WOODLAND PARK ZOO

Introduction to Mammals
PowerPoint script
Prepared by Woodland Park Zoo Education Department
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Slide 1

Woodland Park Zoo logo

Slide 2

Introduction to Mammal Diversity

Slide 3

Numbers of Species of Living Organisms

As can be seen from this graph, mammals may not be as rich in numbers of species as many other groups of organisms, but mammals do exhibit a great diversity of shapes, sizes and adaptations, from tiny bats the size of a bumblebee flying in the air to huge blue whales, the largest animal on earth, swimming in the ocean.

Slide 4

Mammal Numbers

Taxonomists rarely agree 100% on how animals should be identified and grouped, so you will see different numbers listed for how many mammals exist and how many orders they are classified into. In addition, as we continue to research life on earth, new mammals are identified every year, adding to the list.

Slide 5

Numbers of Species in Mammal Orders

Again, taxonomists rarely agree 100% on how animals should be identified and grouped, so you will see different numbers listed for how many species are in each order of mammals. The orders with the most species are rodents, bats, shrews/moles, primates, marsupials (actually consists of seven orders), and even-toed ungulates.

Slide 6

Notes on Mammal Evolution

The earliest mammals were primarily small, shrew-like, nocturnal insectivores. However, a recently discovered fossil from 130 million years ago (Hu, et. al. *Nature*, January 13, 2005) is of a larger mammal that ate small dinosaurs!

Slide 7

Mammal Taxonomy

This slide shows the taxonomy of mammals that currently exist on earth. Some current taxonomic research indicates that marsupials and placental mammals are more closely related to each other than they are to monotremes; other research indicates that monotremes and marsupials are more closely related to each other than either group is to placental mammals. New relationships between existing mammals are continually revealed as more paleontology and genetic research is conducted.

Slide 8

Three Major Groups of Mammals

The three major groups of mammals are differentiated based on embryonic development: monotremes are egg-laying and their young lap up milk from the mother's fur rather than suckling, marsupials give birth to minimally-developed young that attached to a nipple (often in a pouch) and suckle while completing their development, and placental mammals give birth to more completely developed young that are nourished before birth through a placenta attached to the uterine wall.

Slide 9

Orders of Mammals

The colors represented here indicate current taxonomic relationships—Monotremes in green, Marsupials (all seven orders are not listed separately here) in blue, and placental mammals in yellows/oranges/reds. This list uses common names for animals that make up each order rather than the scientific names of the order. The numbers of species in each order are listed in parentheses. There are now more placental mammals on earth than other types of mammals, but this wasn't the case prehistorically when many species of different types of mammals existed.

Note: Taxonomists classify humans (*Homo sapiens*) in the Primates order.

Slide 10

Mammal Physical Characteristics

The three physical characteristics listed here are what define and characterize all mammals: the first two characteristics are most useful with living animals; the last one is mostly used by paleontologists when studying fossils.

Hair/fur:

- At least some hair is found on all mammals at some time during their lives
- Four functions of hair: insulation, sensory, provides color/pattern, protection (e.g. from sun, from predators [e.g. spines])

Mammary glands (this is where the name of this class of animals, Mammalia, comes from):
In monotremes the mammary glands have separate openings (no nipple) and the young lap milk from tufts of fur rather than suckling as in the marsupials and placental mammals.

Middle ear bones:
In reptiles, the middle ear is one bone (the stapes) and the lower jaw is a primary bone plus several smaller bones functioning as a hinge. Mammals are the only vertebrates with three ear bones (the malleus, the incus and the stapes) instead of one—the smaller bones of the reptile jaw gradually shifted to join the stapes in the middle ear.

Slide 11

Middle Ear Diagram

Slide 12

Other Physical Characteristics of Mammals

These characteristics may also be found in other groups of organisms, and some mammals may not have all these characteristics, but most mammals share these physical characteristics in

addition to the three mentioned previously. For example, birds and crocodiles have a similar type of heart to mammals.

Slide 13

Mammal Reproduction

Maternal care increases the chances of survival of offspring so mammals produce fewer young than other animals. Maternal care requires a lot of energy! Mothers must provide enough milk for their young to thermoregulate (maintain their body temperature) as well as grow and develop. Mothers often protect their offspring from predators and in some mammals, such as carnivore and primates, mothers play a role in the offspring's behavioral development, social development and learning. Maternal care can be even more energy-demanding than gestation.

