ARTIODACTYLA

INTRODUCTION TO ARTIODACTYLA (even-toed ungulates)

Ungulates (meaning roughly "being hoofed" or "hoofed animal") are mammals, which are herbivorous, terrestrial and relatively large in size. Most ungulates use the tips of their toes, to sustain their whole body weight while moving. A hoof is really just a modified toenail. Unlike claws and nails, hooves are the principal point of contact between the legs and the ground. The ungulates consists of two orders: **Perissodactyla** (odd-toed ungulates) and **Artiodactyla** (even-toed ungulates). Artiodactyl's weight is borne about equally by the third and fourth toes. *Artiodactyla* comes from the Greek meaning even (*artio*) toed (*dactyl*).

During their evolution ungulates developed hooves instead of claws. The two orders that exist today diverged from a common hoofed ancestor 60 million years ago during the Eocene period. Evolving along a different course the artiodactyls surpassed the perissodactyls in number and continues to thrive, while the perissodactyls are slowly becoming extinct.

Europe was probably the center of evolution of this order. The earliest even-toed ungulates evolved in the Eocene, about 54 million years ago. These early artiodactyls had a full complement of teeth (a total of 44), four distinct digits on each foot, separate foot bones, no frontal appendage, and a simple, non-ruminating stomach. The even-toed ungulates have come into their prime only in recent times. With 77 genera, they represent the largest number of present-day ungulates and the largest number of large mammals.

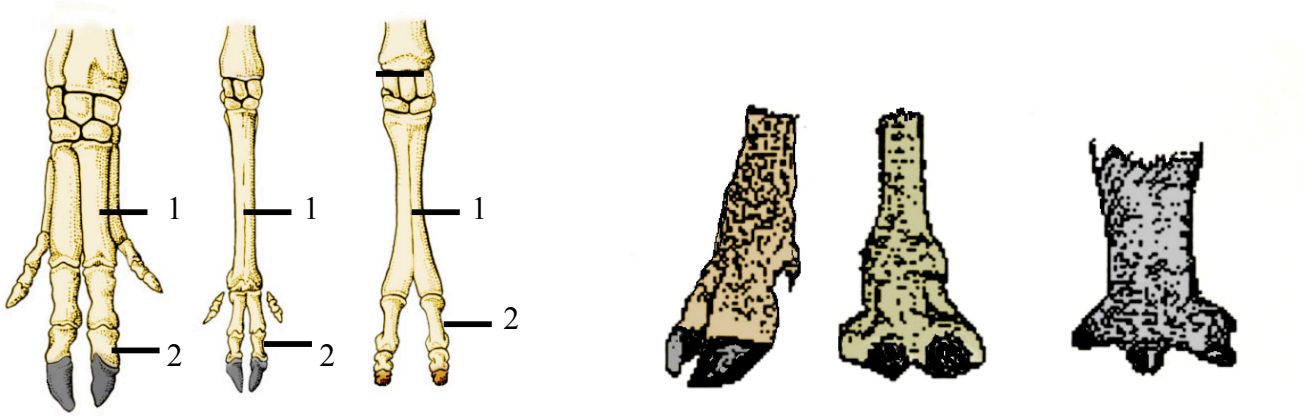
Most of the world's prey animals and nearly all human-related important domesticated species come from the artiodactyla order of mammals, including pigs, camels, llamas, reindeer, yak, cattle, water-buffalo, goats and sheep. From prehistory times they have provided emerging Homo sapiens with food, drink, clothing and transport, enabling the development from primitive hunter-gather to agrarian societies.

TAXONOMY

The Artiodactyla Order is currently composed of approximately 160 species divided into 9 families and 77 genera. They are native to all land areas of the world, except the West Indies, Australia, New Zealand and most oceanic islands. These figures will vary depending upon which zoologists that is doing the classification. All are agreed that are 9 families. What follows is based upon Grzimek (1991).

