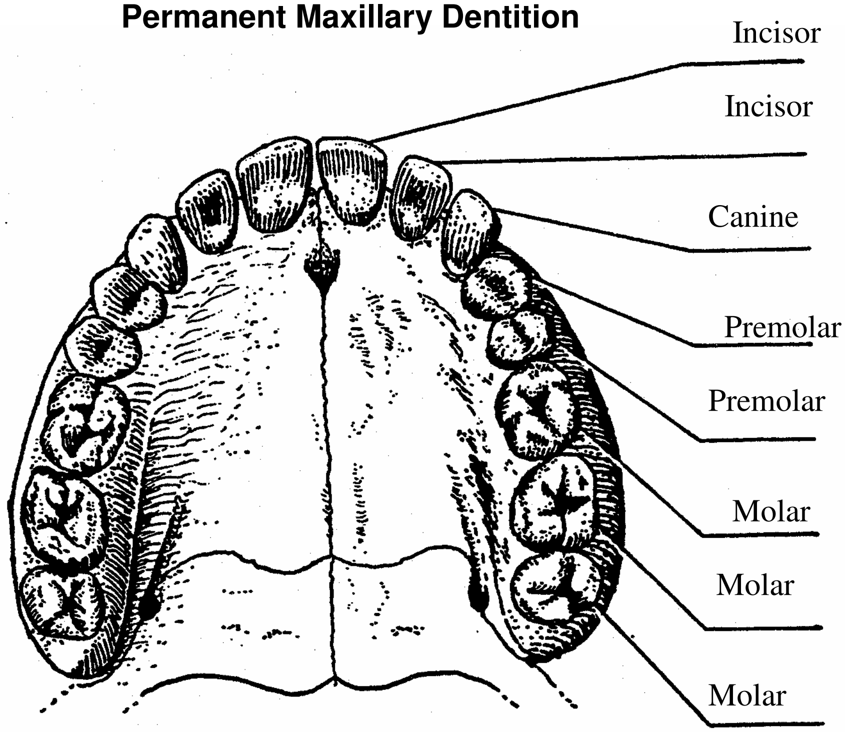


Human Dentition

Deciduous Maxillary Dentition

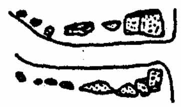


Permanent Maxillary Dentition

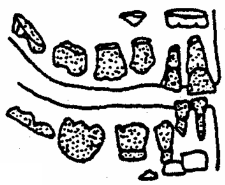


Vick, Robbins, Smith; *A Laboratory Manual of Methods and Techniques in Physical Anthropology*

