Mammalogy (BIOEE 451)
Lab 4 – Mammalian locomotion I
Mammalian Diversity: Orders Cingulata, Pilosa, Scandentia, Dermoptera, Primates

Business:

1. **Return practical –** The practical is graded. Scores ranged from 70 to 96. Overall I thought it went well, but if you are not satisfied with your score and want to do better next time, please feel free to talk to me about how you might better prepare for the next practical. Also, remember that you are welcome to take advantage of lab time (after you finish the current lab) to review material from previous labs.
2. **Field journals –** Your next journal due date is March 30. You should have 4 weeks' worth of entries when you turn your journal in again.
3. **Today's lab –** Note that some specimens are placed at one station, but relevant to others as well. If the lab handout mentions a specimen that is not in front of you, look around to find it at another station. This is particularly true for material shared between station 3 and the diversity section.
4. **Life of Mammals –** Today's Life of Mammals viewing will emphasize the xenarthrans and primates. As you watch, also pay close attention to the modes of locomotion that these animals employ. We will be studying these during this lab and next week.

Goals for this lab:

1. Understand the morphological adaptations that have evolved in different lineages to allow for different types of locomotion: walking/running, digging, climbing, and brachiation
2. Learn about the Orders Pilosa, Cingulata, Scandentia, Dermoptera, and Primates; be able to identify representatives of the major families; understand major life history characteristics and morphological adaptations

<u>Station 1: Terrestrial Locomotion – walking/running (appendicular skeleton)</u>

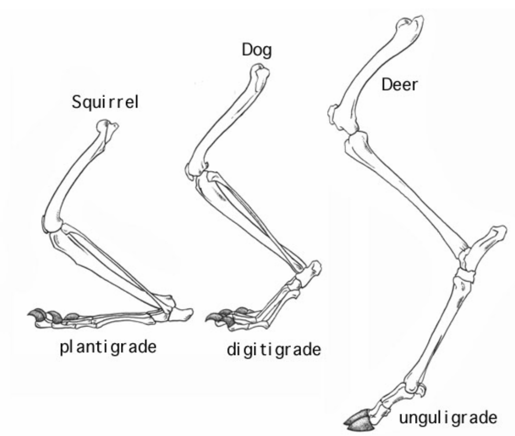
(Martin et al. – Chapter 7)

Few aspects of an animal's natural history have a greater influence on form and function than how they get around. The method of locomotion that a species employs is usually tightly linked to its trophic ecology, skeletal morphology, posture, and strategies for avoiding predation. Because the majority of mammals spend at least part of their lives on the ground, numerous strategies for locomotion have evolved to enable them to move about on a (mostly) two-dimensional landscape. Today we will examine the limbs of mammals that employ the most common of these strategies: walking (**ambulatory locomotion**) and running (**cursorial locomotion**).

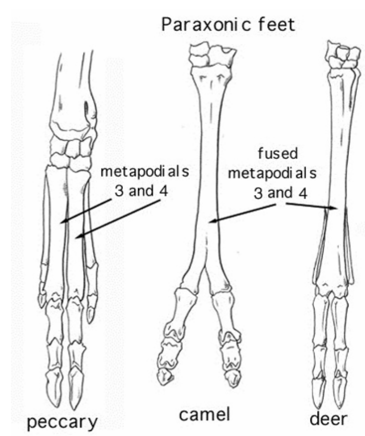
As we have already mentioned, the ancestral condition for mammalian locomotion is a wide stance with the limbs projecting laterally. The platypus skeleton at this station offers an excellent example of this primitive, reptile-like posture. The waddling walk of these ancient mammals is not particularly efficient since muscles are required to move each limb forward and backward with every step. The evolution of limbs that descend straight down from the body (found in metatherians and eutherians) was a big step forward in locomotor efficiency. Such limbs are pendular, using gravity and the body's momentum to help move the limb with each stride.

The platypus also provides a good look at the ancestral condition of mammalian foot posture. In this state, all the bones of the feet, from the tarsals/carpals to the phalanges, are pressed against the ground as the animal walks. This foot posture is termed **plantigrade**, and is typically seen in ambulatory species with five digits on each foot. Plantigrade feet are found throughout Mammalia, from monotremes to marsupials, rodents to humans.

- Examine the platypus and pangolin skeletons. Compare the different positions of the limb bones relative to the body, and identify the phalanges, metatarsals/metacarpals (**metapodials**), and tarsals/carpals (**podials**). You should be able to see that all the bones of the feet lie close to the ground. In an animal that is walking, all the bones in the feet would strike the ground with each step. Note that only the pangolin's hind limbs are plantigrade. Its forefeet are typically held off the ground in front of it as it walks, although it also may walk on the knuckles of its forefeet with its claws curled inward and up (anything to avoid chipping a nail!).

