GROUP 3 TOPIC: FORENSIC ANTHROPOLGY – HUMAN BONES VS ANIMAL BONE SKELTON

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FORENSIC ANTHROPOLOGY: HUMAN BONE VS ANIMAL BONE SKELETON

Consistently, forensic anthropologists are being asked to identify fragmented skeletal remains as their involvement in forensic situations expands. These scientists are required to aid in the identification of human remains from fires and cremations (Mayne and bettie , 2001),and other domestic crimes in which human skeletal remains are often presented as highly fragmented, damaged, and in cases where they are potentially mixed with nonhuman skeletal remains and other artifacts. In this situation, Forensic anthropologists must have vivid knowledge on how to differentiate between animal bone and that of human's for them to be able to carry out the forensic investigation (Mayne and Lynne, 2007).

Forensic anthropology is a special sub-field of physical anthropology (the study of human remains) that involves applying skeletal analysis and techniques in archaeology to solving criminal cases (Byers, 2016). When human remains or a suspected burial are found, forensic anthropologists are called upon to gather information from the bones and their recovery context to determine who died, how they died, and how long ago they died. Differentiating human and nonhuman bone has important applications in both archaeological and forensic contexts. Identifying isolated or fragmentary bones can be difficult in archaeological and forensic contexts. Numerous non-osseous materials such as wood, pottery, plastics, or even stones can sometimes be mistaken for fragmented human bone. It is more common however; human remains are often confused with those of non-human animals. Archaeologists often make initial determinations about whether skeletal remains are human or not in the field, although more detailed analyses often take place in the laboratory, particularly for bulk bone recovered during excavation (Johnson *et al*., 2017).. Even in the most experienced hands it is not always possible to distinguish human from animal skeletal remains. While the skull and vertebrae of most animals possess features quite different to humans, given the common mammalian form it is often difficult to distinguish post-cranial remains, particularly when the articular surfaces are missing (O'Brien, 2020).

In cases where skeletal remains are found unexpectedly, one of the first questions in establishing whether the remains have forensic significance involves determining whether they are of human or nonhuman origin. There are generally three levels of identification that can be utilized to distinguish between human and animal bones: 1) gross skeletal anatomy, 2) bone macrostructure/ molecular analyses, and 3) bone microstructure (histology) (Donlon*et al.*, 2016).

Even in the most experienced hands it is not always possible to distinguish human from animal skeletal remains. While the skull and vertebrae of most animals possess features quite different to humans, given the common mammalian form it is often difficult to distinguish post-cranial remains, particularly when the articular surfaces are missing.

The following are some steps to distinguishing human bone from animal bone;

1. Look for a relatively large, bulbous skull in humans**.** Human brains are large relative to the size of our heads, so our skulls generally look bulbous next to the face. Alternatively, animal skulls tend to be more curved, since they house a smaller brain.
2. Check for a chin to identify a human skull. Most animals do not have a chin. When you're examining a skull, look closely to see if it has a chin extending from the front of the skull at the bottom. If it does, it's likely human. If not, it's likely an animal.

3. Look for eyes above the nose in humans. Humans have the orbits (eye sockets) to the front, above the nose. On the other hand, animals' orbits are to the side and behind the nose. You should be able to distinguish this feature on a skull by examining how the eye sockets are situated in the skull.
4. See if the skull would sit above or in front of the spinal column. Look for the hole at the base of the skull. This hole is called the foreman magnum, and it's how the spinal column connects to the brain. Because humans stand upright, the hole is more centrally located underneath the skull. In other mammals, the hole is further back, since they typically hold their bodies more parallel to the ground.
5. Check for small canines in the mouth for humans. The canines are the pointy, fang-like teeth. Since humans are omnivores, the canines will be present like other meat-eaters. However, human canines tend to be smaller than those of most predators/carnivores, which have long, cone-shaped canines.
6. Look for a dish-shaped pelvis in human remains. Because humans are bipedal, the pelvis is shaped differently than it is in most other animals. It is shorter, and it has a bowl shape. On the other hand, other animals typically have longer pelvises that are more blade-like.

1) Skeletal Anatomy

Figure 1: Adult human (left) and mule deer (right) crania. Note large, bulbous cranial vault and small face in the human compared to the small, angular cranial vault and large face in the deer.