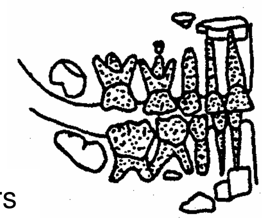
Dentition Eruption Sequence



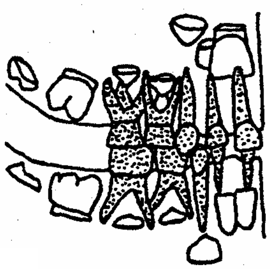
Birth



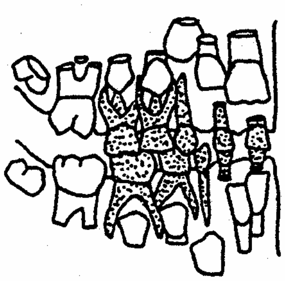
9 Months



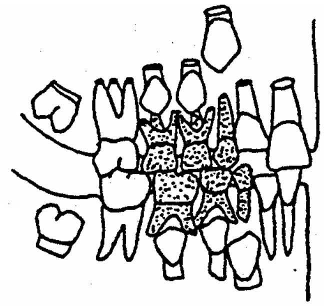
2 Years



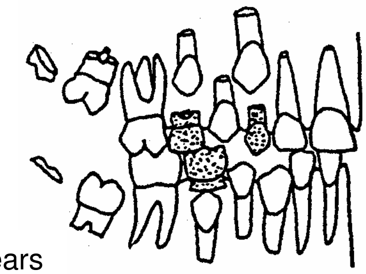
4 Years



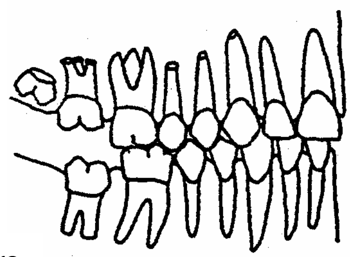
6 Years



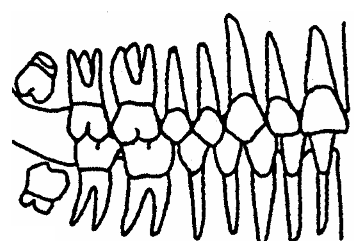
8 Years



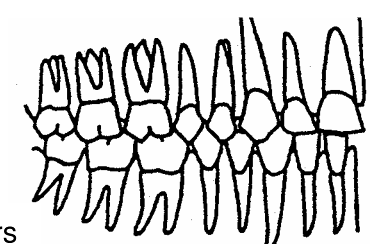
10 Years



12 Years



15 Years



21 Years

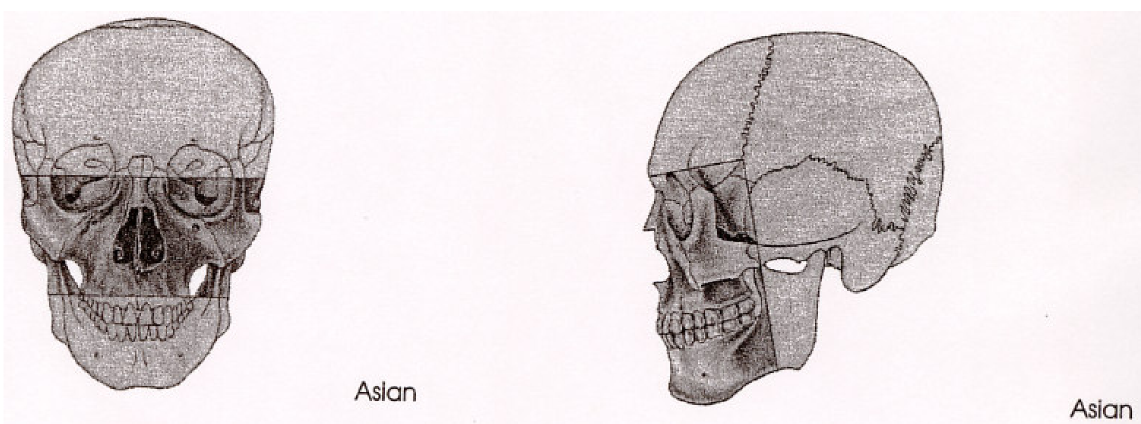
(after Schour and Massler)

Evidence Used in Determination of Race

Race is much harder to determine, as there is much interindividual variation within the various ethnic groups. The following characteristics may be used to aid in racial identification.

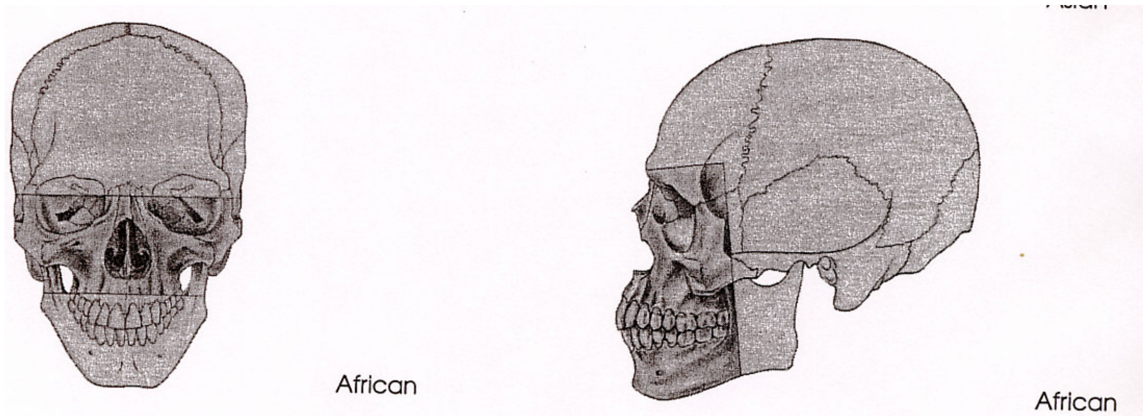
Asian

Asian skulls have a flat, moon-like face. This is caused partly by the fact that the cheek bone protrudes forward. Asians usually have what is called an edge-to-edge bite; this occurs when teeth of the opposing jaw touch each other when the mouth is closed. The incisors are generally shovel-shaped, and the malars (or zygomatics) are robust and flaring. There is usually no crowding of the teeth.