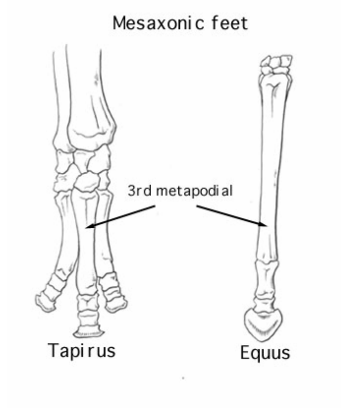


Plantigrade feet provide good stability, but they are not ideal for animals that are in a hurry. Cursorial species have evolved the ability to run swiftly by either increasing the length of their strides or by increasing the stride rate. There are several ways to lengthen a stride. As any sprinter knows, one simple way to do this is to stand up on the balls of your feet. Such a foot posture, in which the weight rests predominantly on the phalanges, is termed **digitigrade**. Many mammals are permanently digitigrade, including canids (dogs) and felids (cats). In these animals, the stride is often further lengthened by elongation of the metapodials, and some digits may be lost or reduced.



- Compare the cat and dog skeletons at this station. How many digits are found in each? Do all the digits touch the ground? Identify the bones of the feet, and note which bones are elongated, greatly increasing the length of each limb and the overall stride length.
- Take a look at the elephant foot again. Remember that the bones sit on a fibrous cushion. Elephants have also been described as digitigrade. Do you agree?

Unguligrade mammals take this strategy of lengthening stride to the extreme. These animals (e.g., equiids, cervids) literally walk on their toenails (i.e., hooves). Unguligrade limbs are highly modified. Typically the radius/ulna and tibia/fibula bones are fused together and the number of digits may be greatly reduced. In cervids (deer) and other cloven-hoofed animals, which retain two digits on each foot (digits 3 and 4; this type of foot is termed **paraxonic**), the paired metapodials elongate and may fuse to form a single **cannon bone**. Equids (horses), which walk on a single digit (the 3rd; recall that this type of foot is termed **mesaxonic**), have a cannon bone that consists of a single long metapodial and the remnants of digits 2 and 4.



- Examine the limbs of the horse and the cloven-hoofed artiodactyl at this station. Note the unguligrade foot posture. Identify the podials, metapodials, and phalanges. Are the metapodials fused in the artiodactyl? Can you identify the remnants of the 2nd and 4th digits in the horse limb? What advantage does the fusion of distal bones offer for a cursorial mammal? What do these animals lose through the fusion of these bones?

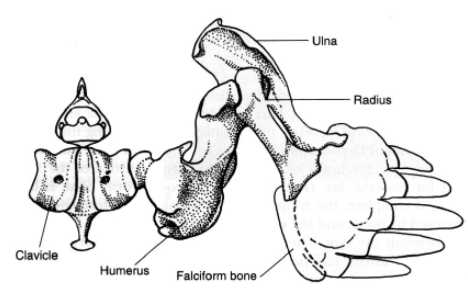
Aside from lengthening the limb elements and standing on the tips of their digits, cursorial species can also increase the length of their stride by freeing the scapula to move with the limb. Rather than lying horizontally against the dorsal surface of a broad rib cage (as in humans), the scapula is positioned vertically, lateral to a deep, narrow rib cage and in the same plane as the forelimbs. During locomotion the scapula swings forward and back with each step. This motion is clearly visible in cursors such as dogs and cats (unfortunately our articulated skeletons are immobile), and ungulates. To free up the scapula's range of motion, the clavicle is often reduced in size in cursorial mammals. Ungulates have lost this bone entirely.

- Note the small size of the cat clavicle. Keep this in mind as you study other skeletons during this lab (e.g., mole, primates).

<u>Station 2: Terrestrial locomotion – digging</u>

We have already discussed adaptations for a digging (**fossorial**) lifestyle in previous labs (e.g., rostral shield, large claws on forefeet, fusiform shape, reduced/absent pinnae, thick fur, vestigial eyes), so we will not dwell on this topic for long. The strong selective pressures applied to animals that fill this niche have resulted in extraordinary morphological convergence in several divergent lineages, which is exemplified by the marsupial moles (Family Notoryctidae) and golden moles (Family Chrysochloridae) and to a slightly lesser extent the "true" moles (Family Talpidae) which we have yet to examine in detail. Today we will take a close look at the skeletal morphology of a talpid mole to see what adaptations have developed beneath the skin to enable fossorial species to exploit their unique niche.

- Compare the mole skeleton to that of the pocket gopher (*Thomomys*), another burrowing mammal of similar size that has not undergone the same degree of specialization. Beginning at the anterior end of the mole, note the narrow, dorso-ventrally flattened skull, which presumably minimizes resistance as the mole digs through soil. The pectoral



Eastern mole
(*Scalopus aquaticus*, Talpidae)

Station 3: Arboreal locomotion – climbing and brachiation

Not all mammals live on the ground, of course. Many have evolved to occupy the three dimensional worlds of forests and rocky cliffs. Animals that climb are referred to as being **scansorial**. Most scansorial animals are **arboreal**, meaning that they spend much of their time in trees, but scansorial animals need not be arboreal, nor vice versa. Scansorial mammals gain several advantages by climbing, including access to food resources, protection from ground predators, improved field of view, sheltered nest sites, and faster routes of travel.