Suidae (pigs)
Hippopotamidae (hippopotamus)
Tragulidae (chevrotain, mouse deer)
Cervidae (deer)
Antelocapridae (pronghorn)
Tayassuidae (peccary, javalina)
Camelidae (camels, llamas)
Gifaffidae (giraffe, okapi)
Bovidae (antelope, bison, cattle, sheep, goats)

Physical Adaptations
The definitive characteristic of the even-toed ungulates is the main axis of the foot passes between the third and forth digits, which have hooves. Most members of this order walk on the tips of their toes with the weight evenly supported on the third and forth digit while the second and fifth are either reduced or lost. The metacarpus and metatarsus of the two main digits are usually merged to form the 'cannon bone'.



1. *Metacarpal* (Cannon) bone
2. *Phalanges*

A	B	C	D	E	F
Pigs	Deer	Camels	Deer	Camel	Hippopotamus

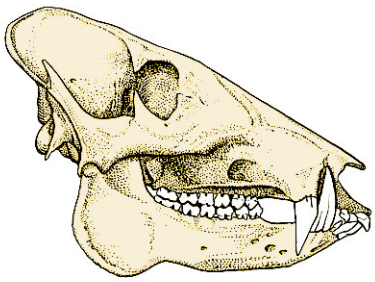
In pigs (A) the 2nd and 5th digits are still well developed and the metacarpal bones are not fused. In deer (B) the 2nd and 5th digits are vestigial and the metacarpals have fused into the cannon bone. Camels (C) no longer have the 2nd and 5th digits and the metacarpals are fused into cannon bone. The cloven hooves of most artiodactyls (D) represent the evolutionary transition of the 3rd and 4th digits that are now sheathed in keratin. Two exceptions are the padded toes of the camel (E) and the four-toed hippopotamus (F).

Senses
Artiodactyls are mostly prey animals. As such, they rely on their senses for survival. The eyes are often large and especially adapted to detect movement. Many species may have color vision. Most species have large, mobile ears, and the sense of hearing ranges from good to very good. The olfactory organs are well developed. There is a tactile sense, at least in lips and tongue. Furthermore, there are tactile bristles around the mouth, eyes, and on the checks.

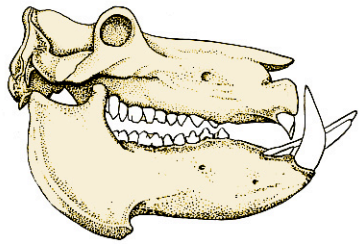
Skull and Dentition
The skull and teeth vary greatly. In all families except the suidae, it is common to have the front teeth separated from the cheek teeth by a gap or **diastema**. In the ruminants, the upper incisors are often absent, being replaced by a horny pad. Against this the lower incisors bite when the animal is tearing off vegetation. See family descriptions for dentition.

Skulls of four families of Artiodactyla

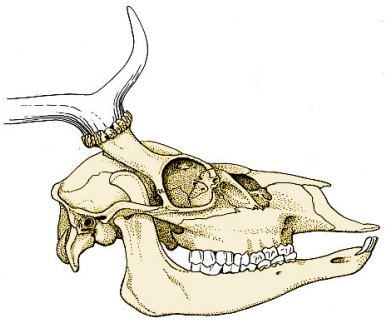
In each of the four families illustrated, the skulls structure has undergone adaptation to provide a survival advantage for the species affected. The elongated, pointed head plates of the peccary allow it to burrow and furrow for food, keeping its sharp incisors and canines in a frontal, attack position. The hippo skull, with its flat cranial plates puts the ryes, nose and ears on top of the head; an ideal position for this highly aquatic mammal. The forward thrusting canines and prominent incisors help in browsing and are excellent attack weapons.



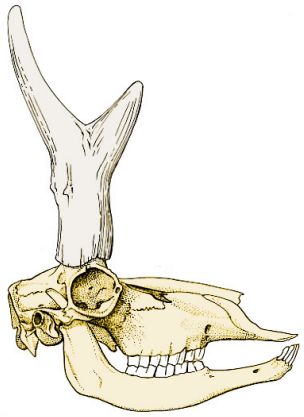
The skull of a peccary (*Tyassu tajacu)* Skull length 8.75" (2.5 cm). The elongated eve-growing snout adaptation for burrowing.



The skull of a river hippo (*Hippopotamus amphibius)* Skull length 23.5" (60 cm). Forward thrusting incisors and canines are major weapons.



The skull of a male fallow deer (*Dama dama)*; Family Cervidae; Skull length 10.5" (26.5 cm). Both antlers are shed yearly.