Slide 14

Gestation

Gestation varies greatly among different types of mammals.

Delayed implantation is an interesting reproductive adaptation to seasonal changes in the environment. Through delayed implantation, mating time and births can be timed independently in relation to seasonally favorable conditions. In delayed implantation (also called embryonic diapause), the fertilized egg divides only to the blastocyst stage (several days after fertilization); at this point the cells stop dividing and the young embryo remains in diapause until it later implants into the uterus lining and continues development. For example, in river otters the blastocyst can remain in diapause for nine to 11 months.

Slide 15

Mammal Social Behavior

Different social groupings have evolved primarily due to habitat conditions, such as the type of food available, the terrain, the types of predators that inhabit the ecosystem, but also to facilitate mating. For example, in an open habitat with lots of predators, prey mammals often live in groups for protection; in areas with scattered food resources, group living helps all individuals to find food; group living can make it easier to find mates and can help to synchronize births, which means that proportionally fewer individuals will be lost to predators than if births were spread out in time.

Slide 16

Mammal Locomotion

Mammals survive in a wide range of ecosystems and thus have adapted many strategies for moving around to find food/catch prey or escape predators:

- Walking/running – ungulates, carnivores, etc.
- Jumping – kangaroos, rabbits, etc.
- Digging/burrowing – moles, shrews, gophers, etc.
- Climbing – primates, squirrels, sloths, etc.
- Gliding – sugar gliders, flying squirrels, colugos (flying lemurs)
- Flying – bats
- Swimming – platypus, shrews, muskrat, beaver, seals, whales, etc.

Slide 17

Mammal Senses

Reflecting their prehistoric development, the majority of mammals remain nocturnal, meaning they are primarily active during the night. Because of this, most mammals have highly developed senses of smell as well as adaptations for better night vision than diurnal animals.

Slide 18

Primary Mammal Senses

Olfactory/Sense of Smell

The sense of smell is important for prey to detect predators, and for predators to detect prey. Smell also functions in social and reproductive processes. Whales have no olfactory sense. Cetaceans have a limited sense of smell—baleen whales can detect smells to some degree, but toothed whales may have no sense of smell.

Hearing

In cetaceans, sound is channeled to the middle ear not through the ear canal, but through the lower jaw. Toothed whales have high frequency hearing; baleen whales have low frequency hearing; both have more nerve cells associated with hearing than terrestrial mammals. Recent research indicates that hippos may also communicate underwater using their jaws to conduct sound to their middle ears. With elephants, big ears (long ear canal, large middle ear bones, big tympanic membrane) allow for hearing low frequency sounds. Elephants may also detect seismic vibrations that travel through the ground with sensory receptors in their feet.

Sight

Primates rely on color vision to find appropriate food (right kind of leaves or ripe fruit). Orangutans find ripe fruit by its color and develop intricate mental maps of their territory that track which trees have ripe fruit at which time of year. Old World primates and humans have three types of cone cells and thus trichromatic vision. Many other primates and other mammals have only two types of cone cells and dichromatic vision, while other mammals (particularly nocturnal mammals) have no color vision at all.

You can experience the different functioning of your rods and cones by:

1) At night: try to notice what you see in your peripheral vision, then turn and directly face the direction you were looking in out of the corner of your eye and look at it head on. Compare what you can see with your peripheral vision (more rods, better night vision) to what you can see when you look straight ahead (more cones, poorer night vision).
2) Make a small stack of squares of colored construction paper, mix up the cards, turn off the lights or go into a dark place and write on each card what color you think it is. Then, turn the lights back on or return to the light and see how you did with identifying colors in the dark!