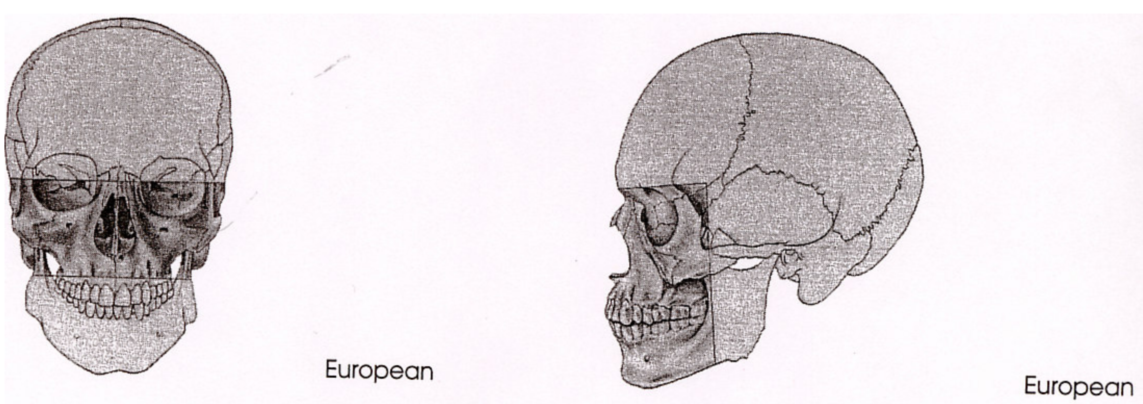
African

African skulls generally have rounded foreheads, and a wide nasal opening that lacks the nasal sill seen in Caucasoids. Africans typically have what is called an over-bite; this happens when the top teeth protrude farther than the bottom teeth. The incisors are generally blade-form, and the malars are small and retreating. There is usually no crowding of the teeth