Cranial morphology differs dramatically between humans and non-human animals due to the uniquely large brains that humans have compared to body mass (Fig. 1). Humans have small faces compared to our large, bulbous cranial vault and this minimizes facial projection compared to non-human animals. Human vault musculature is less well developed than in non-human animals, which often have developed sagittal and occipital crests (Olsen *et al.,* 1964, Gilbert *et al.*, 1990, Watson *et al.,* 2018, McClelland *et al.*, 2018).

In relation to the foramen position;

The foramen magnum is the large hole on the underside of the skull where the spinal cord exists and follows the spinal column. The placement of the foramen magnum underneath the skull allows the eyes to face forwards when the body is upright. In humans, the foramen magnum is positioned centrally, facing directly downwards, which allows the human body to be oriented vertically for bipedalism. In chimpanzees and other apes, the foramen magnum is positioned towards the back of the skull with the spinal cord exiting at the slight angle.

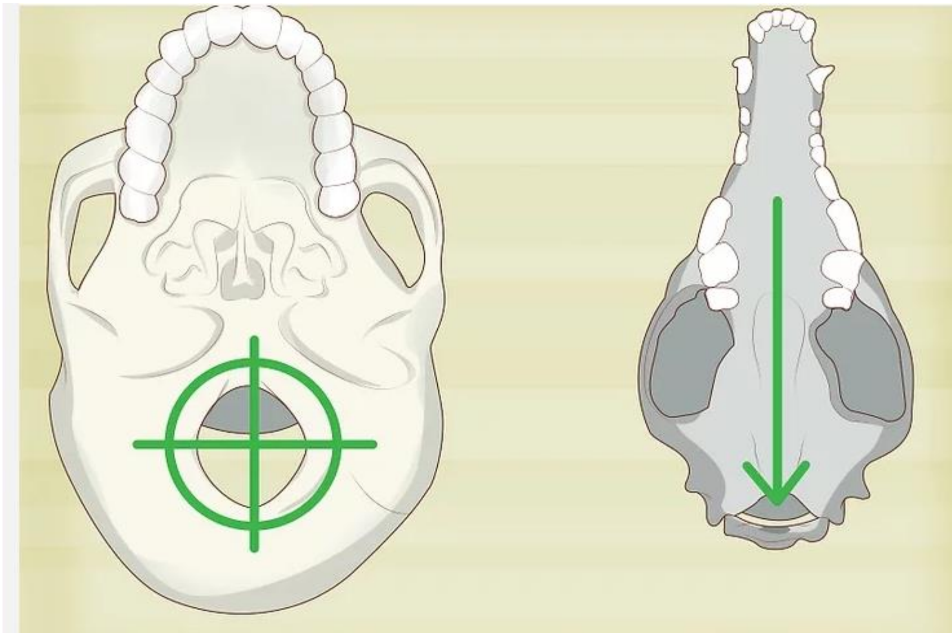


Fig 1b: position of foramen magnum in human and non human skull.

Some basic differences in human and nonhuman animal cranial anatomy are defined in table 1 below.

Table 1. Differential Skeletal Anatomy of Humans and Animals: Cranium of Human and cranium of Animal

Cranium of Human	cranium of Animal
• Large bulbous vault, small face	• Small vault, large face • Pronounced muscle markings, sagittal crest

• Vault relatively smooth • Inferior Foramen Magnum • Chin present • Orbits at front, above nasal aperture • Minimal nasal and midface projection • "U"-shaped mandible (no midline separation)	Inferior • Posterior Foramen Magnum • Chin absent • Orbits at sides, posterior to nasal aperture Significant nasal and midface projection • "V"-shaped mandible (separates at midline)

Table 2. Differential Skeletal Anatomy of Humans and Animals: Dentition

Human	Animal
• Omnivorous • Dental formula 2:1:2:3 • Incisors (maxillary) are larger than other mammals • Canines small • Premolars and molars have low,	• Carnivorous; Herbivorous; Omnivorous • Basic dental formula 3:1:4:3 • Horse maxillary incisors are larger than human incisors • Carnivores have large conical canines; Herbivores have small or missing canines

rounded cusps divided by distinct grooves	• Carnivores have sharp, pointed cheek teeth; Herbivores have broad, flat cheek teeth with parallel furrows and ridges

Much of the difference in long bone anatomy between non-human animals and humans is the result of pattern of locomotion. As quadrupeds (expect for birds), non-human animals have dual axes of orientation and their functional anatomy reflects structures of locomotion in all four limbs, lacks spinal curvature, has a long and narrow pelvis, and is additionally reflected in the posterior position of the foramen magnum and bony development of posterior of the cranium due to musculature. The scapulae are oriented more toward the spine (axial), compared to humans which are wider and oriented inferiorly. The ribs in humans generally display a more curved profile due to this difference in vertical versus horizontal orientation among quadrupedal animals.