Slide 19

More on a few groups of mammals…

Monotremes, Marsupials, Rodents, Bats, Ungulates, Elephants, Carnivores, and Primates

Slides 20 and 21

Monotreme Characteristics

Monotremes are egg-laying mammals that share the three primary characteristics of all mammals (see slide 10): fur/hair, mammary glands and three middle ear bones. In monotremes, the mammary glands have separate openings (no nipple) and the young lap milk from tufts of fur rather than suckling as in marsupials and placental mammals. Monotremes have only one opening, the cloaca, that serves for both waste elimination and reproductive purposes (similar to other vertebrates, such as birds and reptiles, but different from marsupials and placental mammals). As adults, monotremes lack teeth. The monotremes include three types of mammals: the duck-billed platypus, the short-beaked echidna and the long-beaked echidna (three species) that are found only in Australia and New Guinea.

Slides 22 and 23

Marsupial Characteristics

The main physical characteristics of marsupials are very specific in nature: their palate (roof of mouth) is fenestrated, meaning there are large gaps between the upper molars. Marsupials are considered to have smaller and more primitive brains than placental mammals. Finally, dentition is different in marsupial mammals than in placental mammals. Marsupials inhabit North and South America, but are most diverse in Australasia (Australia, New Guinea and nearby islands).

<u>Marsupial Characteristics: Reproduction</u>

These specific anatomical characteristics do distinguish marsupials from placental mammals, but the main defining characteristic of marsupials is in their reproduction. In the female, eggs are shed into a separate uterus to be fertilized. The two vaginae are often matched in the male by a two-lobed penis. In most kangaroos and a few other marsupial species (along with some placental species), implantation of the embryo may be delayed in response to the suckling of a young in the pouch. Once the suckling decreases, the embryo continues to develop. In some species that don't breed year-round, implantation can be affected by changes in day length. There are many advantages to delayed implantation. It ensures that young aren't born when pouch is occupied, it allows for young to be born in a more favorable season, and it makes certain that a lost young can be rapidly replaced, even if males aren't present. Once implanted, the gestation is extremely short compared to placental mammals.

While placental mammals get their name from the female possessing a placenta, the majority of marsupials lack a placenta due to the shortness of their gestation. Only koala, bandicoots, bilbies and wombats form some kind of placenta during gestation. Young are typically born through a third, central, pseudovaginal canal. In most marsupials, a new canal is formed before each birth, but in others, the canal is permanent after the first birth. Due to the short gestation, marsupials are born very early in development, weighing less than 1% of their mother's weight. In some cases, that means weighing only a few milligrams.

The young then makes an incredible journey to finish development. Using comparatively well-developed forelimbs, the young "swim" from the birth canal to the mother's nipple, which is sometimes enclosed within a pouch, called a marsupium. The young then clamps on to a nipple, which enlarges to fit its mouth, and stays attached for one to two months until its jaw is developed enough to let go.

Marsupials called "pouched mammals"

Marsupials are often referred to as "pouched mammals"; in fact, the name marsupial comes from marsupium, the name for a pouch. However, pouches vary widely by species. Some, such as numbats, have no pouch at all. Others, such as quolls and marsupial mice, have flaps of skin on either side of the nipples to protect the young. Some, such as Virginia opossums and Tasmanian devils, have shallow pouches that open posteriorly (to the rear of the female). Some of the deepest pouches belong to active climbers or leapers, such as kangaroos or possums, and have pouches opening anteriorly. Burrowing marsupials, such as wombats, have deep pouches that open posteriorly to keep dirt out of the pouch.

Marsupials include the opossums of North and South America and in Australasia the marsupial moles, carnivorous marsupials, bandicoots and bilbies, and the diprotodonts. With 143 species, the order Diprodotont is the largest of all marsupial orders and is extremely diverse. Diprotodonts have one pair of incisors on their lower jaw instead of many pairs as in polyprotodont marsupials. Diprotodonts are also syndactylous, meaning the second and third digits on the hindfeet are fused except for the claws. Originally a climbing adaptation, it was retained when diprotodonts became territorial and is an effective grooming tool. Originally strictly herbivores, some diprotodonts, namely the possums and gliders, have evolved insectivorous and nectarivorous adaptations in response to insect and nectar-rich eucalyptus forests in Australia. The group includes: koalas, possums and gliders, wombats, kangaroos and wallabies.