European

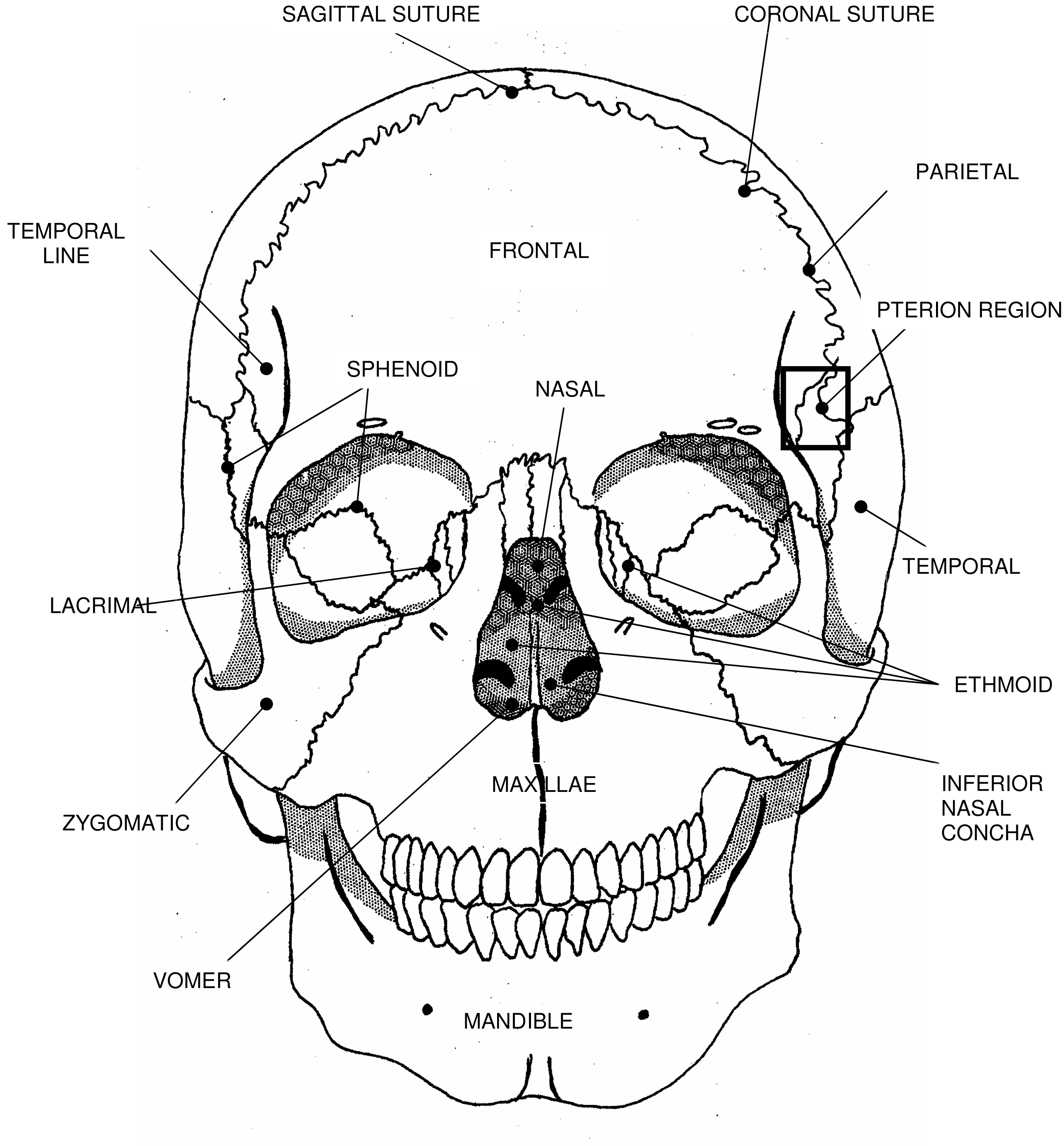
The European skull comes to a point along the midline and cheek bones do not extend forward. The nose in narrow and high bridged, with a nasal sill that dams the nasal opening. Europeans have a “flat” face in the dental area, which is opposite of the African face. The incisors are generally blade-form, and the malars are small and retreating, just as the African dentition. There is frequently crowding of the teeth, particularly the impacted third (3^{rd}) molars.