When we consider the diverse strategies that are used to enable mammals to climb, it is easy to overlook a simple and critically important issue: friction. Friction is a climbing animal's best friend, enabling it to hold a position on or push off from a vertical tree trunk or rock wall. As such, most animals that are adept climbers have adaptations to maximize friction at points of contact with the substrate. Scansorial mammals typically are plantigrade, which increases the surface area of the feet. They usually have soft and supple pads on their hands and feet, which improve friction by molding to the shape of the substrate and increasing the number of points of contact. Some animals have bulbous pads at the tips of their digits which likely improve dexterity and grip (e.g., tarsiers, bushbabies). Many mammals with prehensile tails have hairless pads on their tails. Tiny, even microscopic, folds and ridges on the pads may also increase friction.

- If you did not do so last week, take a close look at the sensitive foot pads of the tree hyrax. Recall that hyraxes improve their footing by keeping these pads moist and supple with special sweat glands in the feet. Special muscles lift the center of each foot, giving them the ability to apply suction to the surface on which they are walking.
- Examine the ethanol-preserved hand, foot, and tail of the New World monkey. Note the sensitive and large hairless pads on each of these appendages, and the complex ridges on the pads that help to increase friction. Also note the opposable thumb and the hook-like position of the digits.
- Examine the pads at the tips of the digits on the ethanol-preserved tarsier.

For many arboreal mammals, the ability to grasp branches and tree trunks allows them to move more efficiently through the treetops than they could run on the ground. Sloths accomplish this by hooking their long, curved claws over tree limbs and hanging from them. Since their claws act as passive hooks, they expend no energy to maintain their position. This is important, since their leafy diet does not provide them with many calories.

- Examine the enormous half circle claws that enable the sloth to suspend itself. These claws belonged to a two-toed sloth named Roscoe. He lived in Corson Hall for years with a blanket and a rocking chair. He was happy until the Institutional Animal Care and Use Committee (IACUC) took his blanket and rocking chair away. They say he died of a broken heart.

Prehensile tails are another fascinating adaptation to an arboreal existence that has evolved multiple times in mammals, including opossums, monkeys, anteaters, pangolins, rodents, and the kinkajou. Prehensile tails may be used simply to aid in climbing, or they may be strong enough to support the full weight of the animal. They are generally long and sensitive and curled at the tip (usually ventrally, though a porcupine with a prehensile tail curls dorsally). Non-prehensile tails may still be useful for climbing by aiding in balance. Watch a squirrel run through the trees and you will quickly see that it is moving its tail very deliberately to counterbalance its weight.

- The Virginia opossum is one of the few North American mammals with a prehensile tail. Examine the tail of the skeleton and compare it to the prehensile tail of the pangolin at station 1 and the howler monkey at station 4. Do you see any common patterns?

Primates excel at grasping and climbing in an arboreal environment, and they have several adaptations that reflect this lifestyle. First, relative to other animals, their long limbs give them excellent length of reach. As discussed in lecture, this reach is not accomplished by elongating the podials, metapodials, and phalanges as they are in digitigrade and unguligrade mammals. Rather, the limb bones (femur, humerus, tibia/fibula, radius/ulna) elongate (e.g., see the gibbon skeleton at right). The bones of the feet and hands are instead modified to increase their gripping ability. These bones tend to be loosely attached to one another, giving hands and feet extraordinary flexibility and dexterity.

Furthermore, limbs must be able to go through the maximum possible range of motion at every joint. In contrast to cursors, whose hinge-like leg joints limit the limbs to a forward and backward motion, primates have ball and socket joints that enable the arms and legs to rotate freely at wide angles to the body. This freedom of movement is accomplished without requiring the scapula to be involved, so a relatively robust clavicle connecting the scapula to the sternum is usually present. The paired tibia/fibula and radius/ulna bones are more roughly equivalent in size and loosely attached, allowing them to move against each other as the limbs twist. In the most arboreal species (e.g., gibbons), the wrist joint is so loosely articulated that the animal can spin its body around the wrist without twisting its arm.

- Examine the articulated skeletons of the New World (howler) and Old World (rhesus) monkeys at the diversity station. Can you identify the skeletal modifications that enable primates to inhabit the trees? Compare these skeletons to the others that you have already examined (platypus, pangolin, dog, cat). How do they differ?
- Look at the hind feet of the squirrel monkey. Do you see how one foot is twisted around so that it actually aims backwards? This reflects the great flexibility of wrist and ankle joints that many arboreal species share. The ability to rotate hind feet allows arboreal mammals to run down a tree trunk as fast as they can run up it. Watch a squirrel come down a tree and you will see the same twisting of the ankles.
- Consider your own body. As a primate, what skeletal characteristics do you have that would enable you to move into an arboreal environment? How large a range of motion do your limbs have? Can you rotate your wrist without allowing your radius and ulna to move? What about a grasping hallux?

Most animals that grasp with their hands and feet have an opposable pollex and hallux, respectively (recall that the koala is an exception – it grasps with the first two digits opposing the last three, resulting in a stronger grip). The size of the gap between the first and second digits and the angle to which they can open varies tremendously. In some species the gap is enlarged through the reduction of the second digit (e.g., lorises and pottos), yielding a wide and powerful clamp.

