THE BURKE MUSEUM IN A BOX

ABOUT THIS PACKET

COMPARATIVE ANATOMY: FOR EDUCATORS AND CAREGIVERS

INTRODUCTION

This Burke Box packet uses the basic principles of comparative anatomy to lead students through a critical thinking investigation. Learners and educators can explore digital specimen cards, view a PowerPoint lesson, and conduct independent research through recommended resources before filling in a final comparative Venn diagram. By the end of the packet, students will use a comparative anatomy lens to independently answer the question: are bats considered birds or mammals?

BACKGROUND

The study of comparative anatomy can be traced back to investigations made by philosophers in ancient Greece. Using firsthand observations and accounts by hunters, farmers, and doctors, Aristotle and other Greek philosophers made detailed anatomical comparisons between species. The field of comparative anatomy has contributed to a better understanding of the evolution of species. Once thought to be a linear pattern, studies utilizing the principles of comparative anatomy identified shared ancestors among many species, indicating evolution occurs in a branching manner. Comparative anatomy has been used to prove relationships between species previously thought unrelated, or disprove relationships between species that share similar features but are not biologically related.

Comparative anatomy can study internal organs and soft tissues, skeletal structures, embryonic phases and DNA. Researchers look for homologous structures, or structures within species that are the same internally. These structures indicate shared ancestry and an evolutionary relationships between species. Researchers also look for analogous structures, which may look similar at a glance but have different internal structures. Analogous structures indicate the species have divergent ancestry. Vestigial structures are also important in comparative anatomy. A vestigial structure is an internal structure across a species that has remained throughout evolution but serves little to no purpose to the species at present. Vestigial structures also indicate shared ancestry.

OUTCOMES

- ☐ Recognize that comparative anatomy serves as evidence of evolution
- ☐ Use comparative anatomy to think critically about relationships between living organisms

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GATHER YOUR INFORMATION

COMPARATIVE ANATOMY PART 1: BIRDS, MAMMALS, AND BATS, OH MY!

Use this sheet to take notes as you look at the Comparative Anatomy **specimen ID cards**, **PowerPoint**, and **Additional Resources**.

BIRDS

MAMMALS

BATS

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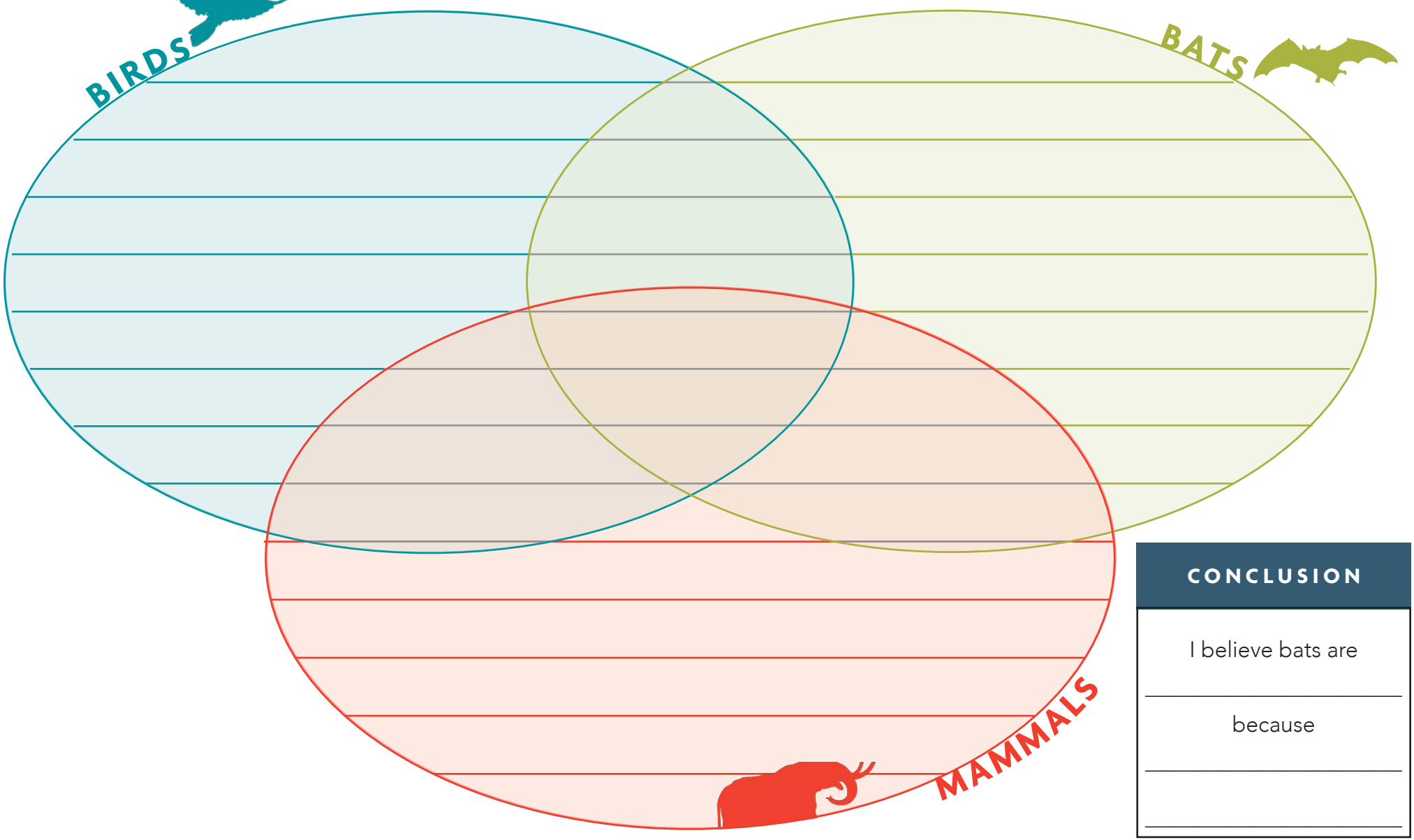
SYNTHESIZE YOUR INFORMATION