Burns, *Forensic Anthropology Training Manual*

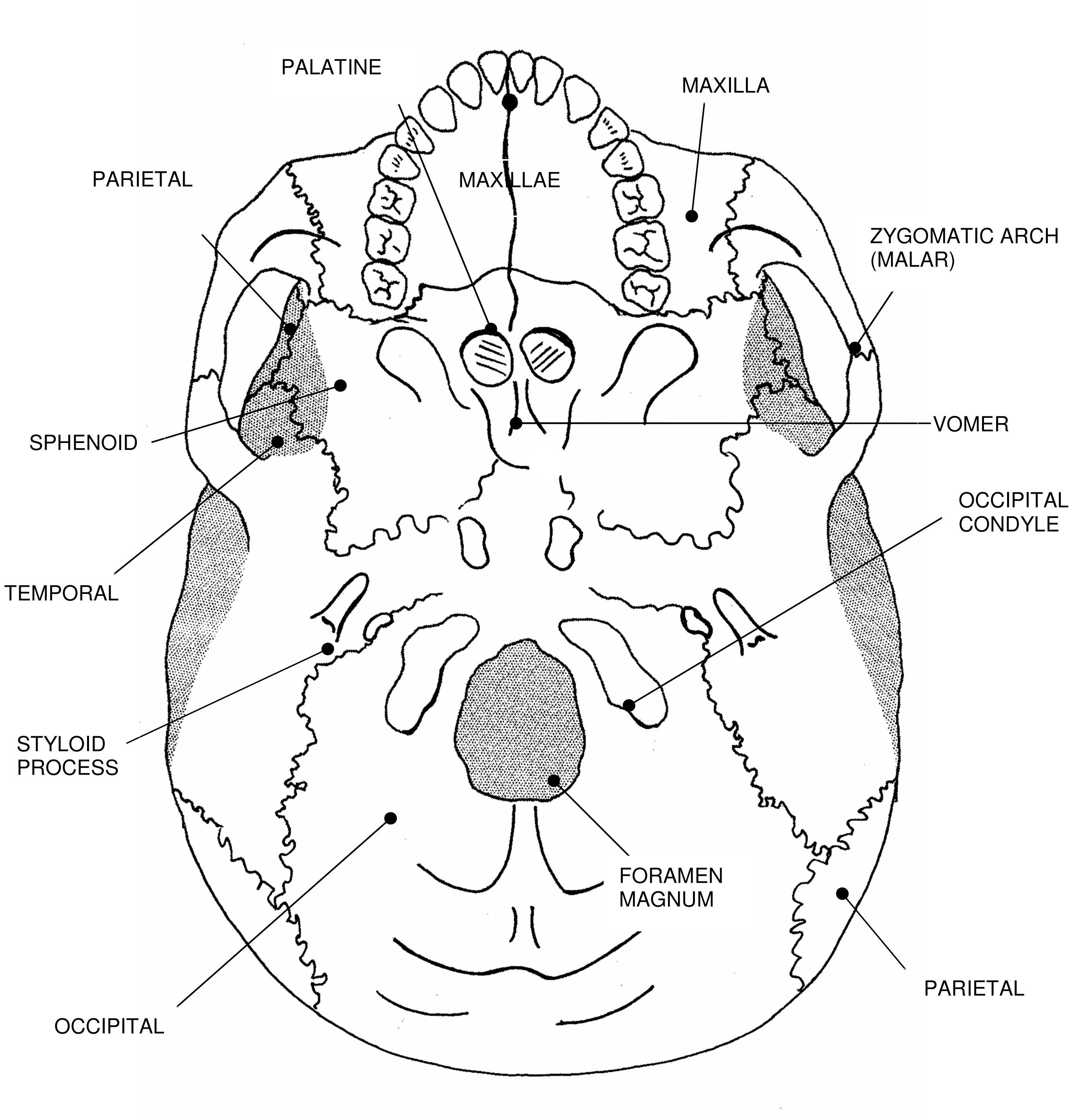
INDIVIDUAL BONES OF THE CRANIUM

(FRONTAL VIEW)



Vick, Robbins, Smith; *A Laboratory Manual of Methods and Techniques in Physical Anthropology*

INDIVIDUAL BONES OF THE CRANIUM
(BASAL VIEW)



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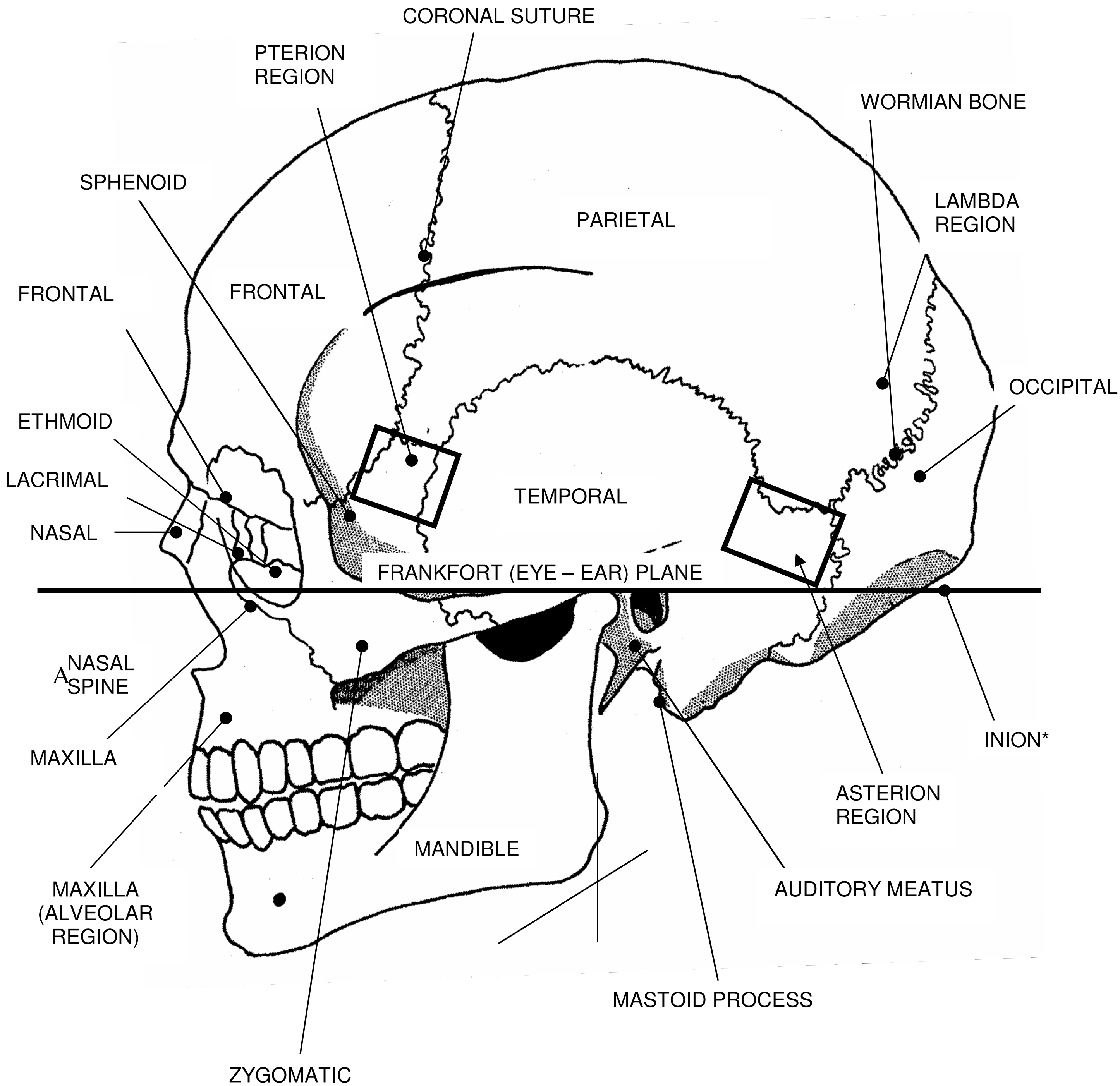
INDIVIDUAL BONES OF THE CRANIUM