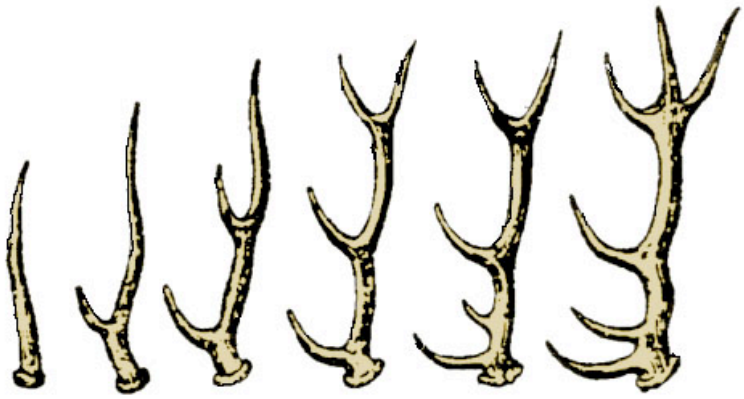


The skull of a male pronghorn (*Antilocapra american)*; Skull length 9.5" (24.2 cm). The sheath of the horn is shed yearly, but the bony core is permanent.

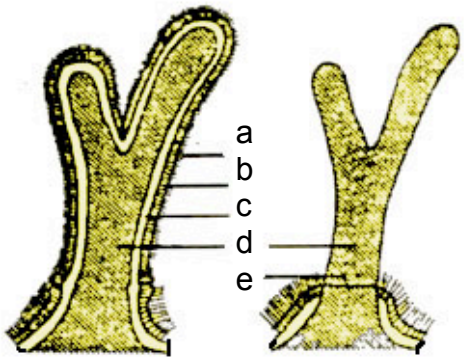
Note the dentition of the Fallow deer and the Pronghorn. The upper incisors have been replaced by a bony plate, an adaptation typical of ruminants. The Fallow deer and the Pronghorn are primarily prey animals relying on speed and agility as survival adaptations. The antlers and horns are their major weapons and their skulls to provide a suitable platform for their growth.

ANTLERS AND HORNS

Antlers only occur in **Cervidae** and then only on the males. The tissue resembles true bones of the body in chemistry composition and cellular structure. Beginning as spikes in yearlings, antlers grow larger each year until prime maturity is reached then decline with age often becoming deformed. Note stages of the Red Deer below.



Stages in the development of antlers of the red deer through the life of the animal.
Antlers increase in size until prime maturity is reached.

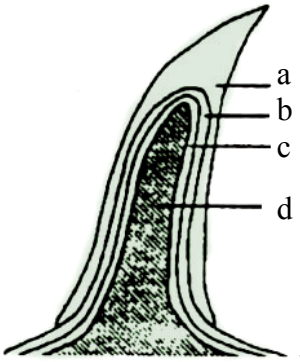


Diagramatic section of antler (A) with velvet and (B) without velvet.
(a) velvet; (b) epidermis; (c) dermis; (d) antler; (e) abscission line at burr.

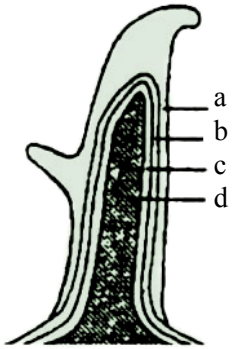
Antlers begin to grow in the spring. The developing antler bulges out of the velvet, a hairy skin covering called the **pedicel**; this is the permanent bony platform atop the frontal bone of the skull. During the period of growth, the velvet is tender and can bleed profusely. About August the antlers ossify, the blood supply and nerves of the velvet are reabsorbed, and sensitivity to injury or pain disappears. The velvet is shed in strips as the animal rubs against trees and shrubs. Once the velvet is removed the bare bone and sharp tines are ready to serve as weapons during the autumn rut in combat with other males for possession of the females.

Antlers are shed annually at the end of the mating season, early in December. The cement holding the base of the antler to the pedicel is reabsorbed, weakening the connection. The antlers fall off painlessly one at a time as the animal happens to strike something.