- Examine the forefeet of the loris at the diversity station. Can you see the shorter second digit? Also, while you are looking at the loris, note the grooming claw on the second digit of the hind feet. This important character identifies this animal as belonging to the Suborder Strepsirhini (see diversity).

As primates diversified into arboreal niches, they developed an entirely new form of locomotion: brachiation (arm swinging). Rather than running along branches, a brachiating monkey travels beneath them, swinging along hand-over-hand exactly as you would swing beneath a jungle gym. The undisputed champions of brachiating are the gibbons, who can race through the treetops with their long arms, covering distance at a rate of 3 meters per swing. They use gravity and their own momentum to increase their velocity, much in the same way that a person on a swing pumps to swing higher and higher. There are several skeletal adaptations for brachiation. The olecranon process (elbow) of the ulna is reduced, allowing the arm to straighten fully. The ulnar styloid in the wrist is reduced, making the wrist more flexible. The clavicle is long and relatively robust, increasing rigidity in the upper torso.

- While we don't have a gibbon for you to look at, examine the two monkey skeletons to look for the features mentioned above. How do these skeletons compare to the other skeletons available? Which of these would you predict to spend more time in the trees?

Life in a three dimensional environment, where one wrong step could mean a long and potentially fatal fall, requires a sensory and neurological system that is able to read and interpret a very complex environment. The ability to judge distances is key. For this reason, primates and other arboreal species have highly developed binocular vision, providing excellent depth perception. The importance of visual information is most apparent in nocturnal species. Unable to navigate the trees without visual input, nocturnal species have evolved various strategies to maximize the light that it is available, such as the tapetum lucidum in strepsirhine primates or the incredibly enlarged eyes of the tarsiers. The latter surely must win the prize for greatest eyeball to braincase volume ratio among mammals.

- Take a look at the impressive eyes of the tarsier. The top of the skull has been removed, but you can still see the enormous orbits that dominate the cranium.

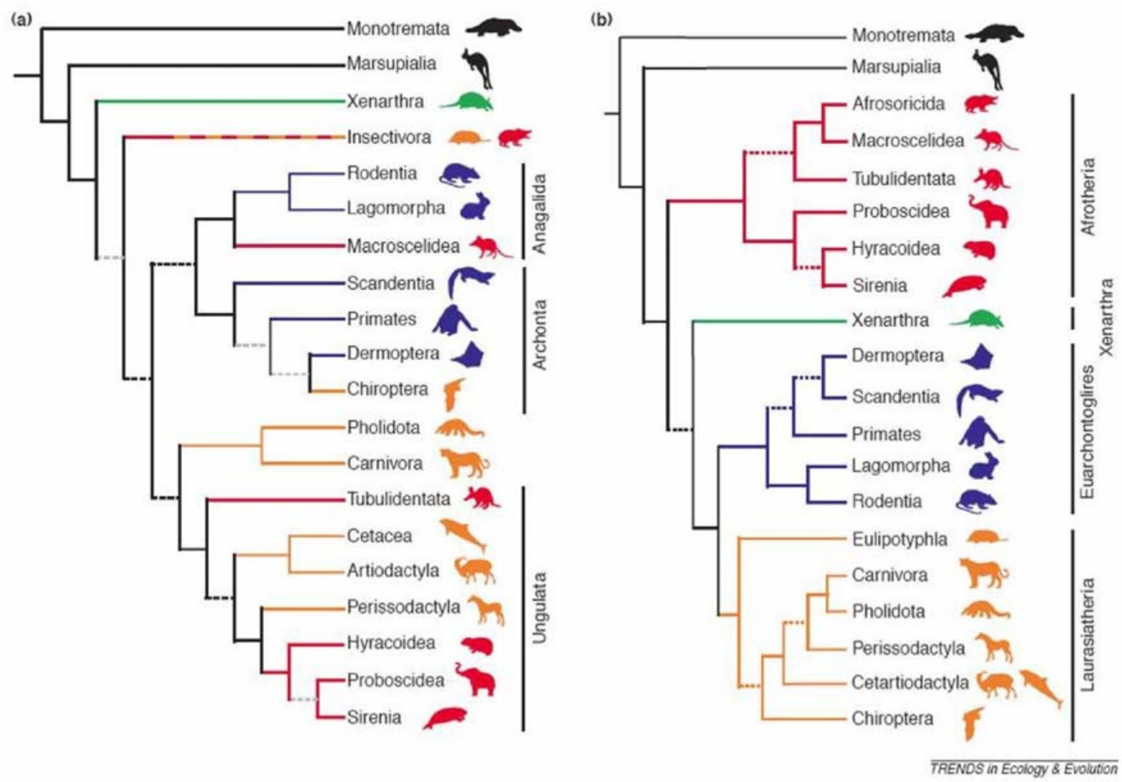
<u>Station 4 – Mammalian diversity – Cingulata, Pilosa, Dermoptera, Scandentia, and Primates</u>

(Martin et al. – Chapter 13, 15, 16, 17; Vaughan et al. – Chapter 9, 10, 11)

Note – if you have questions about the geographic distributions of these animals, consult the world map. Also, remember that you are only responsible for the taxa listed in bold-faced type.