COMPARATIVE ANATOMY PART 2

Fill this chart out to explore the similarities and differences between birds, bats, and mammals.



CONCLUSION

I believe bats are

_____

because

_____

_____

ARCHAEOPTERYX LITHOGRAPHICA

This two-legged dinosaur was the first feathered fossil ever discovered. Though it had a bony tail, sharp teeth, and three-toed claws like a reptile, it also had long, strong flight feathers on its wings like a bird. Because of these shared traits, scientists believe *Archaeopteryx* was an ancestor of the birds we see today. It lived 150 million years ago in the Jurassic Period.

BEAVER SKULL AND JAW

Beaver teeth grow continuously throughout a beaver's life to resist the constant wear of chewing through hard woods. The bright yellow color of its teeth is a characteristic of the rodent family and is not a consequence of poor hygiene. The color comes from iron which also makes the tooth stronger and resistant to decay. The lips of a beaver wrap behind their front teeth so they can swim carrying branches.

BIG BROWN BAT

Big brown bats are one of the most common bats in North America. They have a 12-16 inch wingspan and are insectivorous, eating mainly beetles. Their flat teeth and strong jaw muscles allow them to crush hard beetle shells. Big brown bats live up to 20 years and are known to hibernate in caves and under man made structures. They use echolocation to help them catch their food and stay safe from predators.

BOBCAT SKULL AND JAW

All bobcats are obligate carnivores, meaning that they must eat meat to survive. Cats have special digestive processes that give them their nutrients from animal meat. Their sharp, pointed teeth grip and tear apart prey which help them get the meat they need. Their back teeth are used like scissors for chopping meat into smaller, more digestible pieces.

BOHEMIAN WAXWING WING

Bohemian waxwings are about the size of a robin. They have bright red tips on their secondary feathers. These tips come from pigments in the fruits they eat. The older they are, the bigger the tips get. Waxwings have wide, pointy wings with compact primary feathers. This shape helps them fly fast and far, which is helpful during migration. However, it also requires lots of active flapping to stay aloft.

COMMERSON'S LEAF-NOSED BAT SKULL

Native to Madagascar, the Commerson's leaf-nosed bat lives high in the forest canopy. These small bats are threatened by hunting and the deforestation of their natural habitat. Their diet consists of soft insects like flies and moths. When they are not active, they roost in tight groups under trees and in caves.

DINOSAUR TRACK (ORNITHOPOD)

This track is from an ornithopod dinosaur, a group known for their three pronged, bird-like feet. Ornithopods were herbivores and were successful survivors in the Cretaceous period. Ornithopods were so successful that they evolved into many species. This footprint is an example of a trace fossil, signs of life left behind by an animal. You can clearly see the iconic three pronged feet. Common ornithopods inlcude the iguanodontia and hadrosaur groups.