Non-human animal forelimbs are generally more robust , and the radius and ulna may be fused to give more strength and flexibility in weight bearing. The tibia and fibula are also often fused, sometimes with diminished or completely lacking a fibula. Humans on the other hand, as bipeds, have a singular, central vertical axis of orientation that distributes all the individual's weight through a series of bony mechanisms designed to soften the impact of bipedal locomotion. As a result, human crania are centrally placed on the vertical axis, the spinal column has four slight opposing curves, the pelvis is broad and short, the femora are angled, the tibiae have thicker proximal surfaces for greater weight bearing, the feet have dual arch structures, and the upper limbs have less pronounced musculature and a greater range of motion (Gilbert *et al.* 1996, Watson *et al.*, 2018, McClelland *et al.*, 2018).

Although birds are also bipedal, bird bones are very different in shape from human bones, but they are additionally very light in weight. Bird long bones have very thin walls and only minimal trabecular structure in the ends.

Table 3: Differential Skeletal Anatomy of Humans and Animals: Post cranium

Human	Animal
• Upper limbs less robust • Radius and ulna are seperate bones • Large, flat and broad vertebral bodies with shout spinous processes • Sacrum with 5 fused vertebrae, short and broad • Pelvis is broad and short, bowl shaped • Femur is the longest bone in the body, linea aspera is singular feature	• Robust upper limbs • Radius and ulna are often fused • Small vertebral bodies with convex/concave surfaces and long spinous processes • Sacrum with 3 or 4 fused vertebrae, long and narrow • Pelvis is long and narrow, blade-shaped • Femur is similar length to other limb bones, linea aspera double or plateau

• Separate tibia and fibula • Foot is long and narrow, weight bome on heel and toes	• Tibia and fibula are often fused • Foot is broad, foot elements are dense and may have claws or hooves

Differences between the skeleton of Ape and human

1.**Chest / Rib Cage**

Humans have a broad chest that is flatter (front to back), placing the centre of gravity back towards the spine, helping us to stand more upright. Apes have a rounder, barrel shaped rib cage (Tsegai 2018)..

2. **Spine (Vertebral Column)**

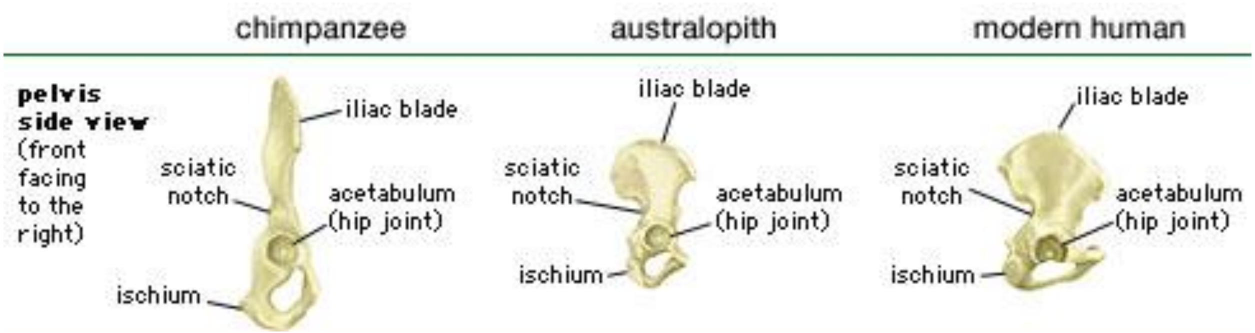
The human spine has an S shape that keeps the head and the torso above the centre of gravity. It also acts a little like a spring to absorb force or jarring during activity.

Vertebral column of monkey is arched in the shape of C, while vertebral column in human is in the form S.