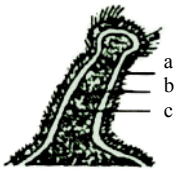
Horns are found on the heads of most species of Bovidae, Giraffidae and Antilocapridae. Horns are permanent, ever-growing, and do not regenerate if injured. In species where both sexes have horns, the males are generally larger. The Pronghorn horn is the only one that is branched, otherwise shape varies with species.



Bovid Horn
a - keratinized epidermis
b - epidermis c- dermis
d – bone



Pronghorn
a - keratinized epidermis
b - epidermis c- dermis
d – bone



Giraffe Horn
a - hair covered epidermis
b - dermis
c - bone

The word “horn” is used to name both the inner bony core and the outer sheath. The outer sheath, the primary component of the horn, is made of keratin, a tough, fibrous protein that forms the outer layer of the epidermal structures such as, hair, nails, horn, hooves, scales, feathers and claws. The sheath is insensitive to pain because it lacks nerves and blood vessels.

Bovid Horns: this group includes antelope, cattle, sheep, goats, etc. have permanent outgrowths that are un-forked and horn covered that are usually present in both sexes.

Pronghorns have permanent un-branching outgrowths, with a horny covering that is forked and shed annually.

Giraffe Horns: in the Giraffe and Okapi, the bony outgrowths are permanent, though they are short, very simple and always covered with skin. The Okapi horns are less prominent than the giraffe.

DIGESTIVE SYSTEM

In pigs and peccaries the stomach is two chambered and non-ruminating, in the hippopotamus it is three chambered and non-ruminating, In families Camalidae and Tragulidae (mouse deer) it is three-chambered and ruminating. All other ruminants are four-chambered and ruminating. Ruminants, or “cud chewers”, make up the vast majority of the order, including deer, giraffes, pronghorn and all bovids.

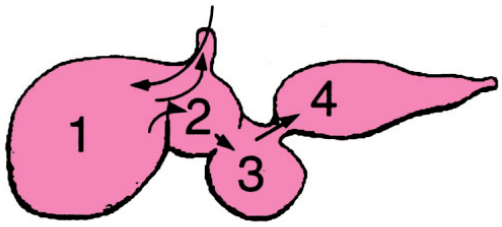


Diagram of four-chambered stomach

Ruminants crop or graze vegetable food, such as grasses and woody material, in which there is relatively low amounts of nutrients they swallow the food rapidly, with little chewing. The food enters the first stomach or **rumen** (1), later when the animal is resting safely, without fear of predators, this food, already worked on by bacteria, is regurgitated into the mouth, where it is re-chewed and further mixed with salivary juices (the "cud"). The food is then swallowed a second time, entering the second chamber of the stomach or **reticulum** (2) bypassing the rumen. This second chamber provides continuing fermentation and from here it passes to the **omasum** (3) aids in the absorption of water, magnesium, and the volatile fatty acids produced by fermentation. Finally it enters the **abomasum** (4) where the greatest digestive activity takes place. This enables cud chewers to quickly consume a large quantity of low-grade food, and later put it through the grinding and chemical process necessary to convert it to energy. It is probably one of the main reasons that this group has had the greatest success surviving in the wild than other ungulates.

Social Behavior
Most artiodactyla are herd or group animals, and all have skin glands. Scent plays a major role in inter-specific relations of many species including marking territory, cohesion of group and attracting mates. Urine and feces are used as well as well as glandular marking among certain species. Tree marking and rubbing are practiced by cervids and bovids.

Courtship and Young
The order is polyestrous and breeding can occur at varied times, although spring months are most frequent to enable young to survive the rigors of winter. They usually have two or four nipples; only in pigs are there six to twelve nipples. One litter a year is typical, except in the largest species, which tend to cycle every two years. Young are usually born precocial and are closely protected by the mother.

Conservation
Large numbers of domesticated species, such as camels, llama and Asiatic buffalo, are generally reduced in the wild, and may be in danger of becoming extinct in their natural environment. Others, like the Musk ox and American buffalo have been saved from extinction by conservation efforts and are now being returned to their natural habitats. Although most of the order suffers from habitat destruction and reduction, few species are considered vulnerable or endangered by the IUCN or CITIES.