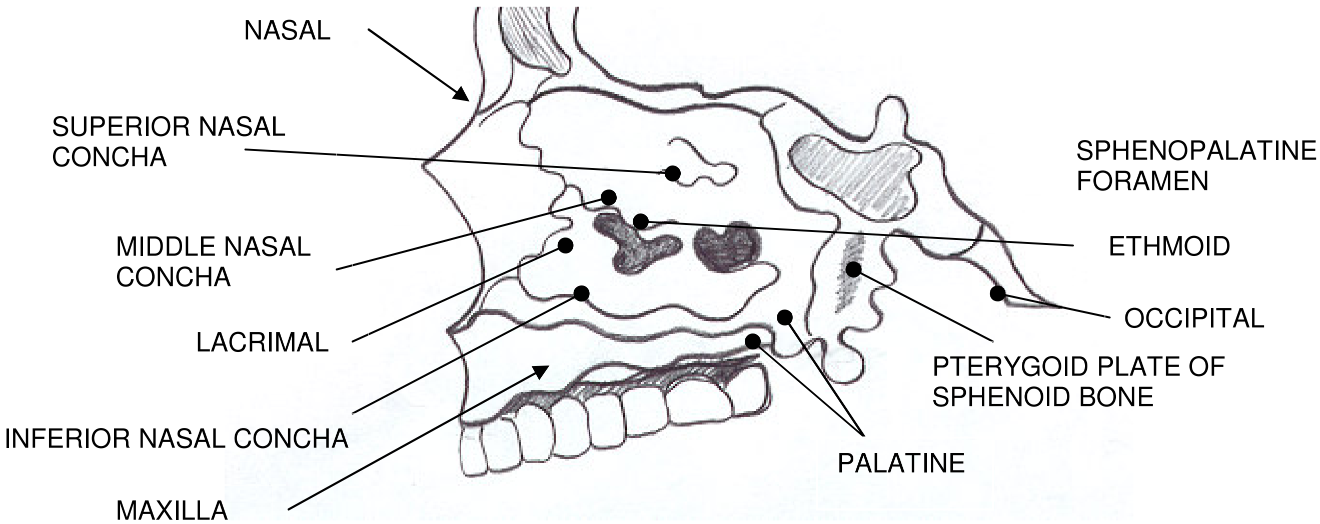
(LATERAL VIEW)