FEATHER TYPES

Feathers serve many different purposes for birds. Some help them stay warm, others keep them dry. Certain feathers are used to attract mates or fend off predators. Tail and wing feathers are specially designed in shape, placement, and length to support speed and agility in flight. The feathers in this display each come from different birds and represent each of the purposes mentioned above.

FLYING FOX WING

Flying foxes are some of the largest bats in the world. They survive on a diet of fruit and can be found throughout lower Asia. This skeleton wing of the flying fox shows the long thin bones of a typical bat wing. A layer of skin connects the bones making a wing. The individual fingers can move left and right allowing for the bat to dive, rise, or tilt while flying. Flying foxes do not have the ability to echolocate and instead rely on their eyesight to hunt.

FLYING SQUIRREL

Found throughout the world, species of flying squirrel span across most climates and geographic locations. Flying squirrels are not true fliers. They hop from trees and stretch out all their limbs. Their skin stretches tight between their limbs to catch air and slow down their fall. This process is known as gliding. Flying squirrels are not very good at walking around on all fours. Instead they will climb and use their gliding to move around.

FOX SPARROW BONE

Birds have special skeletons that help them fly. Their bones are very light and very strong. Some bird bones are hollow. Air can flow through hollow bones to help birds breathe better while flying. Some bones hold extra nutrients that help build eggshells. Fox sparrows find food by kicking leaves around on the ground. That means fox sparrows have stronger leg bones than similar birds that find food by flying.

GREY WOLF SKIN AND FUR

Wolf fur color can be black, reddish or even white, but grey is most common. Wolves live in wooded areas and their colors help them camouflage in their environment. They shed their fur every season, getting a new coat of thick, insulating fur in the winter and thinner fur in summer. When they shed, their fur grows back in different colors to better camouflage.

GULL FOOT

Gulls have three toes that face forward and one small toe facing backward. Their front toes have skin between them. This skin helps gulls swim and walk on wet sand. Gulls perch on flat areas like rocks and logs. Their back toe is smaller and weaker than other birds because they don't need to grip branches or wires. The color of a gull's feet can tell experts its age and species.

HAMMER-HEADED BAT SKULL

One of the largest living bats, the hammer-headed bat has a wingspan of up to three feet. These large bats live on a diet of fruits, particularly figs. They are nocturnal. They hunt for food during the night and return to their large roosts at dawn. Male hammer headed bats can be up to three times larger than females.

HARBOR SEAL FUR

Seals have a dense coat of short, stiff hairs that make them streamlined in the water. The tan, brown and black spots on their fur provide camouflage in the waters of the Puget Sound. Seals also have a lighter underside and a darker topside which helps them blend in with the ocean floor when seen from above, and blend in with the lighter sky when seen from below.

LITTLE BROWN BAT SKELETON

The thin and light bones of the little brown bat keep the bat lightweight enough for flight, but strong enough to hold itself upright and climb. Bats have a strong rib cage that protects vital organs like their heart and lungs. They have adapted wings for flight. Their wings stretch from their hips out to the end of each finger, creating a strong but flexible surface to aid in flight.

NORTHERN FLICKER

Northern flickers are woodpeckers. To make a nest, they use their strong beaks to make a large hole shaped like an upside down L in a tree trunk. The female lays five to eight white, oval eggs. Since the eggs are hard to find inside a tree trunk, they don't need spots or dull colors to help keep them hidden. The male and female take turns keeping the eggs safe and warm until they hatch. This takes about two weeks.

PATAS MONKEY ARM

The patas monkey has not adapted the skill of flight and instead relies on its strong solid bones and its muscles to help it climb trees. The upper arm, forearm, and hand bone forms seen in this example have direct matches to bat skeletons. The bat equivalents of these patas monkey bones are thinner and the finger bones are elongated.

PORCUPINE QUILLS AND FUR

The quills and fur in this vial come from a North American porcupine. Quills are thick, modified hairs adapted to defend a porcupine against predators. Their quills are two to four inches long. Porcupines have a layer of insulating fur beneath the modified guard hairs. Porcupines cannot shoot their quills at attackers from a distance. When their quills get lodged in the skin of an attacker they then detach from the porcupine's skin.

RED-TAILED HAWK

Red-tailed hawks do migrate, but they can usually be found in the United States all year round. This species is named for its iconic colorful tail feathers. They are great hunters, and eat reptiles, bats, other birds, and small mammals. They have a special pouch in their throat, for storing extra food, called a crop. These hawks defend their territory, and are very vocal.