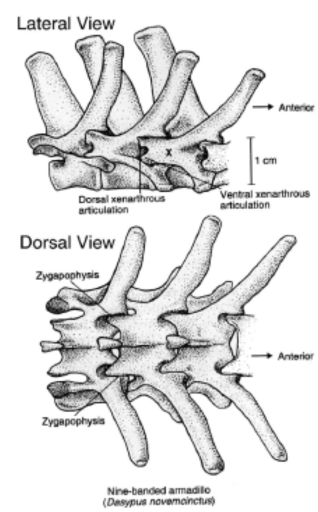
Classification: Class Mammalia

- **Subclass Eutheria**
  - Superorder Xenarthra
    - **Order Cingulata**
      - **Family Dasypodidae**
    - **Order Pilosa**
      - Suborder Folivora
        - **Family Bradypodidae**
        - **Family Megalonychidae**
      - Suborder Vermilingua
        - **Family Cyclopedidae**
        - **Family Myrmecophagidae**
  - Superorder Euarchontoglires
    - **Order Scandentia**
      - **Family Tupaiidae**
      - Family Ptilocercidae
    - **Order Dermoptera**
      - **Family Cynocephalidae**
    - **Order Primates**
      - Suborder Strepsirrhini
        - Infraorder Lemuriformes
          - Family Cheirogaleidae
          - Family Lemuridae
          - Family Lepilemuridae
          - Family Indriidae
        - Infraorder Chiromyiformes
          - Family Daubentoniidae
        - Infraorder Lorisiformes
          - **Family Lorisidae**
          - **Family Galagidae**
      - Suborder Haplorrhini
        - Infraorder Tarsiiformes
          - Family Tarsiidae
        - Infraorder Simiiformes
          - **Family Cebidae**
          - Family Aotidae
          - Family Pitheciidae
          - **Family Atelidae**
          - **Family Cercopithecidae**
          - Superfamily Hominoidea
            - Family Hylobatidae
            - Family Hominidae



Mammalian phylogenies based on morphological (a) and molecular (b) data.

As we move through the mammal phylogeny (Fig. B on the next page) we leave the Afrotheria behind and take a brief detour through the xenarthran mammals (Cingulate and Pilosa), before delving into the clade that includes our order (Primates) and the orders that are most closely related to us (Dermoptera and Scandentia). Recall from lecture that the xenarthran mammals include a diverse array of mammals, from the leaf-eating sloths to the insect-eating armadillos and anteaters. These animals are united by the fact that they all have xenarthrous ("strange joint") articulations in their vertebrae (at least in the lumbar region; see the figure of the armadillo vertebrae below). These extra articulations act to stiffen the spine. The xenarthrans share other characteristics as well, including cheek teeth without enamel, absent incisors and canines, and low metabolic rates. Keep these characteristics in mind as you study the specimens at this station.



Order Cingulata, Family Dasypodidae

Distinguishing characters:	jointed, bony armor scutes made of dermal bone; keratinized plates cover the dermal bone; homodont (peg-like) dentition varies widely in number; fused tibia/fibula; large claws for digging; complete zygomatic arch (contrasts with sloths and anteaters)
Number of species:	21
Representative species:	Nine-banded armadillo, *Dasypus novemcinctus* (only

	species in United States)
Geographic distribution:	central United States to South America
Diet:	primarily insects, some eat carrion and plant material
Habitat:	savannah, pampas, arid desert, forests
Behavior:	usually solitary or in pairs; terrestrial, though some can swim; all burrow
Size:	80 g – 60 kg; 15 – 150 cm
Reproduction:	1 litter of 4-12 young per year
Lifespan:	12-15 years
Other notes:	armadillos are protected from predators by their armor – some can roll into an armored ball, though most simply pull their head into their shell and try to prevent their soft underside from being exposed

- Examine the empty "shell" of the nine-banded armadillo. Does it have nine moveable bands? The number of moveable bands is actually not a good species-level identifier, since there is substantial intraspecific variation in the trait. Though this shell is empty, it approximates the defensive posture of this species. Identify the keratinized plates overlaying the dermal bone.
- The panniculus carnosus muscle enables both armadillos and hedgehogs to curl up, though it accomplishes this in different ways in the two taxa. In armadillos it attaches the pectoral and pelvic girdles, so when it contracts it essentially folds the animal in half. In hedgehogs it attaches to the skin of the back (where all the spines are) and draws the skin up and over the head and limbs, much like the drawstring of a bag.
- Study the armadillo and sloth vertebrae and find the xenarthrous articulations that distinguish them from the vertebrae of other mammals. Compare them to the assorted vertebrae that are available and to the articulated skeletons throughout the lab (cat, dog, monkeys, opossum, pangolin).
- By now you should not be surprised to see the conical, elongated shape of the ant-eating armadillo's skull. Which characters allow you to identify this skull from those of the other ant and termite loving critters that we have discussed?