3. Vestigial tail bone coccyx

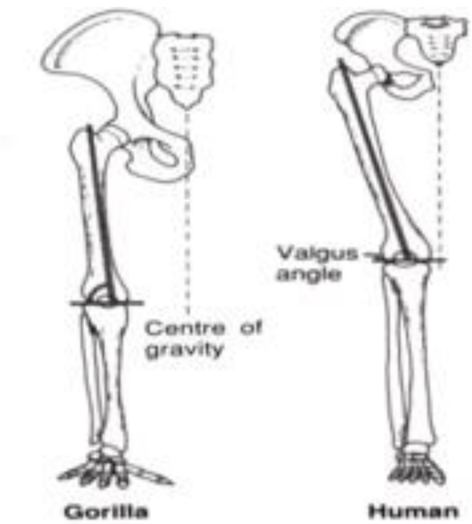
it is present human skeleton, but skeleton of monkey displays a series of tail vertebrae.

Number of lumbar bones more in skeleton of monkey, which are only five in case of human skeleton.



4. **Pelvis**: Humans have a much broader pelvis giving stability when walking upright as it transfers the weight directly to the legs. Humans have a more 'bowl shaped' pelvis to better support the organs above.

5. Femur (thigh bone): Bipedal standing increases the weight on each leg, and the area of the **joint surfaces** of the femur (upper leg bone) reflects this. This photo shows the femur from a chimp (left) through to that of a modern human (right). The intermediates represent different Hominin species (in chronological order). You should be able to see that the top of the femur increases in size, which reflects the increased weight load on the joint as humans spent more time walking on two legs and grew larger in size.



6.Knee -Valgus angle

Humans also have a **larger valgus angle**; the angle the femur makes at the knee. This means that our thighs slope inward (we are 'knock-kneed') bringing our feet in closer to the centre of gravity. This means that we shift less weight when walking, making it more efficient. Apes have a much smaller valgus angle and when they attempt to walk on two legs, they waddle (try walking with your feet at shoulder length apart. Humans also have **wider femoral condyles** (the point on which the bone pivots) to prevent sideways movement of the knee (Ryan *et al .*,2017).

7.Feet

Apes tend to be flat footed (have plantigrade feet). Human have arched feet, supported by ligaments on the underside of the foot. These prevent the arch from collapsing and act like springs, which are stretched, thus storing energy, when the foot comes down. This helps to catapult the body upwards again. Apes have prehensile (grasping) feet with a sideways facing big toe. Humans have a forward facing big toe to provide extra final thrust when walking. The phalanges (toe bones) are curved in apes to aid grasping (Jaiswal,2019).

8.The tibia and fibula;

They are separate in humans while they are fused together in other animals

9. Upper limbs; Humans have shorter upper limbs. Some animals have longer upper limbs and some don't.

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10. **Hands**: As apes developed the habit of brachiating, the thumb became reduced, using the fingers more as hooks. In humans however, the thumb is enlarged. More significantly the first metacarpal (hand bone at base of thumb) is connected to the wrist by a 'saddle' joint, which enables the thumb to be brought across the hand so that it can touch the tip of the first or any other finger. Humans are the only ape which can achieve the full thumb tip to finger tip **precision grip**. Humans also have an independent muscle / tendon dedicated to flexing the last joint of the thumb (apes cannot flex their thumb independently). Lastly, the bones of the finger tip have an enlarged apical tuft, which increase the surface of the finger tip for grasping fine objects (Georgiou *et al.*, 2019) .

2.Bone Macrostructure

Most human bones differ structurally from non-human animals because of evolutionary shifts to increased gracility, which began with our earliest Homo ancestors more than a million years ago. It is largely hypothesized that body size increased at the origin of our genus but became lighter to balance the energy demands of larger brains and bodies. The major difference between human and nonhuman animal bone structure therefore principally relates to density. Nonhuman animal bones have a greater density relative to size; they are less porous and are thicker in cross section than the bones of humans. For example, in human humeral and femoral cortical thickness is about a quarter of the total diameter compared to about half of the total diameter in animal limb bones.

Trabecular bone is largely absent from the interior of non-human animal leg bone diaphyses, resulting in a very smooth medullary surface compared to the web of trabecula covering the medullary surface in human long bones (Fig. 15). Human cranial vault bones have thick diploe relative to cortical (tabular) bone compared to the thin, more compact vault bones of nonhuman animals. Some basic differences in non-human animal and human bone macrostructure are defined in Table 4.