RED-TAILED HAWK SKULL

The red-tailed hawk has a skull adapted to make it a great hunter. This hawk eats a lot of meat. Its bill is strong, sharp, and curved to help it tear and rip. They use their bills and talons to remove feathers from smaller bird bodies before eating them. This skull also has big eye sockets to hold the hawk's large, keen eyes.

RODENT AND WEASEL SPECIMENS

This display houses two rodent species and a weasel. From top to bottom, you can see a Western deer mouse, a short-tailed weasel, and a Pacific jumping mouse. While the weasel is a carnivore, the mice eat both meat and plants. Adaptations over time have allowed these different species to be successful in a wide range of habitats.

SCAUP WING SKELETON

A common type of duck, the scaup's strong wings lift this large bird in flight. Some bones of birds are hollow, making them lightweight for flight. Flight muscles attach to these bones allowing them to fold their wings in and also adjust the shape of their wings mid-flight. Feathers make up the large surface area needed to create lift. Bats do not have feathers--instead, they rely on thinly stretched skin to provide the surface area needed to achieve lift.

SHARP-TAILED GROUSE WING

This brown and white speckled wing helps the sharp-tailed grouse hide from predators in tall grasses. Found in the northern United States and Canada, this bird does not migrate to escape the cold winters. Instead, it burrows into snowbanks to preserve its body heat on winter nights. It feeds on seeds in winter, but eats insects (especially grasshoppers) in the summer. The broad, short shape of this wing has adapted to allow for quick, powerful take-off to avoid predators.

Comparative Anatomy

Exploring bats' relationship to birds and mammals

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COMPARATIVE ANATOMY

Finding relationships through body structures

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Comparative Anatomy looks at the physical structures of a species to help understand their evolution and relationship to other species. Comparative anatomy studies:

- Structures that look different on the outside but are very similar on the inside (*homologus structures*)
- Structures that look similar on the outside but are different on the inside (*analogous structures*)
- Structures that, through evolution, have a minimized purpose (*Vestigtial structures*)

Your goal is to conduct research and determine whether bats are birds or mammals by comparing their:

Basic biology | Movement | Reproduction | Skeletal structures

BASIC BIOLOGY
What makes a bird?

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Bill made of keratin

Feathers

Wings

Vertebrate (backbone)

Vocalize or sing

Bipedal (walk on two legs)

Lay eggs

Warm-blooded

BASIC BIOLOGY
What makes a mammal?

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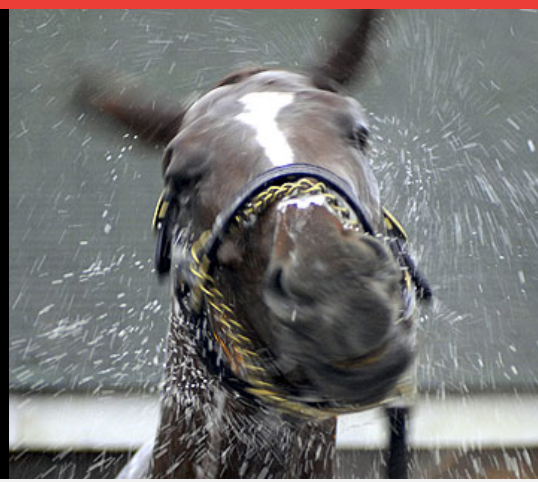
Most give live birth

Warm-blooded



Sweat

Vertebrates (backbone)

Hair on body

BASIC BIOLOGY
What makes a bat?

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- Live birth
- Endothermic "warm blooded"
- Sweat glands
- Hair on bodies
- Vertebrates
- Wings
- Echolocation

Does a bat's basic biology match birds or mammals better?

GETTING AROUND
How do birds move?

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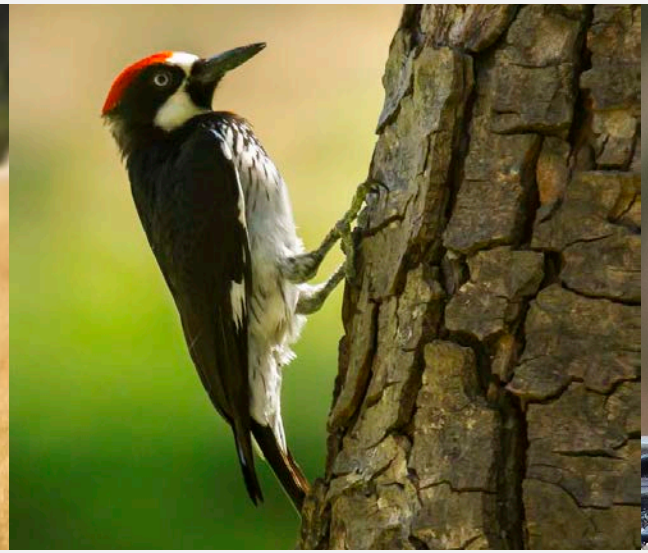
Flying

Burrowing

Swimming

Running



Climbing

Hopping

GETTING AROUND
How do mammals move?