Order Pilosa, Family Bradypodidae

Distinguishing characters:	limbs have 3 enlarged hook-like claws; digits are syndactyl (i.e., they share a single sheath of skin), though claws are separate; forelimbs are longer than hindlimbs; incomplete zygomatic arch; large jugal forks; peg-like cheek teeth reduced to 5/4-5; 8-9 cervical vertebrae; tympanic bullae are present
Number of species:	4
Representative species:	maned three-toed sloth, *Bradypus torquatus*
Geographic distribution:	Neotropical
Diet:	folivores (leaf eating)
Habitat:	rainforest
Behavior:	solitary; arboreal – spend the majority of their time in trees
Size:	3 – 5 kg; ~50 cm
Reproduction:	1 young per year
Lifespan:	~12 years

Other notes:	poorly developed sight/hearing; descend to ground roughly once a week to dig a small hole with their short, stout tail and defecate into it; long, grooved hair holds algae, but it is unknown if this is adaptive; long, multi-chambered stomach with bacteria to aid in digestion; evergrowing teeth

Order Pilosa, Family Megalonychidae

Distinguishing characters:	forelimbs have 2 large hook-like claws (hindlimbs have 3); digits are syndactyl; tail is small/absent; true tympanic bullae absent; incomplete zygomatic arch; large forked jugal; incisors and canines absent, but anterior cheek teeth are enlarged, triangular in cross-section, and canine-like – they are separated from the remaining teeth by a diastema; 5-8 cervical vertebrae; skull longer than in bradypodids
Number of species:	2
Representative species:	Hoffmann's two-toed sloth, *Choloepus hoffmanni*
Geographic distribution:	Neotropical
Diet:	primarily folivorous, also fruit and some small vertebrates
Habitat:	rainforest
Behavior:	solitary and arboreal
Size:	~9 kg; 50 – 70 cm
Reproduction:	1 young per year
Lifespan:	~12 years
Other notes:	"capable of vigorous self-defense" with slashing claws and teeth; descend to ground to defecate; algae in fur; chambered stomach; evergrowing teeth

- Compare the skulls of the two-toed sloths to the picture of the three-toed sloth skull. Identify the major characteristics that distinguish them (presence/absence of tympanic bullae, triangular caniniform teeth, length of skull, diastema)
- What characteristics distinguish sloths from other xenarthrans?

Order Pilosa, Family Cyclopedidae

Distinguishing characters:	prehensile tail; smallest anteater; dense golden fur; relatively short snout; incomplete zygomatic arch (jugal absent)
Number of species:	1
Representative species:	silky anteater, *Cyclopes didactylus*
Geographic distribution:	Neotropical
Diet:	primarily ants, some other insects
Habitat:	lowland rainforest
Behavior:	arboreal, rarely descends to ground; solitary or in pairs
Size:	36 – 45 cm; ~400 g
Reproduction:	1 young per year
Lifespan:	unknown
Other notes:	when threatened will strike predator with large front claws; may prefer silk cotton trees (*Ceiba*) because its resemblance to the tree's seed pod fibers may provide camouflage

Order Pilosa, Family Myrmecophagidae

Distinguishing characters:	edentate; elongated, downward curved skull; incomplete zygomatic arch (jugal small or absent); elongated dextrous tongue; forelimbs have 5 digits with claws – 3rd claw is typically largest; long palate
Number of species:	3
Representative species:	giant anteater, *Myrmecophaga tridactyla*
Geographic distribution:	Neotropical
Diet:	ants and termites
Habitat:	diverse – arid savannah to rainforest
Behavior:	solitary; terrestrial to semi-arboreal
Size:	32 cm – 2 m; 0.3 – 39 kg
Reproduction:	1 young per year
Lifespan:	unknown in wild; up to 26 years in captivity
Other notes:	insects are ground not by teeth, but by muscular pyloric (anterior) region of stomach; excellent sense of smell, but not sight or hearing; giant anteaters will shade themselves with their tails

- Examine the silky anteater and the skin of the giant anteater. Note the dramatic difference in overall size, pelage coloration, and texture of fur.
- Compare the skulls of the tamandua and the giant anteater to those of the other xenarthrans. Be confident that you know which specific characters distinguish the 5 xenarthran families. Note the long hard palate in the anteaters.
- Examine the sectioned tamandua skulls. Note the long, tubular mouth through which the tongue slithers. In anteaters the muscle attachments for the tongue extend back to the sternum. How far back can you trace the tongue muscles?

Order Scandentia, Family Tupaiidae

Distinguishing characters:	4 lower incisors form toothcomb; hole in zygomatic arch; complete post-orbital bar; complete tympanic bullae; complete zygomatic arch; dental formula 2/3, 1/1, 3/3, 3/3; upper incisors are caniniform and upper canines are premolariform
Number of species:	19
Representative species:	common tree shrew, *Tupaia glis*
Geographic distribution:	southeastern Asia
Diet:	omnivorous
Habitat:	deciduous forests
Behavior:	semi-arboreal – climb well and run swiftly on ground; solitary or in small groups; nocturnal or diurnal
Size:	20 – 45 cm; < 400 g
Reproduction:	1-2 litters of 1-3 young per year; minimal maternal care (one 5 minute visit to nurse every 2 days)
Lifespan:	2-3 years in the wild; 12 years in captivity
Other notes:	general appearance is similar to tree squirrels, but with longer snout, no long vibrissae, and 5 functional toes on forefeet (squirrels have 4); communicate via scent marking and several calls

- Examine the tree shrew skins and skulls carefully. Note the hole in the zygomatic arch and the set of thin lower incisors that form the tooth comb, which may be used for grooming.
- Examine the teeth. Do they look familiar? Could you identify the canines?