Table 4. Differential Bone Macrostructure of Humans and Animals

Human	Animal
• More porous cortical bone • 1/4 thickness of diameter of long bone • Diaphyseal trabecula present	• Less porous cortical bone • 1/2 thickness of diameter of long bone • bone Diaphyseal trabecula absent

• Thick diploe in cranial vault bones	• More compact cranial vault bones

2) Bone Microstructure

In the histological examination of small non-diagnostic bone fragments, human cortical bone may be positively differentiated from certain nonhuman species. These species include the smaller mammals of rat, cat, dog, hare, badger, and racoon dog, and the larger mammal of deer. This differentiation is based on differences in the general appearance of cortical bone tissue and the size of histological microstructures, namely Haversian system diameter, Haversian canal diameter, and Haversian system density. Where plexiform bone tissue is present, differentiation of human from nonhuman cortical bone is also possible as humans do not exhibit this type of primary bone tissue (early fetal bone and periostitic bone). Other mammals, including the larger species of goat, sheep, cow, pig, horse, and water buffalo, can be successfully differentiated from human cortical bone when plexiform bone tissue is present. However, where plexiform bone tissue is absent, due to peri- and postmortem alteration, differentiation may not be successful due to commonly shared cortical bone Haversian tissue microstructure. Hence, attention to the preservation of the bone fragment is important. Nonhuman primates share similar cortical bone histology, namely Haversian bone tissue, with humans and cannot be successfully differentiated from human bone. The overall recommendation that can be made for the differentiation of human cortical bone from nonhuman bone is the use of bone microstructure type for primary differentiation. The presence of plexiform bone tissue positively identifies bone fragments as nonhuman and its identification would negate further forensic investigation. The examination of Haversian bone tissue for this purpose should include an assessment of the overall appearance of the tissue and an evaluation of the size of Haversian tissue microstructures. Where Haversian bone tissue is identified, while it is human in arrangement, it is not, and has not been to date, demonstrably uniquely human as it is exhibited by nonhuman mammals in a similar appearance and with similar-sized histological structures. Histomorphometry may be successfully applied and the measurements considered of most use are Haversian system diameter and Haversian canal diameter. Haversian system density, while not as comparably useful, does provide an upper and lower limit for human identification. Human identification beyond these metric parameters is therefore deemed not currently possible.

Human Bone Tissue Microstructure

The typical appearance of a cross-section of an adult human long bone consists of circumferential lamellae bone at the endosteal and periosteal surfaces and a middle component of dense Haversian bone (carrie, 2002). Approximately 50% of this dense Haversian bone consists of Haversian systems while the other 50% consists of interstitial lamellae, occurring at irregular angular spaces between Haversian systems. The Haversian systems appear as both complete and active systems. The complete systems are comprised of a central Haversian canal, often off-centered in position, surrounded by 16–20 cylindrical lamellae with an outer border consisting of a cement line (klevezal,1996). These systems are commonly oval or round in shape. The active Haversian systems, or remodeling units, differ in appearance to that of complete Haversian systems. Depending on where the cross-section intercepts the active Haversian system on its course of formation, three different appearances may be seen: (1) a resorptive bay (also referred to as a cutting cone) bordered by Howship's lacunae; (2) a forming site, with osteoblasts bordering a varied amount of freshly deposited, unmineralized bone that is contained within a cement line; or (3) a complete Haversian system. The circumferential lamellae appearing at the periosteal and endosteal surfaces are often times fragmentary, with the number of periosteal lamellae generally exceeding that of endosteal lamellae. Volkmann's canals may also be seen on a thin section of bone and run perpendicular to the Haversian canals. While the cortical bone tissue of other shaped bones, such as flat (cranial) and short (vertebra), contain the same histological structures as long bones, their histological appearance may differ. Biomechanical forces, among other factors, influence and/or govern the shape and arrangement of bone. Accordingly, the longitudinal forces acting upon long bones that result in longitudinally oriented Haversian systems would be absent on flat and short bones, resulting in Haversian systems that are often irregular in shape.

Nonhuman Mammalian Bone Tissue Microstructure

The nonhuman mammalian species include: rat, hare, badger, raccoon dog, cat, dog, pig, goat, sheep, cow, deer, horse, water buffalo, bear, and nonhuman primates.