Slides 24 and 25

Rodent Characteristics

There are a higher number of rodent species than in any other order of mammals (2,277). Rodents are ecologically diverse and occur naturally all over the world except Antarctica, New Zealand and some oceanic islands. All rodents share one characteristic: their teeth are highly specialized for gnawing. All rodents have one pair of upper and one pair of lower incisors, next to a gap (no canines), followed by the molars or premolars. The incisors are rootless and grow continuously. The back surface of the incisors is not covered with enamel, so the incisors sharpen themselves as they grind against each other during gnawing. The five major groups of rodents include: springhaas and relatives; beaver, kangaroo rats, gophers and relatives; porcupines, guinea pigs, capybaras and relatives; mice, rats, gerbils and relatives; and squirrels and their relatives.

Slide 26

Bat Characteristics

- Second highest number of species among all the mammal orders (after rodents), with 1,116 species.
- Only mammal with true wings and flight – bat wings are modified forelimbs with four fingers covered by a flight membrane. Flight is powered by robust thoracic muscles.
- Commonly divided into two major ecological groups, the Megachiroptera and the Microchiroptera:

Megachiroptera:

- Feed primarily on plant material—fruit, nectar or pollen
- Found only in Old World tropics
- Depend on vision to navigate and find food
- Constant body temperature; none hibernate

Microchiroptera:

- Feed primarily on insects, some have adapted carnivorous diets, others eat fruit, nectar or blood of other vertebrates (vampire bats)
- Broadly distributed around the world
- Use echolocation to navigate and find food
- Fluctuating body temperature; some hibernate

Slides 27 and 28

Ungulate Characteristics (hoofed mammals)

Ungulate classification

New relationships between existing mammals are continually revealed as more paleontology and genetic research is conducted; and taxonomists don't always agree on how groups are related to each other. Formerly, it was believed that there were two orders of ungulates in the mammal group: even-toed ungulates and odd-toed ungulates. Recently, taxonomists have been speculating about whether to create a superorder called Cetartiodactyla to comprise both Cetacea (whales, dolphins and porpoises) and Artiodactyla (even-toed ungulates) due to new findings that indicated that the two might be more closely linked evolutionally than was formerly believed.

Ungulate is a general term given to all terrestrial mammals that have evolved hooves instead of claws. Modified for a terrestrial lifestyle, their sideways-facing eyes give ungulates a wide range of vision, allowing them to keep a watch out for predators. Their teeth are adapted for an herbivorous diet and their feet are adapted for rapid locomotion on land. See below for information on the characteristics shared by terrestrial even-toed ungulates and the aquatic whales, dolphins and porpoises.

Order Artiodactyla: even-toed ungulates

The even-toed ungulates are the most diverse array of large, land-dwelling mammals alive today. Living in all habitats, from rain forest to desert, from montane to marshes, on all continents except Australia and Antarctica. The order Artiodactyla is often divided into three suborders: the Suiformes, the Tylopoda and the Ruminantia. However, all members of Artiodactyla have two to four paraxonic toes, meaning the middle two toes are larger and bear the weight of the animal and the plane of symmetry runs between these two larger digits. Some even-toed ungulates, such as the elk and mountain goat, have paired horns or antlers with bony cores. Antlers, such as those in the elk, are branched structures that are shed annually. Horns, such as those in the mountain goat, are permanent, unbranched structures. Most even-toed ungulates are herbivores with chambered stomachs to aid in digestion. Even-toed ungulates include: pigs, peccaries, hippos; camels and llamas; and the ruminants (deer, giraffe, antelope, gazelles, goats, cattle, sheep, buffalo).

Order Cetacea: whales, dolphins, porpoises

Whales, dolphins and porpoises can be divided into two suborders: the baleen whales and the toothed whales. They have many adaptations to their aquatic habitat: instead of a coat of hair or fur, blubber composed of fat and oil keeps them warm; a blowhole on the top of their head allows for quick exhalation of air. A cetacean's adaptations for speed include a streamlined both shape with no external digits, claws, ears, genitals or hair (except whiskers); their paddle-shaped front limbs and powerful fluke help propel them through the water; their lack of hindlimbs, which are hidden within the body cavity and aren't attached to the backbone, help add to their streamlined body shape.

It has been widely accepted that cetaceans evolved from terrestrial mammals: they must surface to breathe air instead of extracting dissolved oxygen from water like fish; the bones of their fins resemble large jointed hands; and the vertical movement of their spines are more characteristic of a running mammal than the horizontal movement of a swimming fish. Recently, molecular research shows that cetaceans may have evolved from the ancestors of the even-toed ungulates, with hippos being the most closely related artiodactyls to cetaceans.