Order Dermoptera, Family Cynocephalidae

Distinguishing characters:	comb-like (pectinate) lower incisors; double-rooted canines; broad palate; extensive post-orbital processes and temporal ridges; large well-furred membrane extends from neck to all four feet and tail; sharp, hook-like claws on all feet; 1st upper incisor reduced, 2nd is caniniform
Number of species:	2
Representative species:	Philippine colugo, *Cynocephalus volans*
Geographic distribution:	southeast Asia, Indonesia, Philippines
Diet:	herbivorous – leaves, fruit, flowers
Habitat:	tropical rainforests, lowland and montane forests
Behavior:	nocturnal; strictly arboreal
Size:	50 – 80 cm; 1 – 1.75 kg
Reproduction:	1-6 litters of 1 young per year
Lifespan:	unknown
Other notes:	hang upside down while feeding and traveling; can glide for up to 100m between trees, but do not truly fly; can control their glides; lower incisors used for scraping food and possibly also grooming; cecum is long and divided into compartments

- Identify the major characteristics of the colugo skull and skin mentioned above on the available specimens. How does this animal compare to the flying squirrel, another adept glider?

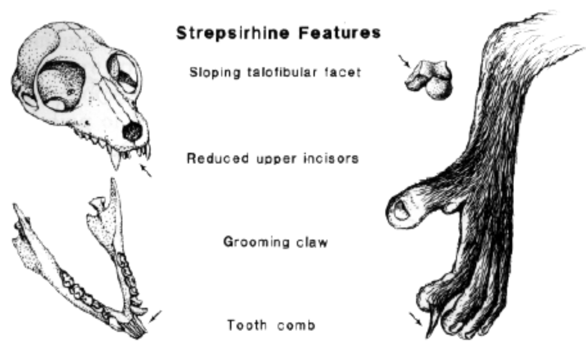
Order Primates, Suborder Strepsirhini, Family Lorisidae

Distinguishing characters:	tails short or absent; prominent temporal ridges; long limbs of equal length; large, close-set eyes point forward; broad zygomatic arches and post-orbital bar; grasping hands and feet
Number of species:	9
Representative species:	slender loris, *Loris tardigradus*
Geographic distribution:	Africa and Asia
Diet:	insectivorous, frugivorous, gumnivorous
Habitat:	forest
Behavior:	arboreal; nocturnal; solitary or in small groups
Size:	12 – 32 cm; 200 – 300 g
Reproduction:	1 young per breeding cycle
Lifespan:	12-15 years
Other notes:	climb through trees with deliberate hand-over-hand motions, never leap

Order Primates, Suborder Strepsirhini, Family Galagidae

Distinguishing characters:	long tail; lack temporal ridges; hind limbs longer than front limbs; males have a baculum (absent in lorisids)
Number of species:	19
Representative species:	Senegal galago, *Galago senegalensis*
Geographic distribution:	Africa
Diet:	varies by species; insectivorous, frugivorous, gumnivorous
Habitat:	forests
Behavior:	nocturnal; arboreal; live in small groups
Size:	40 – 75 cm; 200 – 300 g
Reproduction:	1 young per breeding cycle
Lifespan:	12-15 years
Other notes:	excellent arboreal leapers (up to 12 m); sleep in cavities during the day

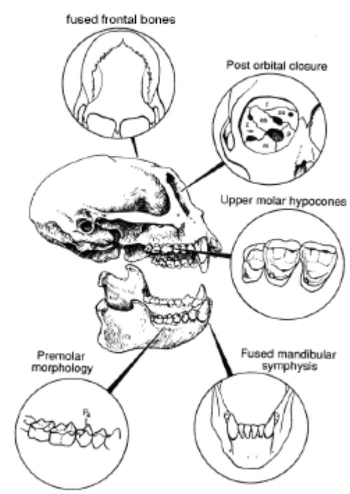
The families Lorisidae and Galagidae are both in the Suborder Strepsirhini. If you recall from lecture, strepsirhines retain many characteristics of ancestral primates, including a small braincase, elongated snout, and highly developed olfactory and auditory regions. They have a dental formula of 2/2, 1/1, 3/3, 3/3=36.



Strepsirhines are distinguished from haplorhines (which we will discuss shortly) by several characteristics, including large orbits with a postorbital bar, eyes with a tapetum lucidum, lower procumbent incisors that form a toothcomb, a grooming claw on the second digit of the hind foot (other digits have nails; recall the loris), and reduced upper incisors.

- Examine the loris and galago specimens and pictures. Identify as many of the characteristics described above as you can. Compare the toothcombs of these animals to those of the tree shrew and colugo. Which are most similar? Why might the latter have once been placed in the order Primates?

The remaining families that we will look at today belong to the suborder Haplorhini. These primates are considered to be more highly derived relative to the strepsirhines (naturally, because humans belong to the haplorhines!). The Haplorhini are distinguished by fused frontal bones and dentaries (mandibular symphysis), a full post-orbital plate that separates the orbit from the temporal region, and hypocones on the upper molars. They have hairy noses, in contrast to the moist, hairless noses of the Strepsirhini.