(Maria L and Lynne S , 2007) described the nonhuman bone microstructure as follows:

Brown Rat—Rattus norvegicus

The histological appearance of rat long bone cortical bone is comprised mainly of primary longitudinal bone tissue. Haversian systems do appear; however, these systems are rare and scattered near the endosteal surface. Endosteal and periosteal circumferential lamellae are also present, but are poorly developed at the endosteal surface due to the presence of Haversian systems here. Additionally, there may be small areas of avascular and acellular bone located throughout.

Hare—Lepus americanus (Snowshoe Hare); Lepus oryctolgus (European Hare)

The long bone and rib cortical bone of skeletally mature hare consists primarily of dense Haversian bone tissue with small Haversian canals. A wide ring of periosteal circumferential lamellae and a thinner, irregular ring of endosteal lamellae surround a middle component of dense Haversian bone. Remnants of primary longitudinal tissue with scattered primary osteons may be present in younger individuals .

European Badger—Meles meles

Cortical bone tissue of badgers is very similar to that of raccoon dogs in terms of the types of bone tissue present, primarily dense Haversian bone tissue. Differences are noted between the size and shape of Haversian systems; in badgers, these systems vary in shape from round to elliptic, are present in various sizes, and contain three to eight lamellae.

Raccoon Dog—Nyctereutes procyonoides

The long bone cortical bone of mature raccoon dogs consists primarily of dense Haversian bone. This tissue contains similar-sized and round-shaped Haversian systems with three to five lamellae. Remnants of primary reticular and radial bone tissue may be present near the periosteal surface, especially in younger animals.

Cat—Felis silvestris catus

Rib and long bone cortical bone of the common cat is composed of dense Haversian bone. Most Haversian canals within this secondary bone are very small and Volkmann's canals are more numerous than in any other similar-sized mammal. Circumferential lamellae consist of a thin layer at the periosteal surface and a thicker, well-developed layer at the endosteal surface.

Dog—Canis lupus familiaris

The cortical bone of the ribs and long bones of mature dogs is predominantly composed of dense Haversian bone. Periosteal and endosteal circumferential lamellae bone is well developed but often interrupted by scattered Haversian systems. Haversian systems are present in various shapes with Haversian canals classified as small. In immature dogs, remnants of osteonal banding and plexiform are present, particularly at the periosteal surface.

Pig—Sus scrofa

Femora of skeletally mature pigs consist primarily of plexiform bone with dense Haversian bone located at the posterior portion of the bone. Haversian canals are mostly medium in shape. The cortical bone of immature pig femora consists of layers of lamellar bone alternating with primary tissue containing osteonal banding. These bands, appearing in twos or threes, contain five to 20 primary osteons and are present near the endosteal surface along with the lamellar bone. The remainder of the femoral section consists of plexiform bone. Plexiform bone may also exist throughout an entire long bone section within immature pigs, with a complete absence of Haversian tissue or osteonal banding.

Goat—Capra aegagrus hircus

In mature goats, the long bone cortical bone consists of both plexiform and Haversian bone tissue. Plexiform bone, with scattered areas of Haversian tissue, is present near the periosteal surface; a mixture of Haversian tissue with large, sporadic Haversian systems and primary tissue is present in the mesosteal zone component and dense Haversian tissue is located near the endosteal surface. The layers of circumferential lamellae at the endosteal and periosteal surfaces commonly appear as narrow rings. Immature specimens will more likely display copious amounts of plexiform tissue as the primary tissue of growth.

Sheep—Ovis aries

The histological appearance of the long bone cortical bone of mature sheep is similar to that of goats. Ribs of mature sheep also display a mixture of secondary and primary tissue, with Haversian tissue serving as a replacement for plexiform tissue. The Haversian canals within the secondary tissue are classified as medium in size and irregular in shape. Immature sheep exhibit plexiform bone throughout entire sections of femora, with a potential for a small number of scattered Haversian systems located posteriorly.

Cow—Bos taurus

The cortical bone of immature cow rib consists of plexiform bone near the periosteal surface, Haversian bone located near the endosteal surface, and osteonal banding at the interface between both. Haversian canals are medium in size and irregular in shape. Fetal calf femora also exhibit the same pattern: plexiform bone tissue near the endosteal surface, a middle portion of laminar bone with an irregular arrangement, and a periosteal area of Haversian bone.