General Family Characteristics

Tayassuidae ~ (Peccaries / Javelinas) 3 species in 2 genera

1. Pig-like mammals found from southwestern U. S. to central Argentina

Suidae ~ (Pigs) 9 species in 5 genera

1. Old world family introduced into the Americas
2. Resembles domestic swine (e.g. Wart Hog)

Hippopotamidae ~ (Hippopotamus) 2 species in 2 genera

Pygmy Hippo ~ *Choeropsis liberiensis*

1. Huge tusk-like canines and incisors
2. Primarily vegetarian
3. Nocturnal
4. Narrow distribution in Western Africa
5. Solitary or in pairs, aggressive
6. Swims, but also found in dense forest
7. Single offspring born on land, nursed on land or in shallow water
8. National mammal of Liberia

River Hippo ~ Hippopotamus amphibius

1. Huge tusk-like canines and incisors
2. Primarily vegetarian
3. Nocturnal
4. Widely distributed along Nile and other Southern African rivers
5. Gregarious herd animal
6. Spends most of day in water, good swimmer
7. Births frequently underwater, baby is thought to be nursed underwater, rides mothers back

Camelidae ~ (2 camels, Llama, Guanaco, Vicuna, Alpaca)

Old World Camels ~ Feet with two toes and well padded soles forms broad feet with sturdy nails and no hooves, three chambered stomach, cud chewers, slender snout with cleft upper lip.

- **Bactrian** ~ Two humped from Central Asia: is rare in captivity: able to withstand severe hot/cold temperatures; wild population is endangered. May have been domesticated c. 3,000 years ago.
- **Arabian** ~ one hump (Dromedary) Domesticated form has been introduced to southern Africa, Australia, southern Asia and South America. Though it has been domesticated for c. 6,000 years the origin of the wild population is unknown. Its disposition is poor being unreliable, surly, mean with a vicious bite and spits

Both species used similarly by man for transportation, meat, milk, clothing and shelter; in some parts of Africa and Asia the camel is the primary means of transportation; the hump is a fat storage depot, containing fat not water, during lean times it does shrink. Disposition poor, typically unreliable, surly, mean, with a vicious bite, spits when angry. Has been domesticated for a long time, original wild population unknown.

- South American Camels (**Llama**, **Guanaco**, **Vicuna**, **Alpaca**)
  1. Habitat: Andes Mountains
  2. Used for food, fuel, clothing and transportation
  3. Disposition is typical of camels
  4. The Guanaco is thought to be the precursor of Llama and Alpaca
  5. The Vicuna is most threatened because of its fine wool
  6. All have the three chambered stomach; cud chewers

Tragulidae ~ Chevrotain or Mouse deer 4 species and 2 genera

- These small mammals are seen as the intermediate between pigs and deer
- Tropical rain forest in Africa, India & SE Asia

Cervidae ~ (Deer) 53* species and 17 genera

- Four digits; 1st is missing, 3rd & 4th well developed, 2nd & 5th are reduced
- Four chambered stomach, cud chewers
- Antlers on males (bucks) grown and shed annually except caribou and reindeer (i.e. domesticated caribou)
    a. Bony core supported on permanent pedicels
    b. Temperate zones follow yearly pattern
        i. Growth starts in early summer - well supplied with blood
        ii. Maximum size reached by late summer, still in velvet; blood recedes, thin skin covering dries, loosens and is rubbed off
        iii. Sheds between January and April - after mating

*** MacDonald states 36 species with the three species of Musk deer in their own family Moschidae**

Giraffidae ~ (Giraffe*, Okapi)

The Giraffe habitat is the savannas of Africa

- Two hoofed digits (3rd & 4th) on each foot
- Large dark eyes, long lashes, and 18' purple tongue
- Reticulated refers to "netted" pattern
- Four chambered stomach, cud chewers
- Horns present at birth as cartilaginous knobs that ossify and grow slowly throughout life in both sexes

* There are presently 9 recognized subspecies

The Okapi habitat is tropical rain forest in Dem. Rep. of the Congo (Zaire)

Bovidae ~ (Cattle 115 species - Antelope, Cattle, Sheep and Goats)

- Number of digits varies between 2 and 4, 1st is always absent, 2nd and 5th are either small or absent.
- The most important group of hoofed animals to man; important for food, clothing, shelter, transportation.
- Horns are usually hollow and retained throughout life; in many species and are carried by males and some females.
- Gregarious animals (for protection) are either browsers or grazers.
- 4-chambered stomach, cud chewers. Browse and graze.