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Gliding or flying

Hopping

Walking or running

Climbing

Swimming

Digging

GETTING AROUND
How do bats move?

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- Flying
- Climbing or crawling
- Swimming

Does a bat's movement patterns match birds or mammals better?

REPRODUCTION
How do birds care for their young?

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Lay eggs

Incubate (keep eggs warm)

Feed babies food

Use nests

REPRODUCTION
How do mammals care for their young?

BURKE MUSEUM

Live birth (most)

Feed young milk

Provide long-term care for offspring

REPRODUCTION
How do bats care for their young?

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- Live birth
- Feed young milk
- Care for young in colonies
- One pup per birth

Does a bat's reproduction patterns match birds or mammals better?

SKELETAL ANATOMY
Birds

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Bills without teeth

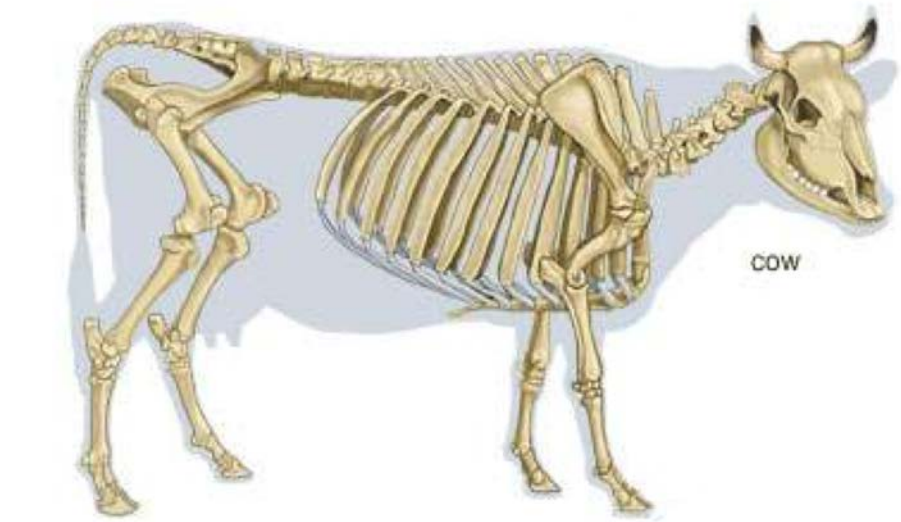
Hollow bones

Cross-braced ribcage

Have backbone

Wings without finger bones

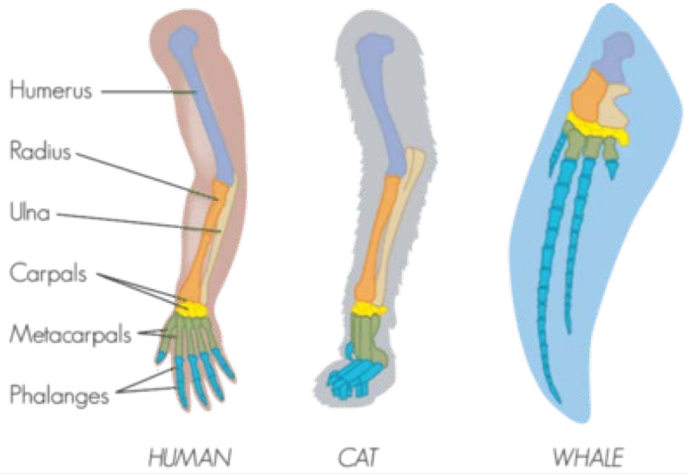
SKELETAL ANATOMY
Mammals



Have backbone

Have teeth

Have tail and hindlimb bones



Have finger bones in forelimbs

SKELETAL ANATOMY
Bats

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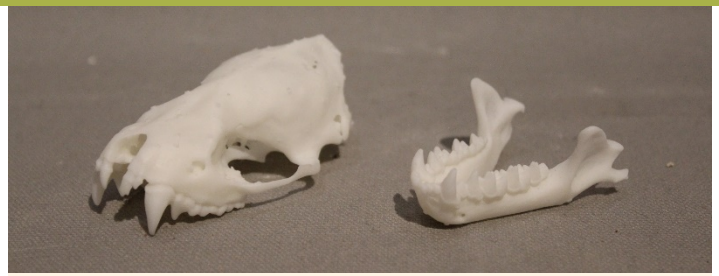
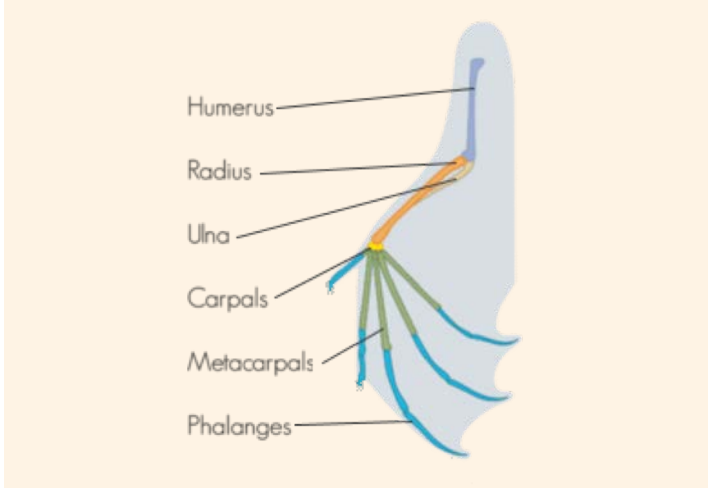
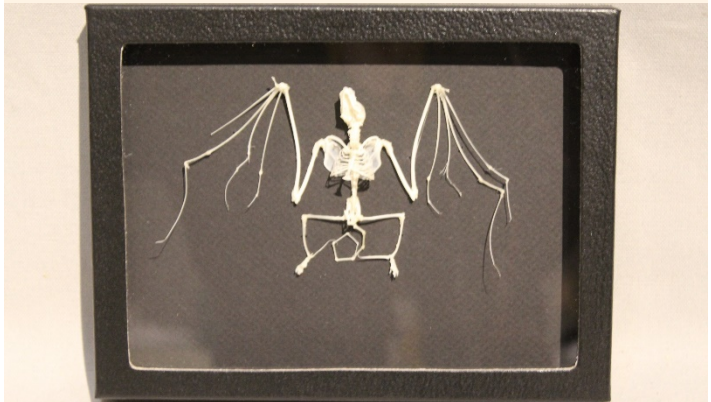
- Have backbones
- Have teeth
- Have hair
- Wings have finger bones
- No cross-bracing on ribs

Does a bat's skeletal anatomy match birds or mammals better?







MORE ABOUT BATS
Special adaptations: Echolocation

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- Bats use echolocation to assist their sight in hunting and catching prey and staying out of danger while on their night hunts.