* INION – ALSO CALLED EXTERNAL OCCIPITAL PROTUBERANCE

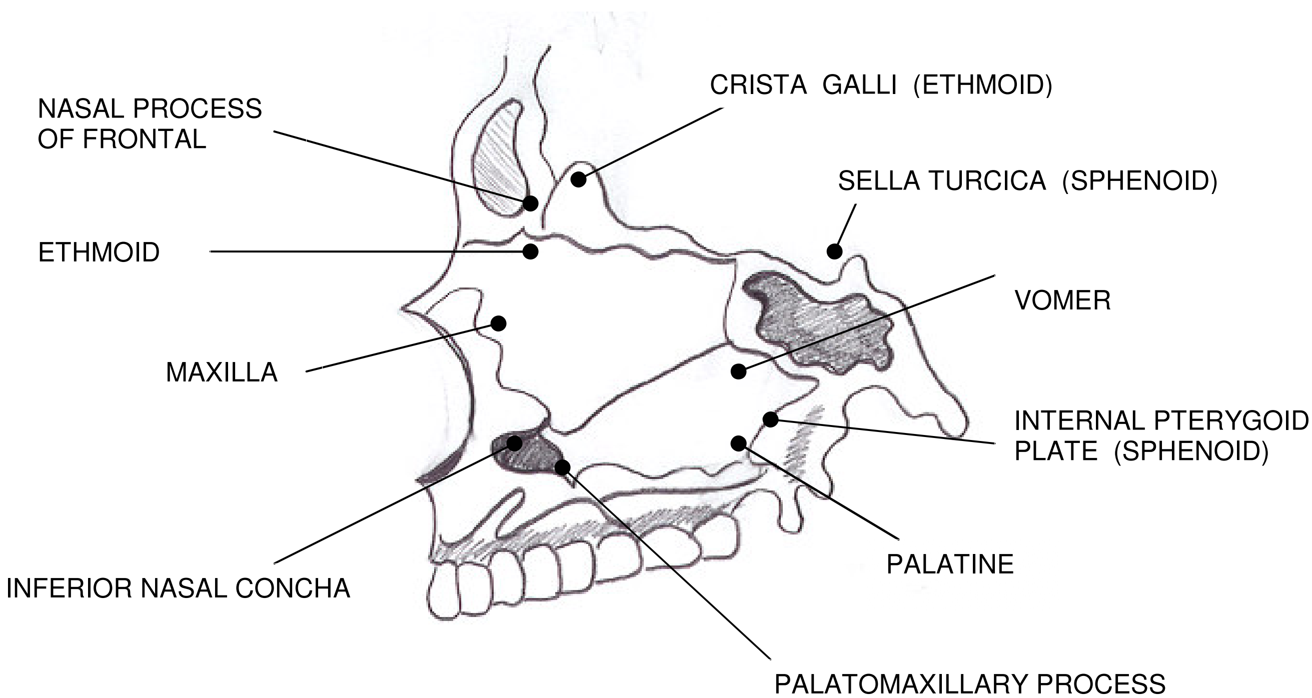
SAGITTAL SECTION LATERAL TO THE CENTER

(ILLUSTRATING INTERNAL STRUCTURE OF THE SKULL)