Order Perissodactyla: odd-toed ungulates

Compared to the even-toed ungulates, the order Perissodactyla is a small order with only three families: the horses, asses and zebras; the tapirs; and the rhinos. The numbers, distribution and diversity of form pale in comparison with the even-toed ungulates, but the familiarity of humans with its members, especially the horse, is significant. Unlike artiodactyls, the odd-toed ungulates have one to three mesaxonic toes, meaning the middle toes is larger and bears the weight of the animal and the plane of symmetry. Tapirs and rhinos have three digits; horses have the middle digit modified into one digit. Also unlike even-toed ungulates, horns occurring in odd-toed ungulates are unpaired and have no bony core. All even-toed ungulates are herbivores with simple stomachs.

Slide 29

Elephant Characteristics

For thousands of years, people have been drawn to elephants because of their immense size and strength, their elongated trunks and oversized ears, their seeming intelligence and gentle spirit, and their ability to entertain. Elephants also play significant roles in the cultures, histories and daily lives of people around the world.

Physical characteristics

Elephants are the largest terrestrial animal (the blue whale is the largest animal in the world) and the next tallest after giraffes. Their characteristic trunk is comprised of their nose fused with their upper lip. This adaptation serves many purposes, namely enabling elephants to feed because their necks are too short for their mouth to reach the ground. Food is grasped by the trunk and brought to the mouth. Trunks are also used to drink, communicate with other elephants, and aids in taking dust baths.

Tusks are modified upper incisors used to strip bark, dig up roots and create waterholes. Tusks are also used as a communication tool in aggressive displays between male elephants. Mammary

glands are located between the front legs; young suckle for several years. Large ears are used to radiate heat and in communication displays.

Extinct and living relatives

Elephants are the only living family in Proboscidae, which formerly included other families including mastodons. Within the modern elephant family were now extinct species such as mammoths and stegodons. Though it seems hard to imagine, it is believed that hyrax, manatees and dugongs share a common ancestor and are each other's closest living relatives.

Elephant classification

There were formerly two species of elephants recognized: Asian (three or four subspecies) and African (formerly two subspecies). The African elephant is now considered two separate species:

- African savanna elephant (*Loxodonta africana*)
- African forest elephant (*Loxodonta cyclotis*)

Distinction due to:

- Genetic differences
- Morphological distinctions (smaller size; smaller, straighter tusks; rounder ears)
- Habitat differences (live in tropical forests)
- Extremely limited gene flow between forest and savanna elephants

Many conservationists believe it is premature to divide African elephants into two species due to insufficient evidence and concern that hybrids may face uncertain conservation status

- Listing on World Conservation Union's Red List is for the single species, encompassing both forest and savanna populations

Slide 30

What's a Carnivore?

When we talk about carnivores, we're referring to two possible groups of animals. The first group is any member of the order Carnivora. This order is in the class Mammalia, thus all animals in this order are mammals. The defining characteristic of this order is that all members stem from ancestors that had so-called carnassial teeth, in which the last premolar of the upper jaw and first molar of the lower jaw are sharp and bladelike. These teeth slide past each other like scissor blades and enable the animal to cut through meat and tendons. Most, but not all, members of Carnivora retained their carnassial teeth. Bears and raccoons are omnivores, meaning they eat both meat and plants; their carnassials became crushing molar teeth. Also, pinnipeds (seals, sea lions and walruses), which are sometimes classified in their own order, have reduced or absent carnassials.

The second group of carnivores is defined as any animal that catches and consumes other animals. This group includes mammals not in the order Carnivora, such as some marsupials, primates and whales. Also, unlike those in the order Carnivora, this definition includes non-mammals such as birds, reptiles and fish. Many of these animals have special adaptations that allow them to catch their prey. Raptors have strong talons that allow them to catch their prey. Snakes use constriction or venomous fangs to kill their prey.