- During echolocation, bats make high pitched clicks and listen for the return vibrations.

    - Bats have very sensitive ears. When the high pitched noise bounces off an object, it reflects back. Bats hear this reflection and their brains interpret that noise letting the bat know exactly where that object is.

        - This process is similar to the way our eyes see! Light bounces off of the things around us, and our brains interpret that information into sight.

MORE ABOUT BATS
Misconceptions about bats

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- Bats are not blind
  - Many bats have eyes that help them see better in low light conditions and the dark. Some bats may be able to see ultraviolet light, which human eyes cannot detect.
  - Echolocation often assists their vision.
    - Some bats, including the flying fox, do not use echolocation for hunting and navigating at all.
- Bats are not pests
  - Often called flying rats by people who dislike them, bats are actually a great help to ecosystems
    - Collectively, they eat thousands of pounds of insects a night.
    - This helps minimize bug bites and can keep down the rates of insect-borne diseases.
- Bats are very common
  - Though you may not see them around often, bats are incredibly abundant and diverse. There are over 1,200 species of bats around the world.

ADDITIONAL RESOURCES

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Birds

OneZoom Tree of Life: Birds

Cornell Lab of Ornithology: All About Birds

Seattle Audubon Bird Web

Mammals

OneZoom Tree of Life: Mammals

Burke Museum: Mammal Diversity

Animal Diversity Web: Mammals

Bats

Burke Augmented Reality Pocket Bats

Bats Northwest

National Geographic Photo Ark