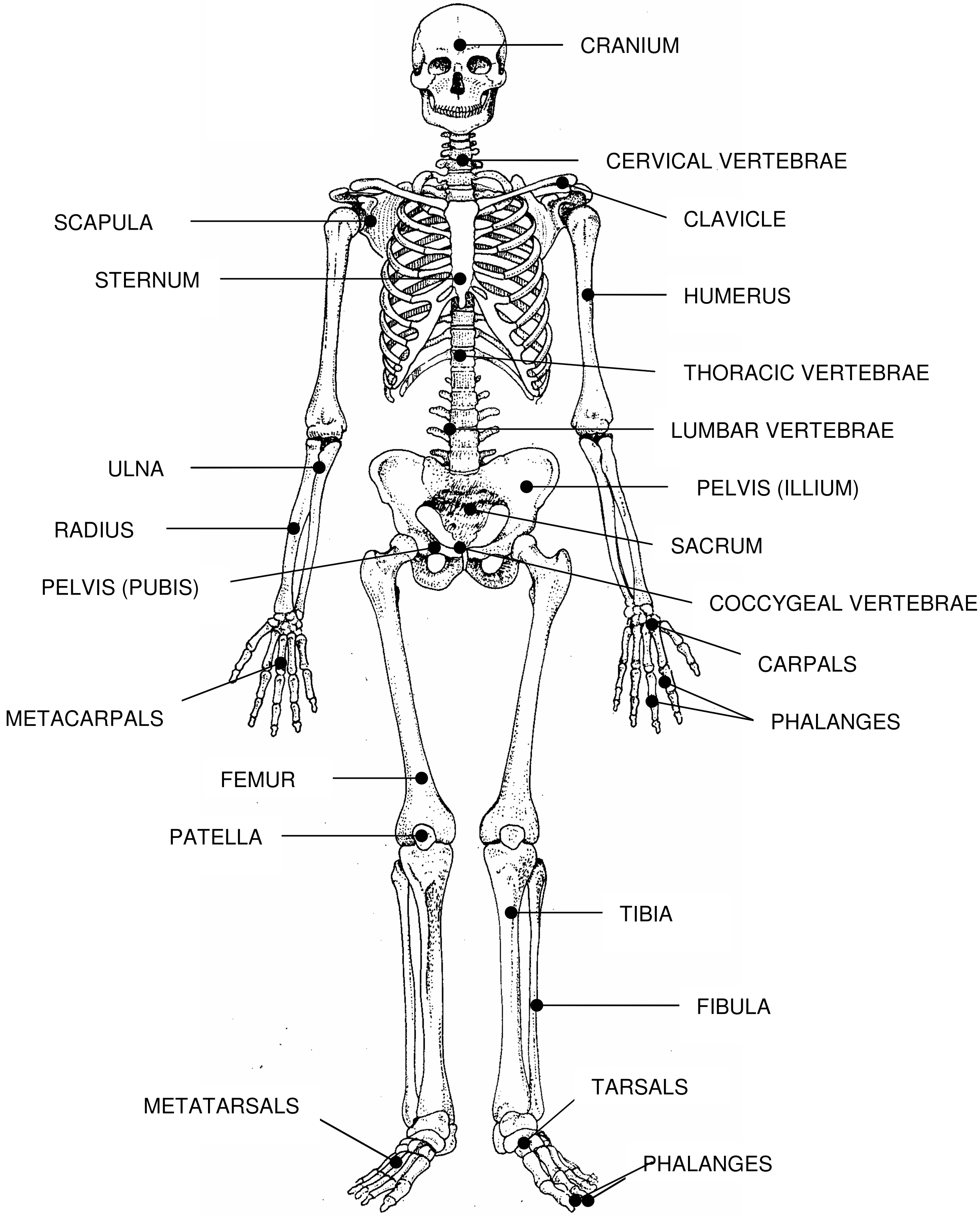


SAGITTAL SECTION OF THE SKULL

(ILLUSTRATING INTERNAL STRUCTURE OF THE SKULL)



BONES OF THE SKELETON



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What and How Many?

When one is dealing with bony remains, one must first determine to what species (one or more than one) the remains belong. In other words, is only one species represented? Or are you dealing with more than one species? Another question involves the minimum number of individuals (**MNI)** represented in the remains. Clues such as **shape, size**, **side,** and **number** are used to answer these question. In addition, **color, degree of weathering,** etc., can also offer valuable information.

One of the first steps in analysis involves sorting. Place bones of the same type together as, for example, all femurs *versus* all humeri. If homologous bones have very different shapes, they probably represent different species. Next look at size; two differently sized humeri will indicate at least two different individuals. With good understanding of the skeletal structure and relative size differences of the various bones, size can also be used as a clue even when one has non-homologous bones. Now check for side. An animal can only have one left femur or one left innominate bone (left half of the pelvis).

Color and weathering are less valuable clues since part of a skeleton may have been exposed to sunlight while another part has been covered by dirt or debris. However, these clues can sometimes help one in assigning remains to one or more than one individual.

Demonstration / Exercise

"Taphonomy Exercise" bags will be assigned to student groups. Each bag contains some rhesus monkey bones (very similar to human bones) as well as some other bones. You will use clues such as **size, size, shape, number, color**, and **weathering** to determine the answers to the questions below.

After your group is ready to “present” your conclusions, check these with the instructor or lab assistant.)

Examine carefully the bones found in your bag. Bag ID Number ______

How many species do you observe? at least