Slides 31, 32, and 33

General Carnivore Characteristics

(see text on slide)

Carnivores are an extremely diverse group. They vary in size from an average of 2 ounces for the least weasel to an average of 1,000 pounds for the polar bear and 5,000 pounds for the elephant seal. Members of the order Carnivora are also extremely diverse in their diets. Many are primarily carnivorous, such as jaguars, but others, such as bears and raccoons are omnivorous. Giant pandas are primarily herbivorous, with 99% of their diet consisting of bamboo. Carnivores are also diverse in their social structure. Cougars, tigers, jaguars and many others are solitary, except during mating and offspring rearing. Lions, wolves and hyenas live in packs, some of which are female-dominated and some of which are male-dominated.

Most carnivores have very acute senses, which aid in finding and hunting prey as well as in communicating with those within their species and outside of their species. Vision, hearing and sense of smell are generally excellent in carnivores, with some senses being stronger than others in different species. Carnivores are also built for running. Most have small, suspended collarbones that allow for long strides. Their fused wrist bones aid in shock absorption, as well as support for climbing and grappling with prey. Some, such as wolves, can run great distances, while cats generally rely on short bursts of speed to overcome their prey.

Many carnivores are very territorial and use scent marking to establish their territories. They either mark their territory with urine or with secretions from their specialized anal glands, which all carnivores possess. All carnivores, except for hyenas, also have a penis bone, which acts to prolong copulation. This is important because in most carnivores, ovulation is induced by copulation.

Slides 34, 35 and 36

Primate Characteristics

Primates are found in approximately 92 countries around the world. Non-human primates are found mostly in tropical regions on every continent except Australia and Antarctica. Over time primates developed the “all important” thumb. This adaptation has made a significant difference in the ability of primates to grasp such things as branches and food, manipulate objects, and utilize tools. In almost all primates (except for humans) the first digit of the hind feet is opposable as well, thereby increasing the dexterity of these animals.

Most species of primates live in tropical regions and the majority of them inhabit the treetops of forested areas part or all of the time. Many of the important general characteristics of primates developed as early primates began to live more arboreal existences. Primates are generally omnivorous, eating anything from leaves and fruit to insects and small vertebrates. Some coastal species of baboons even eat mollusks and other marine animals. Chimpanzees sometimes stalk, kill and eat baboons and other monkeys.

Many, though not all, primates are social animals. Orangutans are mainly solitary, except when they come together for breeding or in the cases of mother-infant pairs. Other species, such as gorillas and colobus monkeys are highly social and live in family groups. Species spending significant amounts of time on the ground tend to live in larger social groups (generally called

troops). Baboons, for example, inhabit open woodlands, savannas, grasslands and rocky hillsides and are generally found in troops of approximately 100 individuals. One sleeping group of 750 animals was observed. Larger social groups are important to terrestrial primates because they provide more eyes to watch for predators.

Primates' color vision allows the animals to select ripe fruit not only by smell but also by color. Furthermore, simply locating fruit in the dense forests is made easier when the colorful fruit can be easily distinguished from the green leafy surroundings.

Other characteristics include:
- Generally erect posture (for sitting, leaping, standing, and bipedalism)
- Flexible, general limb structure (allowing for more than one form of movement)
- Decreased reliance on olfaction (sense of smell)

Stereoscopic vision, made possible by the forward facing eyes of primates, allows for the ability to judge distance. This is very important for those animals living high in forest ecosystems where the need to judge distances when jumping between trees is crucial.

Primate classification is in a constant state of flux. As a result, different resources often illustrate different classification structures. During this presentation we will look at the order primates as it is sometimes divided into three categories: prosimians, monkeys and apes. Monkeys are further divided into New World monkeys and Old World monkeys. The following slides will explore the characteristics of each of these groups.

Slide37

Orders of Mammals in Washington

The mammals of Washington (including several that have been introduced here) represent one marsupial and seven other orders of mammals, with more rodent species than any other type of mammal.

Slide 38

Mammal Conservation

A variety of factors have led to the threatened or endangered status of many mammals, including habitat destruction, introduced species, pollution, global climate change and over-exploitation.

Slide 39

Mammal Conservation

Though mammals are not the largest group of living organisms, they represent a wide diversity of adaptations and fill important niches in ecosystems across the globe. People have an affinity for mammals, which makes them important "flagship species" for conservation.

Slide 40

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