Antilocapridae ~ (lit. "Antelope-goat) Pronghorn is the sole member

- Sheds the outer sheath of horn yearly, keeping the bony core.
- Found only in western North America
- 4-chambered stomach, cud chewers.

UNGULATES

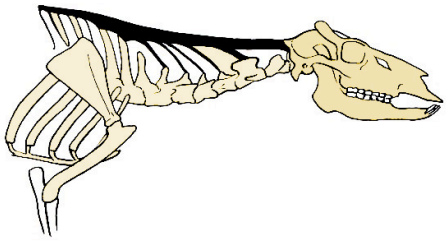


Fig.1
A schematic drawing of the nuchal (nape of neck) ligaments (in black) of an ungulate

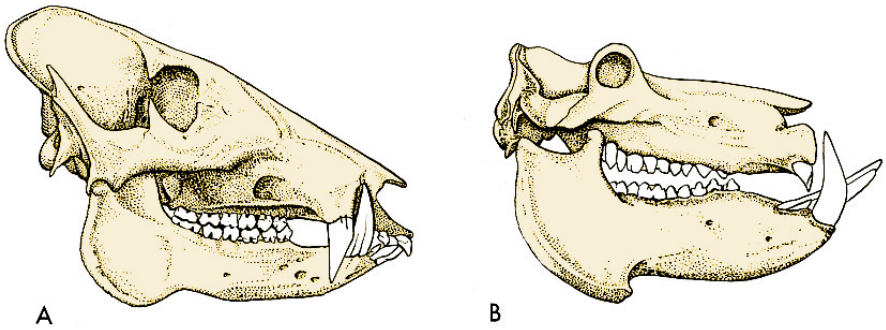


Fig. 2: Skulls of artiodactyls of the sub order Suina:
A *Tayassa tajacu* , Javelina skull, length 225 mm
B Hippopotamus sp., Hippo skull, length 600 mm

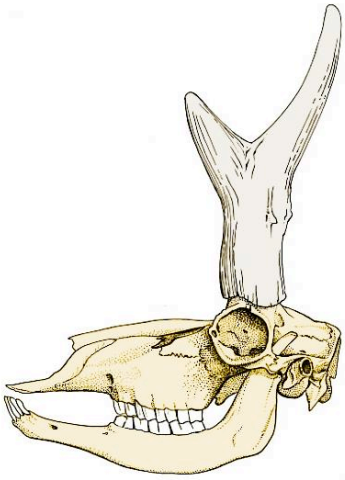


Fig. 3: The skull of a male pronghorn *Antilocapra americana*. The sheath of the horn is shed yearly, but the bony core is permanent. Skull length 292 mm

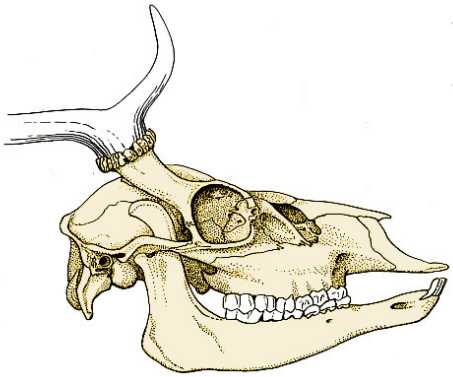


Fig. 4: The skull of a male Fallow Deer *Dama dama* (Ceridae).
The bony antlers are shed yearly.
Skull length 265 mm

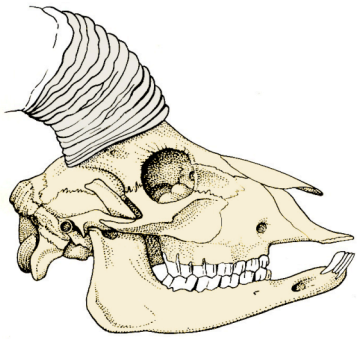


Fig. 5: The skull of a male mouflon sheep, *ovis musimon*. The horns are never shed, but continue to grow throughout the animals life. Skull length 242 mm

QUESTION: Which of these are ruminants? **HINT**: Check the dentition

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