Deer—Odocoileus virginianus

At different ages, deer long bone cortical bone consists of different quantities of plexiform and Haversian bone tissue. In immature individuals, plexiform bone is dominant near the periosteal surface, with Haversian bone forming near the endosteal surface. Long bone cortical bone of skeletally mature individuals consists predominantly of dense Haversian bone as it replaces the plexiform bone, especially near the endosteal surface and posterior portion of the bone. A thin layer of periosteal circumferential lamellae bone surrounds mature bone in all locations. For fetal and new-born deer, long bone cortical bone consists of primary reticular and plexiform tissue with areas of avascular and acellular bone.

Horse—Equus caballus

Generally, horse long bone cortical bone consists of dense Haversian tissue with remnants of the primary reticular and plexiform tissue. Large numbers of resorptive spaces exist near the endosteal surface. Circumferential lamellae at the periosteal and endosteal surfaces are often thin and fragmentary due to the spread of Haversian bone to this area. The cortical bone of the rib is composed of a very thin layer of periosteal circumferential lamellae surrounding an internal structure of dense Haversian bone. Foal cortical bone consists primarily of plexiform bone with an alternating concentric pattern of rows of ‘‘pseudoosteons’’ with Haversian canal-like structures. The ‘‘pseudo-osteons’’ differ histologically from Haversian systems as they contain woven bone.

Water Buffalo—Bubalus arnee

Water buffalo long bone cortical bone contains both plexiform and Haversian bone tissue. Plexiform bone is located near the periosteal surface and anterior in the bone, while Haversian bone is located toward the endosteal surface and posterior in the bone.

Chimpanzees—Pan troglodytes

Juvenile chimpanzees (2.0–15.3 years of age) exhibit cortical bone histology similar to juvenile humans (0–15 years of age) while differences include more secondary bone tissue in the chimpanzee cortical bone in comparison with humans, attributed to an accelerated rate of primary bone replacement. Also important to note is an increase in the number of Haversian systems in the femur as compared with the tibia and fibular of juvenile chimpanzees.

Old World Monkeys—Cercopithecidae

Included in this family of monkeys are baboons, mangabeys, mandrills, and macaques. Generally, the long bone cortical bone of skeletally mature individuals will consist of dense Haversian bone, with thin layers of endosteal and periosteal circumferential lamellae. Immature individuals, on the other hand, will display more primary longitudinal tissue, with the development of Haversian tissue beginning near the endosteal surface.

Rhesus Macaques—Macaca mulatta

The histological appearance of the long bone cortical bone of skeletally mature macaques consists of dense Haversian bone with thin layers of circumferential lamellae near the endosteal and periosteal surfaces. Immature individuals may exhibit long bone cortical bone comprised solely of primary longitudinal tissue or primary tissue with areas of replacing Haversian bone.

New World Monkeys—Platyrrhines

Including the squirrel, spider, and capuchin monkey inhabiting Central and South America, these primates display long bone cortical bone tissue similar to that of Old World Monkeys. This includes the display of Haversian bone in skeletally mature individuals, with remnants of primary longitudinal bone in younger individuals. Thin circumferential lamellae exist near the endosteal and periosteal surfaces.

Osteons in human trabecular and cortical bone are scattered and evenly spaced whereas in many non-human animal's osteons tend to align in rows (osteon banding) or form rectanguloid structures (plexiform bone). Although osteon banding or plexiform bone indicate non-human animal bone, Ubelaker (1999) cautions that considerable variety exists between species and between bones of the same non-human animal which therefore makes the identification of scattered osteon distribution inconclusive.

Differentiating human versus non-human bone by exploring the nutrient foramen:

This technique is based on the macroscopic and computed tomography (CT) analysis of nutrient foramina (Black *et al*.,2010). The nutrient foramen of long bone diaphyses transmits the nutrient artery which provides much of the oxygen and nutrients to the bone. The nutrient foramen and its canal were analysed in six femora and humeri of human, sheep (Ovies aries) and pig (Sus scrofa) species (Hiller ML *et al*.,2007).

The location, position and direction of the nutrient foramina were measured macroscopically.

The length of the canal, angle of the canal, circumference and area of the entrance of the foramen were measured from CT images (Saulsman B *et al.*, 2010). Macroscopic analysis revealed the femora nutrient foramina are more proximal, whereas humeri foramina are more distal. The human bones and sheep humerus conform to the perceived directionality, but the pig bones and sheep femur do not (Piga G *et al.*, 2013). Amongst the parameters measured in the CT analysis, the angle of the canal had a discriminatory power.

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