Haplorhines include the family Tarsiidae (tarsiers), which we will not be studying in detail today (but be sure to check out the tarsier specimen that is available), and the remaining families are subdivided into two groups: platyrrhines and catarrhines. The **platyrrhines** (New World monkeys) are neotropical in distribution and can be identified based on the number of premolars (3), a suture zone between the jugal and parietal bones of the skull, and broad, laterally directed nostrils. The **catarrhines** (Old World monkeys, apes, humans) are found in Africa and southeast Asia (humans, of course, have a global distribution), have 2 premolars, a suture zone between the frontal and sphenoid (alisphenoid) bones of the skull, and close-set, downward directed nostrils. As you work your way through the remaining families, try to identify specimens to one of these two groups based on these characteristics. You should be especially familiar with the 2 cranial characteristics that distinguish the groups.

Order Primates, Suborder Haplorhini, Family Cebidae (platyrrhine)

Note – Recent revisions have scrambled the taxonomic organization of the New World monkeys such that straightforward morphological characters that are diagnostic for each group are not always clear. Therefore, for the New World monkey families (Cebidae and Atelidae) I am providing general information for the representative species that are listed, rather than for the entire family.

Distinguishing characters:	dental formula 2/2, 1/1, 3/3, 22; claws on all digits except the hallux, which has a nail; striking pelage, including an impressive moustache
Number of species:	56
Representative species:	emperor tamarin, *Saguinus imperator*
Geographic distribution:	Neotropical
Diet:	frugivorous, insectivorous, gumnivorous
Habitat:	rainforest
Behavior:	diurnal; arboreal
Size:	~60 cm
Reproduction:	1-2 young per year
Lifespan:	10-20 years
Other notes:	arboreal leapers

Order Primates, Suborder Haplorhini, Family Atelidae (platyrrhine)

Distinguishing characters:	enlarged, bulbous hyoid apparatus in males; strong prehensile tails; large, robust lower jaw
Number of species:	24
Representative species:	black howler monkey, *Alouatta caraya*
Geographic distribution:	Neotropical
Diet:	primarily folivorous - also fruit, buds, flowers
Habitat:	forest
Behavior:	diurnal; arboreal; live in family groups
Size:	4 – 10 kg
Reproduction:	1 young per year
Lifespan:	7-12 years reported for howler monkeys
Other notes:	the enlarged hyoid apparatus acts as a resonating chamber for vocalizations; vocalizations keep troops together and establish territorial borders; sexually dimorphic in coat color and size; vocalizations may travel for up to 5 km

Order Primates, Suborder Haplorhini, Family Cercopithecidae (catarrhine)

Distinguishing characters:	bilophodont molars (lophs connect lingual and labial cusps); upper canines shear across modified p1; flat nails; pollex and hallux opposable if present; tail present, but never fully prehensile; skull is robust and heavily ridged; dental formula 2/2, 1/1, 2/2, 3/3; upper canines are usually large and with a small diastema between them and the incisors
Number of species:	132
Representative species:	rhesus monkey, *Macaca mulatta*
Geographic distribution:	Africa, southeast Asia
Diet:	folivorous; some vertebrates
Habitat:	rainforests, savannah, brush
Behavior:	diurnal; quadrupedal; arboreal or terrestrial
Size:	50 – 110 cm; 0.7 – 50 kg
Reproduction:	1 young per breeding cycle
Lifespan:	20-30 years
Other notes:	many have ischial callosities – colored patches of skin on their rumps – which play a role in establishing dominance or sexual advertising; facial expressions are important to communication

Order Primates, Suborder Haplorhini, Family Hominidae (catarrhine)

Distinguishing characters:	pollex and hallux opposable (except human hallux); flattened nails on all digits; tail absent; large braincase; dental formula 2/2, 1/1, 2/2, 3/3; broad incisors and canines do not develop into tusks; molars are bunodont, upper molars lack lophs connecting labial and lingual cusps (unlike Cercopithecidae)
Number of species:	7
Representative species:	chimpanzee, *Pan troglodytes*
Geographic distribution:	Africa and southeast Asia
Diet:	omnivorous, primarily frugivorous or folivorous
Habitat:	lowland and upland forests, tropical rainforests; savannah
Behavior:	good climbers (only orangutan is arboreal); complex social behavior and communication; diurnal
Size:	48 – 270 kg
Reproduction:	1 – 2 young
Lifespan:	<50 years

- Compare the hominid skulls to the Cercopithecidae. Can you see the difference in the upper molars (bilophodont or not)? What other features distinguish them?
- Compare the hominid skulls to each other. Note the numerous cranial modifications of the human skull relative to the other apes. Compare the male gorilla skull to the pictures of the female gorilla skull. How do they differ? Many primates are sexually dimorphic (including humans, of course). Note the massive sagittal crest and enlarged teeth on the male gorilla.
- How did you do identifying the traits of the platyrrhine and catarrhine lineages? Could you identify the appropriate group for a skull on a practical?

